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APPLIED ANATOMY

THE CONSTRUCTION OF THE HUMAN BODY

CONSIDERED IN

RELATION TO ITS FUNCTIONS,
DISEASES AND INJURIES

BY

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NINTH EDITION

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WITH SIX HUNDRED AND SEVENTY-FOUR ILLUSTRATIONS, MOSTLY FROM
ORIGINAL DISSECTIONS AND MANY IN COLOR

BY

ERWIN F. FABER

PHILADELPHIA LONDON MONTREAL

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PRINTED IN THE UNITED STATES OF AMERICA

To

GEORGE A. PIERSOL, M.D., Sc.D.

LATE PROFESSOR OF ANATOMY IN THE UNIVERSITY OF PENNSYLVANIA,
AN IDEAL SCIENTIST, TEACHER, AND FRIEND

PREFACE TO THE NINTH EDITION

As stated by Dr. Davis in the Preface to the First Edition, this work aims to teach surgical principles through the medium of anatomical relations. As the book is not an operative surgery, operative descriptions are merely sketched and the anatomical relations conjoined.

As the years have passed this book has gone through a number of revisions mostly in the nature of insertions into the original text. This method leads to a certain unevenness and hence the present editor and the publishers felt that for this revision many of the sections must be entirely rewritten. This was particularly true of those sections dealing with the surgical specialties. As a result the book has been entirely reset.

Dr. Bernard J. Alpers who is associated with Dr. C. H. Frazier, has rewritten most of the sections upon the brain and spinal cord; Dr. Robert A. Kimbrough, Jr., an associate of Dr. Floyd E. Keene, has entirely revised the section on gynecology and Dr. Stirling W. Moorhead of Dr. Alexander Randall's Clinic, has done the same for urology. Dr. I. S. Ravdin has made extensive revisions in the various chapters upon the abdomen. It is interesting to note that Dr. S. Dana Weeder found but few corrections and additions to make in the sections devoted to the extremities because Dr. Davis was an orthopedic surgeon and knew his subject. Mr. Erwin F. Faber has checked the illustrations and has provided a number of new ones. Some have been deleted. The editor wishes to thank his assistant, Dr. F. Mogavero, for painstakingly reading the proof, always a difficult task and the J. B. Lippincott Company for their consideration in allowing such a complete revision.

The B. N. A. nomenclature has been extended but its exclusive use throughout has not been considered advisable by reason of the fact that the book is used by those to whom this nomenclature would seem entirely strange, as most teachers in surgery use the older terms.

George P. Muller

PREFACE TO THE FIRST EDITION

It is not the object of this work to teach plain anatomical facts; its aim is to show the relation of structure to function, whether it is normal function or function disturbed or impaired by injury or disease. It is explanatory and utilitarian in character, and not encyclopedic. The bare facts of anatomy can be obtained from the systematic treatises, and they are here only briefly given in order to refresh the memory of the reader, who is supposed to be familiar to a certain extent with systematic anatomy. A person who has studied the subject only from a systematic standpoint cannot utilize and apply the knowledge so acquired unless he considers its relation to the various affections encountered in practice. He can study anatomy, but he will not see its application until it is pointed out to him. He may have studied the palmar fascia, but, unless he is shown how its construction influences the course of pus originating beneath it, his anatomical knowledge is of little value. The inability to make any practical use of the facts or to see their application is the reason why anatomy is so frequently regarded as a dry, uninteresting study and too often designedly neglected.

In considering the subject, after a few general remarks on the part involved, the skeleton and muscles are briefly described, and thereby one is enabled to understand the surface anatomy, which immediately follows. Then comes a consideration of the various affections of the part, with such allusion to the nerves and vessels as is desirable to elucidate the subject. As the book is not intended to be a systematic treatise on anatomy, such anatomical facts as cannot be shown to be useful in practice are not mentioned. To give them here would make the volume too large, obscure its main object, and defeat its purpose.

As regards the anatomical nomenclature used, there is no system so generally accepted as to justify its exclusive adoption. In the desire, however, to aid in furthering the adoption of better anatomical terms, as much of the BNA terminology has been used, or included in parentheses, as a consideration of the subject from the standpoint of a general practitioner would allow.

Most of the illustrations are from original drawings of preparations made by the author and his assistants. Those derived from other sources are duly credited; if there has been any failure in this respect, it is unintentional.

The clinical material, except where otherwise stated, is from the author's own experience.

To the artist in charge, Mr. Erwin F. Faber, and to Mr. Herman Faber, who made a large number of the original sketches, my best thanks are due for their great skill, untiring energy, and most intelligent aid; their work speaks for itself.

I am under great obligations to many friends who have kindly rendered me their aid. Professor George A. Piersol has given me much valuable information and allowed me the unstinted use of his anatomical material; Dr. Astley P. C. Ashhurst made many of the dissections and aided in correcting and preparing the manuscript for the press; Dr. Frank D. Dickson did most of the proof-reading and prepared the index; Dr. T. Turner Thomas made many of the earlier preparations; and Dr. Henry Beates aided in the revision of the first portion of the manuscript. To these and others who have contributed to the formation of the book I desire to express my thanks.

To the hearty coöperation and unfailing generosity of my publishers is due the presentation of such an attractive volume. I asked them for nearly everything I could think of, and they gave me nearly everything I asked for.

In conclusion: this work is recognized as being far from complete, but it is intended to be suggestive rather than absolute. It is not designed so much to present facts as to furnish reasons, and it is hoped that it will appeal to the practising physician and surgeon as well as to the student.

GWILYM G. DAVIS

PHILADELPHIA

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THE SCALP

The scalp is formed by the movable soft tissues which cover the skull. It is composed of three layers: *skin, superficial fascia,* and the *epicranius* (occipito-frontalis) *muscle* with its *galeal aponeurosis.* It is attached to the underlying pericranium by loose connective tissue called the *subaponeurotic layer.* The *pericranium,* or *periosteum* of the skull, is loosely attached to the bones by poorly

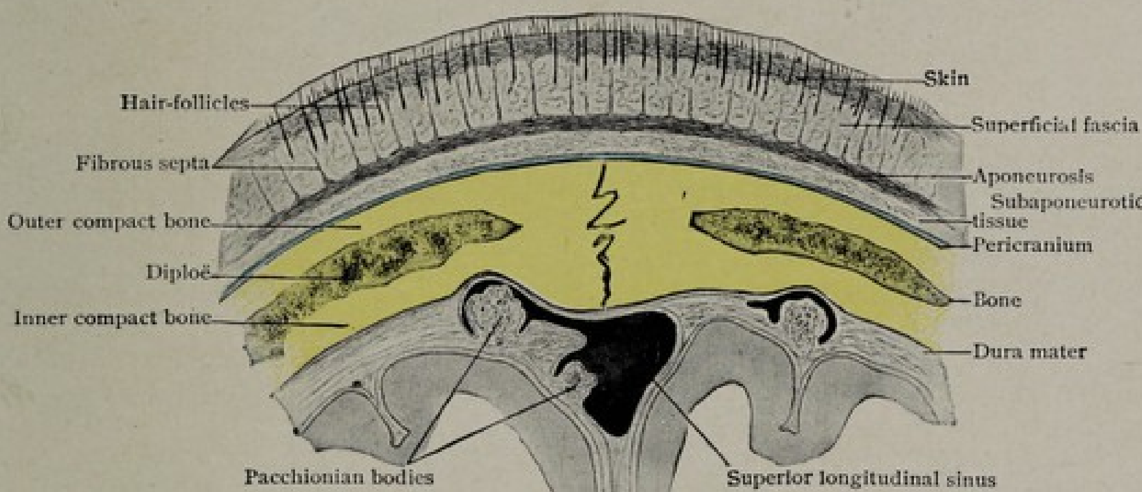


FIG. 1.—Portion of frontal section of head hardened in formalin, showing layers of scalp, skull and meninges. × 2½.

developed connective-tissue fibres called by some anatomists the *subpericranial connective tissue.* At the sutures, however, it is very firmly attached so that subpericranial collections are limited to the bone over which they lie.

The principal affections of the scalp are wounds, inflammation, affections of the blood-vessels, and tumors. The peculiarities of these affections are determined by the anatomical structure of the parts.

The **skin** of the scalp is probably the thickest in the body, although not so dense as that of the heel. Besides the hair, it contains abundant sweat and sebaceous glands. These latter are connected with the hair-follicles and are near the surface. The skin increases in thickness from the frontal to the occipital region.

The **superficial fascia** consists of a net-work of connective tissue fibres which run from the skin above to the aponeurosis of the epicranius below. In its meshes are fat, blood-vessels, nerves, and lymphatics. The hair-bulbs often pierce the skin and extend into this layer.

The fibres of the superficial fascia bind the skin so firmly to the aponeurosis beneath that when the skin is moved the aponeurotic layer is carried with it. The arrangement of the fibres is shown in Fig.3. Fibres starting from the point *A* not only pass directly down to *B*, but also to each side to the points *C* and *D*. In the same way, fibres starting from *B* not only pass upward to *A*, but also forward to *E* and backward to *F*. Now, if the skin is moved in the direction of the forward arrow, the fibres *E B* and *A D* are tightened and drag the aponeurosis forward. If the skin is moved in the direction of the backward arrow, the fibres *A C* and *F B* are tightened and so drag the aponeurosis backward. Thus it is seen that the aponeurosis must follow the movements of the skin.

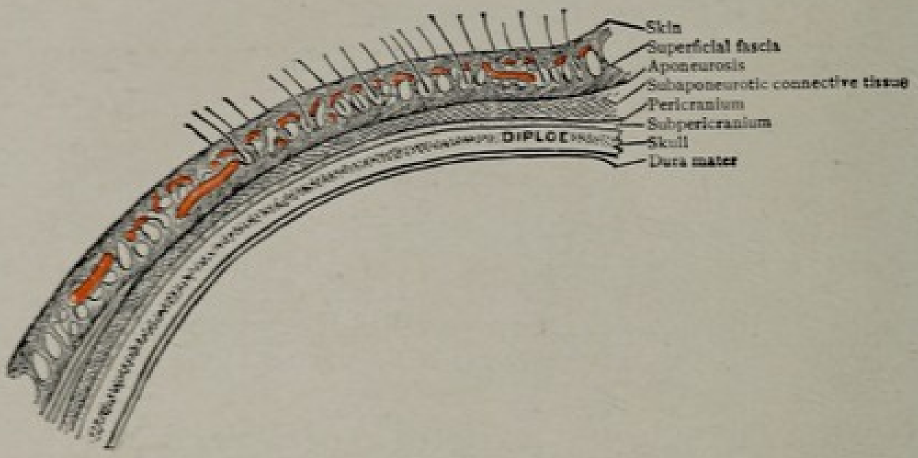


FIG. 2.—Layers of the scalp.

The **epicranius (occipitofrontalis) muscle with its aponeurosis** arises from the superior curved line of the occiput and is inserted into the skin of the frontal region. The epicranial aponeurosis (galea aponeurotica) divides into two layers, one inserting into the skin and the other into the rim of the orbit. The bellies of the muscle are comparatively short, about 5 cm. in length, the remaining tissue extending between them constituting the aponeurosis. As it comes downward from the temporal ridge, over the sides of the head, the aponeurosis becomes thinner and gives attachment by its superficial surface to the *anterior* and *superior auricular* muscles. It then proceeds downward to be attached to the upper edge of the *zygoma*. Contraction of the epicranius muscle causes the skin of the forehead to wrinkle transversely. It also raises the eyebrows and may move the skin of the forehead forward and backwards. It blends with the *pyramidalis nasi* and *corrugator supercilii*. It is supplied by branches of the facial nerve.

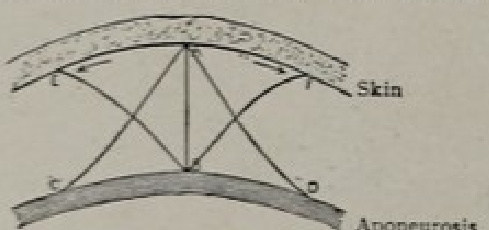


FIG. 3.—Diagram illustrating the method of attachment of the skin to the aponeurosis of the occipitofrontalis muscle.

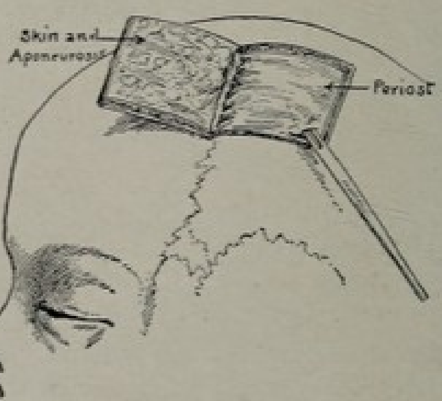


FIG. 4.—Showing how the periosteum in childhood dips between the bones in the line of the sutures.

The **subaponeurotic tissue** is very loose and abundant, so that it does not tend to confine the movements of the scalp, but favors them. Hence the scalp is readily torn loose from the skull in scalping, machinery accidents, etc. This tissue is so loose that effusions accumulate here and spread extensively. It contains only a few blood-vessels.

The **pericranium** in its normal condition is a thin, tough membrane containing few blood-vessels. Except at the sutures, where it is firmly attached and dips down between the bones, it is comparatively easily stripped from the skull and does not convey much nourishment to it. It is deficient in osteogenetic or bone-forming properties, so that when it is raised off the skull in operations, and the bone removed from beneath, as occurs in trephining, fractures, etc., new bone is not produced.

The **subpericranial tissue** is so scanty and loose, particularly in infancy, that it readily allows the pericranium to be raised and effusions to occur beneath.

THE ARTERIES OF THE SCALP

The scalp is supplied by the *frontal, supra-orbital,* and sometimes a small branch from the *lachrymal arteries,* from the *ophthalmic*; by the *temporal,* through

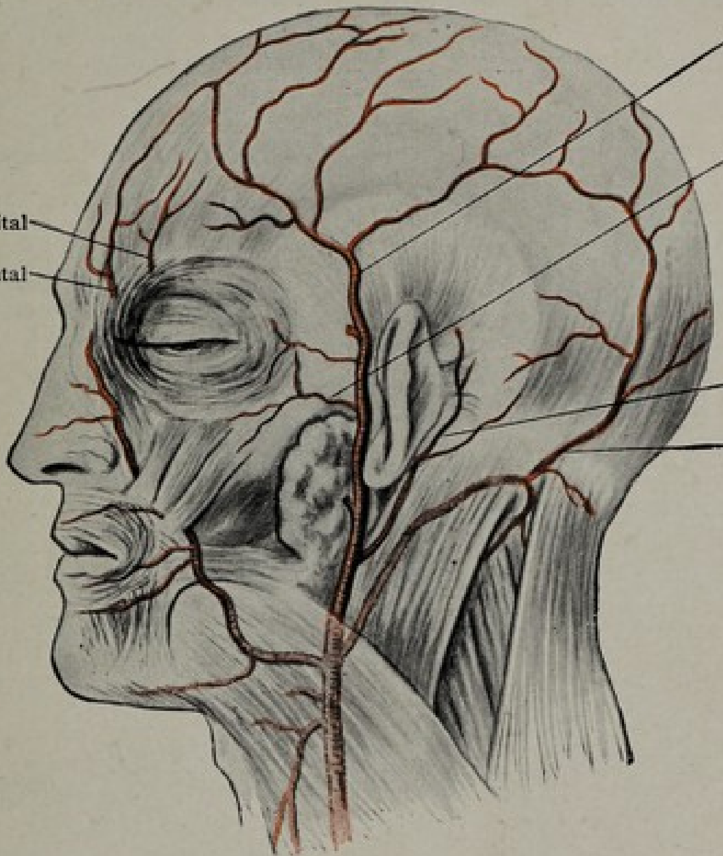


FIG. 5.—Arteries of the scalp.

its anterior and posterior branches; and by the *posterior auricular* and the *occipital arteries* from the *external carotid.* These arteries communicate freely with each other, not only laterally, but also across the top of the scalp. It is not unusual to see a large branch of the temporal communicating directly with the occipital.

The **temporal (superficial temporal) artery** begins in the substance of the *parotid gland,* just below the condyle of the jaw, and mounts over the zygoma, a centimetre (or less) in front of the ear. It lies on the temporal fascia and its pulsations can be felt at this point, if desired, during the administration of an anæsthetic. About four centimetres (1½ in.) above the zygoma, it divides into the anterior and posterior branches. The *auriculotemporal branch* of the *fifth nerve* lies just in front of the ear and between it and the temporal artery.

The **occipital artery** mounts to the scalp in the interval between the posterior border of the *sternomastoid muscle* and the anterior border of the *trapezius.* It is about midway between the posterior border of the *mastoid process* and the *occipital protuberance.* If it is desired to expose it from this point forward, the sternomastoid, splenius capitis, and trachelomastoid muscles will have to be cut, because it passes beneath them. The *occipitalis major nerve* lies to the inner side of the artery.

LYMPHATICS OF THE SCALP

Anteriorly the lymphatics near the median line pass down between the orbits to reach the submaxillary nodes. Those of the anterior parietal and temporal regions empty into the pre-auricular nodes; those of the posterior parietal and temporal, into the nodes behind and below the ear (posterior auricular glands); and those of the occipital regions, into the occipital nodes. Infections of these regions, therefore, will cause enlargement of the corresponding nodes which lie on the occipital attachment of the trapezius.

AFFECTIONS INVOLVING THE LAYERS OF THE SCALP

Wounds of the scalp are common. Incised wounds bleed more freely and the hemorrhage is more difficult to control than in wounds elsewhere on the surface. This is due to the exceedingly free blood supply and to the peculiar arrangement of the blood-vessels in the tissues which does not permit the vessels to retract.

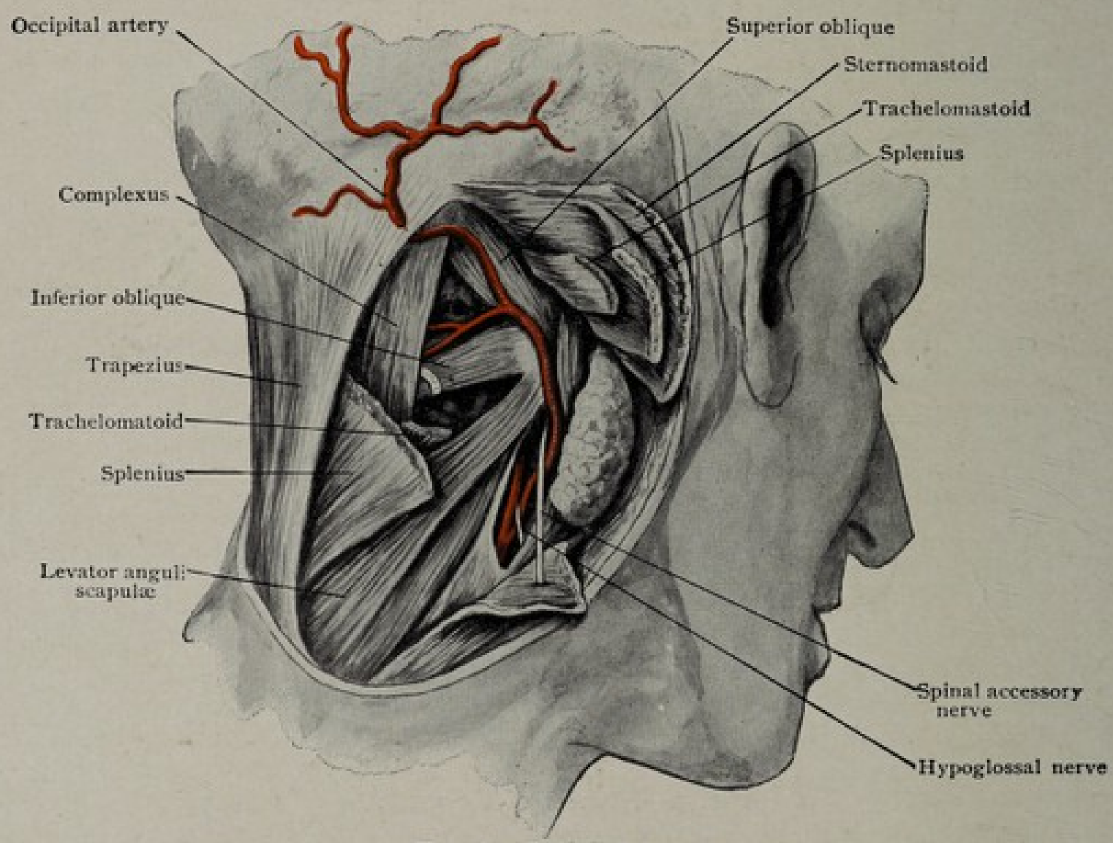


FIG. 6.—Occipital artery.

Small wounds of the scalp do not gape, particularly if they are longitudinal in direction and not very deep. The skin is so intimately bound to the aponeurosis beneath that displacement is impossible. If the cut is deep enough to divide the aponeurosis extensively, especially if the wound is transverse, gaping is marked. This is produced by contraction of the two bellies of the epicranius muscle, which pulls the edges apart.

Bleeding is apt to be persistent and hard to control because the arteries running in the deep layers of the skin and fibrous trabeculæ are firmly attached and, therefore, when cut, their lumens cannot contract nor their ends retract. When large flaps are torn in the scalp, they rarely die because of their free blood supply, and sloughing is limited to the parts which are actually contused. As the subaponeurotic space is often opened, if the wound is sewed too tightly shut, subsequent bleeding instead of escaping externally may extend widely under the aponeurosis. Inasmuch as hair and dirt are often crushed into these wounds, great care should be taken to disinfect them. A cut will open the hair bulbs and sebaceous glands, and, as the hairs project into the subcutaneous tissue, they may serve as a starting point for infection.

Contraction of the epicranius muscle may prevent healing in extensive wounds. To avoid this the scalp is covered by a recurrent bandage or otherwise fixed.

Lacerated wounds do not bleed so freely as do incised wounds, but they are accompanied by a more extensive loosening of the scalp. Large flaps of tissue are frequently raised and turned to one side. The most severe of these injuries have been produced by the hair being caught by a revolving shaft, tearing nearly the whole scalp off. Its loose attachment to the pericranium and bone beneath by the loose subaponeurotic tissue, readily explains the reason of these extensive detachments. The plane of separation is in the areolar tissue between the aponeurosis and the pericranium and often portions of the latter are torn away.

Contusions cause only a moderate amount of swelling, which is usually circumscribed. While the skin is not broken, the blood-vessels and other tissues beneath are often ruptured, and, therefore, extravasation of blood occurs. When this is confined to the superficial fascia, it is small in amount and limited in area. It does not tend to work its way for any great distance beneath the skin. If the extravasation extends below the aponeurosis, it may cover a considerable area of the skull. When the extravasation occurs beneath the pericranium it is called *cephalhæmatoma,* it is fairly common being said to occur in 0.5 per cent of babies. Usually over the right parietal eminence it never extends beyond the bounding sutures because of the adhesion of the pericranium to the sutures. A similar condition, called *caput succedaneum,* is an œdematous swelling of the scalp containing bloody serum and due to prolonged pressure on the engaging head during labor.

FIG. 7.—Arterial angioma or cirsoid aneurism.

Hæmatomas of the scalp possess the peculiarity of being soft in the centre and surrounded by a hard œdematous ring of tissue. In cephalhæmatoma of long standing this ring may ossify, and the new bone may even extend and form a more or less perfect bony cyst. This, however, is very rare.

Hæmatomas produced by blows on the head are often mistaken for fractures. The raised edge is so hard as sometimes to be thought to be the edge of broken bone. The tissues beneath the skin at the site of impact seem to be pulpified and remain perfectly soft to the touch; the smooth unbroken skull can usually be felt over an area equal to the site of the impact. Surrounding this soft area is the hardened ring, composed of tissues between the skin and the bone, into which serum and blood have been effused.

Inflammation and *abscess* are caused by infected wounds, furuncles, erysipelas, caries of the skull and suppurating sebaceous cysts.

The scalp is a favorite location for erysipelas; if not started primarily by an infected wound, the scalp may be involved secondarily by extension from the face.

Caries of the skull is often of syphilitic origin.

Abscesses may occur in three places:

1. Subcutaneous abscesses are usually small and do not tend to spread but rather to discharge through the skin. This is because the firm fibrous trabeculæ prevent lateral extension. Furuncles are quite common in childhood; they are, of course, superficial to the aponeurosis. Sebaceous cysts are especially common in the scalp and they sometimes suppurate. The orifice of the obstructed duct is not usually visible. Sometimes in a small cyst a black spot on its surface indicates the opening of the duct. By means of a needle or pin this opening can be dilated and some of the contents expressed. If nothing further is done the contents will reaccumulate. When these cysts become inflamed they become united to the skin above so that it has to be dissected off. If pus forms, it either remains localized to the cysts or

bursts through the skin and discharges externally. It does not tend to burrow under the skin laterally on account of the fibrous trabeculæ uniting the skin and aponeurosis. The aponeurosis beneath is intact, therefore the pus does not get below it. The cyst, with the lining membrane entire, should be removed, otherwise it will recur.

2. Subaponeurotic abscesses come from infected wounds, erysipelas, or caries of the bones. It is not desirable to close deep wounds of the scalp too tightly. Some suppuration is liable to occur which, not finding an easy escape externally, may spread under the aponeurosis if the wound has been deep enough to divide it. Infection of wounds is the most frequent source of these abscesses, hence the desirability of providing for drainage for at least a short period. In erysipelas, serous effusion, which may become purulent, occurs in the subaponeurotic tissue, as well as in the layers above. It may sink downward and point in the temporal, occipital, or frontal region. In the temporal region the descent of the pus may be limited by the attachment of the lateral expansion of the aponeurosis to the zygoma. The attachment of the occipitalis muscle posteriorly to the superior curved line of the occiput prevents the effusion from coming to the surface at that point. The liquid accumulates low down on the forehead over the orbits, being prevented from entering by the attachment of the *orbitotarsal ligament,* and tends to point close to the median line. The frontal muscles of the two sides are apt to be slightly separated, leaving a weak spot just above the root of the nose, and this is where fluctuation can most easily be felt. These accumulations in the frontal, temporal, and occipital regions may require incisions for their evacuation and drainage. Suppuration arising from carious bone readily perforates the pericranium and then infiltrates the loose subaponeurotic tissue. The bones of the vault of the skull are not infrequently affected by syphilitic disease, producing caries and suppuration, which invade the subaponeurotic space.

3. Subpericranial abscesses are comparatively rare. They usually start from diseased bone and spread laterally beneath the pericranial tissue. The pus may be limited to a single bone on account of the firmer attachment of the pericranium at the site of the sutures. To prevent its breaking into the subaponeurotic space a free opening should be made into the abscess so as to allow the pus to drain externally.

AFFECTIONS OF THE BLOOD-VESSELS

The arteries or veins alone may be affected, or both may be involved.

Arterial varix is the name given to an enlargement of a single artery. It forms a swollen, tortuous pulsating mass in the course of the artery. The temporal artery is liable to be so affected, particularly by its anterior branch.

Cirsoid aneurism, or aneurism by anastomosis is formed by numerous enlarged arteries. It is sometimes called an *arterial angioma* or *plexiform angioma.* The veins are also somewhat involved. Pulsation is marked. The mass is not an isolated one and compression of the main artery does not reduce the size of the mass or arrest the pulsation.

Venous angioma is a tumor formation in which the venous blood is contained in large spaces, which are lined with endothelium, instead of in normal veins.

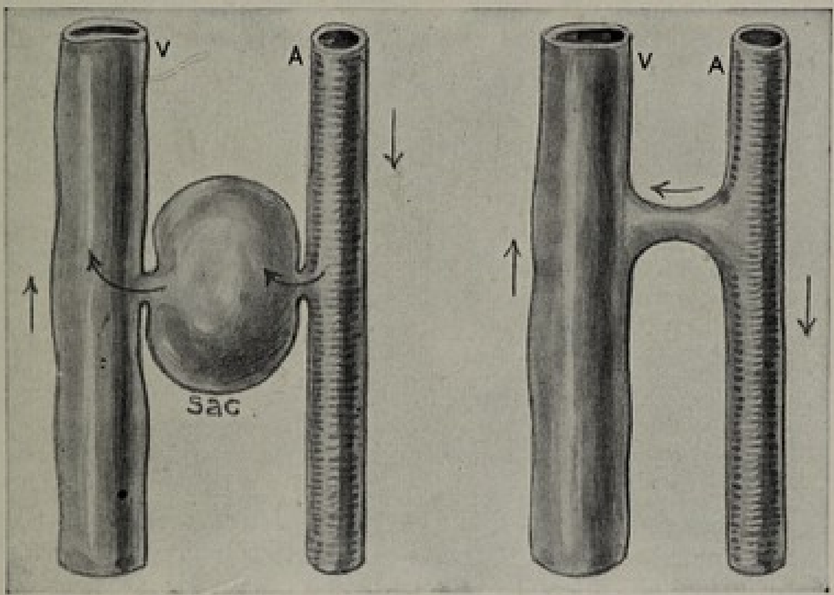
Telangiectasis, or *nævus,* is a hemangioma formed of enlarged arterioles, capillaries or venules. Nævi vary in color and size. If arterioles predominate the color is pink, while if venules predominate the color is blue. Frequently they are multiple. There are two distinct types. 1. Those formed largely of capillaries with either thin or thick walls and situated in connective tissue stroma. This group has been called the simple angiomata or angioma telangiectoides. 2. The second form, known as the angioma cavernosum consists of a series of blood spaces or sinuses which communicate. The spaces are irregular in size and shape and are lined with endothelium. These resemble the erectile tissue of the penis or clitoris, and are formed by the dilatation of old and new formed capillaries. No intervening sac is found, but a direct fistulous communication is established.

Aneurismal varix, or *arteriovenous aneurism* (Fig. 8), occurs where an adjacent artery and vein have been wounded,—as the femoral artery and vein,—and the blood passes directly from the artery into the vein.

Varicose aneurism (Fig. 8) is the condition in which a sac intervenes between the artery and vein, so that the blood passes first from the artery into the sac and then into the vein. Both the aneurismal varix and the varicose aneurism are classified as arteriovenous aneurisms. These affections are characterized by disturbances in the venous circulation, by venous pulsations, the presence of thrill and purring, and vibratory murmurs transmitted to the veins.

Treatment of Vascular Affections of the Scalp.—Vascular tumors are usually ligated and excised. The new types of high frequency dissecting apparatuses (Bovie) are ideal for some of these procedures. The exceedingly free anastomosis renders thorough excision preferable. The simple nevi and cavernous angiomata may be treated by the injection of boiling water or by the use of radium

FIG. 8.



Varicose aneurism. Indirect arteriovenous fistula. Aneurismal vein. Direct arteriovenous fistula.

or electro-desiccation. The latter two methods have been successfully used in the less extensive cases and the cosmetic result has been gratifying.

TUMORS OF THE SCALP

Sebaceous cysts arise from obstructed sebaceous glands; the contents consist of epithelial cells, fat, and cholesterin. They sometimes calcify, and may undergo malignant transformation. They spread in the subcutaneous tissue, stretching and raising the skin above and causing atrophy of the hair bulbs, but do not involve the epicranial aponeurosis below. In removing them, if they have never been inflamed, they can readily be turned out through a slit in the skin. The subaponeurotic space will not be opened, therefore their removal is not often followed by bad results.

Cephalocele is a tumor of congenital or traumatic origin protruding through the skull, composed of brain matter or membranes or both and covered by the scalp. Cephaloceles have fairly definite sites in that they usually occur in the occipital or sinicipital regions. The posterior ones may be above or below the tentorium. If above they are called superior and may communicate with the posterior fontanelle. The inferior commonly occur through a defect which communicates with the foramen magnum. The frontal or sinicipital type occurs through a defect in the longitudinal plate of the ethmoid near the base of the nose. It is also known as the naso-orbital, naso-frontal or naso-ethmoidal cephalocele. It is usual to distinguish an *encephalocele* consisting of brain only covered by arachnoid, a *meningocele* composed of thickened pia around a cyst, and an *hydrencephalocele*, the most common, which is really a protrusion of the lateral or fourth ventricles covered with a thin layer of brain tissue and the arachnoid. From the neurological viewpoint we know that even though a cranial defect is present no extrusion of hernia occurs unless coexisting increase in the intracranial pressure also exists. It is likely therefore that when a cephalocele is present there was some increase in the fœtal intracranial pressure before the lateral plates had enclosed the primitive nervous system.

Dermoid tumors occur in the median line and are most common over the anterior fontanelle and external occipital protuberance. They often have a thin

FIG. 9.—Sebaceous cyst of scalp.

FIG. 10.—Meningocele.

pedicle attaching them to the dura mater and may grow either inside or outside the skull. They are formed by an inclusion of some of the tissue of the ectoderm by the bones as they approach from each side to ossify and unite in the median line.

A congenital tumor located at the root of the nose is probably an encephalocele; one located at the anterior fontanelle is probably a dermoid; a tumor in the occipital region may be either, but a dermoid is apt to occur higher than an encephalocele.

THE SKULL

The skull is the bony framework of the head. It is divided into the bones of the cranium and those of the face. The hyoid bone is usually classified with the bones of the head.

The **cranium** consists of the bones forming the brain case. They are the *occipital*, two *parietals*, the *frontal*, two *temporals*, the *sphenoid*, and the *ethmoid*.

The **bones of the face** are fourteen in number, there being two single bones and six pairs. The single bones are the *mandible*, or *inferior maxilla*, and *vomer*; the pairs are the *superior maxilla, malar, nasal, palate, lachrymal,* and *inferior turbinated bones.*

THE SKULL IN CHILDHOOD

The skull of the infant is markedly different from that of the adult. At birth the face is quite small and undeveloped, while the cranium is relatively large. The frontal and parietal eminences are prominent. The vault of the skull is not entirely ossified and the sutures are not completed.

The bones of the base of the skull originate in cartilage, while those of the vault originate in membrane. This membrane has one or more centres of ossification appearing in it for each bone. These centres increase in size and finally meet at the edges of the bone, thus forming the sutures. At the time of birth the sutures are represented by membrane, which joins the adjacent bony edges.

The frontal bone has two centres of ossification; one for each side. These form a suture in the median line of the forehead which becomes obliterated in the course of the first or second year. Traces of it in the shape of a groove or ridge can sometimes be seen or felt in the adult skull. The *frontal eminences* are far more marked in childhood than later in life and give to children the prominent forehead which is so characteristic.

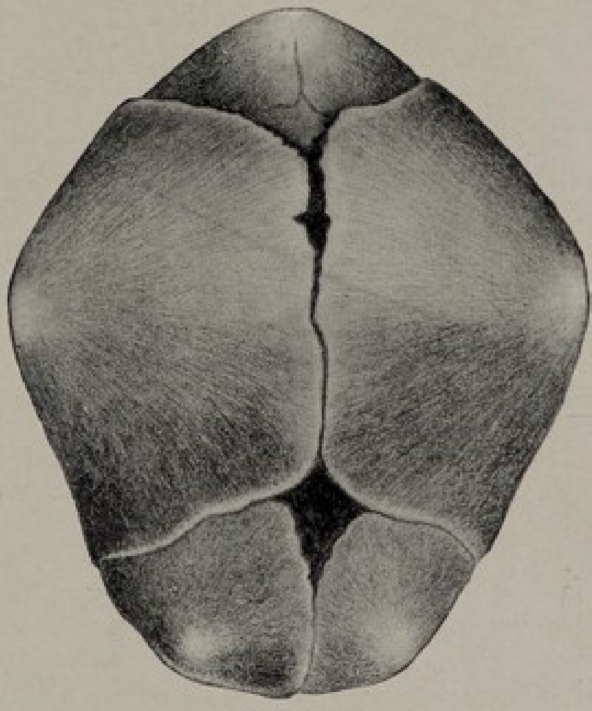


Fig. 11.—Infant's skull, showing posterior and anterior fontanelles.

A similar peculiarity is seen in the parietal bones, the parietal eminences being quite prominent. On this account, they are often injured in childbirth, sometimes being compressed by the obstetrical forceps, and are frequently the seat of *hæmatoma neonatorum.* The cranial bones not being firmly united allow of a certain amount of play or even overlapping, thus facilitating the delivery of the head at birth.

Fontanelles.—At the juncture of the various bones are six spaces called fontanelles. Two, the anterior and posterior, are in the median line of the cranium, and four, the two anterolateral and two posterolateral, are at the sides. The fontanelles are situated at the four corners of the parietal bones.

The *anterior fontanelle* is the largest. It is diamond-shaped and formed by the frontal suture in front, the interparietal behind, and the coronal at each side. It is usually closed by the end of the second year, but may be delayed until the fourth. In rickets and malnutrition the fontanelles remain open longer than would otherwise be the case.

The *posterior fontanelle* is formed by the juncture of the parietal (sagittal) suture with the lambdoidal suture. It is triangular in shape with the apex forward between the two parietal bones, the sides passing down, one to the right and the other to the left of the top of the occipital bone.

These fontanelles are of the greatest importance in diagnosing the position of the head during labor. If the examining finger encounters first a large diamond-shaped or four-cornered depression with its anterior angle more acute than the posterior, the accoucheur will know that it is the anterior fontanelle which is presenting. By following one of the sutures backward he will come to a triangular or Y-shaped ridge which will be recognized from its shape as being the boundary of posterior fontanelle. He will then know that the position of the head is occipitoposterior. If the position is the more usual occipito-anterior one, the finger will first encounter the posterior fontanelle with its three sutures, which are distinctly recognizable. On following the suture which leads backward, the four-cornered anterior fontanelle will be felt. The various sutures constituting the fontanelles can usually be distinctly felt, and, as the presentations are nearly always occipito-anterior, the fontanelle that will usually be first felt will be the posterior, and the sutures forming it can readily be identified. The anterior fontanelle is used in infancy in order to transfuse blood into the superior longitudinal sinus.

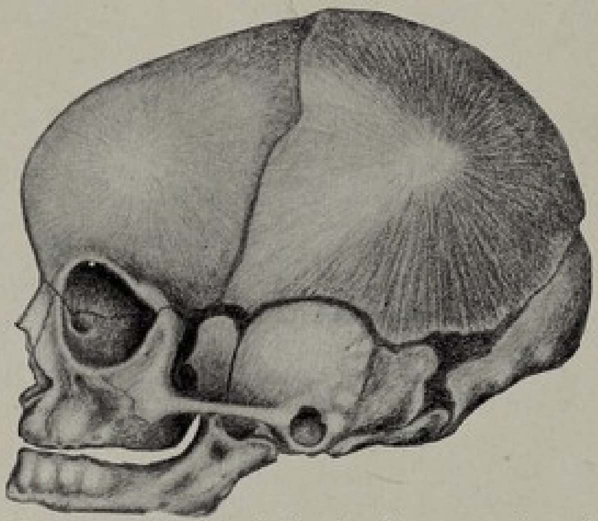


FIG. 12.—Infant's skull, showing anterolateral and posterolateral fontanelles.

The *antero-* and *posterolateral fontanelles,* located at the anterior and posterior angles of the parietal bones, are of no service in diagnosing the position of the head. They are indistinct, nearly closed, and thickly covered by tissues. In injuries to the skull in young children and infants, we should not mistake the fontanelles and lines of the sutures for fractures. Fissures extending into the occipital bone from the posterolateral fontanelles are normal at birth and not due to injury.

Dura Mater.—The dura mater in children is more firmly attached to the interior of the skull than in adults. If, therefore, a true fracture does occur, laceration of the dura is more liable to be produced. This firm attachment also prevents the formation of epidural hemorrhages, because the force of the blow is not sufficient to loosen the dura from the bone, and when the middle meningeal artery is torn, as Marchant has pointed out, the bleeding is more apt to be external than internal.

Cells and Air-sinuses.—In the infant the bones of the face are so slightly developed that there is no room for the cavities which afterward develop in them. The ridges of the bones also become more marked as age advances. The young child has no superciliary ridges.

The *maxillary sinus,* or *antrum of Highmore,* and the *mastoid antrum* are the only cavities that exist at birth. They are both much smaller than they ultimately become.

The mastoid antrum in relation to the size and age of the child is comparatively large, being about five millimetres in diameter. As the bone in the child is undeveloped, and the tympanum lies nearer to the surface, the antrum likewise is somewhat higher and nearer to the surface than is the case in adults. This should be borne in mind when operating on the bone in this region (Fig. 13).

The *frontal, ethmoidal,* and *sphenoidal sinuses* appear about the seventh year, but it is not until puberty is reached that they really begin to develop. The mastoid cells likewise appear at puberty and increase with age. At birth, they are represented by simple cancellous bone.

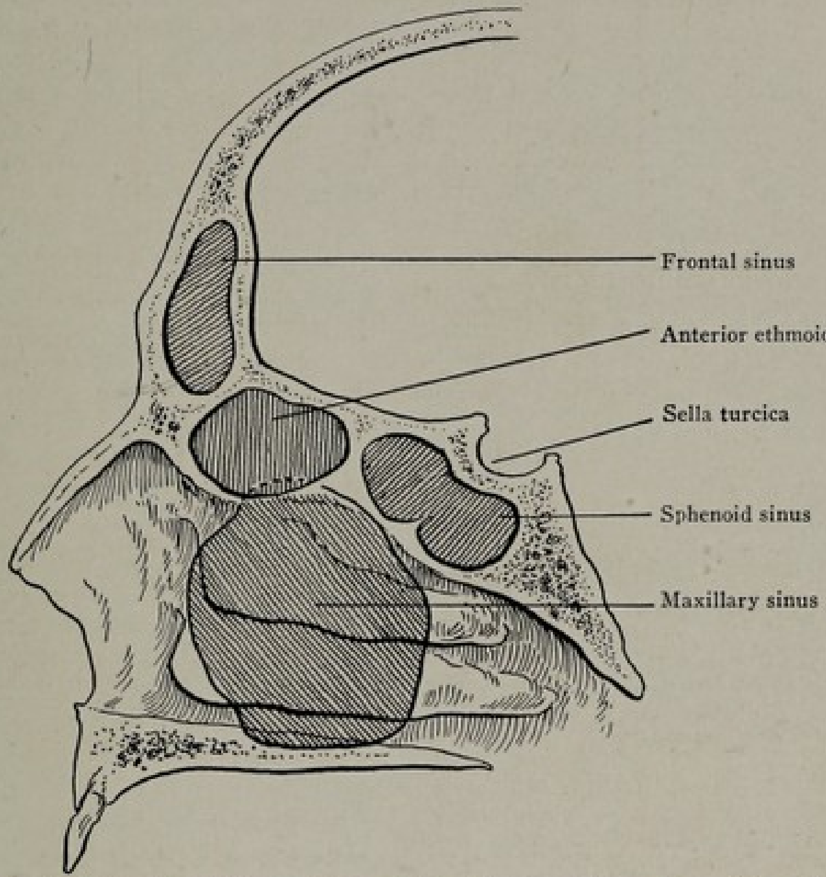


FIG. 13.—Diagrammatic representation of the relative size and position of the sinuses.

THE SKULL IN ADULTS

As the child grows, the bones of the face increase more rapidly than do those of the vault. The bony prominences become marked, due to the action of the various muscles of mastication, expression, etc., inserted into them. The face is much larger in size in proportion to the calvarium than was the case in infancy. While in infancy bone is practically homogeneous, in late childhood and early adult life cavities begin to develop in it.

Outer and inner tables of compact tissue are formed, separated by diploic structure. The frontal, ethmoidal, and other air-sinuses are an exaggeration of these diploic spaces. They are lined with mucous membrane and communicate with the nasopharynx. The diploë first begins to appear about the age of ten years, but is not well formed until early adult life. It contains large veins, called the diploic veins, which communicate with the veins both of the inside and outside of the skull. In injuries to the skull bleeding from these veins is rarely troublesome and usually stops spontaneously.

The skull is thinner in the white than in the Negro race. It is thickest over the occipital protuberance and mastoid processes. The bone is thinnest in the temporal and lower occipital regions. The two tables are separated widely from one another in the region of the frontal sinuses.

Tables.—The inner table is thinner and more brittle than the outer one, and in fractures it is almost always more extensively splintered than the outer. In rare cases the outer table may be temporarily depressed by a glancing blow and spring back into place without showing any depression, while the inner table may be fractured.

The two tables are not exactly parallel. Where the skull is thin, as in the temporal and occipital regions, they are close together; where it is thick, they are farther apart. The outer surface of the skull is comparatively even and smooth. The inner surface is quite uneven, being depressed in places to receive the convolutions of the brain. For this reason it is necessary to use the trephine with great care, as it may cut through on one side of the circle and injure the dura mater before it cuts through the other part.

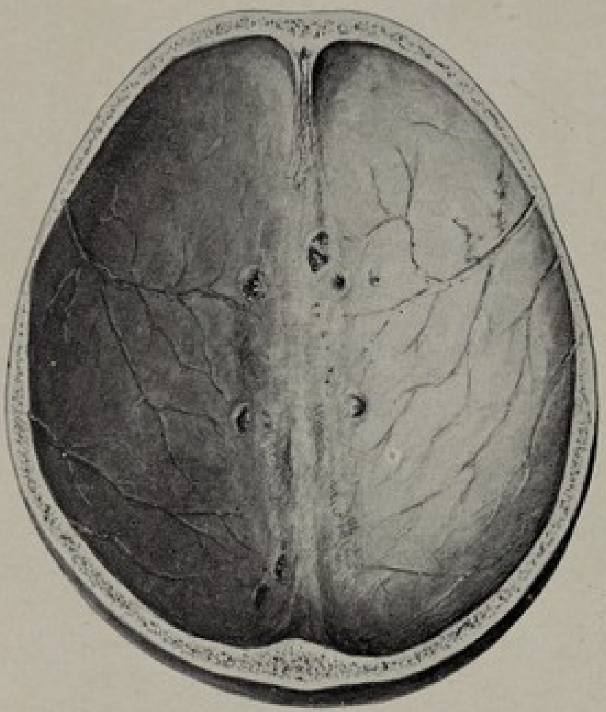


Fig. 14.—Illustration showing the relative thickness of the frontal, temporal, and occipital bones as well as the diploë within the skull bones.

The **sutures** of the skull begin to ossify at about the age of forty years and continue to fuse until about the eightieth year.

Frontal Sinuses.—The frontal sinuses begin to develop at the age of seven years, but do not increase rapidly in size until puberty. When adult age is reached they are well developed. They may extend well out over the orbits, reaching to within a short distance of the temporal ridge, while in other instances they do not go beyond the supra-orbital notches. In height they may reach the lower portion of the frontal eminences or may cease at the level of the superciliary ridges. The size of the sinus cannot be judged from the size of the bony prominences. Neither is the size nor sex of the individual any criterion. In a small female we have seen them of considerable size. When diseased sufficiently to give rise to symptoms, they will be found to be quite large. They are separated from each other by a septum, and if extensive are divided into several pockets or recesses. They open into the infundibulum, at the anterior extremity of the middle turbinated bone in the middle meatus of the nose. Fracture of the outer wall of the sinus not infrequently occurs without involvement of the inner table.

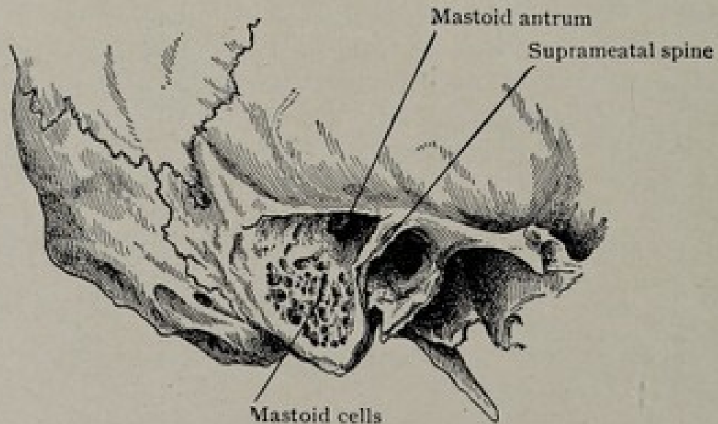


Fig. 15.—Surface chipped away to show the mastoid antrum and cells, the latter unusually well developed.

Mastoid Process.—The mastoid process is continuous with the superior curved line of the occiput. It increases in size from the time of birth, but is composed of cancellous tissue until after the age of puberty, when the mastoid cells develop. The mastoid antrum, a cavity five millimetres in size at birth, which opens into the upper posterior portion of the tympanum, is relatively larger at birth than in the adult. It is of importance in operating for infection arising from middle-ear disease. Minute veins run from the antrum into the lateral sinus.

Suprameatal Triangle.—This triangle, so named by Macewen, is formed above by the posterior root of the zygoma, anteriorly by the bony posterior wall of the external auditory meatus and posteriorly by a line from the floor of the meatus passing upward and backward to meet the first line. The mastoid antrum is reached by operating through this triangle (see section on Ear).

Cerebral Venous Sinuses.—The fibrous membrane which lines the interior of the skull is composed of two layers which are in most places intimately united, forming one single membrane known as the dura mater. The outer layer is applied to the bone, while the inner layer covers the brain. In certain places these

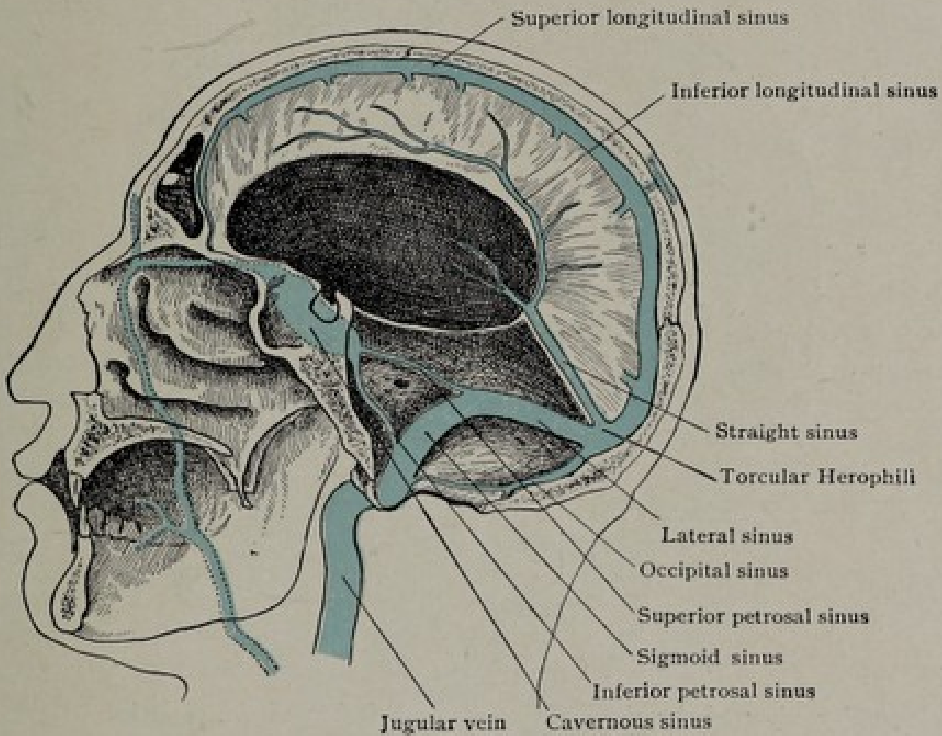


Fig. 16.—The cerebral blood sinuses.

two layers separate to form channels in which venous blood flows; these channels are called sinuses. In certain other places these layers separate and enclose some special structure, as the *Gasserian (semilunar) ganglion.*

The cerebral sinuses lie between layers of the dura mater. There are five unpaired and six paired sinuses. Those of most importance are the *superior longitudinal, the lateral or transverse*, and the *cavernous.*

The *superior longitudinal (superior sagittal) sinus* is unpaired and begins in a small vein ascending from the nose through the foramen cæcum. It runs in the median line from the foramen cæcum in the ethmoid bone in front, to the torcular Herophili (confluens sinuum) behind. As it passes backward it inclines more to the right side, so that at the torcular Herophili the left side of the sinus is about in the median line. This sinus receives the veins from the cortex of the brain and also some of the diploë of the bones above it. A vein pierces the upper posterior angle of each parietal bone and forms a communication between the superficial veins of the scalp outside and the superior longitudinal sinus within. The deviation of the superior longitudinal sinus toward the right, as it proceeds posteriorly, is to be borne in mind in operating in this region, as one can approach the median line nearer on the left side posteriorly than the right, without wounding it. In the parietal region the *Pacchionian bodies* are surrounded by extensions from the longitudinal sinus and free hemorrhage will ensue if the bone is removed too close to the median line.

The *torcular Herophili* (confluens sinuum), or confluence of the sinuses, does not correspond exactly to the external occipital protuberance or *inion* on the exterior of the skull. It is a little above and to the right of it. This torcular Herophili is formed by the meeting of the longitudinal sinus from above, the lateral, or transverse sinuses from the sides, the straight sinus from in front and the occipital sinus from below.

The *lateral* or *transverse sinuses*, of which there are two, pass from the torcular Herophili toward each side in the tentorium between the cerebrum and cerebellum, following the superior curved line of the occiput until just above the upper posterior

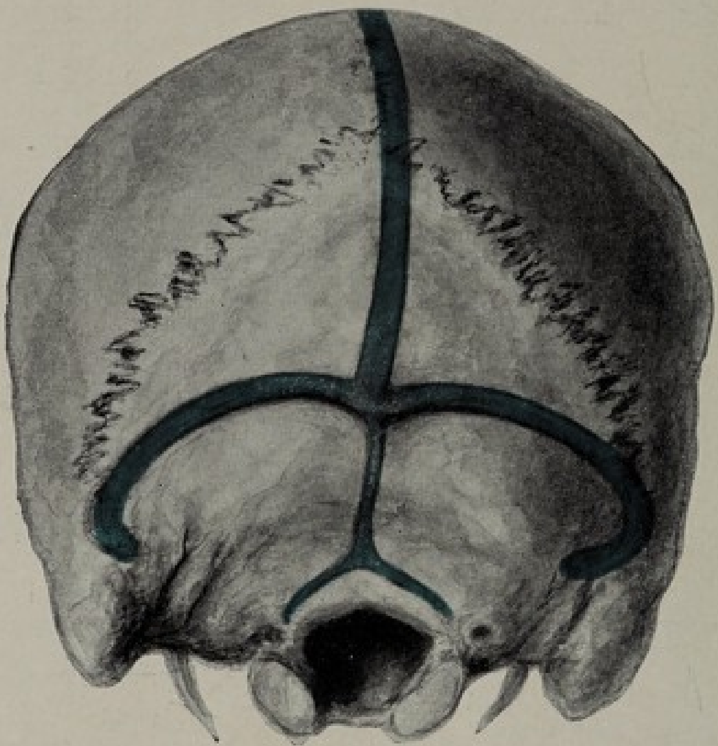


FIG. 17.—Posterior view of the skull, showing the relation of the superior longitudinal sinus and torcular Herophili to the median line and external occipital protuberance.

portion of the mastoid process. They then bend downward to within a centimetre of the tip of the process and again curve forward to end in the jugular foramen and be continued as the internal jugular vein. The S-shaped curve which they make in this part of their course has given rise to the name *sigmoid sinus*. In their course along the superior curved line the sinuses rise above the level of a line drawn from the inion to the centre of the external auditory meatus.

In operating for cerebellar lesions or angle tumors, remember to place the trephine opening sufficiently low to avoid wounding this sinus. It is in great danger of being wounded in operating for septic conditions involving the mastoid antrum and cells. Its distance from the surface of the skull varies in different individuals, and is greater as it descends to the level of the tip of the mastoid process. If care is exercised its bluish color can be seen through the medial wall of the mastoid. It receives the blood from the posterior lower portion of the cerebrum and upper portion of the cerebellum, and communicates with the veins outside the skull through the mastoid and posterior condyloid foramina.

Running along the upper posterior edge of the petrous portion of the temporal bone, in the attachment of the tentorium, is the *superior petrosal sinus*. It is a paired sinus. It connects at the lateral, or transverse, sinus at about its middle with the *cavernous sinus*. More deeply situated, and running from the cavernous sinus to the lateral sinus, just as it enters the jugular foramen, is the *inferior petrosal sinus.*

The petrosal and lateral sinuses are frequently torn in fractures of the skull. A fracture passing through the petrous portion of the temporal bone may tear the petrosal sinuses, and hemorrhage from the ear may come from this source. A fracture through the posterior cerebral fossa may tear the lateral sinus. Leeches are sometimes applied behind the ear in inflammation of the brain, with the idea of drawing blood from the lateral sinus through the mastoid vein.

The *occipital sinus* is usually small and brings the blood up from the region of the foramen magnum to the torcular Herophili. It extends up the falx cerebelli.

The *straight sinus* runs along the line of juncture of the tentorium and falx cerebri. It is unpaired. It receives the blood from the ventricles of the brain which

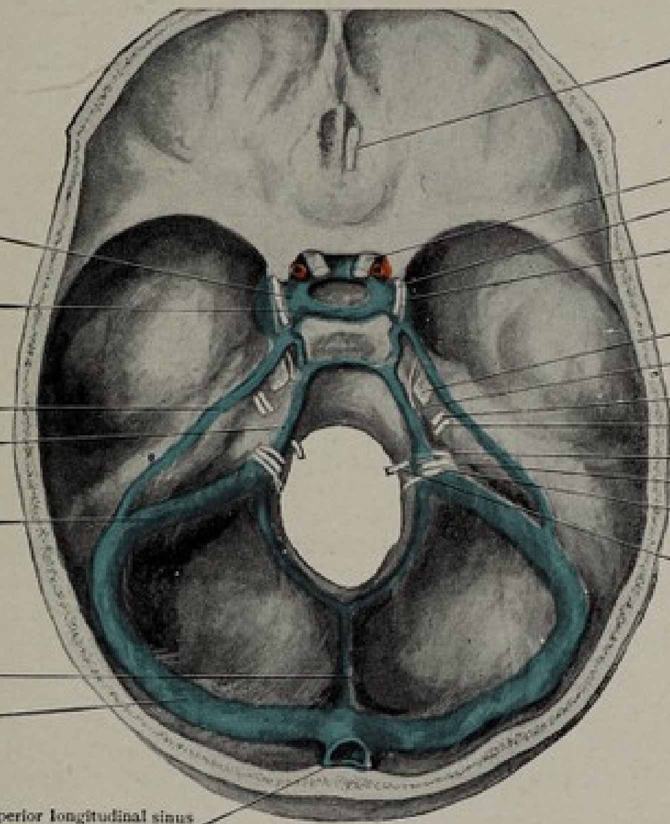


FIG. 18.—Exit of cranial nerves and venous sinuses at the base of the skull.

are drained by the veins of Galen (v. cerebri magna), and the blood from the falx through the *inferior longitudinal sinus.* This latter is usually very small and sometimes almost lacking, the blood in that case passes upward to empty into the superior longitudinal sinus.

The *cavernous sinus,*—one on each side,—is a large, irregular space on the side of the body of the sphenoid bone. It runs from the sphenoidal fissure in front to the apex of the petrous portion of the temporal bone behind. In front it is continuous with the ophthalmic vein, and receives the *sphenoparietal sinus* which brings the blood from the diploë; behind it communicates with the superior and inferior petrosal sinuses. The two sinuses communicate across the median line around the pituitary body, forming the *circular sinus,* and across the basilar process, forming what is sometimes called the *transverse sinus,* but which is more correctly described as a plexus of veins.

The cavernous sinus has embedded in its outer wall the third and fourth nerves and the ophthalmic branch of the fifth. Farther below and to the outer side of the sinus are the superior and the inferior maxillary, or mandibular, branches of the fifth nerve. Within the sinus and toward its lower and inner portion, is the *internal* *carotid artery*. It is surrounded by the blood-current. Between the carotid artery and outer wall of the sinus runs the sixth nerve, held in place by fine, trabecular, fibrous bands which pass from side to side in the cavity of the sinus.

The cavernous sinus is sometimes torn in fractures of the base of the skull, resulting in the traumatic communication between the carotid artery and the sinus. The cavernous sinus may be torn in attempting the removal of the Gasserian (semilunar) ganglion. Its interior is not one large cavity, but is subdivided by fibrous

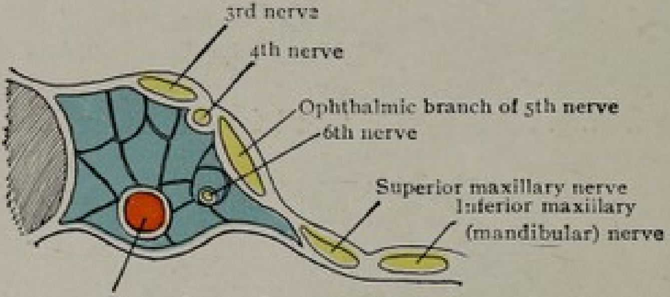


FIG. 19.—Transverse sections of the right cavernous sinus, showing the position of the nerves and internal carotid artery (from a dissection).

septa, which pass from side to side. It is sometimes the seat of thrombosis and infection, which may reach it through the ophthalmic vein.

FRACTURES OF THE SKULL

Fractures of the skull are almost always produced by violent contact of the skull with some solid body. In some cases the fracture is produced by a blow from a moving body, as when a person is struck by a club. In others, the skull is moving and strikes a body at rest, as when a person falls and strikes the head on a pavement. It is not necessary to discuss in detail the mechanism of fractures of the skull; it is sufficient to state that nearly all fractures start from the point of impact and radiate to distant regions. The effect of fracturing blows on the skull of a child is different from their effect on the skull of an adult. It should be remembered however that a fracture of the skull may exist without demonstrable cerebral damage, while the latter may occur after injury without demonstrable fracture.

Fractures of the Skull in Children.—A child's skull is thin and weak, and while, to a certain extent fragile, is more flexible than that of an adult. It is on this account that blows are more liable to expend their force locally, at the point of impact, and not produce fractures at a distance. Therefore, it follows that fractures of the base are rare in children in comparison with fractures of the vault. Extensive fissured fractures are also rare. A blow will crush the skull of a child at the point of impact, much as an egg-shell is broken at one spot by hitting it with a knife handle. In the infant a blow of moderate force by a pointed object such as the corner of a table or stair may simply indent the entire thickness of the skull at the point of impact. This has been aptly termed "ping-pong ball" fracture. It may be necessary to make a small trephine opening beside the depression which can then readily be pried or bent back by means of a lever. The trephine button is replaced. Doctor Davis observed the case of a small boy who, while playing, was struck by a baseball on the left frontal eminence. A distinct circular depression or cup was produced exactly corresponding to the shape of the ball. There were no symptoms of cerebral concussion, because the force of the blow was expended on the bone and not transmitted to the brain within. The sutures in very young children are soft, hence the transmission of the force from one bone to another is prevented.

The diploic structure of the skull is not well developed until adult age, therefore the bone is homogeneous. It is also elastic, and, particularly in infants, it may be dented without being seriously fractured; these dents are apt to disappear and become level with the surrounding bone as the child grows older. The dura mater is more adherent in children and fractures are, on that account, more liable to tear it and even lacerate the brain beneath.

Fractures of the Skull in Adults.—As adult life is reached the inner and outer tables of the bones become separated, leaving the space between to be filled by the diploic tissue. The diploë consists of cancellous bone in the meshes of which run the diploic veins and capillaries. Both the inner and outer tables are brittle, but the inner especially so. It is also harder and more compact than the outer table. On account of this difference we find in cases of fracture that the inner table is more comminuted than the outer, so that, while the outer may show a single line of frac-

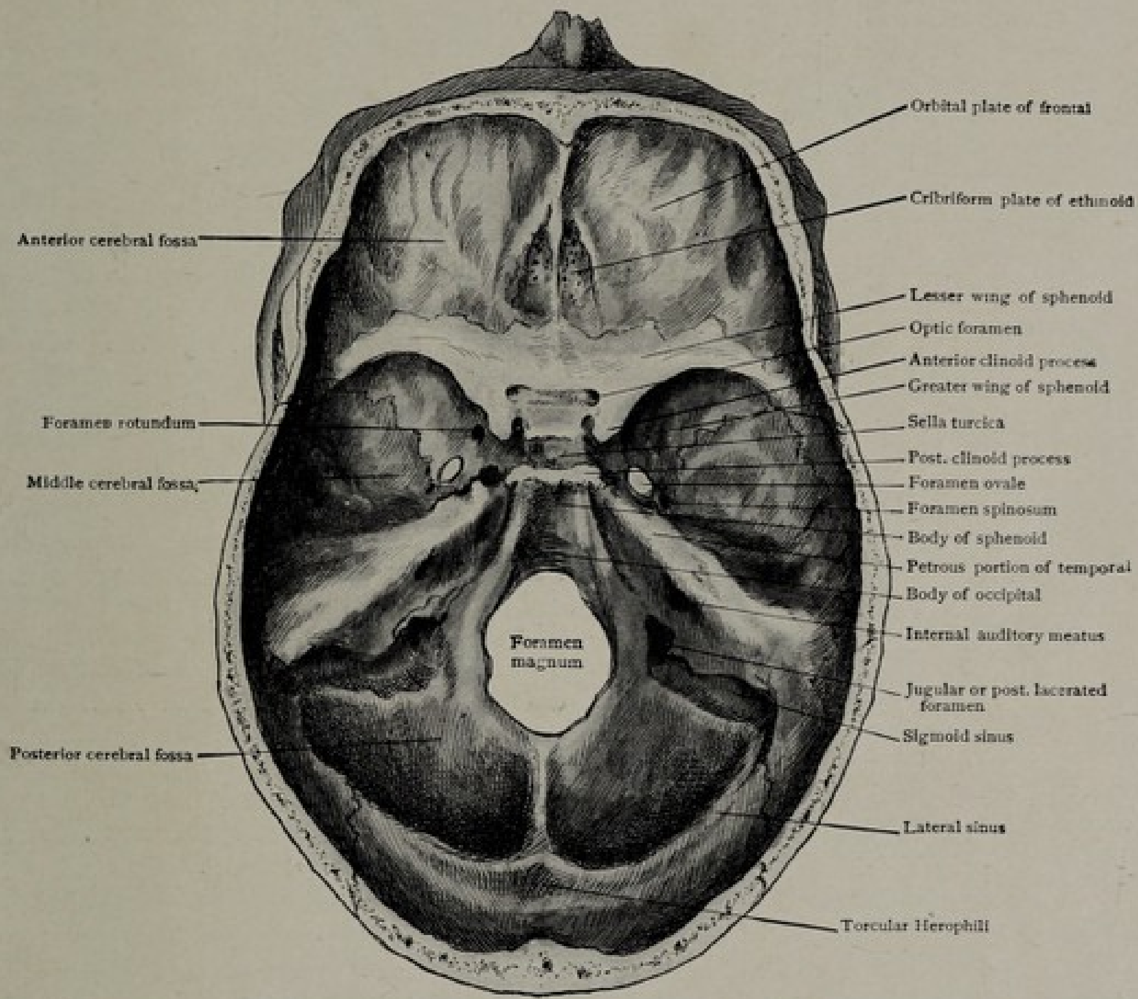


FIG. 20.—Interior view of the base of the skull, showing the parts most liable to be involved in fractures.

ture, the inner table immediately beneath may be broken into several fragments. Rawlings states that the squamo-temporal and cerebellar regions are practically devoid of this inter-tabular buffer.

In rare cases there may be depression of the inner table with none of the outer.

The bones of the adult skull are very strong and firmly fixed. The sutures begin to unite at the age of forty years and are likely to have disappeared at the age of seventy. Even in young adults the fibrous tissue between the bones has so nearly disappeared that they practically act in transmitting force as one continuous bone. For these reasons slight blows as a rule do not cause fractures. It takes a very heavy blow usually to cause a fracture and the force is so great that shock or concussion of the brain with disturbance of its functions is a common symptom.

The force of the blow is expended first at the point of impact, and if a fracture occurs it usually starts there. Aran's theory states that "fractures of the base result as extensions from fractures of the vault, the fracture following the shortest anatomical route to the base." Rawlings believes this theory accounts for only 30 per cent. of base fractures and that it errs in stating that the line follows the shortest anatomical route to the base but rather picks out the weaker areas and avoids the strong buttresses. In 60 per cent. of cases he found that the blow was inflicted at or near the level of the base of the skull, the resulting fracture therefore due to direct violence, the force splitting the bone from the "level of the base" down into the fossæ, usually the middle one; the direction of the line being governed by the resistance of the basic buttresses and other factors. The mechanism advocated by Besley suggesting that the counter force exerted by the articulation of the condyles and atlas against the base of the skull produces the fracture by inbending, has much to commend it.

Fractures of the skull may be linear or depressed. The lateral aspects of the skull are more readily fractured than other parts, due largely to their greater exposure. The fracture line passes commonly down from the vault to the base, involving the middle fossa and extending down to or through the sphenoid sinus and pituitary fossa. The posterior aspect of the skull is fractured less often than the lateral portions, the fracture line extending downwards across the base of the posterior fossa towards the foramen magnum. In the frontal region the fracture line usually runs across the floor of the anterior fossa, involving the orbital plates.

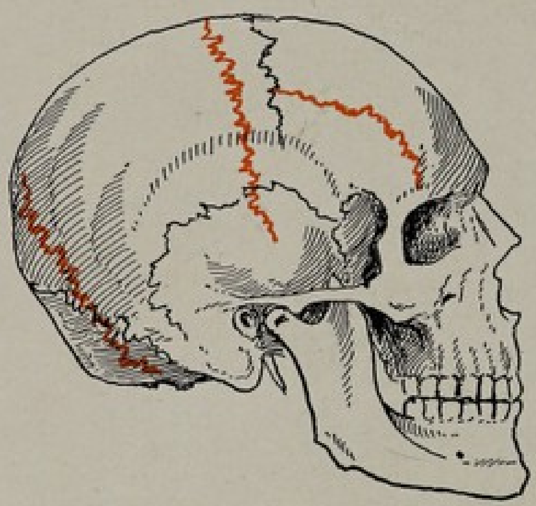


Fig. 21.—Lateral view of the skull showing the common fracture lines involving the cranial vault.

About 5 per cent. only result from causes of the bursting or compression types. Fractures by contre-coup can occur rarely if at all. This statement, however, does not reject contre-coup brain injury which occurs frequently.

Hemorrhage in Fractures of the Skull.—Hemorrhage is a frequent and very valuable symptom in diagnosing the existence of fracture and in determining its location.

Fracture through the anterior cerebral fossa may open the frontal, ethmoidal, or sphenoidal cells and cause bleeding from the nose and mouth.

A fracture through the roof of the orbit causes bleeding into the orbital cavity; the blood works its way forward and makes its appearance under the conjunctiva of the ball of the eye. Its progress forward toward the lids is blocked by the orbitotarsal ligaments, and it therefore works its way downward to the bulbar conjunctiva, under which it advances to the edge of the cornea. The ordinary ecchymosis of the lids and cellular tissue around the eye is usually due to a rupture of the vessels of the subcutaneous tissue by a blow from the outside, and not to a fracture of the base of the skull.

Fracture through the middle cerebral fossa may pass through the body of the sphenoid or basilar process of the occipital bone and cause bleeding into the mouth. It may also cause an accumulation of blood behind the posterior wall of the pharynx, pushing it forward. When it passes through the petrous portion of the temporal bone, as is frequently the case, it may involve the external auditory meatus and bleeding from the ear will result.

Fractures through the posterior cerebral fossa may cause bleeding into the structures of the back of the neck. While this is not of common occurrence its presence is strong evidence of an adjacent fracture of the skull. It does not occur as frequently as subconjunctival hemorrhage, but the latter occurs frequently without an associated fracture. The mastoid ecchymosis may not appear for several days since the blood must work its way around the splenius capitis and the sternomastoid muscles to the subcutaneous tissues before it becomes visible.

Middle Meningeal Hemorrhage.—Bleeding from the middle meningeal artery, epi- or extradural hemorrhage, occurs in those fractures which pass through the region of the pterion. This point is the junction of the coronal and sphenoparietal

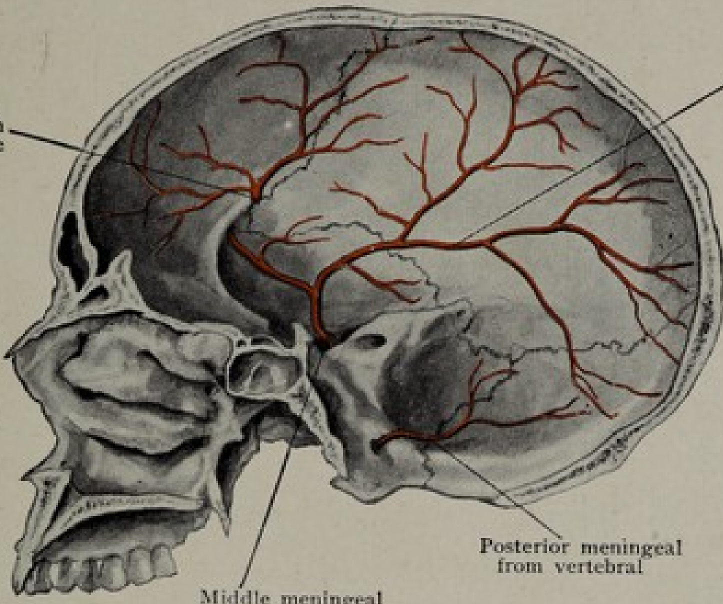


FIG. 22.—Middle and posterior meningeal arteries supplying the interior of the skull.

sutures, about 4 cm. (1½ in.) behind and slightly above the external angular process of the frontal bone. The middle meningeal artery comes up through the foramen spinosum and then goes forward, upward, and outward to the lower anterior angle

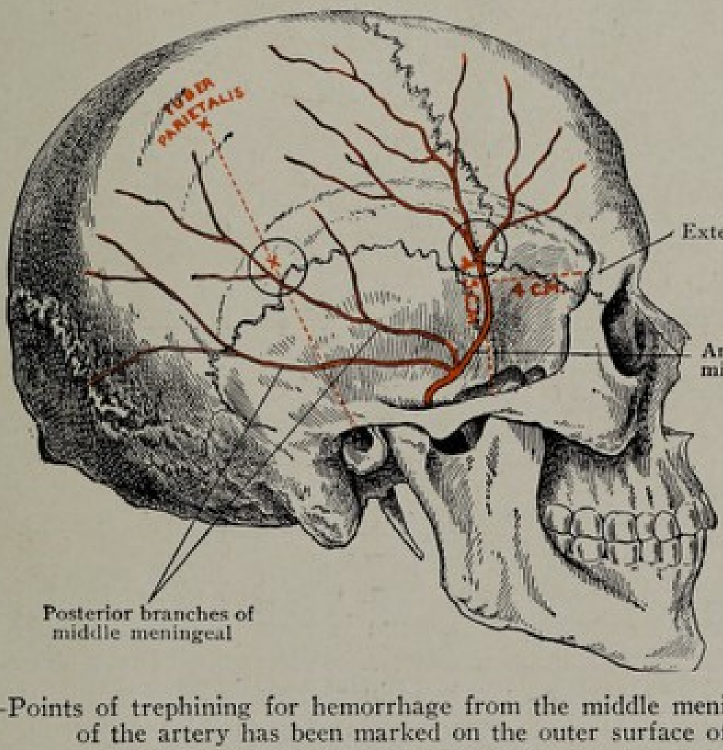


FIG. 23.—Points of trephining for hemorrhage from the middle meningeal artery. The course of the artery has been marked on the outer surface of the skull.

of the parietal bone. It sends branches forward to the frontal region and backward to the parietal and temporal regions. During two to three centimetres of its course, at the pterion, it passes entirely through bone, and therefore if a fracture occurs at this point it must of necessity tear the artery. The posterior branches are not regular in their course, one passing backward, low down, parallel to the zygoma, and another higher up in the direction of the parietal eminence. The branches of the meningeal artery nourish the bone as well as the dura, therefore if the dura is loosened from the bone, hemorrhage from these branches occurs. The most frequent site of middle meningeal hemorrhage is in the region of the pterion or temple.

In extradural hemorrhage the artery may be torn low in the middle fossa where it lies in a groove in the bone, or over the cortex where it runs in the dura. The symptoms of extradural hemorrhage are quite typical. There is loss of consciousness usually followed by a lucid interval, after which there occurs headache, often convulsions, increasing stupor, and evidence of increasing intracranial pres-

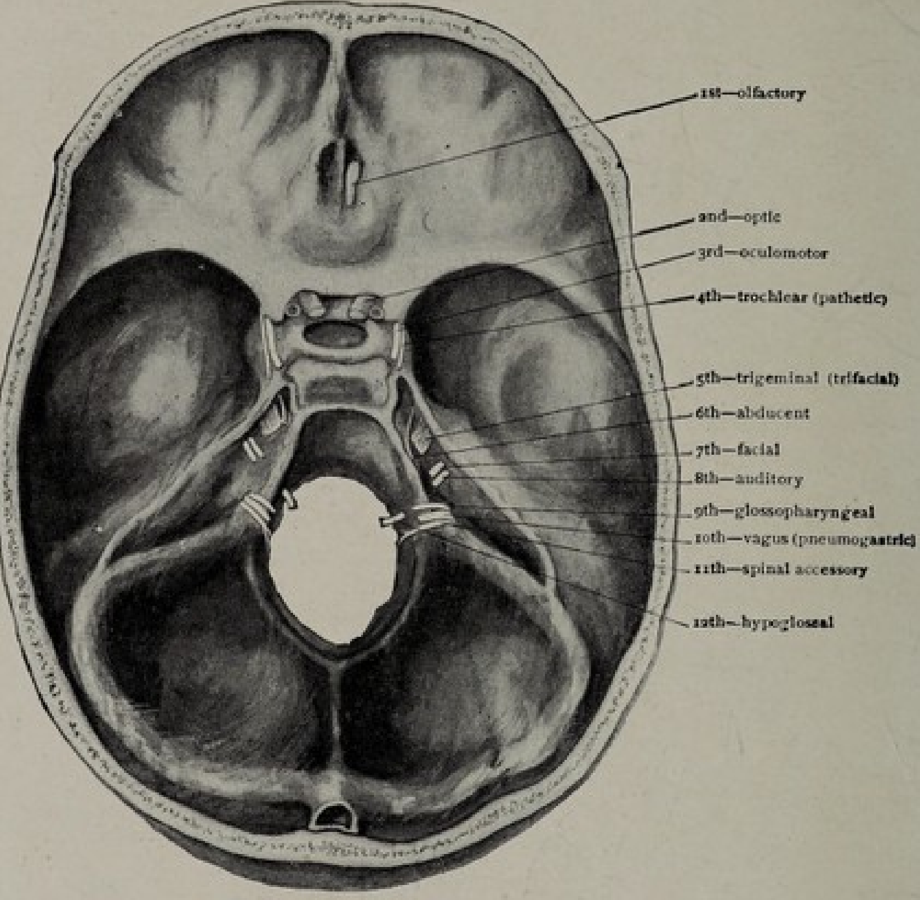


FIG. 24.—Exit of cranial nerves at the base of the skull.

sure. The symptoms are due to a spurting branch of the middle meningeal vessel. Extradural hemorrhage occurs in only about ten percent of cases of cranial trauma. It is not very common. Treatment may be by a decompression or by the elevation of a bone flap.

In decompressing, the centre of the trephine is to be placed on an average of 4 cm. (1½ in.) behind the external angular process of the frontal bone, and on a level with the upper edge of the orbit or 4.5 cm. (1¾ in.) above the zygoma. If the artery is not sufficiently exposed more bone is to be removed by the rongeur forceps. It is in this region that epidural hemorrhages are apt to be extensive, because the vessels torn are the largest; but epidural hemorrhage can also occur in the frontal region from the anterior branches and in the parietal, from the posterior branches.

The advantage of *subtemporal decompression* is due to the anatomical position of the opening. The squamous portion of the temporal bone underlying the temporal muscle is the thinnest portion of the skull and is the area most frequently injured. The middle meningeal is exposed where it is torn or the temporal lobe lacerated. The thick temporal muscle allows for a firm closure with no danger of a hernia cerebri if the closure is made carefully.

Trephining for bleeding from the posterior branch of the middle meningeal artery is somewhat uncertain. In some cases the artery runs low, about 2 cm. (4/5 in.) above the zygoma and parallel to it. In other cases it runs upward and backward toward the parietal eminence. The trephine may be placed as high as for the anterior branch of the middle meningeal artery, 4.5 cm. (1¾ in.), and 5 cm. (2 in.) farther back. This will be below and anterior to the parietal eminence and about midway on a line joining the parietal eminence and external auditory meatus. After the button of bone has been removed, additional bone may be cut away with the rongeur forceps until access can be had to the bleeding point.

Rupture of the large venous sinuses and of the small vessels passing between the bone and dura also contribute to the formation of the clot. Owing to the firmer attachment of the dura mater in children, the meningeal arteries are more liable to be torn and cause hemorrhage than is the case in adults. For the same reason the blood pressure is not sufficient to dissect the dura from the skull, therefore epidural clots are rare. If there is a fracture, blood may collect beneath the scalp, and if an external wound exists, the blood will find an exit through it.

Sub-dural Hemorrhage.—This form of hemorrhage occurs frequently in cranial trauma in about twenty to thirty percent. It results from the tearing of a vein running from the cortex to the dura due to a shift in the brain from violent trauma; or it may result secondarily from a cerebral laceration with rupture of blood through the arachnoid space under the dura. The bleeding in subdural hemorrhage is venous in contradistinction to that in extradural bleeding which is arterial. The formation of a subdural hemorrhage or clot may be acute, coming on very quickly after trauma, or it may be chronic, symptoms occurring weeks or even months after an insignificant cranial trauma. The symptoms vary according to the acuteness and extent of the hemorrhage. There is usually headache, drowsiness and mental slowing with possibly the development of weakness in the limbs of one side or Jacksonian convulsions. Intracranial pressure is increased and choked disc is present in about half the cases. The hemorrhage forms on the under surface of the dura; into it penetrate vascular channels later and at a still later stage a capsule is formed around the clot, the contents becoming filled later with a greenish fluid. Treatment consists of operative removal of the clot or cyst by the elevation of a bone flap.

Subarachnoid Hemorrhage.—This form of hemorrhage into the subarachnoid space occurs frequently in cranial trauma. It is found in cases both with and without skull fracture. It is characterized by the presence of blood in the spinal fluid, the blood coming from the rupture of a pial vein into the subarachnoid space. The symptoms consist of headache, stiffness of the neck and spine (meningeal irritation) and of localized palsies or irritative phenomena depending on the part of the brain involved. There is usually slight fever and always blood in the spinal fluid. The hemorrhage may be chiefly over the cerebral hemispheres or chiefly at the base of the brain. It may be a thin sheet or a thick clot. It may be completely absorbed; it may be resolved by organization, or it may form a firm clot with more or less complete destruction of the brain tissue which lies beneath it. Repeated daily lumbar puncture is the best treatment until the spinal fluid is clear.

Cerebral Changes.—Often in cases of cranial trauma there are small punctate hemorrhages in the brain substance. These may be widespread or localized. They occur both in the gray and white matter, chiefly the latter. They are followed later by focal areas of gliosis and may account for some of the late sequelae of head injuries. Extensive hemorrhages into the brain are not so frequently seen and are usually fatal. Brain edema is a concomitant of all trauma cases.

Bleeding from the Venous Sinuses.—Bleeding may occur from the sinuses of the base as well as from those of the vault. In severe injuries of the vault detached fragments frequently penetrate the superior longitudinal and lateral sinuses. In these cases profuse bleeding occurs as soon as attempts are made to remove the loose pieces of bone, and it is necessary to use a packing of gauze to control it. The gauze should be replaced by a graft of muscle applied to the bleeding point and the graft should be left in place. During the War, injury of the longitudinal sinus was frequently encountered, usually from gutter or tangential wounds or blows through an intact helmet. Involvement of the motor cortex on either side of the sinus produces in these cases a symptom complex having its counterpart in the traumatic spastic paralysis of childbirth (Little's disease). Fractures passing through the petrous portion of the temporal bone wound the petrosal sinus, and this no doubt contributes to the blood which flows from the ear.

Emphysema is most likely to occur if the frontal air sinuses are involved, particularly if the patient blows his nose in the attempt to relieve it of blood clots. Emphysema is not so liable to occur in cases of fracture involving the mastoid cells. Pneumatocele may occur if the fracture is through the frontal sinus. Figure 24 is an X-ray picture of such a lesion.

Cerebrospinal fluid may escape whenever the meninges are torn and the subarachnoid space is opened. It is most frequently seen in the fractures involving the middle fossa and passing through the internal auditory meatus. The meninges are prolonged into the internal meatus, and the clear fluid is not infrequently seen coming from the ear of the injured side. Although the normal amount of cerebrospinal fluid is only 125 to 150 cubic centimeters much greater quantities can escape. A serous discharge, perhaps of several ounces, is indicative of a rupture into the subarachnoid space.

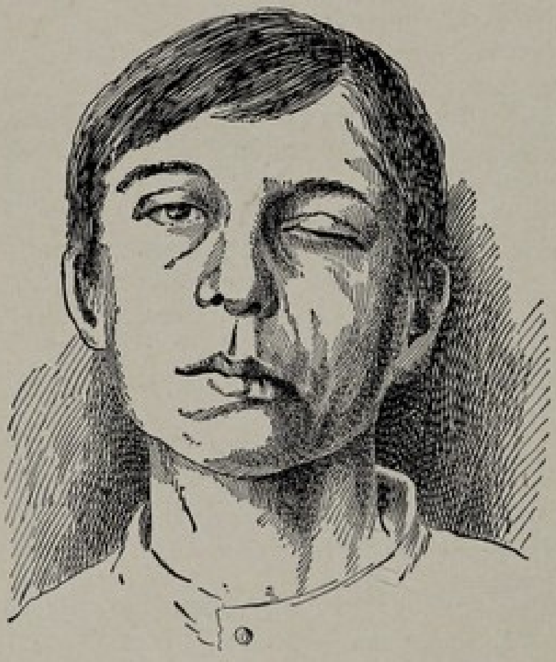


Fig. 25.—Paralysis of the facial nerve from fracture of base of skull (Dr. Davis' case).

Cerebrospinal rhinorrhea occurs also from fractures through the ethmoid plate which penetrate the meninges and cause an escape of spinal fluid through the nose. Such cases usually develop an aerocele in the brain because of a sucking in of air through the nose into the subarachnoid space.

Injuries to Nerves in Fracture of the Skull.—The nerves most often disturbed in injuries of the skull are the first, second, third, seventh, and eighth.

The *first* or *olfactory nerve* may be injured directly in the line of fracture, or by concussion. Davis saw two such cases in women who struck the occiput on an asphalt pavement in getting off backward from a moving trolley car. These patients left the hospital after several weeks with the sense of smell still lacking.

Injuries to the *second* or *optic nerve* are apt to be accompanied by such severe injuries to other parts as to cause the death of the patient before the loss of sight is discovered. If the optic nerve is injured at the optic foramen, there may be impairment of sight without any intra-ocular changes to be seen with the ophthalmoscope. Inside of two weeks, however, the pinkish color of the disk gives way to the gray-white color of atrophy, and this progresses until complete. The nerve never resumes its functions and the eye remains blind.

Injury of the *third*, or *oculomotor*, *nerve* has also come under our notice. In this the pupil of the affected eye is moderately dilated and does not respond to light. The ciliary muscle, as well as the circular fibres of the iris, is supplied by the third nerve, so that the accommodation is paralyzed and, if the eye has been normal in its refraction, the patient will be unable to read or see objects clearly at close distances. The extrinsic muscles of the eye, with the exception of the superior oblique and external rectus, are also supplied by this nerve and the eye is therefore pulled outward and slightly downward, and diplopia, or double vision, may be produced. The patient is unable to move the eye either upward, inward, or downward. The levator palpebræ muscle is also paralyzed and there is ptosis, or drooping of the upper lid. The orbicularis palpebrarum muscle, being supplied by the seventh nerve, has its function unimpaired, and the eyelids can be closed.

The *fourth* or *trochlear nerve* is almost never injured. It supplies the superior oblique muscle, which turns the eyeball down and slightly outward. Paralysis of it causes diplopia, with the image of the injured eye below that of the sound eye and tilted to the right, if the right eye is affected, and to the left, if the left is affected.

The *fifth* or *trigeminal nerve* is very rarely injured. If it is completely paralyzed there will be loss of power in the muscles of mastication of the affected side, deviation of the jaw toward the side of the paralysis, loss of sensation over the side of the face, of one half of the interior of the mouth, of the side and front of the tongue, and loss of the corneal reflex.

The *sixth* or *abducens nerve* supplies the external rectus muscle of the eye, and if paralyzed causes internal strabismus, the eye looking inward. While more often paralyzed than the fourth and fifth, it is not so frequently paralyzed as are the two following nerves.

The *seventh* or *facial nerve* is the one most frequently injured in fractures of the skull. It enters the internal auditory meatus with the auditory nerve, lying above it. Reaching the end of the meatus internus, it enters the canal of Fallopius and emerges from the temporal bone at the stylomastoid foramen. When paralyzed the entire face cannot be moved. The forehead on the paralyzed side cannot be wrinkled, the eyelids cannot be closed, the facial muscles cannot be moved, the mouth droops, the saliva drools, the entire face is flattened, and there may be a loss of taste over the anterior two-thirds of the tongue on the paralyzed side. The cheek cannot be blown out on the affected side and whistling is impossible. Food is lost in the cheek of the paralyzed side.

The *eighth* or *auditory nerve* is injured with moderate frequency. This may be the result of direct injury to the nerve or to hemorrhage into the sheath surrounding it. The eighth nerve is embraced in the same extension of the meninges into the internal meatus as the seventh and injuries to it may often be accompanied by loss of cerebrospinal fluid. The seventh and eighth are said to be more often paralyzed than any of the other nerves.

Injuries to the remaining nerves—the *glossopharyngeal, vagus, spinal accessory* (*accessory*), and *hypoglossal*—have been observed too rarely to require extensive attention.

Many times a focal symptom supposedly due to injury of a cranial nerve is the result of injury to a cerebral centre.

THE MENINGES

The meninges of the brain consist of three separate coverings: the outer, or the *dura mater*, the middle, or *arachnoid*, and the inner, or *pia mater*.

The dura is a dense membrane enclosing the brain and spinal cord. It is composed of two layers, the outer lining the inner surface of the skull and the interior of the vertebral canal forming the periosteum in these regions. The inner layer covers the brain and cord. The layers split in the cranial cavity to enclose the venous sinuses, the Gasserian ganglion and other structures. It separates the two cerebral hemispheres by means of a flat sheet, the falx cerebri, and has also a portion which separates cerebrum and cerebellum, the tentorium cerebelli. The dura is composed of dense fibrous tissue with a few elastic fibrils. It is lined by

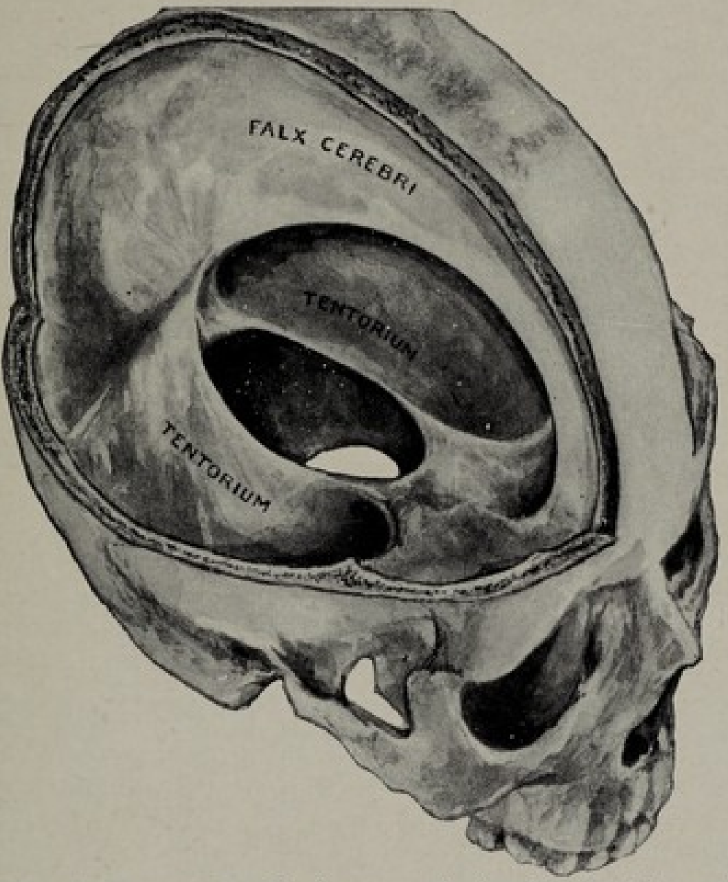


Fig. 26.—Vault of the skull opened and brain removed, showing the falx cerebri and tentorium.

flat cells arranged in a single layer. Some look on these cells as mesothelial elements, while others say they are fibroblasts.

The Arachnoid.—This is a delicate membrane of connective tissue which lies under the dura. It spreads over the sulci of brain and spinal cord forming a complete investment of the nervous system, like the dura. Beneath it and the pia lies the subarachnoid space which contains the cerebrospinal fluid. It forms large cisternae at the base of the brain, such as the Cisterna Pontis, the Cisterna Interpeduncularis, and other large reservoirs of spinal fluid. While it is separated from the dura in general, it is connected with it through the arachnoid villi which are prolongations of the arachnoid into the walls of the dural sinuses. Many of these villi or Pacchionian bodies project into the longitudinal sinus. The arachnoid is lined by cells which are flat and which cover both its inner and outer surfaces. Some consider these cells as mesothelial, while others think they are fibroblasts. Beneath the arachnoid and dura lies the subdural space.

The Pia Mater.—This membrane lies beneath the arachnoid and lies in close approximation to the cortex. It is a thin sheet of connective tissue which contains a large number of blood vessels. It is connected with the overlying arachnoid by delicate strands of tissue. The pia mater surrounds the vessels which dip into the cortex, so that between the wall of the vessel and the pia is a potential space known as the space of Virchow-Robin. This is supposed to be a perivascular lymph space, and to be in connection with the subarachnoid and perineuronal spaces.

Affections of the Membranes of the Brain.—Both the dura and the pia are subject to inflammation and hemorrhage.

Diseases of the Dura Mater.—The dura mater is subject to three main types of processes: 1. tumor formation; 2. hemorrhage; 3. inflammation.

Both primary and malignant tumors arise in relation to the dura. The primary tumors, known as meningiomas or meningeal fibroblastomas, arise from the arachnoid villi, but are usually firmly adherent to the dura. Their removal, to be complete, must include the overlying dura. Metastatic tumors such as melanatic sarcoma or some forms of carcinoma may involve the dura as well.

The dura is susceptible to hemorrhage in the form of Subdural Hemorrhage. This has been considered elsewhere. It was formerly considered an inflammatory process and called Pachymeningitis Hemorrhagica Interna. Another important cause of Subdural Hemorrhage besides trauma, syphilis and alcoholism is purpura which is an infrequent cause.

Inflammation may involve both the outer and inner layers of the dura, giving rise to the terms Pachymeningitis Externa and Interna. The distinction is useful but should not be insisted on too rigidly. In the former there is inflammation of the outer layer of the dura which may go on to abscess formation. The dura itself is not frequently involved in the usual type of meningitis. Extra dural abscess formation is seen as the result of direct extension of infection from the frontal sinuses or less frequently from the mastoid area. It consists in a localized accumulation of pus over the dura, a diffuse collection which is poorly localized which later becomes more or less completely organized. It is usually confined to the dura. Sometimes it reaches large proportions and is accompanied by inflammation of the other membranes of the brain. *Pachymeningitis interna* is an inflammation which involves the inner side of the dura. It is often syphilitic. Sometimes it is hemorrhagic and is spoken of as Pachymeningitis Hemorrhagica interna. It is better spoken of as Subdural Hematomas.

DISEASES OF THE PIA ARACHNOID

Meningitis.—This is probably the most frequent affection of the pia-arachnoid membranes. Inflammation of these is spoken of as *Leptomeningitis.* The causes of such inflammations are many, but some of the commoner causes are the meningococcus, tuberculosis, pneumonia, pyogenic organisms, trauma, influenza and other less common causes such as gonorrhea, typhoid fever and anthrax. These types of meningitis are characterized by an inflammatory exudate in the pia-arachnoid membranes. The type and distribution of the exudate varies with the cause of the meningitis. In the meningococcus variety there is involvement both of the brain and spinal cord giving rise to *Cerebrospinal Meningitis.* In tuberculous meningitis the exudate is over the brain stem chiefly, but spreads out over the hemispheres as well. In the pneumococcus variety there is a thick heavy purulent exudate over the hemispheres. The same is true of the traumatic and pyogenic types of meningitis. In the types of meningitis which extend directly from the sinuses or mastoid there is usually a heavier exudate over the side of the focus. The nature of the exudate varies in different meningitides varying from polynuclear to lymphocytic cells as well as other cells which lie within the meninges. In the meningococcus type for example the exudate is polynuclear in the acute stages, whereas in the tuberculous type the exudate is chiefly lymphocytic. The pyogenic organisms give rise mainly to a polynuclear exudate. Some forms of meningitis, as for example the tuberculous type, are prone to invade the underlying cortex, giving rise to a *Meningo-encephalitis* or what is loosely called a *Cerebritis*.

The cranial nerves at the base of the brain are not infrequently involved in

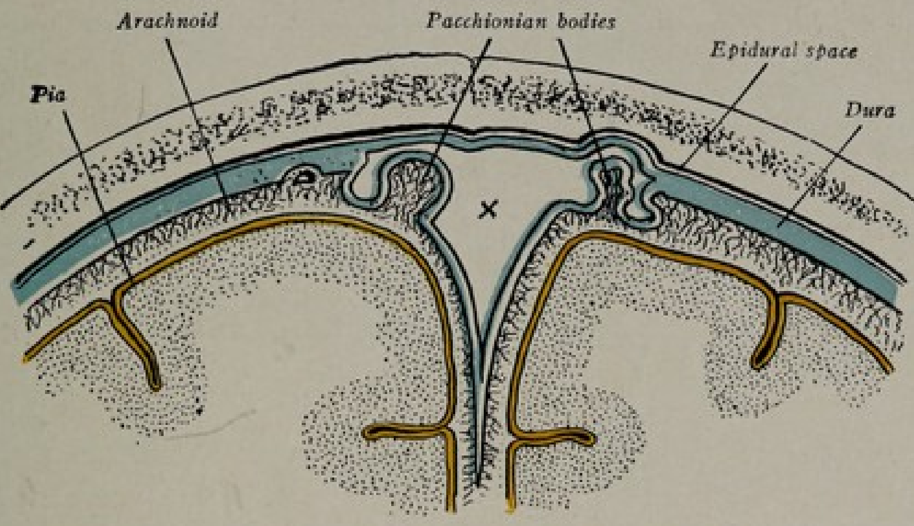


FIG. 27.—Schematic section through the skull and the meninges, showing Pacchionian bodies in the superior longitudinal sinus (×).

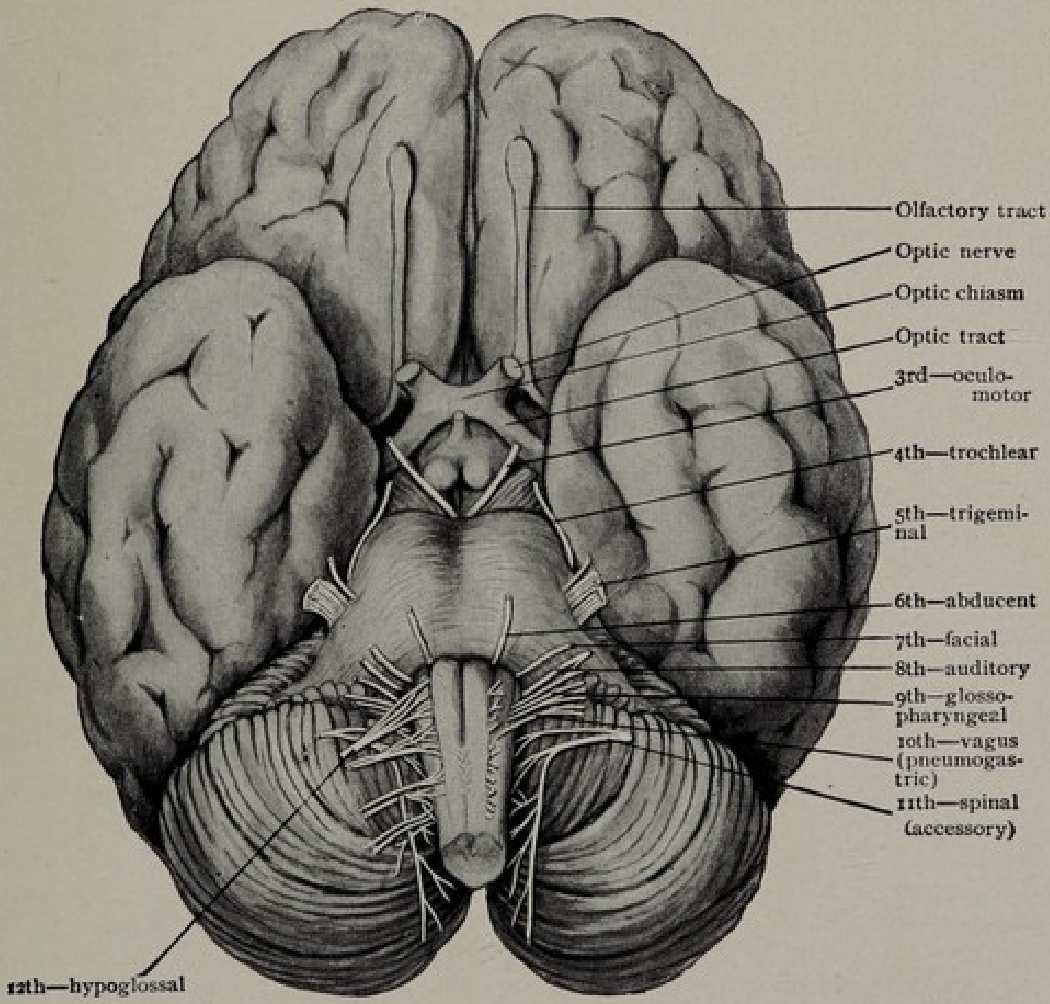


FIG. 28.—Base of brain, showing exit of cranial nerves.

these meningitides, especially in the basilar types such as tuberculous meningitis. The nerves most frequently involved are the oculomotor, facial and auditory. Any of the cranial nerves may be affected however, depending on the degree of compression by the exudate.

HEMORRHAGE

Subarachnoid Hemorrhage has been discussed in relation to trauma. In addition to the traumatic form there is a spontaneous type of subarachnoid hemorrhage which occurs in young people and which is characterized by sudden severe headache, signs of meningeal irritation, disturbance in consciousness and localizing signs depending on the part of the brain affected. These may be paralyses, convulsions, or cranial nerve palsies. The cause of such hemorrhage is usually a minute aneurysm which is congenital, arteriosclerotic or mycotic. It is rarely syphilitic. Subarachnoid hemorrhage is seen also in purpuric disorders. It is not infrequently seen in newly-born infants as a result of difficult labor. In these cases the amount of hemorrhage varies greatly from slight extrusions to massive hemorrhage.

THE BRAIN

The affections of the brain of most anatomical interest are those involving its circulation, the motor areas, and the motor paths. Paralyses may arise from (*a*) interference with the motor areas in the cortex by hemorrhages, injuries, or tumors; (*b*) destruction of the motor paths from the cortex to their point of exit from the brain; (*c*) injury of the nerves at their exit from the brain.

Disturbances of the circulation may be either of the nature of anæmia or ischæmia, causing softening, or of congestion, causing apoplexy.

Tumors of the brain interfere with the functions of the part in which they are located, as do also wounds. In all of these a knowledge of brain localization is essential.

THE CIRCULATION OF THE BRAIN

The blood reaches the brain by means of the two internal carotid and the two vertebral arteries. The vertebrals, which arise from the first part of the subclavian,

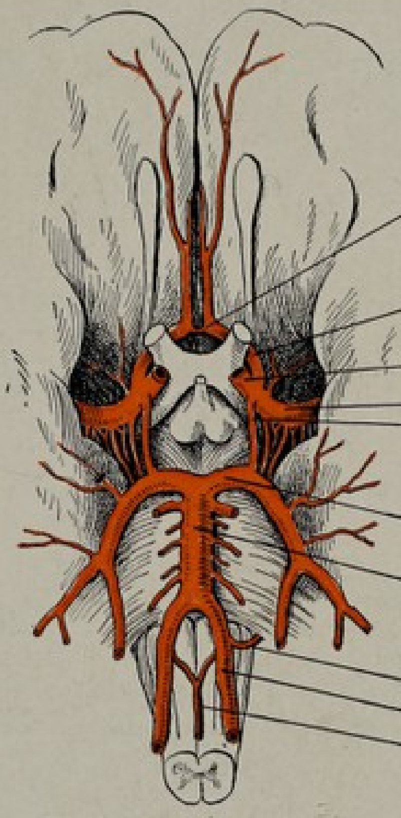


FIG. 29.—Circulus arteriosus or circle of Willis.

enter through the foramen magnum and unite at the lower border of the pons to form the basilar, which at the upper border of the pons divides into the two posterior cerebrals. These give off two small branches which go to the internal carotids; they are the posterior communicating arteries. The carotids divide into the anterior and middle cerebral arteries, the anterior communicating with one another by means of the anterior communicating artery. Thus we have the *circle of Willis* (*circulus arteriosus*), formed by the *posterior cerebral, posterior communicating, internal carotid, anterior cerebral,* and *anterior communicating* arteries on each side.

The blood supply of the brain is divided into an anterior division, furnished by the carotids, and a posterior division, supplied through the basilar and posterior cerebrals. The communication branch running between these two sets of vessels is so small that if either is occluded the supply of blood is practically cut off from that point and ischæmia results, at least in most cases.

The anterior division is subdivided into a right and a left half by the two carotid arteries. These communicate across the median line through the anterior

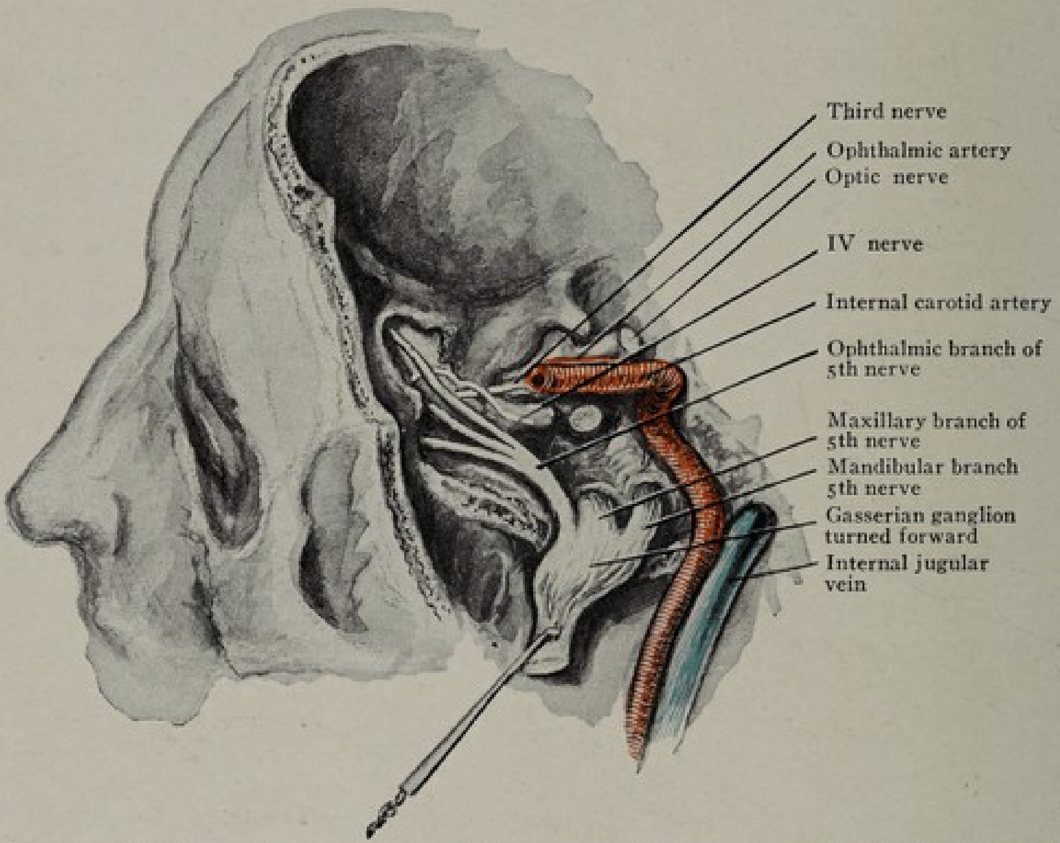


FIG. 30.—The internal carotid artery in its course through the skull, showing its relations to the jugular vein and cranial nerves. The Gasserian ganglion has been raised from its bed and turned forward.

cerebral and anterior communicating. Here again the anterior communicating branch is so small that it is sometimes unable to furnish blood to the opposite side

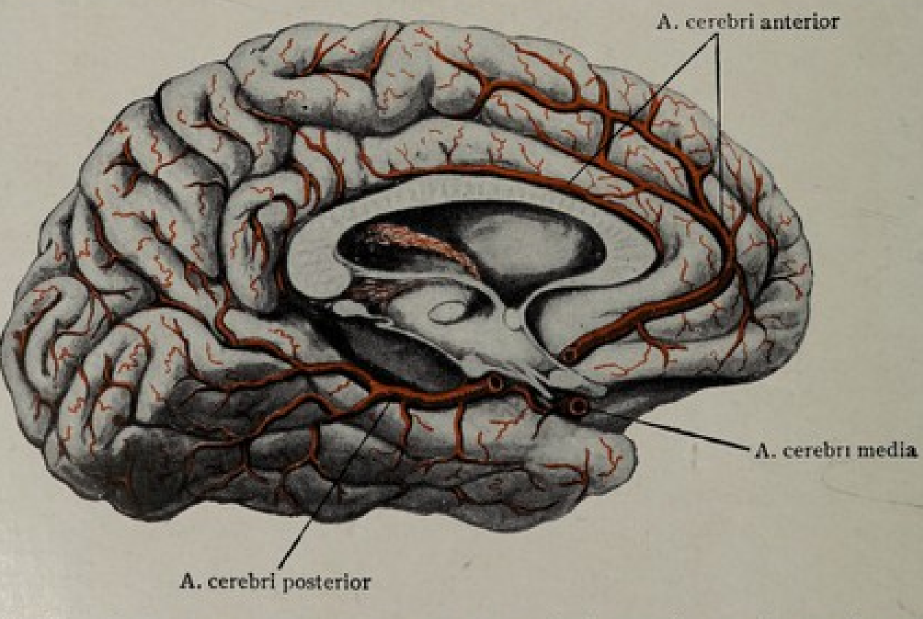


FIG. 31.—Distribution of the A. cerebri anterior and A. cerebri posterior on the medial surface of the brain.

of the brain when the carotid supply of one side is shut off. This may cause syncope, stupor or delirium, hemiplegia, often softening of the brain and death.

These results have not infrequently followed ligation of the carotid artery in cases of aneurysm or in bleeding. Obstruction of one vertebral artery would produce no effect because circulation would be restored by the other vertebral through the basilar.

FIG. 32.—Distribution of the A. cerebri anterior, A. cerebri posterior, and A. cerebri media on the lateral surface of the brain.

Internal Carotid Artery.—The internal carotid artery, the second terminal branch of the common carotid (Fig. 30) enters the petrous portion of the temporal bone, then turns inward and upward through the foramen lacerum medium, pierces the periosteal layer of the dura, and then passes forward through the outer wall of the cavernous sinus and finally turning upward gives off the ophthalmic artery; it then pierces the dura mater just behind the anterior clinoid process, where, after

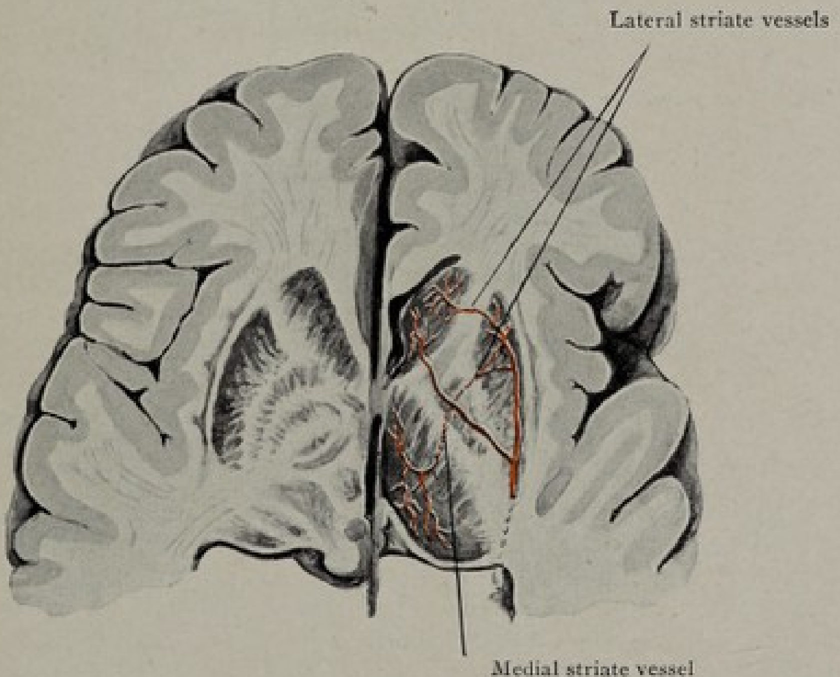


FIG. 33.—A horizontal view of the brain showing the striate vessels and their relation to the basal ganglia and internal capsule.

giving off the posterior communicating and anterior choroid, it divides into the anterior and middle cerebral arteries.

Anterior Cerebral Artery.—The anterior cerebral (Fig. 31) passes forward and above the optic chiasma, between it and the olfactory nerve, to the anterior of the median fissure, where bending over the rostrum of the corpus callosum it continues posteriorly along the median surface of the hemisphere to the posterior portion of the parietal lobe, where it anastomoses at the posterior end of the corpus callosum with the posterior cerebral. It gives cff at its entrance into the median fissure the anterior communicating artery which joins the anterior cerebral of the other side. This shows the wide extent of brain tissue on the medial surface of the brain which would be affected by the blocking of this vessel by an embolus.

The terminal branches of the anterior cerebral spread laterally over the surface of the brain (Fig. 32) outward from the longitudinal fissure for a short distance, about 2 cm. As it crosses the anterior perforated space, it gives off the antero-median perforating (ganglionic) arteries which pierce the lamina cinerea to supply the anterior portion of the caudate nucleus above.

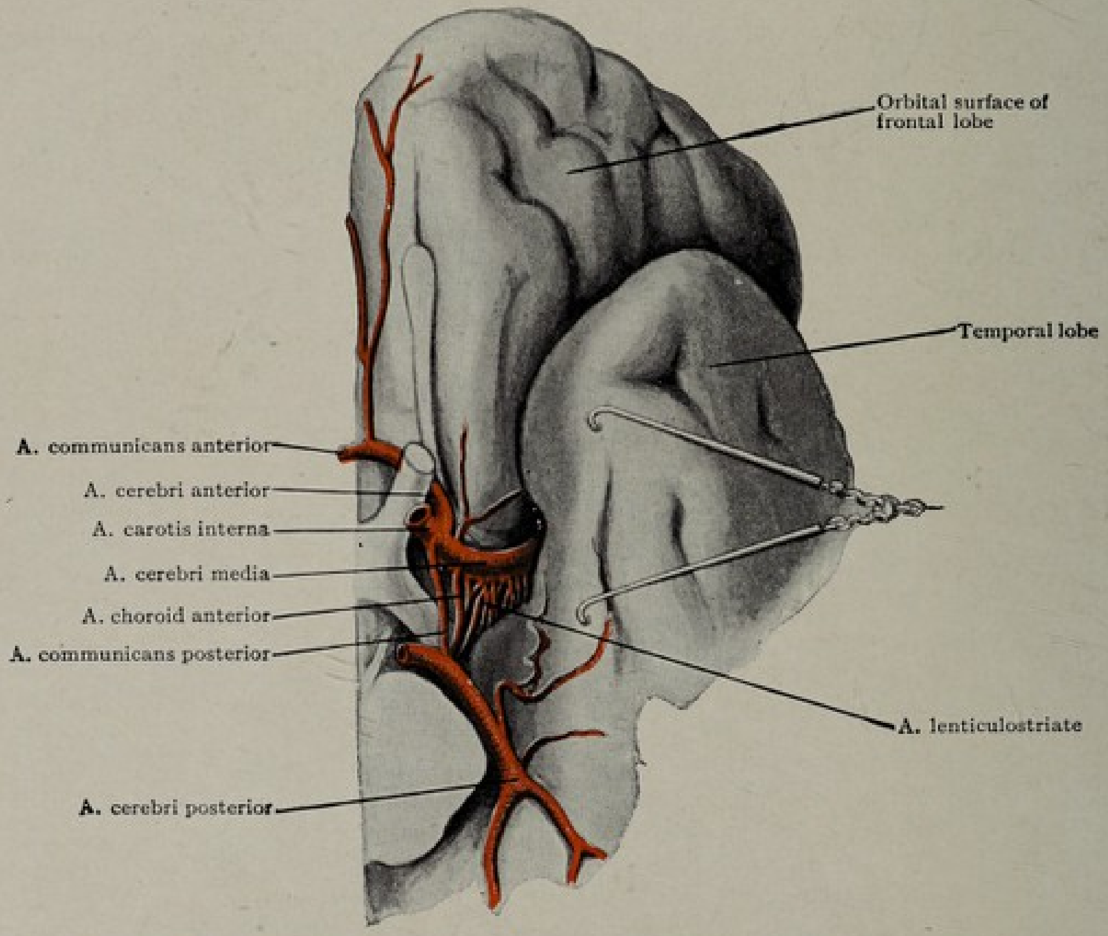


Fig. 34.—Arteries of the base of the brain, especially the branches of the middle cerebral giving rise to apoplexy.

Middle Cerebral Artery.—The middle cerebral artery passes upward and outward in the fissure of Sylvius (lateral cerebral fissure), lying at first deep, close to the island of Reil (insula), and then turning backward and upward, becoming more superficial. At the posterior end of the horizontal limb of the Sylvian fissure it reaches the surface and ends by dividing into cortical branches which supply the lateral surface of the cerebral hemisphere (see Fig. 32). On its way toward the island of Reil, at the commencement of the fissure of Sylvius, many small straight branches enter the brain substance to supply the basal ganglia. Two or three supply the caudate nucleus, others, called the anterolateral perforating (ganglionic), enter the anterior perforated space to supply the lenticulostriate ganglion and the anterior portion of the thalamus. One of the largest of these arteries, the *lenticulostriate*, has been called the *artery of cerebral hemorrhage*, by Charcot, on account of the frequency with which it is found ruptured in cases of apoplexy (Fig. 34).

Anterior Choroid.—The anterior choroid artery comes sometimes from the

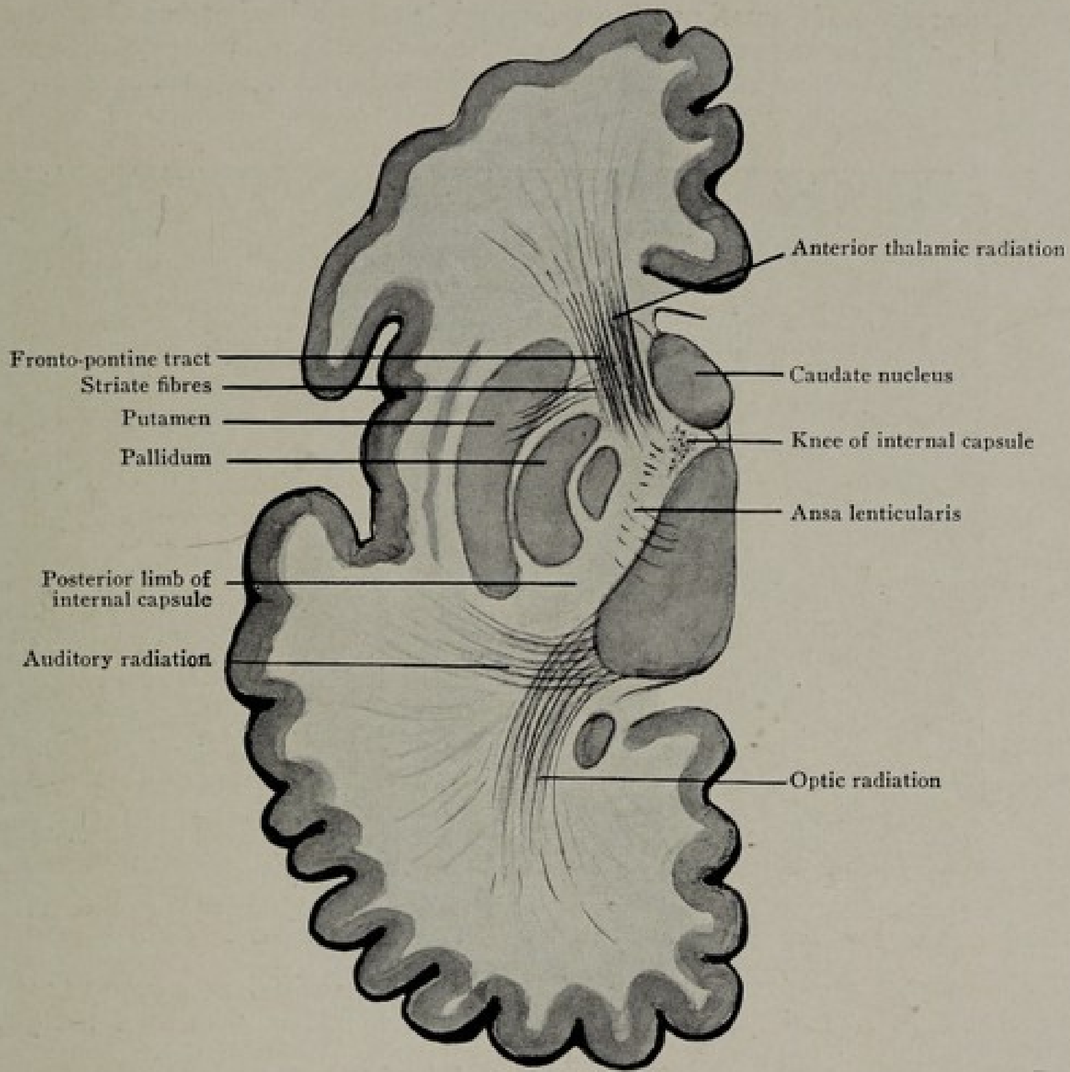


FIG. 35.—Diagram illustrating the internal capsule and basal ganglia in a horizontal section of the brain. The various structures in the anterior limb, knee, and posterior limb of the capsule are shown. The auditory and visual radiations are also shown.

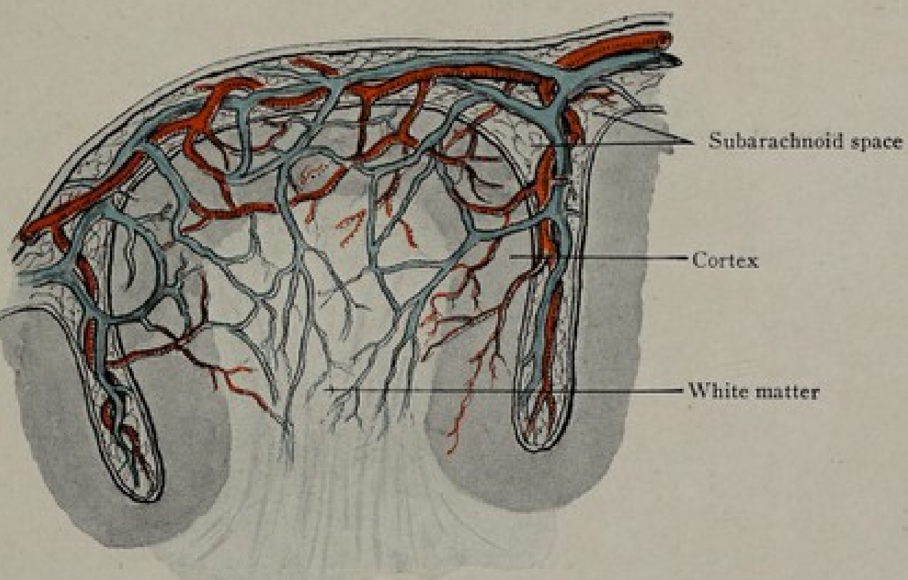


FIG. 36.—A diagram indicating the blood supply of the cortex showing the supply coming mainly from the pial vessels.

internal carotid and sometimes from the middle cerebral. It passes backward and outward on the optic tract and crus cerebri and enters the transverse fissure at the descending horn of the lateral ventricle. It ends in the choroid plexus (see Fig. 34).

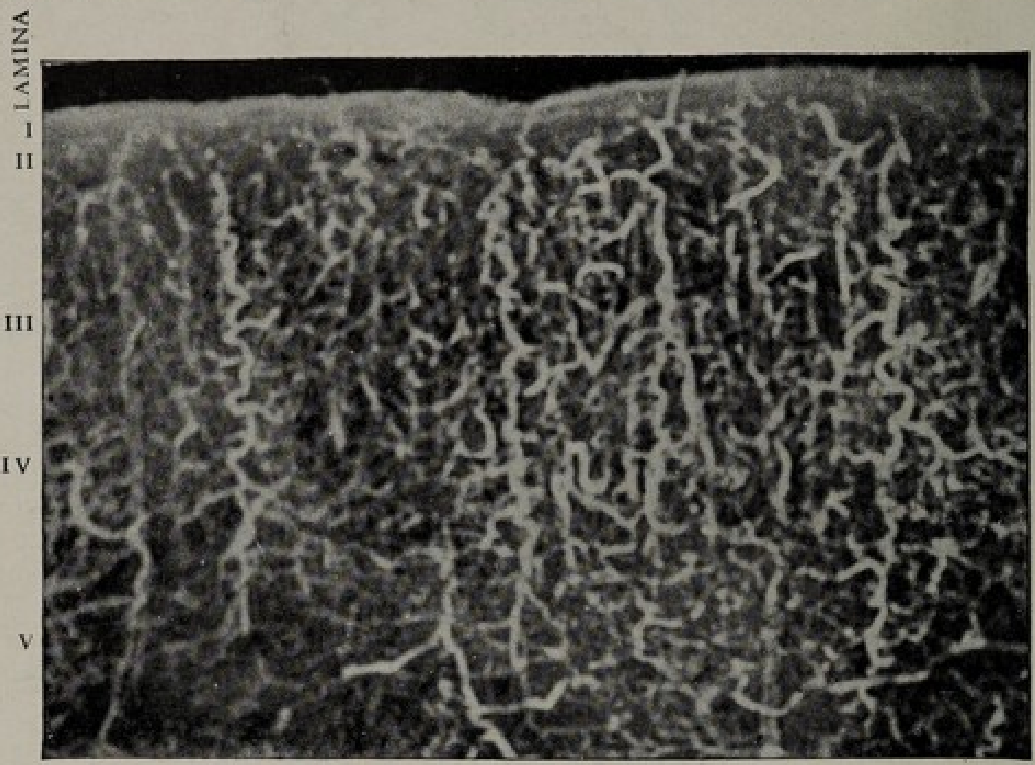


Fig. 37.—Microphotograph of infected cortex showing the rich anastomoses of the vessels within it. From Penfield's Cytology of Nervous System.

Posterior Cerebral Artery.—The posterior cerebral artery passes outward over the crus cerebri, just above the pons, to the under surface of the posterior

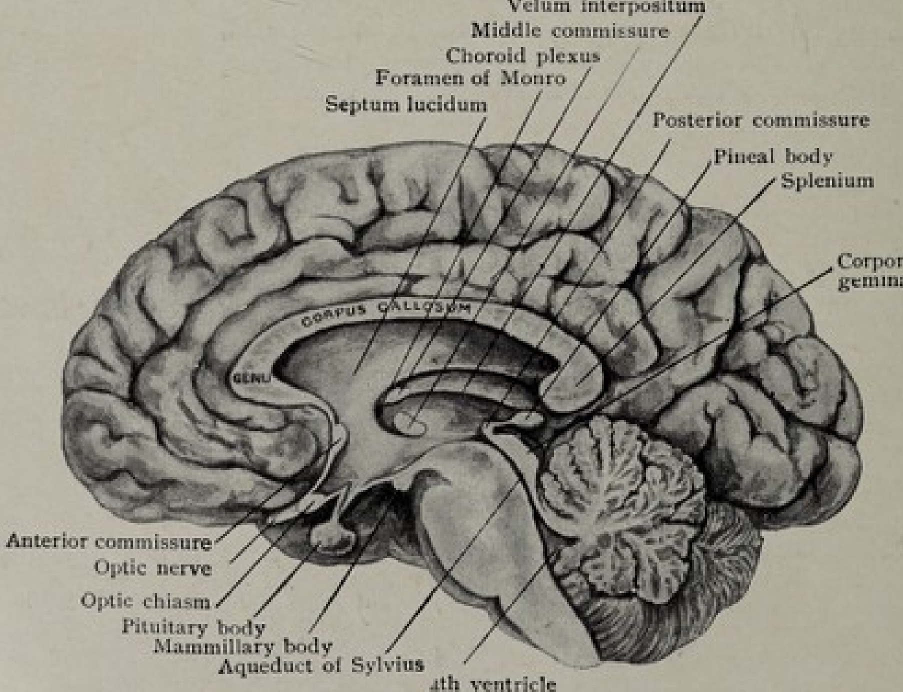


Fig. 38.—Medial section of the brain.

portion of the cerebral hemisphere. Before it receives the posterior communicating artery it gives off the posteromedian perforating (ganglionic) arteries, which enter the posterior perforated space to supply the thalamus and third ventricle. Just beyond the posterior communicating artery it gives off the posterolateral perforating (ganglionic) arteries, which supply the posterior portion of the optic thalamus, crus cerebri, and corpora quadrigemina. The branches to the cortex supply a small

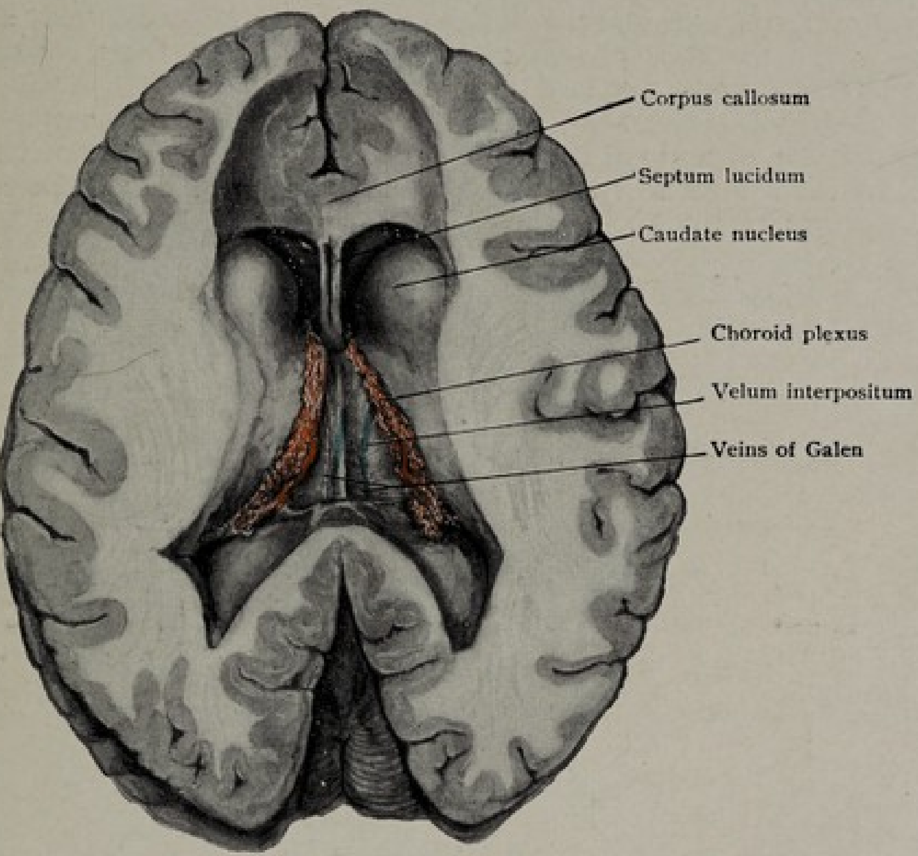


FIG. 39.—Horizontal section of brain; the corpus callosum and fornix have been removed, exposing the lateral ventricles, with the caudate nuclei projecting into them anteriorly and the velum interpositum farther back, with the choroid plexus at the sides and the veins of Galen nearer the middle line. The lateral ventricles in this brain are somewhat larger than usual.

portion of the inferior surface of the temporal lobe and the occipital lobe as seen in Figs. 31 and 32.

VASCULAR SUPPLY OF CORTEX

It has been taught in the past that the vessels supplying the cortex and in the brain are end vessels without anastomoses. Recent studies indicate that this viewpoint needs material modification. These studies show that there are numerous anastomoses between the larger cerebral vessels such as the anterior, middle and posterior cerebrals. Not only are these anastomoses present in the two hemispheres, but there is evidence to show that it exists between vessels of opposite hemispheres. These anastomoses are found not only in the cortex but also in the basal ganglia. The capillaries in the cortex form an endless network. Vital dye studies show that the capillary bed forms a rich anastomotic network everywhere in the brain, the capillary beds of one vessel extending over into that of another. The old idea of end arteries in the cortex must be modified in view of these findings.

VASCULAR ACCIDENTS

Cerebral Softening.—This is the most common cause of a "stroke." It is responsible for about seventy-five percent of such cases. In the majority of instances it is due to thrombosis of a cerebral vessel such as the middle cerebral artery or one of its branches. These vessels are practically always sclerotic. Less frequently it is due to an embolus which comes from an endocarditis or thrombus elsewhere in the body. The extent of the softening may vary from a minute area due to occlusion of a small cortical or subcortical vessel, to very extensive areas which may involve most of one cerebral hemisphere, due to occlusion of the middle cerebral artery itself. The softening may involve only the cortex, when it is due to interference with vascular drainage, or it may involve cortex, underlying white matter and the basal ganglia region. Of the latter, the thalamus and putamen are most commonly involved.

Cerebral Hemorrhage.—This occurs with fair frequency. It is often due to a rupture of a vessel in the basal ganglia region. The vessel most frequently involved is a branch of the middle cerebral artery, the lenticulostriate, called the

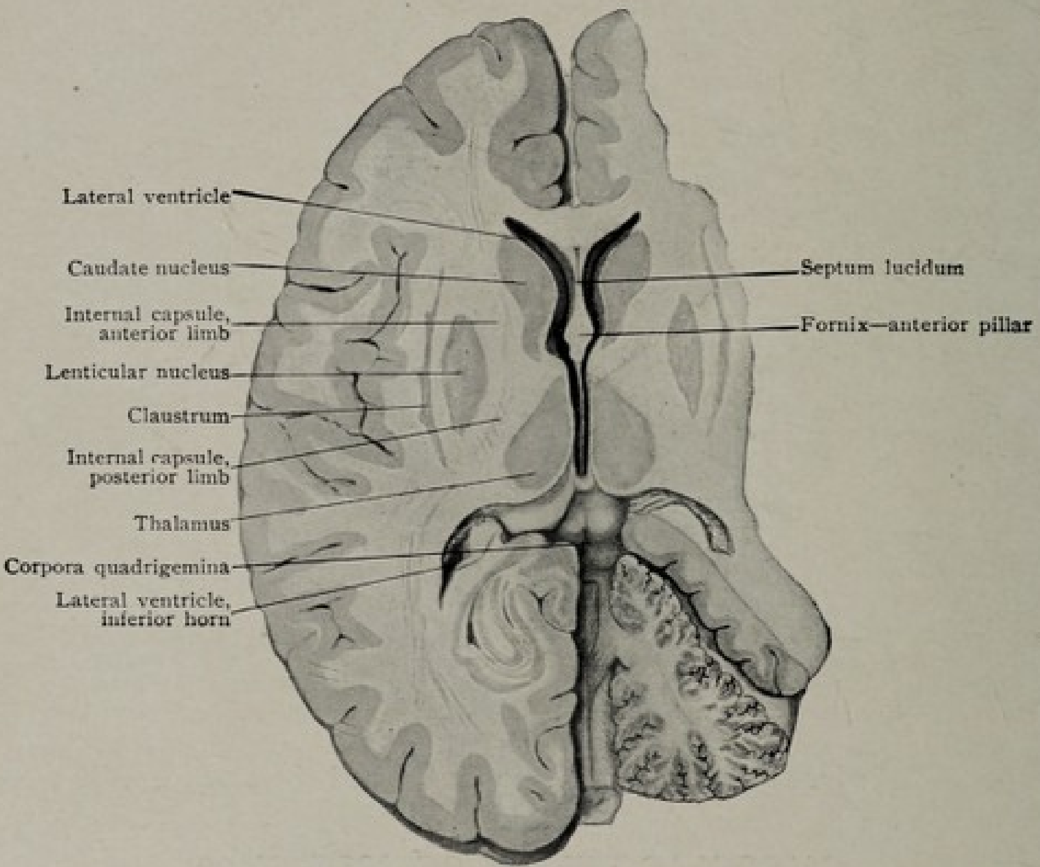


FIG. 40.—Horizontal section of the brain, showing the internal capsule and its relation to the lateral ventricles.

artery of cerebral hemorrhage of Charcot. Rupture of this vessel causes extensive hemorrhage in the brain substance resulting in loss of consciousness and a hemiplegia. It is most common within the cerebral hemispheres and basal ganglia, but hemorrhage may occur in the pons and medulla, especially in cerebral trauma. Hemorrhage into the lateral ventricles may occur from a primary cerebral hemorrhage which extends into the ventricles, or it may occur primarily within the ventricles. Rarely, ventricular hemorrhage may be confined to the fourth or third ventricles.

Figure 38 is a medial section of the brain, giving a lateral view of the ventricles.

Figure 39 is a horizontal transverse section of the brain, opening up the ventricles. In front are seen the two *lateral ventricles*, separated by the *septum lucidum*. The cavity shown in the septum lucidum (pellucidum) is the so-called *fifth ventricle* (cavum septum pellucidum). The round body bulging into the lateral ventricle and forming its floor is the *caudate nucleus* portion of the corpus striatum. The *third ventricle* is posterior and below the lateral ventricles, and extends from the septum lucidum in front to the posterior pillars of the fornix behind. It extends from side to side as one large cavity with no median partition. Bulging into the third ventricle on each side are the *optic thalami*. They are separated from the corpora striata by some white fibres, the *tænia semicircularis*. To the inner side of the tænia semicircularis is seen the *choroid plexus*, which runs down anteriorly over the thalamus to the *foramen of Monro* (interventricular foramen), through which it enters the lateral ventricle. Two large veins, the *veins of Galen* (internal cerebral veins), pass down near the middle line of the third ventricle to empty into the *straight sinus*. Posteriorly, the choroid plexus follows the descending horn of the lateral ventricle. The choroid plexus hangs from the under surface of the *velum interpositum*, which is a fold of the pia mater entering through the transverse fissure. The veins of Galen run between the two layers of the velum interpositum.

Turning now to Fig. 40, showing a somewhat deeper transverse horizontal section, running through the *corpus striatum* and *thalamus*, it will be seen that to

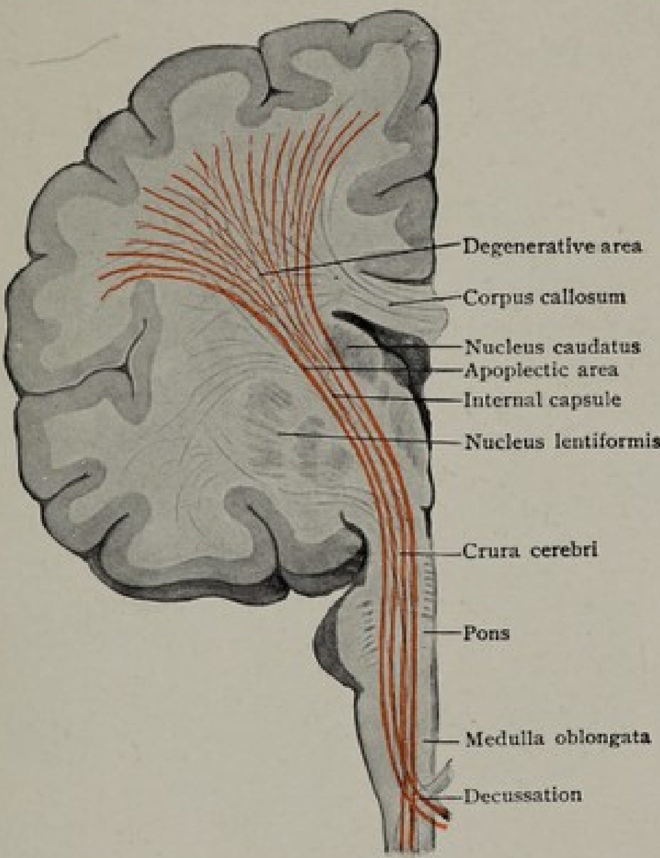


FIG. 41.—Showing the degenerative and apoplectic areas of the brain and the course pursued by the motor fibres from the cortex, through the internal capsule, crura, pons, and medulla to the decussation, where they cross the median line to supply the opposite side of the body.

the outer side of the corpus striatum and thalamus is a white layer constituting the *internal capsule*. It divides the corpus striatum into two parts, one to its inner side, which projects into the lateral ventricle, called the *caudate nucleus*, and the other to its outer side, called the *lenticular nucleus*. The lenticular nucleus is divided into two portions, the outer part forming the *Putamen* and the inner part the *Globus Pallidus* or *Pallidum*. The internal capsule is composed of anterior limb, knee and posterior limb. In the anterior limb runs the thalamic radiation connecting cortex and thalamus. The knee and anterior third of the posterior limb transmit the motor fibers from the precentral area. The middle third carries the sensory fibers from the post central and parietal lobes and in the posterior third of the posterior limb run the visual fibers to the occipital lobes.

In Figure 41, there is a coronal transverse section of the brain showing the course of fibers of the internal capsule from the motor area (precentral gyrus) of the brain, through the internal capsule, into the cerebral peduncles of the mid-brain, then into the pons, into the medulla where they decussate in its lower portion, terminating finally around the anterior horn cells of the spinal cord. This constitutes the motor pathway from the precentral area to the extremities and when it is injured, the extremities of the opposite side are paralyzed.

Hemorrhage into the Pons—Crossed Paralysis.—Apoplexy may also occur in other portions of the brain. It may occur in the pons. This produces two different sets of symptoms, according to its location, which is due to the fact that the fibres of the seventh or facial nerve, in their passage from the cortex to the face, decussate in the pons. If a small hemorrhage occurs into the upper portion of the pons, it will destroy the motor fibres to the face and the extremities of the opposite side. If, however, the hemorrhage is below the point of decussation, the side of the face on the side of the lesion will be paralyzed and the extremities of the opposite side, thus producing what is known as crossed paralysis, that is, a paralysis of the face on one side and of the extremities on the other.

Cortical Apoplexy.—Hemorrhages on the cortex are apt to be less extensive and more localized on account of the smaller size of the vessels affected. They either destroy or irritate the brain at the site of injury, and produce, if they involve certain areas of the brain, definite peripheral symptoms which serve to indicate the seat of lesion.

THE CEREBRAL LOBES

Each cerebral hemisphere is composed of five lobes, called the *frontal, parietal, occipital, temporal*, and *central*, or *island of Reil* (insula).

The **frontal lobe** comprises the anterior portion of the brain, as far back as the fissure of Rolando (*central sulcus*) and as far toward the base as the fissure of Sylvius (lateral cerebral fissure.)

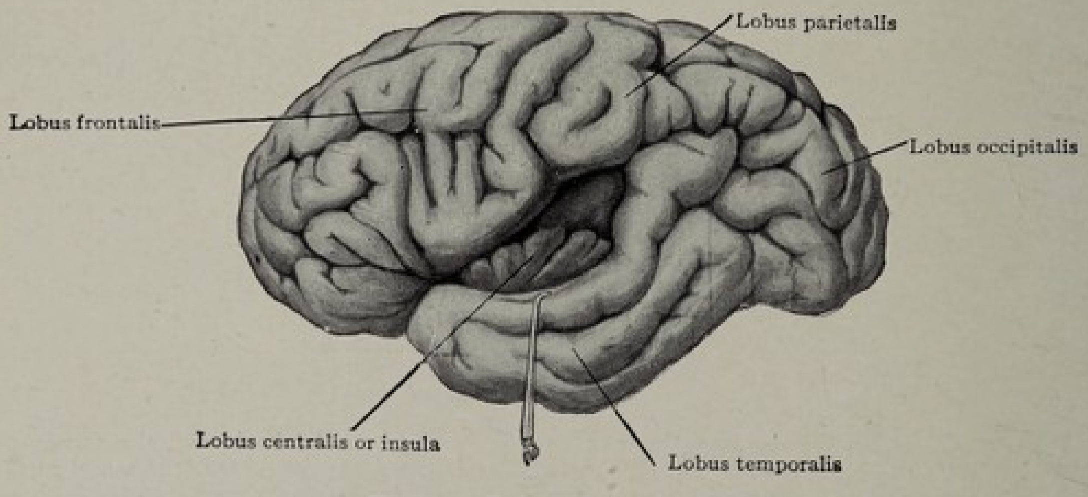


Fig. 42.—Lobes of the brain.

The **parietal lobe** extends from the fissure of Rolando (central sulcus) in front to the parieto-occipital fissure behind. Below, it is limited anteriorly by the fissure of Sylvius (lateral cerebral fissure), while its posterior portion merges into the temporal lobe.

The **occipital lobe** extends posteriorly from a line joining the occipitoparietal fissure above to the pre-occipital notch below.

The **temporal lobe** consists of that portion of the brain below the fissure of Sylvius (lateral cerebral fissure), as far back as the pre-occipital notch. It occupies the middle fossa of the skull.

The **central lobe** or **island of Reil (insula)**, consists of five to seven convolutions which radiate upward; it can be seen by separating the two sides of the anterior portion of the fissure of Sylvius (lateral cerebral fissure).

THE FISSURES AND CONVOLUTIONS OF THE BRAIN

The surface of the brain is wrinkled or thrown into folds, producing elevations and depressions. The elevations are called convolutions or *gyri*, and the depressions, fissures or *sulci*.

The fissures are called main or subsidiary fissures, according to their importance. The four main fissures are the *longitudinal fissure*, which separates the hemispheres; the *fissure of Sylvius* (lateral cerebral fissure); the *fissure of Rolando (central fissure)*, and the *parieto-occipital fissure*. The *transverse fissure* is the cleft which separates the cerebrum from the cerebellum, the corpora quadrigemina, and the pineal body. This fissure is filled behind by the tentorium cerebelli and in front by a fold of pia. The posterior end of the longitudinal fissure ends in the transverse fissure.

THE LATERAL SURFACE OF THE HEMISPHERES

The frontal lobe has a superior, an inferior, and a precentral sulcus. The first two divide the anterior portion into the *superior, middle,* and *inferior frontal convo-*

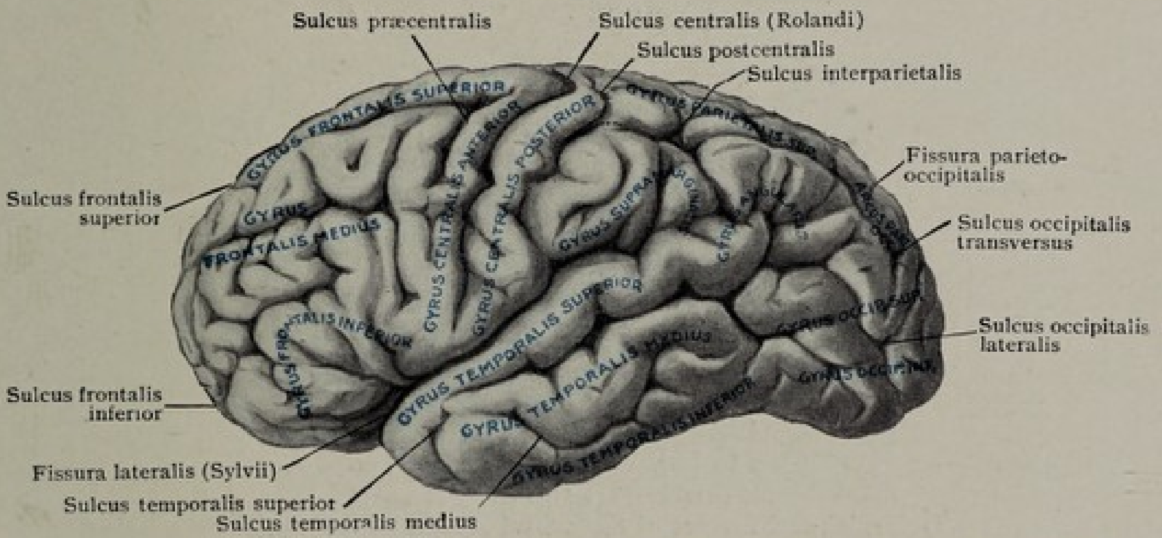


FIG. 43.—Fissures, sulci, and gyri (convolutions) of the lateral surface of the cerebral hemisphere.

lutions. Posterior to these and running upward and backward, forming the anterior wall of the central fissure, is the *precentral* or *ascending frontal convolution*.

The convolution forming the anterior extremity of the parietal lobe and the posterior wall of the central sulcus or fissure of Rolando is called the *postcentral* or *ascending parietal convolution*. Immediately behind it is the postcentral or interparietal sulcus. The upper portion of this sulcus divides, one branch going upward and one backward. Immediately above the posterior branch is the *superior parietal gyrus* or lobule, and below it and surrounding the posterior extremity of the fissure of Sylvius (lateral cerebral fissure) is the *supramarginal gyrus*. Posterior to the supramarginal gyrus and surrounding the posterior extremity of the superior temporal, or temporosphenoidal sulcus is the convolution known as the *angular gyrus*.

The occipital lobe on its convex surface is divided into *superior* and *inferior occipital convolutions* by the lateral occipital sulcus.

The temporal or temporosphenoidal lobe is also divided into *superior, middle,* and *inferior,* or *first, second,* and *third temporal convolutions* by the superior, or parallel, and middle fissures. On the under surface is a *fourth temporal convolution*, separated from the third by the inferior temporal fissure. These fissures may not be distinct.

THE MEDIAL SURFACE OF THE HEMISPHERES

If now the medial surface of the hemisphere, which forms one side of the longitudinal fissure, be examined, there is seen a large convolution running just above and parallel with the corpus callosum. It is called the *gyrus cinguli* (*fornicatus*). Below and separating it from the corpus callosum is the callosal fissure; above it is the callosomarginal (cinguli) fissure. The convolution above the latter, forming the margin of the hemisphere, is the *marginal convolution*. The callosomarginal fissure at its posterior portion turns upward and ends on the margin of the hemisphere, just posterior to the fissure of Rolando (*central fissure*), and serves to identify it. This marks the posterior limit of the frontal lobe. The posterior end of the frontal lobe surrounds the upper end of the central fissure and on that account is called the *paracentral lobule*. Its anterior boundary is marked by the paracentral fissure, or sulcus. Between the callosomarginal fissure in front and the parieto-occipital fissure behind is the parietal lobe, called, from its square shape on the medial surface, the *quadrate lobule*, or from being anterior to the cuneus

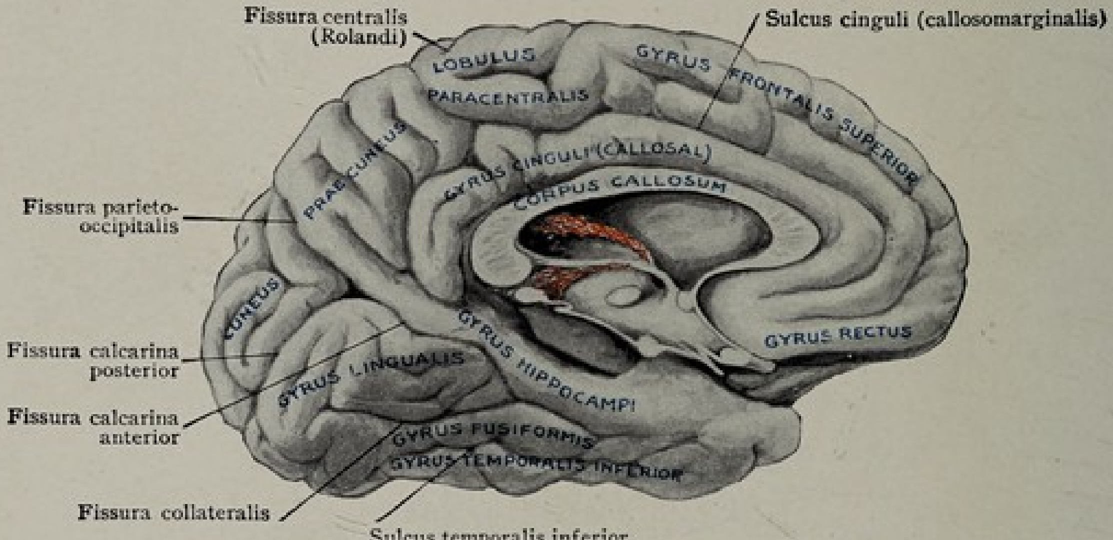


FIG. 44.—Gyri, sulci, and fissures of the medial surface of the cerebral hemisphere.

lobule, the *precuneus*. Running downward and backward from the deeper portion of the parieto-occipital fissure is a very distinct depression called the *calcarine fissure*. These two fissures include a wedge-shaped piece of the occipital lobe called, from its shape, the *cuneus lobule*. It is of interest in reference to the sense of sight.

FUNCTIONS OF THE CORTEX OF THE BRAIN: CEREBRAL LOCALIZATION

A knowledge of the functions of the various portions of the brain is necessary in order to localize a diseased area. The diseases and injuries to which the brain is exposed oftentimes do not involve the whole brain, but only certain distinct and isolated parts. The brain is not a single, homogeneous organ that acts only as a whole; it is complex. It is composed of a number of separate parts or areas, which may act either singly or in conjunction with other areas. These separate areas have different functions, so that if the disease or injury is limited to one of them, we have its functions abolished, and the symptoms produced indicate the area affected.

These areas are situated on the surface or cortex of the brain in the gray matter. They receive impressions from, and transmit impulses to, all parts of the body through the white matter or fibres of the brain. An injury to the cortex or gray matter destroys the originating and receptive centres. An injury to the white matter destroys the paths to and from these centres and therefore prevents them from receiving impressions or sending out impulses. Thus, we may have a paralysis of the leg and arm caused by an injury to the leg and arm centres in the cortex of the brain, as by a hemorrhage from a fracture, or we may have the same paralysis produced by an injury to the path leading from those centres, the motor tract as it is called, by a hemorrhage, as from apoplexy, involving the corresponding white matter fibres.

The exact localization of the functions of all parts of the brain has not been accomplished, but the functions of many areas have been definitely proven. In cases of brain tumor, abscess, hemorrhage, injury, etc., a knowledge of these areas enables one to localize the seat of the lesion.

FUNCTIONS OF THE CONVOLUTIONS ON THE SURFACE OF THE CEREBRUM

Motor Area.—This area lies in the posterior part of the frontal lobe just in front of the Rolandic fissure. It includes the ascending frontal gyrus, the frontal adversive field, and the paracentral lobule. It is motor in function. Histologically it is characterized by the presence within the cortex of giant pyramidal cells or the cells of Betz. It gives rise to the fibers of the Cortico-spinal (pyramidal) tract. Stimulation of this area causes voluntary motion in various parts of the oppo-

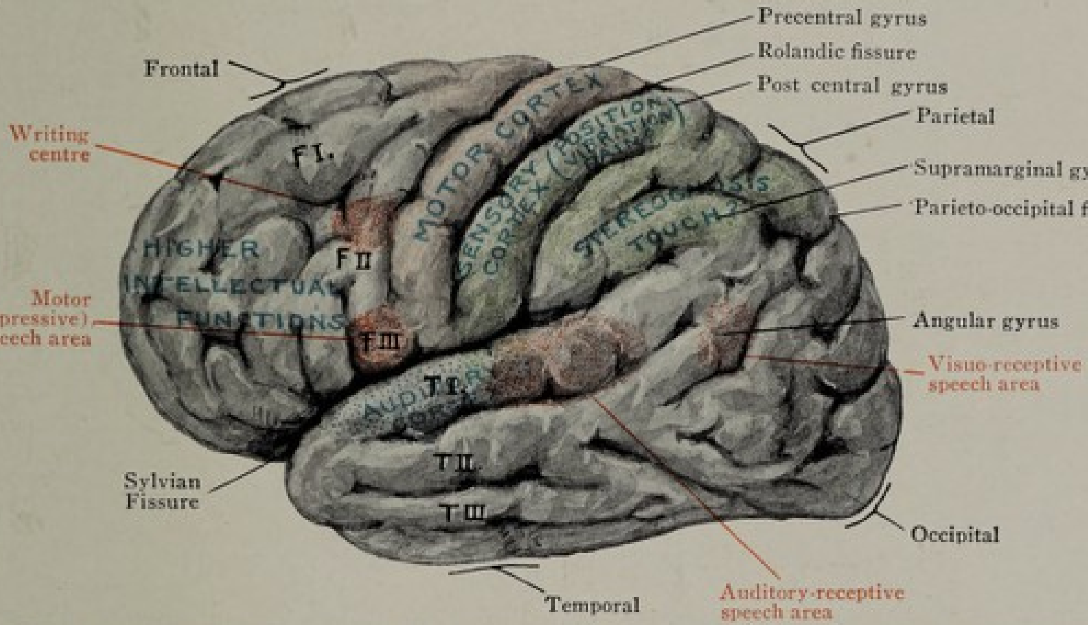


Fig. 45.—Diagram illustrating the probable functions of the lateral surface of the brain.

site side of the body. Roughly speaking the upper parts of the body are represented in the lower part of the precentral gyrus, the trunk and arm in the middle portion and the leg and foot in the paracentral lobule. The most recent studies of electrical stimulation of the cortex indicate that rhythmic chewing, licking, swallowing and grunting movements are located in the lowermost part of the precentral gyrus just above the point where it touches the Sylvian fissure. Just above this are the areas for the larynx, palate, tongue, face, neck, thumb, digits, hand, forearm, arm, chest, abdomen, thigh, leg and foot in the order named. Conjugate deviation of the head, eyes and trunk is located in a field comprising the posterior third of the first and second frontal gyri. Experimental removal of the precentral gyrus in monkeys results in a transitory paralysis of the opposite side of the body. Destruction by softening or other disease in man results in paralysis of the opposite side, the extent of involvement depending on the degree of destruction of the precentral gyrus. If the lower part is destroyed there is a facial, facial-arm paralysis, or face-palate-tongue-arm type of paralysis.

In the posterior part of the third frontal gyrus is a small area of cortex known as Broca's area, which has to do with motor speech. Destruction of this area results in the inability to express oneself in words, though understanding of auditory speech and of reading is intact.

The Somatic Sensory Area.—This includes the post-central gyrus and the supramarginal gyrus and is concerned with ordinary type of sensation exclusive of special types such as audition and vision. There are two main centers of somatic sensation. These are in the thalamus and post-central gyrus. All types of somatic sensation terminate in the thalamus, a lesion of this area causing loss of touch, pain, temperature, vibration and position senses. There is a topical bodily representation in the post central gyrus similar to that found in the precentral gyrus. Stimulation of the human post central area causes paresthesias of various sorts in the corresponding areas. In disease conditions there are sometimes focal convulsions of an epileptic nature characterized by paresthesias rather than motor movements. Lesions in the post-central gyrus on the other hand produce chiefly disturbances in discriminative types of sensation such as differences in texture, the distance between points on a compass, and differences in degree and intensity of stimuli. Such sensations as touch, pain and temperature escape in cortical lesions, while vibratory sense is involved. In the supramarginal gyrus in the parietal lobe is the centre for stereognosis, the appreciation of the size, shape and texture of objects.

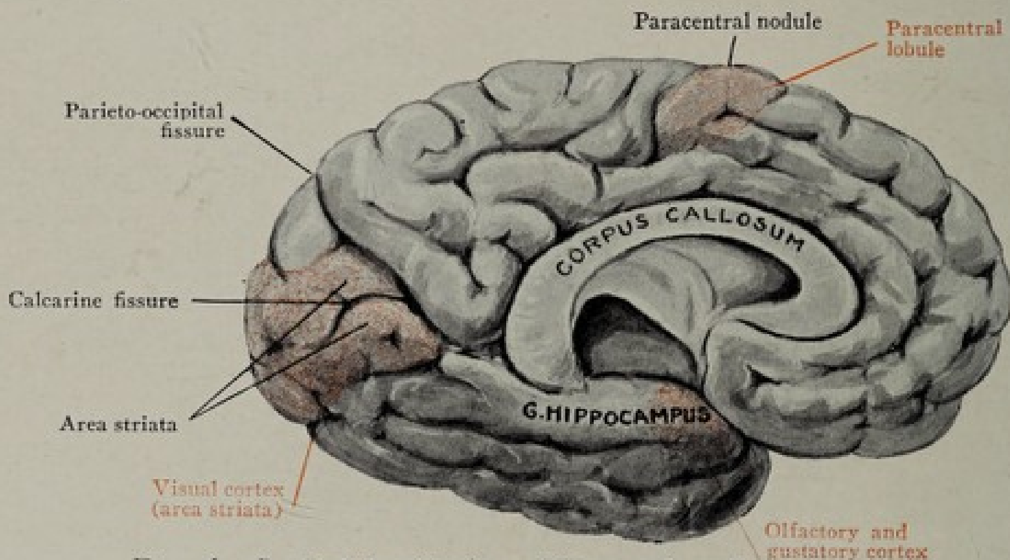


Fig. 46.—Cerebral localization. Motor and auditory centres.

The Visual Area.—The cortical visual area lies around the *Calcarine fissure,* which lies on the mesial surface of the occipital lobe. The visual fibres from the retina and primary visual centres (lateral geniculate bodies) terminate in the *Area Striata* which surrounds the Calcarine fissure. It has two lips, an upper and a lower, the fibres from the inferior part of the retina terminating in the lower lip, and the fibres from the upper part ending in the upper lip. In the occipital lobe lies the *angular gyrus* which has to do with visual speech. A lesion in this region results in the inability to appreciate the context of written words and sentences (alexia).

The course of the visual fibres is important. These fibres come from the retina. Those from the temporal halves continue on the same side, those from the nasal halves cross over. The decussation takes place in the optic chiasm, the fibres continuing from here by way of the optic tracts chiefly to the lateral geniculate bodies. Thence they pass around the inferior horn of the ventricle through the temporal lobe and pass to the occipital lobe where they end around the Calcarine fissure. Lesions around the optic chiasm produce a loss of vision in both temporal fields, a bi-temporal hemianopsia. A lesion behind the chiasm causes a homonymous hemianopsia, a loss of the temporal field on one side and of the nasal field on the other.

The Auditory Area.—The auditory fibres from the ear terminate in the opposite temporal lobe chiefly, ending in the transverse temporal gyri (Heschl's convolutions) which lie on the dorsal surface of the temporal lobe in the opercular portion. They lie in about the middle of the upper temporal gyrus. In the posterior third of the superior temporal gyrus lies the area of Wernicke or the so-called centre of auditory speech. A lesion in this area causes a marked disturbance in the ability to understand spoken speech. Unilateral lesions in the area of the transverse temporal gyri do not cause loss of hearing because all the auditory fibres do not cross over; some are ipselateral.

Gustatory and Olfactory Areas.—These areas are presumably located in the uncus region of the temporal lobe. Lesions in this area sometimes cause uncinate fits which are seen also in epilepsy. They are characterized by tasting movements and the occurrence of disagreeable tastes or smells.

FUNCTIONS OF THE BASAL GANGLIA

Our knowledge of the functions of the basal ganglia is still very incomplete and much of the knowledge is controversial. There is much controversy first of all about what should be included in the Basal Ganglia. Some include the Striatum (Putamen and Caudate), Pallidum, Corpus Sub-thalamicum and parts of the Thalamus. Others designate the Striatum, Pallidum, Corpus Sub-thalamicum and

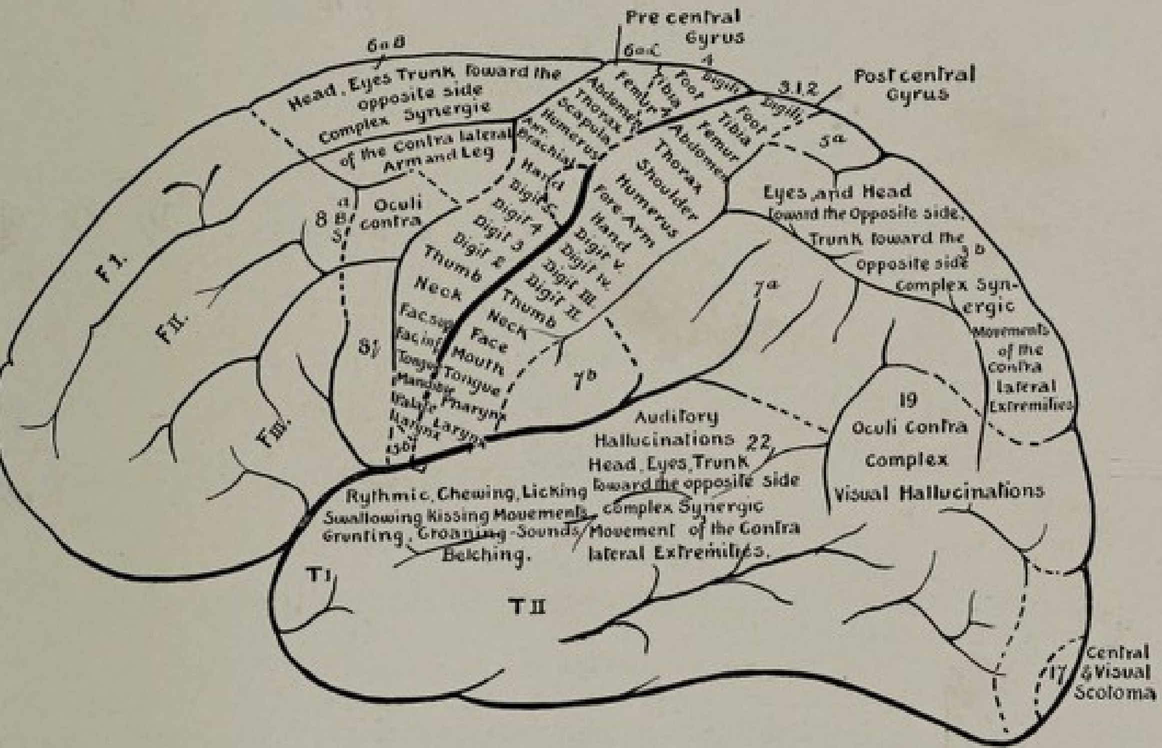


FIG. 47.—Diagram of the external surface of the brain to show the localisat of movements as mapped out by electrical stimulation. After Foerster.

Substantia Nigra as the basal ganglia system. Still others include Striatum, Pallidum, Corpus Sub-thalamicum, Substantia Nigra, Nucleus Rubei and Nucleus Dentatus of the Cerebellum.

Most of our knowledge of localization of function in the basal ganglia has come from study of pathological material. Lesions in the Striatum (Putamen and Caudate) produce involuntary movements such as chorea and athetosis. The putamen particularly is affected in Huntington's chorea. The pallidal system, which includes Pallidum and Substantia Nigra, is diseased in paralysis agitans. The latter is especially implicated in the post encephalitic type of paralysis agitans. The nucleus rubei presumably has a slight function in the regulation of muscle tonus and so too possibly has the pallidal system. The nucleus rubei has something to do also with the righting capacity of animals, that is, their ability to right their heads, trunks and limbs to their normal postures. Lesions of the Corpus

Subthalamicum are reported to produce throwing movements on the opposite side of the body, so-called hemiballism.

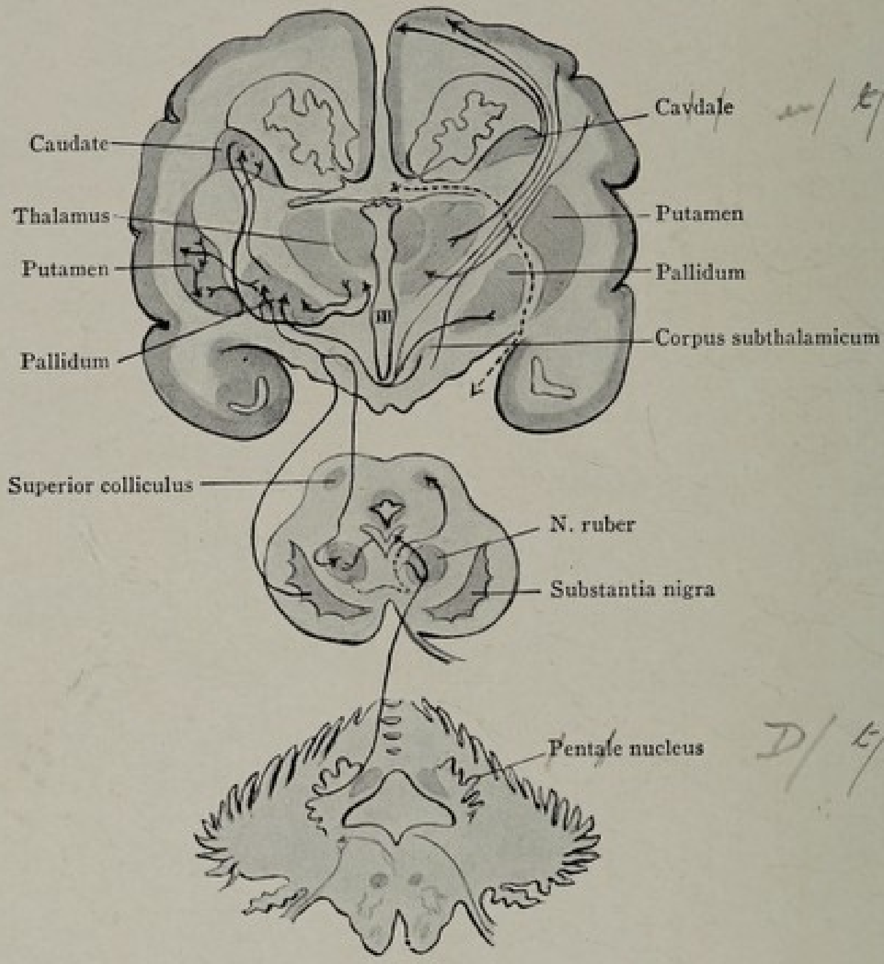


FIG. 48.—A diagram illustrating some of the connections between the basal ganglia.

THE CORONA RADIATA, INTERNAL CAPSULE AND MOTOR TRACT

The *corona radiata* is the bundle of white fibres which spreads out like a fan and connects the cortex of the brain with the basal ganglia and spinal cord. Proceeding downward from the cortex, the corona radiata becomes smaller and passes, in the form of a band, between the lenticular nucleus on the outside and the caudate nucleus and thalamus on the inside. This band is known as the *internal capsule.* It transmits in its anterior portion fibres from the prefrontal or higher psychical area; then come the motor paths; and still farther back, in the posterior third of the posterior portion, sensory fibres.

The *functions of the external capsule,* which lies to the outer side of the lenticular nucleus, are not known.

THE CEREBROSPINAL FLUID

The cerebrospinal fluid is a watery fluid which lies within the cerebral ventricles, the cisternae at the base of the brain and within the subarachnoid space of the brain and spinal cord. There is no fluid in the subdural space. It forms a fluid cushion around the central nervous system. Its source is chiefly from the choroid plexuses which lie within the ventricles. It is poured directly into the ventricles. The fluid produced in the lateral ventricles flows through the Foramina of Monro which connect the lateral and third ventricles into the latter. From the third ventricle it passes through the aqueduct of Sylvius or iter and from here into the fourth ventricle. From the latter it passes into the subarachnoid space. It reaches the latter by means of small perforations in the roof of the fourth ventricle, the medial foramen of Magendie, and the laterally placed foramina of Luschka. The existence of these foramina is not absolutely certain but there is good presumptive evidence that they exist. The fluid seeps down the spinal subarachnoid

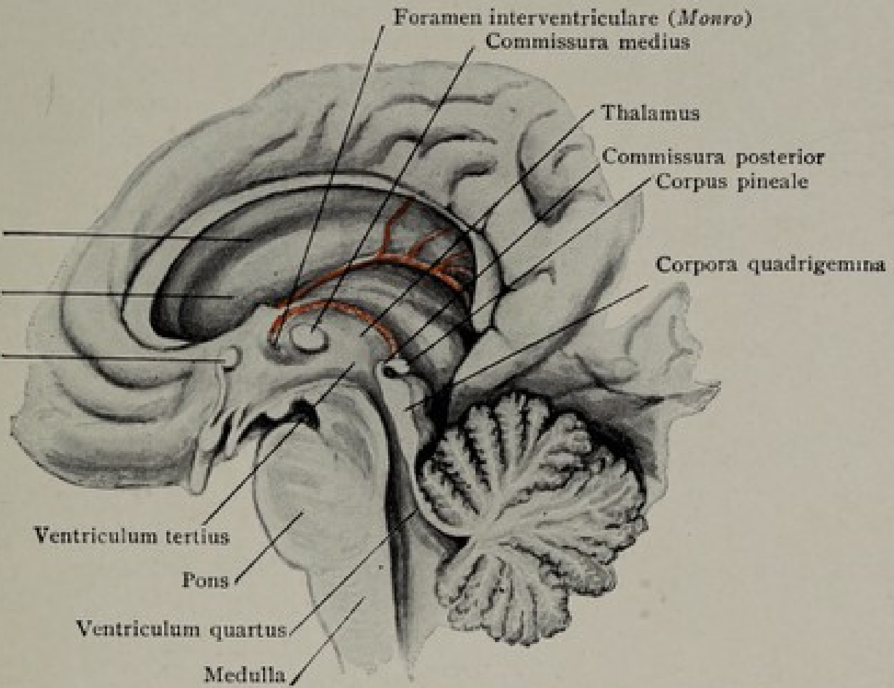


FIG. 49.—Foreshortened view showing corpus striatum, thalamus, corpora quadrigemina, lateral, third, and fourth ventricles, etc.

space from this region quite slowly, more rapidly over the base of the brain and slowly over the cerebral hemispheres. The fluid circulates therefore around the hemispheres and base of the brain and around the spinal cord. It circulates also

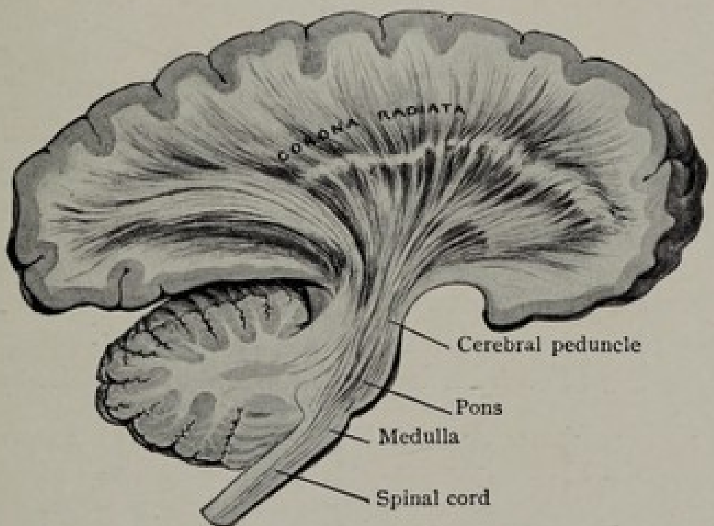


FIG. 50.—The corona radiata or projection fibres which connect the cortex above with the thalamus, corpus striatum, tegmental region, pons, medulla, and spinal cord below. These fibres go to form the internal capsule.

probably in the perivascular spaces of the cortex in a space lined by mesothelium. It is said also that it circulates around the nerve cells in the peri-neuronal spaces. The entire fluid system, therefore, around nerve cells, vessels, brain and spinal cord is closely related.

The spinal fluid lies within a space which is under the arachnoid membrane, lying between it and the pia mater. This membrane is lined with mesothelium

(Weed) or fibroblasts (Mallory). While the fluid lies within the subarachnoid space only, in one place the arachnoid and dura come into close contact. This is through the arachnoid villi or Pacchionian bodies which are arachnoidal formations penetrating into the dural sinuses so that the arachnoidal cells come to lie directly beneath the endothelium of the dural sinuses. These villi are covered by arachnoid cells. Within the villi the cerebrospinal fluid comes into close contact with the blood in the dural venous sinuses.

The method of absorption of the spinal fluid is important. It probably takes place through two channels: a rapid drainage into the dural venous sinuses, and

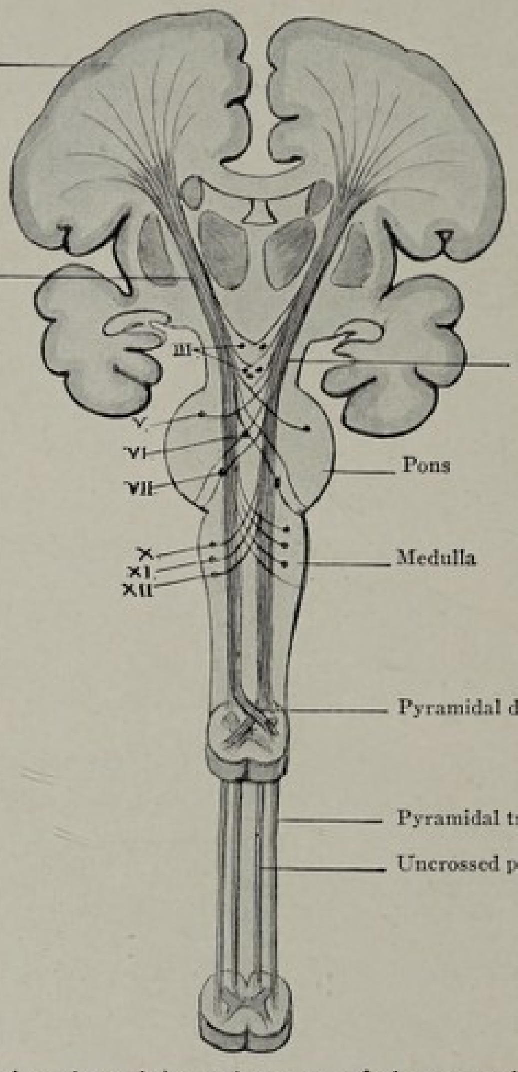


FIG. 51.—Diagram illustrating the origin and course of the pyramidal tract and the cortico-bulbae tract giving fibres to the various motor nuclei in the base of the brain.

a slow drainage into the lymphatic channels around the blood vessels. The drainage into the venous sinuses is probably the more important.

The cerebrospinal fluid pressure is important both in normal and pathological conditions. The normal pressure is 100 to 200 mm. of water or 6 to 8 mm. of mercury. Normally, the pressure is a balance between the new production of fluid and its absorption and upon arterial and venous pressures within the brain. Under pathological conditions the fluid pressure is raised as in the case of brain tumors. In most cases of brain tumor the spinal fluid pressure is raised except in pituitary tumors. The highest levels are usually in posterior fossa tumors or in tumors which block the ventricular system. Usually the pressure is well over 200 mm. of water.

In cases of spinal cord tumor there occurs what is known as subarachnoid block. This is demonstrated by what is known as the Queckenstedt test. Lumbar puncture is performed with a manometer in place, compression of the jugular veins in the neck causes a rapid rise in the spinal fluid pressure due to increase in venous pressure within the skull. Release of the jugular veins results in a rapid fall of the pressure to the former level. This is a normal response and constitutes a negative Queckenstedt test. When the subarachnoid space is blocked by a tumor or is obliterated by adhesions from inflammation, there is a failure of communication between the subarachnoid space above and below the compression. Hence compression of the jugular veins will result in no transmission of the increased pressure beyond the block in the subarachnoid space. There will, therefore, be no rise in the fluid column in the manometer in cases in which there is a complete block, whereas in cases of only a partial block there will result a slow, slight rise in the fluid level and a slow fall on release of compression which does not reach the previous level. The difference in the manometric readings is clearly seen when a combined cistern and lumbar puncture is performed. Where there is a subarachnoid block between the cistern and lumbar areas, compression of the jugular veins will cause a rise in the cisternal manometer with none in the lumbar manometer.

In cases of meningeal inflammation there is, of course, increase in the cells in the spinal fluid, the number of cells varying with the type of inflammation.

THE VENTRICULAR SYSTEM

The need of considering the ventricular system separately finds justification in the importance of this system in brain tumor diagnosis. The cerebral ventricles form a part of the cerebrospinal system, together with the sub-arachnoid spaces.

There are two lateral ventricles which are each composed of three horns and a body: the anterior (frontal) horn, the posterior (occipital) horn and the inferior (temporal) horn. The anterior horn is situated in the frontal lobe, extending from the genu of the corpus callosum to the body. The latter is continuous anteriorly with the frontal horn at about the level of the Foramen of Monro, and posteriorly with the point of confluence of the body, posterior and inferior horns. The body of the ventricle lies chiefly within the parietal lobe. The posterior horn of the ventricle lies chiefly within the occipital lobe, while the inferior horn is chiefly in the temporal lobe. This horn is the only one to possess a choroid plexus, neither the posterior nor inferior horns containing one. The lateral ventricles connect with the third ventricle by means of the Foramen of Monro. The third ventricle lies chiefly in the diencephalon, its lateral walls being formed mainly by the thalami, its floor by the cerebral peduncles, tuber region and corpora mamillaria and its roof by the corpus callosum and the tela chorioidea. It has a choroid plexus. It communicates with the fourth ventricle by the aqueduct of Sylvius which lies chiefly in the mid-brain. The fourth ventricle is a fairly large cavity whose floor is formed by the medulla, the roof by the anterior medullary velum, the superior cerebellar peduncles, and the posterior medullary velum. It contains a choroid plexus. The fourth ventricle lies within the pons and medulla.

Ventricular Tap.—It is important at times to tap the lateral ventricles for diagnostic purposes in brain tumors, or for the introduction of air into the ventricular system. This is carried out by the following technique as described by Grant: bilateral trephine openings are made 6 centimeters above the occipital protuberance and 1.5 centimeters lateral to the mid-line to avoid the longitudinal sinus. From this position the ventricles should be encountered at a depth of from four to five centimeters, the cannula being directed slightly outward and in a horizontal plane level with the tip of the ear. The cannula is directed to enter the body of the lateral ventricle, its widest point. The occipito-parietal approach is used because the cannula passes through a relatively silent cerebral area, well behind the post central area and above the visual tracts.

Injection of air into the ventricles is a procedure relatively recent in origin. Its purpose is to produce a contrasting medium in order to detect shadows in the ventricles themselves, or to find distortion of the ventricular shadows which are produced by filling defects from tumors in particular. In the normal ventriculogram the ventricular system is seen without difficulty, the lateral, third and fourth ventricles being easily visualized. The fourth ventricle is seen in only one half the cases. The lateral ventricles lie normally to either side of the midline and what is very important, the midline structures are not shifted to one or the other side. The third and fourth ventricles lie normally in midline and show no filling defect. Usually the amount of air necessary to fill normal sized ventricles varies from 10 to 15 centimeters.

The type of ventricular deformities seen in brain tumors in which air has been injected into the ventricles has been well described by Grant. Intracranial lesions produce either symmetrical or asymmetrical changes in the size, shape and position of the shadows in the ventricular and arachnoid spaces. A tumor in one cerebral hemisphere always produces obliteration of, or a filling defect in, the lateral ventricle of that hemisphere, while the size and contour of the other lateral ventricle may not be changed. There is, therefore, an obliteration of the ventricle on the side of the tumor, the obliteration being partial or complete. On the opposite side the ventricle is either normal in size or enlarged. There is usually a shift of the mid-line structures to the opposite side. A supra-tentorial tumor lying in the midline between the cerebral hemispheres, and any sub-tentorial lesion causes a symmetrical dilatation of the ventricles above the point of obstruction, causing an internal hydrocephalus. In such cases the ventricular system above the point of obstruction is markedly dilated. Thus a tumor filling the third ventricle will cause an internal hydrocephalus involving the lateral ventricles. A tumor filling the fourth ventricle will cause a hydrocephalus involving the lateral ventricles, third ventricle and aqueduct of Sylvius.

In some cases of head trauma, there is a distortion of the ventricular system. This is seen in cases wherein there is a cortical scar due to a penetrating wound or to intracerebral pathology. The scar penetrating deep into the cortex exerts a pull on the portion of the adjacent ventricle causing a local dilatation of it. It may cause a local dilatation of one anterior or posterior horn in this way.

Any space taking lesion within the cranium whether it be tumor, abscess or hemorrhage is capable of producing distortion of the ventricular system. In cases of intracranial lesions with definite evidence of increased pressure within the skull, but with no localizing neurological signs, ventriculography is very important in arriving at a localizing diagnosis. It is attended with a mortality of 6.2% (Grant).

ENCEPHALOGRAPHY

Recently there has been developed a rather simple method of injecting air into the ventricular and sub-arachnoid spaces. This is known as encephalography. The technique varies greatly with each individual worker. The technique used by Grant is as follows: The patient is in the sitting posture. A lumbar puncture is performed, a three-way stopcock being attached to the needle, one for the attachment of a manometer, one for the escape of fluid, and one for the insufflation of air by means of a 10 cc. syringe. Fluid is removed and the pressure watched. An equal amount of air is then introduced so that the pressure is that recorded before the withdrawal of fluid. This is repeated until all the fluid is removed and an equivalent or nearly equivalent amount of air is introduced. The amount of fluid removed varies almost with each patient, depending on the size of the ventricles. Grant reports a mortality of 0.3% and advises its careful use in cases with increased pressure. It should never be used in cases of posterior fossa tumors.

The localization of *tumors* by encephalography depends on the same principles as those described for ventriculography. The only information of value obtainable by using encephalography rather than ventriculography in *tumors* of the brain is the fact that by the former technique the cortical arachnoid channels are outlined.

Encephalography has been performed in all sorts of neurological conditions—in tumors, scars, epilepsy and innumerable other conditions. It may be of diagnostic value, as in the determination of porencephalic cysts, for example.

CRANIOCEREBRAL TOPOGRAPHY

For the purpose of operating on the brain it is essential to know the bony landmarks of the skull, the lower level of the brain, and the relation which the various fissures and convolutions bear to the surface.

The most important fissures are the *longitudinal, Sylvian, Rolandic,* and *parieto-occipital.* If these can be properly located, the convolutions and subsidiary fissures can be readily filled in.

BONY LANDMARKS

Nasion.—The nasofrontal suture in the median line.

Glabella.—The smooth spot in the median line on the frontal bone between the superciliary ridges. It is about on a level with the upper edge of the orbit.

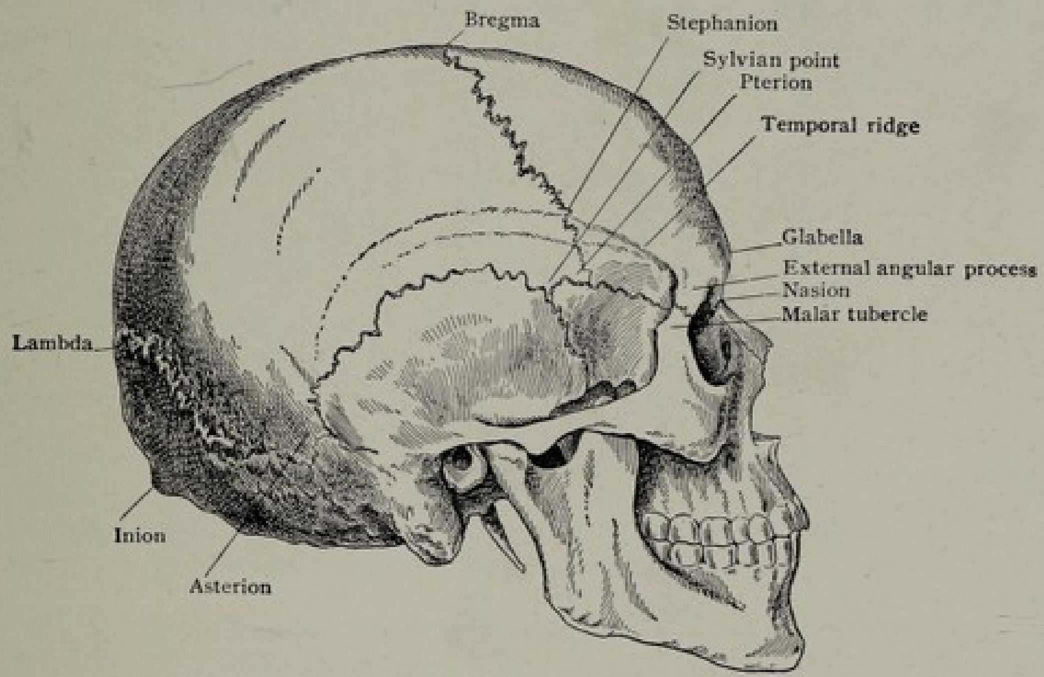


FIG. 52.—Landmarks of the skull.

Bregma.—The point in the midline where the sagittal and coronal sutures cross. It corresponds with the anterior fontanelle in the infant, which is closed during the second year.

Lambda.—The point of meeting of the sagittal and lambdoid sutures. It is about 6 cm. (2¼ in.) above the occipital protuberance.

Inion.—The external occipital protuberance.

Pterion.—This name was given by P. Broca to the point where the frontal, parietal, and sphenoid bones meet in the region of the temple. It is about 2.5 cm. (1 in.) behind the angular process and should not be confounded with the Sylvian point, which is 1.5 cm. (⅝ in.) farther posterior, where the temporal, parietal, and sphenoid bones meet. Horsley called this latter point the pterion. The region of the pterion is the seat of the anterolateral fontanelle in the fœtus.

Asterion.—This lies 2 cm. (⅘ in.) behind the base of the mastoid process, where the parietal, occipital, and temporal bones meet. It is on the superior curved line and in fœtal life forms the posterolateral fontanelle.

Temporal Ridge.—This marks the upper attachment of the temporal fascia and muscle. It begins at the external angular process of the frontal bone and ends at the asterion. Its interior third is well marked, but as it crosses the coronal suture it fades away and gradually broadens out, its upper margin being called the superior and its lower the inferior temporal ridge. The superior ridge marks the attachment of the superficial layer of the temporal fascia, the inferior, the deep layer.

External Angular Process.—This is the outer extremity of the frontal bone, where it articulates with the malar. The line of the suture can be felt in the living.

Malar Tubercle.—This is the small bony projection on the posterior edge of the malar bone, 1.25 to 2 cm. (½ to ¾ in.) below the frontomalar suture.

Stephanion.—The point where the temporal ridge crosses the coronal suture.

TOPOGRAPHICAL POINTS

Pre-auricular Point.—The depression in front of the ear and just behind the condyle of the lower jaw.

Sylvian Point.—Where the anterior ascending and anterior horizontal limbs come off from the posterior horizontal limb of the fissure of Sylvius. It lies 4 cm. (1⅝ in.) posterior and a little above the external angular process, at the junction of the parietal, sphenoid, and temporal bones.

Superior Rolandic Point.—Where the upper end of the line marking the Rolandic fissure crosses the median line.

Inferior Rolandic Point.—Where the lower end of the line marking the Rolandic fissure crosses the line of the Sylvian fissure.

The Lower Level of the Brain

The lower level of the brain is marked by a line beginning in the median line 1 cm. (⅖ in.) above the nasion, thence above the orbit 1 cm. from its edge to the external angular process; from here it goes to the middle of the zygoma, thence backward along its upper border, above the auditory meatus and along the superior curved line to the inion (occipital protuberance).

FISSURES AND CONVOLUTIONS

The confirmation of the various fissures and convolutions varies so much within normal limits that it is not possible to outline them on the surface of the scalp or skull with absolute exactness. The various lines which are laid out to indicate their course are, therefore, only approximate, but they are sufficiently accurate for operative purposes. To allow for variations, the openings made are usually large, and the motor areas are sometimes identified by the application of an electrode.

Fissure of Sylvius (fissura cerebri lateralis).—To indicate the course of the Sylvian fissure, a line is drawn from the external angular process of the frontal bone through a point 2 cm. (¾ in.) below the most prominent part of the parietal eminence and ending 1.5 cm. (⅝ in.) above the lambda. The main portion of the Sylvian fissure begins 2 cm. (¾ in.) behind the angular process; 2 cm. farther back or 42 mm. (1⅝ in.) behind the angular process is the Sylvian point, where the anterior horizontal and anterior ascending limbs are given off. From this point the posterior horizontal limb passes backward to 2 cm. (¾ in.) below the highest point of the parietal eminence and then curves upward and backward for a distance of 1.25 cm. to 2 cm. (½ to ¾ in.).

Central Fissure, or Fissure of Rolando (sulcus centralis).—The line of the central fissure begins at the upper Rolandic point, 1.5 cm. (⅝ in.) behind the middle of a sagittal line passing from the glabella to the inion. It then passes down and forward at an angle of approximately 70° (67½, Chiene) toward the middle of the zygoma (Le Fort) to end at the lower Rolandic point, where it intersects the Sylvian line. It is about 9 cm. (3½ in.) long. The central fissure stops 1 cm. above the Sylvian line or fissure. This fissure can be marked out on the skull by folding a piece of paper to a right angle and then dividing this into angles of 45°, and this into 22½°. The 45° angle plus the 22½° angle will make a 67½° angle which placed 1.5 cm. back of the midline from glabella to inion and pointing downward and forward, will mark the Rolandic fissure (Fig. 54).

Parieto-occipital Fissure (fissura parieto-occipitalis).—The position of this fissure is quite variable, an average being 1.5 cm. (⅝ in.) above the lambda, and extending 1.25 cm. (½ in.) out from the median line. It is about 6 cm. (2¼ in.) above the inion and on or below the line of the Sylvian fissure.

SUBSIDIARY FISSURES AND CONVOLUTIONS

The **precentral and postcentral sulci** are about 15 mm. (3/5 in.) anterior and posterior to the fissure of Rolando.

The **inferior frontal convolution** lies between the line of the fissure of Sylvius below and a line just below the temporal ridge above.

The **middle frontal convolution** lies under the frontal eminence, and occupies about the lower two-thirds of the distance between the temporal ridge below and the midline above.

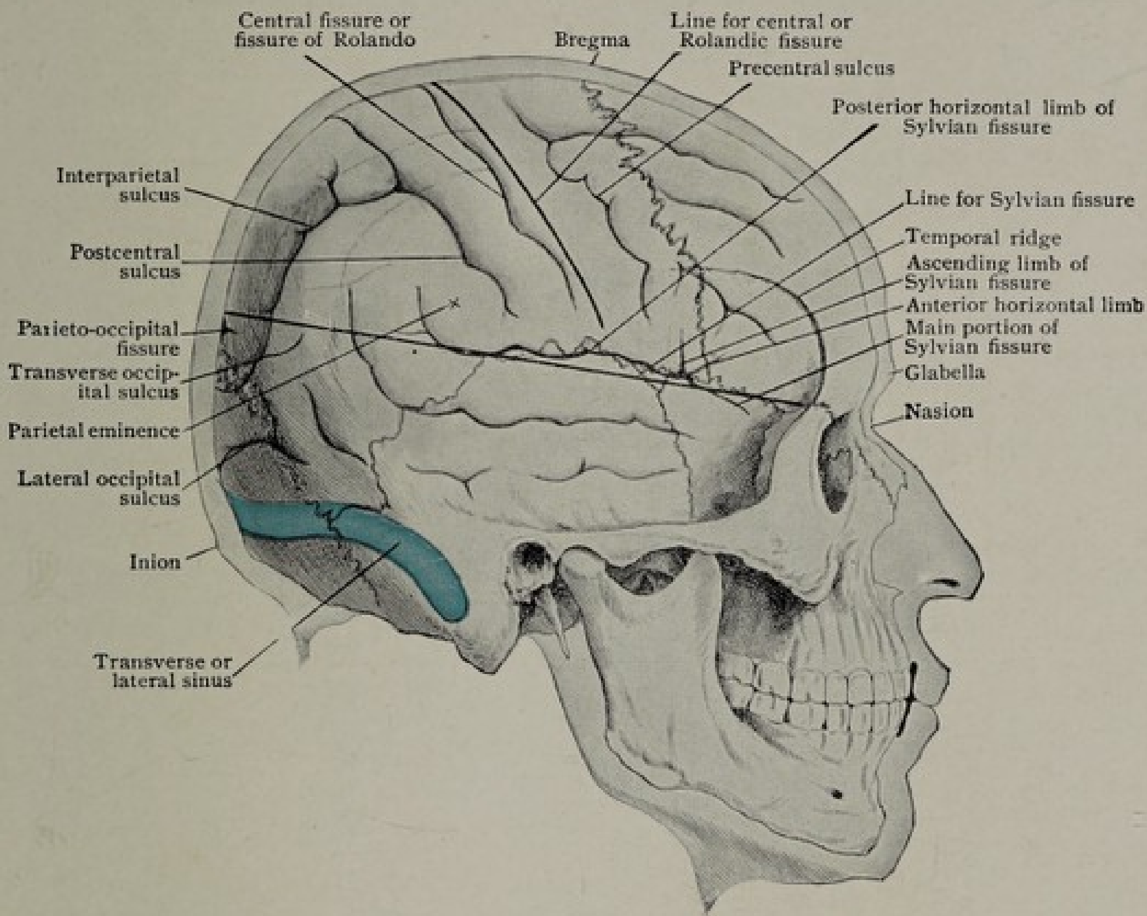


FIG. 53.—Semidiagrammatic view of head, showing relation of Rolandic and Sylvian fissures and lines.

The **superior frontal convolution** covers about the upper one-third of the distance from the median line above to the temporal ridge below.

The **superior frontal sulcus** passes upward from the supra-orbital notch.

The **inferior frontal sulcus** runs just below the temporal ridge.

The **first** or **superior temporal convolution** runs along the lower side of the fissure of Sylvius. It is about 15 mm. (3/5 in.) wide.

The **first** or **superior temporal sulcus** or **parallel fissure** runs parallel to the Sylvian fissure and 15 mm. below.

The **second** or **middle temporal convolution** is wider than the first and lies a short distance above the level of the base of the skull.

The **middle temporal sulcus** runs close above the zygoma.

The **third** or **inferior** and the **fourth temporal convolutions** lie on the base of the brain, separated by the inferior temporal sulcus. The fourth temporal convolution has on its inner side the collateral fissure (see Fig. 44).

The **interparietal sulcus (pars horizontalis)** leaves the postcentral sulcus near its middle and passes upward and backward to a point opposite the lambda.

The **supramarginal convolution** surrounds the termination of the fissure of Sylvius and is, therefore, under the parietal eminence.

The **angular gyrus** surrounds the posterior end of the first temporal sulcus (parallel fissure) and is, therefore, 3 or 4 cm. (1¼ to 1½ in.) posterior to the parietal eminence.

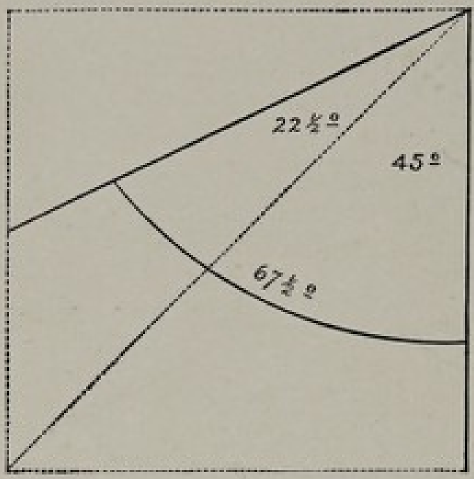


Fig. 54.—Chiene's method of folding a square piece of paper in order to obtain an angle of 67½ degrees.

The **transverse occipital sulcus** is a continuation of the interparietal sulcus to just beyond the parieto-occipital fissure.

The **lateral occipital sulcus** lies close to the tentorium; it divides the occipital lobe into superior and inferior convolutions. (Sometimes these two sulci divide the lobe into three convolutions, superior, middle, and inferior.)

The Fissures in Children.—In childhood the fissure of Rolando (*central fissure*) is somewhat more vertical than in adults; the fissure of Sylvius has its point of division a little higher and runs up to and usually above and in front of the parietal eminence. After the age of three years the relative position of the fissure to the parietal eminence, begins to approach that of the adult.

The objects of cerebral topography are mainly to ascertain in case of injury or disease of the superficial structures what parts of the brain beneath are liable to be involved, and for operative procedures, in order to expose the affected areas. The convolutions and sulci are so variable that all guides are only approximate. In order to overcome this defect and provide for unusual conditions, the openings in the skull are usually made large. The flaps of scalp and bone may even embrace the entire parietal bone or a quarter of one hemisphere. As regards the various points—the upper Rolandic point is generally conceded to be 15 mm. (½ to ⅝ in.) posterior to the midpoint between the glabella and inion. The angle which the fissure forms with the median line varies from 64° to 75°. Cunningham gives it as 70° and Arthur W. Hare as 67°. Chiene's method of finding the desired angle is usually accepted as reliable. He takes a square piece of paper and folds it obliquely from corner to corner making 45°, and then folds it a second time making 22½°. The two being added together give 67½° as the angle made by the fissure of Rolando (*central fissure*) with the anterior portion of the longitudinal fissure.

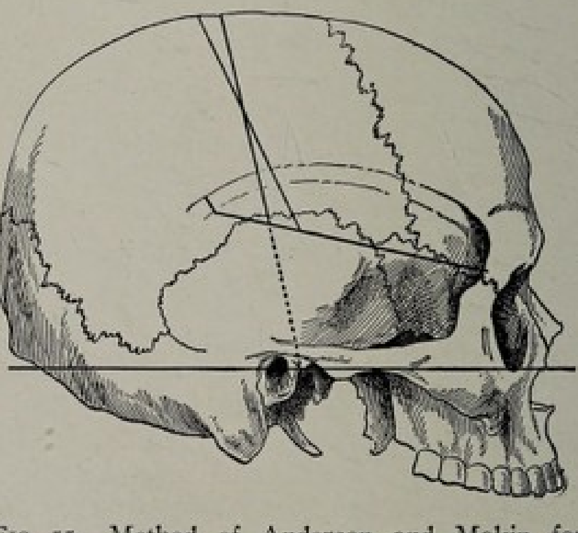


Fig. 55.—Method of Anderson and Makin for locating the fissures of the brain.

The pterion was placed by Broca at the coronal suture. This is 15 mm. (⅗ in.) in front of the Sylvian point. In several formalin hardened brains, we found this latter to be at the posterior angle of the pterygoid wing, and in twenty measured skulls the Sylvian point averaged 42 mm. (1⅝ in.) behind the angular process. Reid placed it at 50 mm. (2 in.), which we think too much. Anderson and Makin placed it at ½ to 2 in. Thane and Godlee placed it 35 mm. back and 12 mm. up, which is just a trifle farther forward than we have located it. Landzert and Heffler gave it as at the summit of union of the great wing of the sphenoid with the temporoparietal suture, as we have given it.

When prolonged, the Sylvian fissure sometimes crosses the median line 1.5 cm. (⅝ in.) above the parieto-occipital fissure, but more usually we have found it to be close to the fissure, which agrees with Reid. The parieto-occipital fissure has been located by some authors near the lambda, but we would place it 1.5 cm. (⅝ in.) above. We believe the parietal eminence to be a fairly reliable guide to the posterior extremity of the fissure of Sylvius.

Method of Anderson and Makin.—We consider this method as the most reliable for general use. Draw a mid- or sagittal line from opposite the highest point of the supra-orbital arches to the external occipital protuberance. From the midpoint on this line draw another to the pre-auricular point at the level of the upper border of the meatus. This is the frontal line. From the most prominent point of the external angular process draw a line to the junction of the middle and lower thirds of the frontal line and prolong it 1½ in. beyond.

The Sylvian fissure begins between 1⅛ and 1½ in. behind the angular process or 5/12 of the distance between that point and the frontal line. The bifurcation is 1½ to 2 in. behind the angular process or 7/12 of the distance between it and the frontal line, the fissure then runs to an equal distance behind the frontal line, and up for ½ in. parallel to the frontal line. The fissure of Rolando runs from a point ⅜ in. behind the midsagittal point to one ⅜ of an inch in front of the intersection of the frontal line and line of the Sylvian fissure. The parieto-occipital fissure is 7/12 of the distance from the midsagittal point to the inion. It lies near the apex of the lambdoid suture.

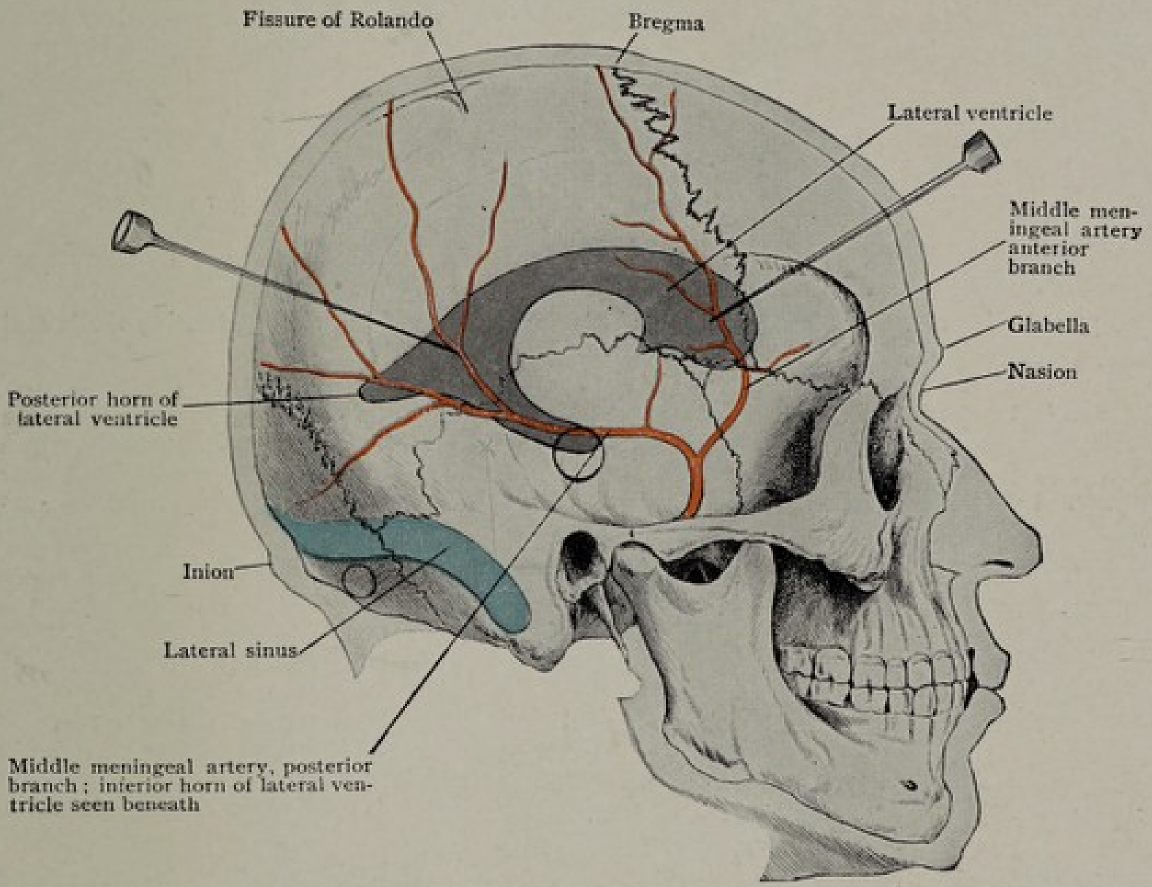


FIG. 56.—Tapping the lateral ventricles and trephining for cerebral abscess. Semidiagrammatic view of head, showing relation of Rolandic and Sylvian fissures and lines.

The Lateral Ventricles.—A lateral ventricle is found in each hemisphere. It occupies the frontal, occipital and temporal lobes. The ventricle has three horns, an anterior, a posterior and an inferior. The central portion or body unites the three horns. The choroid plexus, which is composed of pial tissue seemingly lies within the lateral ventricle. The ventricle is lined with ependyma which invests the plexus with an epithelial layer, making the plexus really ventricular.

The cerebrospinal fluid is found in the subdural and subarachnoidal spaces. It is scanty in the region of the vault, but is abundant at the base in the middle and posterior fossa, where it affords protection to important basal structures. The subarachnoidal space is continuous with the ventricles through the foramina of Magendie and Luschka. At the foramen magnum the cerebral subarachnoid is continuous with the spinal subarachnoid, this connection allowing for a displacement of fluid in increased intracranial or intraspinal pressure. Occlusion of the foramen of Magendie by tumor, inflammatory products, or trauma, will increase the intra-ventricular pressure and give rise to symptoms. A condition of this kind is known as internal hydrocephalus. It is frequently congenital. Schuchard reports one case of congenital hydrocephalus in every 743 births.

The ventricles may be tapped by the method of Keen, as follows: (1) One-half to three-fourths of an inch (1.25 to 2 cm.) on either side of the median line and one-third of the distance from the glabella to the upper end of the central (Rolandic) fissure. This is high enough to avoid the frontal air-sinuses and is in advance of the motor area. A grooved director is to be thrust in the direction of the inion. The ventricle is reached at a depth of 5 to

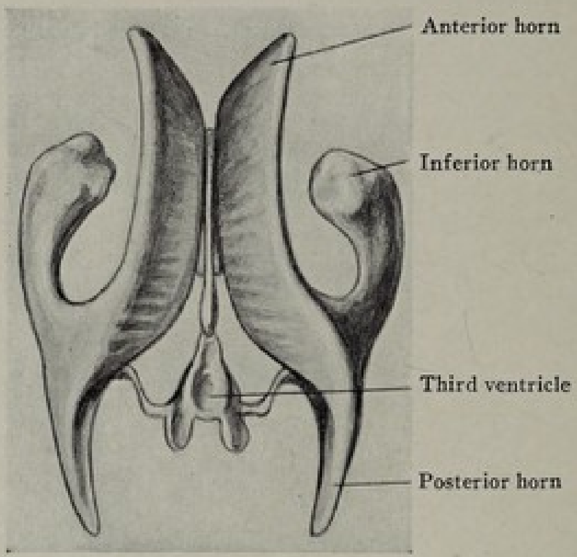


Fig. 57.—A diagrammatic view of the ventricular system seen from above, showing the lateral ventricles and the fluid ventricles.

6.5 cm. (2 to 2½ in.) through the first frontal convolution. (2) Midway between the inion and upper end of the central (Rolandic) fissure 1.25 to 2 cm. (½ to ¾ in.) from the median line. The director is to be thrust toward the inner end of the supra-orbital ridge of the same side. The ventricle will be reached at a depth of 5.5 to 7 cm. (2¼ to 2¾ in.) from the sur-

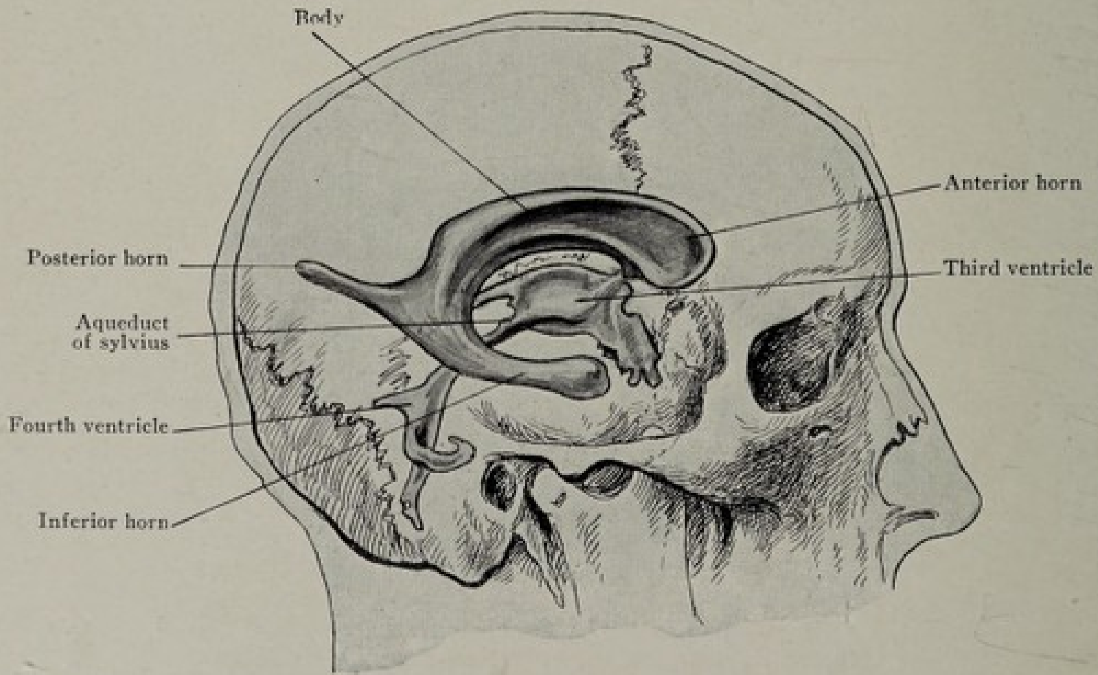


Fig. 58.—The ventricles are here shown in situ and in relation to the various brain structures.

face. (3) Three centimetres (1¼ in.) behind the external auditory meatus and the same above Reid's base line (from the lower border of the orbit through the centre of the external auditory meatus). The director is to be thrust toward a point 6.25 to 7.5 cm. (2½ to 3 in.) directly above the opposite external meatus. The ventricle will be reached 5 to 5.75 cm. (2 to 2¼ in.) from the surface. The director passes through the second temporal convolution. Dandy has used ventriculography in the localization of brain tumors and the method has met with success in his and other hands. Dandy states that a "tumor of any size will modify the shape, size, and position of the corresponding lateral ventricle." Quite frequently the lateral ventricle of the opposite hemisphere will be dislocated. He suggests the injection of air into the ventricle and later a röntgenogram to determine alterations in the size, shape or position of the ventricles.

Cerebral Abscess.—About one-half of the abscesses of the brain occur from disease of the middle ear, and they are located in the temporal lobe, in the cerebellum, or between the dura and petrous portion of the temporal bone. The remainder are caused either by blows or infection carried to the part in infectious disease. They may, therefore, occur anywhere in the brain.

When the motor areas around the fissure of Rolando (*central fissure*) are involved, the location of the trouble will be shown by spasm or paralysis of the corresponding muscles. If the occipital lobe is affected there may be disturbance of sight, as hemiopia. Involvement of the frontal lobes produces mental dulness, and if of the third left frontal gyrus, or Broca's convolution, there may be impairment of speech. Disease of the middle lobe of the cerebellum may be accompanied by a staggering gait. In many cases localization symptoms are rare, particularly when the abscess is small and located in the temporal, parietal, or frontal lobes (see chapter on cerebral localization).

Trephining.—If the abscess arises from middle-ear disease, it is customary to first open the mastoid antrum (see chapter on ear), and then by removing the bone above to explore the surface of the petrous portion of the temporal bone. To explore the temporal lobe an opening may be made 2.5 cm. (1 in.) above the external auditory meatus and a needle passed inward, forward, and a little downward.

To reach the cerebellum, the trephine should be applied 5 to 7 cm. (2 to 2¾ in.) behind the external meatus and well below the superior curved line. The bone at this point is apt to be thin, and care is to be exercised not to wound the membranes. The place of trephining in abscess from other causes is to be decided by the localizing symptoms.

THE FACE

The face may be divided into the regions of the *forehead, temples, ears, eyes, nose, mouth, cheek,* and *upper* and *lower jaws.* The regions of the eyes, ears, nose, and mouth will be considered separately. Owing to the face being that part of the body most open to scrutiny and most difficult of concealment, deformities and disfigurements of it, resulting from injury or disease—to both of which it is prone—assume a greater importance than the same troubles elsewhere. Therefore, the anatomy of the part should be studied with regard to the treatment of its various affections from a cosmetic as well as from a curative point of view. What is usually regarded as constituting the face embraces the anterior half of the head as viewed from the front.

The Bones.—The bones of the head have been divided into those of the cranium and those of the face. The bones of the cranium are eight in number, viz.: the frontal, occipital, two temporals, two parietals, the sphenoid, and ethmoid. The bones of the face are fourteen in number, of which twelve are in pairs, viz.: superior maxillary, malar, nasal, palate, lachrymal, and inferior turbinated bones—the vomer and inferior maxilla or mandible are the two single bones.

From this it will be seen that the bony framework of the face embraces some of the bones of the skull, as well as those of the face proper; thus, the region of the forehead is formed by the frontal bone, the temporal region is formed by the frontal, parietal, sphenoid, and temporal bones, all belonging to the cranium, and so on. The palate bones are called face bones, yet they are placed deep in the region of the mouth and nose.

The Soft Parts.—The soft parts are likewise of importance. The skin, thin in some parts, thick in others, is in many places loosely attached and has inserted in it the muscles of expression. It is frequently the seat of disease, particularly of cancer.

On each side of the face are the parotid glands, often the site of inflammations.

The **blood-vessels**, both arteries and veins, particularly the former, are very numerous and give special characters to wounds and diseases of the face.

The **nerves** are abundant and complex. They are, with the exception of the *auricularis magnus*, which comes from the second and third cervical, and to a slight extent the *occipitalis minor* from the second cervical, all derived from the cranial nerves and are both motor and sensory. The paralyses and neuralgias which affect them are among the most distressing and disfiguring of any in the body. Wounds of the facial nerve produce paralysis of the muscles of expression.

The relatively small size of the face in relation to the cranium in the child as compared to that of the adult has already been alluded to (see page 11). The reasons for this are evident: dentition must be complete to insure the proper development of the jaws; the use of the special senses and the expression of the emotions cause the facial muscles to develop, and this in turn causes the bones to which they are attached to become more rugged in outline and larger in size. In old age, as the teeth are lost, the jaws are diminished in size by absorption of their alveolar processes.

THE FRONTAL REGION

The frontal region embraces that part of the face above the eyes and nose in front and anterior to the temples at the sides.

The Frontal Suture.—The frontal bone develops from two centres of ossification, one on each side. These unite in the median line to form the frontal suture which joins the anterior fontanelle and is closed about the same time, within the age of two years. The suture occasionally persists through life and sometimes the line of junction can be felt in the living; it should not be mistaken for fracture.

The **frontal eminences** in the child are particularly prominent, the forehead projecting beyond the edge of the orbit. This makes it difficult to apply a bandage securely to the head in children unless it is twisted to draw in its sides.

The **superciliary ridges** are about a centimetre above the edge of the orbit over its inner half. Aided by the hair of the eyebrows they serve to divert the sweat to the sides, as pointed out by Humphry. They are best developed in the adult male. Directly between them in the median line on a level with the upper edge of the orbit is a depression called the *glabella*. It is the anterior point from which measurements are taken in cerebral topography.

Fig. 59.—Frontal region of a child's skull.

Frontal Sinuses.—Beneath the superciliary ridges are the frontal air-sinuses, but the size of the sinuses is not necessarily proportional to that of the ridges; they may extend quite far back over the orbit. They do not appear as distinct spaces until the seventh year, being developed by a separation of the two tables of the skull. They vary in size in different individuals and the two sides may not be equal in the same individual. A septum divides the two, and this is frequently found beyond the midline. Fractures of the outer wall of these sinuses not infrequently occur without the inner table being injured. Frequently after these fractures emphysema of the subcutaneous and orbital tissues results or an aerocole may result. (Fig. 20.) The lining membrane of these sinuses is often inflamed and suppurates, discharging pus into the nose. Tumors also grow in them.

Margins of the Orbit.—At the upper and outer margin of the orbit is the *external angular process* of the frontal bone. The line of junction or suture between it and the malar bone can be distinctly felt in the living, both on the side of the orbit and on the side toward the temple. This is an important landmark in cerebral topography, as it is used to locate the fissure of Sylvius and also the middle meningeal artery. On the upper margin of the orbit at about the junction of its middle and inner thirds is the *supra-orbital notch*. This can usually be readily felt through the skin. Sometimes it is a complete foramen instead of simply a notch. It is then to be located by feeling on the orbital surface just behind the edge. It transmits the supra-orbital nerve and artery.

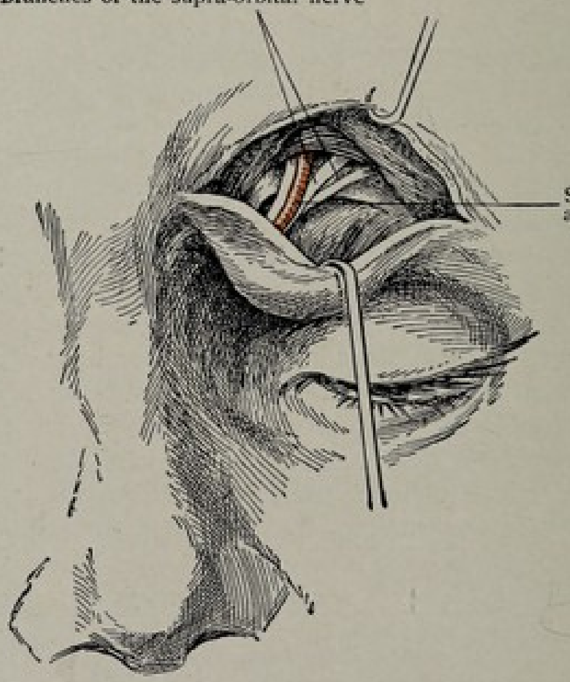


Fig. 60.—Supra-orbital nerve and artery.

The **supra-orbital nerve**, a branch of the ophthalmic division of the fifth nerve, is sometimes the seat of neuralgia, for which resection of the nerve is performed. The pain is felt above the orbit radiating from the supra-orbital notch, sometimes as far up as the vertex. Pain is also felt on pressure over the supra-orbital notch. If the entire ophthalmic branch of the fifth nerve is affected, pain is felt in the eyeball and down the side of the nose. The incision in operating may be made at the lower border of the eyebrow, its centre being over the notch. If the notch is not readily felt on the edge of the bony orbit at the junction of the inner and middle thirds, it can be detected by feeling with the tip of the finger on the orbital surface. The incision is made through the fibres of the orbicularis palpebrarum, corrugator supercilii, and frontalis muscles, then through the palpebral ligament immediately below the bony edge of the orbit, and the orbital fat separated with forceps; the nerve is then caught with a hook before it enters the notch, and brought up and removed. Considerable ecchymosis may follow this operation if the accompanying artery is divided. In operations on the sensory root of the fifth nerve for trigeminal neuralgia the ophthalmic portion is not severed if it can be distinguished, since corneal ulcer may result if this branch is cut.

Nasion.—About a centimetre below the glabella, in the adult skull, is the nasion or line of junction of the frontal and nasal bones. It is along this fronto-nasal suture, to one side of the median line, that an anterior meningocele is apt to show itself.

The **internal angular process** of the frontal bone articulates with the nasal process of the superior maxilla and the lachrymal bones. The line of suture is continuous with the nasion in front and the upper edge of the ethmoid behind. Pus originating in the ethmoidal cells, frontal sinuses, and lachrymal apparatus is apt to point at this locality. The frontal bone is a favorite seat of exostoses.

THE TEMPORAL REGION

The region of the temple is on the side of the head as far forward as the eye and as low as the zygoma and infratemporal crest. The floor of the temporal fossa

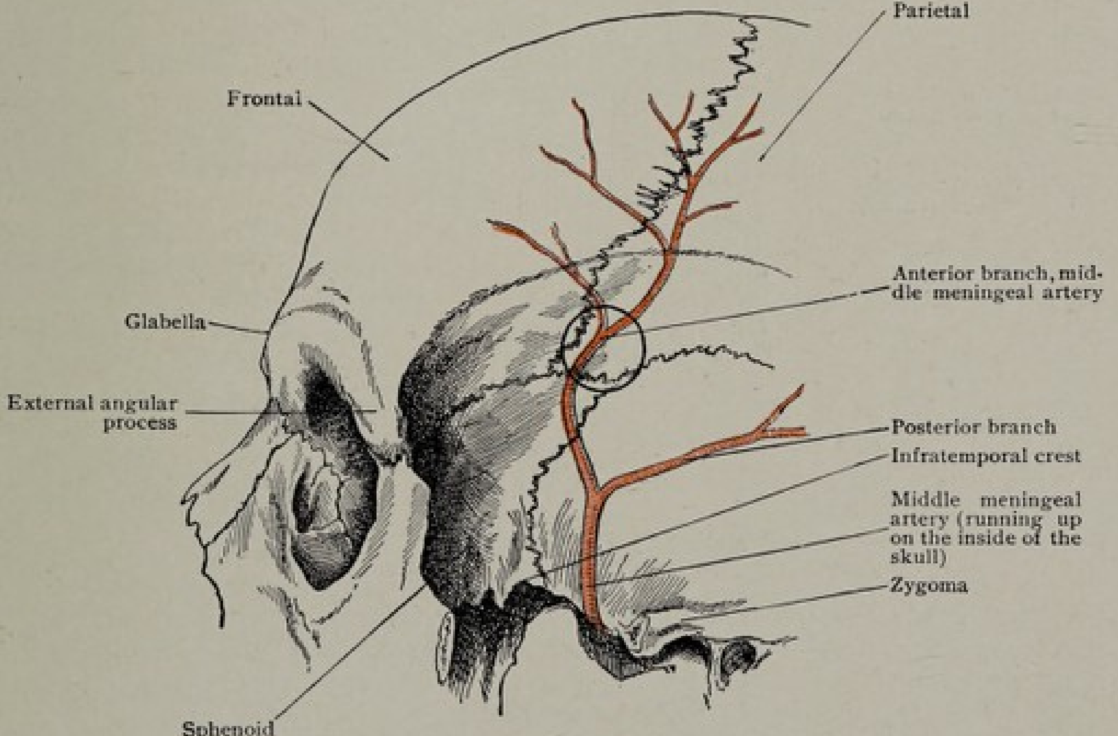


Fig. 61.—Frontal and temporal regions of an adult skull.

is formed by the posterior portion of the frontal and anterior portion of the parietal bones as high as the temporal ridge, the outer surface of the greater wing of the sphenoid, and the squamous portion of the temporal bone. These four bones meet to form the region of the pterion (see p. 49). The anterior edge of the temporal bone overlaps and is superficial to the posterior edge of the sphenoid. The anterior edge of the parietal overlies the posterior edge of the frontal. The upper edges of the temporal and sphenoid overlap the lower edges of the frontal and parietal bones. That the temporal region of the skull is distinctly weaker than other regions is due to the thinness of the bones, and the reason that fractures here are exceptionally dangerous is on account of the middle meningeal artery running through a canal in the bone in this region; so that in cases of fracture the artery is torn and hemorrhage occurs above the dura, which causes compression of the brain (Fig. 61).

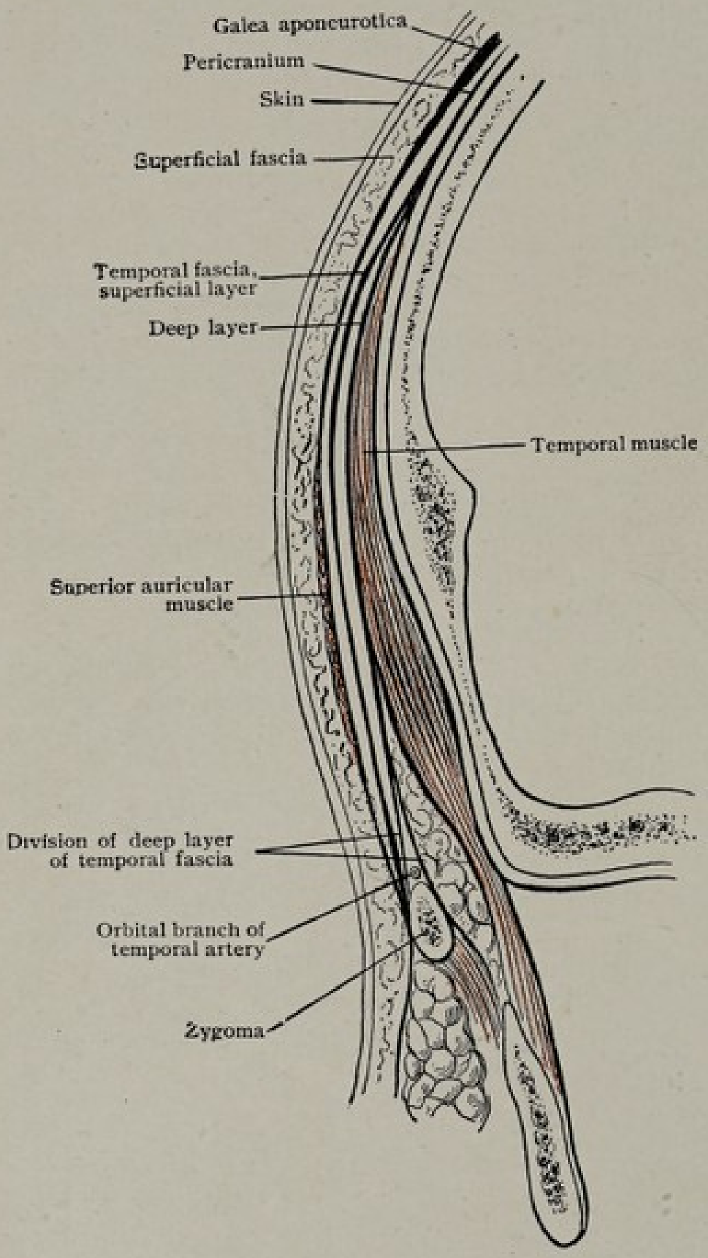


Fig. 62.—Transverse coronal section in the region of the temple, showing the various layers.

The **infratemporal crest (crista infratemporalis)** or pterygoid ridge separates the temporal region from the pterygoid region below. It is an important landmark in operating on the Gasserian ganglion.

A spot two centimetres behind the external angular process and slightly above its level marks the anterior extremity of the fissure of Sylvius. In trephining in the temporal region no diploë is found in the bones, so that extreme care is necessary to avoid wounding the dura mater. The trephine should be placed 4 cm. (1½ in.) behind the external angular process and 4.5 cm. (1 4/5 in.) above the zygoma to strike the middle meningeal artery. This will be level with or a little above the highest part of the edge of the orbit.

Temporal Fascia.—This is the dense fascia covering the temporal muscle; it is formed as follows: The pericranium as it comes down from the vault of the skull and reaches the temporal ridge passes under and gives attachment to the temporal muscle. The temporal fascia consists of two distinct sheets of fascia, the superficial one from the superior temporal ridge being attached to the zygoma below and to the malar bone in front; the deeper layer from the inferior temporal ridge covers the temporal muscle, and a short distance above the zygoma divides into two layers, one of which is attached to the outer edge, and the other to its inner edge. The upper or superficial layer of the temporal fascia leaves the bone at the superior temporal ridge and is attached below to the top of the zygoma, blending near the bone with the layer beneath. This is a distinct layer though not always readily demonstrable in dissections. Between the layers above the zygoma is some fat and the orbital branch of the middle temporal artery. Anteriorly the temporal fascia is attached to the posterior border of the malar bone and the temporal ridge of the frontal. The temporal fascia is tough and dense and gives attachment by its under surface to the temporal muscle. Abscess occurring under the temporal fascia, therefore, does not tend to come to the surface, but sinks downward. It is prevented from making its exit on the face below the zygoma by the parotid gland and masseter muscle, so it passes inward to the pterygoid region and may point in the throat or go down into the neck.

The occipitofrontal aponeurosis, or *galea aponeurotica* as it approaches the side of the head becomes thinner and passes down to insert into the top of the zygoma so that in the temporal region the layers are as follows: Skin, superficial fascia, *galea aponeurotica*, two layers of the temporal fascia, temporal muscle, an indistinct periosteum, and bone. These layers are extremely important when closing an incision following subtemporal decompression, the first five being closed separately. If this is not done a hernia cerebri may result if sufficient intracranial pressure is present. Immediately above the zygoma we have the deep layer of the temporal fascia dividing, instead of a single layer as is the case higher up. The temporal fossa contains considerable fat which disappears in serious illness. Disfiguring depressions are also left in this region after operations involving the temporal muscle.

The **temporal artery** begins opposite the neck of the lower jaw, then passes over the temporomaxillary articulation, lying on its capsule, thence over the zygoma about a centimetre in front of the ear. It lies on the temporal fascia and about 4 cm. above the zygoma divides into an anterior and posterior branch. The course of the temporal artery and its anterior branch is usually quite conspicuous in old people and affords a ready means of ascertaining whether or not the arteries possess the calcareous deposits characteristic of antheroma. The location of the artery in front of the ear should be remembered, as the pulse is readily felt there in the administration of anæsthetics. In certain angiomas of the scalp the blood supply may be diminished by ligating the vessel at this point.

The *temporal muscle* receives blood from the middle temporal artery, which comes from the temporal and perforates the temporal fascia just above the zygoma, and from the anterior and posterior temporal branches of the internal maxillary. The temporal fossa is frequently the site of operations to expose the Gasserian (semilunar) ganglion or its sensory root. The auriculotemporal nerve lies slightly posterior to the artery, and the vein in front of it. They are not important. The artery and its branches, however, are important in planning osteoplastic flaps for the exposure of the parietal or temporal regions. The flap must be planned so that either the major vessel or one of its larger branches enters at the base of the flap. If this is not provided for, the flap may have insufficient nourishment and may slough.

THE REGION OF THE CHEEK

In this region we may include the parts limited above by the zygoma, in front by the eye, nose, and mouth, below by the lower edge of the lower jaw, and behind by the ear. The soft parts of the cheek are supported by the malar and superior and inferior maxillary bones. Between the skin and the buccinator muscle, the hollow beneath and in front of the malar bone and masseter muscle is filled with fat, sometimes called the sucking pad or cushion. In disease this fat disappears, hence the hollow cheek of invalids. The muscles of expression are superficial to this fat and have their insertion in the skin. Swelling occurs readily from contusions and inflammations because the tissues of the cheek are lax. Inflammations may either start in the skin, which is quite prone to disease, or may be the result of inflammation of some surrounding structure, as the parotid gland, the roots of the teeth, the lachrymal sac, eyelids, etc.

The **skin** of the cheek contains numerous sebaceous and sweat glands. The skin is thin and vascular and the subcutaneous tissue is loose. It is a favorite site for the pustular eruptions of infancy and childhood, the acne of youth, and the non-malignant as well as the cancerous ulcers of the aged. It is also the seat of *noma* or *cancrum oris*. This starts on the mouth surface as a gangrenous stomatitis and implicates the cheek, causing death or great disfigurement owing to the loss of cheek substance. Cellulitis tends to spread, and edema is often exaggerated even after aseptic wounds. Because of the delicacy of the skin infections fortunately point early if they are superficial. Facial carbuncle or malignant pustule occurs on the cheek, or sometimes on the lips. It is very often fatal because of the anastomosis of the facial and ophthalmic veins at the inner canthus and the danger therefore of intracranial complications.

Wounds and *contusions* of the cheeks are common, and, as the blood supply is abundant, bleeding is free and healing prompt. On account of the insertion of the muscles into the skin, gaping is quite marked.

The **malar bone** is the most prominent bone of the cheek. It is such a strong bone and so strongly supported that fracture of it, as well as that of the zygoma, is rare. It may be broken by direct violence, as being hit with a stone, etc. It is extremely difficult and often impossible to restore the fractured parts to their

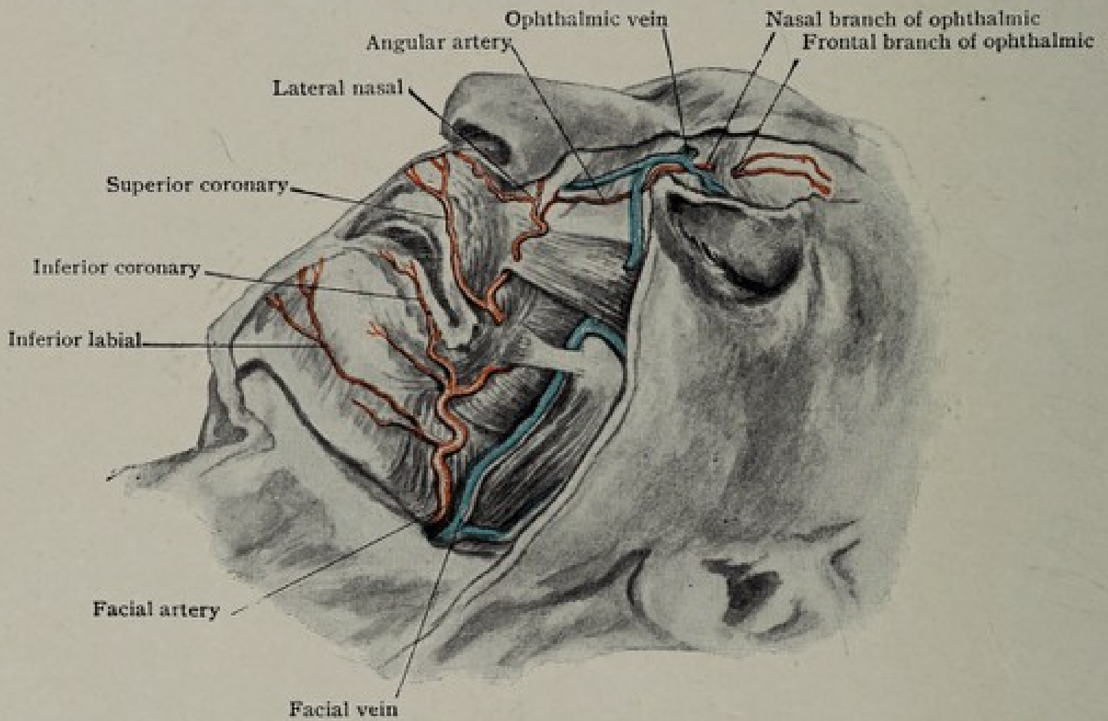


FIG. 63.—The facial artery and its branches.

original level, therefore deformity following fracture is of frequent occurrence. The fracture may involve the margin of the orbit and cause an effusion of blood into the orbit, pushing the eye forward. A fracture of the zygoma, if very much depressed, may interfere with the use of the temporal muscle below, necessitating operation. This occurrence is, however, rare.

The **facial artery** runs upward and inward, from a couple of centimetres in front of the angle of the jaw, along the anterior border of the masseter muscle to the angle of the mouth, and thence to the inner canthus of the eye. The anterior edge of the masseter muscle can usually be distinctly felt beneath the skin. At this point the vessel can be ligated or temporarily compressed by passing a pin beneath it and winding a silk ligature above it, around the ends of the pin. This procedure is desirable in some operations on the cheek, as angiomas frequently affect this region. If the facial artery is ligated, the blood supply comes from the superior and inferior coronary arteries of the opposite side; the nasal branch of the ophthalmic, anastomosing with the angular; the transverse facial below the zygoma, from the temporal; the infra-orbital, a branch of the internal maxillary; and to a slight extent from the inferior labial and others still less important (Fig. 63).

The **internal maxillary artery**, one of the terminal branches of the external carotid, arises in the parotid gland opposite the neck of the lower jaw. This is just below and behind the articulation, which can be readily felt through the skin. It passes between the bone and the sphenomandibular (long internal lateral) ligament, then between the two pterygoid muscles or between the two heads of the external pterygoid muscle to the posterior surface of the superior maxillary bone in the sphenomaxillary fossa. The branches of its first part, where it is behind the neck of the jaw, are the *deep auricular, tympanic, middle* and *small meningeal*, and *inferior alveolar* (*dental*). The branches of its second part, as it passes between the pterygoid muscles, are all muscular: they are the *masseteric, pterygoid, anterior* and *posterior deep temporal*, and the *buccal*. The branches of the third portion of the artery, in the sphenomaxillary fossa, are the *posterior dental, infra-orbital, descending palatine, Vidian, pterygopalatine,* and *spheno-* or *nasopalatine*.

The main trunk of the internal maxillary artery is not often involved either by injury or operation. The various branches are, however, of considerable impor-

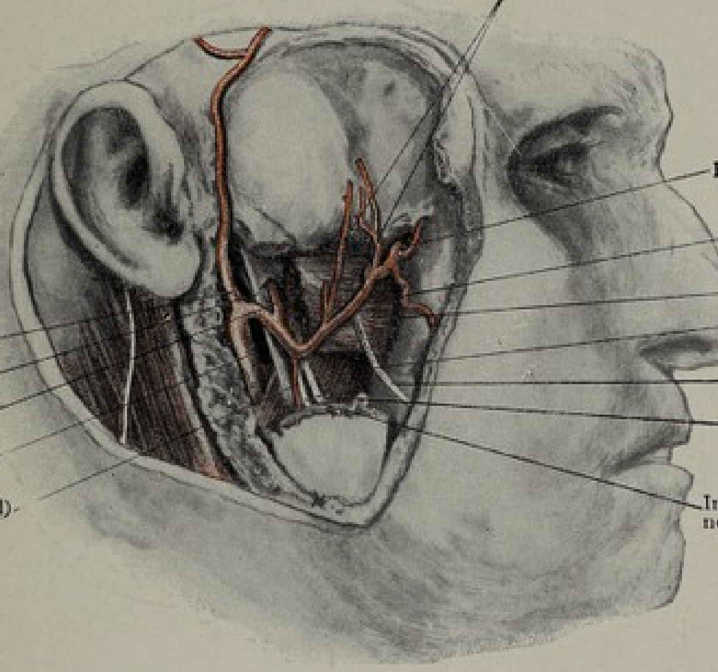


FIG. 64.—The internal maxillary artery.

tance, as they supply parts which are often the site of operative measures. The importance of the middle meningeal artery in reference to fractures of the skull has already been pointed out. The inferior alveolar gives rise to troublesome hemorrhage when the lower jaw is operated on. The deep temporal branches bleed freely when the temporal muscle is incised in operating on the Gasserian ganglion. The infra-orbital is involved in operating on the infra-orbital nerve. The posterior or descending palatine branch descends in the posterior palatine canal, in company with a branch from Meckel's (sphenopalatine) ganglion, to emerge on the roof of the mouth at the posterior palatine foramen. It causes free hemorrhage in operations on cleft palate.

The Vidian and pterygopalatine branches supply mostly the roof of the pharynx; they bleed when adenoids are removed. The descending and sphenopalatine supply the upper part of the tonsil with blood and may give rise to serious hemorrhage in the removal of the tonsils. In operating on Meckel's ganglion, bleeding from these vessels is free. The nasopalatine runs forward in the nose in the groove on the vomer. It is often the cause of serious nasal hemorrhages in operations on the septum. In removal of the upper jaw, bleeding occurs from many of the branches of the internal maxillary, but it is hardly so free as might be expected, especially if the external carotid has been previously ligated.

PAROTID GLAND

The parotid gland lies on the cheek, behind the jaw and below the ear. The limits (Fig. 65) of the gland are important because suppuration may occur in any portion of its structure. The limits are variable in all directions but in the average gland are as follows: above to the zygoma, lying below its posterior two-thirds; posteriorly, to the external auditory canal, the mastoid process, and digastric and sternomastoid muscles; below to a line joining the angle of the jaw and mastoid process; and in front about half the width of the masseter muscle. This latter is, however, quite variable, and when large and nearly distinct from the remainder of the gland is known as the *socia parotidis.*

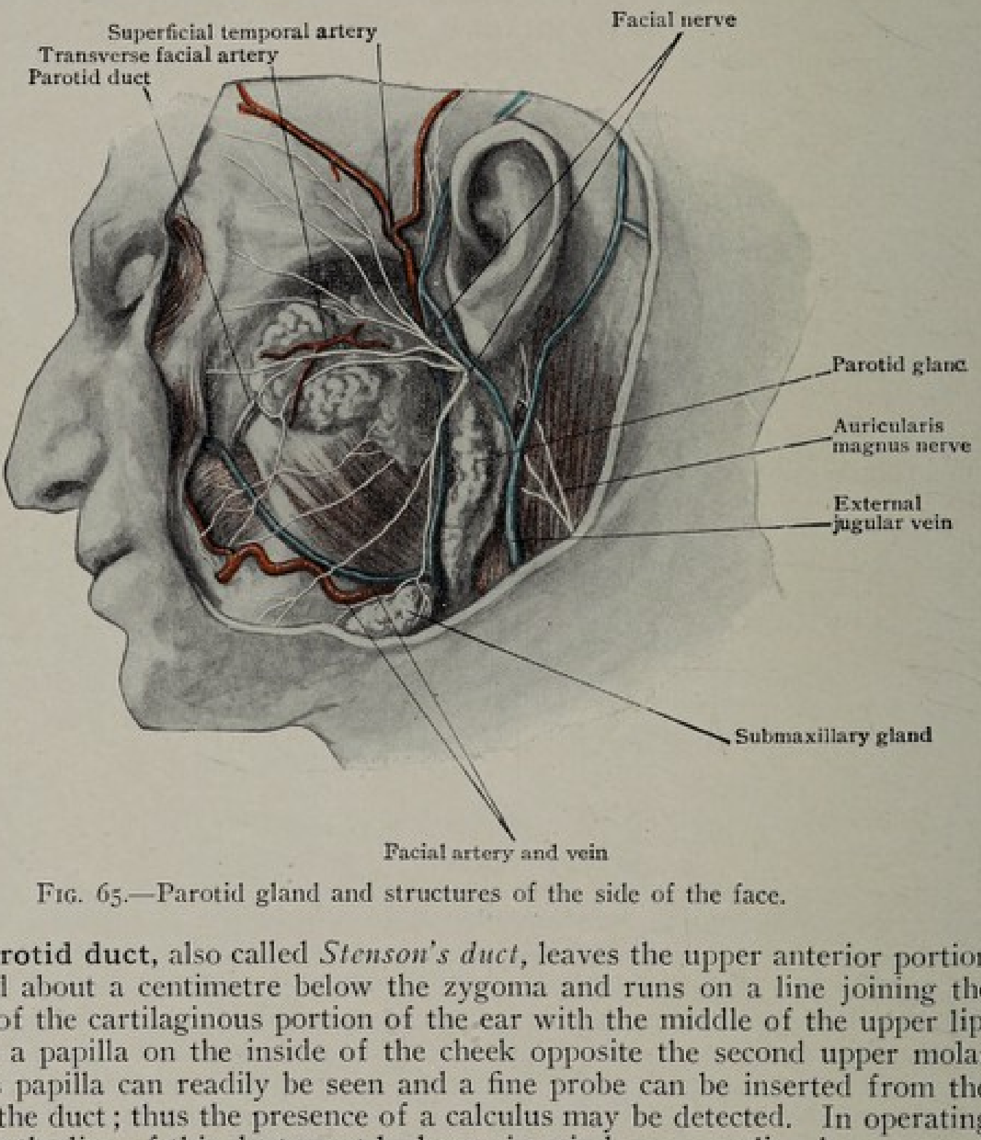


FIG. 65.—Parotid gland and structures of the side of the face.

The **parotid duct,** also called *Stenson's duct,* leaves the upper anterior portion of the gland about a centimetre below the zygoma and runs on a line joining the lower edge of the cartilaginous portion of the ear with the middle of the upper lip. It opens on a papilla on the inside of the cheek opposite the second upper molar tooth. This papilla can readily be seen and a fine probe can be inserted from the mouth into the duct; thus the presence of a calculus may be detected. In operating on the cheek the line of this duct must be borne in mind, as wounding it may cause a salivary fistula. Wounds of the lobules of the gland are not nearly so liable to result in fistula as those of the duct itself.

Parotid Fascia.—The gland is covered by the parotid fascia. This fascia is extremely dense, which accounts for the pain associated with parotid inflammations and the slowness with which suppurative processes point. The sheath is really a continuation of the cervical fascia. It is continuous with the fascia separating the lobules of the gland. Above it is attached to the zygoma; in front it is continuous with the masseteric fascia over the masseter muscle; and below and posteriorly it is continuous with the deep fascia of the neck. It stretches from the angle of the jaw to the sternomastoid muscle and somewhat deeper to the styloid process; the band running from the styloid process to the lower jaw is called the stylomandibular ligament. From thence it is continued over the internal carotid artery and the upper surface of the internal pterygoid muscle.

Lobes of the Parotid Gland.—The gland has extensions in various directions (Fig. 66). A prolongation behind the articulation of the lower jaw, into the posterior portion of the glenoid cavity immediately in front of the external auditory canal, is called the *glenoid lobe*. Another extension winds around the posterior edge of the lower jaw on the lower surface of the internal pterygoid muscle and is called the *pterygoid lobe*. A prolongation inward, passing between the external carotid on the outside and the styloid process and the internal carotid artery on the inside, is called the *carotid lobe*. A separate portion of the gland, sometimes quite detached, lies at its upper anterior portion between the zygoma and the duct of Stenson; it is called the *socia parotidis*.

Vessels and Nerves Traversing the Gland.—The external carotid artery enters the gland to divide opposite the neck of the lower jaw into the temporal and internal maxillary. The temporal, before it leaves the gland, gives off the trans-

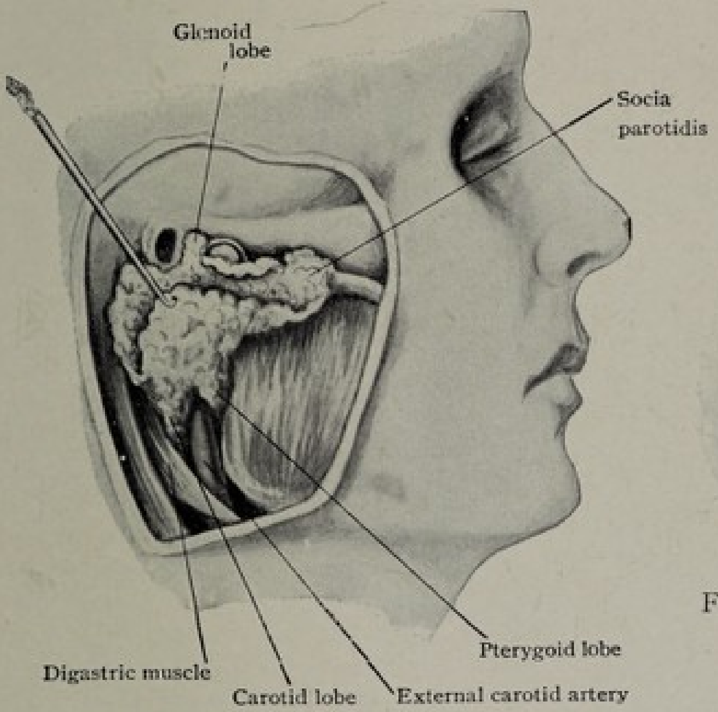


FIG. 66.—The lobes of the parotid gland.

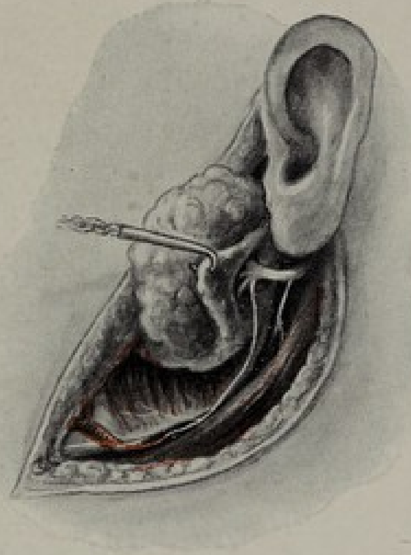


FIG. 67.—Relation of facial nerve to parotid gland.

verse facial artery which runs forward on the face between the zygoma and parotid duct. It is usually small but at times may be quite large and even extend to the angle of the mouth and form the two coronary arteries. The temporal vein, as it descends into the gland, is joined by the internal maxillary vein to form the temporomaxillary vein, which, after it receives the posterior auricular vein, goes to form the external jugular.

The facial nerve emerges from behind the jaw just below the lobe of the ear and divides into its various branches while still in the gland. There is usually a large branch passing parallel to the duct of Stenson and below it. The auriculotemporal nerve follows the temporal artery, emerging from the gland a little posterior to the artery. Dr. Skillern has shown that, by injecting it with cocaine, operations on the walls of the meatus externus for furuncles, etc., can be rendered painless. The auricularis magnus from the second and third cervical supplies the skin over the gland.

Lymphatic nodes are found both on the gland and in its substance. These may be involved in general disease of the cervical lymphatics.

Affections of the Parotid Gland.—The duct may be obstructed by calculus, as already mentioned. As the opening of the duct at the papilla is smaller than the lumen of the canal farther back, calculi are apt to lodge close to the anterior extremity. They are, therefore, readily felt and removed by incision on the inside of the mouth. The parotid nodes receive lymph vessels from the scalp, the outer part of the eye-lids, the eye, the cheeks, the nasal fossa, the naso-pharynx, the external auditory meatus, and the region of the temporo-mandibular articulation. Infections in these regions may cause intra- or periparotid suppuration. There is one node just below the zygoma and in front of the ear that is not infrequently enlarged in strumous children. This is apt to be involved when affections of the lids or scalp are present. In opening abscesses of these nodes there is little likelihood of injuring either the nerve or the duct, because the nodes are superficial. The transverse facial artery is usually too small to cause trouble. The possibility of its supplying the coronary arteries of the lips, as already described, in which case it would be very large, should be remembered. Chronic lymphangitis may be

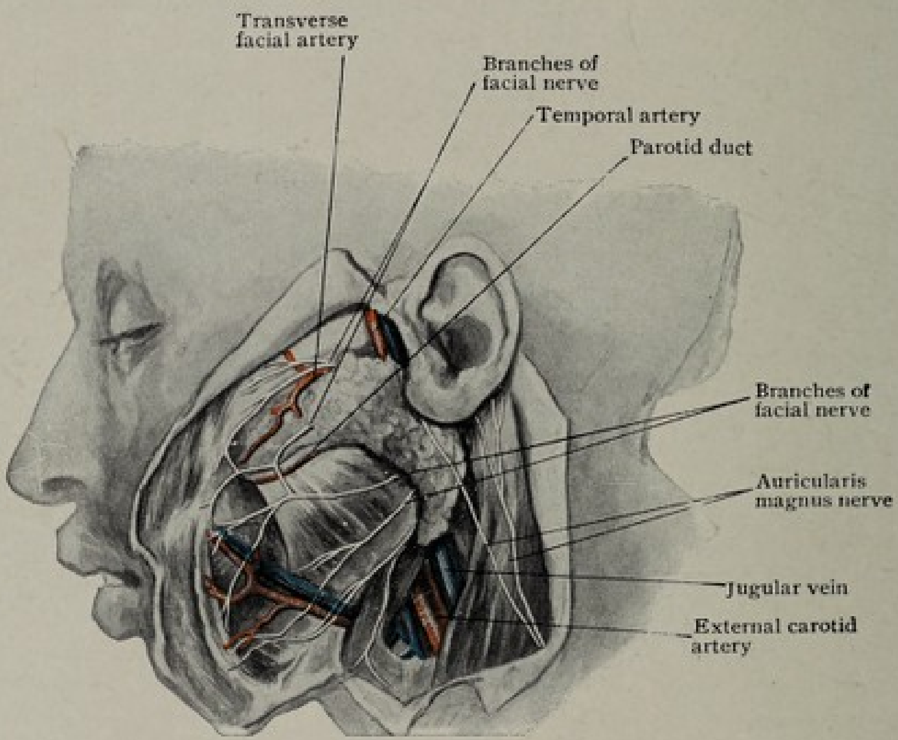


Fig. 68.—Structures in relation with the parotid gland.

mistaken for parotid tumor. The gland proper is subject to inflammations and tumors.

Simple *parotitis* or *mumps* is really an infectious inflammation, nevertheless, it rarely suppurates. *Suppurative parotitis* may occur from infected wounds or arise in the course of the eruptive fevers, etc. In inflammation of the gland, pain and swelling are important symptoms. The pain, which is considerable, is not due so much to the so-called dense parotid fascia covering the gland, for this is only moderately thick, as it is to the fact that the gland is of a racemose type and the fibrous septa between the lobules are abundant and prevent free expansion of the contained lobules. Expansion is also hindered by the peculiar location of the various parts of the gland. Swelling of the glenoid lobe produces pain in the ear and also in the temporomaxillary articulation. Swelling of the carotid and pterygoid lobes causes pain and fulness in the throat. Opening the lower jaw reduces the space posterior to it in which the gland lies and pinches it against the bony meatus and mastoid process, so that it is impossible to open the jaw widely.

If suppuration occurs it is liable to progress from one lobule to another; when this is the case comparatively small abscesses may appear in different parts of the gland with unaffected tissue between them. As an abscess heals in one lobule, suppuration is apt to occur in another, consequently the disease may persist for a long time. More rarely in the course of or following infectious diseases, particularly in debilitated patients, considerable portions of the gland may slough. This form is apt to be fatal. If the suppurating focus is confined to lobules which are deeply placed, the diagnosis may be obscure because it is difficult to localize the affected spot. If, however, it is near the surface of the gland, the pus does not tend to extend sideways, the fibrous septa preventing this, but it tends to work its way up and perforate the skin. If the glenoid lobe is affected, the pus may find an exit through the external auditory meatus or even involve the temporomaxillary joint. If the carotid or pterygoid lobes are affected, the pus may go between the pterygoid muscles, or around the internal carotid artery and project and open into the pharynx. It may also break into the carotid artery or jugular vein, or perforate through the fascia below and go down the neck. Large abscesses and sloughs may be followed by a parotid fistula.

Lines of Incision for Abscess.—The manner of opening a parotid abscess depends on its location and size. If it is desired to open an abscess anterior to a point 1.5 cm. or about half an inch in front of the ear, the structures to be avoided are the duct and facial nerve. The incisions are to be made parallel to the zygoma, and the duct is to be avoided by not cutting on a line joining the lower edge of the cartilage of the ear with the middle of the upper lip. The branches of the facial nerve lie deep and are to be avoided by making the incision parallel to their course and not extending it too deeply. After incising the skin, the deeper tissues may be separated by introducing a pointed pair of hæmostatic forceps and opening the blades. In operating in the region below the ear, the blood-vessels are to be avoided. To do this incise the skin longitudinally, not transversely, and open the deep parts carefully with the hæmostatic forceps, as already described. Another method, when the abscess is farther forward, is to make a horizontal incision rather low down on the angle of the jaw and then introduce a grooved director or hæmostatic forceps from below upward. It is important to examine the patient for weakness of the muscles of expression prior to operation since the swelling may injure the facial nerve.

FIG. 69.—Malignant tumor of the parotid gland producing facial paralysis (Dr. Davis' case).

Tumors of the parotid gland are liable to be mixed in character, with a sarcomatous element. They are often fairly circumscribed and, particularly if they do not involve the parotid duct, can be removed comparatively readily. If they are malignant and large, complete removal is practically impossible. The possibility of parotid fistula and paralysis of the facial nerve following operation on this gland should always be borne in mind and explained to patients. The presence of facial paralysis is indicative of malignancy (see Fig. 69).

THE UPPER JAW

The upper jaw carries the upper teeth and contains the maxillary sinus or antrum of Highmore. The affections of the antrum will be alluded to in the chapter on the nose (see page 119). Fractures of the superior maxilla involve the nasal process, the alveolar process, or pass transversely through the body of the bone. The nasal process is sometimes broken in fractures of the nose. In this injury, the lachrymal canal and sac may be injured and the flow of tears through them prevented, causing the tears to run over the cheek.

Fractures of the alveolar process are common enough as a result of blows and extracting teeth. These fractures, as they communicate with the mouth through the broken gums or mucous membrane or tooth socket, are necessarily compound, and consequently become infected from the mouth and suppurate. This may cause necrosis of the fragment, but the blood supply of the jaws is so good that death of a fragment is rare, and it is not customary to remove fragments not completely detached. The front wall is sometimes driven in.

Fractures occasionally occur in which the line passes through one or both superior maxillary bones from below the malar bone into the nose. If this fracture passes completely backward, it detaches the lower portion of the palate bone and pterygoid processes of the sphenoid bone. The fragment in such cases has a tendency to slip backward. It can be replaced by inserting a hook through the mouth and behind the soft palate and pulling the fragment forward. This injury is produced by a blow on the anterior portion of one or both bones, passing downward and backward. In order to determine the existence of fracture, Guerin recommended inserting the finger in the mouth and feeling for the pterygoid plates. The hamular process of the internal pterygoid plate can readily be felt about one centimetre above and behind the last upper molar tooth. Fractures in the neighborhood of the first and second molar teeth are liable to open the antrum, as the roots of these teeth project into it.

Resection of Upper Jaw.—Tumors of the antrum may necessitate a resection of the superior maxilla of one side. Heyfelder was the first to remove both superior maxillæ, in 1844; this was before the discovery of anæsthesia. In removing one superior maxilla, the incision known as Fergusson's is used. This is made through the middle of the upper lip, around the ala of the nose to the inner canthus of the eye, thence outward along the lower border of the orbit to the malar bone. The bleeding from this incision is free. The coronary arteries should be looked for near the mucous surface of the lip toward its free edge. Bleeding will also occur from the lateralis nasi and the angular arteries. The soft parts are raised from the bones as far back as the masseter muscle. This is just about level with the outer edge of the bony orbit. In doing so the infra-orbital nerve and artery will be divided. The artery is not large but may bleed freely. The fibrous floor of the orbit is raised and the attachment of the inferior oblique muscle loosened. The malar bone is sawed downward and outward opposite the sphenomaxillary fissure, and the division completed with forceps. The nasal portion of the superior maxilla is sawed through from the orbit into the nose. The soft parts of the roof of the mouth are divided in the median line to the posterior edge of the hard palate, and thence along its edge to the last molar tooth. The soft palate is firmly attached to the hard palate and has to be detached with scissors. An incisor tooth is then drawn, and the bony palate sawed through from the nose into the mouth. The bone with the tumor is wrenched loose with lion-jawed forceps. The union between the posterior portion of the superior maxilla and the pterygoid processes of the sphenoid is not bony, but fibrous, so that the bone is torn away from the processes and the latter are left behind. As the bone comes away, the maxillary nerve should be cut. The bleeding which follows is from the infra-orbital, superior alveolar (posterior dental), and posterior palatine arteries, branches of the internal maxillary. It is not so free as might be expected, provided preliminary ligation of the external carotid has been performed. It will be observed that the facial nerve is not touched nor is the parotid duct wounded.

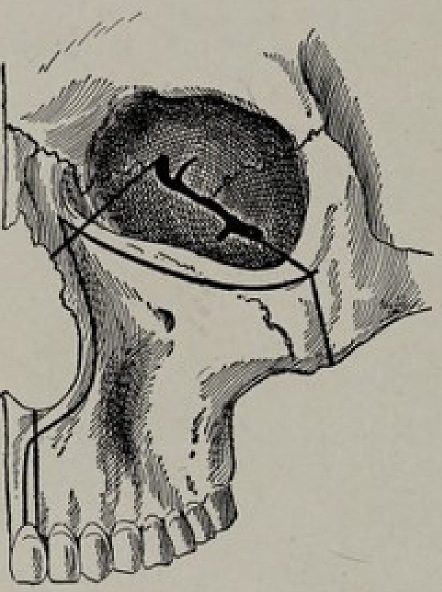


Fig. 70.—Resection of the upper jaw. The curved lines indicate the skin incision and the straight lines where the bones are to be divided.

Neuralgia of the Maxillary Nerve.—When the maxillary division is affected, there is pain in the cheek and ala of the nose. The tender points are the exit of the infra-orbital nerve at and below the infra-orbital foramen, at the exit of the malar branch on the malar bone, and the upper gums and hard palate. The operations devised for its relief are both numerous and intricate, and necessitate an accurate anatomical knowledge of the parts. The maxillary nerve is the second division of the fifth cranial nerve. It leaves the skull cavity by the foramen rotundum, then crosses the sphenomaxillary fossa, enters the sphenomaxillary fissure and infra-orbital canal to emerge on the cheek, opposite the middle of the lower edge of the orbit and about 6 mm. below it. The intracranial portion is 6 to 8 mm. in length. From the sphenomaxillary fossa to the infra-orbital foramen is about 5 cm. (2 in.). Its branches are as follows: one or two small branches to the dura mater, the *orbital* or *sphenomalar branch* to the cheek and anterior temporal region, *sphenopalatine branches* going to Meckel's (spheno-palatine) ganglion, the *posterior, middle,* and *anterior dental* to the upper teeth, and the terminal branches, *labial, nasal,* and *palpebral,* on the face.

Its anterior portion has been removed through an incision on the face, but its entire sensory division is best attacked by severing the posterior or sensory root to the Gasserian ganglion as in the Frazier-Spiller operation. Removal of the infra-orbital portion of the nerve is liable to be followed by recurrence of the pain.

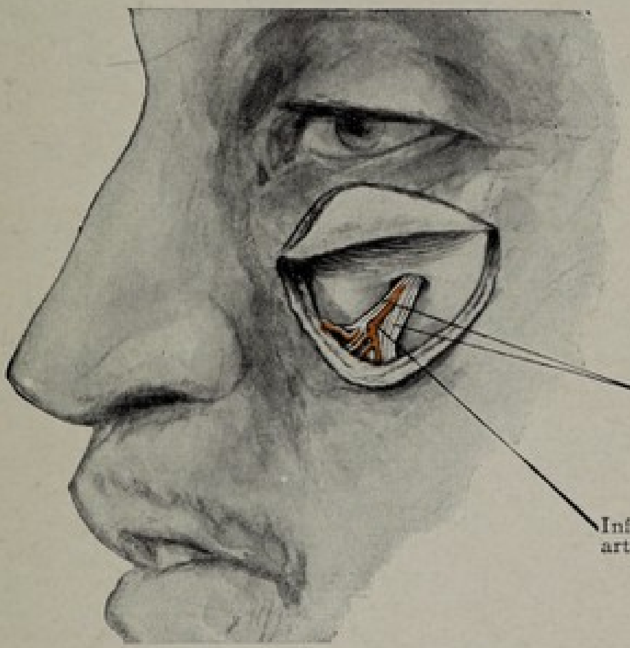


FIG. 71.—Exposure of the infra-orbital nerve and artery.

Removal of the Infra-orbital Nerve.—An incision 3 cm. in length is made along the lower edge of the orbit. This divides the orbicularis palpebrarum muscle. Arising from the bone, between the infra-orbital foramen and the edge of the orbit, is the levator labii superioris muscle. This should be carefully detached, and the foramen with its artery and nerve will be found opposite the middle of the lower edge of the orbit and about 6 mm. (¼ in.) below it, on a line drawn from the supra-orbital notch to between the premolar teeth. The artery and vein should be avoided and the nerve grasped with a hæmostat and slowly twisted out of the canal and then by reversing the movement most of the nerve will be pulled from its facial distribution. Some of the dental branches are thus pulled out. Formerly, the operation was sometimes extended back to the spheno-maxillary fissure by chiselling away the orbital roof of the canal, but this method has been abandoned in favor of the intracranial procedure.

Removal of Meckel's (Spheno-palatine) Ganglion.—Despite the fact that the spheno-palatine ganglion derives its sensory supply from the maxillary division of the fifth nerve, Gasserian ganglion removal may fail to relieve the patient in certain of the pain phenomena of the face (Meckel's neuralgia). Methods of approach to this ganglion have been described by Carnochan (1858), Mixter, Frazier and others. Carnochan's operation approaches the ganglion from in front through the maxillary sinus. It is simpler to work from the side and the new Frazier operation is excellently adapted for a good exposure of the ganglion. It traverses first the zygomatic, then the spheno-maxillary fossa after resection of the malar bone. The internal maxillary artery is not jeopardized and the structures seen are the maxillary division of the nerve, the artery that accompanies it

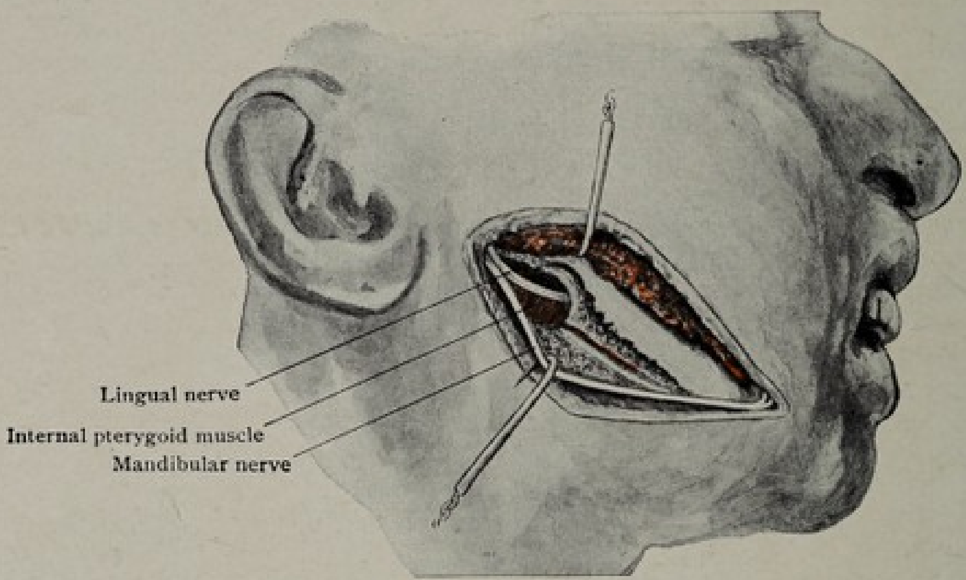


FIG. 72.—Excision of the lingual and mandibular (inferior dental) nerves.

and the areolar tissue surrounding the ganglion. The steps of the operation as given by Frazier (1921) are as follows:

I. The incision (Fig. 73a) has been designed with due regard for its cosmetic effect and to avoid important branches of the facial nerve. There are three limbs,

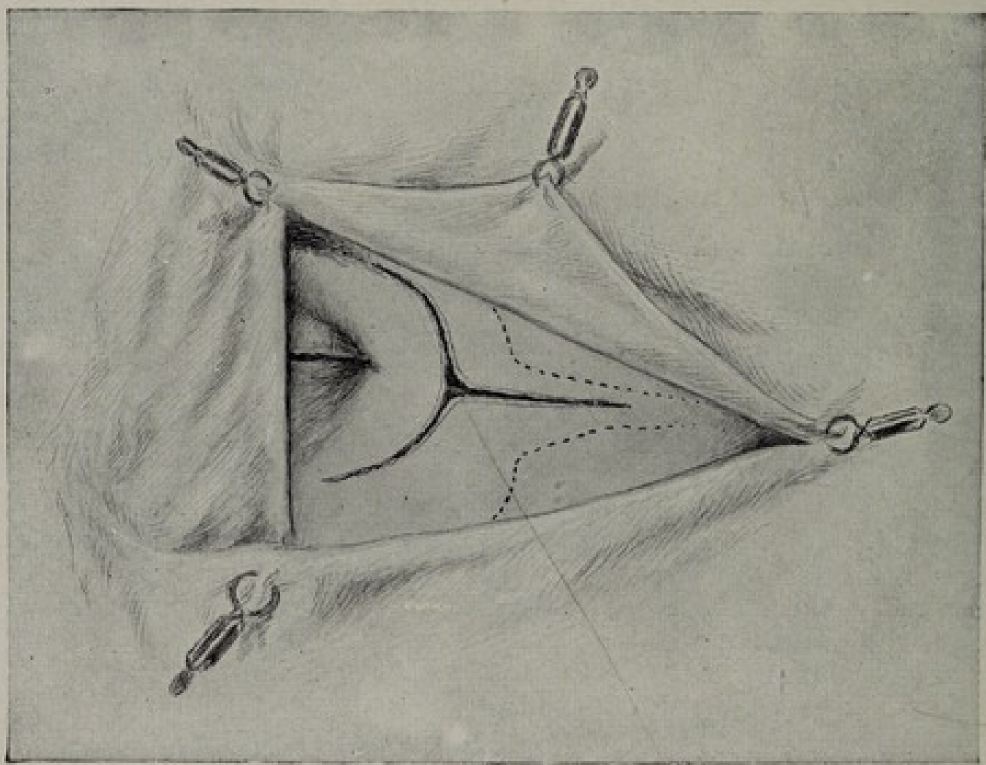


FIG. 73.—The incision in relation to the orbit and the zygoma. (Frazier.)

one straight, in the direction of the zygoma, and two curved, following the lines of the supra- and infra-orbital ridges. With careful apposition of the margins of the wound the healed scar is quite inconspicuous. The branches to the orbicularis palpebrarum and the occipito-frontalis have not been disturbed.

II. Upon reflection of triangular flaps (Fig. 74) the malar bone is exposed and with a Gigli saw is passed through the sphenomaxillary fissure. At section 3 the zygomatic process is sawed only partly through, the outer shell and the periosteum being left intact. Thus an attachment is conserved which prevents any dislodgment of the malar bone when replaced at the completion of the operation.

III. The malar bone reflected backwards (Fig. 75) at once exposes to view the zygomatic fossa and its areolar tissue. One sees in the anterior portion of the wound the external aspect of the orbit.

IV. A clearing of the contents of the zygomatic fossa is made now to expose the pterygoid plate (Fig. 76). This is accomplished by following closely the surface of the posterior wall of the antrum and displacing backwards and down-

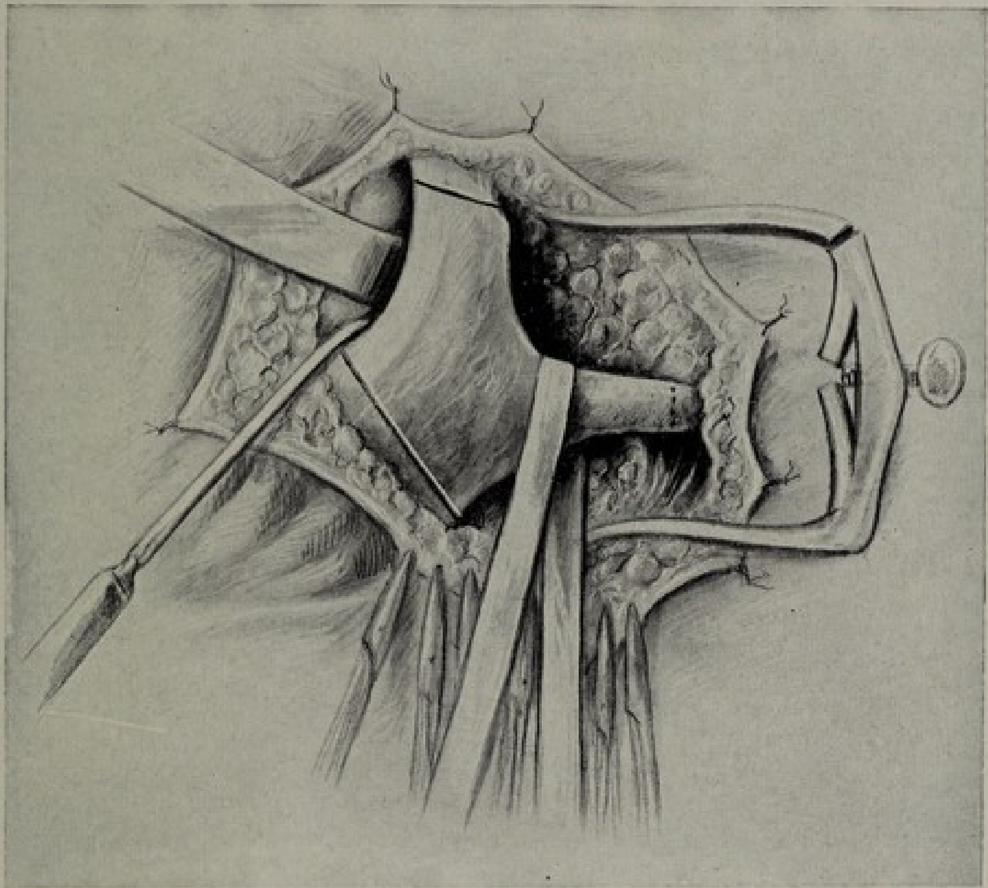


Fig. 74.—The isolation of the zygoma and malar bone. (a) Malar bone sectioned above and below. (b) Dotted line represents the point at which zygoma is divided with Gigli saw from within outward, leaving the outer periosteum intact. (Frazier.)

wards the areolar tissue and the temporal muscle. Before the pterygoid plate is exposed to view the internal pterygoid muscle must be detached.

V. With rongeur forceps a portion of the pterygoid plate is removed and the contents of the sphenomaxillary fossa exposed. To find the sphenopalatine ganglion one should expose first the maxillary division, as it enters the orbit through the sphenomaxillary fissure, and follow it up to the ganglion. The ganglion itself is deeply placed in the sphenomaxillary fossa, close to the sphenopalatine foramen. Surrounded by fat it is not readily seen, hence the necessity of following the course of the maxillary division as a guide.

Excision of the Lingual and Inferior Dental Nerves.—Neuralgia involving the face below the line of the mouth, the lower teeth, and side of the tongue requires the same treatment as the superior maxillary neuralgias. Although more permanent results are obtained by the intracranial operation and the cosmetic result is far better, some surgeons still persist in excising the lingual and inferior dental nerves. The exposures are as follows: A curved incision following the lower edge of the mandible is made. It ends anteriorly in front of the mandibular foramen, and posteriorly it stops a centimetre below the ear to avoid wounding the facial nerve. The masseter muscle is raised from the bone, and, with the parotid gland, is drawn up. The ramus of the jaw is trephined in its middle, rather high up toward the coronoid notch. The outer table of bone is then to be chiselled off, from the trephine opening as far down as the mental foramen. A delicate, curved, hæmostatic forceps is then made to grasp both nerves through the trephine opening, and on rotating very slowly the nerves are wound around the forceps and are gradually torn loose from the base of the skull above to their ultimate branches

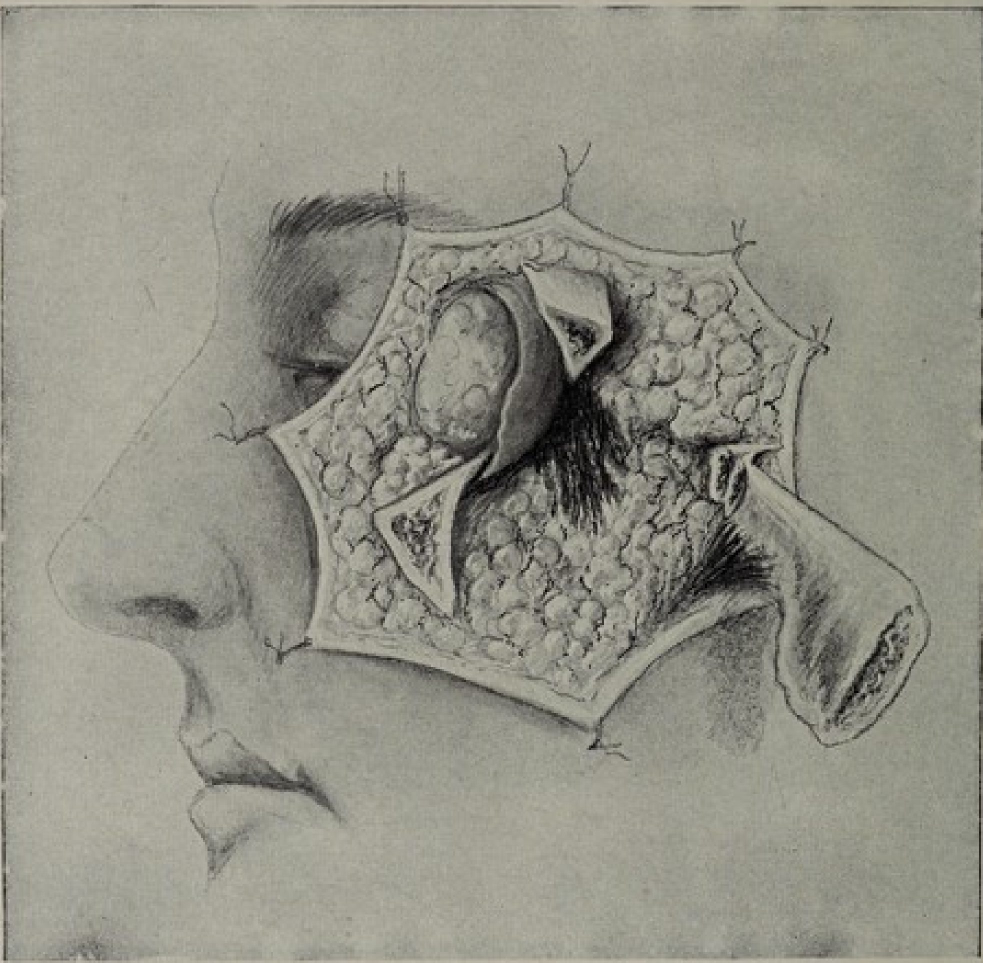


Fig. 75.—The malar bone reflected backwards uncovering: (a) The fat and muscle tissue in the zygomatic fossa. (b) A portion of the orbital contents. (Frazier.)

below (see Fig. 72). The lingual nerve can be exposed in the floor of the mouth by retracting the tongue to the opposite side. The nerve then forms a ridge in the floor of the mouth and an incision over this ridge opposite the lower molars and close to the mandible exposes the nerve.

Operations on the Gasserian (Semilunar) Ganglion or its Sensory Root. —The Gasserian ganglion lies in its capsule, formed by a splitting of the dura, on the anterior surface of the apex of the petrous portion of the temporal bone and on the root of the greater wing of the sphenoid. From its posterior extremity, which rests on the ridge separating the anterior and posterior surfaces of the petrous portion of the temporal bone, to the foramen rotundum anteriorly is 2.5 to 3 cm. (1 to 1¼ in.). The foramen ovale, which transmits the third or mandibular branch, is midway between these two points, and corresponds on the outside of the skull to the eminentia articularis or root of the zygoma. In removing the ganglion one works not only inward but also backward. Rose first operated on the ganglion from below. He removed the zygoma and coronoid process, ligated the internal maxillary artery, and trephined the skull in front of the foramen ovale. This operation was succeeded by that of Hartley and Krause. They went in through the temporal fossa. A large horseshoe-shaped flap, with its base above the zygoma, was cut and deepened with chisels through the bone to the dura. This was elevated by breaking across its base, and turning it down. The dura was then lifted from the base of the skull, and the maxillary and mandibular nerves recognized as they passed into the round and oval foramina. The capsule having been incised, these were seized with forceps, and as much of the ganglion as possible torn away.

Other surgeons, like Doyen, Quenu, Poirier, and Cushing, have combined these pterygoid and temporal routes. The operation usually performed at this time is that proposed by Spiller in 1901 and paraphrased, "the physiologic extirpation

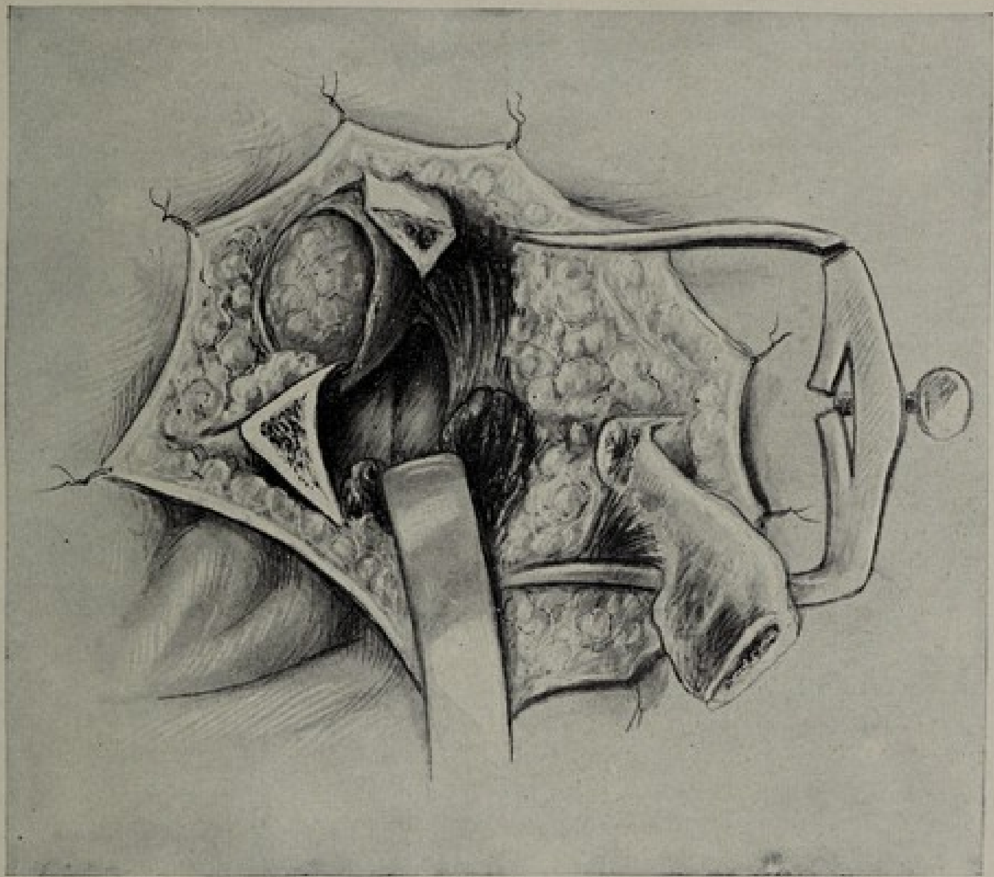


Fig. 76.—(a) Temporal muscle is retracted downwards exposing wall of antrum. (b) Internal pterygoid muscle above, intact. (Frazier.)

of the ganglion." Frazier has done the most to develop this operation. The cutaneous incision is composed of a horizontal limb a little over 1 centimeter in length, along the superior border of the zygoma and about half a centimeter in advance of the tragus of the ear, and of a vertical limb extending upward about 4.5 and curving forward 2 centimeters. Pressure by the assistant on the temporal artery, where it crosses the zygoma, will keep the field bloodless while the cutaneous incision is being made. As the temporal artery is cut across in the lower horizontal limb, it is grasped with a hemostat. The resulting skin flap is dissected free of the underlying tissue, reflected forward, and sutured to the draperies, thus avoiding the use of a self-retaining retractor.

Musculo-aponeurotic incision.—An incision is made in the temporal fascia and muscle—just the reverse of the cutaneous incision. The resulting musculo-aponeurotic flap after it has been separated, with the pericranium, from the temporal bone is reflected backward and sutured to the draperies. Thus a sufficient area of temporal bone is exposed without the use of retractors. This incision is so designed to be quite within the hair line and to avoid injury to the superior branch of the facial nerve.

Removal of Bone.—A small perforation in the skull is made with hammer and chisel below the level of the middle meningeal artery and the opening enlarged with rongeur forceps. An opening 4 cm. in diameter usually is ample. The lower margin of the opening must correspond to the base of the skull.

Separation of Dura.—The separation of the dura from the skull without laceration may be very difficult, especially as one approaches the base of the skull, where it is most adherent and of most delicate texture. When the dura is snugly adherent, it is advisable to begin the separation on either side of the cranial defect.

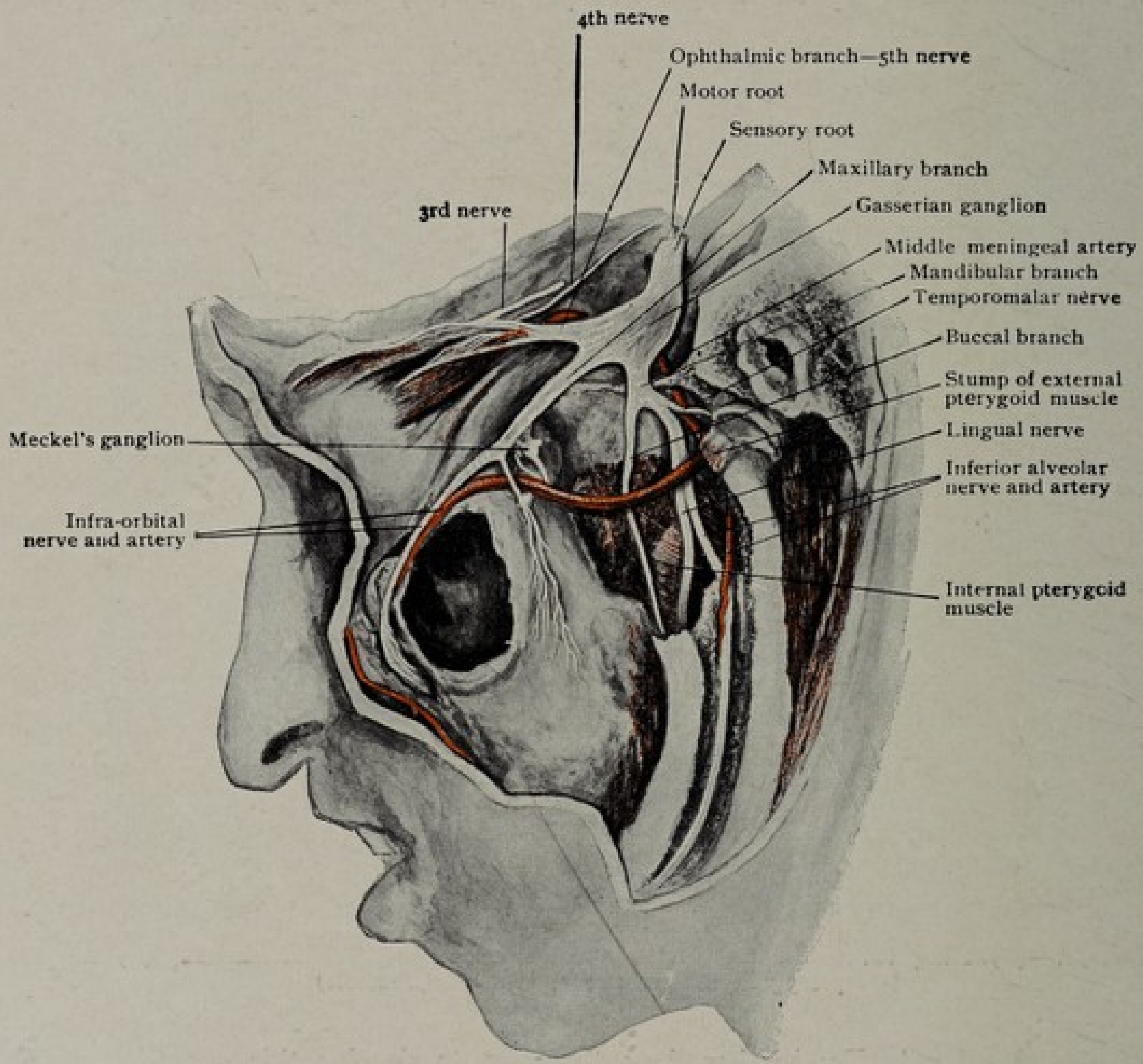


FIG. 77.—The fifth or trifacial nerve with its various branches.

A small perforation is made in the dura in the center of the exposure to allow the escape of cerebro-spinal fluid throughout the operation. This reduces the bulk of the intracranial contents and thus facilitates the elevation of the temporal lobe. With gentle pressure by means of an illuminated brain retractor, especially designed for this operation, the operator commences to separate the dura from the floor of the middle fossa. Usually this is readily accomplished with a septal elevator, but occasionally the dura is so adherent that lacerations of the dura may be unavoidable.

The operative field, at this stage, is kept bloodless by means of a specially designed, curved metal aspirator and by the judicious use of dental cotton tampons.

Approach to the Ganglion.—The first landmark is the groove of the middle meningeal artery on the floor of the fossa. When this is seen, the operator fol-

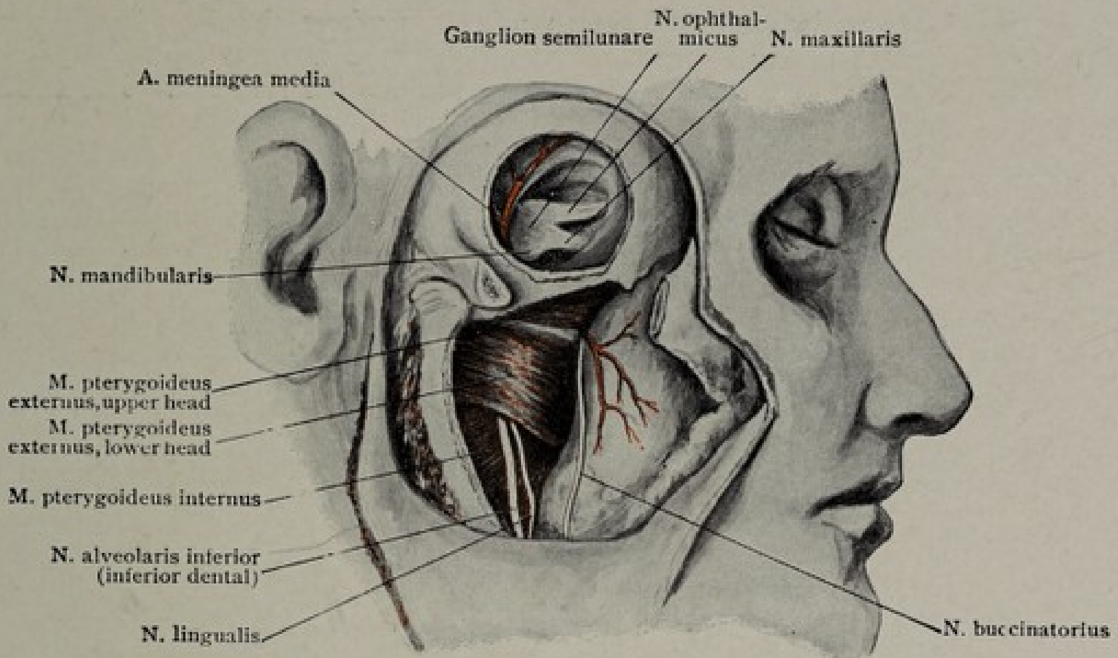


FIG. 78.—The upper portion of the illustration shows an operation of removal of the gasserian ganglion (ganglion semilunare). The lower portion shows the pterygoid muscles.

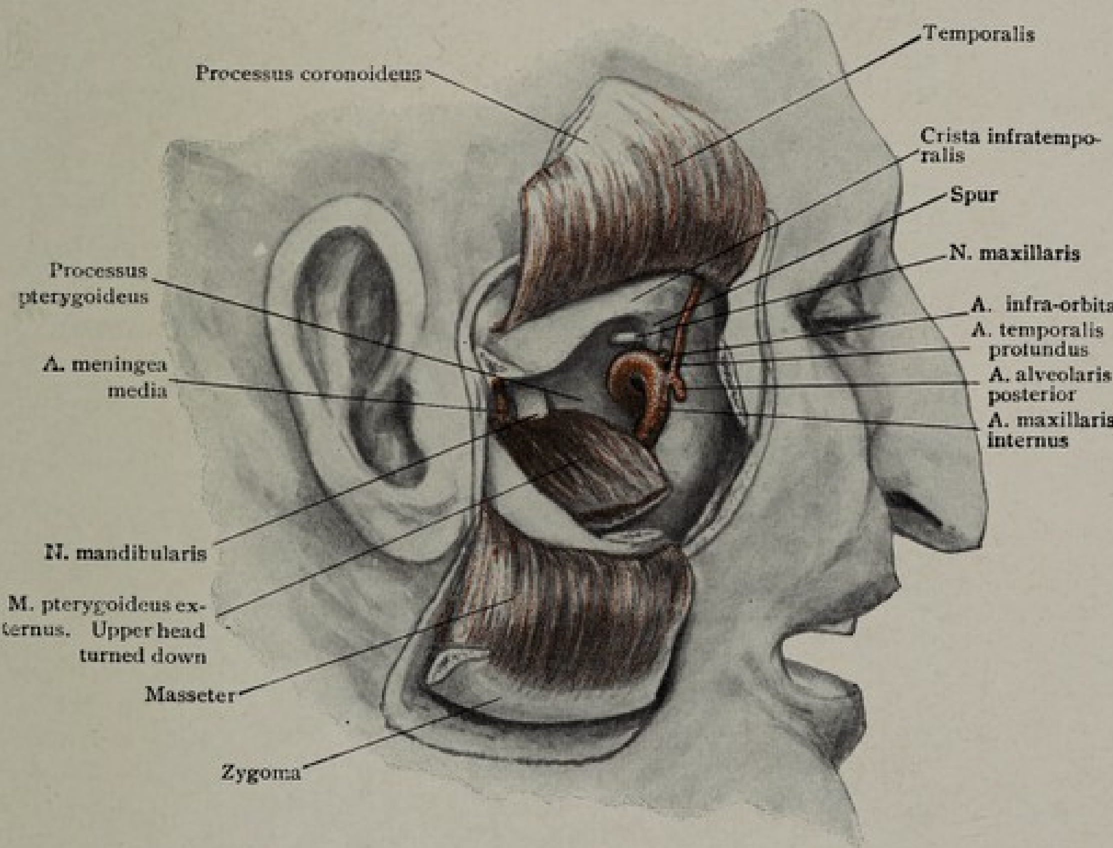


FIG. 79.—Operating through the pterygoid fossa (Mixter's method). The skin with the zygoma and masseter have been turned down. The coronoid process is divided and turned up. The upper head of the external pterygoid has been detached and turned down. The maxillary nerve is in front of the pterygoid plate (processus pterygoideus) and the mandibular nerve and middle meningeal artery just behind it.

lows it to its termination at the foramen spinosum where the dura is separated gently to avoid rupture of the artery, sufficiently fore and aft of the foramen to permit a clear view of the artery as it emerges from the foramen. The middle

Fig. 80.

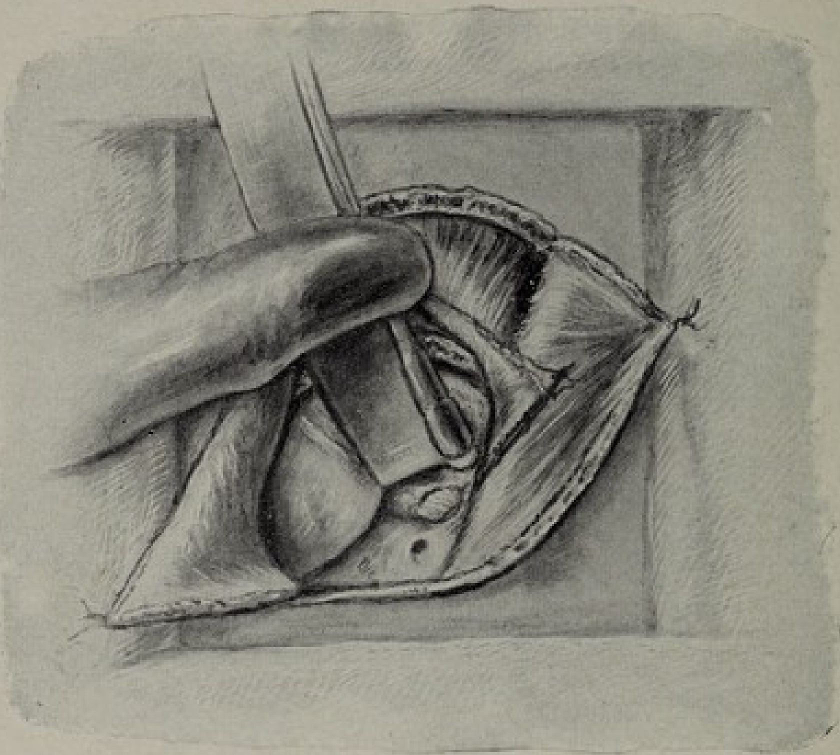
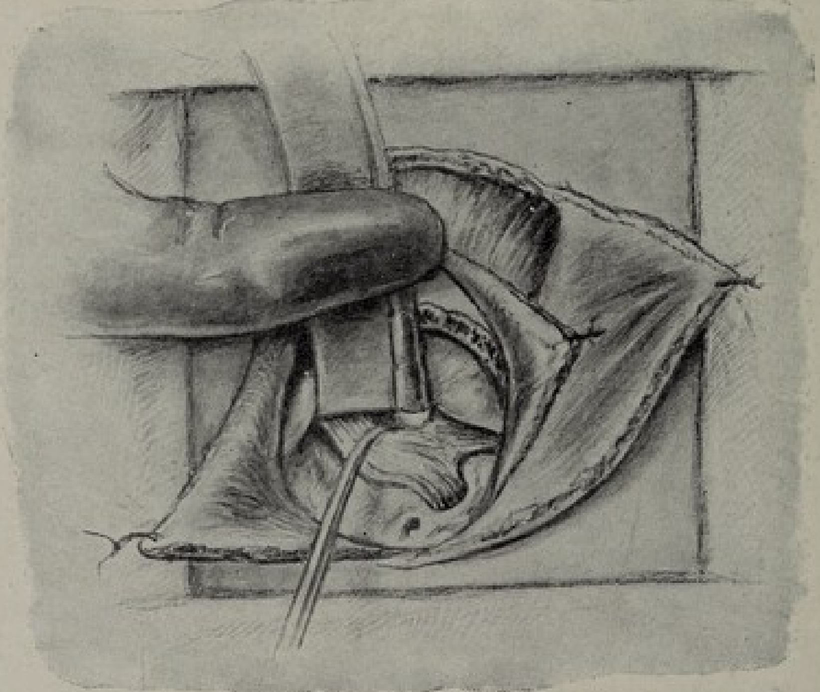


Fig. 81.



Figs. 80 and 81.—Exposure in Frazier-Spiller operation for Trigeminal neuralgia.

meningeal artery and foramen is thus exposed with a small dental applicator, and the foramen is plugged with a wisp of cotton so as to obliterate its lumen. The artery and vein are then divided with a scalpel.

Exposure of the Ganglion.—The next objective is the mandibular division of the trigeminal nerve as it enters the foramen ovale. This foramen lies just mesial and a little anterior to the foramen spinosum, and is partly hidden from view by a small bony eminence on the floor of the fossa. This eminence is removed with a chisel.

The next step of the operation is the most important and sometimes the most difficult. The dura must be separated from the sheath of the ganglion. Often the line of cleavage is difficult to find, or the dura may be intensely adherent to the ganglion's sheath. One must avoid perforating the dura or penetrating the sheath. For this separation, a septal elevator combined with a suction apparatus all in one will be found helpful, and pressure is made directly over the foramen ovale until this line of cleavage becomes manifest. The dura is separated from the surface of the ganglionic sheath as far forward as the maxillary division, and backward and inward until the arachnoid covering of the sensory root comes into view. One cubic centimeter of 2 per cent novocaine is injected into the

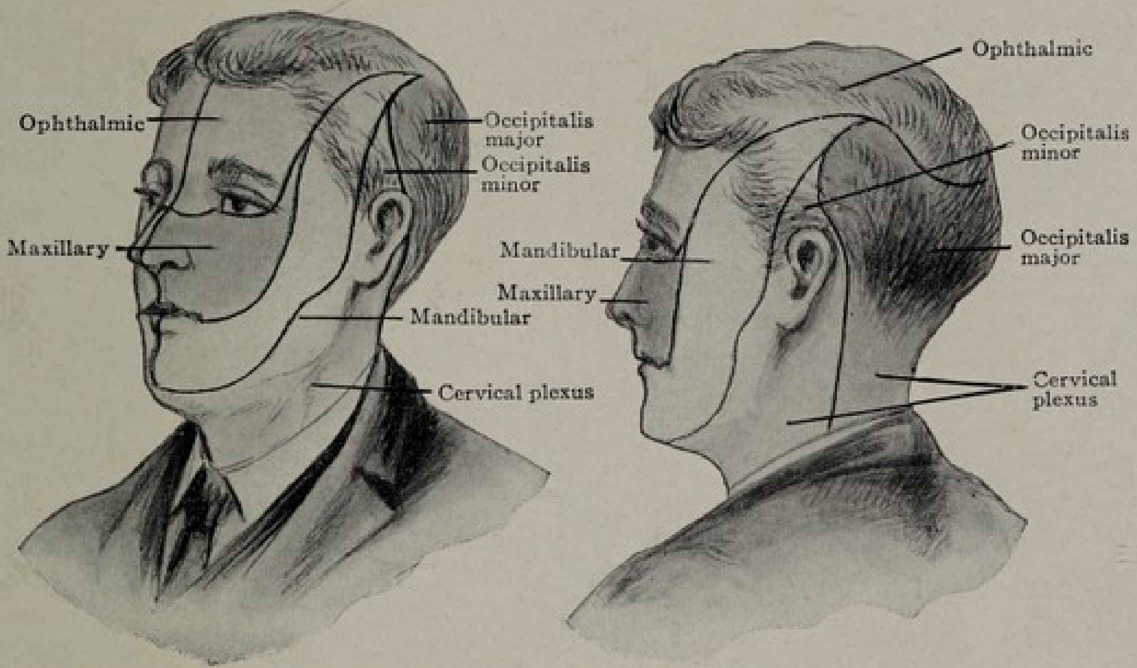


FIG. 82.—Diagrams showing distribution of cutaneous branches of trigeminal and cervical spinal nerves (Piersol).

ganglion, the ether is discontinued and the operation concluded under regional anesthesia.

Exposure of the Sensory Root.—One should be familiar with the appearance of the line of junction between the ganglion and root. It is usually readily recognized in various ways and the dura must be dissected for enough mesad so that an ample exposure of the root may be obtained. The facility with which fractional division of the root is accomplished will depend upon the liberality of this exposure. Without such exposure the nicety of the subsequent steps is an impossibility. To expose the root, an oblique incision is made in the dural sheath parallel and a little in front of the posterior margin of the ganglion. The sheath is bluntly separated on either side of this incision and the sensory root is exposed to view.

Exposure of the Motor Root.—When the sensory root is elevated the motor root may be seen on the floor of the skull as a separate isolated fasciculus. Sometimes the motor root is composed of two fasciculi. It is quite separate and distinct from the sensory root and may be seen to pass behind the ganglion. If there is any question about its identity, it may be identified by stimulation with an electrode.

Section of the Sensory Root.—There remains now only to section as much of the root as may be required in the individual case. The upper and inner third of the root supplies the ophthalmic division; the lower and outer third, the mandibular division; and the intermediate fibres, the maxillary division. As in most cases pain is referred to the maxillary and mandibular divisions, this portion of the root must be sacrificed. Section of the necessary fasciculi is readily accomplished with a small scalpel after the fasciculi have been isolated on a specially designed blunt hook.

THE LOWER JAW

The *mandible* or *inferior maxilla* is subject to fractures, dislocation, and tumors. In its composition it is very dense, so that in dividing it a groove should be cut with a saw before the use of the bone-cutting forceps is attempted, otherwise splintering of the bone will ensue. It is the last bone to decay. Its horseshoe shape and exposed position render it unusually liable to fracture. The strongest portion is what one would expect to be the weakest, viz., the symphysis. Its weakest part (or rather the part where it is most often broken) is the region of the mental foramen. The bone is weakened at this point not only by the foramen but also by the deep socket of the canine tooth.

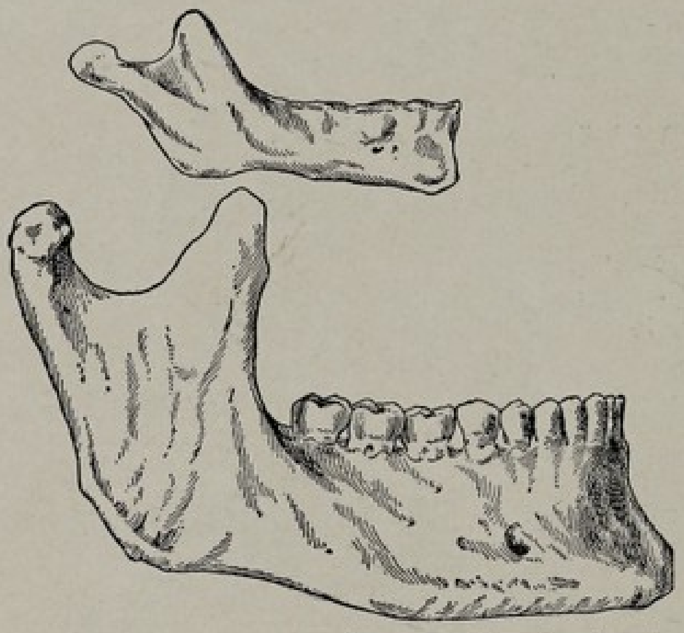


Fig. 83.—Lower jaw of child and adult, showing the mental foramen.

The position of the *mental foramen*, normally between the two bicuspids (beneath the second in the negro—Humphry), varies in its vertical location between the alveolar border and lower edge of the body, according to age. In infancy it is low down, in young adults it is midway, and in old people it is high up.

The body of the jaw is composed of two parts, one above and one below the external oblique line, which runs from the base of the anterior border of the coronoid process, downward and forward to end at the mental tubercle, to one side of the symphysis. The part above this oblique line is the alveolar and the part below is the basal portion of the body.

The mental foramen opens on the oblique line separating the alveolar and basal portions. In early adult life the two portions, basal and alveolar, are about even in size, so that the foramen is below the middle of the jaw. As the teeth are lost the alveolar process atrophies; this naturally leaves the basal portion with the mental foramen on or near its upper surface; therefore, in operating for neuralgia in the aged, if it is desired to attack the mandibular nerve in its canal, it should be searched for near the upper border of the bone.

In infancy the teeth, not having erupted, are contained in the jaw, the alveolar portion is, therefore, large. The basal portion, on the contrary, is quite small, serving merely as a narrow shelf on which the unerupted teeth lie. As the mandibular nerve runs beneath the teeth, the mental foramen is of necessity comparatively low. At birth the condyle is about level with the upper portion of the symphysis, and the body forms with the ramus an angle of 175 degrees. At the end of the fourth year the angle has decreased to about 140 degrees. By adult age the angle has decreased to about 115 degrees, and as the teeth are lost the angle gradually increases until it again reaches 140 degrees.

Temporomandibular Articulation.—A knowledge of the movements of the jaw is essential to a proper understanding of the fractures and dislocations to which it is subject.

The mandible articulates with the glenoid fossa and its anterior edge or eminentia articularis of the temporal bone. Interposed between the condyle below and the bone above, is an interarticular cartilage. This divides the articulation into two portions, an upper and a lower. The *ligaments* are a capsular, strengthened by

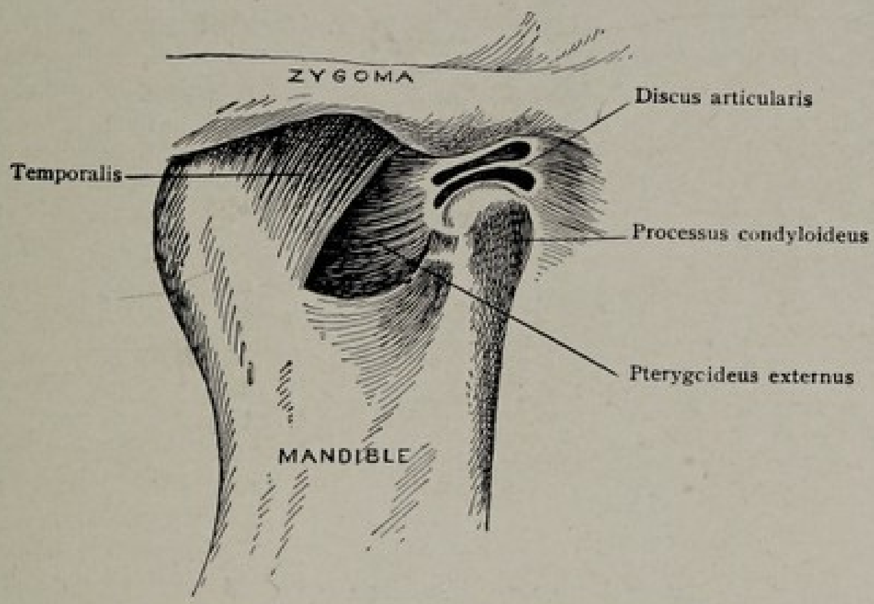


Fig. 84.—The temporomandibular articulation.

an external lateral (temporomandibular) and an internal lateral. The capsular ligament is weakest anteriorly and strongest on the outer side. The thickening of the capsule on its outer side forms the external lateral or temporomandibular ligament. The sphenomandibular or internal lateral ligament is practically distinct from the articulation. It runs from the alar spine on the sphenoid above to the mandibular spine or lingula, just posterior to the mandibular foramen below. Between it and the neck of the bone run the internal maxillary artery and vein. When the condyle glides forward it puts the posterior portion of the capsule on the stretch, and if the jaw is dislocated this part of the capsule is torn. The interarticular cartilage is more intimately connected with the lower portion of the articulation. The same muscle that inserts into the neck of the jaw (the external pterygoid) likewise inserts into the cartilage; therefore, the two move together, so that when the condyle goes forward the cartilage goes forward and rides on the eminentia articularis.

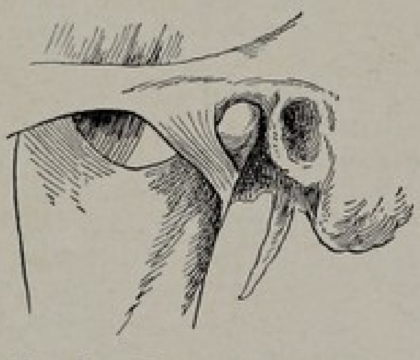


Fig. 85.—External lateral ligament of the lower jaw.

Movements of the Jaw.—The jaw has four distinct movements. It can be moved directly forward or backward; up and down, a pure hinge motion; a rotary movement on a vertical axis through one of the condyles; and rotation on a transverse axis passing from side to side through the mandibular or inferior dental foramina. The muscles of mastication are the *temporal, masseter,* and *pterygoids*; these are supplied by the motor branch of the fifth nerve. To these we may add the *buccinator,* which is supplied by the seventh nerve, and the depressors of the jaw,—the *digastric, geniohyoid, geniohyoglossus, mylohyoid,* and *platysma.* The posterior belly of the digastric receives its nerve supply from the facial; its anterior belly from the mylohyoid branch of the inferior dental from the fifth. The mylohyoid is supplied by the mylohyoid branch of the inferior dental. The geniohyoid and geniohyoglossus are supplied by the hypoglossal nerve. The platysma is supplied by the inframandibular branch of the facial nerve. The upward movement is produced mainly by the masseter and temporal muscles. It is the principal movement in carnivorous animals; therefore, these muscles in them are well developed, and the joint is a pure hinge joint. The internal pterygoid and buccinator likewise aid in closing the mouth; the depressors already mentioned open it. The lateral or rotary movement around a vertical axis passing through one condyle is used in chewing; therefore, we find the muscles most concerned, the pterygoids, best developed in herbivorous animals, or those which chew the cud. The external pterygoid is especially efficient in pulling the jaw forward; superficial fibres of the masseter help in this. The posterior fibres of the temporal muscle pull the jaw back, as do likewise the depressor muscles of the jaw. In this rotary movement one condyle remains back in its socket while the other is brought forward on the eminentia articularis.

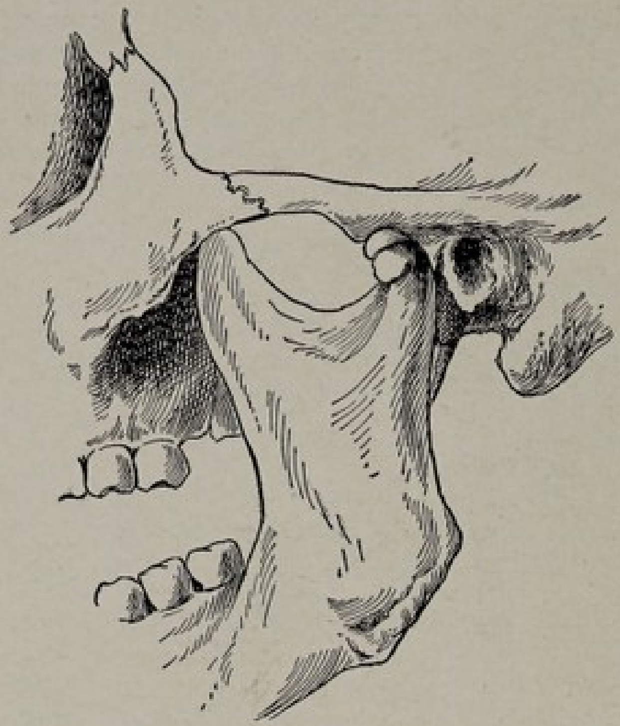


Fig. 86.—Illustrating up-and-down or pure hinge motion of the mandible.

The up-and-down movement of the jaws, when limited in extent, is a pure hinge movement without any anteroposterior displacement, and takes place between the condyle and the interarticular cartilage (Fig. 86). The anteroposterior movement is necessarily accompanied by a slight descent of the jaw, as the condyle glides from the glenoid cavity (Fig. 87) onto the eminentia articularis. It goes nearly, but not quite, to the highest point of the articular eminence. If the jaws are kept closed during this anteroposterior movement, some of the teeth of the upper and lower jaws will still be in contact, the number varying in different individuals. The last molar teeth are usually higher than those in front, so that as they glide forward the last lower molars strike the second upper ones. The incisors likewise can be kept in contact as the jaw moves backward and forward. It is this movement in the rodent animals which keeps their edges sharp. In chewing, the jaw is depressed, the teeth separated, and the food held between them by the tongue and buccinator muscle. The teeth are then approximated by the lower jaw closing and the condyle sliding upward and backward from the eminentia articularis into the glenoid cavity, carrying with it the articular cartilage.

Fig. 87.—Illustrating direct anteroposterior movement of the mandible. The condyle is resting on the eminentia articularis.

The hinge motion takes place between the condyle and the interarticular cartilage. The anterior posterior motion takes place between the interarticular cartilage and the eminentia articularis: the cartilage is carried forward with the mandible. A rotary movement occurs when, in chewing, the condyle of one side remains in the glenoid cavity while that of the other rises on the articular eminence. The radius of rotation is a line passing from one condyle to the other. In widely opening the mouth, as in yawning, the condyles are tilted forward while the angles of the mandible are carried somewhat backward. As the axis of this motion passes from side to side through the mandibular foramina, this portion of the bone moves but little, and the inferior dental vessels and nerve are not put on the stretch.

Ankylosis of the Jaw.—Ankylosis of the mandible is seen following traumatism or infection to the temporomandibular articulation. A pseudo-ankylosis may be due to extra-articular disease. The growth of the ramus of the jaw is very largely dependent upon the epiphysis of the condyle and fixation of this interferes with proper development. The ankylosis may be fibrous or osseous in character. Unilateral ankylosis, if it occurs before the fifteenth year, when the centre of ossification of the condyle unites with the ramus, presents a typical deformity due to shortening of the affected side. For many years this condition was treated by excision of the mandibular condyle, but more recently flaps of fat or fascia have been used between the denuded bony surfaces of the joint. The position of the facial nerve, the internal maxillary and the superficial temporal vessels must be kept in mind when exposing the joint. Since the facial nerve divides in the substance of the parotid gland into its temporo-facial and cervico-facial divisions it is only the former which is liable to injury. There is thus a triangular area with its base upward between the superficial temporal artery on the one side and the internal maxillary artery and temporo-facial nerve on the other which is devoid of important structures and which permits a safe approach to the joint.

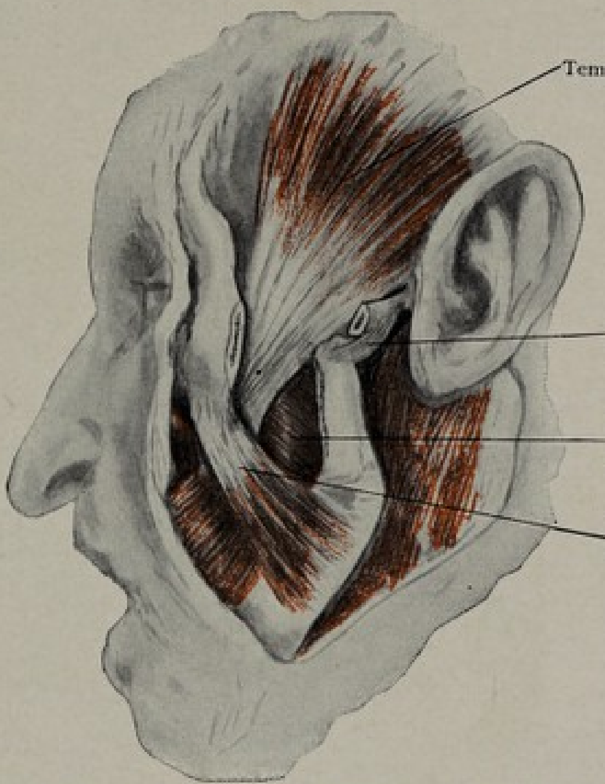


FIG. 88.—Dislocation of the lower jaw; the zygoma and part of the masseter muscle have been cut away.

Dislocation of the Lower Jaw.—The forward dislocation is practically the only one to which the jaw is subject. Dislocations in other directions are apt to be accompanied by fractures. An understanding of the mechanism of the production and reduction of this dislocation requires a knowledge of the movements of the jaw, and the influences which the ligaments and muscles exert in limiting them. The normal movements of the jaw have already been discussed.

The ligaments which limit the movements of the jaw are those forming the *capsular ligament*. This is made up of four parts: *anterior, posterior, internal lateral*, and *external lateral*. The anterior is very weak, hence pus in the joint is most apt to make its exit forwards. It is readily ruptured in dislocations. The posterior ligament, though stronger, may also be torn. The two lateral ligaments, the outer being the stronger, become tense when the condyle slips forward on the articular eminence. In dislocation they remain attached to the mandible and are not ruptured (see Fig. 88).

Dislocation occurs when the month has been widely opened and the condyles are forward on the articular eminences. Some sudden jar accompanied by contraction mainly of the external pterygoid muscle causes the condyle to slip forward just in front of the articular eminences. The pterygoid muscles and the superficial fibres of the masseter muscles aid in producing the luxation. As the condyle leaves the articulation to jump forward, it will be noted that it does so by an extensive movement, which is one of rotation on a transverse axis passing across in the region of the mandibular foramina. The condyle once out of its socket is kept out by the contraction of the temporal, masseter, and internal and external pterygoid muscles.

Reduction of Dislocation of the Lower Jaw.—In reducing the dislocation, the condyles must be depressed and pushed back. This can be done by one of two ways: viz., the thumbs of the surgeon, being protected by wrapping with a towel or bandage, are placed on the last molar teeth, and the jaw firmly grasped with the fingers beneath it. The back part of the jaw is then pressed downward, the chin tilted upward, and the condyles slid back into place.

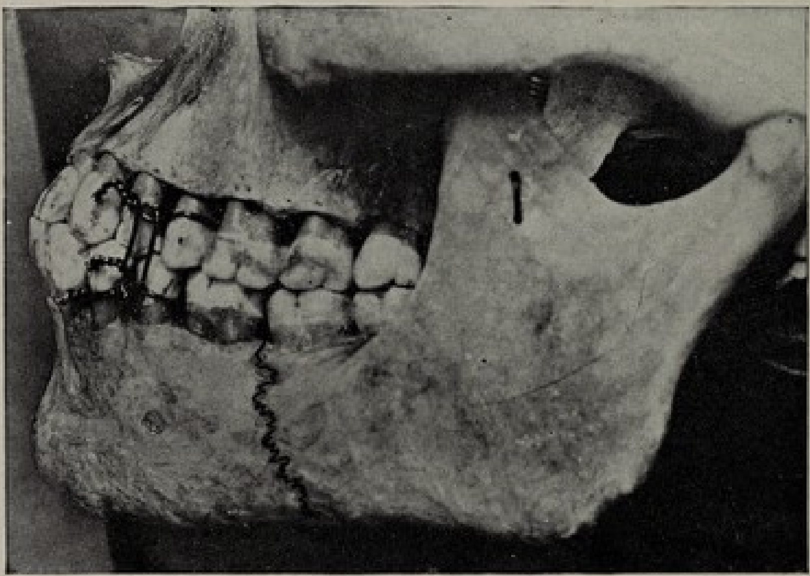


FIG. 89.—Fracture of the mandible through the horizontal ramus. (Ivy.)

The other method is to place two corks, one on each side, or a piece of wood, transversely, between the last molar teeth, then raise the chin and push it backward.

The undetached lateral ligaments are put on the stretch when the condyle is luxated forward. Lewis A. Stimson believes that in attempting reduction the jaw should first be opened wider to relax these and then pushed back, but we are not prepared to admit that so doing does relax these ligaments. He has, however, shown that the interarticular cartilage may become displaced and, by filling up the articular cavity, prevent a proper reduction. In rare instances the catching of the coronoid process beneath the malar bone may hinder replacement.

Fractures of the Lower Jaw (Mandible).—Fractures of the lower jaw almost never occur through the symphysis; this is on account of its being the thickest and strongest part of the bone. When a fracture of the anterior portion of the jaw detaches a median piece a most dangerous condition is produced. The piece, if sufficiently loosened by the injury, is drawn back into the throat, carrying the tongue with it and tending to suffocate the patient. Such a case is recorded by A. L. Peirson, 1841. A man was run over by a wheel which passed over his jaw, fracturing it on each side and forcing the piece into his mouth. The piece was drawn backward and nearly caused death from suffocation.

In the *Annals of Surgery* (1894), Doctor Davis recorded a case in which a man, while drunk, fell and struck his chin on the curbstone. A fracture was produced through the symphysis above and branching to each side of the genial tubercle below. This small median piece was drawn back into the throat nearly to the hyoid bone, and suffocative symptoms were marked. These disappeared when the detached piece was drawn forward and wired in place. The piece was drawn backward by the geniohyoid and geniohyoglossus muscles. The digas-

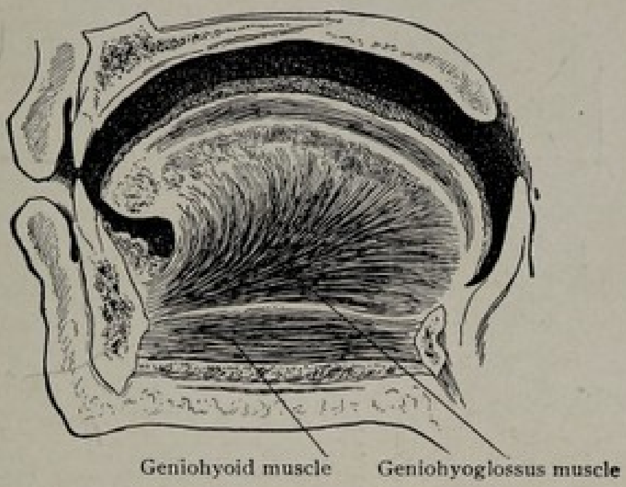


FIG. 90.—Anteroposterior section of the tongue and floor of the mouth, near the midline.

trics may also have aided in depressing the fragment (Figs. 89 and 90). The four most common seats of fracture are: (1) the alveolar processes; (2) the articular processes; (3) the ramus; (4) the body.

The most usual site of fracture is in the neighborhood of the mental foramen. This is located just below the second premolar tooth (sometimes between the first

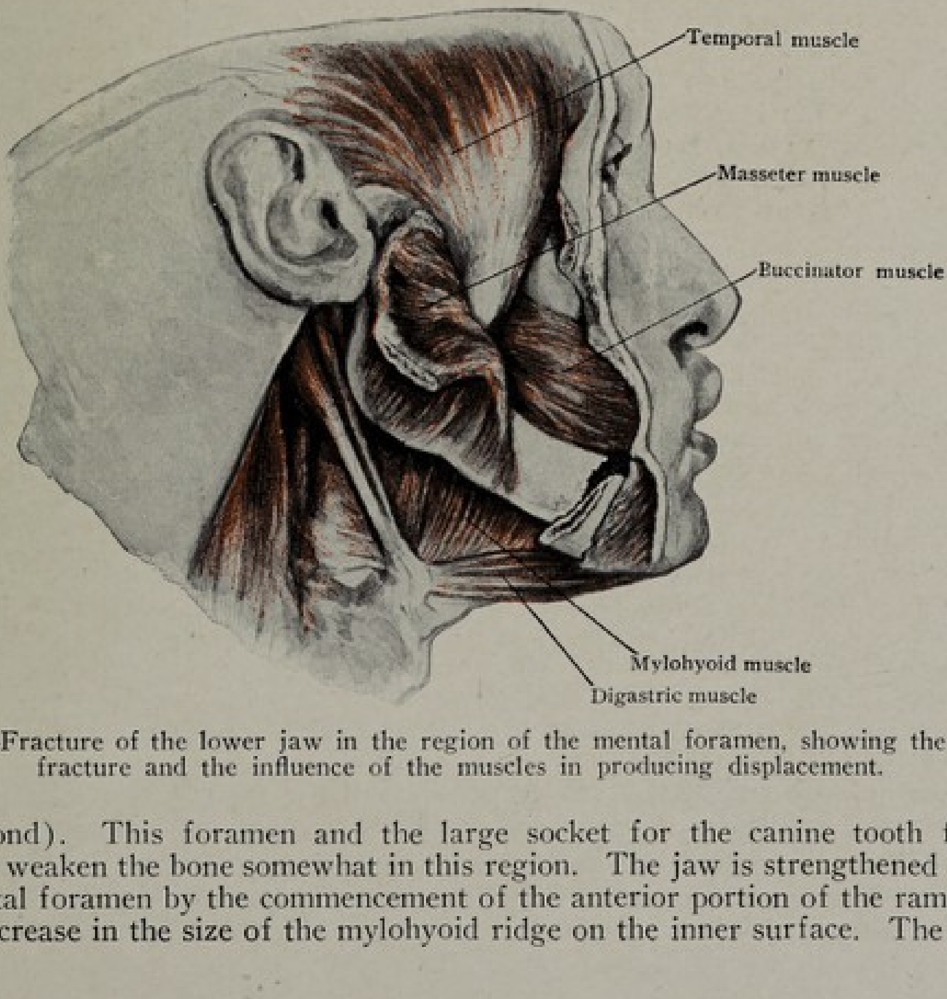


FIG. 91.—Fracture of the lower jaw in the region of the mental foramen, showing the line of fracture and the influence of the muscles in producing displacement.

and second). This foramen and the large socket for the canine tooth farther forward weaken the bone somewhat in this region. The jaw is strengthened behind the mental foramen by the commencement of the anterior portion of the ramus and by an increase in the size of the mylohyoid ridge on the inner surface. The jaw is also protected by the thick masseter muscle, and fracture is most liable to occur just in front of it. This constitutes the typical fracture of the lower jaw (Fig. 91).

Displacement.—The displacement of the fragments will depend on the line of fracture; and the line of fracture may be determined by the direction and character of the fracturing force. The line of fracture is oblique. It may be oblique from above down or from without in. An examination of the muscles attached to the mandible will show that the elevators of the jaw are attached to it posteriorly and its depressors anteriorly. On this account, when the fracture runs obliquely down and forward there is little or no displacement, because the depressors and elevators tend to press the fragments together. When the fracture runs downward and backward (see Fig. 92), the depressors and elevators tend to separate the fragments. The depression of the anterior fragment is particularly marked when the fracture is double, involving both sides of the jaw. The muscles which tend to depress the anterior fragment are the geniohyoglossus, geniohyoid, mylohyoid (anterior portion), digastric, and platysma. The muscles which elevate the posterior fragment are the temporal, masseter, buccinator, and internal pterygoid.

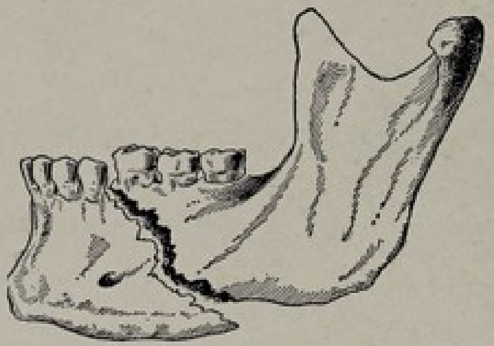


Fig. 92.—Fracture of the lower jaw, showing the line of fracture proceeding downward and backward, favoring displacement.

The displacement may not only be up and down, but may also be lateral. The line of fracture may run from the outside either inward and backward or inward and forward. The jaw is held in place by its own rigidity when intact; when broken, the smaller fragment is liable to be pulled inward by the muscles passing from it toward the median line. These muscles are the internal pterygoid and the mylohyoid. The influence of the former is more marked than of the latter, because the fracture frequently divides the mylohyoid, leaving a part of it attached to each fragment. When the fracture passes from without inward and backward, then there will be little or no displacement, because the internal pterygoid and mylohyoid draw the fragments together (see Fig. 93). When the line of fracture is from without inward and forward, the internal pterygoid of the injured side and the mylohyoid draw the posterior fragment inward, while the internal pterygoid of the opposite side draws the anterior fragment outward (Fig. 94).

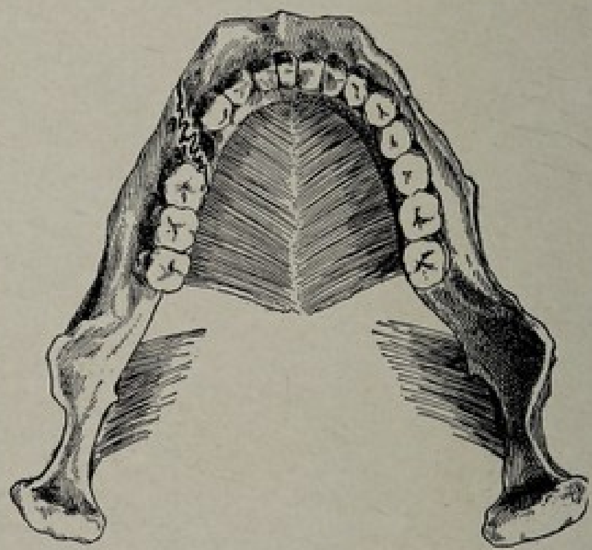


Fig. 93.—Fracture of the jaw, showing absence of displacement when the line of fracture runs from the inside forward and outward.

From a consideration of the foregoing facts, we see that when there is displacement it is because the fracture runs from above downward and backward, and from without inward and forward. The anterior fragment is displaced downward and the posterior fragment is displaced inward.

Fractures through the region of the molar teeth are not particularly uncommon, and this is likewise the case with fractures obliquely downward and outward through the angle of the jaw. In these injuries the firm attachment of the masseter on the external surface of the jaw and the internal pterygoid on its inner prevent displacement.

Fractures of the coronoid process are exceedingly rare. In them displacement is prevented by the attachment of the temporal muscle, which passes much farther down on the inside than on the outside.

Fractures of the neck of the jaw are particularly serious. Inserted into the condyle and neck of the jaw is the external pterygoid muscle. When a fracture of the neck occurs, this muscle pulls the upper fragment anteriorly and tends to tilt its upper end inward. This displacement is so marked that an excessive amount of callus is thrown out and ankylosis may result. This so seriously interferes with the use of the jaws as to justify an operation to remove or replace the upper fragment in proper position. The injury is liable to be overlooked in children, and as they grow up the deformity shown in Figure 95 develops.

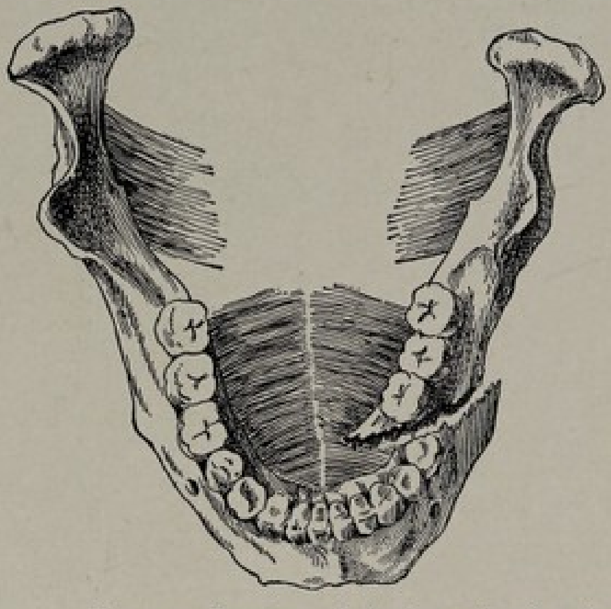


Fig. 94.—Fracture of the jaw, showing the action of the internal pterygoid and mylohyoid muscles in producing displacement when the line of fracture runs from the outside forward and inward.

The Barton bandage should only be used as a first-aid dressing. As soon as possible more efficient treatment which aims to hold the mandible against the upper teeth should be instituted. This is done by a number of methods; *e.g.*, wiring, gutta percha interdental splint, or the metal screws of Kingsley or Trauman.

Fig. 95.—Deformity of the face following ankylosis due to fracture of the neck of the lower jaw in infancy (from an original sketch).

Treatment.—The method illustrated in Figure 89 is an ingenious method used by Dr. Robert Ivy. The upper and lower teeth are fastened to each other, immobilizing the mandible and serving the same purpose as an interdental splint. It is, however, simpler and equally as efficient.

Excision of the Condyle of the Jaw.—The condyle can be removed through an incision 3 cm. long, running from in front of the ear along the lower border of the zygoma. The temporal artery runs a centimetre in front of the ear with the auriculotemporal nerve posterior to it. By care in recognizing the artery, it may be saved and dragged posteriorly. The soft parts on the lower side of the wound with the parotid gland and facial nerve are pushed downward. The condyle can then be dug out, care being taken not to go beyond the bone and wound the internal maxillary artery, Figure 84. This incision is the same as that for exposure of the temporo-maxillary articulation (page 79).

Excision of the Mandible.—In removing one-half of the mandible, the incision is made from the symphysis along the lower border of the jaw to the angle and thence upward as high as the lobe of the ear. If it is desired to take extra precautions, the last centimetre of this incision, from the lobule of the ear down, may be carried through the skin only. This will prevent wounding to any great extent the parotid gland tissue, the parotid duct, and positively avoid injuring the

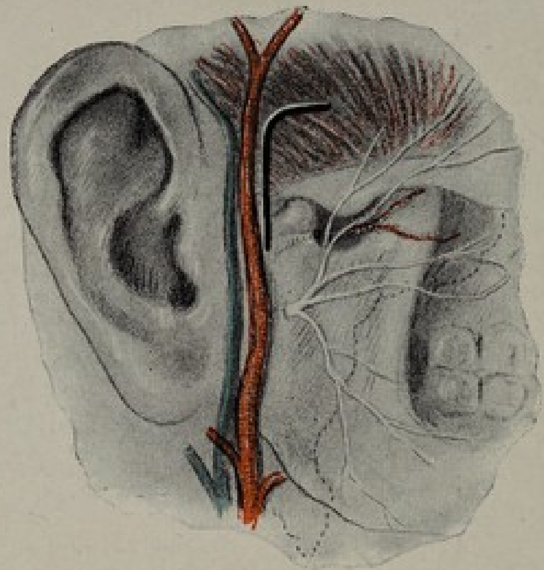


Fig. 96.—Incision for tempero-maxillary arthroplasty. Modified from Mayo Clinic.

facial nerve. The incision, however, is rather far back to wound any large branch of the duct, and is too low down to wound the facial nerve. If it is desired to carry the incision higher than the lobule of the ear, it should go through the skin only. The facial artery and vein will be cut just in front of the masseter muscle.

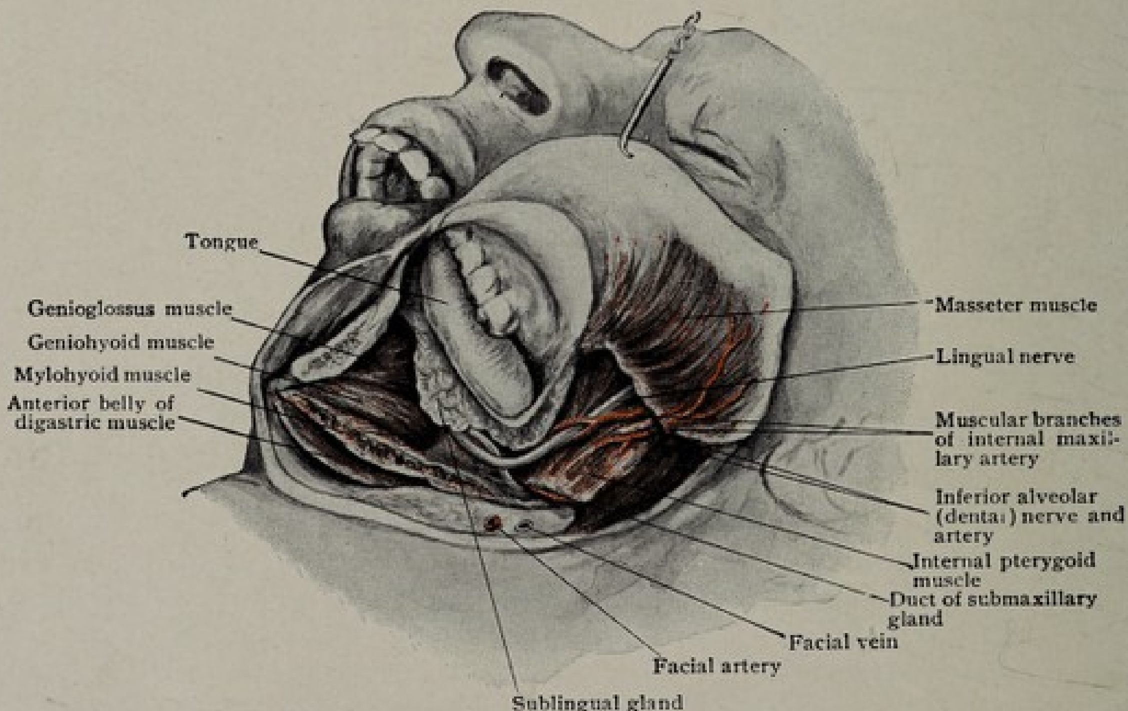


Fig. 97.—Excision of one-half of the lower jaw, showing the structures exposed.

The soft parts, including the masseter muscle, are raised from the outer surface. In dividing the bone anteriorly, it should be done 0.5 cm. outside the median line. This will be about through the socket of the second incisor. The object of this is to retain the attachments of the geniohyoid and geniohyoglossus muscles to the genial tubercles, and so prevent any tendency of the tongue to fall back. The jaw is pulled out and separated from the parts beneath, the mylohyoid muscle being made tense. Care should be taken not to injure the submaxillary gland, which lies below the mylohyoid muscle, and the sublingual gland, which lies above it. The lingual nerve is also liable to be wounded if the knife or elevator is not kept close to the bone.

As the detachment proceeds posteriorly, in loosening the internal pterygoid and the superior constrictor, if care is not taken, the pharynx may be wounded. The bone still being depressed and turned outward, the temporal muscle is to be loosened from the coronoid process or else the process is detached and removed later. Access is now to be had to the mandibular foramen at the mandibular spine or spine of Spix. The inferior alveolar artery is then secured and, with the nerve and spheno-mandibular ligament, divided. The jaw can now be well depressed and brought inward. The temporo-maxillary joint is to be opened from the front, having first cleared off the attachment of the external pterygoid muscle. There is great danger of wounding the internal maxillary artery at this stage of the operation. It lies close to the neck of the jaw, and it is to avoid bringing it too close to the bone that Jacobson advises that the jaw be not twisted outward when disarticulation is being performed.

The distance between the coronoid process and malar bone varies in different individuals. The process may be displaced by the tumor and thus prevent detachment of the temporal muscle. If so, the process is divided with forceps or saw and removed after the rest of the jaw has been taken away. Injury of the temporo-maxillary veins may be avoided by not going behind the posterior edge of the ramus, as is also the case with the external carotid artery. Access to the joint may be facilitated by dragging upward the parotid gland, which carries with it the facial nerve and parotid duct.

REGION OF THE EYE

The **eyeball** rests in its socket, which is hollowed out of the soft parts contained in the bony orbit. It is covered in front by the *lids*, which, as they slide over the eye, are lubricated by the tears. These are secreted by the *lachrymal gland* at the upper outer portion of the orbit, flow over the eye, and are drained off by the *lachrymal canals* and *sac* to empty into the nose through the *lachrymonasal duct*.

The Orbits.—The orbits are large four-sided cavities, pyramidal in shape. The orbit in an adult male is about 4 cm. in diameter from side to side, and 3.5 cm. from above downward. The depth is 4.5 cm. It is thus seen that the orbit is wider than it is high. On receding into the orbit from its bony edge, the roof arches upward toward the brain to receive the lachrymal gland, thus making the up-and-down diameter slightly longer than the transverse.

The rim of the orbit is very strong and not readily broken by injuries. It is formed by the frontal bone above, the malar bone to the outside, the malar and superior maxillary below, and the superior maxillary and frontal to the inside. The inner (medial) walls of the two orbits are parallel, running distinctly antero-posteriorly. The outer (lateral) walls diverge at an angle of about 45° from the inner ones.

The outer or lateral edge of the orbit is nearly or quite a centimetre and a half posterior to the inner or medial edge. This fact, together with the divergence of the outer wall, is the reason that, in enucleation of the eye, it is always tilted toward the nose, and the scissors introduced and the nerve cut from the outer side.

The outer wall of the orbital cavity is formed mainly by the broad flat surface of the greater wing of the sphenoid bone, and is thick and strong. The other three walls, on the contrary, are thin and weak. The thin orbital plate of the frontal bone above is frequently fractured in puncture wounds by foreign bodies, and the frontal lobe of the brain injured.

To the medial side of the inner wall are the *ethmoid cells*, covered by the thin lachrymal bone and the os planum of the ethmoid. They are readily perforated by suppuration from within those cavities. The floor is chiefly formed by the thin

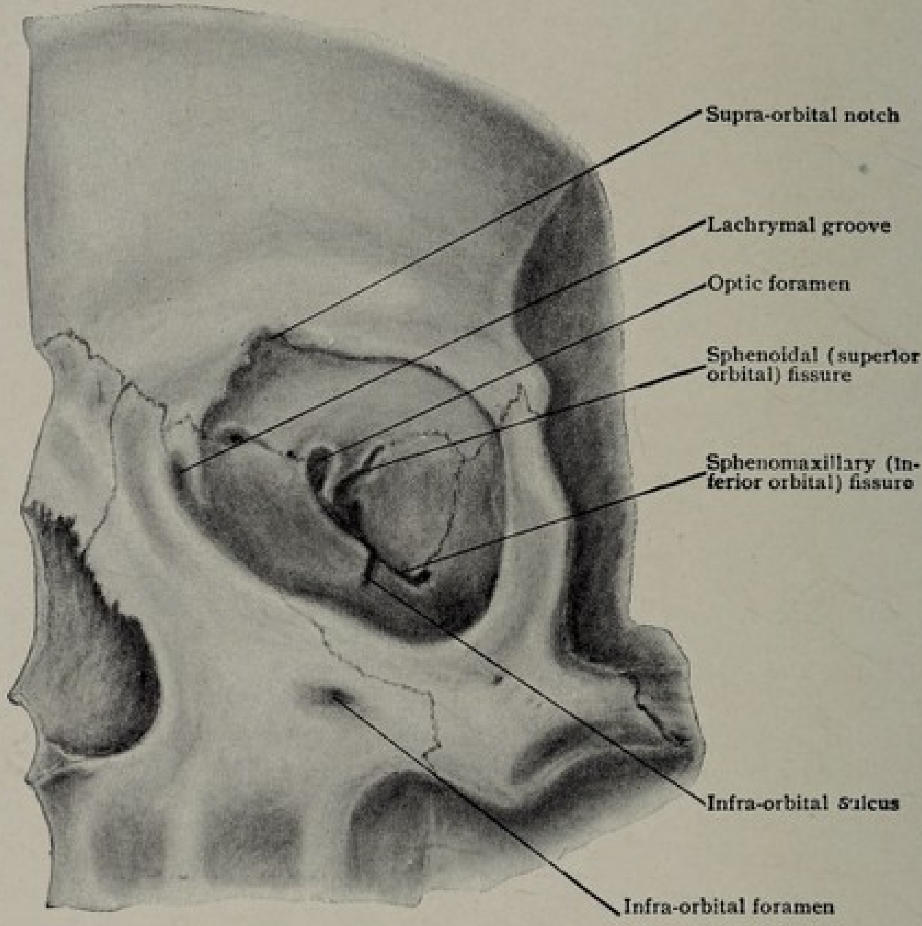


FIG. 98.—The bony orbit.

orbital plate of the superior maxilla. In operations involving the floor of the orbit, care is necessary to avoid breaking through into the maxillary sinus (antrum) beneath.

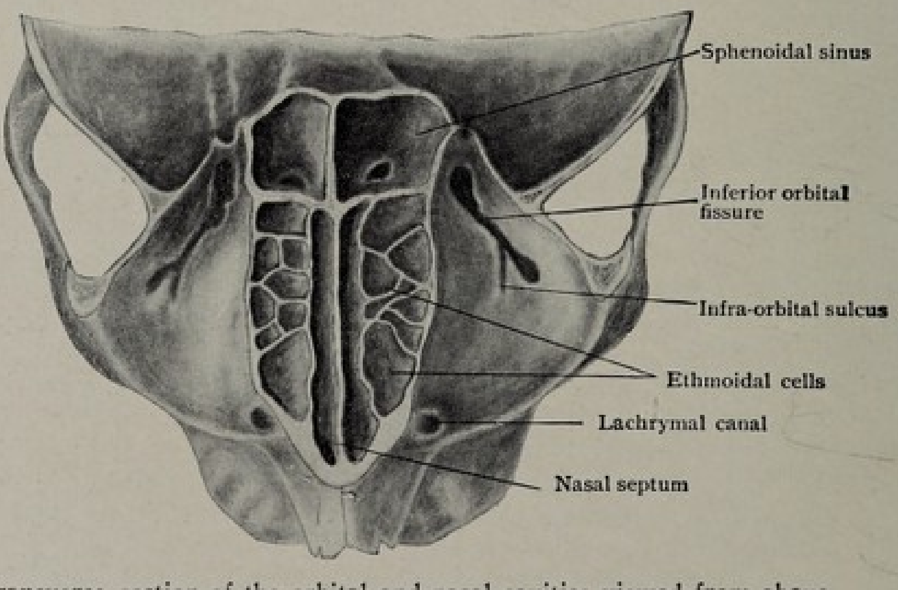


FIG. 99.—Transverse section of the orbital and nasal cavities viewed from above.

At the edge of the junction of the outer and lower walls lies the *inferior orbital* (*sphenomaxillary*) *fissure*. It runs forward to within 1.5 cm. of the edge of the orbit and extends back to the apex of the orbit, where it unites with the *superior orbital (sphenoidal) fissure,* which lies between the roof and outer wall and extends forward about one-third of the distance to the edge of the orbit. The *optic foramen* enters the apex of the orbit at its upper and inner portion.

At the lower inner edge of the orbit is the lachrymal groove for the lachrymo-nasal duct, leading from the eye to the inferior meatus of the nose. At the junction of the middle and inner thirds of the upper edge is the *supra-orbital notch.* This can be felt through the skin. It transmits the *supra-orbital artery* and *nerve.* If a complete foramen is present instead of a notch, its location cannot be so readily determined.

Contents of the Orbit.—The orbit is lined with a periosteum, and contains the eyeball, the muscles which move it, the veins, arteries, and nerves which go to it together with some which traverse the orbit to go to the face, and the lachrymal

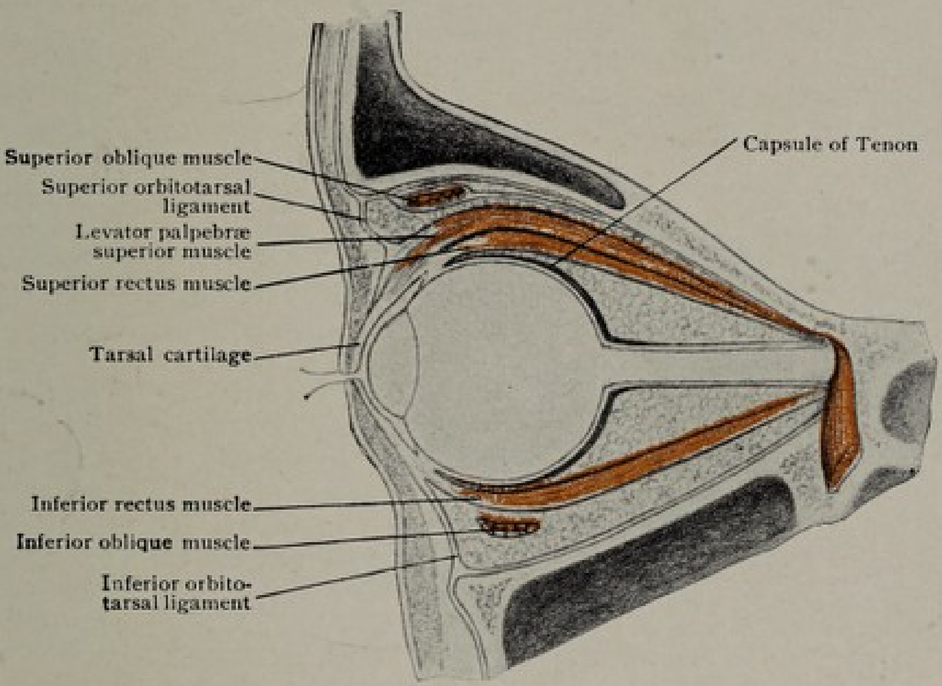


FIG. 100.—Sagittal section through the eye and orbit.

gland. These structures are more or less surrounded with a fascia which is continuous with the periosteum.

Periosteum.—The periosteum of the orbit is not tightly attached and in cases of disease can readily be raised from the bone beneath. Anteriorly, it is continuous at the orbital rim with the periosteum of the bones of the face. Posteriorly, it is continuous through the optic foramen and sphenoidal fissure with the dura mater. It sends prolongations inward, covering all the separate structures in the orbit. From the edge of the orbit it stretches over to the tarsal cartilages, forming the *superior* and *inferior orbitotarsal ligaments.* These form a barrier (called the *septum orbitale*) to the exit of pus from within the orbit, and for that reason it is advised that orbital abscesses should be opened early. The lower portion, as it reaches the lachrymal groove, splits to cover the lachrymal sac. Another extension from above splits to enclose the lachrymal gland, which is seen to lie comparatively loose in the upper outer portion of the orbit, sustained by its suspensory ligament. It then sends thin fibrous layers which cover the muscles, arteries, veins, nerves, fat pellicles, and finally the eyeball posterior to the insertion of the muscles and optic nerve. This last portion, called the *capsule of Tenon,* begins as far forward as the insertion of the recti muscles on their under (inner) side, passes over the globe posteriorly, over the optic nerve, and blends with the layer covering the deep surface of the muscles. It is joined to the sclerotic coat of the eye and dural sheath of the nerve by a loose net-work of delicate fibrils. This forms practically a space lined with endothelial plates, similar to the subarachnoid space in the brain. The capsule of Tenon is a distinct, well marked membrane, and the eyeball lies loose and revolves freely within it. It is this space into which the strabismus hook is put when it is desired to cut the recti muscles for squint. Fibrous prolongations are also sent to the sides of the orbit from the internal and external recti muscles. They are the *check ligaments*; and one from the inferior rectus forms the suspensory ligament of the eye.

Affections of the Orbit.—The orbit is often invaded by tumors, pus, hemorrhages, and air (producing emphysema).

Tumors may either originate in the orbital contents, as sarcomas of the lachrymal gland or eye, or they may come from surrounding regions. It is more rare for them to enter through the natural openings of the orbit than it is for them to push through its thin walls. Coming through natural openings, they may make their entrance: (1) from the brain through the optic foramen or sphenoidal fissure; (2) from the region of the zygomatic and temporal fossæ through the sphenomaxillary fissure; (3) from the nasal cavities, coming up the lachrymonasal canal.

In invading the orbit through its walls they may come: (1) from the nasal cavities and ethmoidal cells, pushing through the thin internal wall; (2) from the frontal sinus, appearing at the upper inner angle; (3) from the sphenoidal cells at the posterior portion of the inner wall; (4) from the brain cavity above, breaking through the roof; (5) from the maxillary sinus below, pushing through the floor.

FIG. 101.—Dermoid of orbit. Boy, 15 years of age. It extended back to the body of the sphenoid bone. Case of Dr. Wm. Zentmayer.

Dermoids.—In the fœtus, the frontonasal process comes from above downward to join the maxillary processes on each side. This leaves an orbitonasal cleft to form the orbit. Owing to defects in the development of this cleft, dermoid tumors may occur in its course. They are seen either at the outer or inner angle of the eye. They are more common at the outer angle near the external angular process, and may have a prolongation to the dura mater. They also occur at the inner angle at the frontonasal suture (Fig. 101). At this point, also, meningoceles are liable to occur. As pointed out by J. Bland Sutton the question of diagnosis is of importance, as an attempt to remove a meningocele by operation is apt to be followed by death, whereas a dermoid, though it may have a fibrous prolongation to the dura mater, can be more safely removed.

Orbital Abscess.—Suppuration may either originate within the orbit or extend into it from the neighboring tissues. If the former is the case, it may occur from caries of the bones of the orbit, as in syphilis. It may originate from erysipelas involving the orbit. General inflammation and suppuration of the eye may break through the eye and spread in the orbital tissues (panophthalmitis). If pus enters the orbit from the outside, it is usually from suppuration and caries of the frontal sinus and ethmoidal cells. In this case, the swelling shows itself at the upper portion of the inner angle of the eye. Pus in the maxillary sinus is most apt to discharge into the nose, and not break through the roof into the orbit above. Pus within the orbit tends to push the eyeball forward and even distend the lids. As the orbitotarsal ligament runs from the bony edge of the orbit to the lids, pus does not find an easy exit. The abscess should be opened by elevating the upper lid, and incising the conjunctiva in the sulcus between the globe of the eye and the lid. Pus from suppuration of the lachrymal sac does not tend to invade the orbit but works its way forward to the skin.

Foreign Bodies in the Orbit.—Owing to the considerable space which exists between the eye and orbital walls, large foreign bodies may find a lodgment there, often producing serious symptoms for a considerable length of time. The tang of a gun barrel has been so found. This should lead one to search for foreign bodies carefully when this portion of the orbital contents has been wounded.

Emphysema.—In cases of fracture involving the inner wall and opening up the nasal cavities or sinuses the air, particularly in blowing the nose, may be forced into the orbit, distending the lids and producing a peculiar crackling sensation when

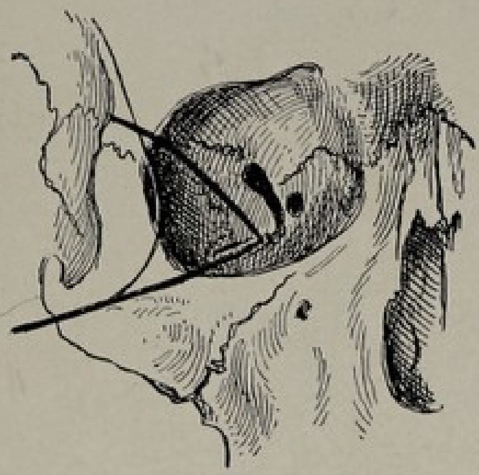


FIG. 102.—Lines of the skin incision. (Krönlein's operation for obtaining access to the retrobulbar region.)

palpated. No treatment directed to removal of the air is necessary. It is valuable as a diagnostic sign of fracture communicating with the nasal cavities.

Hemorrhage.—Hemorrhage into the orbit may occur either as the result of direct traumatism involving the contents, or from fracture of the base of the skull through the orbital plate. The blood pushes its way anteriorly and shows itself under the conjunctiva surrounding the cornea. It is prevented from appearing on the lids by the orbitotarsal ligament. A subconjunctival hemorrhage alone is

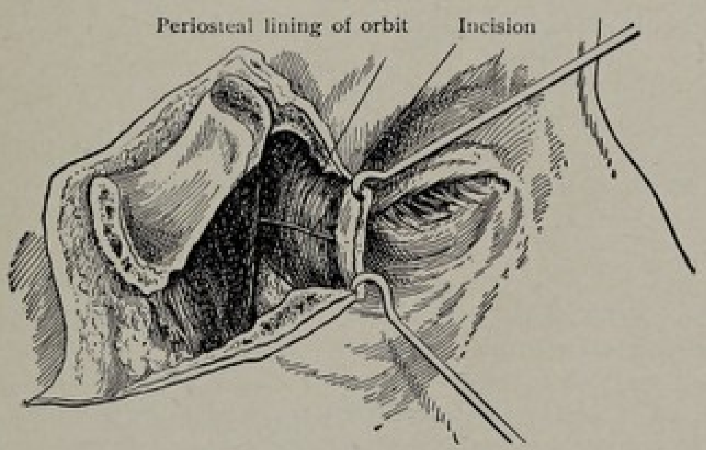


FIG. 103.—The rim of the orbit has been divided and the piece of the bone turned outward; an incision is then made through the periosteal lining. (Krönlein"s operation for obtaining access to the retrobulbar region.)

not sufficient to justify a diagnosis of fracture of the base of the skill, although it is a significant confirmatory symptom.

Krönlein's Operation.—In order to gain access to the back part of the orbit to remove tumors, Krönlein resects the outer wall, divides the periosteum and external rectus muscle, and so gains access to the retrobulbar space. The operation consists of dividing the soft parts with a curved incision (as is shown in Fig. 102) commencing above the supra-orbital margin to the upper edge of the zygoma and thence along this to its centre. The convexity of the incision is toward the orbit. The middle of the incision is bisected by the horizontal line from the outer canthus to the outer orbital margin. The incision should be sufficiently deep at its centre to expose the orbit. An elevator is introduced in this area and the periosteum is separated from the outer orbital wall. The inferior orbital fissure is then found and at its anterior end a chisel or electric saw is introduced so as to cut through the outer wall of the orbit. The wall is cut through upward and outward to a point above the external angular process of the frontal bone, the incision being nearly along the suture between the malar bone and the great wing of the sphenoid and forward and externally over the outer surface of the malar bone in a line above the insertion of the zygomatic arch. This mobilizes a wedge-shaped piece of bone, giving free access to the orbit.

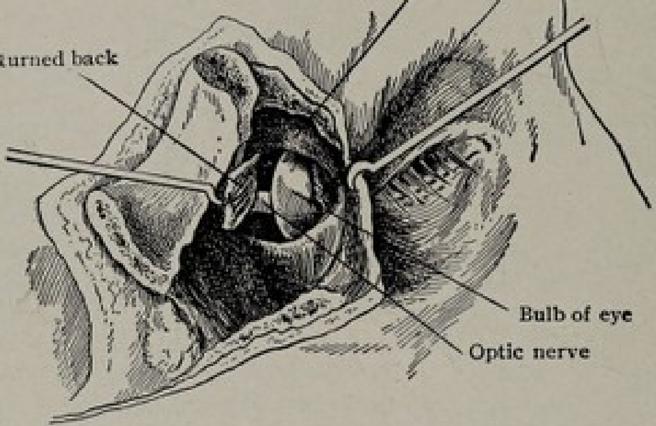


FIG. 104.—The edges of the incised periosteum have been separated and the external rectus muscle divided, exposing the space posterior to the bulb. (Krönlein's operation for obtaining access to the retrobulbar region.)

Gifford has recommended a resection of the outer wall of the orbit as a substitute for the Krönlein operation. Either procedure is applicable for the removal of intra-ocular tumors or cysts; especially if the lesion is retro-orbital.

THE EYEBALL AND OPTIC NERVE

The eyeball has three main coats, viz.: a fibrous outer coat, called the sclerotic; a vascular middle coat, the choroid; and a nervous inner coat, the retina.

Sclerotic Coat.—The sclerotic coat forms a firm protective covering or case for the delicate retina within. It is continuous posteriorly with the fibrous coat or dura of the optic nerve, which is a continuation of the dura mater of the brain. At the optic foramen, the dura mater splits into two layers; the outer layer forms the periosteum, while the inner forms the dural coat of the optic nerve. This nerve also, like the brain, has an arachnoid and a pial membrane. The sclerotic coat is continued forward over the front of the eye as the *cornea*. As it is essentially a membrane intended to be protective in its function, its diseases are those of weakness: thus, if the cornea is affected, it bulges forward and is called an *anterior staphyloma*; if the posterior part is affected, the sclera is stretched, and it forms a *posterior staphyloma*.

Anterior staphyloma may occur either rapidly as a small local protrusion, resulting from ulceration of the cornea or a wound, or it may be slow in forming, and involve nearly or quite the whole of the cornea, pushing it forward in the shape of a cone; this is called *conical cornea*. Posterior staphyloma occurs in near-sighted people, the anteroposterior diameter of the eye being longer than normal. If this posterior staphyloma or stretching of the eye becomes marked, the choroid atrophies and the functions of the retina are lost. The white sclera is seen with the ophthalmoscope, surrounding or to one side of the optic nerve.

Although the cornea has no blood-vessels, it still, from its exposed position, becomes inflamed (*keratitis*) and ulcerated, and eventually blood-vessels may develop into it from its periphery, constituting the disease known as *pannus*.

The weakest portion of the globe is at the junction of the sclerotic coat with the cornea. It is here that the sclera is thinnest. On this account, blows on the eye cause it to rupture usually at this point, the tear incircling the edge of the cornea for a variable distance (usually at its upper and inner quadrant) according to the force and direction of the injury. On healing, a staphyloma may form at this point.

The **choroid** or vascular coat of the eye contains the *pigment* or *color* of the eye. It is continued forward as the *ciliary body* (or processes) and *iris*. Being a vascular tissue, its diseases are inflammatory. If the choroid is affected we have *choroiditis*; if the ciliary region is inflamed, it is called *cyclitis*; and if the iris is inflamed we have *iritis*.

The **retina** or nervous coat of the eye is concerned in the function of sight and it, like other nerves, may be affected with inflammation, called retinitis. Sometimes

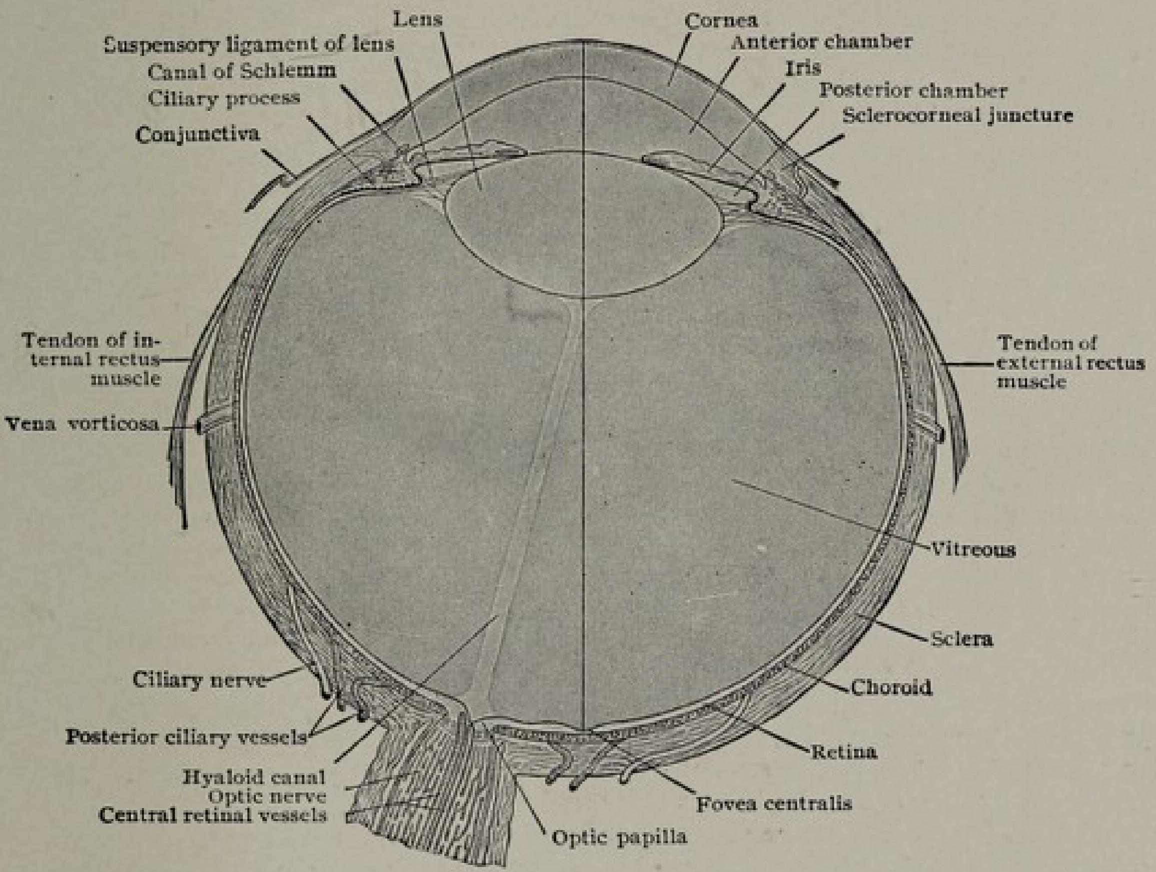


FIG. 105.—Diagrammatic horizontal section of right eye. × 3½. (Piersol.)

it becomes loosened from the choroid beneath by a hemorrhage or rapid stretching of the sclera, constituting a *detachment of the retina*. Outside the disk is the *macula lutea* and fovea centralis or region of distinct vision.

Filling the interior of the eye is the jelly-like transparent *vitreous humor*, enclosed in the *hyaloid membrane*. In front of the vitreous humor is the *lens*; and the clear, limpid liquid between the anterior surface of the lens and the posterior surface of the cornea is the *aqueous humor*.

The **lens**, immediately behind the iris, is suspended in its capsule from the ciliary processes by its suspensory ligament or *zone of Zinn*. Between the ciliary processes and the sclera lies the *ciliary muscle*, which regulates the accommodation or focussing power of the eye. The ciliary processes are formed of convoluted blood-vessels supported by connective tissue and covered by the pigmented extension of the retina. This ciliary region is an exceedingly sensitive one and a serious wound of it usually means a loss of the eye.

Cataract.—When the lens is opaque it constitutes the disease known as cataract: this name is also applied to opacities of the capsule of the lens. When the lens alone is opaque it is called a *lenticular cataract*; when the capsule alone is affected, it is a *capsular cataract*. Both are sometimes involved, constituting a *lenticulo-capsular cataract*. The lens is made up of layers like an onion. Some of these layers may become opaque, leaving a surrounding rim of clear tissue. The nucleus within the affected layer is also clear. This form is called a *zonular* or *lamellar cataract*. A capsular cataract may affect the anterior portion of the capsule, forming an *anterior polar cataract*, or the posterior layer of the capsule, forming a *posterior polar cataract*.

If the cornea has been perforated by a central ulceration, the aqueous humor escapes, the lens falls forward, and its anterior capsule becomes adherent at the site of perforation. As the aqueous humor reaccumulates, it pushes the lens back, leaving a small portion of inflammatory tissue clinging to its anterior capsule, thus forming an anterior polar cataract. A posterior polar cataract is the result either of disease, such as *choroiditis*, in which the posterior capsule becomes involved, or of a persistence of the remains of the *hyaloid artery*, a fetal structure.

Secondary cataracts are the opacities of the capsule or inflammatory bands and tissues which are left, or which occur, after the removal of the lens. The lens in childhood is soft; it grows harder as age increases. If the aqueous humor obtains access to the lens through a wound of the anterior capsule, the lens becomes opaque, constituting a *traumatic cataract*. In operating for cataract in childhood, the lens, being soft, is first rendered opaque by the aqueous humor admitted through a puncture made in the capsule; if it is admitted repeatedly to the lens by the surgeon's needle (needling or discission operation) the lens matter is completely dissolved. The fluid lens matter can also be removed by a suction instrument. In old people the nucleus becomes hard and opaque, forming a *senile cataract*. The aqueous humor does not dissolve the opaque lens after the age of thirty-five years. Senile cataract rarely occurs before the forty-fifth year, so there is a period of ten years in which a cataract may be a nuclear cataract without being senile.

To remove a nuclear or a senile cataract, a slit is made through the cornea near its scleral junction, a piece of the iris may (or may not) be removed, the anterior capsule is cut with a cystotome and the opaque lens pressed out through the opening so made, then through the pupil (either artificial or dilated with atropine), and finally through the sclerocorneal incision. The posterior capsule is not injured, and it prevents the vitreous humor from escaping. If inflammation follows the operation, the iris and ciliary region throw out lymph and the remains of the capsule become opaque, forming a secondary or capsular cataract. This is removed by tearing or cutting it across with needles or extremely fine scissors. In the Smith Indian operation the lens is delivered in its capsule.

Iris.—The iris is the continuation of the choroid through the ciliary body, and extends down to the pupil, its free edge resting on the anterior surface of the lens. The iris is composed of a vascular and fibrous anterior portion, and a muscular and pigmented posterior portion. In consequence of its vascularity, the iris is the frequent site of inflammation. When inflamed it pours out lymph which may cause it to adhere to the lens behind, forming a *posterior synechia*. An *anterior synechia* is where, on account of a perforation of the cornea, the iris washes forward and becomes attached to the cornea in front.

The circular muscle fibres surrounding the pupil are anterior, and form the *sphincter pupillæ muscle*; it contracts the pupil. The radiating muscular fibres, which lie posteriorly, form the *dilator pupillæ*; it dilates the pupil. The dark pigment layer is on the posterior surface of the iris, and after an attack of iritis, as the adherent iris is torn loose from the lens, it leaves patches of pigment adhering to the anterior capsule.

The iris, as it rests at its pupillary margin on the lens, divides the space anterior to the lens into two parts. The part between the posterior surface of the iris and the anterior surface of the lens forms the *posterior chamber*. The *anterior chamber* lies between the anterior surface of the iris and the posterior surface (*Descemet's* *membrane*) of the cornea. The two chambers communicate through the pupil. The anterior surface of the iris toward its periphery is of the nature of a coarse mesh-work, the spaces of which are the *spaces of Fontana*. They communicate with a venous or lymph canal which passes around the eye at the sclerocorneal junction (*canal of Schlemm*).

Aqueous Humor and Anterior Lymph Circulation.—The aqueous humor is of the nature of lymph. It is secreted by the ciliary processes and posterior surface of the iris. It passes through the pupil to the anterior chamber, and enters the spaces of Fontana to empty into the canal of Schlemm. The canal of Schlemm empties its contents into the anterior ciliary veins. In iritis and glaucoma the lymph-

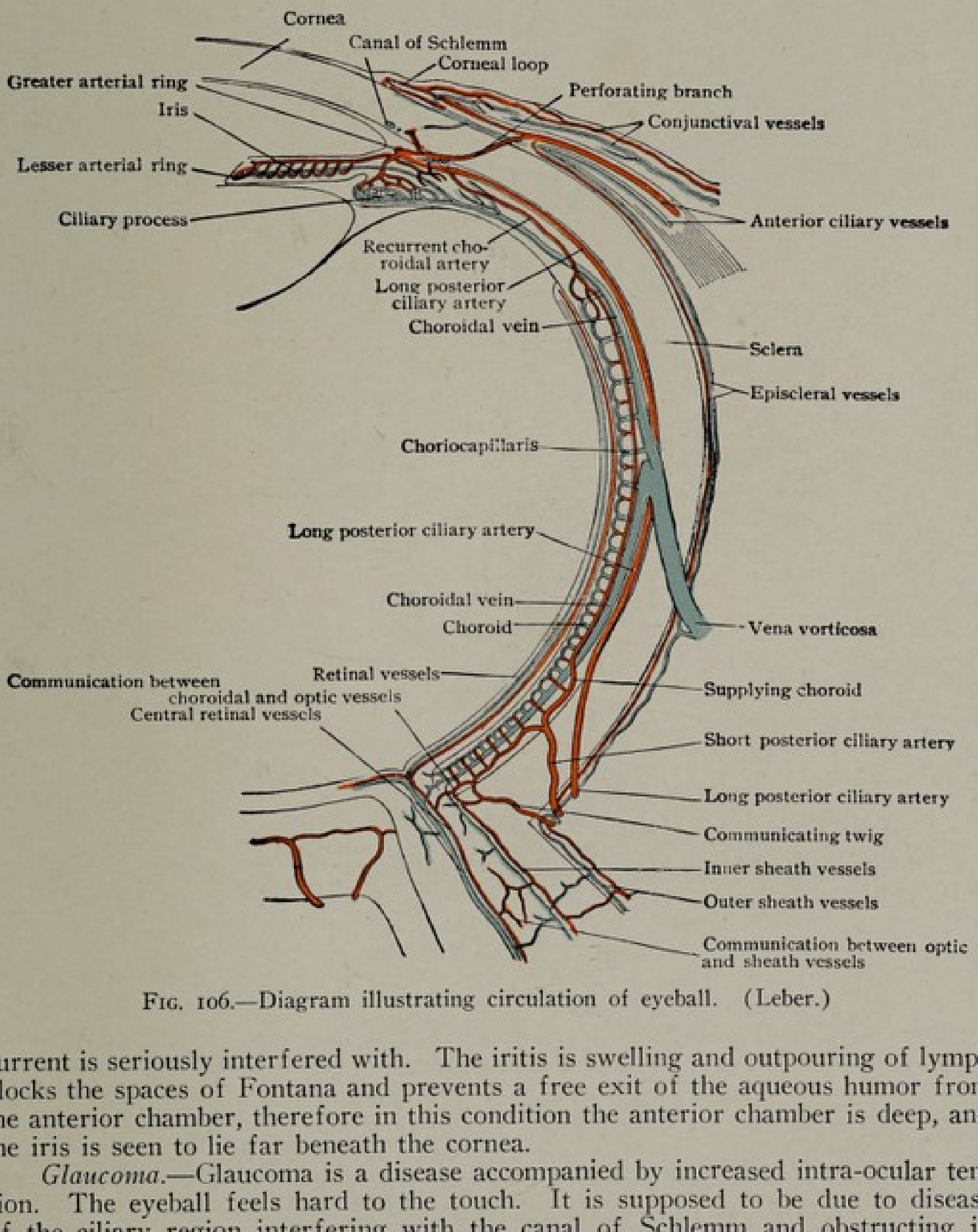


Fig. 106.—Diagram illustrating circulation of eyeball. (Leber.)

current is seriously interfered with. The iritis is swelling and outpouring of lymph blocks the spaces of Fontana and prevents a free exit of the aqueous humor from the anterior chamber, therefore in this condition the anterior chamber is deep, and the iris is seen to lie far beneath the cornea.

Glaucoma.—Glaucoma is a disease accompanied by increased intra-ocular tension. The eyeball feels hard to the touch. It is supposed to be due to disease of the ciliary region interfering with the canal of Schlemm and obstructing it. Therefore, the drainage of the eye and the circulation of the aqueous humor is interfered with. In iritis the anterior chamber becomes deeper, but in glaucoma, as the intra-ocular tension increases, it pushes the lens forward, and it is seen to lie close up to the cornea; so that a shallow anterior chamber causes the ophthalmologist to suspect glaucoma and a deep anterior chamber iritis. The increased pressure within the eye pushes the optic nerve backward at its point of entrance, so that it is seen sunk below the surface of the adjoining retina, forming a distinct cup-shaped cavity or pit. This is *cupping of the disk.*

Optic Nerve.—The optic nerve reaches from the *optic chiasm* to the eyeball, a distance of about 5 cm. (2 in.). It enters the apex of the orbit through the optic foramen at the upper inner angle, in company with the ophthalmic artery. The artery crosses the under surface of the nerve from its inner to its outer side. The optic nerve has as its covering a prolongation of the membranes of the brain. The dura mater when it reaches the foramen splits and gives one layer to form the periosteum lining the orbit and the other to form a fibrous sheath of the nerve. This arrangement prevents pus, forming in the orbit, from passing through the optic foramen into the skull. The *arteria centralis retinæ* enters the nerve on its

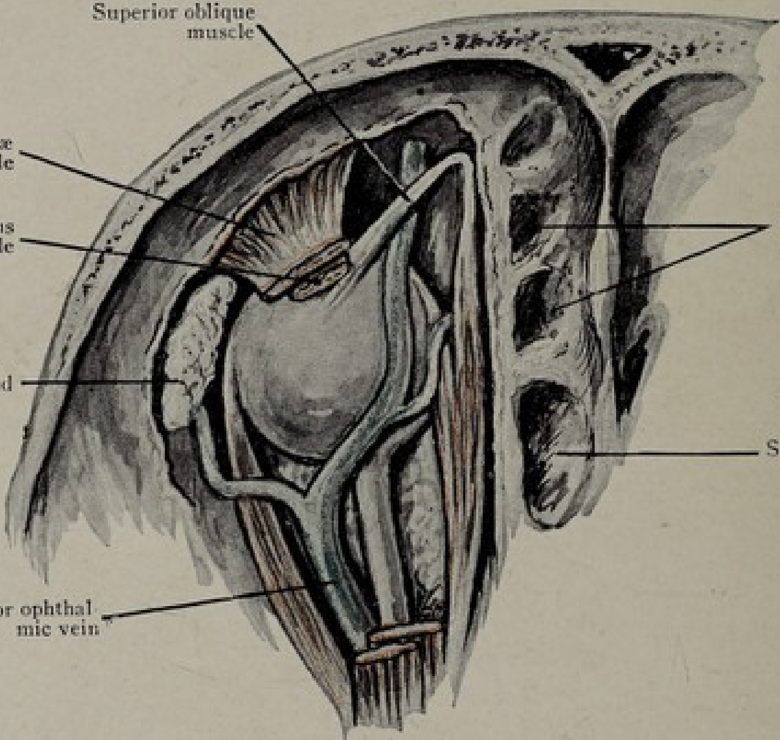


FIG. 108.—The roof of the orbit has been removed, showing the contents.

under side and passes through its centre to the interior of the eye. The nerve itself is covered with a fine pial membrane and an arachnoid separating it from the dura, thus forming subdural and subarachnoid spaces. As these membranes and spaces are continuous with those of the brain, hemorrhage or serous effusions occurring within the brain can thus find their way into the sheath of the nerve.

As the nerve enters the eye, it is contracted and forms the *optic disk* or *papilla.* It is readily seen with the ophthalmoscope as a round spot somewhat lighter in color than the surrounding eyeground. Coming from a depression or cup in the disk, called the *porus opticus,* are the retinal arteries and veins. A certain amount of cupping is normal, but if wide and deep, with overhanging edges over which the vessels can be seen to dip, it is indicative of glaucoma.

Sometimes the papilla or disk is swollen, constituting an *optic neuritis.* In brain tumor this is frequently the case and is called *choked disk,* or *"papilledema,"* so named because the circulation was thought to be interfered with owing to the intracerebral pressure being transmitted directly to the nerve. On the subsidence of a severe neuritis the nerve is left in a state of optic atrophy and blindness is the result.

Muscles of the Orbit.—Six muscles are connected with the eyeball, four straight and two oblique. One muscle, the *levator palpebræ,* goes to the lid. The

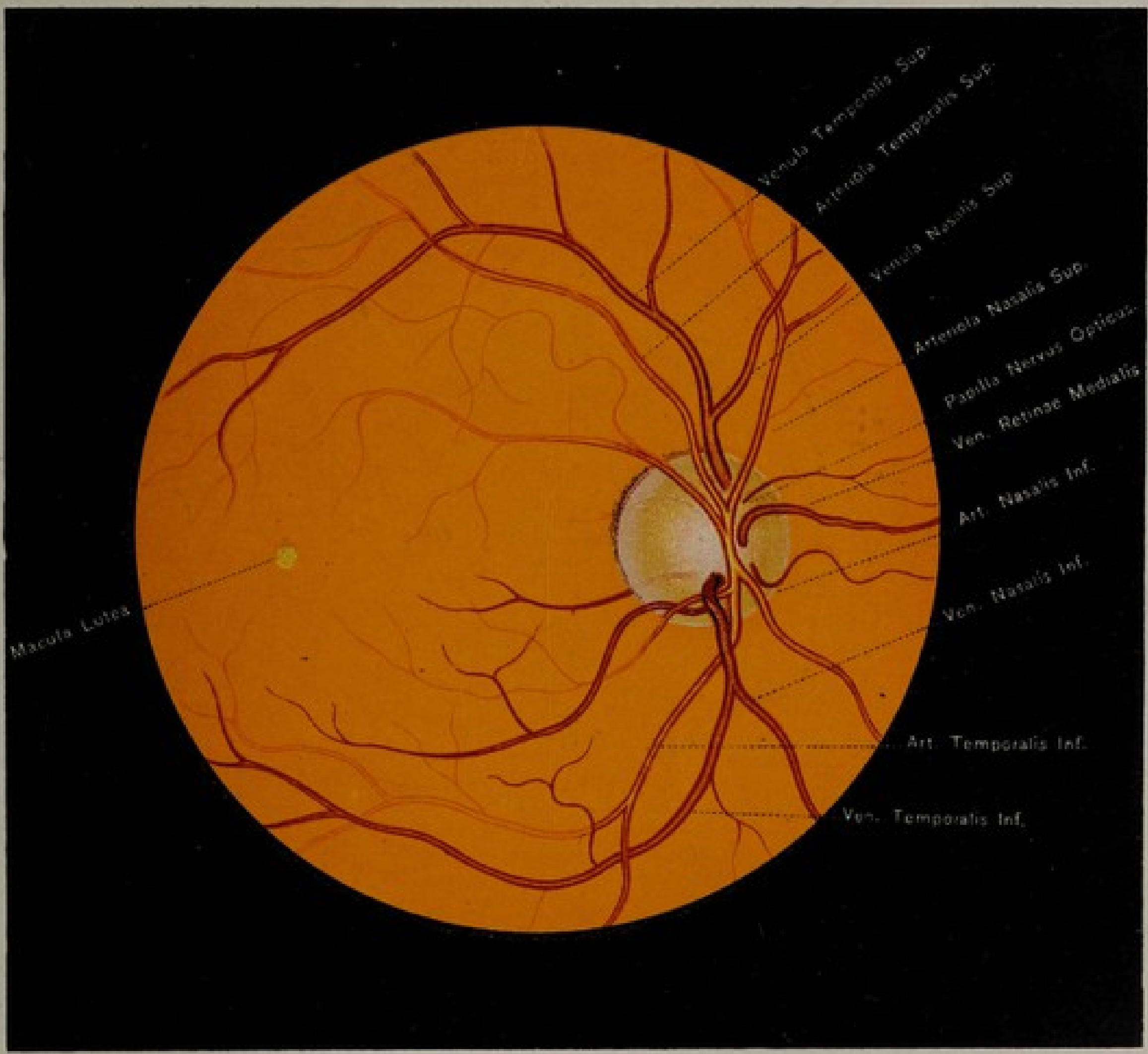


FIG. 107. NORMAL HUMAN FUNDUS OCULI, SHOWING OPTIC PAPILLA AND BLOOD VESSELS; ALSO THE MACULA LUTEA. DRAWN BY MR. LOUIS SCHMIDT.

four recti muscles, *superior, inferior, external* (lateral) and *internal* (medial), arise from a common tendinous origin, forming a ring or tube called the *ligament of Zinn*. This ligament or tube surrounds the optic foramen and is attached to the opposite side of the sphenoidal fissure. Through it run the optic nerve and ophthalmic artery, the third, fourth, and the nasal branch of the ophthalmic (fifth) nerve.

The *levator palpebræ superious*, and *superior oblique arise* to the inner side and above the optic foramen close to the origin of the other muscles. The superior oblique, after passing through its trochlea or pulley at the inner upper angle of the orbit, continues downward, backward, and outward between the superior rectus and the eye, to be inserted above the extremity of the inferior oblique.

The *inferior oblique* arises from the anterior edge of the orbit just to the outer side of the lachrymal groove. It passes outward, upward, and backward, over the external surface of the inferior rectus, to be inserted beneath the external rectus.

The *recti muscles* insert into the sclera 5 to 7 mm. back from the cornea. In the operation for internal squint or strabismus, the internal rectus muscle is cut. It possesses the longest tendon of insertion, while the external possesses the shortest. The recti muscles pull the eyes toward their respective sides. The superior oblique turns the cornea down and out and rotates it inwardly. The inferior oblique turns the cornea up and slightly out and rotates the eye outward. A disarrangement of any of these muscles produces diploplia or double vision.

Blood-Vessels of the Orbit.—The arteries of the orbit are derived from the *ophthalmic artery*, which breaks up into its various branches soon after it passes through the optic foramen. In enucleation of the eye there is practically no bleeding, because the *arteria centralis* is the only one divided, and it is small. In evisceration, or cleaning out of the contents of the orbit, the main trunk of the ophthalmic will not be cut unless the very apex is invaded. Hemorrhage is readily controlled by packing gauze into the orbital cavity.

The veins of the orbit are the *superior* and *inferior ophthalmic*. The former is much the larger and more important. It not only drains the upper portion of the orbit, but communicates directly with the angular branch of the facial, at the inner canthus of the eye. The infection of erysipelas sometimes travels along these veins directly from the nose, face, and scalp without, to the cavernous sinus and meninges within, causing thrombosis and death. The inferior ophthalmic usually empties into the superior; its anastomoses at the anterior portion of the orbit with the veins of the face are much smaller and, therefore, not nearly so dangerous.

Nerves of the Orbit.—The *optic nerve* is the nerve of sight. Interference with it produces blindness. The *oculomotor* or *third nerve* supplies all the muscles of the orbit except the external (lateral) rectus and superior oblique. The lateral rectus is innervated by the abducent or sixth nerve, the superior oblique by the trochlear or fourth nerve. If the oculomotor is paralyzed, the eye cannot be moved upward, inward, or to any extent downward. There will be ptosis of the upper lid from paralysis of the levator palpebræ, and dilatation of the pupil and paralysis of the accommodation of the eye. If the *sixth* or *abducens* is paralyzed, the eye cannot be turned outward. If the *fourth* or *trochlear* is paralyzed, the superior oblique fails to act, and the double vision produced is worse when the patient looks down, because it is normally a depressor muscle. The *lachrymal, frontal*, and *nasal branches of the fifth* are nerves of sensation, hence, in supra-orbital neuralgia and that affecting the nasal branch, pain is felt in the orbit at the inner angle of the eye and down the side of the nose.

Retina.—On the interior of the eye, the expansion of the optic nerve forms the retina. The retina is divided into two lateral halves, each supplied by a corresponding half of the optic nerve. When the nerve reaches the optic chiasm it splits into two parts, one (internal fibres) going to the opposite side of the brain, and the other (external fibres) to the ganglia on the same side of the brain. Posterior to the chiasm, the nerve fibres form the optic tracts. The optic tracts, after leaving the chiasm, wind around the crura cerebri to the external geniculate bodies, thence they pass to the thalami and anterior corpora quadrigemina, and are continued backward into the cuneus lobule of the occipital lobe of the brain.

It will thus be seen that a lesion affecting any portion of the optic pathway posterior to the chiasm will produce blindness of one-half of the retina of both eyes on the side of the injury; a right-sided lesion will produce blindness of the right half of both retinæ, and a lesion on the left side, blindness of the left half of both eyes. This is called *hemianopia*. It is *right lateral hemianopia* if the right half of the visual fields is affected, and *left lateral* if the left sides are affected. Affections of the optic nerve produce total blindness of that eye if the whole nerve is involved.

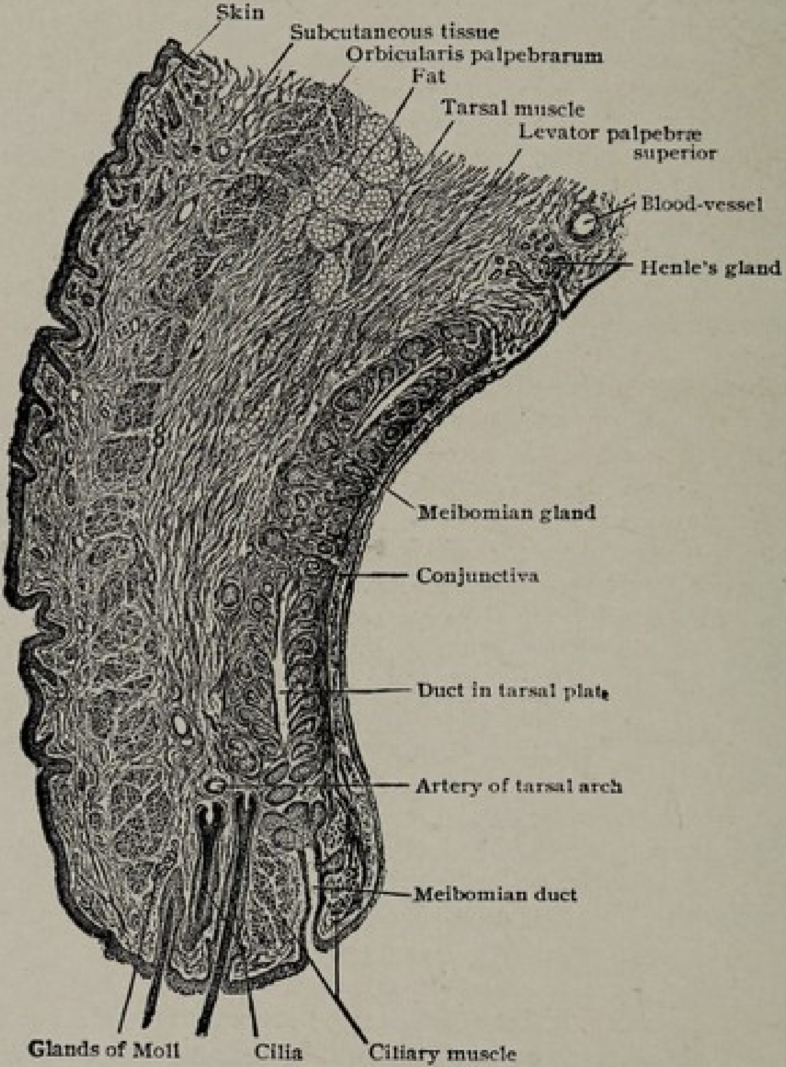


FIG. 109.—Vertical section of upper eyelid of child. × 15. (Piersol.)

If only a part is involved, then a *unilateral hemianopia* may ensue. A *bitemporal hemianopia* may be caused by a tumor involving the anterior or middle portion of the chiasm. A *binasal hemianopia* requires a symmetrical lesion on the outer side of both optic nerves or tracts. A brain tumor located in the cuneus lobule would cause a lateral hemianopia of the same side, right or left, of both visual fields, hence sometimes called *homonymous*.

The Eyelids and Conjunctiva.—The eyelids are composed of five layers, viz: (1) *skin*, (2) *subcutaneous tissue*, (3) *orbicularis palpebrarum muscle*, (4) *tarsal cartilage* with the contained *Meibomian glands*, (5) the *conjunctiva*. The juncture of the two lids at each end is called the inner and outer *canthus*.

The skin of the lids is thin and the subcutaneous tissue loose and devoid of fat. For these reasons blood finds its way readily into the lids and shows plainly beneath the skin, constituting the familiar "black eye." The skin lends itself readily to plastic operations, as it is easily raised and the gap left can be readily closed. The blood supply of the lids is abundant, so that the flaps are well nourished and sloughing is not apt to occur. The folds in the skin run parallel to the edge of the lids, therefore the incisions should be made as much as possible in the same direction. The orbicularis palpebrarum muscle passes circularly over the lids and lies on the tarsal cartilage toward the edge of the lids and on the orbitotarsal ligament above. The so-called *tarsal cartilage* or *plate* is composed of dense connective tissue and contains no cartilage cells. It is attached externally by the *external* (*lateral*) *palpebral ligament* and internally by the *internal* (*medial*) *palpebral ligament* or *tendo-oculi*. This latter passes in front of the lachrymal sac. The tarsal plate is continued to the rim of the orbit by the *orbitotarsal ligament* or *septum orbitale*. The expansion of the levator palpebræ muscle ends in the upper edge of the tarsal cartilage and sends some fibres to the tissues immediately in front. The orbitotarsal ligament and tarsal cartilage prevent the fat of the orbit from protruding and also act as a barrier to the exit of pus.

The tarsal cartilage contains the *Meibomian glands*. These can be seen in life, by everting the lid, as yellow streaks passing backward from the edge of the lids. Frequently these glands become obstructed and their mucus contents dilate the gland, forming a cyst known as chalazion. Suppuration may occur and pus instead

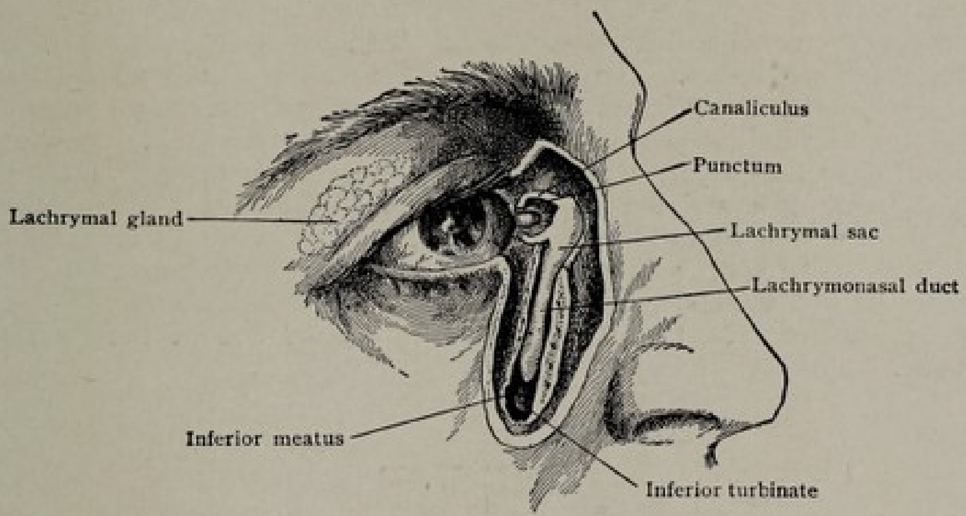


FIG. 110.—Lachrymal apparatus.

of mucus is then contained within them. The wall of these cysts is formed by fibrous tissue containing some of the epithelial cells of the glands; therefore, if an uninflamed cyst is simply opened and its contents expressed, it will soon reform. To prevent this recurrence, the lining membrane is curetted in order to remove the mucus-forming cells. The cyst may point and be opened either on the side of the skin or conjunctiva, preferably the latter.

The openings of the Meibomian ducts are on the inner edge of the lids where the conjunctiva joins the skin. At the outer edge of the lids are the *ciliæ* or *eyelashes* and connected with them are sebaceous and sweat glands. Infection of these glands produces a small abscess called a *stye*. As they are on the outer edge of the lids they tend to discharge anteriorly and not toward the conjunctiva.

The *conjunctiva* covers the outer surface of the eye and the inner surface of the lids. The fold where it passes from one to the other is called the *fornix*. The *tarsal* or *palpebral conjunctiva* adheres closely to the tarsus and as it is transparent the Meibomian glands can readily be seen through it. The *ocular* or *bulbar conjunctiva* is loosely adherent to the sclerotic coat and through it the conjunctival vessels, which move with it, can be seen. The straight vessels going toward the cornea do not move when the conjunctiva is moved, because they lie deeper and are attached to the sclera.

The Lachrymal Apparatus.—The *lachrymal gland* consists of two portions: an orbital or superior portion and a palpebral or inferior portion. The orbital portion is enclosed in a capsule and slung from the orbital margin by its suspensory ligament. Beneath, it rests on the fascial expansion of the levator palpebræ muscle. The palpebral portion is smaller than the orbital and is partially separated from it by the fascial expansion. It lies on the conjunctiva at the upper and outer portion of its fornix. The lachrymal gland opens by several fine ducts into the fornix of the conjunctiva. It is sometimes the seat of malignant tumors, but rarely of other troubles. The remaining lachrymal passages running from the eye to the nose are frequently the seat of inflammation, causing suppuration and obstruction.

The *puncta lachrymalia* in the top of each papilla lead into the *canaliculi*. These enter the lids perpendicular to their margin and turning at right angles join just before entering the upper end of the *lachrymal sac*.

The *lachrymal canal*, embracing the sac and lachrymonasal duct, each about 12 mm. in length, extends from just above the internal tarsal ligament or tendo oculi to the inferior meatus of the nose. The sac is strengthened posteriorly by the *tensor tarsi* or *muscle of Horner*, which passes from the lachrymal bone to the *puncta*, and by some fibres of the palpebral ligament. Anteriorly is the strong, palpebral ligament. Below the palpebral ligament, the sac is comparatively weak and here it is that distention occurs and pus makes its exit. The duct lies in the lachrymal groove in the bone. It is narrower than the sac, being 3 to 4 mm. in width, and is the usual seat of obstructions. To keep the passage open in case of stricture probes are passed. The direction of the duct is slightly outward and more markedly backward, being indicated approximately by a line drawn from the inner canthus to just behind the second premolar tooth. In probing the duct it is customary to first open the punctum in the lower lid—which is normally only one mm. in size—by slitting it and the caniculus with a Weber's canaliculus knife. The probe is directed horizontally until the sac is entered, which is recognized by the end of the probe striking the bone; it is then raised vertically and passed downward and backward and sometimes slightly outward until it can be seen in the inferior meatus of the nose about 1 cm. behind the anterior end of the inferior turbinated bone.

THE EAR

The *external auditory meatus*, the *tympanum*, and the *Eustachian tube* are the remains of the first branchial cleft in the fœtus. A failure of any portion of the cleft to close normally may leave small sinuses or depressions in the neighborhood of the ear. Congenital fistulæ in this region are fairly common. They may be due to a defective closure of the first branchial cleft or to defects in the union of the crus helicis and the crus supratragicus. The *external ear*, also called the *auricle* or *pinna*, is composed mainly of a cartilaginous framework covered with thin skin; the *lobe* or *lobule* forms its lower part and is composed of dense connective tissue containing fat. The large concavity leading into the meatus is the *concha*. The skin of the ear is thin and moderately firmly attached to the cartilage. The hearing mechanism consists of two portions, the conductor and the receptor. The external and middle ear represents the former while the internal ear represents the latter. The auricle collects and intensifies the sound waves and guides them to the external auditory meatus. It has no part to play in actual reception for Treves and others have pointed out that loss of an ear does not cause much loss in hearing. The subcutaneous tissue contains little or no fat. Although well supplied with blood, the exposed condition of the blood-vessels renders the ear sensitive to cold, and frost-bites are common. Injuries and wounds of the cartilage are slow to heal, and if inflamed the cartilage becomes exceedingly sensitive. Swelling of the ear readily occurs from injury or erysipelas, and the tension is quite painful.

Hæmatoma auris, or effusions of blood, occur from traumatism, especially in the boxer and wrestler. They may occur without traumatism as in the insane.

While a hæmatoma may occur between the skin and perichondrium, on account of the firm binding of the skin to the perichondrium it is usually between the perichondrium and cartilage.

Angioma, or enlargement of the blood-vessels, not infrequently affects the external ear and may not only be disfiguring but, by showing a tendency to exten-

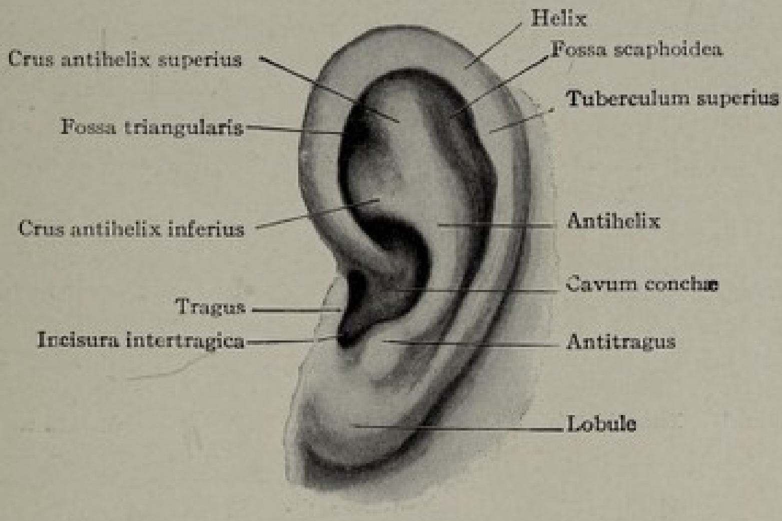


FIG. 111.—The auricle.

sion, may demand operation. The external ear derives its blood supply from the auricular branches of the temporal, internal maxillary, posterior auricular, and occipital arteries. As these are all branches of the external carotid, that artery is sometimes tied as a preliminary step to excising the angiomatous vessels.

The External Meatus.—The external auditory meatus extends from the concha to the drumhead, and is about 2.5 cm. in length. A little less than one-half of it is cartilaginous and a little over one-half bony. Viewed anteroposteriorly the canal has a slight curve with its convexity upward (Fig. 112). Viewed from above (Fig. 113), it is seen first to pass backward and then forward, forming an angle before the bony wall is reached. In order to look into the ear and see the membrane it is necessary to straighten the canal, either by inserting a speculum or by pulling the auricle outward, upward, and backward. The general direction of the canal in the adult is from without, downward, inward and slightly forward. In children, upward traction is not so necessary as in the adult. The length of the canal is approximately the same in childhood as in adults, but the bony part is still in a cartilaginous condition. The external opening is oval, while farther in the canal is more circular; hence the Gruber speculum, which is oval in shape, or the round speculum of Wilde can be used with almost equal satisfaction. The point of junction of the bony and cartilaginous parts is narrower than either end, and it is difficult to remove a foreign body which has passed this point. This is particularly true in

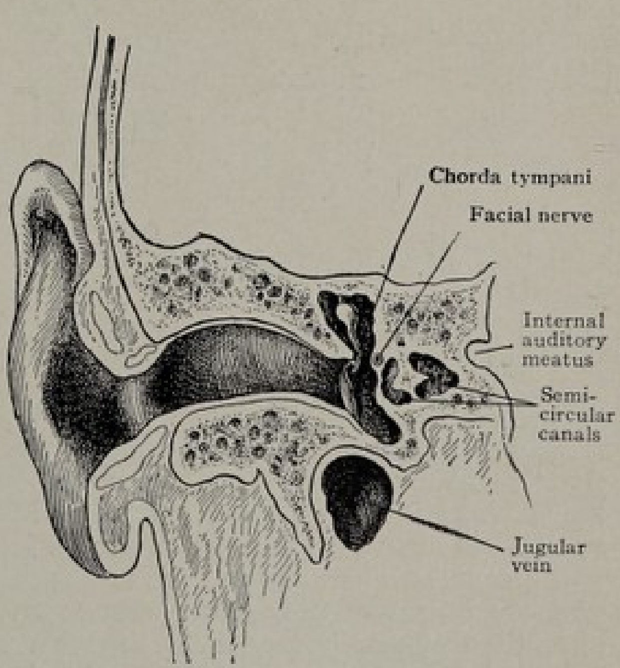


FIG. 112.—Vertical section of the right ear.

children, the lumen of the external meatus being quite small and narrow while the tympanic membrane is nearly as large as in adults.

The floor is longer than the roof, owing to the drum membrane inclining at an angle of 140 degrees. Cartilage forms the lower part of the canal, while the upper part is completed by a fibrous membrane. Below and in front is the temporo-maxillary joint, and just posterior is the *glenoid lobe of the parotid gland*. When the gland is inflamed and swollen it presses on the cartilaginous canal and produces pain; and in cases of suppuration pus may discharge through the external meatus, gaining access to the canal through fissures in the cartilage called the *fissures of Santorini*. The cartilaginous portion of the meatus contains sweat-glands, sebaceous glands, and hair-follicles. There are only a few glands in the upper posterior portion of the bony meatus. On account of the location of the glands in the external portion of the canal, accumulations of wax, and abscesses, which result from infection of the glands, occur nearer to the surface than to the drum membrane. It is only when the canal begins to fill up that the wax pushes its way to the membrane. When furuncles occur, the lining membrane swells and by closing the canal pre-

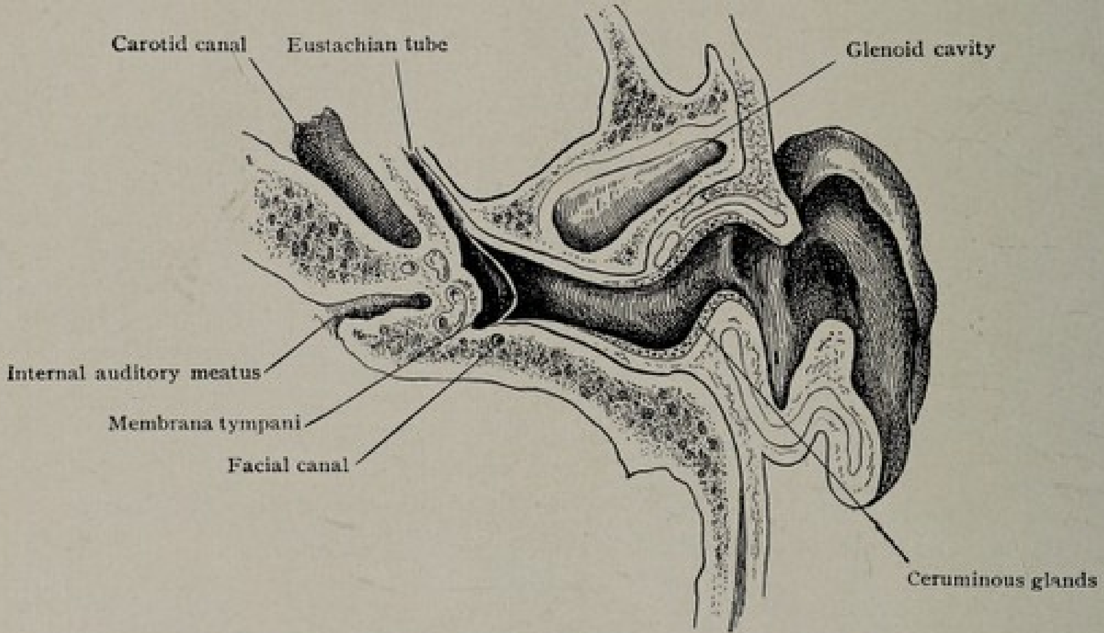


Fig. 113.—Right ear; horizontal transverse section.

vents a view of the drum being obtained. Incising of furuncles of the auditory meatus is sometimes required. The site of the inflamed spot having been located an incision can be made where indicated. If care is exercised, one is not likely to injure the drum membrane, because the abscess starts in one of the sebaceous glands, which are located in the external half of the meatus. The membrane lies 2.5 cm. from the surface, and the point of the knife should not be carried so deeply as that for fear of wounding it; there is no necessity of going so far inward.

The meatus is supplied by the *auriculotemporal branch* of the fifth and the *auricular branch* of the pneumogastric nerve. Irritation of the latter nerve is said to be the cause of feeling it in the throat when anything is put in the ear. Congenital atresia of the meatus is not frequent and when it does occur, it is usually associated with defects of the auricle.

Membrana Tympani.—The membrana tympani is inclined downward and inward at an angle of about 140° to the upper wall (Tröltsch), 27° to the lower wall (Bezold) of the meatus, and 50° opening outward; it does not lie directly transverse, therefore in introducing instruments into the ear the upper posterior part will be first encountered. The membrane is located 2.5 cm. (1 in.) from the surface; this is to be borne in mind in puncturing the membrane or other operations. The membrane has three coats: an outer, continuous with the skin of the meatus; a fibrous or middle layer; and an internal or mucous layer, continuous with the lining of the tympanic cavity. The membrana tympani at birth is fastened at its circumference to the tympanic bone, which unites with the other portions of the temporal bone soon after birth. This ring of bone is incomplete at its upper portion for a distance equalling one-eight of its circumference. This is called the *notch of Rivinus*. The fibrous layer does not extend across this notch, which is closed by the mucous membrane on the inside and by the skin layer of the membrane on its outer side. The part closing the notch is called *Shrapnell's membrane* or membrana flaccida. As it possesses no fibrous layer it is weaker than the membrane elsewhere and consequently is a favorite spot for pus to perforate, in order to find exit from the middle ear.

In examining the membrane by means of light thrown into the meatus through a speculum by the head mirror, one sees extending downward from its centre a small cone of light; any depression or bulging of the membrane will cause this cone of light to be altered in its position, or even cause it to disappear entirely. From the centre of the membrane upward extends a line which indicates the attachment of the long handle of the malleus, one of the bones of the middle ear. Stretching

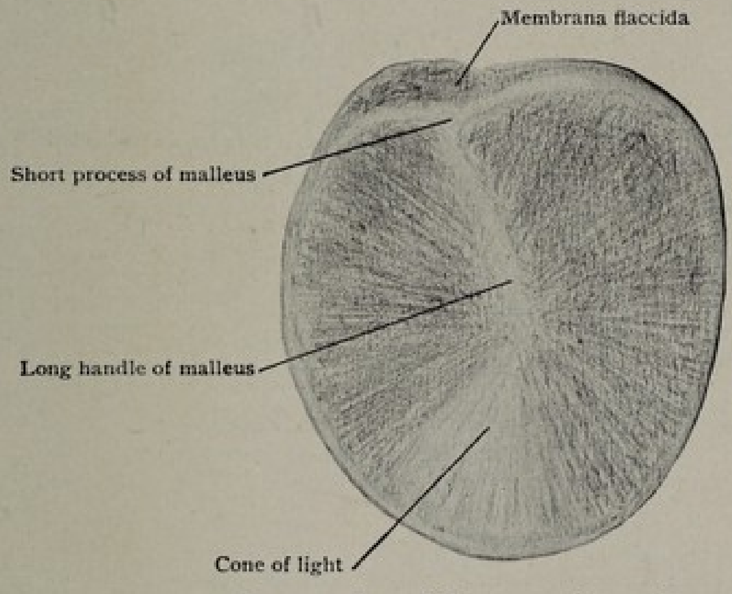


Fig. 114.—Outer surface of the tympanic membrane of the left ear.

across the upper portion is the membrane of Shrapnell or membrana flaccida, so called on account of its not being so tense as the remaining portion. It is better supplied with blood-vessels than the other portion.

The membrana tympani is of surgical interest on account of its being often distended or perforated. A purulent discharge from the ear usually indicates disease of the middle ear or tympanum. If pus is coming from a furuncle of the meatus, the latter will be swollen and its source can readily be recognized. If it comes from outside of the meatus, as in cases of suppuration of the parotid gland, it will be recognized by an examination of the gland. There is no other source of pus but the middle ear and for it to gain exit it must perforate the membrane; this perforation can usually be seen with the speculum and head mirror, as can also bulging.

In inflammation of the middle ear the effused serum or pus bulges the membrane outward. When this condition is accompanied, as it often is, by intense pain, *paracentesis* or puncture is resorted to. The preferable spot is the posterior lower quadrant. Paracentesis of the membrane should be done by beginning the incision a little above and behind the centre of the tympanic membrane, which slopes downward and forward at an angle of 140° to the upper wall, and cutting downward to its lower edge. One must avoid the long handle of the malleus, which extends directly upward from the centre of the membrane. In the upper posterior part are the incus and stapes, therefore this portion should be avoided; and running across the upper edge beneath the mucous membrane is the *chorda tympani nerve.* Division of this nerve is said to be a matter of not much account. Incision through the anterior part is not considered suitable for drainage.

Perforations frequently occur through Shrapnell's membrane on account of its not having any fibrous layer; thus the pus does not go through the tympanic membrane proper. If perforation with a purulent discharge has existed for a long time granulations come through the opening, forming an aural polyp. To remove these a snare is used or caustic is applied.

The Tympanum or Middle Ear.—The tympanic cavity is flat and narrow and is situated directly behind and also above the membrane. It has a floor and roof, and external and internal walls. It is divided into the portion behind the membrane and the portion above the membrane called the *attic.* The *floor* is narrower than the roof and is formed by the *tympanic plate,* which separates it from the jugular fossa containing the commencement of the internal jugular vein. The tympanic cavity extends above the membrane into the attic and below the membrane into the cellar or hypo-tympanic cavity. Because of this latter arrangement pus on the floor of the cavity may not be seen on external examination. The bone forming the floor is more difficult for pus to perforate than is that of the

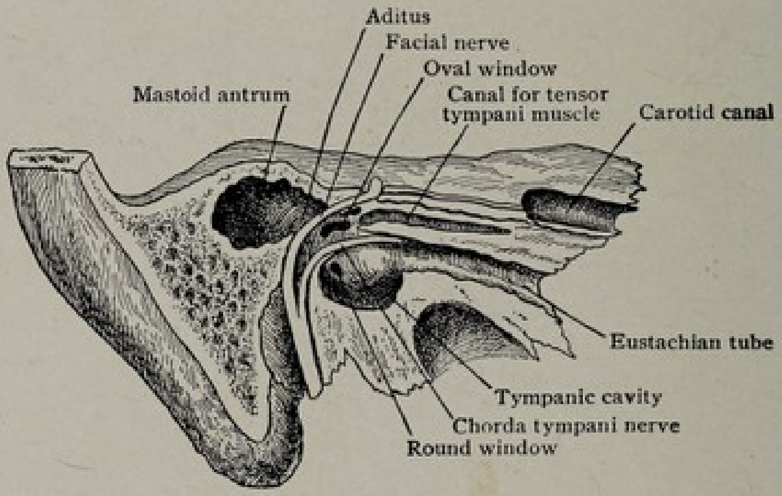


Fig. 115.—Right temporal bone:—The outer surface has been cut away, exposing the tympanic cavity, its inner wall, the mastoid antrum, Eustachian tube, etc.

roof, so that extension of middle-ear disease is less frequent through it. The *roof* is comparatively thin and formed of cancellous tissue with a thin and weak outside compact layer; therefore it is a somewhat common site for pus to perforate and thereby obtain access to the middle fossa of the skull. The distance from the floor to the roof is approximately 15 mm. (3/5 in.); half is behind the membrane and the rest forms the attic above.

The *external wall* is formed below by the tympanic membrane and above by the bone. As the membrane is the weakest portion of the walls, collections of pus in the middle ear most often find a vent through it. Immediately behind the membrane are the lower portions of the ossicles, and above is the chorda tympani nerve.

The *internal wall* is formed of bone and is from 2 to 4 mm. (1/12 to 1/6 of an inch) behind the membrane. It is so close that in doing the operation of paracentesis care must be taken not to thrust the knife too deeply. In it are the oval and round windows (Fig. 115).

There is no well-defined anterior or posterior wall. The anterior portion of the cavity is continued forward into the Eustachian tube; the canal for the tensor tympani muscle is immediately above it. Posteriorly the cavity of the attic is continuous through the *aditus* with the mastoid antrum and the cells beyond. Posterior to the opening of the Eustachian tube is an elevation on the internal wall called the *promontory,* formed by one of the semicircular canals. Above the promontory is the *fenestra ovalis,* which lodges the *stapes* bone and communicates with the vestibule. Below and behind is the *fenestra rotunda*, closed by a membrane separating the *cochlea* from the middle ear. Above the fenestra ovalis is a ridge of bone marking the *aqueduct of Fallopius*, in which runs the facial nerve.

The **Eustachian tube** passes from the anterior portion of the tympanic cavity downward, forward, and inward to the upper posterior portion of the pharynx about level with the floor of the nose. The upper border of the pharyngeal opening is approximately one-half inch above the soft palate and about an equal distance below the basilar process. Injury to the orifice of the tube may occur during operations on the nasopharynx and the turbinate bones, such injury causing an atresia of the opening from cicatrization. It is about 3.5 cm. (approximately 1½ in.) in length. The outer third, near the ear, is bony and the inner two-thirds are cartilaginous. The point of junction of the bony and cartilaginous portions is the narrowest portion of the tube and is called the *isthmus*. The tube is usually closed, but opens in swallowing, yawning, etc., thus admitting air to the tympanic cavity and mastoid cells. Catarrhal affections of the throat readily travel up the

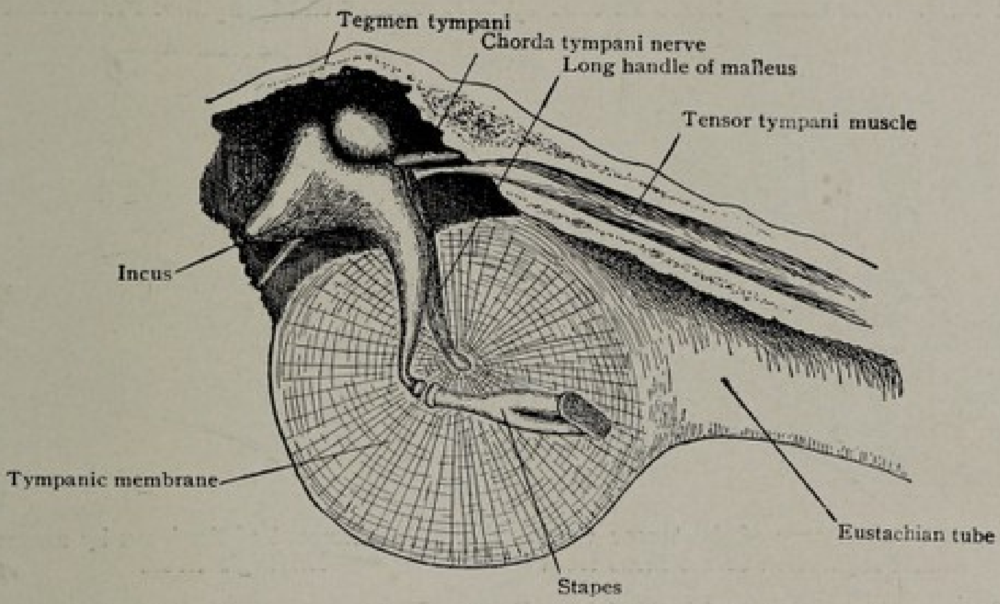


FIG. 116.—View of the tympanic membrane and ossicles of the left ear from within.

tube and set up an inflammation of the middle ear. Swelling of the lining of the tube follows and air no longer passes to the ear. To open the tube two methods are employed—that of Valsalva, and that of Politzer. The former consists in holding the nostrils and mouth shut and attempting to blow, when the action of the throat and palate muscles opens the tube and allows the air to enter. In the method of Politzer, the patient is given a sip of water which he swallows on command. The nozzle of a rubber air-bag is placed in one nostril and the other held shut. As the patient swallows, the air-bag is compressed and the air enters the Eustachian tube. Sometimes this method is varied by asking the patient to say "hock," thus causing the tube to open, when the air-bag is compressed. The calibre of the tube is sometimes so small that probes are passed up it to dilate it. Care is necessary to avoid introducing the probe too far or it will injure the ossicles of the ear. Pus will sometimes discharge through the tube. I have seen pus coming from the middle ear pass down the tube into the inferior meatus and be blown out the anterior nares.

Lying in a separate canal immediately above and parallel with the Eustachian tube is the canal for the *tensor tympani muscle*.

The **attic** is directly above the tympanic cavity and contains the greater part of the ossicles. Between the two along the inner wall runs a ridge of bone within which is the equæductus Fallopii, containing the facial nerve. The roof of the attic is called the *tegmen*. It is a thin shell of bone, varying in thickness, and separates the cavity of the ear from the middle cerebral fossa above. Pus frequently eats its way through at this point and forms a subdural abscess, which by working its way backward involves the lateral (transverse) sinus, causing thrombosis and general septic infection.

The **antrum** is a little larger than the attic. The two cavities are continuous through the aditus. The roof of the antrum is level with the roof of the attic and its floor is about level with the top of the membrane. It is thus seen to be directly above and posterior to it.

Mastoid Cells.—The mastoid cells are continuous with the antrum and permeate the mastoid process down to its tip. The cells come so close to the surface that suppuration within them often bursts through and discharges behind the ear. The upper, inner and lower portions of the bone are also sometimes perforated, which will be referred to later.

Middle-ear Disease.—Suppuration from middle-ear disease is caused by an infective inflammation travelling up the Eustachian tube from the pharynx and nasal cavities. It may pass to the attic above and thence to the mastoid antrum and mastoid cells. Pus usually finds an exit by perforating the tympanic membrane and

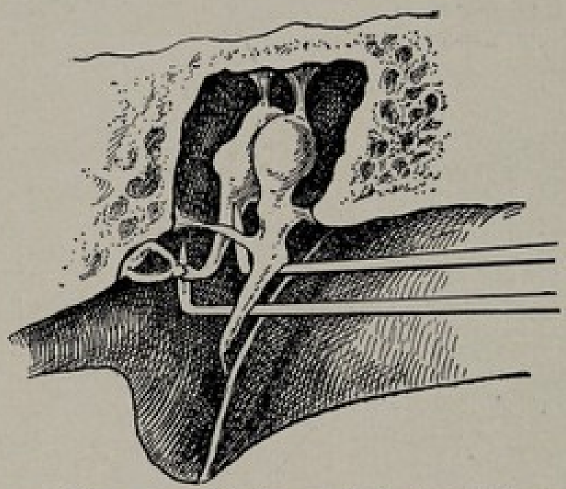


Fig. 117.—Tenotomy of the tensor tympani tendon and separation of the incus from the stapes.

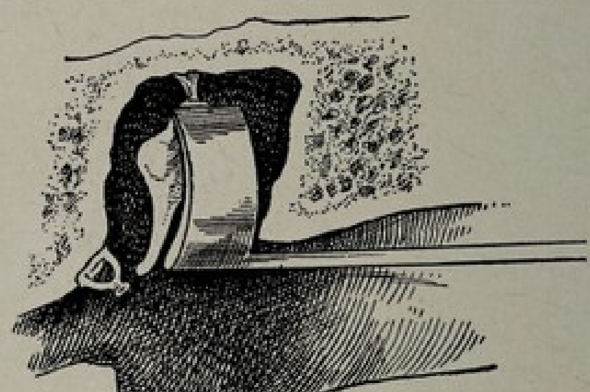


Fig. 118.—Removal of the incus by means of Ludwig's hook.

Modified from Georges Laurens.

discharging through the external auditory meatus. As already stated, it may pass down the Eustachian tube to be blown out of the anterior nares. It has been known to pass down the canal for the tensor tympani muscle, and form a *retropharyngeal abscess*. As the pus reaches the pharynx behind the prevertebral fascia, it may extend laterally and appear externally behind the sternomastoid muscle. Having thus reached the base of the skull, the infection may involve the meninges and brain through the crevices in the bone. It is rare for it to perforate the bone below and anteriorly, and thus implicate the jugular vein and internal carotid artery. It may eat into the posterior wall and involve the facial nerve, which is covered by only a thin shell of bone, and produce facial paralysis, attack the internal ear through the fenestra ovalis and rotunda and pass through the internal meatus to the brain. If it extends upward and involves the attic and antrum, it may perforate the roof, or tegmen, and form an *extradural abscess* in the back part of the middle cerebral fossa, whence it travels a distance of about a centimetre to the lateral sinus, causing a *thrombus* to form, or it may produce an abscess of the temporosphenoidal lobe of the brain. The antrum and mastoid cells being continuous, the posterior and inner walls may be perforated, the pus thereby reaching the posterior cerebral fossa, again involving the lateral sinus, or producing a cerebellar abscess. If it perforates the mastoid process on its inner wall at the groove for the digastric muscle, the pus gains access to the back of the neck, forming what is known as *Bezold's abscess*.

Operations on the Middle Ear.—The operations on the middle ear, besides those involving the membrane, are done either for the removal of the remains of the membrane and ossicles, or else to clear out the antrum and mastoid cells and even, if necessary, examine the lateral sinus and jugular vein and explore the brain. They are done for suppurative affections, which may be either chronic, producing local symptoms, or acute, producing in addition constitutional disturbances and even general infection. Caries of the bones is a prominent condition in suppurative cases of long standing, and the character of the operation is dependent on the extent to which the disease has progressed.

In removal of the ossicles, the tympanic membrane is first separated around its edges. Then the tendon of the tensor tympani muscle is cut, and the incus disarticulated from the stapes. The latter is done by cutting with a bent knife across the axis of the stapes and not of the incus (see Fig. 118). The malleus is seized and drawn first down and then out, bringing the membrane with it, and afterwards the incus, which is detached by Ludwig's hook (see Fig. 119), is removed, and, if desired, the stapes. Granulation tissue and pus are removed by the snare, forceps or curette. Care is to be taken to avoid, if possible, scraping away the thin shell of

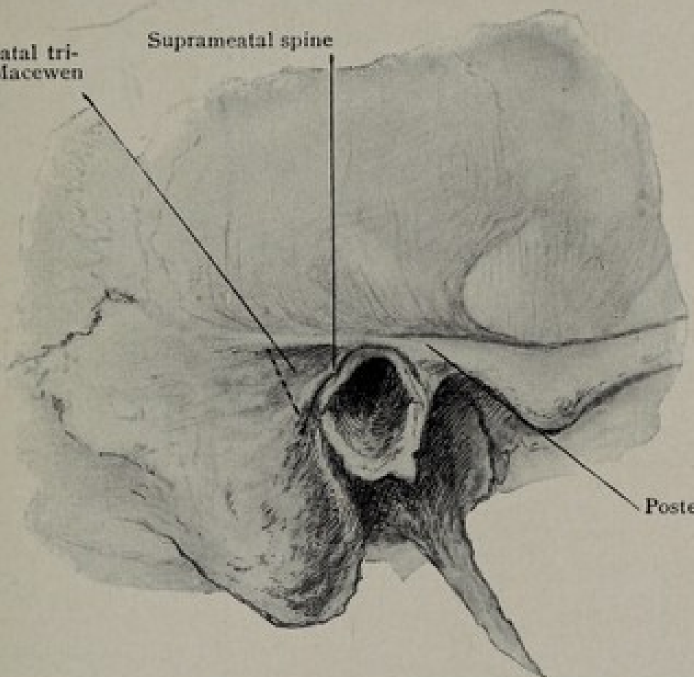


FIG. 119.—Landmarks for operating to enter the mastoid antrum.

bone on the internal wall that covers the facial nerve. Any twitching of the muscles of the face indicates that the nerve is being irritated. The chorda tympani nerve, which passes on the inner side of the handle of the malleus and lies beneath the mucous membrane, is of necessity removed. No important symptoms follow its removal.

Operations on the Antrum and Mastoid Cells.—In order to understand these operations, one must recall that the *suprameatal crest* is the ridge of bone forming the upper edge of the bony meatus, and a continuation backward of the posterior root of the zygoma. The upper and posterior edge of the meatus is formed by a thin, small shell or edge of bone running from the suprameatal crest downward and backward to the posterior wall; this is the *suprameatal spine*, which is about 10-12 mm. above the floor of the antrum which is about half-way up the posterior wall of the bony meatus and about 5 mm. posterior to the inner end, behind the suprameatal spine and between it and the posterior portion of the suprameatal crest is a depression, the *suprameatal fossa*. This suprameatal fossa is triangular in shape. The crest forms the upper side, the spine its anterior side, and the ridge of bone, running from the posterior portion of the crest to the lower portion of the spine, forms the posterior side. These three lines form the *suprameatal triangle of Macewen*. It is through this triangle that the antrum may be reached. The operation may be restricted to the antrum and tympanic cavity, or may include the whole part of the mastoid cells, constituting the operation known as *tympano-mastoid exenteration.*

To reach the antrum a semicircular cut is made a centimetre back of the ear and the ear and membranous canal loosened and pushed forward. With a gouge

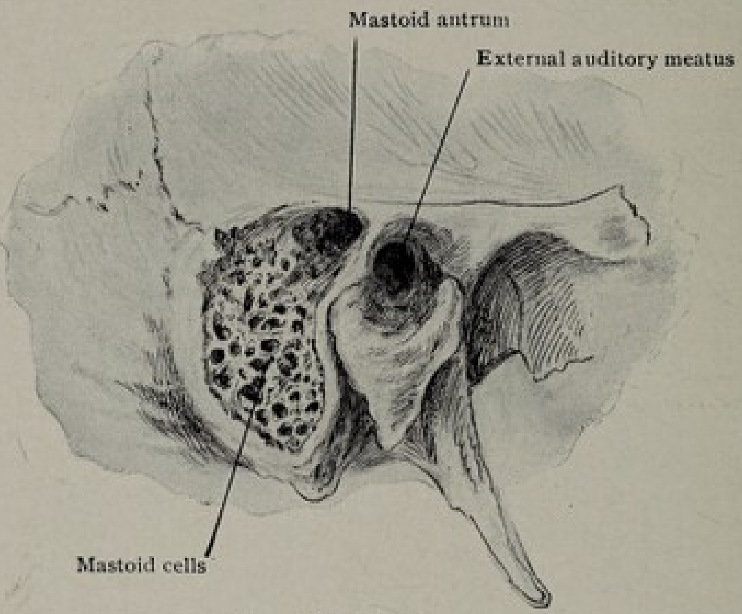


FIG. 120.—The mastoid antrum exposed by chiselling through the suprameatal triangle. The mastoid cells exposed by chiselling off the surface of the mastoid process.

chips of bone are removed from the suprameatal spine backward and from the crest downward as far as desired. This will extend considerably beyond the line marking the posterior boundary of Macewen's triangle. The outer table of bone being removed, the cells are broken through parallel to the meatus and slightly upward, for the lower level of the antrum corresponds to the upper edge of the meatus. It is hardly safe to penetrate deeper than 1.5 cm. (3/5 in.) from the meatal spine inward, for fear of wounding the facial nerve. The mastoid antrum lies not only above and posterior to the membrane and tympanic cavity, but extends outward along the posterior and upper portion of the canal, and the facial nerve can be wounded only by passing across the antrum and attacking the bony covering of the Fallopian canal below and anteriorly.

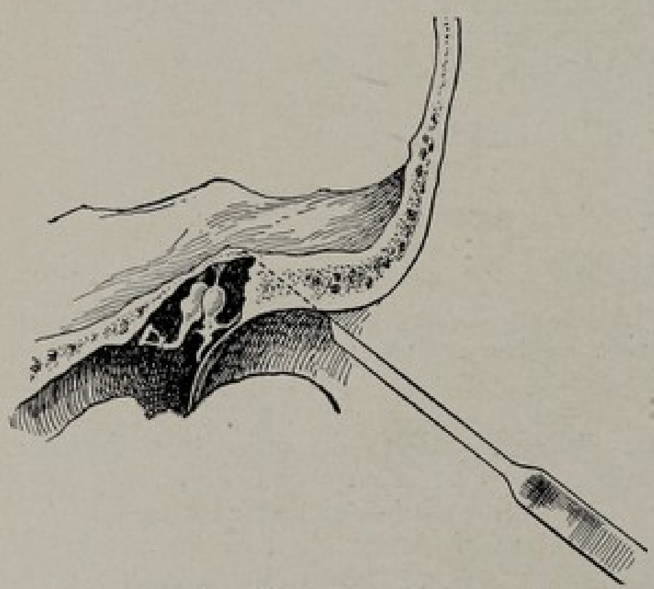


FIG. 121.—Chiselling away the spur of bone between the roof of the external auditory meatus and attic or epitympanum.

In doing a tympano-mastoid exenteration, a more extensive procedure is performed. It consists in cleaning out the various communicating cavities and throwing them together, thus making their interior more accessible. The antrum is reached in one of two ways: either posteriorly, or anteriorly through the meatus. The posterior operation, or that of Schwartze, Zaufal, and others, consists in removing the membranous lining of the bony meatus on its upper and posterior portions down to the tympanic membrane. The antrum is then entered as already described; the posterior bony wall of the meatus is chiselled away, giving access to tympanum; the ridge of bone separating the roof of the bony meatus from the attic or epitympanum is chiselled away (see Fig. 121), and the

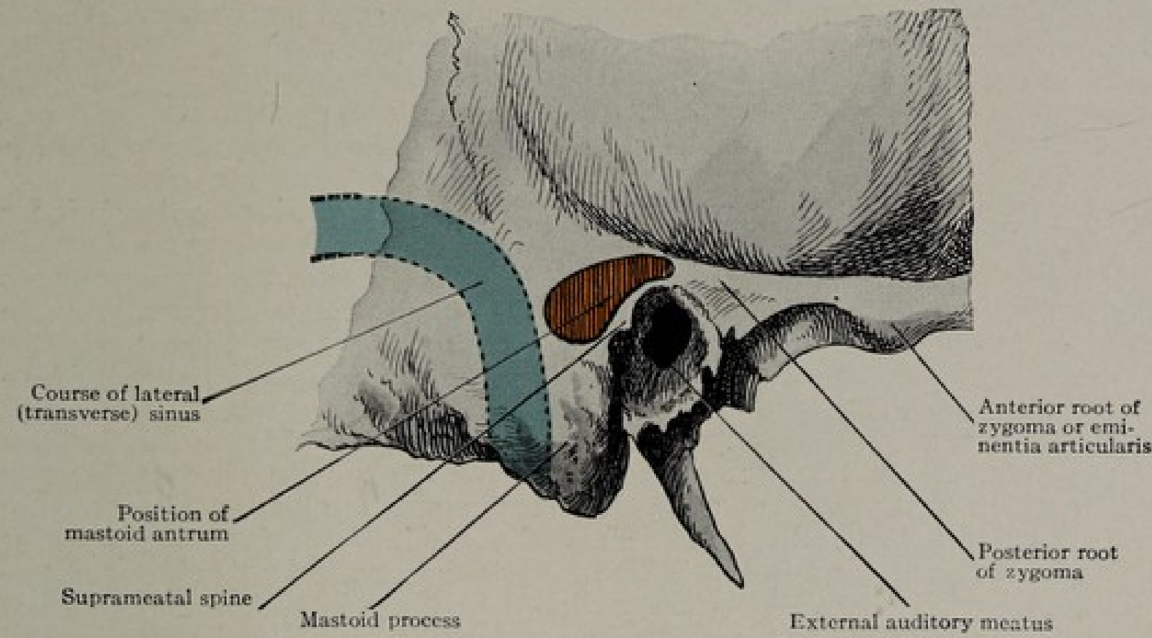


Fig. 122.—Lateral view of the temporal bone, showing the relations of the lateral or transverse sinus and mastoid antrum.

membrane and ossicles removed. This gives access to the tympanic cavity, epitympanum, and antrum. As much of the mastoid cells as necessary is exposed by chiselling away their external covering of bone even down to the tip of the mastoid process.

If the anterior operation of Stacke is performed, the membranous lining of the bony meatus is to be loosened and divided as close to the membrane as possible and drawn forward with the cartilaginous meatus. The drum membrane and as much of the ossicles as possible are then to be removed, and with a chisel or bent gouge the angle, or ridge of bone between the upper side of the bony meatus and epitympanum, or attic, cut away. The antrum is now entered by chiselling away the upper posterior wall and the chiselling away of bone continued until the mastoid cells have been sufficiently exposed. The final result of these two methods is the same. The external meatus, tympanum, epitympanum, antrum, and mastoid cells are all thrown into one large cavity. Wounding of the facial nerve is to be avoided by first learning its course and then by sponging away the blood and cutting only the structures which are

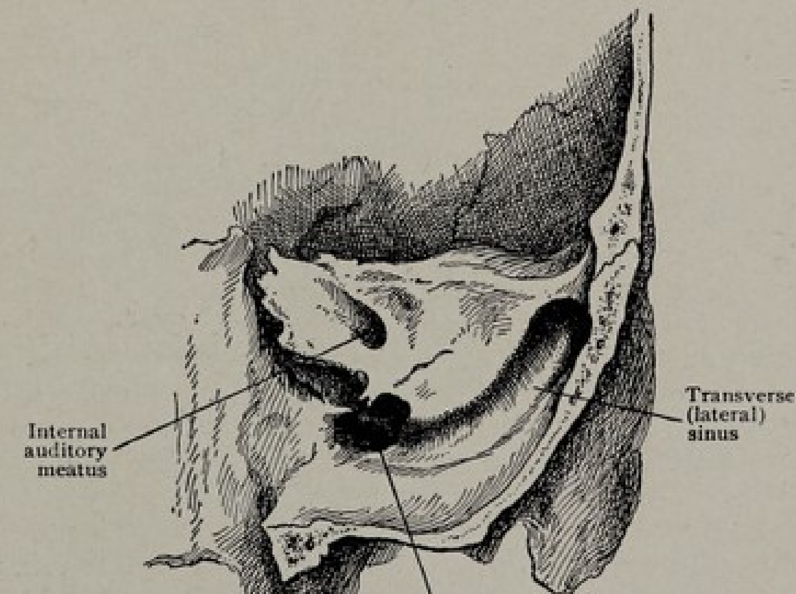


Fig. 123.—Transverse section of the right side of the skull just behind the mastoid process; looking forward.

clearly visible. The nerve is most likely to be injured in removing the deep portion of the posterior meatal wall, directly above the aditus ad antrum. In this area it is protected by a thin but dense bony covering. Tracing the facial nerve backward, it is seen (Fig. 115) entering the stylomastoid foramen, passing upward posterior to the tympanic cavity, and crossing at about its upper edge to pass above the oval window. Viewed in Fig. 113, it is seen that the Fallopian canal lies a trifle nearer to the external surface than does the tympanic membrane, so that in making the opening into the antrum or in connecting the mastoid cells below the antrum with the tympanic cavity, care should be taken to keep a little anterior or superficial to the membrane.

Relations of the Brain and Lateral Sinus.—In operating on the skull for middle-ear disease, it is desirable to know how to reach and how to avoid the brain and lateral sinus. The lower level of the brain in the region of the ear corresponds to a prolongation directly backward in a straight line of the posterior root of the zygoma. If one keeps below this line, he is not likely to open the brain case. If it is desired to explore the under surface of the brain or dura directly over the middle-ear cavity, then one trephines above this line or suprameatal crest, the lower edge of the trephine opening being .5 cm. above it. This will lead to the middle fossa of the skull, occupied by the temporosphenoidal lobe. The sharp upper and posterior edge of the petrous portion of the temporal bone gives attachment to the tentorium and separates the middle cerebral fossa in front from the posterior fossa, containing the cerebellum, behind. The point at which this ridge and tentorium reach the side of the skull is indicated by the point of crossing of a line drawn up from the tip of the mastoid process, midway between its anterior and posterior borders, and the line of the posterior root of the zygoma. The course of the lateral sinus is indicated by a curved line from above and to the right (about .5 to 1 cm.) of the external occipital protuberance to the upper posterior portion of the mastoid process and thence to its tip. The proximity of the sigmoidal portion of the lateral sinus to the mastoid cells and antrum accounts for the frequency with which this sinus is involved in middle-ear disease. Sinus thrombosis may result from one of six conditions: (1) From chronic suppurative otitis media; (2) from the extension of acute infections in the pharynx or tonsils into the middle ear by way of the Eustachian tube; (3) extension of thrombosis from other sinuses, especially the superior petrosal; (4) following basal fractures of the skull; (5) from the pressure of tumors or abscesses; (6) following infected wounds of the head, neck or mastoid region (Macewen). The genu of the sigmoid sinus extends further inward and forward on the right side than the left. The right sinus is also larger than the left. These two facts probably explain the greater frequency of sinus complications on the right side. The anterior edge of the lateral sinus reaches as far forward as a line drawn from the tip of the mastoid upward, midway between its anterior and posterior borders. The point at which it turns is where this mastoid line intersects the line of the zygoma. Its upper edge rises above this line approximately 1 cm. The sinus is 1 cm. in width. The distance of the sinus from the surface varies from .5 cm., or even less, at the top of the mastoid process to 1.5 cm. at its tip. So uncertain is this that the only safe way to expose the sinus is to cut the bone off with a mallet and gouge in thin chips parallel to the surface. The use of a trephine or other boring instrument is not to be advised. If the infection of the lateral sinus has extended to the jugular vein this latter must be reached by means of a separate incision in the neck.

THE NOSE

Externally the nose forms a prominent projection on the face, hence it is frequently injured and its construction should be studied in relation to those injuries. It forms a conspicuous portion of the features, hence deformities or disfigurements of it are very distressing, so that plastic operations are done for their relief. Internally, the nasal cavities are concerned in the sense of smell and form the passage-way to and from the lungs and the various accessory cavities for the air in respiration. It likewise serves as a receptacle for the tears as they come down the lachrymonasal duct. Interference with the flow of air by obstruction of the nasal chambers may cause affections of the pharynx, larynx, lungs, ears, or accessory sinuses—ethmoid, sphenoid, maxillary, and frontal. Catarrhal troubles may start in the nose and invade any of these parts. They may even extend up the Eustachian tube and cause deafness; or up the lachrymonasal duct and cause trouble with the lachrymal canal or conjunctiva. A knowledge of the nose is essential to all those who wish to devote themselves especially to affections of the eye, ear, and throat, because the origin of the affections of these organs may be in the nasal chambers instead of the organ in which they are most manifest.

The skin over the root of the nose is thin and lax. It is well supplied with blood by the frontal and nasal branches of the ophthalmic, and the angular branch of the facial arteries. In reconstructing a nose by means of a flap taken from the forehead, it is these branches that nourish it. The laxity of the skin allows the pedicle to be twisted around without interfering with the circulation.

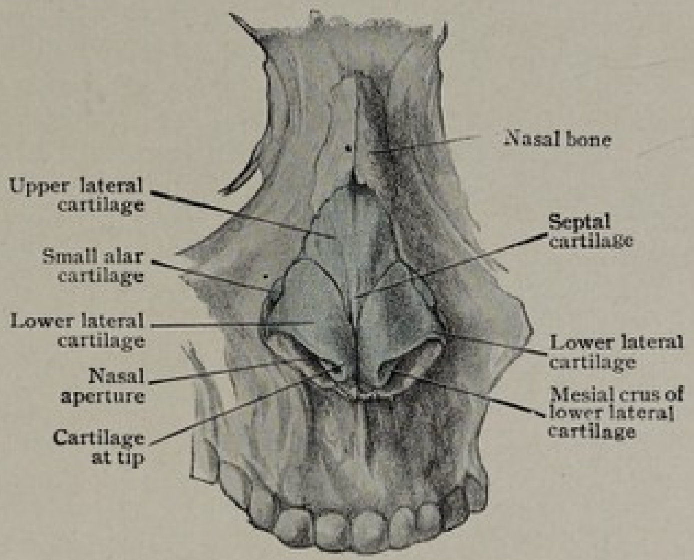


Fig. 124.—Bony and cartilaginous framework of nose, front aspect. (Piersol.)

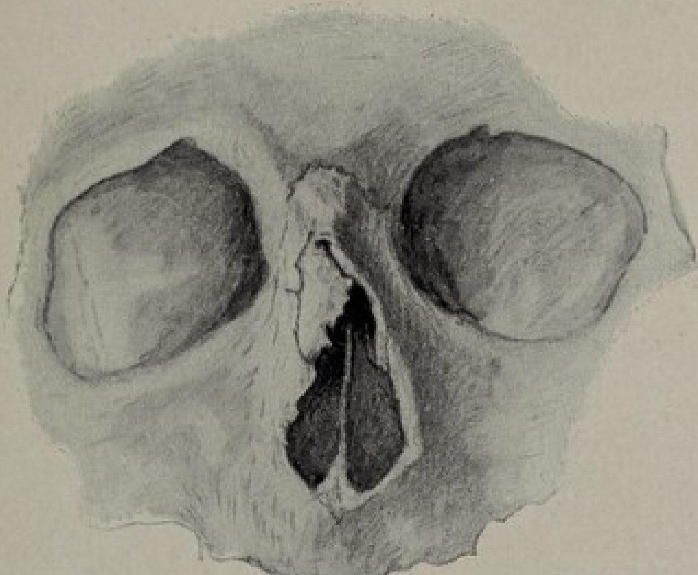


Fig. 125.—Fracture of the nose with deflection of the nasal bone laterally.

The skin over the tip and alæ is thick, and adherent to the cartilages. It possesses a comparatively scanty blood supply, hence its liability to suffer from cold, and is a favorite site for ulcerations, as lupus, superficial epithelioma (rodent ulcer), etc. Sebaceous and sweat glands are abundant, and stiff hairs guard the inside of the nostrils. These latter are not seldom the seat of small furuncles or boils, which are extremely painful. This is due to the tension caused by the congestion and swelling, which is restricted by the tissues being so firmly bound to the cartilages beneath.

Nerves.—In addition to the *olfactory nerve*, the nose is supplied by the *nasal*, *infratrochlear*, and *infra-orbital branches* of the fifth nerve, hence the eyes water when the nose is injured. In certain cases of neuralgia affecting the ophthalmic division of the fifth nerve, pain is felt along the side of the nose. As the nasal nerve enters the skull from the orbit through the anterior ethmoidal foramen, it may be involved in disease of the ethmoidal sinuses.

The nose proper consists of a bony and a cartilaginous portion. The *bony portion* is formed by the two nasal bones articulating with the frontal bone above, with each other in the median line, and with the nasal process of the superior maxilla on the side. They are supported on the inside by the upper anterior portion of the perpendicular plate of the ethmoid. This articulation does not extend the whole length of the nasal bones to their tip, but only about half their length.

The *cartilaginous portion* consists of four lateral cartilages, two on each side, upper and lower, and the triangular cartilage, or cartilages, two on each side.

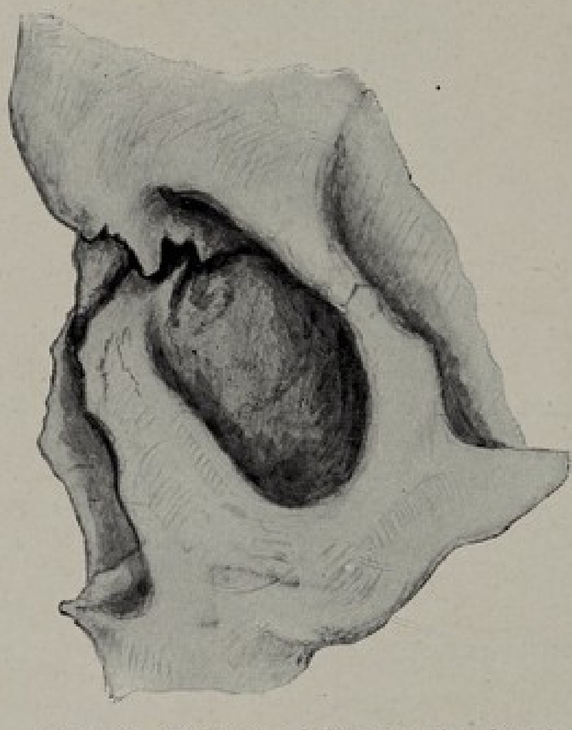


FIG. 126.—Fracture of the nose showing depression of the nasal bone.

The external shape of the nose viewed in profile is composed of three portions: an upper of bone, a middle of cartilage—the upper lateral cartilages—and a lower, or tip, formed by the lower lateral cartilages. The bridge of the nose is formed by bone; it slopes downward and forward and where it joins the upper lateral cartilage the line changes and slopes more downward, until the tip is reached, here the lower lateral cartilages bulge forward, forming a rounded and more or less projecting tip.

Injuries to the Nose.—Injuries to the nose are frequent because of its exposed position. These injuries are important because any alteration in its shape readily attracts attention. The bones and cartilages may be fractured or dislocated. This may involve either the outside structures or those forming the septum, and often both. The fracture occurs more frequently nearer the lower end of the nasal bones than the base. However, the high fractures are more apt to be serious because of the proximity of the ethmoid and frontal sinuses and the cribriform plate. When the latter is involved a compound fracture of the base is produced and the meninges are exposed to an ascending infection. The displacement depends on the character and direction of the injury. It is either a displacement to one side, or the nose is crushed, producing a flattening of the bridge. If the displacement is lateral, whether by a dislocation or fracture, there is liable to be a deviation of the septum, because the bony and cartilaginous septum is connected with the bones and is apt to be carried with them to the side. If the displacement is inward, not only are the nasal bones depressed, but the septum beneath may be either bent or fractured. The pushing of the septum toward the floor causes it to buckle and bend or even break at the junction of the triangular cartilage with the perpendicular plate of the ethmoid and the vomer. In treating these fractures, the most efficient method is to grasp the septum with the flat blades of an Adams forceps (after cocainization) and lift the bones up or to one side as needed. In cases where it is not desired to use the forceps, the writer grasps the nose with a wet towel, makes traction to loosen the fragments, and then pushes them over into place. The triangular cartilage is frequently injured; with the displacement or loosening of the upper lateral cartilages a great amount of displacement may be caused, so that the nose instead of forming a straight line is bent to one side from the ends of the bones down to the tip. Injuries to the septum in childhood are probably the cause of a large number of the cases of deviation of the septum, spurs, etc., seen later in life.

The fractures are almost always compound because of the intimate relation of the mucous membrane to the injured bone and cartilage. This allows air to enter the tissues at the site of fracture, producing emphysema. If such a patient blows the nose violently, the air may be forced under the skin of the face, around the eyes and up the forehead.

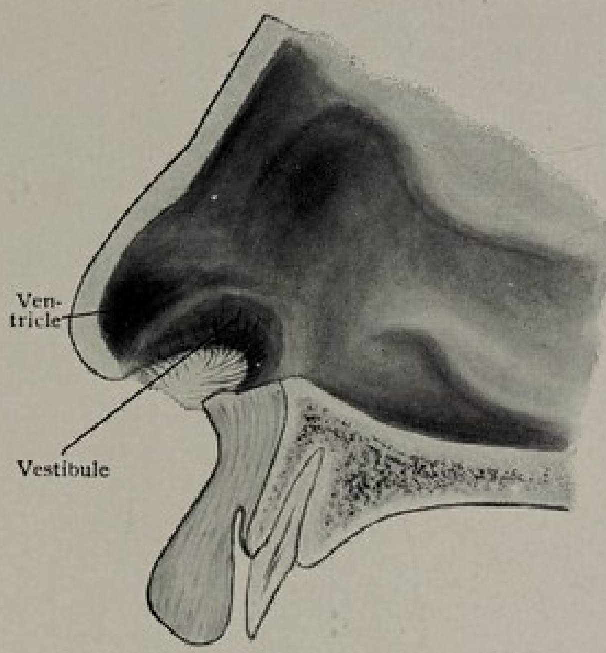


Fig. 127.—Lateral view of the interior of the nose.

Anterior Nares.—The nostrils or anterior nares in the white race are an elongated oval in shape and run in an anteroposterior direction, being separated from each other by the *columna*. They lie in a direction parallel with the floor of the nose, so that to examine the nasal fossæ with a speculum the instrument is first introduced from below, then tilting the tip of the nose upward, the speculum is directed backward. To see the floor of the nose, it is necessary to raise the outer end of the speculum still higher, because the floor is below the bony edge. From the outer edge of the nostril the nasal cavities go upward and backward for a distance of .5 to 1 cm. This part, called the vestibule, is covered by skin, not mucous membrane. It bears stiff hairs—vibrissæ. Inflammation of these hair-follicles and associated glands produces exceedingly painful pustules. It is here likewise that dried mucus collects and forms scabs, which stick to the hairs and are hard to remove. The attempt to remove them probably is the cause of infection and inflammation around the roots of the hairs. The vestibule leads to the ridge of bone or crest, which is directly posterior to the side of the nasal spine. This ridge of bone is on a higher level than the floor of the nose, and in order to view the latter the nostrils must be raised, by means of the speculum, above it (Fig. 127).

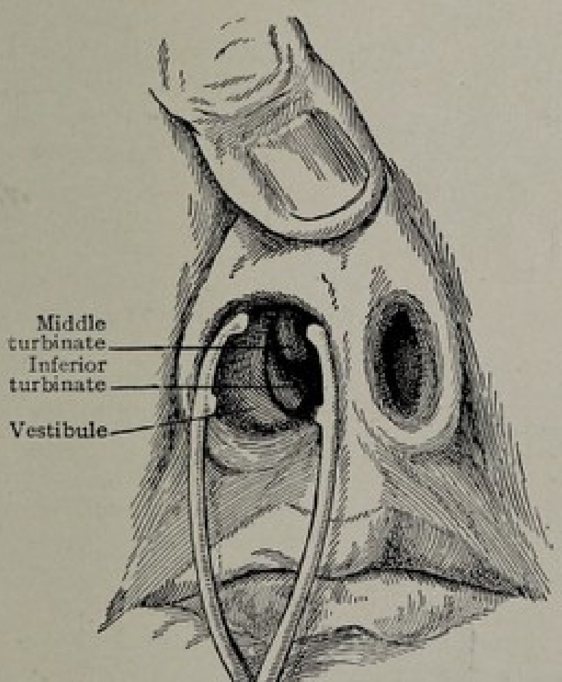


Fig. 128.—Examining the anterior nares. Middle and inferior turbinates exposed to view.

View from the Anterior Nares.—In looking into the nose from in front, if the speculum is directed downward, the floor of the nose and the inferior meatus can be seen. On the inner side is the septum, on the outer the anterior end of the inferior turbinated bone. Still higher is the middle meatus and the anterior end of the middle turbinated bone. The superior turbinated bone is not visible from the front, being in the upper posterior corner and hidden from sight by the middle turbinated. Sometimes in the upper portion of the nose, beneath the outer surface of the anterior extremity of the middle turbinated bone, is seen a small cleft, the *hiatus semilunaris*, leading through the infundibulum into the frontal sinus. If the inferior turbinate has been shrunk with cocaine, and if the inferior meatus is roomy, one can see the posterior wall of the pharynx. This can be seen moving if the patient swallows, pronounces the letter "k," etc. (Fig. 128).

Septum.—The *nasal fossæ* are separated from each other by the *septum*. This septum is formed (see Fig. 129) by the triangular cartilage in front, forming the *cartilaginous septum*, and the perpendicular plate of the ethmoid and vomer behind, forming the *bony septum*. The posterior edge of the septum is formed solely by the edge of the vomer; it can readily be seen with the rhinoscopic mirror. The affections of the septum are hæmatoma, ulcer and abscess, deviation to one side, spurs or outgrowths, and it may be the site of nasal hemorrhages. Infections in the septal way are exceedingly dangerous in that the septal lymphatics may carry the infection through the cribriform plate to the meninges. *Hæmatomas* affect the cartilage of the septum and resemble those of the ear. They are usually due to traumatism and may become infected, forming a pus-like detritus or abscess. They can readily be recognized as a fluctuating swelling on the septum, one or both sides being affected.

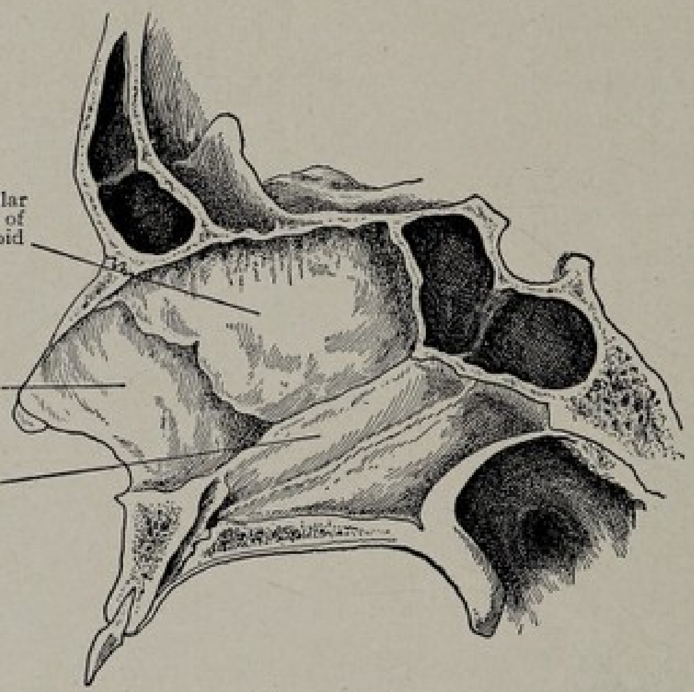


Fig. 129.—Septum of the nose.

Deviations of the septum are bendings toward one side, and cause serious obstruction to breathing. They are probably traumatic in origin and involve the cartilaginous portion. In operating for their correction, an incision is made in the mucous membrane of one side and this is separated from the septum. The cartilage may then be cut through and the mucous membrane lifted from the opposite side or a separate incision made on the opposite side. This may, however, result in a permanent perforation of the septum which is most undesirable and which may cause a very objectionable whistling sound when the patient breathes. As the mucous membrane covering the cartilage is thin, great care is necessary in dividing the cartilage to avoid wounding the side which it is desired to leave intact. The triangular cartilage is thin at its centre and thick at its edges.

Spurs are usually outgrowths of bone or cartilage occuring in the line of juncture of the cartilage and vomer. On the floor of the nose the nasal crest may project quite perceptibly to one side; a cartilaginous projection may likewise occupy this site. As these spurs are found on the anterior edge of the vomer, they sometimes form a distinct ridge of bone running upward and backward. If the spur is short in extent, the further posterior it is situated, the higher up it is on the septum. If marked, it is often accompanied by deviation of the septum and it may impinge on the lower turbinated bone opposite to it. These spurs are usually removed by sawing. A narrow-bladed saw is introduced with its back on the floor of the nose and the spur removed by sawing upward (Fig. 130).

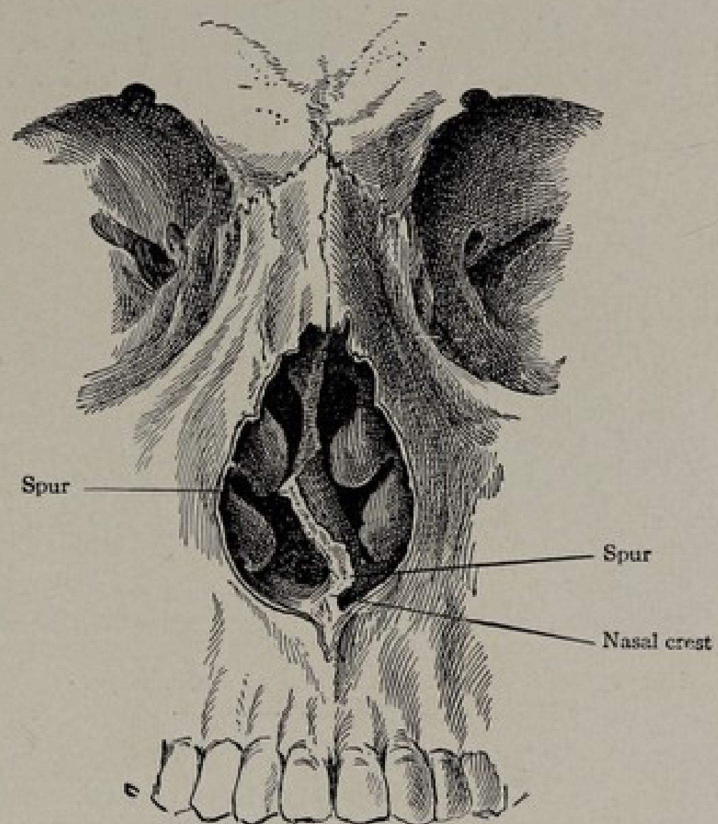


Fig. 130.—Nasal crest and septal spurs.

Epistaxis or bleeding from the nose is said to occur in a large percentage of the cases from the septal branch of the sphenopalatine artery. This comes from the internal maxillary artery through the sphenopalatine foramen and passes downward and forward as the nasopalatine or artery of the septum. It anastomoses below with the anterior palatine branch of the descending palatine artery as it comes up from the roof of the mouth through the *foramen of Stenson* (incisor foramen). It also anastomoses with the inferior artery of the septum, a branch of the superior coronary. The bleeding point is to be sought for low down on the anterior portion of the cartilaginous septum near the anterior nares. Hemorrhage can be stopped by packing only the anterior or both the anterior and posterior nares.

The **arteries** supplying the nasal cavities (Fig. 131) come from three directions: superior—the *anterior* and *posterior ethmoidal*, supplying the ethmoidal cells,

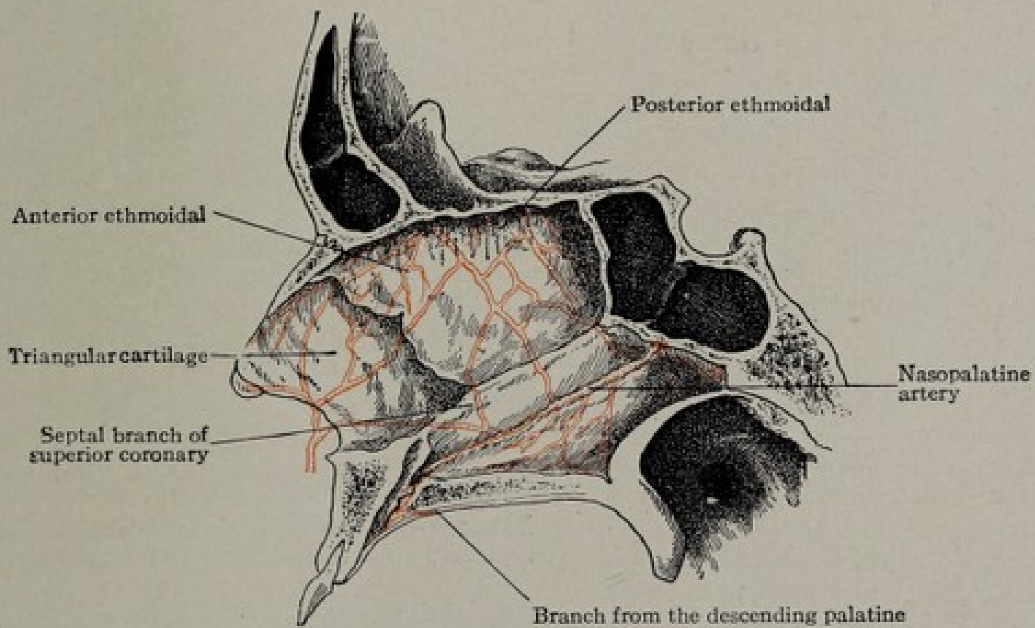


Fig. 131.—Arteries supplying the septum of the nose.

the upper portion of the septum, the roof, and the outer wall anteriorly; inferior—the *septal branch of the superior coronary artery* and a *branch of the descending palatine artery* coming up through the incisor foramen; posterior—the *spheno-*

palatine, giving its *nasopalatine branch* to the septum and also supplying branches to the ethmoidal cells, frontal and maxillary sinuses, and outer wall of nose, the *Vidian* and *pterygopalatine* going to the posterior portion of the roof, and the *descending palatine* giving branches to the posterior portion of the inferior meatus and posterior end of the inferior turbinated bone.

The **veins**, like the arteries, are in three sets: the *superior* are formed by the *anterior* and *posterior ethmoidal* and some smaller veins passing upward through the foramen in the cribriform plate, or *foramen cæcum*, to the longitudinal sinus; the *inferior* communicate with the facial veins through the anterior nares; the *posterior* drain upward and backward through the sphenopalatine foramen into the pterygoid plexus.

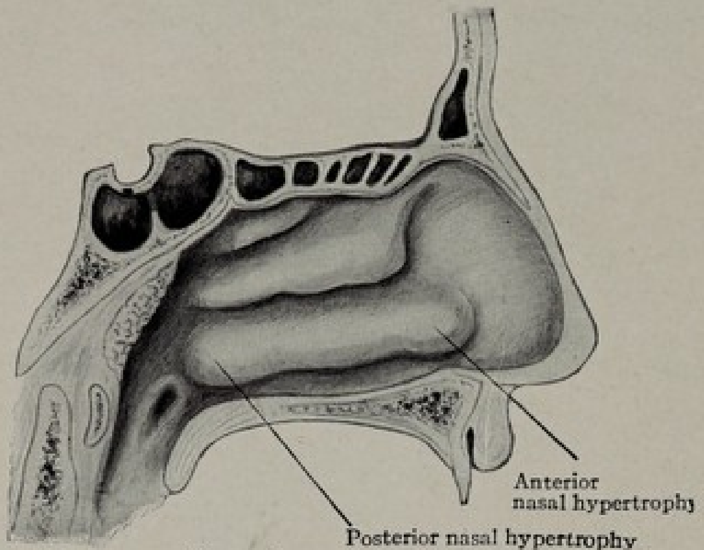


FIG. 132.—View of anterior and posterior hypertrophies of the inferior turbinate.

The **lymphatics** drain either anteriorly on the face or posteriorly through the deep lymphatics of the neck. Therefore, acrid secretions causing ulcerations of the anterior nares are liable to be accompanied by swelling of the submaxillary lymphatic nodes; while enlargement of the deep cervical lymphatics follows disease of the deeper nasal cavities, while some of the nasal lymphatics empty into the retropharyngeal lymph-node and infection carried by this route may result in a retropharyngeal abscess. Some of the lymphatics in the septum enter the anterior cranial fossa through the cribriform foramina. In this way a septal infection may be the cause of meningitis.

Nasal hypertrophies are enlargements of the nasal mucous membrane. The mucous membrane of the nose or *Schneiderian membrane* has columnar ciliated cells on its surface and mucous cells beneath. It is prolonged into the various sinuses and cavities in connection with the nasal fossæ. The membrane on the upper third of the septum, the upper portion of the middle turbinated, and the superior turbinated bone, contains the terminal filaments of the olfactory nerve. The membrane over the lower portion of the septum, over the lower edge of the middle, and the greater part of the inferior turbinated bones, contains a venous plexus which renders it erectile. On the slightest irritation this portion of the membrane will swell and obstruct the passage of air through the nostrils. Repeated swelling of the membrane of the septum produces thickenings of the septum, which if anterior may be seen through the nostrils, and if posterior by the rhinoscopic mirror. The membrane over the inferior turbinated bones also becomes swollen and enlarged, constituting, if at the forward end, *anterior hypertrophy*, and if at the posterior extremity, *posterior hypertrophy* (Fig. 132). They can be readily seen through

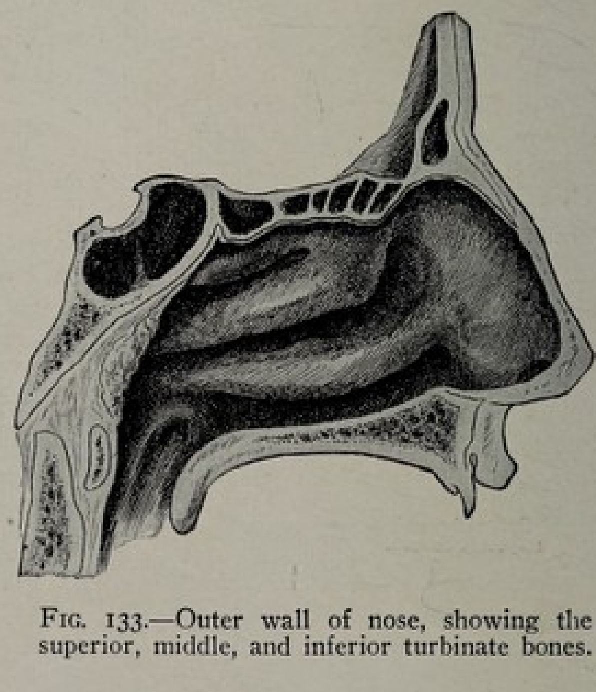


FIG. 133.—Outer wall of nose, showing the superior, middle, and inferior turbinate bones.

the nasal speculum anteriorly and by the rhinoscopic mirror posteriorly. They are treated by applications of acids, as chromic and trichloracetic, by the electrocautery, or are snared off with the cold snare. Snaring is more often employed in reducing posterior hypertrophies, but both the anterior and posterior can be reached by an electro-cautery point or a knife introduced through a speculum in the anterior nares.

The Outer Wall.—The outer wall has on it the three turbinated bones—superior, middle, and inferior. The inferior is a separate bone but the middle and superior are parts of the ethmoid bone (Figs. 133 and 134).

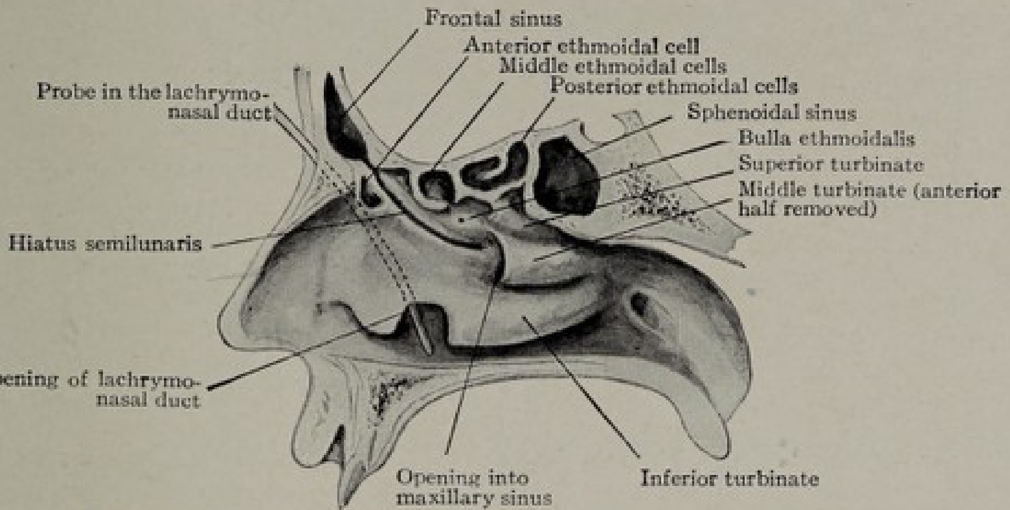
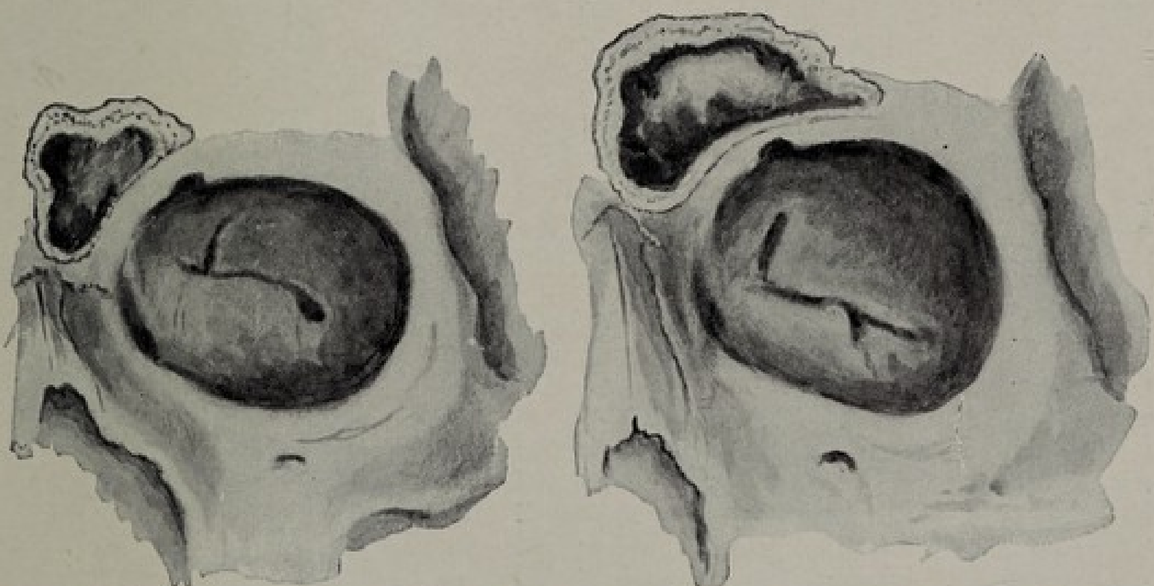


Fig. 134.—View of outer wall of the nose and accessory cavities.

The **inferior meatus** is between the inferior turbinated bone and the floor of the nose. The *lachrymonasal duct* enters this meatus just below the anterior end of the inferior turbinated bone. It pierces the mucous membrane obliquely, being guarded by a fold called the *valve of Hasner*. The opening is not visible from the anterior nares and usually it is impossible to introduce a probe into it from them.



Figs. 135 and 136.—Two views of the frontal sinus, showing variation in size in different individuals. The anterior wall has been cut away to expose the interior of the sinus.

The **middle meatus** is between the middle and inferior turbinated bones. The mucous membrane covering the middle turbinated bone lies closer to it than does that of the inferior turbinated bone, so that it is comparatively rare that treatment is necessary to reduce it.

Polypi usually have their origin in this meatus. Beneath the middle turbinated bone on the outer wall of the nose and only to be seen after removal of the bone, there is, just anterior to its middle, a rounded eminence, the *bulla ethmoidalis.* In it is an opening for the middle ethmoidal cells. Immediately in front is a slit, the *hiatus semilunaris,* into which open the maxillary sinus (*antrum of Highmore*) and the anterior ethmoidal cells. The hiatus is continued above as the *infundibulum,* which enters the frontal sinus. The relation between the hiatus and the opening into the maxillary sinus is such, in some cases, that it is possible for pus originating in the frontal sinus to discharge into the maxillary sinus. A knowledge of the relation of these parts is essential to those desirous of treating nasal diseases.

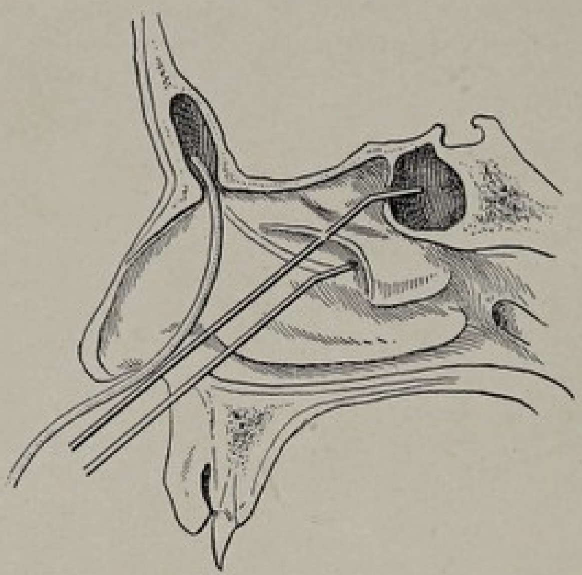


FIG. 137.—Probes introduced into the frontal, maxillary, and sphenoidal sinuses. The anterior portion of the middle turbinate has been removed.

The **superior meatus** is comparatively small and lies above the middle turbinated bone. At the anterior edge of the superior turbinated bone is the opening for the posterior ethmoidal cells. Sometimes there are two or three superior turbinals.

The *spheno-ethmoidal* recess is the cleft above the superior turbinated bone; into it opens the sphenoidal sinus. In order to examine and reach the openings of any of these sinuses, it is practically necessary to take away a part or all of the middle turbinated bone before they can be exposed to view. When this is done, they can be probed, washed out, drained, etc. (see Fig. 137).

The **frontal sinuses** begin to develop about puberty. They occupy the lower anterior portion of the frontal bone. Their size and extent vary considerably. The usual size is from the nasion below to the upper edge of the superciliary ridges above and laterally from the median line to the supra-orbital notch. These limits may be exceeded considerably. They may go as far out as the middle of the upper edge of the orbit or even nearly to the temporal ridge. The anterior and posterior walls are separated a distance of 0.5 to 1 cm. The distance which they extend back over the orbit and upward also varies. The two sinuses are separated by a partition which is often to one side of the median line, so that it is apt to be encountered in opening the sinus through the forehead. The two cells often differ greatly in size and may be divided into various recesses by incomplete septa. They have the infundibulum as their lower extremity, which passes into the hiatus semilunaris beneath the middle turbinated bone and empties into the middle meatus. The frontal sinuses are frequently the seat of suppurative inflammation. This gives rise to pain and tenderness in the supra-orbital region and to a discharge from the corresponding nostril. This discharge can be seen coming from beneath

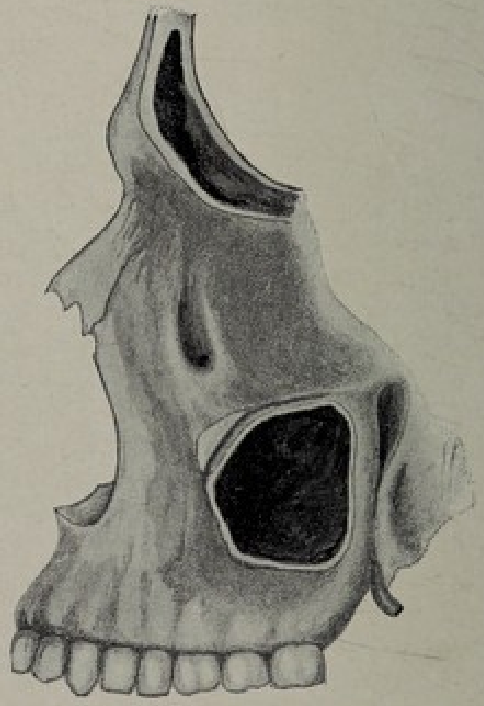


FIG. 138.—Lateral view of the maxillary and frontal sinuses.

the anterior extremity of the middle turbinated bone. Owing to the proximity of the opening into the maxillary sinus, pus, coming down the hiatus from the frontal sinus, may pass into the maxillary sinus, thus simulating disease of that cavity. In order to wash out the sinus, cocaine may be first applied to shrink the nasal membrane; then sometimes one is able to pass a probe or irrigating tube into the hiatus semilunaris and thence up into the sinus. By removing the anterior extremity of the middle turbinated bone access to the hiatus semilunaris is more readily obtained. In certain cases the frontal sinus is opened either through the supra-orbital region or entered through the roof of the orbit at its inner upper corner. The *glabella* is the depression in the median line separating the superciliary ridges. In operating on the sinus from in front, the opening is to be made just to the outer side of the glabella in order to avoid the septum between the sinuses. In curetting the sinus, the thinness of the upper and posterior wall separating it from the brain, and of the lower wall or roof of the orbit, should be borne in mind, otherwise they are apt to be perforated. The sinus may be divided into recesses by partial septa projecting from the sides. Drainage into the nose is obtained by passing an instrument from above downward through the anterior ethmoidal cells. In entering the sinus from below from the outside, the opening is made at the extreme anterior upper edge of the orbit, perforating the bone in a direction upward and inward. The opening into the sinus may be enlarged from within the nose by first inserting a probe to protect the brain and posterior wall and then chiselling or gnawing away the bone in front so that easy access is obtained through the nose for drainage, packing, etc.

The **ethmoidal sinuses or cells**, three in number on each side, anterior, middle, and posterior, lie between the sphenoidal sinus posteriorly, and the lower extremity of the frontal sinus anteriorly. The anterior cells lie in front of or just above the hiatus and open into it. The middle lie just posterior to the hiatus and open into the outer wall of the middle meatus, perforating the *bulla ethmoidalis*, which is a rounded projection on the outer wall beneath the middle turbinated bone. The posterior cells open still farther back beneath the superior turbinated bone in the superior meatus. In disease of these cells, pus from the middle and anterior ones will show in the middle meatus; from the posterior cells in the superior meatus. In this latter case it is to be detected posteriorly by means of the rhinoscopic mirror. Access to the cells is obtained by removing the middle turbinated bone. This is done by dividing it into two pieces by a transverse cut with forceps or scissors and then removing the two halves with a snare. By means of probes, curettes, and forceps, the openings into the cells may be discovered and enlarged as thought necessary. The region of the ethmoidal cells is that from which mucous polypi of the nose take their origin. They are a common accompaniment of suppuration of the accessory nasal cavities. They are usually removed by snares introduced through the anterior nares or more rarely by forceps. Caries affecting the anterior cells may extend into the orbit and the pus may form a fluctuating tumor above the inner canthus of the eye. Care should be taken not to mistake a meningocele for such a tumor.

The **sphenoidal sinuses** are the most posterior, lying still farther back than the ethmoidal. They open into the spheno-ethmoidal recess above and posterior to the superior turbinated bone. Discharge from them goes into the pharynx and is to be seen with the rhinoscopic mirror. They can be reached by first removing the middle turbinated bone and then introducing a probe upward and backward from the anterior nares for a distance of 7.5 cm. (3 in.) in women and 8 cm. in men. They can be drained by cutting away their anterior wall with punch forceps introduced through the anterior nares.

The **maxillary sinuses** lie beneath the orbit and to the outer side of the nasal fossæ. It is the seat of tumors, often malignant, and inflammation; the latter accompanied by an accumulation of mucus or pus. The walls of the sinus are thin, so we find tumors bulging forward, causing a protrusion of the cheek. They press inward and obstruct the breathing through that side of the nose, or they push upward and cause protrusion of the eye by encroaching on the orbit. In operating on these tumors, the superior maxilla is usually removed; the lines of the cuts through the bones being shown in Fig. 70. In prying the bone down posteriorly, it may not be torn entirely away from the pterygoid processes and some plates of bone may be left attached. This should be borne in mind in operating for malignant growths. The sphenoidal cells are behind the upper posterior portion of the maxillary sinus, therefore in operating on Meckel's ganglion, if too much force is used in breaking through the posterior wall of the antrum, the instrument may pass across the sphenomaxillary fossa, a distance of about 3 mm., and open the sphenoidal sinus.

The infra-orbital nerve is usually separated from the cavity of the sinus by a thin shell of bone. At the upper anterior portion of the sinus there may be a small cell between the bony canal in which the nerve runs and the bony floor of the orbit. The superior dental nerves reach the upper teeth usually by going through minute canals in the bone, but sometimes, particularly the middle set supplying the bicuspid teeth, may run directly beneath the mucous membrane, and thus be irritated by troubles originating within the sinus.

The inflammatory and infectious diseases of the sinus originate either by extension from the nose or the teeth. The sinus opens into the nose by a slit-like opening into the middle meatus about its middle, posterior to the hiatus semilunaris and 2.5 cm. above the floor of the nose. When the opening is close to the hiatus, liquids may run into it from the hiatus. The bone beneath the hiatus and opening almost down to the floor of the nose is quite thin, so that the sinus can readily be drained by thrusting a trocar and cannula through the outer wall of the nose into the sinus just below the hiatus semilunaris. The sinus is also opened from the front through the canine fossa to the outer side of the canine tooth. This opening affords direct access to the cavity, but is some distance above the floor, thus it does not drain the cavity completely. The roots of the upper teeth project into the antrum forming elevations, usually covered by a thin plate of bone. This is particularly the case of the first and second molars. Disease of the roots of these teeth frequently infects the antrum and drainage is often made through their sockets. It is now possible, with the use of iodized oils, to demonstrate the size and shape of the accessory sinuses. This is a step forward in sinus diagnosis.

THE MOUTH AND THROAT

The **lips** are formed mainly by the *orbicularis oris muscle* with its subdivisions and the *accessory facial muscles* (buccinator, levator and depressor anguli oris, levator labii superioris, levator labii superioris alæque nasi, the zygomaticus major and minor, and the depressor labii inferioris). The orbicularis oris is attached to the superior maxilla in the incisor fossa above the second incisor tooth and also above to the septum. In the lower lip it is attached to the mandible beneath the second incisor tooth. The lips contain, beside muscular tissue, some areolar tissue, arteries, veins, and lymphatics. The muscular fibres are inserted into the skin. The mucous membrane lining the lips has lying beneath it some mucous glands. They sometimes become enlarged and form small, shot-like, cystic tumors containing mucus.

Affections of the Lips.—The lips are affected by *wounds, angioma, cancer (epithelioma)*, and *clefts (harelip)*. Wounds of the lip when properly approxi-

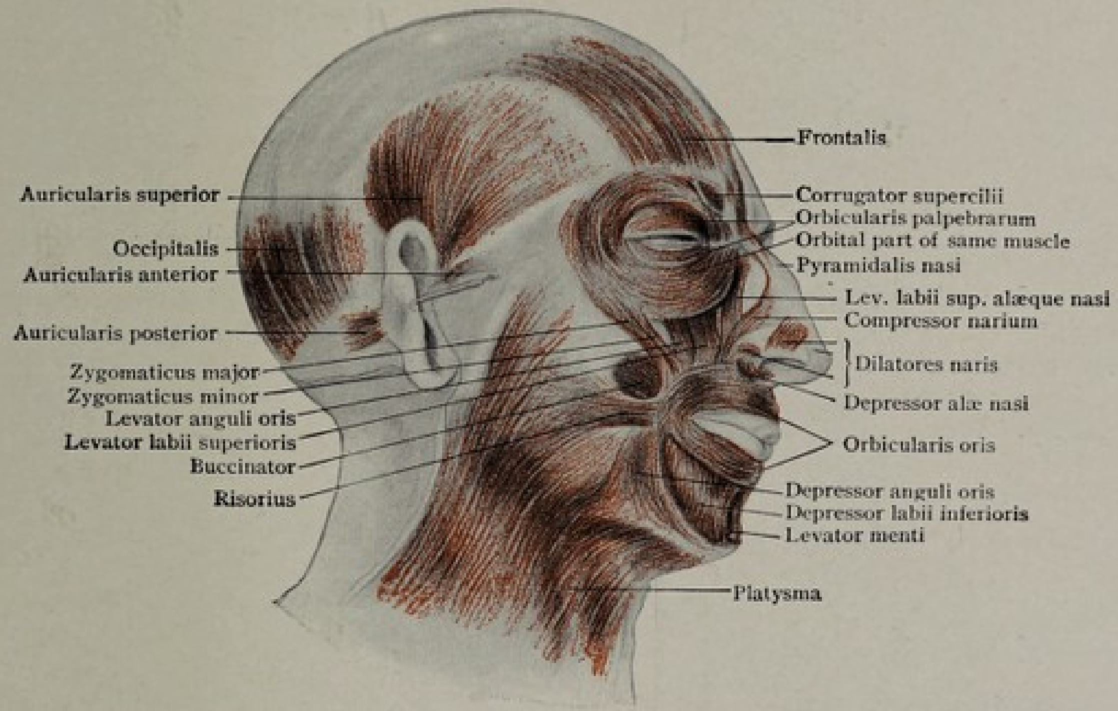


FIG. 139.—Superficial dissection, showing the muscles of the head and face. (Piersol.)

mated heal readily on account of the free blood supply. This free blood supply also accounts for the extensive swelling which occurs after injury or infection, the latter, however, only rarely occurring after injury. The arteries supplying the lips are the *superior* and *inferior coronary* branches of the external maxillary (facial). They are given off about opposite the angle of the mouth and pierce the muscle to run beneath the mucous membrane about midway between the edge of the lip and its attachment to the gums or nearer the free border of the lip. Therefore, in operating on the lip, the artery should be looked for in this situation and not toward the skin surface or in the substance of the lip. The superior coronary sends a branch to the nasal septum, called the *inferior artery of the septum*. In the sulcus between the lower lip and chin lies the *inferior labial artery*. The bleeding from this branch is not so free as that from the coronary arteries, because the anastomosis across the median line is not so marked.

Angioma.—The blood-vessels, mainly the veins, of the lips sometimes become enlarged, forming a large protrusion. This may be noticed at or soon after birth as a dusky blue, slightly swollen spot on the lip. As the child grows the swelling enlarges. Sometimes it enlarges rapidly and operation is necessary to check its growth; otherwise it may involve a large portion of the face and prove incurable. It is composed of dilated veins with thin walls and large lumen. It does not pulsate and disappears under pressure, only to return when this is removed. It is treated by excision. The thin skin is dissected off and the growth cut away from the tissues beneath, the bleeding being controlled by pressure, hæmostats, and ligatures. In

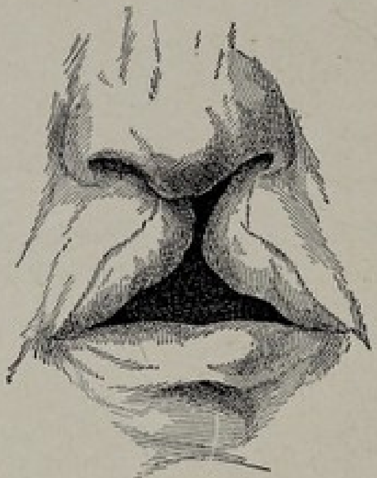


FIG. 140.—Single harelip.

FIG. 141.—Double harelip, showing the projecting premaxilla.

the case figured, the facial vein, as it crossed the mandible, and the transverse facial vein were obliterated by means of acupressure pins passed beneath them, and the growth was excised.

Cancer or *epithelioma* of the lip almost always affects the lower and not the upper lip. When it does affect the upper lip it affects the lateral portion and begins

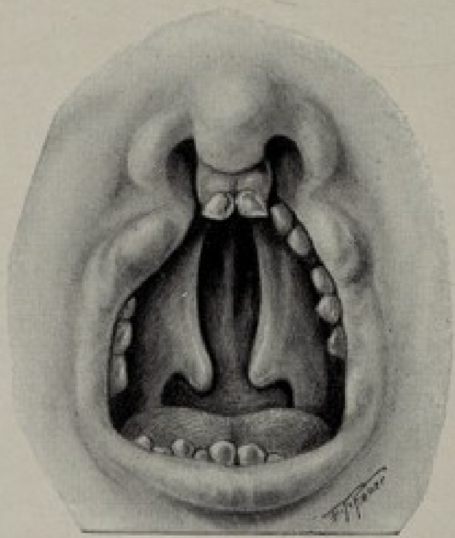


FIG. 142.—Dr. Müller's case, cleft palate.

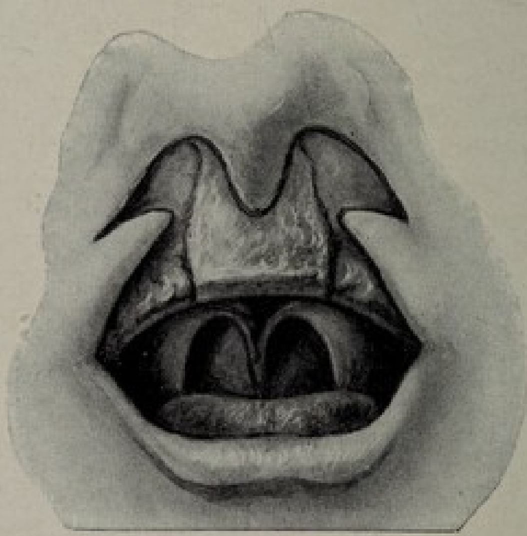


FIG. 143.—Method of suture.

in the cheek. The disease extends through the lymphatics. These pass down and laterally from the lips to the submaxillary lymph-nodes and then to the nodes along the great vessels of the neck. It is in these regions that lymphatic infection is usually seen. The middle of the lower lip is drained into a node in the submental region in front of the submaxillary nodes. This also is sometimes involved. In operating for cancerous growths it is advisable to remove all nodes from both the submental and submaxillary triangles. Since there is a decussation of the lymphatic channels in the submental region it is best to do a bilateral excision of the glands. Frequently a patient who has had a careful excision of the growth and a unilateral neck dissection returns several months later with a metastatic growth in the opposite submaxillary region.

Cleft or *Harelip*.—This is the most frequent congenital deformity of the face. It is so named because of its resemblance to the lip of a hare. It is frequently associated with a cleft of the soft or hard palate or both. The deformity is the result of a failure of union of the embryological components that after union differentiate the nasal and buccal cavities. The first or mandibular arch very early in embryonic life becomes separated into a short upper maxillary process, and a longer lower, mandibular process. The maxillary process together with that of the other side and the intervening portion known as the premaxillary (fronto-nasal) process, which has descended in the median line from the head, unite and form the superior and lateral boundaries of the oval cavity and the nose. If the premaxillary process unites with only one maxillary process then a unilateral cleft is found, but if it unites with neither, a bilateral cleft is present and the premaxillary process extends forward as a proboscis and a cleft exists in the alveolus. It can thus be seen that all gradations of a deformity may exist from a slight V in the lip to a complete cleft of lip, alveolus and palate. The importance of the fronto-nasal process (premaxilla) should always be understood. It is never to be excised, for if this is done the source of the central portion of the upper alveolus with its central incisor teeth is lost.

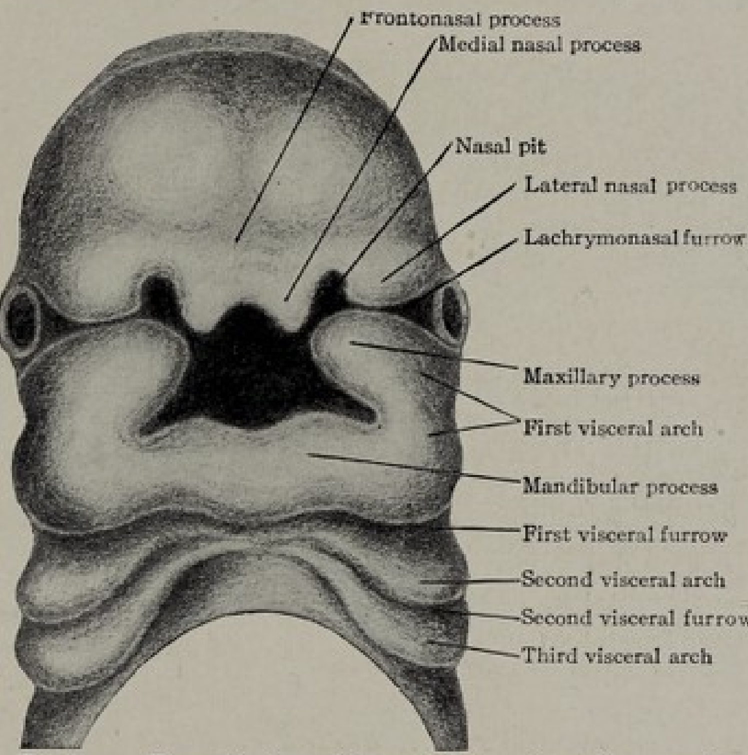


Fig. 144.—Frontal view of human fœtus about four weeks old. (After His.)

Paralysis of the lips is due to interference with the functions of the seventh nerve. The muscles of expression of the face and lip are likewise supplied by the seventh or facial nerve. This is frequently paralyzed, owing to its tortuous passage through the temporal bone in the canal of Fallopius it may be injured in fractures of the base of the skull in operations on the mastoid cells and may become affected from middle ear disease or neuritis. When paralyzed, the muscles of the lips, both upper and lower, on the affected side, droop. The drooping of the lower lip may allow the saliva to run out of the mouth. It is also impossible for the patient to pucker his mouth, as in whistling or to wrinkle the forehead. If the lesion of the facial nerve is inside the skull and not in the Fallopian canal, the *great petrosal nerve* and some of the palatal muscles will be paralyzed, the voice will be altered and swallowing affected.

The depressor labii inferioris instead of receiving its nerve supply from the supramandibular branch of the facial, frequently is supplied by the inframandibular branch; pressure or injury of this branch in enlargements of or operations on the submandibular lymph-nodes has produced paralysis of the muscle with a peculiar alteration of the facial expression (see Fig. 145).

Mouth.—*Surface Anatomy.*—In looking into the mouth, one sees the tongue below and the roof above, surrounded in front and on the sides by the teeth. On each side are the inner surfaces of the cheeks and posteriorly are seen the uvula, the arches of the palate, and the pharynx. On the mucous membrane of the cheek, opposite the second upper molar tooth, is a small papilla in the top of which opens the duct of the parotid gland. A small probe can be inserted into it and passed outward and backward toward the gland.

Tongue.—The tongue is covered with a mucous membrane which is modified skin; therefore it is subject to the same diseases as the skin. It is covered with papillæ of three kinds—the *filiform, fungiform,* and *circumvallate.* The filiform are the smallest and most numerous and form a sort of ground-work in which the others are embedded. The fungiform are larger and fewer in number and are scattered on the dorsum, sides, and tip of the tongue among the filiform. The circumvallate, seven to twelve in number, form a V-shaped row at the base of the tongue. In the eruptive fevers, particularly scarlet fever, the tongue gets very red and the papillæ become enlarged, forming what is known as the strawberry or raspberry tongue. Just beyond the apex of the circumvallate papillæ in the median line is the *foramen cæcum.* It is sometimes patulous for a short distance and is the upper extremity of the fœtal *thyroglossal duct.*

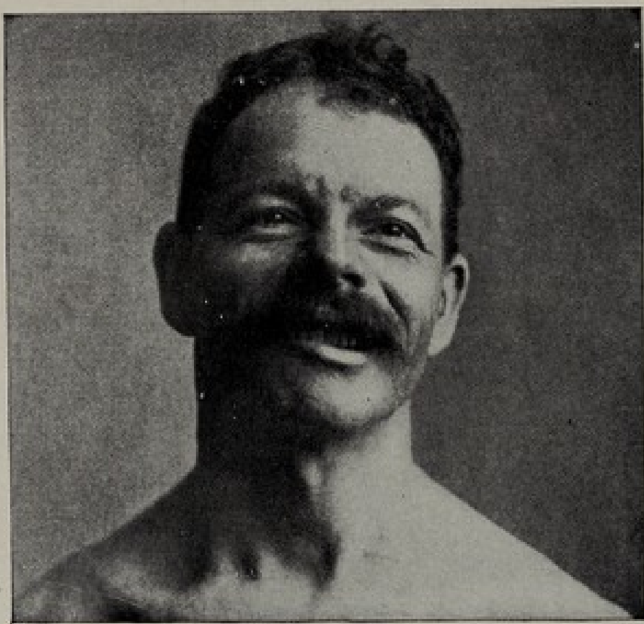


Fig. 145.—Paralysis of depressor labii inferioris from section of the lower filament of the facial nerve. (Dowd.)

On the posterior portion of the tongue behind the circumvallate papillæ, on each side of the median line, is a mass of adenoid tissue which forms what is known as the *lingual tonsil.* It sometimes becomes hypertrophied and is then cut off with a specially curved tonsillotome just as is done with enlarged faucial tonsils. The mucous membrane from the back of the tongue is reflected in a thin layer on to the front of the epiglottis. This forms three folds, the median and the two lateral glosso-epiglottic folds. Between the folds are the glosso-epiglottic fossa.

In the middle of the dorsum of the tongue is a furrow; this is caused by the septum binding the middle of the tongue down and allowing the muscles to rise on each side.

On turning the tip of the tongue up (Fig. 148), a fold of membrane, the *frænum,* is seen extending from the under surface to the floor of the mouth beneath. In newborn children, this frænum appears sometimes to be too short, hence the name *tongue-tie.* In cutting it, the split end of a grooved director is placed over the frænum and the tongue pushed back. This makes the frænum tense and it can readily be snipped with the scissors. Care should be taken not to cut too deeply, or the ranine artery may be cut and cause troublesome bleeding. Running across the floor of the mouth, between the teeth and tongue, parallel to the alveolus, is the *sublingual ridge,* formed by the *sublingual gland.* This gland lies on the mylohyoid muscle beneath and the lower jaw in front. On its inner side are the lingual nerve and the submaxillary duct. On each side of the frænum on the sublingual ridge is a papilla into which the duct of the submaxillary gland, *Wharton's duct,* opens. Opening into Wharton's duct, or by a separate duct into the same papilla, is the duct of the sublingual gland, called the *duct of Bartholin.* Although when present it is larger than the other sublingual ducts, its presence is inconstant. The sublingual *ducts of Rivinus* vary in number from four to twenty. Some enter Wharton's duct while the major portion open in the floor of the mouth on the sublingual ridge to the outer side of the papilla. Accessory bits of sublingual gland, if present, are drained by the *ducts of Walther.*

Ranula and Cysts of the Salivary Glands. Cysts involving the parotid gland are quite rare, so that the term ranula is usually restricted to those in relation to the

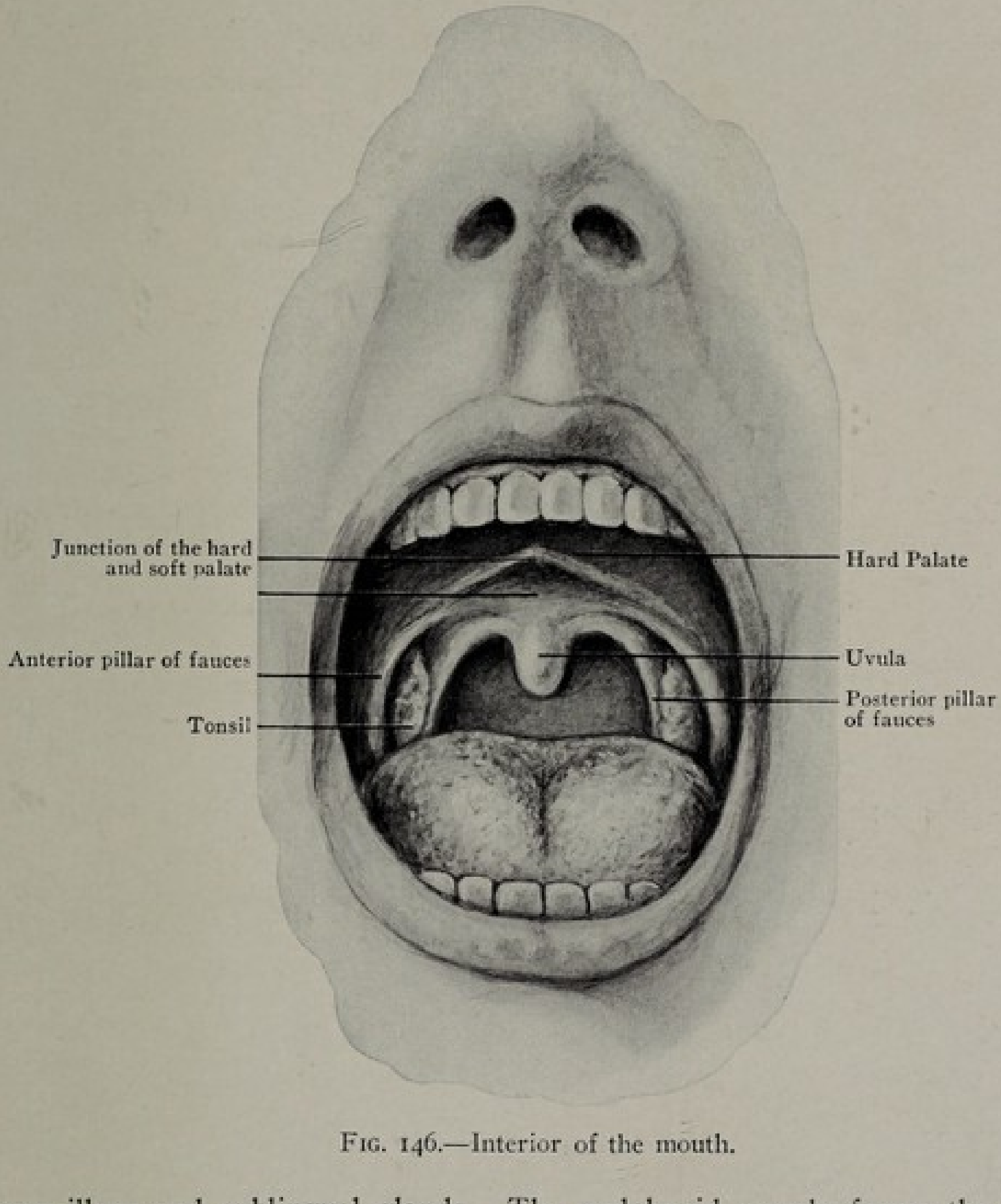


FIG. 146.—Interior of the mouth.

submaxillary and sublingual glands. The mylohyoid muscle forms the floor of the mouth and these cysts lie on it beneath the tongue and between the tongue and the gums (Fig. 149). If the cyst is large it causes a protrusion or swelling beneath the jaw. The bulk of the submaxillary gland lies on the side of the mylohyoid muscle nearest the skin; only a small portion of it winds around the posterior edge of the muscle. Therefore, cysts involving the substance of the gland would show in the submaxillary region of one side. If, however, the duct were obstructed (as by a calculus) it would form a cyst, which would bulge into the mouth beneath the tongue. The sublingual gland may be the starting point of these cysts, and it will be seen that as they enlarge they push the ranine artery with the tongue backward and are only covered by the mucous membrane. On this account there is little or no danger in operating on them. They are either dissected out or the front wall of the cyst cut away and the interior cauterized or packed with gauze to promote the formation of granulations. The jaw-bone is in front of them and the mylohyoid

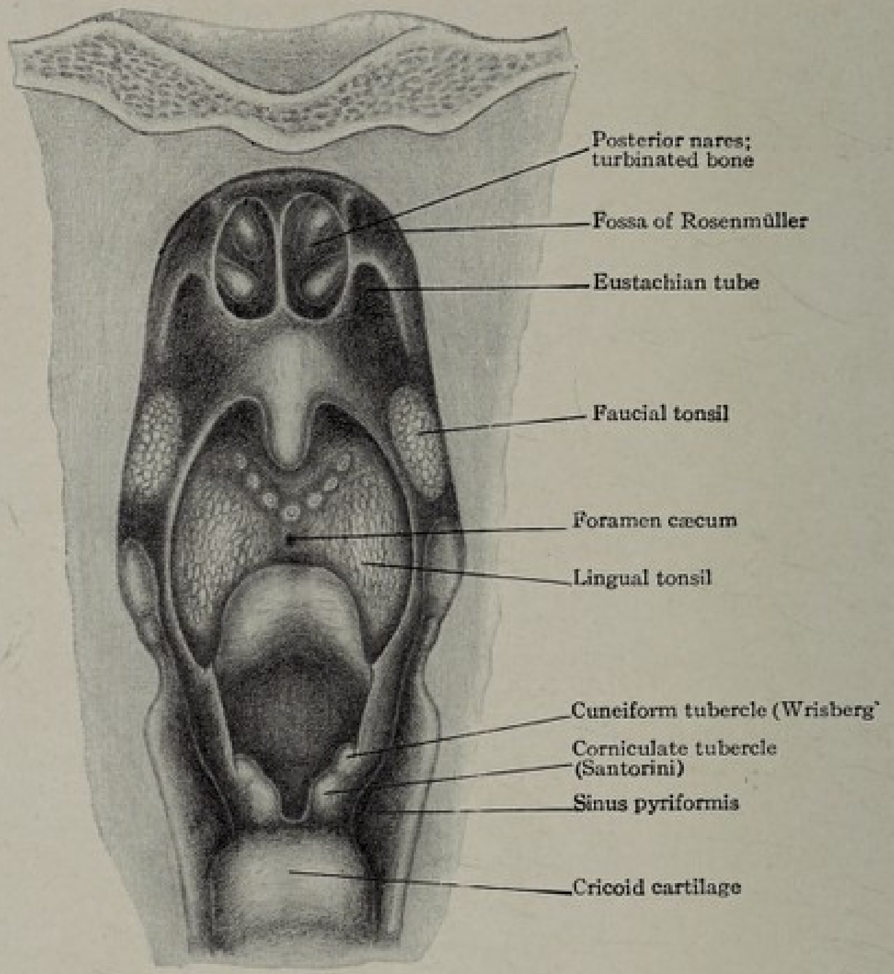


FIG. 147.—View of pharynx, looking forward; posterior wall removed, showing the posterior nares, base of tongue, and opening of the larynx.

muscle beneath. Posteriorly lies the duct of the submaxillary gland and the ranine artery. Fillaux has described a sublingual bursa, situated between the genio-hyoglossus and the mucous membrane, its tip extending to the frænum and its base to the sublingual gland. This bursa is certainly not constant, but its presence may explain the so-called acute ranula. Whether or not ranulæ are ordinary retention cysts or whether or not they are really branchiogenic cysts, as suggested by Thompson, is not definitely decided, but we favor the latter view. Anyone who has done a careful dissection for this cyst cannot but have been impressed by the fact that although in relation to, they are distinct from the gland itself. For this reason we believe they are the result of an incomplete closure of the first branchial cleft.

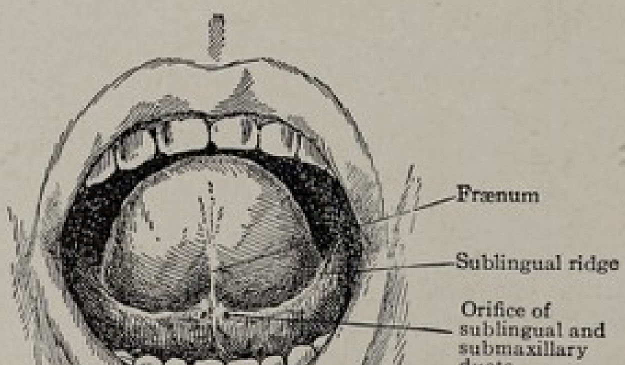


FIG. 148.—Under surface of tongue and floor of mouth.

Mucous cysts can occur from the mucous glands of the mouth and tongue itself. There is a gland on the under side of the tip of the tongue, usually larger than the others, called the *anterior lingual gland* or *gland of Nuhn*. As a rule, these mucous cysts are small and are felt as hard rounded bodies beneath the mucous membrane. Dermoid cysts occur in connection with the tongue but very rarely.

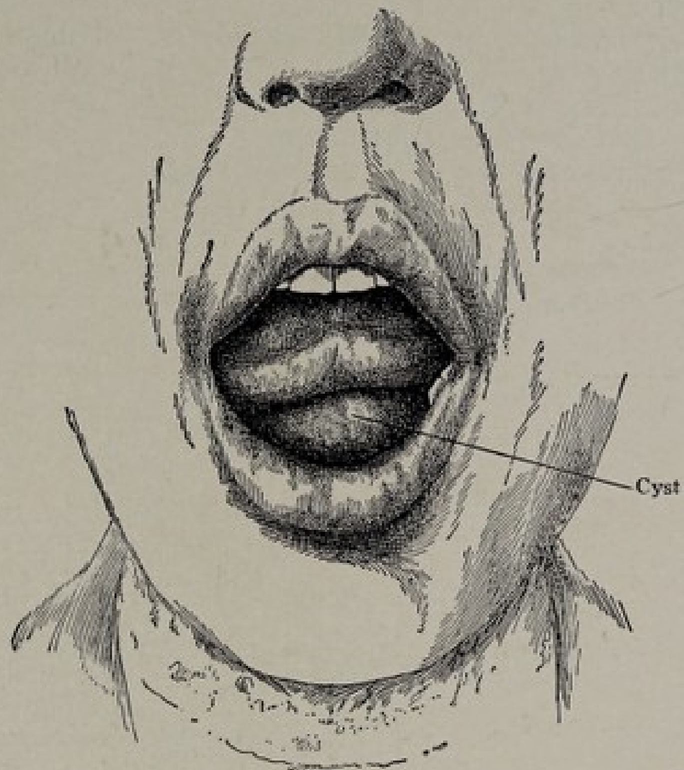


FIG. 149.—Sublingual cyst (ranula). (From a photograph by Dr. Ashhurst.)

Carcinoma of the tongue is a moderately frequent disease and as the tongue is covered by modified skin, the cancer is epithelial type. It begins on the surface of the tongue either by a change in the epithelial covering or else in fissures or ulcers at its edges. The lymphatics from the tip of the tongue empty into the submental group of lymph-nodes and in the lowest nodes of the internal jugular group of the sternomastoid chain. The middle third of the tongue is drained by lymphatics which course both along its margins and in its midline. The most anterior of the marginal groups drain into the anterior nodes of the submaxillary group. Otherwise the drainage is into the lower nodes of the internal jugular group. The posterior part drains into the uppermost nodes of the internal jugular group by both median and láteral collecting trunks.

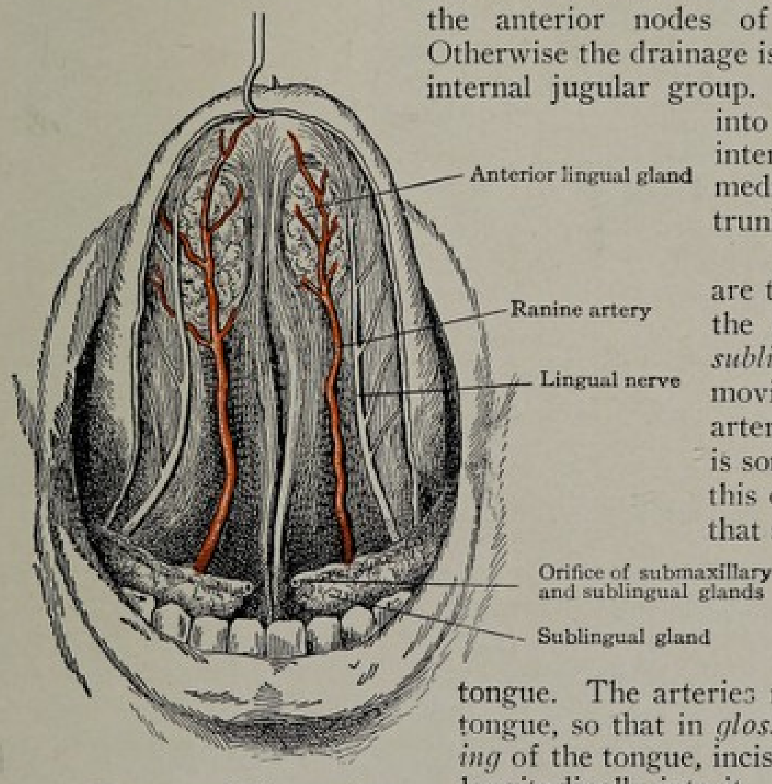


FIG. 150.—Under surface of the tongue, mucous membrane removed.

The **arteries** of the tongue are the *lingual and its branches*, the *hyoid*, the *dorsalis linguæ*, *sublingual*, and *ranine*. In removing the tongue, the lingual artery on the side to be removed is sometimes ligated in the neck; this cuts off the blood supply to that side and there is practically no bleeding. There is very little anastomosis between the vessels of the two sides of the tongue. The arteries run lengthwise through the tongue, so that in *glossitis* or *inflammatory swelling* of the tongue, incisions should always be made longitudinally into it.

The ligation of the lingual artery will be found described in the section on the neck. As the lingual artery passes above the hyoid bone, it gives off its *first branch*, the *hyoid*. It is quite small and goes above the hyoid bone superficial to the hyoglossus muscle. The lingual then goes beneath the hyoglossus muscle and near the posterior edge gives off its *second branch* or *dorsalis linguæ*.

In *excision*, the tongue is usually cut through on the distal side of the dorsalis linguæ artery. When this is the case, the bleeding which occurs from the branches of the dorsalis linguæ is not marked because it is not a large artery.

In order to draw the tongue out, it must be loosened posteriorly by cutting the anterior pillars of the fauces and palatoglossus muscle, and anteriorly at the frænum by cutting the geniohyoglossus muscle. By drawing the tongue up, the ranine artery is drawn out of the way and there will be only slight bleeding from small branches of the sublingual, which comes from the main trunk at the anterior edge of the hyoglossus muscle. From this point forward to the tip, the lingual artery is called the ranine. The tongue having been loosened and pulled out, a transverse cut is made through the mucous membrane behind the growth and then, by pushing

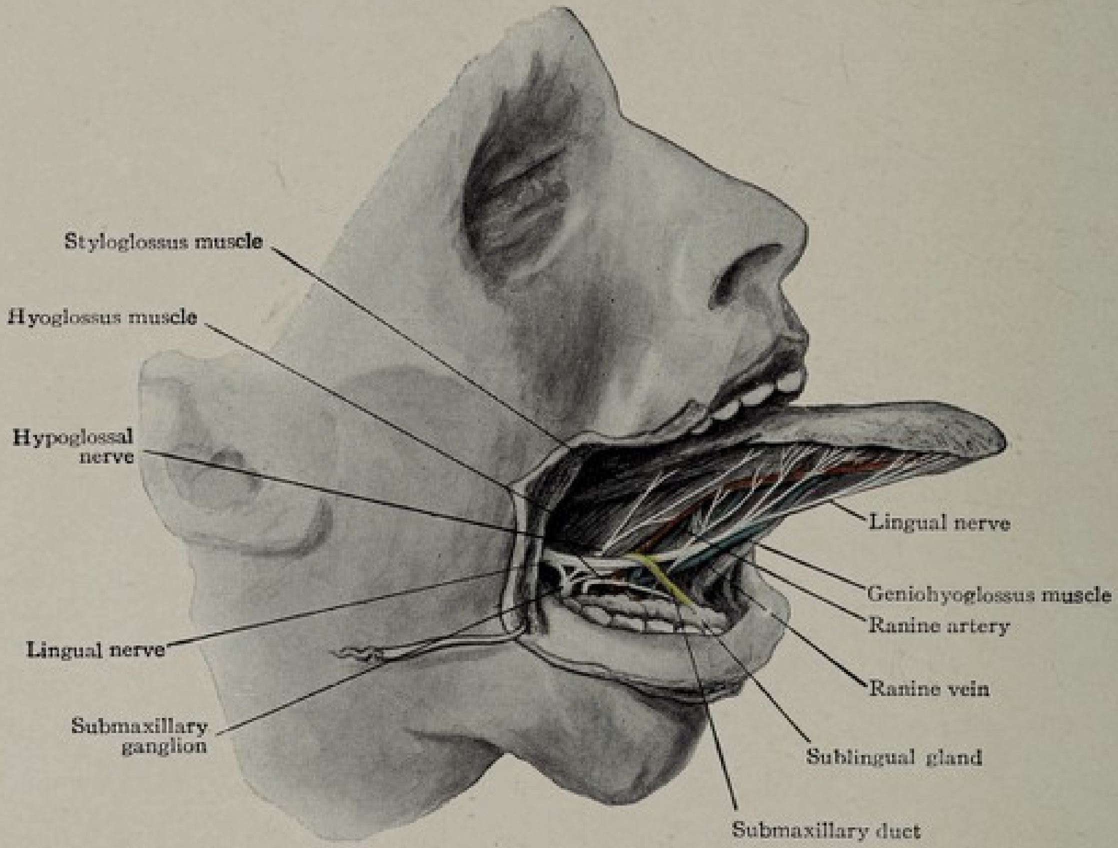


FIG. 151.—The cheek has been split, the tongue drawn forward, and the mucous membrane removed from its under surface, exposing the ranine artery and vein, the lingual and hypoglossal nerves, the sublingual gland, the submaxillary ganglion, and the duct of the submaxillary gland.

the tissues aside with a blunt instrument the lingual nerve and artery are exposed lying together beneath the mucous membrane. The artery is then tied and the growth removed.

In order to secure any bleeding points after the tongue has been cut away, the floor of the mouth can be raised and pushed forward by the fingers beneath the chin. This brings the stump into view and within reach. If lymphatic nodes are to be removed, they must be sought for by an additional incision on the outside beneath the jaw.

The **roof of the mouth** is formed by the *hard palate* and the *soft palate*; the former comprising about three-fourths and the latter one-fourth. The hard or bony palate is composed in its anterior two-thirds of the palatal processes of the superior maxillary bones, and in its posterior third of the palatal bones. In the median line close to the incisor tooth, in the dried skull, is the *anterior* or *nasopalatine foramen*. This is subdivided into four foramina, two lateral and two anteroposterior. The former, called the *foramina of Stenson,* transmit the terminal branches of the descending palatine arteries; of the latter, called the *foramina of Scarpa,* the anterior one transmits the left nasopalatine nerve, and the posterior one the right nasopalatine nerve. The soft tissues of the roof of the mouth are thicker than they appear to be, so that when they are raised, as in operating for cleft palate, they form quite a thick layer. Infection of the roof of the mouth when it occurs is usually by extension from neighboring diseased teeth, abscesses being sometimes produced. The upper and lateral boundaries of the oral cavity and the differentiation of the nasal and oral cavities, is the result of fusion of the two lateral maxillary processes of the first branchial cleft and the medial fronto-nasal process which descends from the anterior part of the head. Failure of these processes to meet in part or entirely results in one or another variety of *cleft palate.*

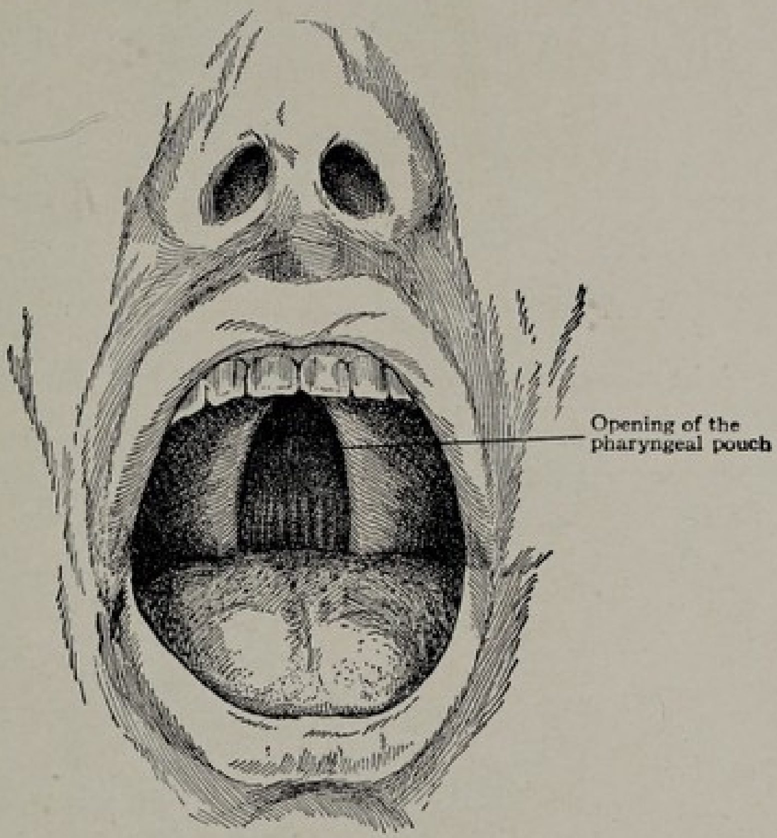


Fig. 152.—Cleft palate, showing the opening of the pharyngeal pouch on the posterior wall.

The blood supply of the roof is of importance in relation to the operation for *cleft palate* (*staphylorrhaphy*). The blood comes anteriorly from the nasopalatine arteries and posteriorly from the descending palatine arteries, which come down through the pterygopalatine canal from the internal maxillary artery and make their appearance on the hard palate at the posterior palatine foramen. This foramen is on the roof of the mouth opposite the last molar tooth and 0.5 cm. to the inner side and in front of the hamular process (Fig. 153). This hamular process can be felt just posterior and to the inner side of the last molar tooth. If, in operating for cleft palate, the tissues are loosened from the bone too close to the hamular process, this artery may be torn near its exit from the foramen, in which case the bleeding is very free. To control it, the canal can be plugged with a slip of gauze. In detaching the soft palate from the posterior edge of the hard palate, it should be remembered that this attachment is quite strong. Not only are the muscles of the soft palate themselves attached to the bone, but the pharyngeal aponeurosis which lies under the mucous membrane on the posterior or upper surface of the soft palate is also attached to the bone.

Palatal Arches.—Farther back in the mouth, one sees the anterior and posterior arches of the palate or *pillars of the fauces* with the *uvula*. The anterior pillar runs from the soft palate to the tongue and is formed by the *palatoglossus muscle*. The posterior pillar runs from the soft palate downward to the sides of the pharynx and is formed by the *palatopharyngeus muscle*. In front of these arches and running from the roof of the mouth opposite the posterior edge of the last molar tooth downward to the posterior edge of the alveolar process of the lower jaw is an

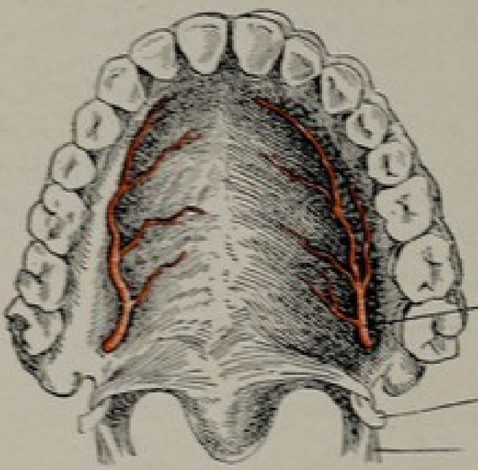


FIG. 153.—Roof of the mouth, mucous membrane removed.

elevation of the mucous membrane which shows the line of junction of the hard and soft palates.

Faucial Tonsils.—Between the pillars of the fauces lie the *faucial tonsils*. They are limited above by the sulcus, called the *supratonsillar fossa*, formed by the approximation of the pillars and a fold of mucous membrane, called the *plica trian-*

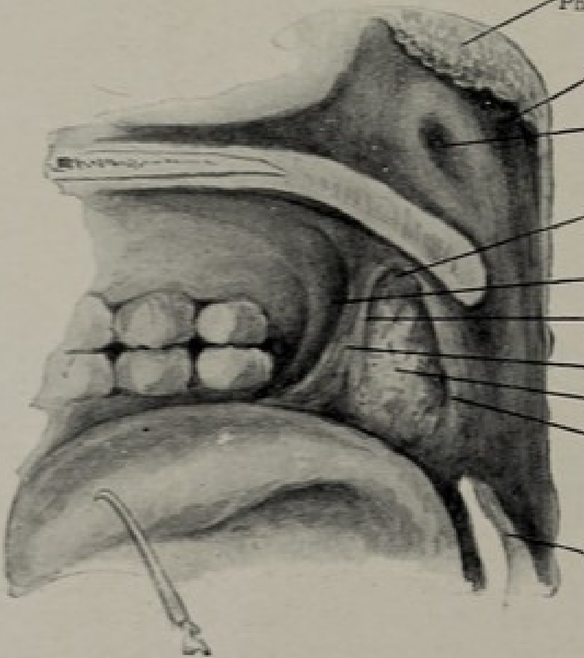


FIG. 154.—Lateral view of the faucial tonsil and pharyngeal region.

gularis (His), running downward from the anterior pillar and often blending with the tonsil. Below they extend a variable distance, necessitating depression of the tongue with a spatula in order to make their lower limit accessible. They lie opposite the angles of the jaw on the pharyngeal aponeurosis (p. 132) with the superior constrictor muscle and bucco-pharyngeal fascia outside. A knowledge of their structure is essential to the proper treatment of their diseases. The *tonsils* are oval in shape and when normal in size project but little beyond the pillars of the fauces. They are about 2.5 cm. long by 1 cm. wide and consist of about a dozen recesses or crypts formed by the folding inward of the mucous membrane. From these crypts follicles extend. The walls of the crypts contain adenoid tissue as well as mucous glands. The tonsil is held together by connective tissue which is continuous with its capsule and the submucous fibrous tissue of the pharynx. This capsule rests on and blends more or less completely with the fibres of the pharyngeal aponeurosis. On this account while an enlarged tonsil can at times, usually in young children, be shelled out of its bed, especially its upper portion, at others it is necessary to dissect or cut it out by means of a knife, scissors, tonsillotome, or snare.

The blood-vessels supplying the tonsil are five in number. They are: the *ascending pharyngeal branch* of the *external carotid*, the *ascending palatine* and

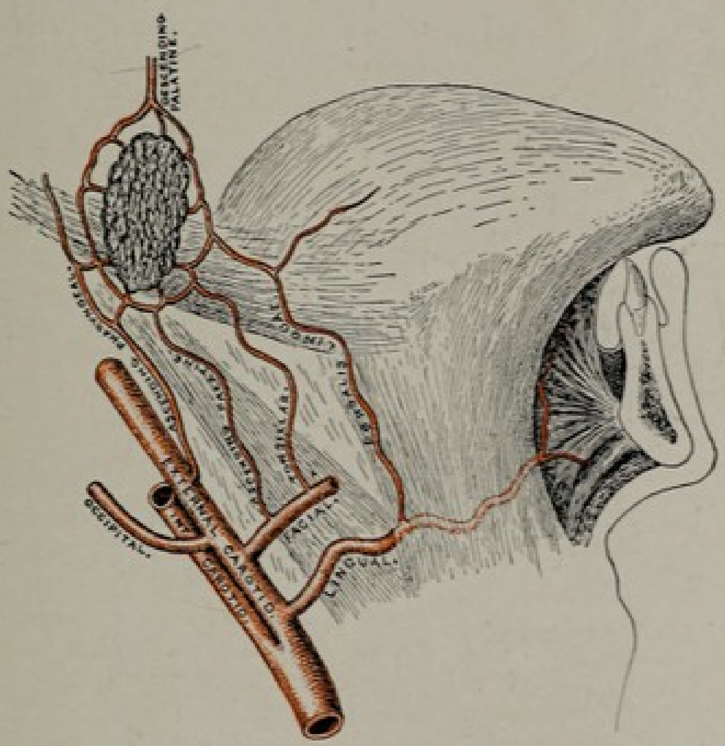


FIG. 155.—Diagram illustrating the blood supply of the faucial tonsil.

tonsillar branches of the *facial*, the *tonsillar branch of the dorsalis linguæ*, and the *descending palatine branch* of the *internal maxillary*. Ordinarily, these branches are small, but sometimes some of them are large and may cause troublesome hemorrhage. In inflammation of the tonsils, these vessels of course are larger than usual. The vascular relations are important in performing tonsillectomy. The tonsillar artery, a branch of the facial, is usually the largest vessel. It passes upward on the outer side of the superior constrictor muscle through which it passes to give branches to the tonsil and soft palate. The branches from the ascending palatine and ascending pharyngeal also pass upward outside of the superior constrictor and pierce it to ramify in the tonsil and faucial pillars. If these branches are severed as they enter the capsule of the tonsil the hemorrhage is usually only slight, but if they are severed on the outer aspect of the muscle before they are broken up into small branches the hemorrhage may be alarming. The internal carotid is usually nearly 2.5 cm. behind and to the outer side of the tonsil and the external carotid is still further removed since it lies outside of the stylopharyngeus and stylo-glossus muscles. Occasionally the internal carotid lies more closely to the tonsil and its pulsation is transmitted to the gland. This should always be a danger signal to the surgeon.

The tonsils are subject to inflammation and tumors. Tumors are rare; they grow inward and obstruct breathing and swallowing. Attempts are made to remove them either by scraping, cutting, snaring, or burning them with the electro-cautery from the mouth; or they are sometimes removed through an external incision through the neck. This latter is a very severe procedure on account of the depth of the tonsil and the number of important structures which overlie it.

Phlegmonous tonsillitis or **quinsy** is an inflammation of the peritonsillar tissue. It results from infection of the crypts in the supratonsillar fossa, which are in contact with the posterior and outer aspect of the tonsil. In mild cases the crypts or lacunæ are affected, forming a *follicular* or *lacunar tonsillitis*. In this form epithelium and inflammatory matter are poured into the follicles and distend them, often showing as white plugs protruding from the mouth of the crypt. In severe cases, the whole substance of the tonsil and even the connective tissue around it are involved in the inflammation, forming a *parenchymatous tonsillitis* or the inflammation may become phlegmonous and an intratonsillar abscess result. When this forms in the substance of the tonsil it may break into a follicle and discharge into the throat. An abscess of the tonsil may become quite large, bulging toward the median line, and on breaking may cause suffocation by passage of the pus into the larynx. If, as is usually the case, the pus involves the tissue around the tonsil, forming a peritonsillar abscess, it pushes upward behind the anterior pillar into the supratonsillar fossa and bulges forward, stretching the pillar over it. To evacuate this pus an incision should be made directly anteroposteriorly, with the flat side of the blade parallel with the edge of the pillar, or a slender pair of hæmostatic forceps may be used. A centimetre and a quarter (½ in.) is deep enough usually to plunge the knife; the point should not be pointed outwardly but directly backward. The incision should be just above the upper and lateral edge of the anterior pillar (Fig. 156). Some small vessels may bleed, but this will either stop spontaneously or may be controlled by packing. The ascending pharyngeal artery lies beneath the tonsil. Sometimes pus may burrow through the constrictor muscle and enter the tissues of the neck. In severe tonsillitis the deep lymphatics beneath the angle of the jaw become enlarged.

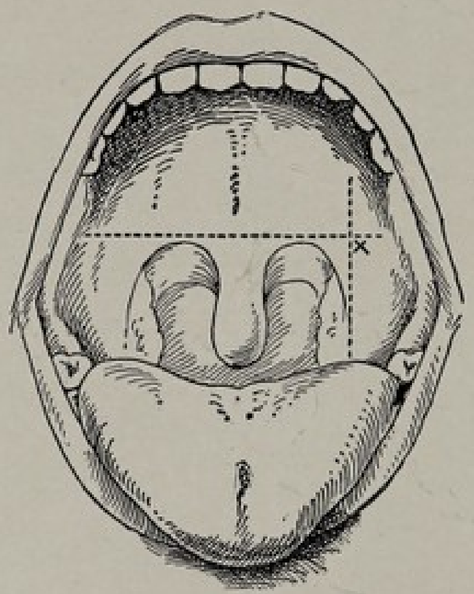


FIG. 156.—Point of puncture for tonsillar abscess. "If an imaginary horizontal line is drawn across the base of the uvula, and another vertically along the anterior faucial pillar, they will intersect at a point overlying the supratonsillar fossa. Just external to this is the best point for opening a quinsy."—St. Clair Thomson.

The tonsils are removed when diseased since they are a frequent source of focal infection. They often harbor organisms which cause cardiac, arthritic, optic and many other diseases. Through them the tubercle bacillus reaches the lymph glands of the neck. They are removed by actual dissection with a scissors and knife or by the snare or tonsillotome as in the Sluder method. Care must be exercised so as not to injure the pillars or the uvula. If hemorrhage results, which cannot be controlled by ligation or packing and oversewing the pillars, the external carotid should be ligated.

Retropharyngeal abscess may arise from any one of three causes,—cervical caries, suppuration of lymphatic nodes, or extension of pus from the middle ear through the canal for the tensor tympani muscle. The pharyngeal aponeurosis lies under the mucous membrane and between it and the constrictor muscle. It is thick above and fades away below. It fills up the gap above between the superior constrictor and the base of the skull and is attached to the pharyngeal spine on the under surface of the basilar process. It is lined with the mucous membrane and covered by the constrictor muscles. Over all is the *buccopharyngeal fascia*, a thin layer continuous forward over the buccinator muscle and separated from the prevertebral fascia by very loose connective tissue. The space between these two layers of fascit is known as the *retropharyngeal space* and pus can follow it downward behind the pharynx and œsophagus into the posterior mediastinum. Retropharyngeal abscesses occur external to the pharyngeal aponeurosis and bulge into the throat. On account of the looseness of this aponeurosis and its lack of firm attachments, these abscesses may not bulge forward as a distinct circumscribed

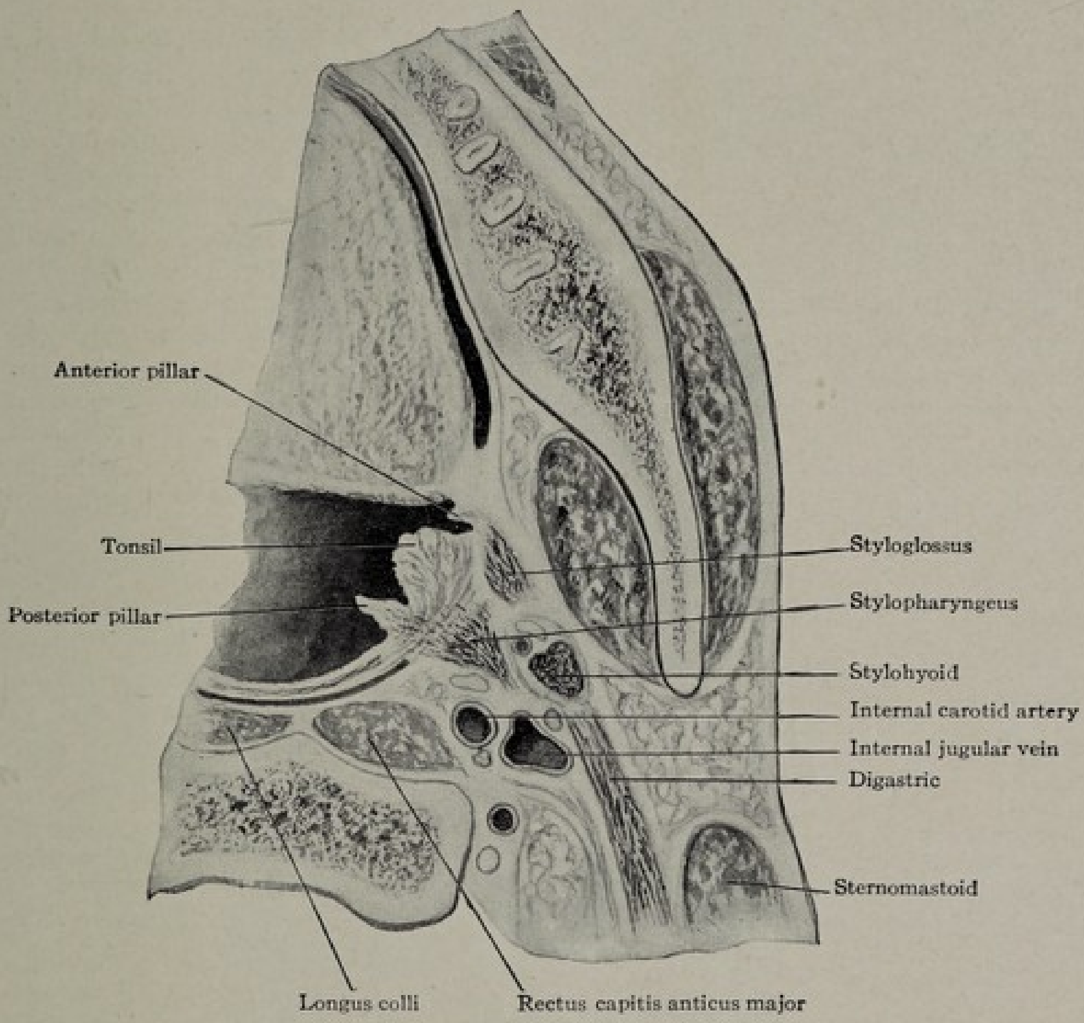


FIG. 157.—Transverse frozen section passing through the faucial tonsil and showing its relation to the internal carotid artery.

swelling, as abscesses do elsewhere, but are more apt to gravitate downward and hang in a loose bag-like manner opposite the base of the tongue. They are not easily felt, being so soft, and to see them properly the tongue should be held down with a tongue depressor. In looking for their origin, a careful examination of the spine should be made to detect the possible existence of spinal caries or Potts' disease, and the ear should be examined for suppurative otitis media. The lymph-nodes, which often give rise to these abscesses, especially in children under two years of age, are one or two lying on the anterior surface of the vertebral column between it and the pharyngeal aponeurosis and constrictor muscles. In evacuating these abscesses the safest way is to place the child on its back with the head hanging; the pus then gravitates toward the roof of the pharynx. The tongue is held out of the way with a tongue depressor and the abscess can be well seen and incised. Raising the body causes the pus to flow from the mouth.

The pus may not only point in the mouth but can work its way laterally. In such a case it may pass out behind the sheath of the great vessels and make its appearance behind the posterior edge of the sternomastoid muscle. If a tumor is present in this situation, the pus may be evacuated by an incision at this point and the abscess drained there instead of making an opening through the pharynx. This, of course, tends to guard against infection from the mouth.

Fig. 158.—Cervical caries with retropharyngeal abscess opening just posterior to the sternomastoid muscle.

Lingual Nerve.—The lingual nerve or gustatory branch of the fifth can be readily exposed in the mouth. On looking into the mouth, a fold can be seen going up and back just behind the last molar tooth. This is formed by the *pterygomandibular ligament*, running from the tip of the internal pterygoid plate to the posterior extremity of the mylohyoid ridge and joining the buccinator with the superior constrictor muscle. An incision made just internal to this fold, below and behind the last molar tooth, will lead one down to the lingual nerve close to the bone.

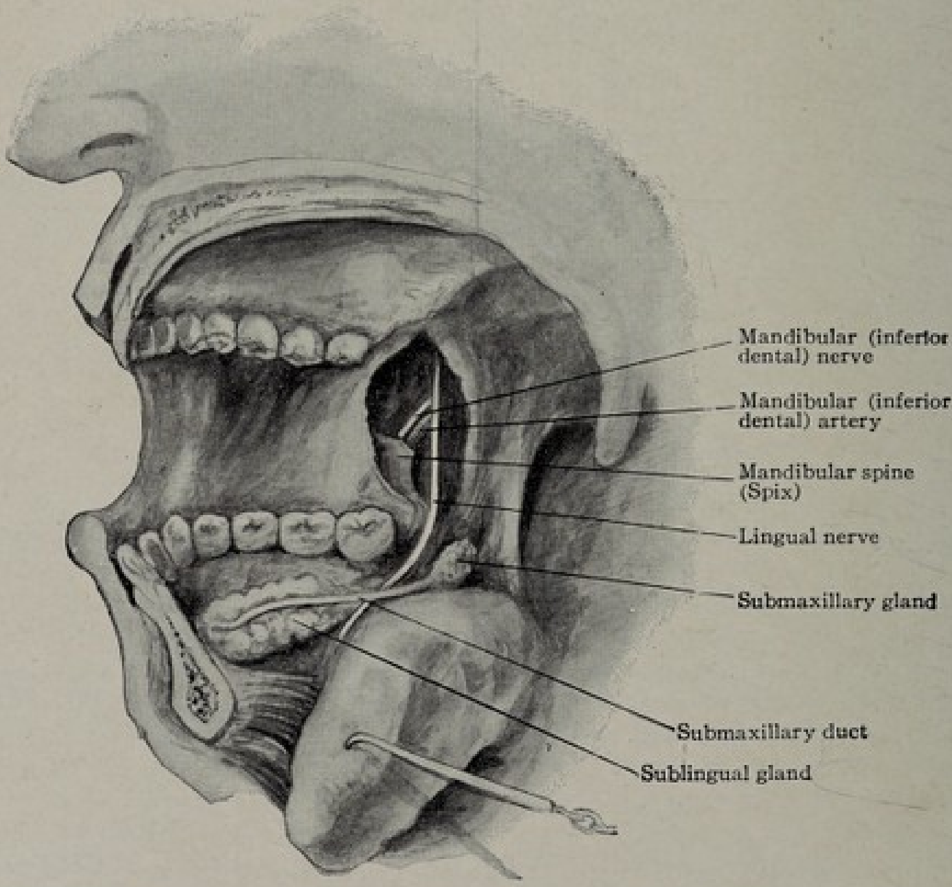


Fig. 159.—View of mandibular and lingual nerves from within.

The **mandibular** (inferior dental) **nerve** is also reached through an incision running from the last upper to the last lower molar tooth. The finger is introduced and the spine of Spix felt at the inferior dental foramen. The nerve and artery enter the mandible at this point, the artery being below and posterior. The operation of Paravicini on this nerve through the mouth is unsatisfactory on account of the lack of proper exposure. It is better to attack the nerve from the outside as detailed on page 60.

The nerve is frequently injected in order to produce anæsthesia in operations on the lower teeth. The following method is that of Labat. A 10 cm. needle is used. The anterior margin of the ascending ramus is defined by the tip of the left forefinger placed in the mouth. With the shaft of the needle resting on the dental arch between the canine and the first bicuspid on the opposite side, the needle is advanced toward the palpating finger and introduced just medial to it and 1 cm. above the triturating surface of the last molar tooth. It then comes in contact with the retromolar trigone. The needle is then swung horizontally from this position to a direction parallel with the dental arch of the molars on the side of the puncture, and its hub raised 1 cm. above the teeth. The shaft of the needle thus becomes parallel with the triturating surface of the molars and lies lateral to the dental arch. The needle is now introduced gently through the mucosa, gradually feeling the bone on its way backward. Soon the bony contact is lost, indicating that the internal oblique line or inner side of the trigone is being passed. At that particular instant the hub of the needle is gently displaced horizontally toward the midline, above the incisors and the needle introduced from 1.5 to 2 cm. deeper. Its point is then at the lingual, that is, in close proximity to the inferior dental nerve, 2 cc. of 2 per cent. novocaine are introduced without trying to hit the nerve.

PHARYNX

The pharynx is the common air and food tract that lies behind the nose, mouth, and larynx. It extends from the base of the skull above to the œsophagus below. Its lower end is at the cricoid cartilage, which is opposite the sixth cervical vertebra. In passing an instrument directly backward through the nose, one strikes the base of the skull or interval between the basilar process and the atlas. In looking into the throat through the mouth, one is level with the body of the second vertebra. If, by means of a hook, the soft palate is raised or pushed aside and the head tilted slightly backward one sees the anterior tubercle of the atlas. The rounded projection can readily be felt. The pharynx has seven openings into it, viz.: the two posterior nares, the two Eustachian tubes, the mouth, the larynx, and the œsophagus.

Posterior Nares or Choanæ.—These can readily be seen by means of the rhinoscopic mirror. They are separated by the posterior edge of the bony septum, the *vomer bone*. They are 2.5 cm. (1 in.) long and 1.25 cm. wide, hence are of sufficient size to allow a well lubricated little finger to pass into them from the anterior nares. The tip of an index finger can be inserted through the mouth below, hence the entire length of the lower meatus of the nose and upper surface of the soft palate can be palpated.

Projecting from each lateral wall toward the septum are the rounded posterior ends of the middle and inferior turbinated bones. Sometimes, high up, the posterior end of the superior turbinate can be seen. The posterior end of the inferior turbinate is frequently enlarged by a swelling of its membrane, forming a *posterior turbinate hypertrophy*. Not only does the mucous membrane of the inferior turbinate bones become enlarged, but that on the septum likewise. This constitutes *hypertrophy* or *thickening of the septum*. A polypus may project from the nasal cavities backward into the throat. I removed a very large one by pushing it with the finger into the pharynx and then dragging it out of the mouth.

The posterior nares are quite a distance anterior to the edge of the soft palate, hence it is extremely difficult to make applications by way of the mouth. A much easier way is to make them through a tube introduced into the nose, or even, as when the electrocautery is used, without a protecting tube.

Eustachian Tube.—On each side, at a point about opposite the inferior turbinals, are the orifices of the *Eustachian tubes* with the *fossa of Rosenmüller* above. The Eustachian tube runs from the upper portion of the pharynx to the middle ear, opening just behind the tympanic membrane, on the anterior wall. It is about 4 cm. long, 2.5 cm. being cartilaginous (pharyngeal portion) and 1.5 cm. being bony. At the junction of the bony and cartilaginous portions the lumen is slightly diminished, forming the *isthmus*. The tube runs upward, backward, and outward.

The mucous membrane of the throat is continuous with that lining the tube and tympanum, therefore inflammation of the pharynx travels up the tube and affects the middle ear. This is the manner in which earache or inflammation and suppuration of the middle ear is produced. This also explains why impairment of hearing so often accompanies or follows sore throat, since following inflammation in this region adhesions may form, obstructing the pharyngeal opening of the tube.

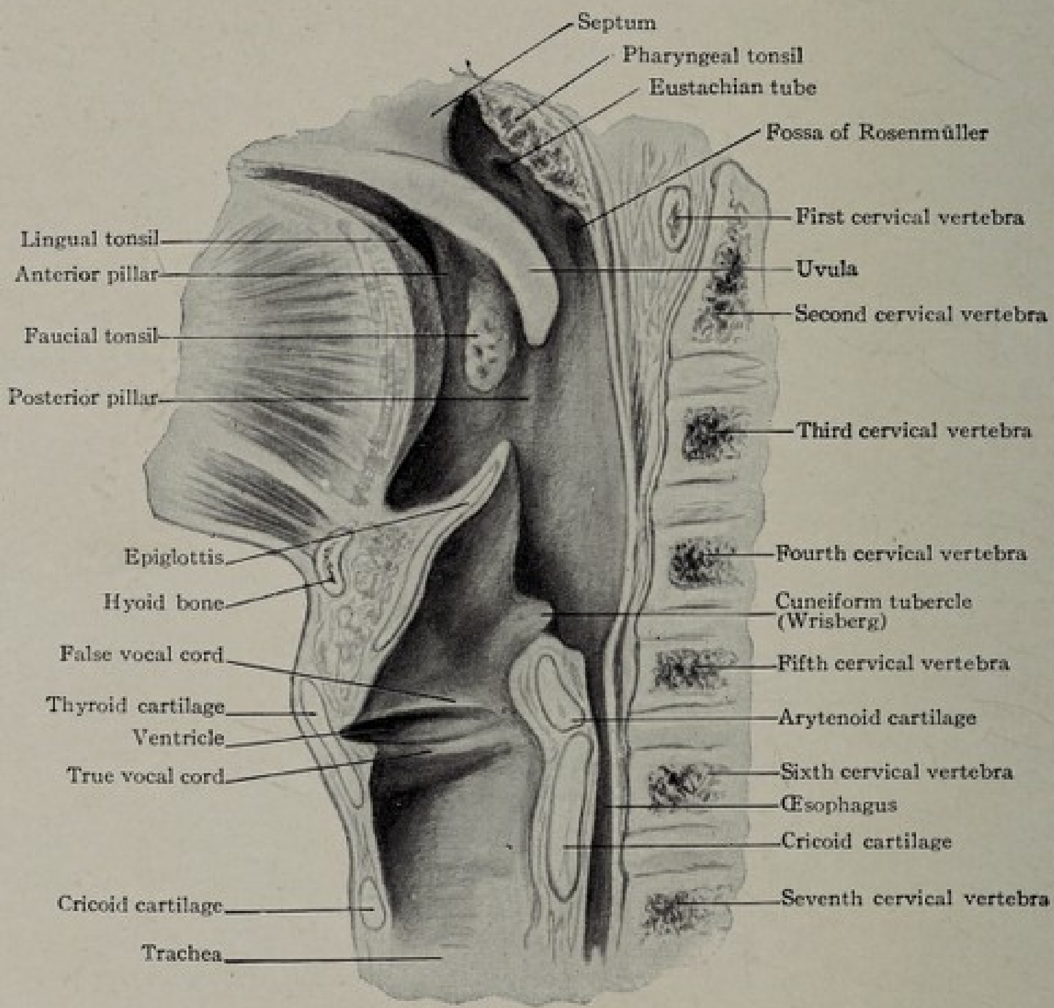


FIG. 160.—Lateral view of pharynx and larynx.

The deafness associated with hypertrophied adenoid growth is the result of obstruction of the orifice of the tube. When the tube is in a healthy condition, the air finds free access to the ear, in swallowing, sneezing, etc. This is readily demonstrated by closing the nostrils and swallowing, when the pressure of air outside the ear drum will be distinctly felt. When inflammation affects the lining membrane it swells and blocks up the tube and prevents the free access of air to the ear. If the swelling is not too great, air can be forced from the throat to the ear by three different means. The distention of the middle ear by air is called inflating it. The method of Valsalva consists in holding the nostrils and mouth shut and blowing. If the air enters the middle ear, the tympanic membranes will be felt to bulge outward. The method of Politzer is to have the patient hold a small quantity of water in the mouth. The nozzle of a rubber bag is introduced into one nostril, closing both nostrils with the fingers and thumb of the unengaged hand. On telling the patient to swallow, the bag is compressed and the air enters the Eustachian tube.

As the patient swallows, the tensor palati muscle opens the mouth of the tube and as the bag is compressed the air rushes up the tube. Sometimes the vapors of ether, chloroform, etc., are used. The third method is by the Eustachian catheter.

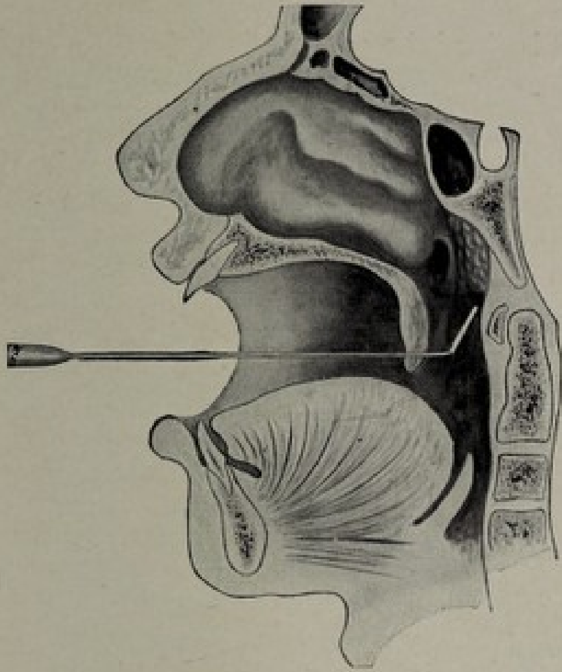


FIG. 161.—Rhinoscopic mirror in position. A view can be obtained of the vault of the pharynx and posterior nares.

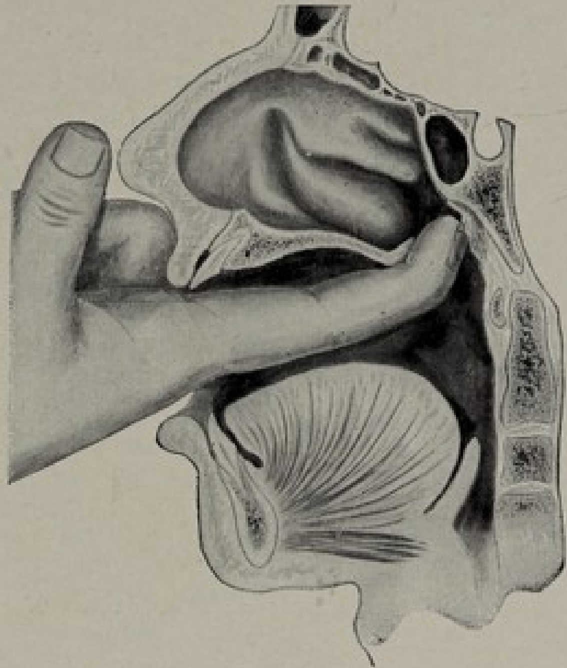


FIG. 162.—Palpation of the posterior nares and pharyngeal tonsil.

The **Eustachian catheter** is a small, hard rubber or silver tube, slightly bent at the extremity and long enough to reach from the anterior nares in front to the posterior wall of the pharynx. The end of the catheter having been inserted into the mouth of the Eustachian tube, air is blown in with the Politzer air-bag. By means of a rubber tube going from the patient's ear to the surgeon's ear, the air can be heard entering the middle ear.

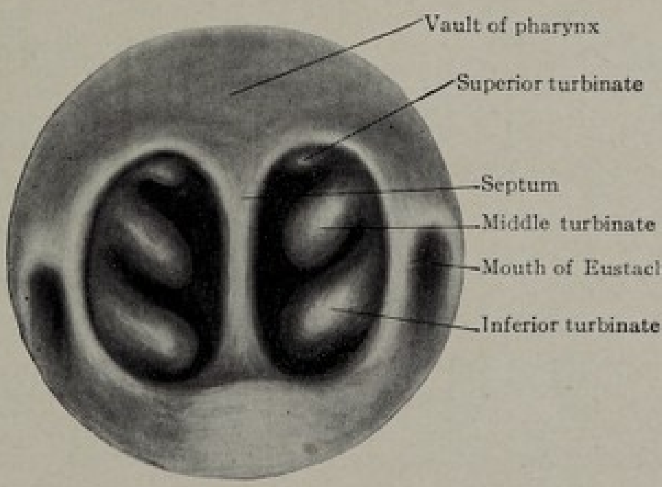


FIG. 163.—View of posterior nares in the pharyngeal mirror.

Introducing the Eustachian Catheter.—In introducing the Eustachian catheter, the tip of the nose is to be tilted upward until the anterior nares are raised to the level of the floor of the nose. The tip of the catheter is then passed first upward (Fig. 165), then along the floor until it is felt to pass beyond the soft palate and strike the posterior wall of the pharynx (Fig. 166). It is usually advised to enter the catheter in a vertical position and then change to a horizontal one as soon as the beak passes over the elevation which marks the separation of the vestibule of the nose from the interior. If this method is used, care should be taken to keep the tip of the catheter on the floor of the nose and not pass it up in the region of the middle turbinate bone.

There are three ways of introducing the beak of the catheter into the mouth of the tube after it is felt touching the posterior pharyngeal wall. The first is to with-

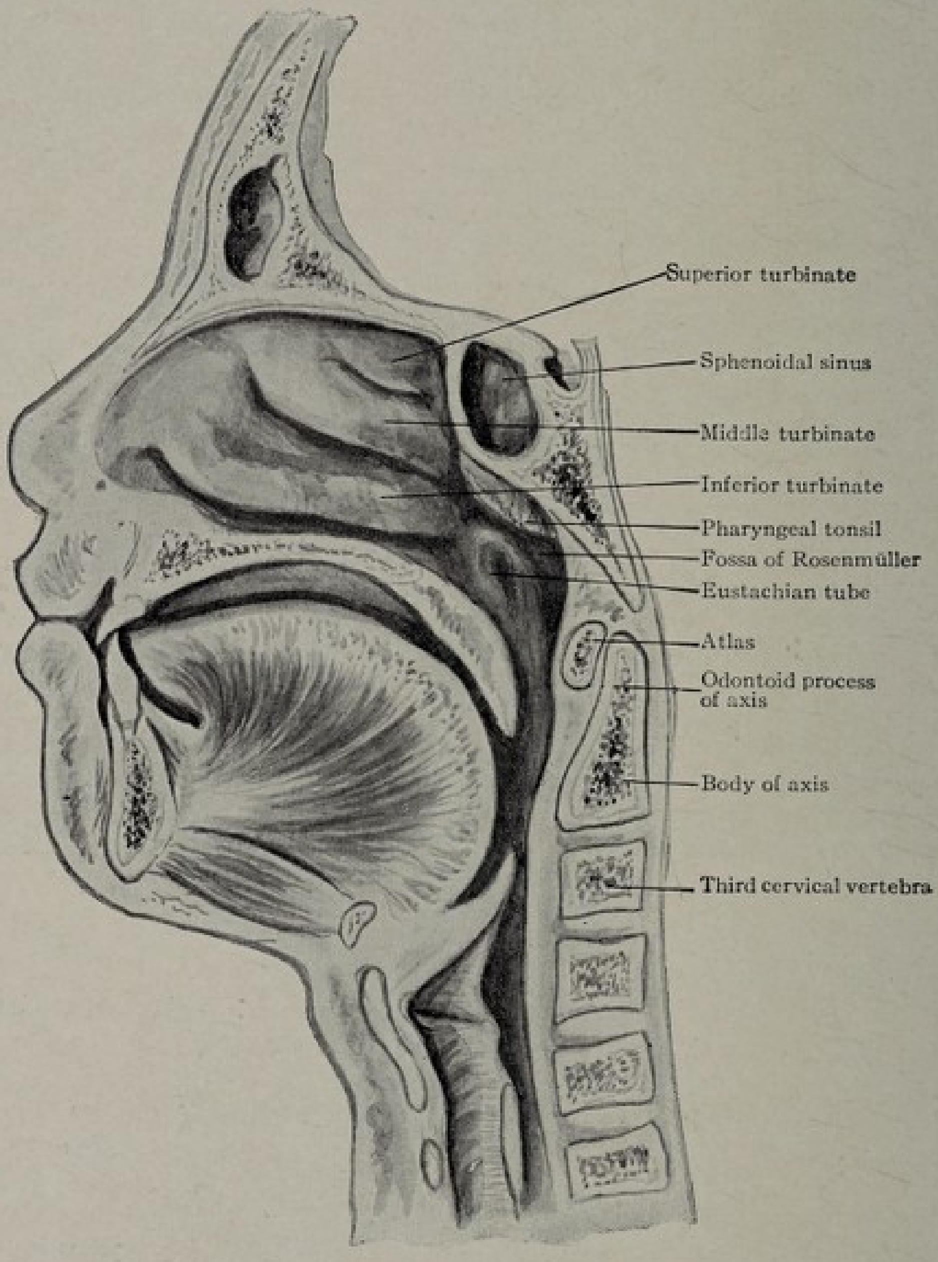


FIG. 164.—Anteroposterior frozen section, showing a lateral view of the pharynx and the relation of the various neighboring structures.

draw the beak about 2 cm. away from the wall of the pharynx and then turn it upward and outward, pushing it a trifle onward. The second way is to turn the beak directly outward and draw it forward, when it can be felt passing over the cartilaginous opening of the tube. The third way is to turn the beak inward and draw it forward until it catches behind the septum. This is opposite the anterior edge of the mouth of the tube. The beak is then rotated downward and then upward and outward into the tube.

Liquids and sprays are sometimes injected into the ear through the catheter; bougies are also passed into the tube in the same manner as the catheter or, if flexible bougies are used, they are passed through the catheter. As the tip of the bougie passes into the bony portion of the canal, the constriction of the isthmus can be felt 2.5 cm. up from its mouth. The bougie should not be passed farther than 3 cm. into the tube, otherwise, if the tympanum is entered, the ossicles are apt to be injured.

Openings of the Mouth, Larynx, and Œsophagus.—The opening of the mouth into the pharynx is sometimes narrowed from cicatricial contractions, resulting from ulcerative processes due to syphilis, cancer, caustics, etc. There is rarely obstruction downward, so that these patients can usually swallow, but the cicatrices contract the opening upward, and the soft palate, its arches, and the walls of the pharynx may be all bound together in one cicatricial mass, preventing, as I have seen, all respiration through the nose. This condition is an exceedingly difficult one to remedy, as the contraction tends to recur even after the most radical operations.

Fig. 165.—Introducing the Eustachian catheter, first step.

The opening into the larynx is more accessible than is often supposed. On drawing the tongue well forward, the tip of the epiglottis can be seen. If a long straight tongue depressor is used, Kirstein has shown that in many patients the arytenoid cartilages and even a portion of the vocal cords can be seen. The opening into the larynx can readily be felt by a finger introduced into the mouth. In cases of suffocation from a foreign body, as a piece of meat, it is usually lodged at this point, part of the foreign body being in

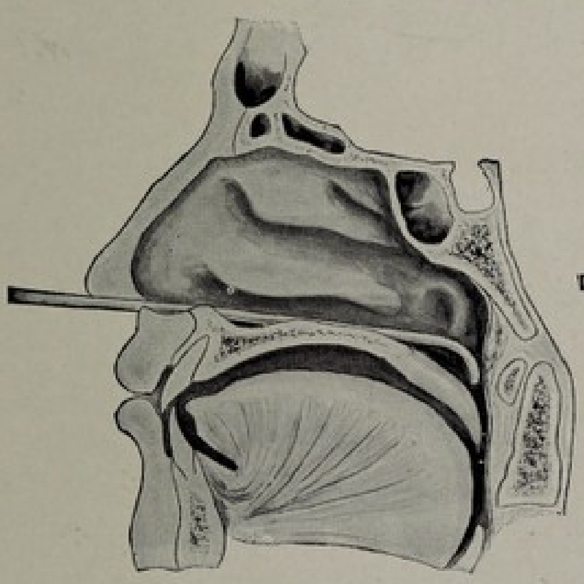


Fig. 166.—Introducing the Eustachian catheter, second step.

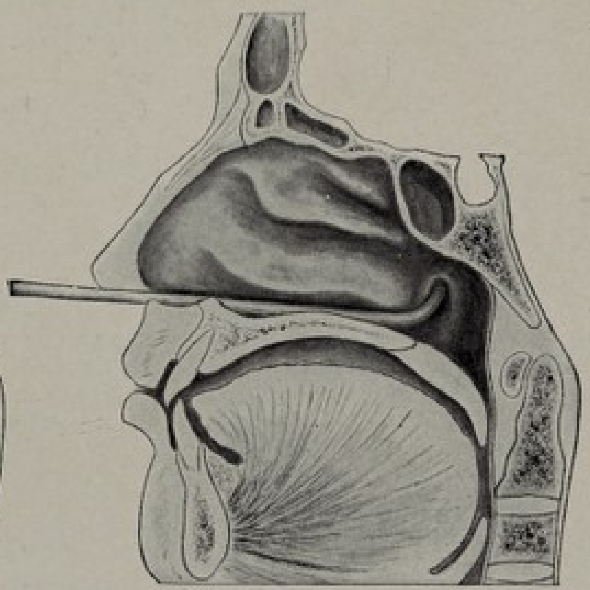


Fig. 167.—Introducing the Eustachian catheter, third step.

the larynx and part in the pharynx. It can readily be dislodged by the finger, as I have done in impaction of meat, the result of vomiting in ether narcosis. The forefinger should be thrust its full length into the mouth and throat and swept from side to side. The obstructing body can usually be brushed aside and brought up in front of the finger into the mouth.

The opening of the œsophagus is in a line with the long axis of the pharynx; it is at its lower end. The opening of the larynx, on the contrary, is more on its anterior wall. It is for this reason that when an œsophageal tube is introduced, either through the mouth or through the nose, it goes down into the œsophagus and does not enter the larynx. The œsophagus is narrowest at this point.

The **pharyngeal tonsil** stretches across the posterior wall and roof of the pharynx from the opening of one Eustachian tube to that of the other. It is also known as *Luschka's tonsil.* It is composed of lymphoid tissue, and when enlarged constitutes the disease known as **adenoids.** It is not true secreting gland tissue, though it contains some mucous glands. It hangs from the vault of the pharynx in a more or less lobulated mass and when large, in children, obstructs nasal respiration. Mouth-breathing results, the child is apt to snore and make queer sounds when sleeping, and the habit of keeping the mouth open causes a peculiar expression of the face almost pathognomonic of the affection. The blood supply at times is abundant. When adenoids are present, their removal is usually undertaken.

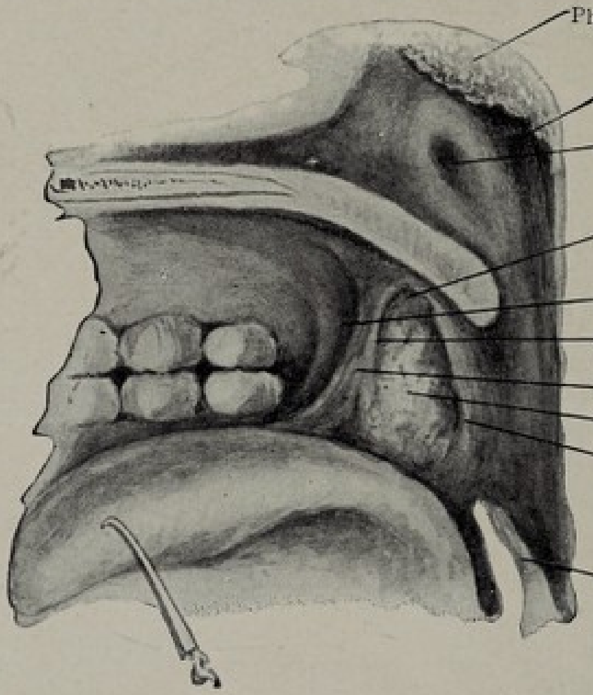


FIG. 168.—Lateral view of the pharyngeal region.

This is done by introducing an instrument through the mouth and scraping them off. A curette is used for this purpose. That known as Gottstein's consists of an oval-shaped ring set at right angles to a long shaft. It is introduced through the mouth and up behind the soft palate. It is then pushed against the vault of the pharynx and posterior wall and drawn downward cutting and scraping the adenoid tissue away. Free bleeding may occur from this operation. To control it, injections of ice water or a strong alum solution may be tried or gauze may be packed behind the soft palate or pushed in from the anterior nares. A folded pad of gauze may be attached to the thread of a Bellocq cannula and the pad introduced as is done in plugging the posterior nares. A curved forceps with cutting blades is also used to remove this growth.

Fossa of Rosenmüller.—This is the depression above and behind the openings of the Eustachian tubes. The walls of the pharynx are weakest at this point owing to the superior constrictor muscle not coming so high up. Hernia of the mucous membrane sometimes occurs here. When the beak of the Eustachian catheter fails to enter the mouth of the tube it usually enters this fossa.

The **internal carotid artery** runs up the neck outside of the pharynx and opposite the space between the posterior arches of the palate and the posterior wall of the pharynx. It is from 1 to 2 cm. behind and to the outer side of the tonsils.

It is separated from the cavity of the throat by its own proper sheath, by the thin buccopharyngeal fascia covering the constrictor muscles, by the constrictor muscles, the pharyngeal aponeurosis, and the mucous membrane. As the tonsils lie between the pillars of the fauces, in opening a tonsillar abscess the knife is not carried either behind or through the posterior pillar of the fauces. It is practically impossible to wound a normal internal carotid artery. In old people the internal carotid sometimes becomes lengthened and tortuous in the same manner as do the temporal arteries. In such cases the artery may form a pulsating swelling behind and projecting farther inward than the edge of the posterior pillar. This I have once seen. It may be mistaken for a true aneurism, as it pulsates and the pulsation is readily

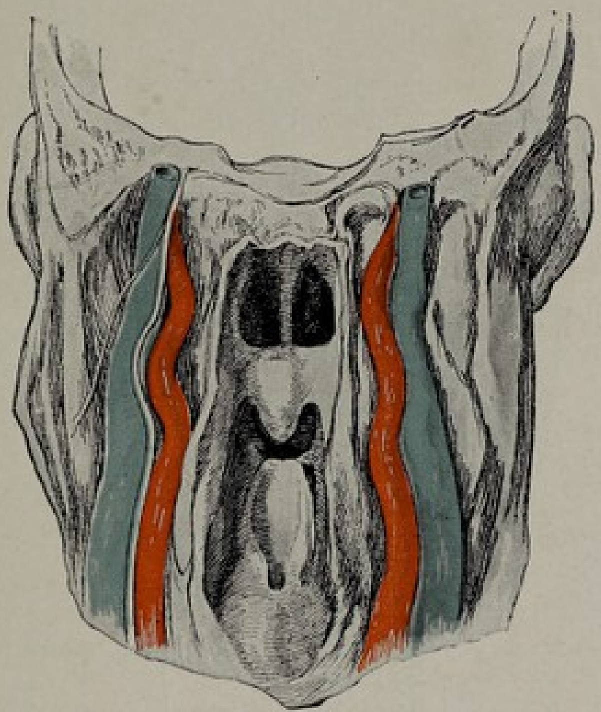


Fig. 169.—Transverse dissection of the neck. The posterior wall of the pharynx has been removed and the vessels exposed. The internal carotids are seen to be abnormally tortuous, with a tendency to bulge into the pharynx.

stopped by pressure on the common carotid on the outside of the neck. If, however, the possibility of this condition is borne in mind, the diagnosis can readily be made. The pulsating swelling can readily be seen and felt with the finger just behind the posterior pillar of the fauces.

The **mucous membrane** of the nasopharynx is ciliated columnar; that of the lower portion is squamous. It contains racemose mucous glands and follicles or crypts surrounded by lymphoid tissue. It is well supplied with blood-vessels. It is frequently affected by inflammation or pharyngitis. When the follicles are markedly involved they can be seen studded over the posterior wall of the pharynx. This constitutes a *follicular pharyngitis*. Not infrequently some ulceration may be present, forming an *ulcerative pharyngitis*. Infection attacks it, as in *diphtheritic pharyngitis*. Should pus or pharyngeal abscess form around the pharynx, arising from an infection from the oral cavity, the pus occupies the retropharyngeal space between the buccopharyngeal fascia and prevertebral fascia. Its spread upward is limited by the skull; laterally it is limited by the sheath of the carotid vessels; hence it passes downward behind the œsophagus and may enter the posterior mediastinum.

Foreign bodies may become lodged at the lower end of the pharynx and at the beginning of the œsophagus. As this is about 15 cm. (6 in.) from the teeth, it is beyond the reach of the finger. Luckily, this is below the opening of the larynx and the need for immediate relief is not so urgent.

THE LARYNX

The larynx extends from the top of the epiglottis to the lower edge of the cricoid cartilage. It is composed of the three large cartilages—*epiglottis, thyroid,* and *cricoid*—and three pairs of small ones—the *arytenoids,* the *corniculæ laryngis* or *cartilages of Santorini,* and the *cuneiform* or *cartilages of Wrisberg.*

The position of the larynx in relation to the spine varies according to age. In the infant it lies opposite the second, third, and fourth cervical vertebræ; in the adult it lies opposite the fourth, fifth, and sixth. The larynx being loosely attached varies in relation to the vertebræ according to the position of the head, so that the anterior portion of the cricoid cartilage may be opposite the seventh cervical vertebra in some positions.

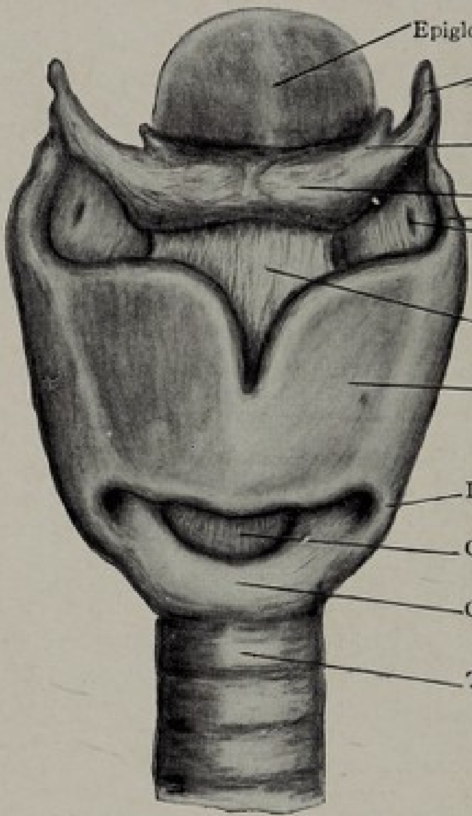


FIG. 170.—Anterior view of hyoid bone and larynx.

Epiglottis.—Usually the tip of the epiglottis lies lower than the dorsum of the tongue, so that looking into the mouth it is not seen; it may, however, be brought into view by depressing the base of the tongue and drawing it forward with a long tongue depressor. As the epiglottis rises above the level of the hyoid bone, a cutthroat wound passing above that bone may cut its tip entirely off. In viewing the epiglottis from above downward it is seen to project somewhat backward in its middle. This is visible in the laryngoscopic mirror and is called the cushion of the epiglottis.

Running forward from the epiglottis to the base and the sides of the tongue are three folds of mucous membrane, one median and two lateral, called the glosso-epiglottic folds. These form four fossæ; those on each side of the median line are called the *valleculæ.* In these fossæ foreign bodies, such as fish-bones, etc., may become lodged. They are readily seen by the laryngoscopic mirror.

The **thyrohyoid membrane** passes between the hyoid bone above and the thyroid cartilage below; crossing it is the hyoid branch of the superior thyroid artery. It is a quite small vessel, of little clinical importance, and ordinarily does not reach the median line.

The posterior edge of this membrane, running from the superior cornu of the thyroid cartilage to the hyoid bone, is called the *thyrohyoid ligament.* This ligament has a small cartilaginous nodule in it, the *cartilago triticea.* Piercing the membrane on its side are the internal branches of the superior laryngeal nerve and the superior laryngeal vessels. The *external branch* of the superior laryngeal nerve supplies the cricothyroid muscle, while the *internal* is the nerve of sensation of the larynx.

Pharyngotomy.—Sometimes, in order to remove foreign bodies in the larynx or œsophagus, an opening is made through the membrane between the hyoid bone and thyroid cartilage.

Thyroid Cartilage.—This is the largest cartilage of the larynx and contains the vocal cords. They lie immediately behind or just below the most prominent portion of its anterior edge, commonly called "Adam's apple." Since the cartilage is large and strong and as age advances tends to calcify, cut-throat wounds, while

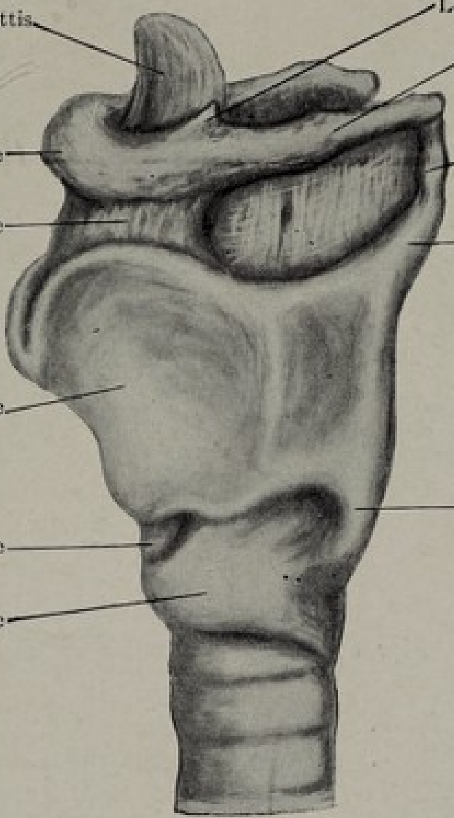


FIG. 171.—Side view of hyoid bone and larynx.

opening the cavity within, do not often pass entirely through the cartilage. This cartilage may be fractured by violence. This is often fatal on account of the blood flowing into the trachea and lungs below or on account of œdema of the lining mucous membrane causing obstruction of the breathing. Thyrotomy or division of the thyroid cartilage in the median line is sometimes done to remove foreign bodies or new growths. In these cases the voice will be likely to be impaired by the interference with the vocal cords.

Cricothyroid Membrane.—The space between the cricoid and thyroid cartilages is small. This is due to the increase in width of the cricoid as it proceeds backward. The space is readily felt on the living subject between the thyroid above and the cricoid beneath; the membrane passes between them. It is crossed by a small branch of the superior thyroid artery, the cricothyroid. It is not large enough to cause serious trouble. Introducing a tube through this membrane constitutes the operation of *laryngotomy.* This operation is but seldom performed. The space is too small in many cases, the opening is not made sufficiently low and it is too close to the vocal cords. It is an operation of emergency. It is much easier to make a quick opening at this point than it is in the trachea below, as it is more superficial and is held steady in place by the cartilage above and below it. Even in adults the space is sometimes too small to introduce a tube without force and the operation should never be done below the age of thirteen. On account of the membrane being nearer the surface than is the trachea, a shorter tube should be used. Before introducing the tube, care must be taken that the mucous membrane has been thoroughly divided, as otherwise the tube will push it before it and slip between the mucous membrane and the cartilage and, therefore, not enter the cavity of the larynx.

Cricoid Cartilage.—This is much larger posteriorly than anteriorly and fills the space between the posterior edges of the thyroid cartilage. Its outside diameter is larger than that of the trachea, hence it can readily be felt and forms one of the most important landmarks on the front of the neck. It is about opposite the sixth

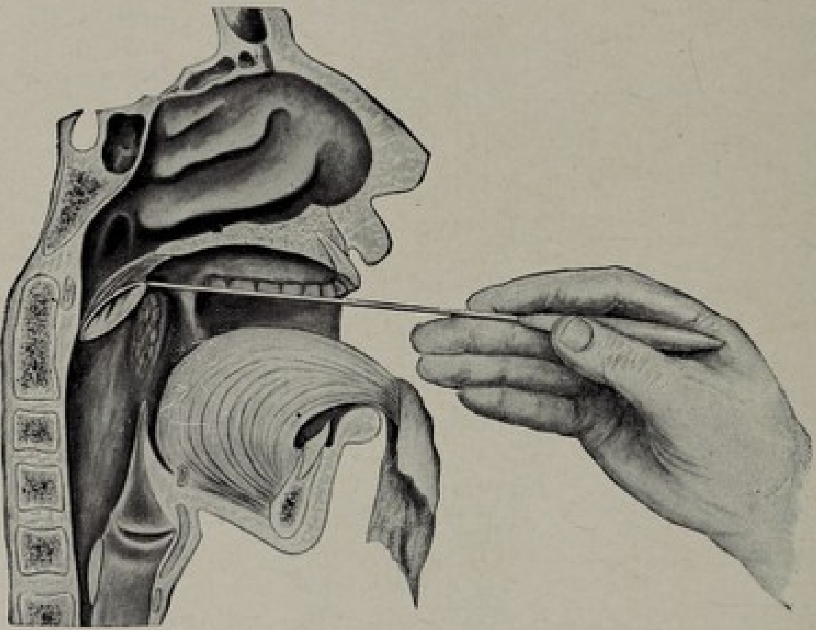


FIG. 172.—Examining the interior of the larynx by means of the laryngoscopic mirror.

cervical vertebra. It is thick and strong and forms a complete circle, being unlike the tracheal rings in this respect. It is rare that it is divided in operations.

For the parts concerned in tracheotomy see the section on the neck.

Laryngoscopy.—The interior of the larynx is examined by means of a small mirror, 1 to 3 cm. in diameter, introduced through the mouth and placed just below the uvula at an angle of a little more than 45 degrees. The opening of the larynx is not directly beneath the mirror but slightly anterior. The base of the tongue and lingual tonsils, the glosso-epiglottic folds and pouches, and the epiglottis can be seen in front. Posteriorly one sees the two arytenoid cartilages capped with the cartilages of Santorini. Between the arytenoids is the *commissure* or *interarytenoid space*. To the front and outer side of the tip of the arytenoid cartilages is the cartilage of Wrisberg, and running from it forward are the *aryepiglottic folds*. To the outer side of the aryepiglottic fold is the depression called the *sinus pyriformis*. It is here that congenital cervical fistulæ sometimes open. Near the middle are seen the two, white, *true vocal cords*, and to the outer edge of these are seen the *false vocal cords*. Between these two is the opening of the *ventricle* of the larynx. The rings of the trachea can readily be seen and not infrequently even the point of bifurcation of the trachea opposite about the second rib.

Bronchoscopy.—The development of this method is largely due to Chevalier Jackson, of Philadelphia. He has devised instruments by which the trachea and larger bronchi can be explored. Thus foreign bodies which previously remained in the lung or had to be removed by exploratory thoracotomy can be removed through the trachea. Lung abscesses if they are favorably situated, can be treated by a similar procedure. Bronchiectasis may be considerably improved by bronchoscopic aspiration.

Diseases of the Larynx.—*Syphilis* affects the larynx and produces ulcers. These may involve almost any portion but usually they are anterior, involving the epiglottis. They are often associated with syphilitic manifestations in the mouth. *Tuberculosis* affects the posterior portion of the larynx and the bulb-like swellings of the arytenoids are almost pathognomonic. Ulcers when they occur are most marked posteriorly. This affection is associated with a blanching of the mucous membrane of the mouth and the presence of a white frothy mucus, which will lead the laryngologist to suspect the existence of the disease before a view of the larynx is obtained.

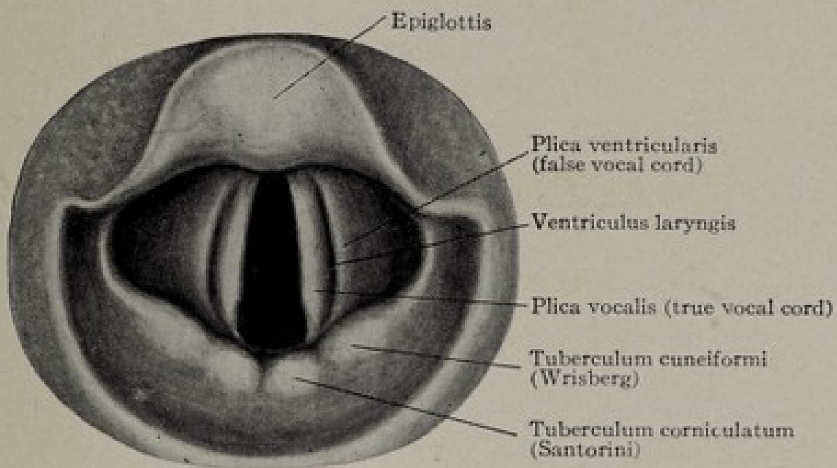


Fig. 173.—View of the larynx as seen in the laryngeal mirror.

Laryngitis of a simple nature produces a reddening of the cords and a swelling of the membrane generally.

In *œdema* of the larynx, the serous effusion puffs up the loose mucous membrane, particularly of the aryepiglottic folds and epiglottis.

Tumors both benign and malignant affect the larynx and can at times be seen to arise from the vocal cords.

Paralysis of the muscles is most frequent from interference with the recurrent laryngeal nerve. This nerve supplies the abductor muscles and when paralyzed the cords tend to fall together. The nerve may be injured in operations on the neck or involved in cancer of the thyroid gland, or œsophagus, or in aneurisms. If one cord is paralyzed, the voice is lost temporarily, and when it returns, it is changed in character. Paralysis of both nerves does not cause entire loss of voice because the cords fall together, but may induce suffocative symptoms ending in death. Paralysis of the left vocal cord is believed by Fetterolf and Norris to be due to compression of the left recurrent laryngeal nerve between the left pulmonary artery and the aorta or the aortic ligament. Frazier has operated on several patients in whom the recurrent laryngeal nerve was damaged during thyroidectomy. He anastomosed the *descendens noni* to the peripheral end of the recurrent nerve; there has been some return of function in a few of these cases.

THE NECK

The neck supports the head. It is a pedestal for the head, and is long in proportion to its thickness; the apparent object of this being to elevate the head and allow it to be moved freely in different directions. The animal is thus better enabled to discover its enemies and to guard itself against them.

The various structures of the neck are mostly long, running between the head above and the trunk below. This is the case with the spine, the air- and food-passages, the blood-vessels, nerves, and even some muscles, as the sternomastoid and trapezius. The shorter structures are either the component parts of the longer ones, as the vertebræ of the spine and the rings of the trachea, or are separate organs like the larynx, thyroid, and submaxillary glands. The presence of these latter organs is not dependent on the length of the neck as is that of the others. In the frog, which practically has no neck, the head being placed directly on the trunk, there still exist both larynx and thyroid gland. In the singing birds the vocal organ or syrinx is placed in the chest at the bifurcation of the trachea. As regards the cervical spine, blood-vessels, air- and food-passages, and muscles, these evidently are proportionate to the length of the neck. In the batrachians or frogs there is but a single cervical vertebra; in the swan there are twenty-five cervical vertebræ, and in the fishes none. In man of course the number of cervical vertebræ remains the same, seven, no matter what the length of the neck. From a consideration of these facts we may perhaps state that the neck itself is a subsidiary organ, not of any great importance in itself, but rather in relation to some other portion of the body—that portion being the head. It is the staff which supports the head by means of the cervical spine and muscles.

The neck contains the great currents of blood which pass to and fro between the head and trunk. It carries the air- and food-passages, which run from the mouth above to the lungs and stomach below, and incidentally it contains the larynx, the thyroid and submaxillary glands, and some lymphatic nodes. The cerebrospinal nerves of all the body below the head pass either into the neck or through it to the parts beyond. From these facts it becomes evident that, while the neck in itself may be a subsidiary organ, for our purposes it is of the greatest importance, because interference with its structure either by disease or injury—operative or accidental—may destroy the brain above, by interfering with its nourishment, or the body below, by interfering with the vital functions of respiration and nutrition, or may paralyze it by destroying the conductivity of its nerves. The construction of the neck then should be studied with a view of explaining or understanding the diseases and injuries of its various parts and the operations performed for their relief.

Injuries and Diseases of the Neck.—Owing to its exposed position the neck is frequently injured by sprains, contusions, cuts, and punctures, gunshot, and all sorts of wounds. The cervical spine may become dislocated or fractured and is frequently the seat of caries. The muscles become contracted, producing torticollis or wry-neck. They may sometimes be ruptured, as in childbirth.

The *arteries* are affected with aneurism, necessitating their ligation. They are also divided in cut-throat cases and wounds. The *veins* are of importance in almost every operation; bleeding from them is dangerous and may be difficult to control.

The *lymphatic nodes* are more numerous than elsewhere in the body. Frequently they are the seat of tuberculous or sarcomatous enlargement, necessitating their removal. They may break down and produce wide-spreading and dangerous abscesses, which are guided in their course by the fascias; hence a knowledge of the construction of the deep fascias of the neck enables us to understand them.

The *submaxillary* and *thyroid glands* are the seat of enlargement, inflammation or growths requiring the performance of extensive operations for their extirpation. Although extirpation of the former is not difficult removal of the latter, because of hemorrhage and the close proximity of the recurrent laryngeal nerve and the trachea, is fraught with danger.

The *skin* and *subcutaneous tissue* become the seat of inflammation and cellulitis. In cases of wounds this cellular inflammation may involve the structures beneath the deep fascia; this occurs in cut-throat and gunshot wounds.

The neck is also liable to other affections, such as cysts due to embryological defects. Large cysts are formed called *hygromas*, also sinuses or fistulæ, the *congenital fistulæ* of the neck. The larynx may be the seat of malignant disease; hence its removal is undertaken. The operations of *tracheotomy, laryngotomy,* and *œsophagotomy* are also at times necessary. In order to understand these various affections and procedures one must be familiar with the construction of the neck, what composes it, where the various structures lie and their relation to one another. In order to utilize this knowledge we must be able to recognize and identify the position of various structures before the skin is incised, for it is rarely that a case presents itself with a wound that permits a view of the deeper structures; hence the importance of a thorough knowledge of its surface and the structures capable of being recognized through the skin.

SURFACE ANATOMY OF THE NECK

For convenience of study we may consider the structures in the median line, and those regions anterior and those posterior to the sternomastoid muscle, between it and the trapezius. The posterior portion of the neck will be described in the section devoted to the back.

These regions or triangles are simply arbitrary divisions, made for convenience of description. They are sometimes spoken of in reference to the location of growths, operative incisions, etc. They comprise the space between the trapezius muscle posteriorly, the median line anteriorly, the clavicle below, and the lower jaw above.

Viewed from in front, the median portion of the neck may be divided into three regions, the *submental, laryngeal,* and *tracheal.*

The **submental region** extends from the chin to the lower border of the body of the hyoid bone; it is limited laterally by the anterior belly of the *digastric muscle* on each side. Ranula and other sublingual tumors cause a bulging in this region and it is frequently occupied by an enlarged lymphatic node, which at times suppurates and forms an abscess. The floor of the space is formed by the *mylohyoid muscle* and there are no dangerous structures, so that no hesitancy need be had in incising abscesses in this locality nor in removing diseased lymph-nodes. In carcinoma involving the lower lip near the median line these nodes may be affected and their involvement in such cases should always be looked for. The submaxillary lymphatic nodes farther outward may also be implicated. The tip of the epiglottis projects above the hyoid bone in this region.

The **laryngeal region** extends from the under surface of the hyoid bone to the lower edge of the cricoid cartilage. Laterally it is limited to the space occupied by the larynx. The cricoid cartilage is included in this region as a part of the larynx. The vocal cords are just beneath the most prominent part of the thyroid cartilage.

The **tracheal region** extends from the lower edge of the cricoid cartilage to the top of the sternum. Just above the sternum, between the sternal origins of the sternomastoid muscles, is the *suprasternal notch* or, as it is called by the Germans, the *Jugulum.* Laterally the region is limited by the sides of the trachea.

There are seven or eight rings of the trachea between the cricoid cartilage and the top of the sternum. It is covered partly by the *sternohyoid* and *sternothyroid muscles.* The former in the lower half of their course pass outward, leaving a space in which the *sternothyroid muscles* are seen. The sternohyoid muscle arises from the upper and outer portion of the manubrium, the sternoclavicular ligament, and the inner end of the clavicle. The origin of the sternothyroid is wider than that of the sternohyoid and is lower down. It arises from the first piece of the sternum near the median line, below the sternohyoid, and from the cartilage of the first rib. The first ring of the trachea is not covered by any important structure. The second, third, and fourth rings are covered by the *isthmus* of the thyroid gland; from here down the *inferior thyroid veins* may lie on the trachea for at least part of their course. The *anterior jugular vein* may exist either as a single vein in the median line or to one side of it, or one may pass downward on each side of the median line with a communicating branch from one to the other crossing the median line in the suprasternal notch. The *cricothyroid artery*, a small branch of the superior thyroid, may cross the cricothyroid membrane, but it is usually too small to cause any troublesome bleeding.

Structures to be Felt in the Median Line.—On passing the finger downward from the symphysis it sinks into a hollow, on crossing which the hyoid bone is felt. On pressing the finger into this hollow it rests between the digastric muscles

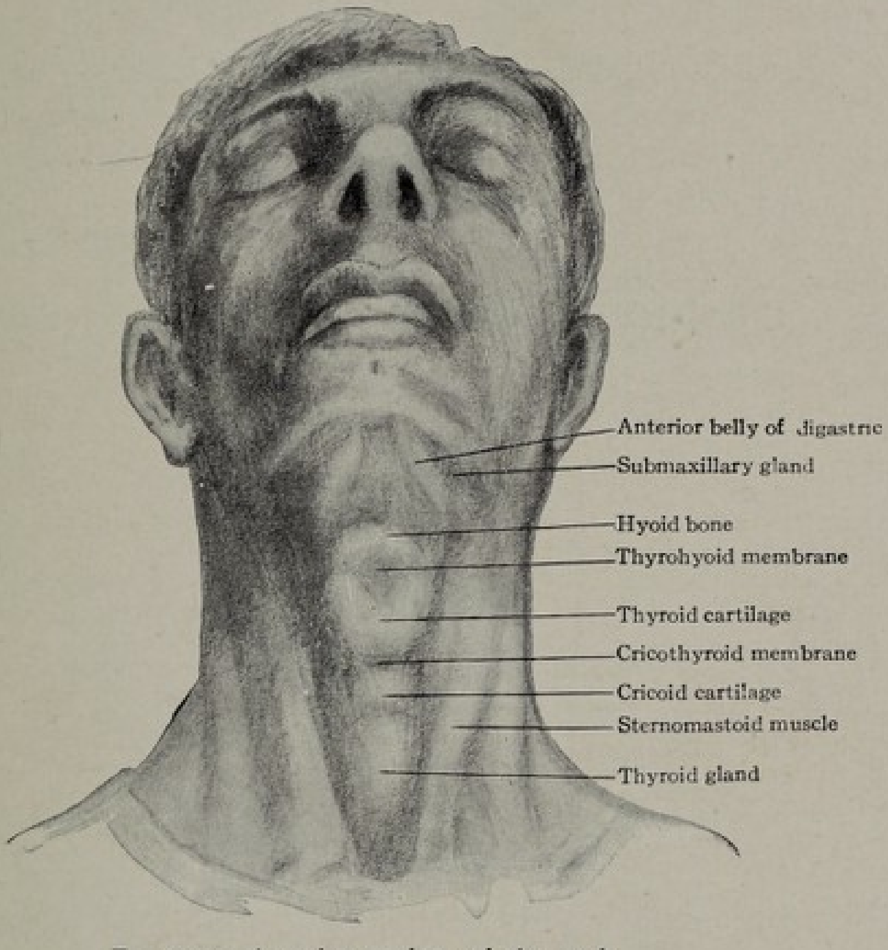


FIG. 174.—Anterior surface of the neck.

on each side and the mylohyoid muscles beneath. Still deeper than the mylohyoid are the geniohyoid and geniohyoglossus muscles attached to the genial tubercles on the inner side of the mandible. If the lymphatic nodes at this point are enlarged they may be felt. (Fig. 174.)

The hyoid bone can usually be readily felt in the median line. If it is not easily discovered in the median line it can be felt by a finger and thumb placed on each side of the neck above the thyroid cartilage.

Passing over the hyoid bone the finger then sinks into the space between it and the top of the thyroid cartilage. This space is bridged by the thyrohyoid membrane. Next comes the thyroid cartilage or "Adam's apple." It can readily be seen in adult males and thin people, but in the fat necks of women and children, though it can still be felt, it often cannot be seen. The finger then sinks into the space between the thyroid cartilage above and the cricoid below. They are connected by the cricothyroid membrane, over which runs a small branch (cricothyroid) of the superior thyroid artery.

The prominence of the cricoid cartilage can be seen in thin people and if carefully searched for can be felt in almost all cases. It is opposite the sixth cervical

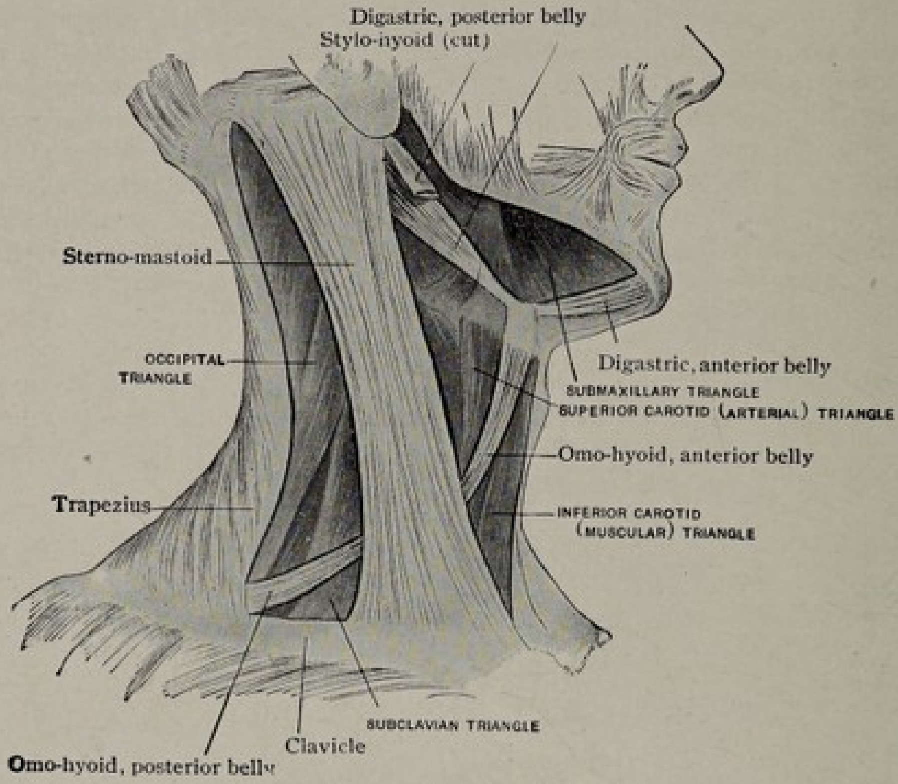


FIG. 175.—Triangles of neck.

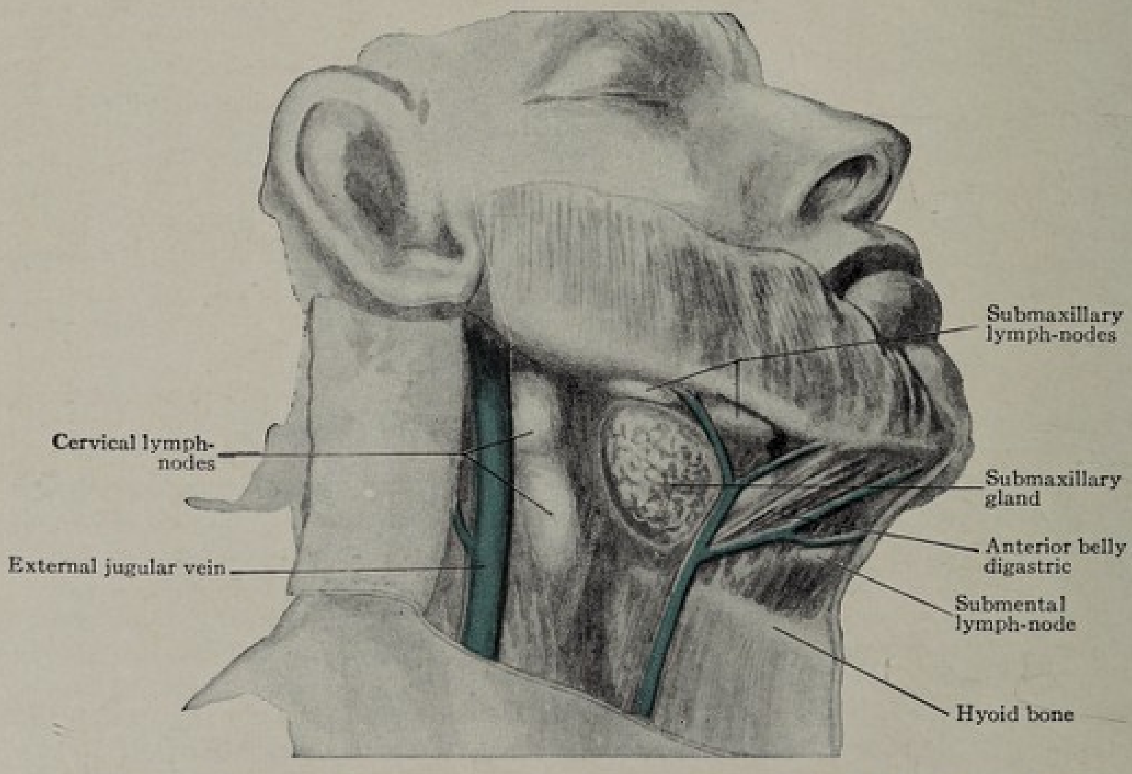


FIG. 176.—Submaxillary region, superficial structures. (From a dissection, lymph-nodes enlarged by disease.)

vertebra, a most important landmark. From the cricoid cartilage down to the sternum only soft structures can be felt. The sternum projects forward and the trachea inclines backward so that opposite the top of the sternum the trachea is about 2 cm. behind it. The distance between the top of the sternum and cricoid cartilage in an adult male is about 4.5 cm. (1¾ in.). The trachea may be lengthened and brought closer to the anterior portion of the sternum by over-extending the head. This should be remembered in the operation of low tracheotomy. Surface anatomy will vary greatly in different subjects. Some necks are short and stout while others are long and thin with many gradations between them. For this reason it may be easy or difficult to identify all the structures described.

THE CERVICAL TRIANGLES

On viewing the neck from the sides one may see the folds of the neck produced by the platysma, a thin, frayed-out muscle in the superficial fascia, extending from the mandible to the clavicle. The fibres run in a line from the chin to the shoulder. The sternocleidomastoid muscle, running obliquely from the mastoid process to the sternoclavicular articulation with its thick anterior and thin posterior edge, is seen to divide the neck into two spaces, an anterior and a posterior. They are called the *anterior* and *posterior cervical triangles.*

Anterior Cervical Triangle

The anterior cervical triangle has for its anterior side the median line of the neck. Its posterior side is the anterior edge of the sternomastoid muscle. Its upper side is the lower edge of the mandible from the symphysis to the angle and thence across to the mastoid process. The anterior triangle is further divided into the space above the digastric muscle called the *submaxillary triangle,*—from its containing the gland of that name,—the *superior carotid* or *arterial triangle* above the anterior belly of the omohyoid muscle, and the *inferior carotid* or *muscular triangle* below the omohyoid muscle.

The SUBMAXILLARY TRIANGLE is so called from its containing the submaxillary gland. It is sometimes called the lingual triangle, from the lingual artery, and more recently has been termed the digastric triangle. It has as its upper side the lower edge of the mandible from near its symphysis around the lower edge of the body to the ramus and thence in a straight line across to the mastoid process. Its anterior side is the anterior belly and its posterior side is the posterior belly of the digastric muscle. The submaxillary gland can usually be felt beneath the jaw. Beneath it runs the facial artery to pass over the body of the mandible in front of the anterior edge of the masseter muscle. The gland lies on the hyoglossus and mylohyoid muscles, which form the floor of this triangle. It is encased in a sort of pocket formed by a splitting of the deep cervical fascia. The posterior portion of this fascia runs from the styloid process to the hyoid bone and is called the *stylohyoid ligament.*

Lymphatic nodes lie on the submaxillary gland and in carcinomatous disease they become enlarged and then can be readily palpated. In operating on these lymphatic nodes for tuberculous disease, care should be taken to distinguish between them and the submaxillary gland. The tendon of the digastric muscles does not come clear down to the hyoid bone but the loop which binds the two together is sometimes a centimetre or more in length. The lingual artery enters the submaxillary triangle near the apex of the angle formed by the tendon of the digastric. It crosses beneath the posterior belly of the digastric muscle and, particularly if the digastric muscles contract, it may lie close to the tendon. Frequently the search for it is made too high in the triangle and too far away from the hyoid bone. If the loop which binds the digastric to the hyoid is long the artery will be found below the central portion of the muscle and posterior to the loop instead of in the apex of the triangle. When the submaxillary gland is lifted from its bed the hypoglossal nerve is seen beneath lying on the hyoglossus muscle. The lingual artery lies beneath the hyoglossus muscle and the muscle is cut through in order to find it. This space bounded above by the hypoglossal nerve and on the sides by the anterior and posterior bellies of the digastric muscle is known as Lesser's triangle. The submaxillary region is the seat of *Ludwig's angina,* a septic inflammation involving the cellular tissues beneath the tongue and jaw around the submaxillary gland and the upper portion of the neck. It is a dangerous affection and may cause death not only by sepsis but also by œdema of the larynx.

Dr. T. T. Thomas (1908), has pointed out that the infection passes from the inside of the mouth to the submaxillary region outside by following the connective tissue around the submaxillary gland as it winds around the posterior edge of the mylohyoid muscle through the opening existing between this muscle in front and the anterior portion of the middle constrictor of the pharynx behind.

The SUPERIOR CAROTID TRIANGLE is limited posteriorly by the sternomastoid muscle, superiorly by the posterior belly of the digastric, and inferiorly by the anterior belly of the omohyoid. The location of the omohyoid muscle can be determined by that of the cricoid cartilage, as the muscle crosses the common carotid artery about opposite that point. The sternomastoid muscle can be both seen and felt. It is attached above from the apex of the mastoid process to the middle of the superior curved line on the occipital bone. It is attached below by a sternal head to the upper anterior part of the first piece of the sternum, and by a clavicular head

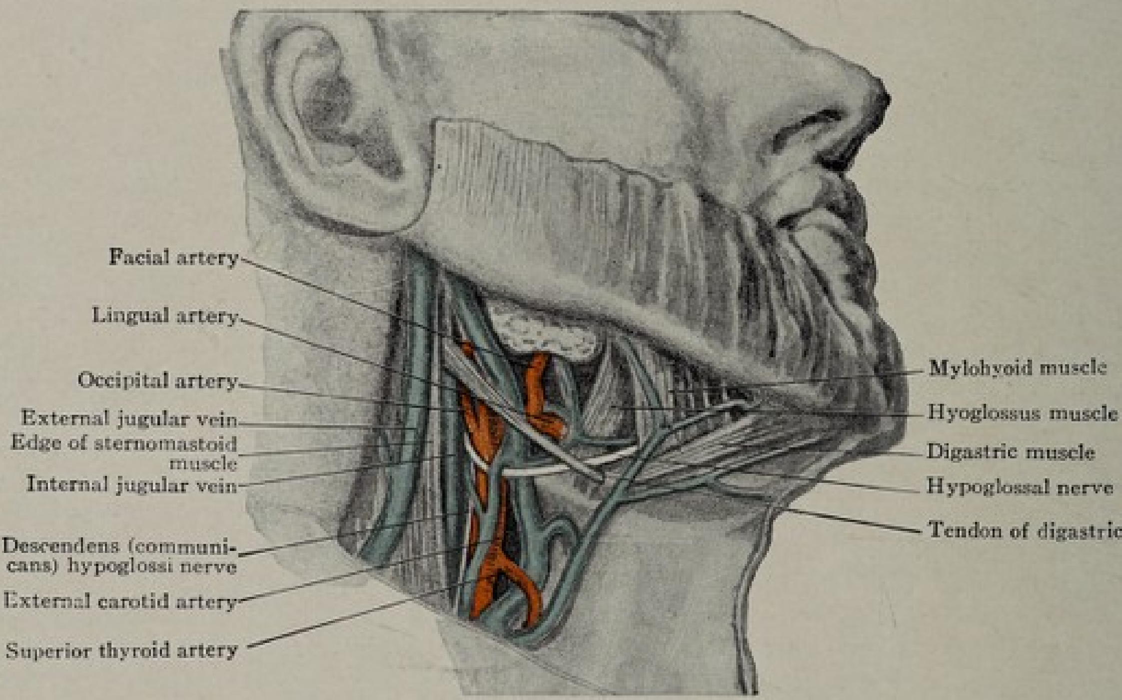


FIG. 177.—Deeper structures of the submaxillary region, especially the vessels.

to the inner third of the clavicle on its superior and interior border. Its action will be mentioned in discussing wry-neck.

Arteries.—The carotid arteries and their branches are found in this triangle. The line of the carotid arteries is from a mid-point between the mastoid process and the angle of the jaw to the sternoclavicular articulation. The line of the sternomastoid muscle is from the mastoid process to near the middle of the upper edge of the sternum. Thus the carotids are internal to the anterior edge of this muscle above, behind the angle of the jaw, and external to it below. The **common carotid** at its upper portion—it ends opposite the upper border of the thyroid cartilage—is just about at or close to the edge of the sternomastoid muscle. The upper border of the thyroid is opposite the fifth cervical vertebra. The anterior transverse process of the tubercle of the sixth cervical is prominent and easily palpated. It is known as Chassaignac's tubercle. It is opposite the cricoid cartilage and the common carotid can be compressed against it. From the thyroid cartilage up are the **internal** and **external carotids.** The internal lies behind and to the outer side of the external. The internal gives off no branches until it reaches the skull, while the external is practically all branches. Sometimes the external and the internal carotids are covered by the anterior margin of the sternomastoid muscle. The branches of the external carotid are the *superior thyroid, ascending pharyngeal, lingual, facial, occipital, posterior auricular, internal maxillary,* and *temporal.* The superior thyroid or the ascending pharyngeal may either one be the first given off by the external carotid, or may come off the common carotid itself just before its bifurcation.

The **superior thyroid artery** is given off from the anterior surface of the external carotid in the interval between the hyoid bone and upper border of the thyroid cartilage. It gives a small *infrahyoid branch* to the thyrohyoid membrane, also a superior laryngeal branch to the inside of the larynx. This branch pierces the thyrohyoid membrance in company with the superior laryngeal nerve to reach the interior of the larynx. The *sternomastoid branch,* to the muscle of that name, comes off at this point and crosses the common carotid artery. It is of some importance on this account because in ligating the common carotid artery above the omohyoid muscle it is likely to be cut and cause bleeding. Another branch of the

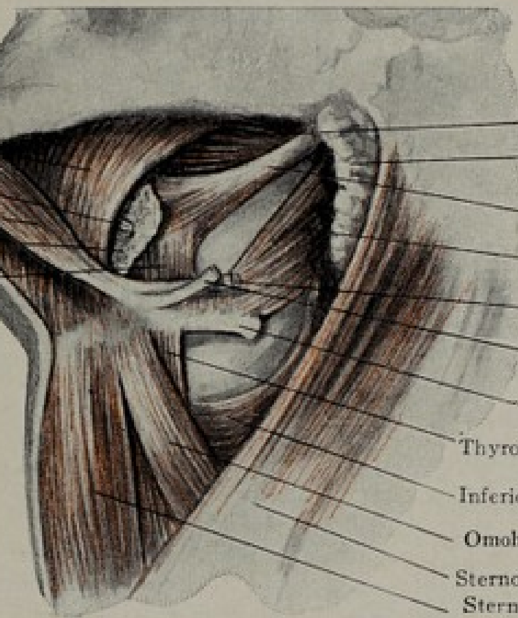


FIG. 178.—Submaxillary region. The anterior portion of the submaxillary gland is seen winding around and beneath the posterior edge of the mylohyoid muscle. The posterior portion of the gland has been cut away. The posterior belly of the digastric and the stylohyoid muscles have also been removed.

superior thyroid artery is the *cricothyroid.* It is small, rests on the cricothyroid membrane, and is the first artery liable to be cut in an incision down the median line. Bleeding from it is not apt to be serious. The remainder of the superior thyroid artery supplies the thyroid gland. The artery varies in size according to the size of the gland, and the amount of blood reaching the gland from other sources. It anastomoses freely with its fellow of the opposite side and with the inferior thyroid from the thyroid axis. Accompanying the superior thyroid as it enters the gland are the fibres of the cervical sympathetic which join it just outside of the superior pole.

The **ascending pharyngeal** is a long slender branch that comes from the under side of the main trunk. It lies on the superior and middle constrictors of the pharynx and goes clear to the skull, giving off some meningeal branches. In ligating the external carotid care should be taken not to include this vessel in the ligature. It also gives branches to the soft palate, tonsil, recti capitis antici muscles and tympanum.

The **lingual** is given off just below the greater horn of the hyoid bone, and passes forward beneath the hyoglossus muscle to supply the tongue and sublingual tissues. The hypoglossal nerve lies above the artery and on the hyoglossus muscle.

The **facial** comes off just above the lingual artery or often in a common trunk with it. It passes upward and forward in a groove in the under surface of the submaxillary gland and passes over the edge of the jaw at the anterior border of the masseter muscle. The facial vein at this point is posterior to it.

The **occipital artery** comes off almost opposite the facial. It passes upward and backward between the mastoid process and the transverse process of the atlas, then along in the occipital groove beneath the origin of the sternomastoid muscle, the splenius, trachelomastoid, and digastric to make its appearance a little to the inner side of the middle of a line joining the mastoid process with the external occipital protuberance.

The **posterior auricular** is given off just above the posterior belly of the digastric muscle and runs backward and upward on it, then through the parotid gland and up between the external auditory meatus and the mastoid process. In ligating the external carotid artery with a view of preventing bleeding in removing the Gasserian ganglion, it is endeavored to place the ligature just above the digastric

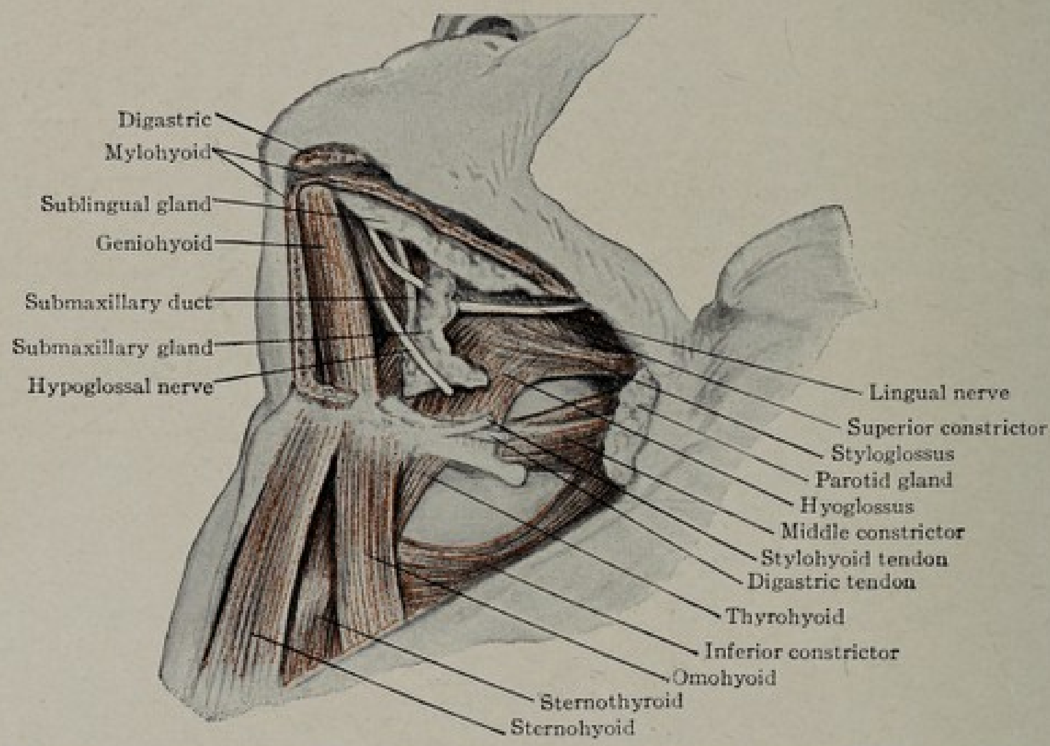


FIG. 179.—Submaxillary region—mylohyoid muscle cut away showing the sublingual gland and anterior portion of submaxillary gland.

muscle and posterior auricular artery in order to preserve the blood supply of the tissues above and behind the ear. The internal maxillary and the temporal arteries have already been considered.

Veins.—The veins found in and near the superior carotid triangle are the *anterior* and *internal jugulars* and their branches. A small portion of the commencement of the *external jugular* may also be in its extreme upper angle.

The **anterior jugular vein** begins just above the hyoid bone from veins in the submaxillary and submental regions. It lies on the deep fascia and passes down the neck about 1 cm. from the median line, then just above the sternum it turns down and out under the sternomastoid muscle to empty into the external jugular or subclavian. At the point of turning it sends off a branch across the median line to the vein on the opposite side. Thus the blood-current can pass directly across the neck from one external jugular vein to the other. Sometimes there is another communication between the two anterior jugulars through a small branch crossing just above or below the hyoid bone. Instead of two anterior jugular veins there may be one; in this case it is likely to go down the median line of the neck and so be wounded in tracheotomy. It receives branches from the inferior thyroid veins and hence may bleed freely. It has no valves.

The **internal jugular vein**, the principal venous trunk of the neck lies to the outer side of and bulges somewhat anterior to the carotid arteries. It is formed by the junction of the inferior petrosal and lateral sinuses at the jugular foramen. As it descends in the neck it increases in size, and just before it joins the subclavian to form the innominate vein it has a spindle-shaped enlargement (bulbus venæ jugularis inferior). At its upper end this dilatation has either one or a pair of valves with their cavities directed downward so as to prevent an upward flow of blood. It receives the facial, lingual, pharyngeal, superior and middle thyroid, and sometimes the occipital veins. A large communicating branch from the external jugular unites either with the facial or with the internal jugular, so that a wound of the external jugular may draw blood directly from the internal jugular.

These tributary veins are superficial to the arteries and in ligating the external carotid artery they will have to be displaced. In the upper part of its course it is external and somewhat posterior to the internal carotid artery, the glosso-

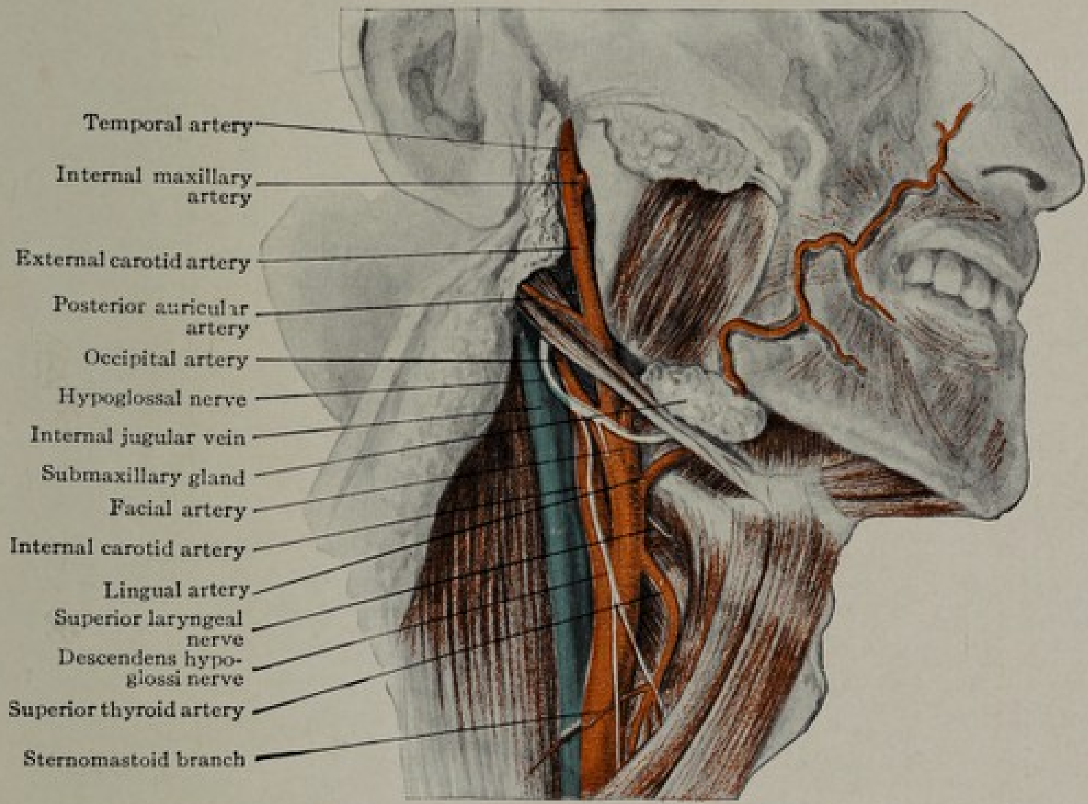


FIG. 180.—Carotid arteries and branches.

pharyngeal, vagus, and spinal accessory and hypoglossal nerves separating the two above. It then passes to the outer side of the upper portion of the common carotid, being enclosed with it in a common sheath formed from the cervical fascia, while between and behind the two lies the vagus nerve. Below the omohyoid muscle it tends to separate from the artery and passes more anterior to it. The internal jugular vein is sometimes excised in operations for enlarged lymph-nodes or for infective thrombus. It is not so large above the facial vein as below that point. It becomes so involved in enlargements of both tuberculous and carcinomatous lymph-nodes that it may be necessary to excise it along with the tumor. Its removal does not give rise to any serious symptoms. In operations on the neck it may be opened and if not immediately recognized air may be drawn into it. This may cause death if the amount introduced is enough to over-distend and paralyze the right side of the heart.

It becomes thrombosed by the extension of a thrombus from the transverse (lateral) sinus, which in turn becomes affected by the extension of suppurative middle-ear disease through the medium of caries of the bones. When the internal jugular is thrombosed it is evidenced by swelling, redness, and tenderness along the anterior border of the sternomastoid muscle just behind the angle of the jaw. Bleeding from the veins in this region is particularly dangerous because the internal jugular itself is so large and having no valves, will bleed both from the side towards the heart and that towards the head.

The veins also, which are tributary to it in this region, are so large and are wounded so close to the main trunk that the blood from the internal jugular itself regurgitates. The walls of the veins are thin and, if the fascias happen to be relaxed, fall readily together and thus are difficult to see, and are so adherent to the fascias as not to be readily seized. The surgery of this region requires extreme care and the avoidance of haste.

Nerves.—Lying between the internal jugular vein and the internal and common carotid arteries is the *pneumogastric* or *tenth nerve*. It here gives off the

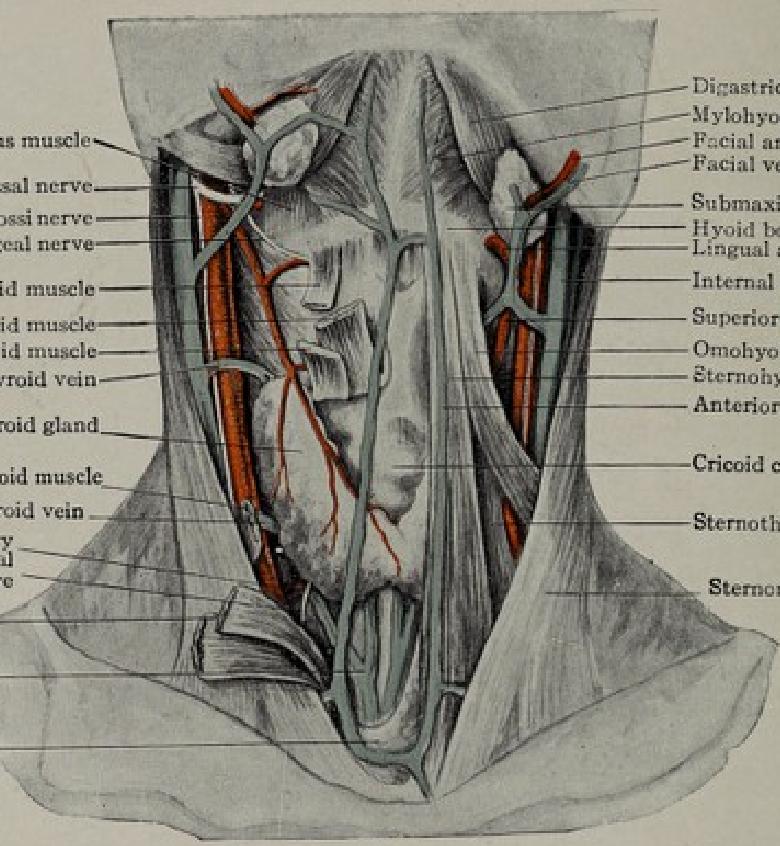


FIG. 181.—Dissection of the deep structures of the front of the neck.

superior laryngeal nerve, the internal branch of which enters the larynx through the thyrohyoid membrane to endow the interior of the larynx with sensation; the external branch goes to supply the cricothyroid muscle. The pneumogastric nerve is frequently seen in operations in this region. Its division has not been fatal.

The *hypoglossal nerve* winds around the occipital artery and goes forward on the hyoglossal muscle, which separates it from the lingual artery. The *descendens hypoglossi filament* leaves the parent nerve as it winds around the occipital artery. It lies on the carotid artery in the form of a loop formed by the addition of branches from the second and third cervical nerves. As it descends on the sheath of the vessels it gives a branch to the anterior belly of the omohyoid muscle. The loop sends branches to the sternohyoid, sternothyroid, and posterior belly of the omohyoid, and if the nerve is divided, paralysis of these muscles will occur. The nerve is to be pushed aside when ligating the artery and not included in the ligature. The superficial branches from the cervical plexus which come from the middle of the posterior edge of the sternomastoid muscle and ramify towards the median line, are nerves of sensation, and their division in operative work causes no serious symptoms, hence they are disregarded. The *inframaxillary branches* of the seventh or *facial nerve* supply the platysma.

Lymphatics.—The lymphatics are composed of four groups: (1) A superficial set, not always present, are found along the anterior border and over the sterno-cleido-mastoid muscle and along the external jugular vein in the posterior triangle. They lie between the deep fascia and the platysma. They become enlarged after infections of the external ear, the skin of the face or neck, or after infections of the suboccipital (occipital), mastoid (post-auricular), parotid (preauricular) or submaxillary nodes. Those in the posterior triangle are enlarged in the secondary stage of syphilis and are of use diagnostically. (2) The deep set follow the great vessels and are divisible into two groups: the upper one situated above and about the bifurcation of the common carotid and the upper part of the internal jugular, some of these extending into the posterior triangle; and a lower group near the termination of the internal jugular and its junction with the subclavian. This group is continuous with the subclavian, axillary, and mediastinal nodes. The deep nodes drain the superficial set. (3) The glands around the submaxillary gland, and (4) a set two or more in number in the submental region. These drain the lower central part of the face, lips, tongue and floor of the mouth. The nodes may be enlarged secondary to infections of the head and face, or in tuberculous or Hodgkin's disease, lympho-sarcoma or secondary to malignant growths in the regions which they drain.

The INFERIOR CAROTID TRIANGLE is limited posteriorly by the lower portion of the sternomastoid muscle, anteriorly by the median line of the neck, and superiorly by the anterior belly of the omohyoid muscle. In this triangle, or reached through it, are the lower portions of the common carotid artery and internal jugular vein, with the pneumogastric nerve between. Anteriorly are the larynx, trachea, thyroid gland, and sternohyoid and sternothyroid muscles. The carotid artery, jugular vein, and pneumogastric nerve lie partly in the triangle but rather under the edge of the sternomastoid muscle. Operations on the air-passages, laryngotomy and tracheotomy; on the thyroid gland, thyroidectomy; and ligation of the common carotid artery and removal of lymph-nodes are all done in this triangle. The superficial and deep lymphatics accompany the vessels; there are also some in Burns's space above the sternum. In children, instead of the innominate artery ceasing at the sternoclavicular articulation, it sometimes rises above it and may be wounded in operation on the trachea. The *thyroidea ima* artery, if present, will lie on the trachea, coming up from the innominate or directly from the aorta.

POSTERIOR CERVICAL TRIANGLE

The posterior cervical triangle has as its base the middle third of the clavicle; its anterior side is the posterior edge of the sternomastoid muscle; its posterior side is the anterior edge of the trapezius; its apex is at the point of junction of these two muscles at the superior curved line of the occiput. It is customary to divide it into two triangles by the posterior belly of the omohyoid muscle. The upper triangle is large and is called the *occipital triangle*. The lower triangle is small and is called the *subclavian triangle*. This division by the posterior belly of the omohyoid muscle is not always satisfactory. The muscle runs upward and inward in a line from about the junction of the outer and middle thirds of the clavicle to a variable distance, up to 2.5 cm. (1 in.), above the clavicle at the posterior edge of the sternomastoid muscle. The omohyoid muscle has its lower attachment at the posterior edge of the suprascapular notch, which is below the level of the clavicle, and its posterior belly is sometimes concealed behind the clavicle and does not rise above it except at its inner extremity beneath the sternomastoid muscle. It is rare that any distinct triangle is formed, hence, as far as the surface markings are concerned, there is often no subclavian triangle. Therefore the posterior cervical triangle will be considered as a whole and not divided.

It is covered by the skin, beneath which is the subcutaneous tissue, which at its lower portion contains the fibres of the platysma muscle. Its floor is composed from above downward of the *splenius*, *levator scapulæ*, *scalenus posticus*, *scalenus* *medius* and *scalenus anticus muscles.* The deep fascia of the neck spans the space and splits anteriorly to enclose the sternomastoid muscle and posteriorly to enclose the trapezius. The space contains important arteries, veins, nerves and lymphatics.

External Jugular Vein.—Lying on the deep fascia and beneath the superficial fascia and platysma is the external jugular vein. This begins below the ear and posterior to the ramus of the jaw, being formed by the union of the temporo-maxillary and posterior auricular veins. It passes downward and slightly backward on the surface of the sternomastoid muscle to its posterior border, which it reaches at about the middle and follows down until about a centimetre above the clavicle; here it pierces the deep fascia and dips behind the clavicular origin of the sterno-mastoid muscle to empty into the subclavian. It has one pair of valves about 4 cm.

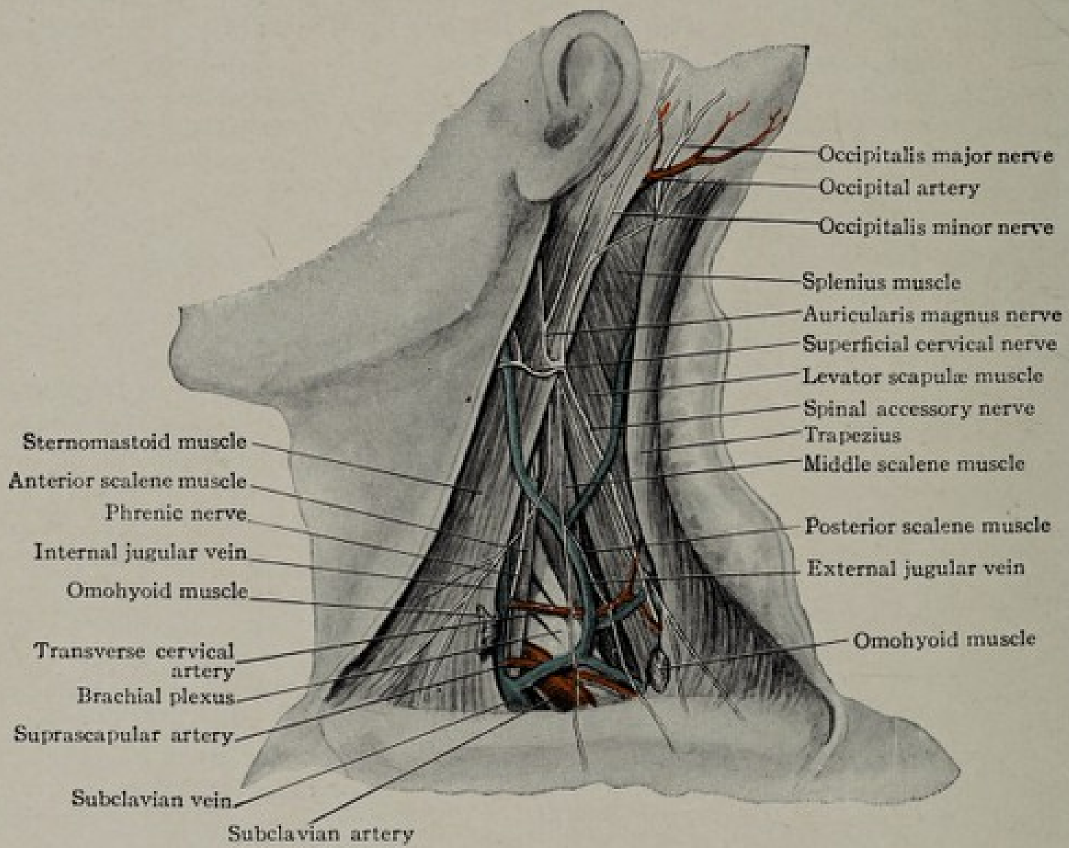


FIG. 182.—Dissection of the posterior cervical triangle.

above the clavicle, and another pair at its point of entrance into the subclavian. They do not entirely prevent a regurgitation of the blood.

The external jugular vein receives the posterior external jugular vein, and the suprascapular and transverse cervical veins. The occipital may also enter into it. The veins of the neck are exceedingly irregular in their formation and may vary considerably. The external jugular is readily seen through the skin, it may be made more prominent by compressing it just above clavicle. In operations in this region of the neck in some cases it is necessary to divide this vein; in others one may be able to avoid it, at all events it should be recognized before the incision is made. Behind the angle of the jaw there is usually a branch communicating with the facial, lingual, or internal jugular vein, and just above its lower extremity it is enlarged, forming the part called the sinus. For these reasons, if the vein is cut low down near the clavicle or high up near the angle of the jaw bleeding is liable to be free. The valves are not competent to prevent the reflux of blood and it therefore drains the large internal jugular above and the subclavian below. The attachment of the vein to the deep fascia, as it pierces it above the clavicle, tends to keep its lumen open when the vein is divided and favors the entrance of air into the circulation. The size of the veins in the posterior triangle varies according to those in the anterior. If the anterior and external jugulars are large the posterior and internal jugulars are apt to be small. The external jugular is frequently used in the transfusion of blood in children.

Arteries.—The arteries in the posterior cervical triangle are the *subclavian*, the *transverse cervical*, and sometimes the *suprascapular* when it runs above the clavicle instead of behind it. The line of the subclavian is from the sternoclavicular joint to the middle of the clavicle. It rises about 1.25 cm. (½ in.) above the clavicle. The clavicular origin of the sternomastoid muscle covers the inner third of the clavicle so that the subclavian artery is only visible in the posterior cervical triangle from the outer edge of this muscle to the middle of the clavicle. Both the suprascapular and transverse cervical arteries are given off from the thyroid axis, which arises from the first portion of the subclavian just internal to the scalenus anticus muscle. Therefore at their origin they are both considerably above the level of the clavicle, but as they proceed outward they incline downward, and on leaving the outer edge of the sternomastoid muscle the suprascapular is usually behind the clavicle while the transverse cervical runs parallel to it and a short distance (1 cm.) above it, where it can be felt pulsating.

The posterior belly of the omohyoid muscle can be represented by a line drawn from the anterior edge of the sternomastoid muscle opposite the cricoid cartilage, obliquely down and out to the junction of the middle and outer thirds of the clavicle. It is superficial to the transverse cervical artery and at its inner end is above it. These arteries and their accompanying veins will be encountered in operating in these regions for the removal of lymphatic nodes.

Nerves.—The superficial branches of the cervical plexus emerge, after piercing the fascia, at the middle of the posterior edge of the sternomastoid muscle. Immediately after their emergence they separate into the auricularis magnus, which passes upward and slightly forward, crossing the sternomastoid, to supply the ear and region of the parotid gland; the occipitalis minor which follows the posterior edge of the muscle to the sub-occipital portion of the scalp; the superficial cervical branch which turns forward to supply the submaxillary region and the three descending superficial clavicular branches which supply the skin from the suprasternal notch to the upper portion of the scapula. The most important nerve of the cervical plexus is the *phrenic*. Injury to this nerve causes paralysis of the diaphragm on the affected side. It can first be seen opposite the hyoid bone on the scalenous anticus muscle which it crosses from without inward as it passes downward and accompanies the scalenus anticus as that muscle passes between the subclavian artery and vein. It is easily exposed by an incision made just posterior to the lower end of the sternomastoid muscle. It has been sectioned to paralyze the diaphragm in order to assist in the obliteration of tuberculous or bronchiectatic cavities after pulmonary lobectomy. I have also injected it for persistent hiccough. In order to remove the entire nerve it must be twisted from its lower attachments. The accessory phrenic branches do not meet the main branch until it passes under the clavicle.

The *spinal accessory* although a cranial nerve is of extreme importance in this region because of its liability to injury during gland dissection of the neck. This nerve enters the under surface of the sternomastoid muscle 3 to 5 cm. below the tip of the mastoid process and emerges at the posterior edge of the muscle just above its middle. At or just below this point the external jugular vein reaches the posterior border of the sternomastoid, and the cervical plexus emerges. The nerve then crosses the occipital triangle from above downward and dips under the anterior margin of the trapezius along the under surface of which it descends. This nerve supplies the sternomastoid and the trapezius, although both receive some supply from the cervical plexus. Recently it has been suggested that the nerve is so frequently injured in gland dissections that it would probably be better to treat them conservatively. I feel, however, that there is no excuse in injuring the nerve except in the very occasional case. It would be better to say that no one should attempt a neck dissection unless they are familiar with the anatomy of the region.

The lower part of the occipital and the subclavian triangle contains the *brachial plexus* which emerges from behind the lower part of the anterior scalene muscle. The plexus lies first above and then to the outer side of the subclavian vessels, is crossed by the posterior belly of the omohyoid, and frequently has the transverse cervical artery threading through it.

Just above the plexus will be found the dorsalis scapulæ or nerve to the rhomboids. It emerges from the scalenus medius and courses backward toward the vertebral border of the scapula.

Lymphatics.—The lymphatics of the posterior cervical triangle are numerous and often enlarged. They lie along both the outer side of the internal jugular vein and under the posterior edge of the sternomastoid muscle, which they follow clear

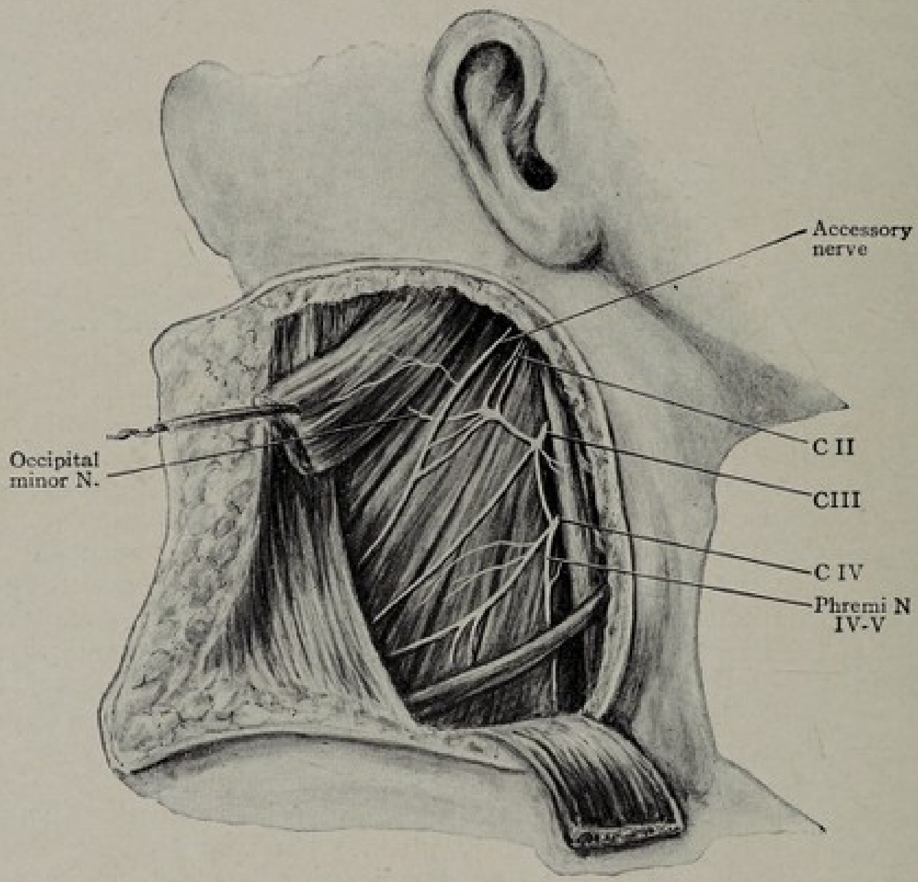


Fig. 183.—The phrenic nerve.

up to the base of the skull. They also follow the edge of the trapezius muscle and lie in the space between it and the sternomastoid; they extend downward under the clavicle and become continuous with the axilliary lymphatics. The right and left lymphatic ducts empty into the venous system at the junction of the innominate and internal jugular veins. That on the left side is called the *thoracic duct*; it begins as the receptaculum chyli on the body of the second lumbar vertebra and is about 45 cm. (18 in.) long. It drains all the left side of the body and the right as far up as and including the lower surface of the liver.

The duct on the right side is called the *right lymphatic duct*; it is only 1 or 2 cm. in length and drains the right side of the head and neck, the right upper extremity and the right side of the chest as far down as and including the upper surface of the liver. Costain (1923) exposes the thoracic duct by making a three-inch incision along the lower posterior border of the left sternomastoid muscle. That muscle is freed by blunt dissection and drawn in exposing the omohyoid muscle which is drawn up. The internal jugular is then exposed and liberated to its junction with the subclavian. When this is rolled inward the thoracic duct is exposed as it enters the junction of the subclavian and jugular veins.

TORTICOLLIS OR WRY-NECK

In this affection the head and the neck are so twisted that the face is turned toward the side opposite the contracted muscle and looks somewhat upward. It is usually caused by some affection of the sternomastoid muscle. Should the trapezius alone be involved the head will be drawn backward and toward the affected side. The sternomastoid is not always the only muscle involved, as the trapezius and others are often likewise affected. This is due to an attempt of the other cervical rotators to sustain and relax the sternomastoid and thus obtain physiological rest for it. It is congenital or acquired. In the congenital cases it is caused by an injury to the sternomastoid muscle, occurring during childbirth; a swelling or tumor may be present in the course of the muscle. In the acquired form the distortion may be more or less permanent and may be due to caries or other disease of the spine. In such cases it is evident that treatment is to be directel to the diseased spine rather than to the sternomastoid muscle, which will be found to be relaxed.

Inflammation of the lymph-nodes of the neck may cause the patient to hold the head and neck in a distorted position. The wry-neck in this case will disappear as the cause subsides. Rheumatic affections of the neck are a common cause, and the sternomastoid muscle may then become contracted and require division. In rare instances a nervous affection causes a spasmodic torticollis. This is an extremely distressing affection. Frequently it is due to a central irritation of the spinal accessory so that this must be resected in order to give relief. In these cases the muscle shows no secondary changes. The muscular branches of the cervical plexus may also be involved so that Keen has resected the muscular branches of the second and third cervical nerves and the suboccipital nerve from the first cervical.

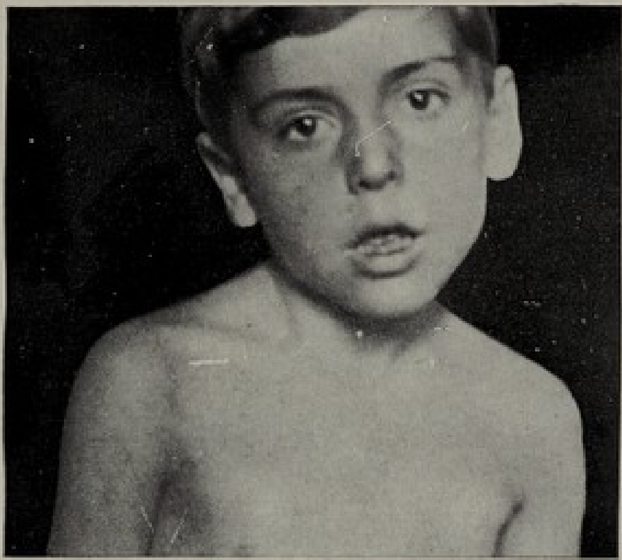


FIG. 184.—Torticollis or wry-neck.

Division of the sternomastoid muscle should be done by open and not by subcutaneous incision. The sternal origin of the sternomastoid muscle is a sharp, distinct cord, but its clavicular origin is a broad, thin band extending outward a third of the length of the clavicle. An incision 2 or 3 cm. or more in length is made over the tendon and the bands are to be carefully isolated before being divided. The structure most important to avoid is the internal jugular vein. It lies close behind the sternal origin of the muscle and great care must be taken to avoid it. In one case in which it was accidentally wounded it was necessary to ligate it. As the deep fascia of the neck splits to enclose the sternomastoid muscle it is opened by the operation and infection has caused in such cases wide-spread phlegmonous inflammation.

ARTERIES OF THE NECK.—LIGATION

Carotid and Subclavian Arteries and Branches.—Both these arteries are affected at times with aneurisms, necessitating their ligation. Ligation of the main trunks or their branches is also required in various operations on the head, as in removal of the Gasserian ganglion or maxilla, or excision of the tongue, thyroid gland, etc. The communication between the arteries on the two sides of the body is quite free, as also is that between the arteries above and those lower down. For this reason bleeding from the distal end of a cut artery will be almost as free as from its proximal end. The various branches of the external carotid anastomose across the median line of the body. The vertebrals communicate above through the basilar. The internal carotids communicate through the anterior cerebral and anterior communicating and with the basilar through the posterior communicating and posterior cerebral. Between the parts above and those below we have the superior thyroid anastomosing with the inferior thyroid branch of the thyroid axis from the subclavian artery. The princeps cervicis, a branch of the occipital, anastomoses with the ascending cervical branch of the inferior thyroid, the transverse cervical of the thyroid axis, and the profunda cervicis from the superior intercostal. These free communications enable the surgeon to ligate to any extent without incurring the risk of gangrene. The *line of the carotid arteries* is from a point midway between the mastoid process and the angle of the jaw to the sternoclavicular articulation. At the upper border of the thyroid cartilage the common carotid divides into the internal and external carotids; this is opposite the fifth cervical vertebra.

Common Carotid Artery.—This lies on the longus colli muscle and a small portion of the rectus capitis anticus, which separate the artery from the transverse processes of the vertebræ. The artery can be compressed against the vertebræ and its pulsations stopped by pressing backward and slightly inward. It is superficial in the upper portion of its course but becomes deeper as it approaches the chest. The anterior tubercle of the transverse process of the sixth cervical vertebra is called *Chassaignac's tubercle*. It is about opposite the cricoid cartilage. It is one of the guides to the artery. The omohyoid muscle crosses the artery opposite the cricoid cartilage and just above it is the site of election for ligation.

Ligation of the Common Carotid Artery.—In making the incision, which should be 5 or 6 cm. long, it should be laid along the anterior edge of the sternomastoid muscle with its middle opposite to or a little above the level of the cricoid cartilage. This incision may be a little anterior to the direct line of the artery as given from midway between the angle of the jaw and mastoid process to the sternoclavicular articulation. This is because the muscle bulges forward and overlaps and hides the artery. The artery is beneath its edge. On cutting through the superficial fascia and platysma the deep fascia is reached, some small veins perhaps being divided in so doing. The deep fascia is divided along the edge of the sternomastoid muscle, which is then pulled outward. Beneath it and running obliquely across the lower portion of the wound is the omohyoid muscle. It is recognized by the direction of its fibres, they being more or less transverse or oblique. Sometimes a small artery, the sternomastoid branch of the superior thyroid, crosses the common carotid just above the omohyoid muscle. The artery is also crossed by veins. The lingual, superior, and middle thyroid veins all pass over it to enter the internal jugular. The middle thyroid vein may be above or just below the omohyoid muscle. These vessels all pass transversely across the artery and beneath the deep fascia. The artery lies in a separate sheath to the inner side of the jugular vein. In the living body it is to be recognized by its pulsations. The vein being filled with blood may overlap the artery. Veins are readily emptied of their blood by pressure on the parts during the operation; hence if the vein happens to be collapsed it may not be recognized and is liable to be wounled. Therefore in examining for the artery see that the pressure from the retractors or other sources does not obstruct the flow of blood through the jugular vein. Running down on the anterior surface of the artery is the descendens hypoglossi nerve. If seen it should be pushed aside. It supplies the sternohyoid, sternothyroid, and both bellies of the omohyoid muscles. The pneumogastric nerve lies posteriorly, between the artery and the vein. Care will be necessary to avoid including it in the ligature. The ligature is to be carried from the outer to the inner side, the needle being passed between the vein and the artery.

Ligation of the Common Carotid Artery Below the Omohyoid Muscle.—The artery below the omohyoid muscle becomes deeper and less accessible. The sternomastoid muscle overlaps it and is less easily displaced. The sternohyoid and sternothyroid muscles likewise tend to encroach on it and have to be drawn inward. The internal jugular vein and carotid artery diverge as they descend, so that at the level of the sternoclavicular joint they are separated 2.5 cm. In this interval the first portion of the subclavian artery shows itself. The anterior jugular vein will probably be encountered along the edge of the sternomastoid muscle, and near the omohyoid muscle the artery will be crossed by the middle thyroid vein. Still lower it may be that the inferior thyroid will be encountered. Posterior to the carotid artery is the inferior thyroid artery, coming from the thyroid axis and going to the thyroid gland, and winding around from posteriorly to the inner side is the recurrent laryngeal nerve. The ligating needle is to be passed from without inward. The exposure of this vessel is, from the anatomical standpoint, very simple. In the cadaver one does not meet the complications for which ligation is frequently done on the living subject. Injury, aneurism, diseased lymphnodes and neoplastic glands renders the exposure difficult. In hemorrhage from this vessel it is important to have a wide exposure so that the surgeon can work with expedition. In cases of

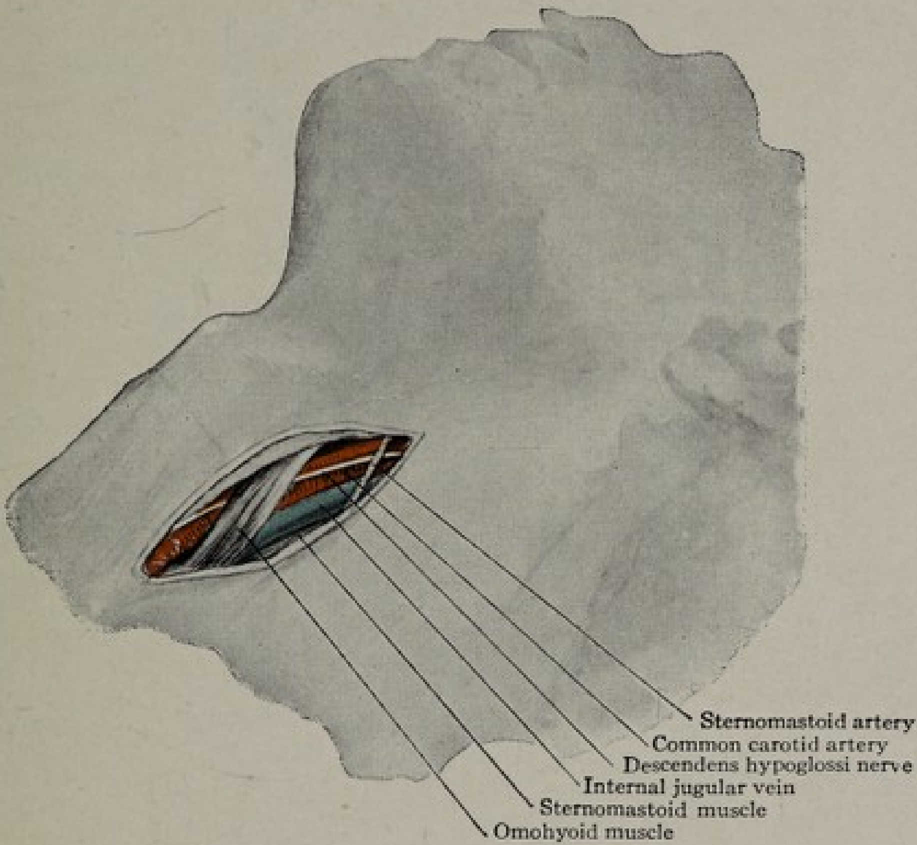


Fig. 185.—Ligation of the common carotid artery.

this kind the classical incision is insufficient. The sternomastoid should be divided if any difficulty in exposure is met.

Collateral Circulation After Ligation of the Common Carotid Artery.—When the common carotid has been tied the blood reaches the parts beyond from the branches of the carotid of the opposite side and from the subclavian artery of the same side. The branches of the external carotid anastomose across the median line. This is particularly the case with the superior thyroid and facial. The internal carotids communicate by means of the circle of Willis. From the subclavian the vertebral artery communicates by means of the basilar with the circle of Willis. The thyroid axis by its inferior thyroid branch communicates with the thyroid arteries of the opposite side. An ascending branch of the inferior thyroid as well as one from the transverse cervical, also from the thyroid axis, anastomose with branches of the princeps cervicis, which is a descending branch of the occipital. Finally the superior intercostal, which, like the vertebral and thyroid axis, is a branch of the first portion of the subclavian, through its profunda cervicis branch anastomoses with a deep descending branch of the princeps cervicis (Fig. 186).

The Internal Carotid Artery.—The internal carotid lies posterior and to the outer side of the external. It gives off no branches in the neck. Entering the skull through the *carotid canal,* in the apex of the petrous portion of the temporal bone and directly below and to the inner side of the Gasserian ganglion, it passes through the inner side of the *cavernous sinus* and at the anterior clinoid processes it bends up to divide into the *anterior* and *middle cerebrals.* Before its division it gives off the *posterior communicating artery,* the *anterior choroid artery* to supply the choroid plexus in the lateral ventricles, and the *ophthalmic artery.* The internal carotid artery in the neck is normally straight, but sometimes, particularly in elderly persons, it is tortuous. This may then be mistaken for aneurism. It lies about 2 cm. posterior and a little to the outer side of the tonsil. As the pharynx is the side of

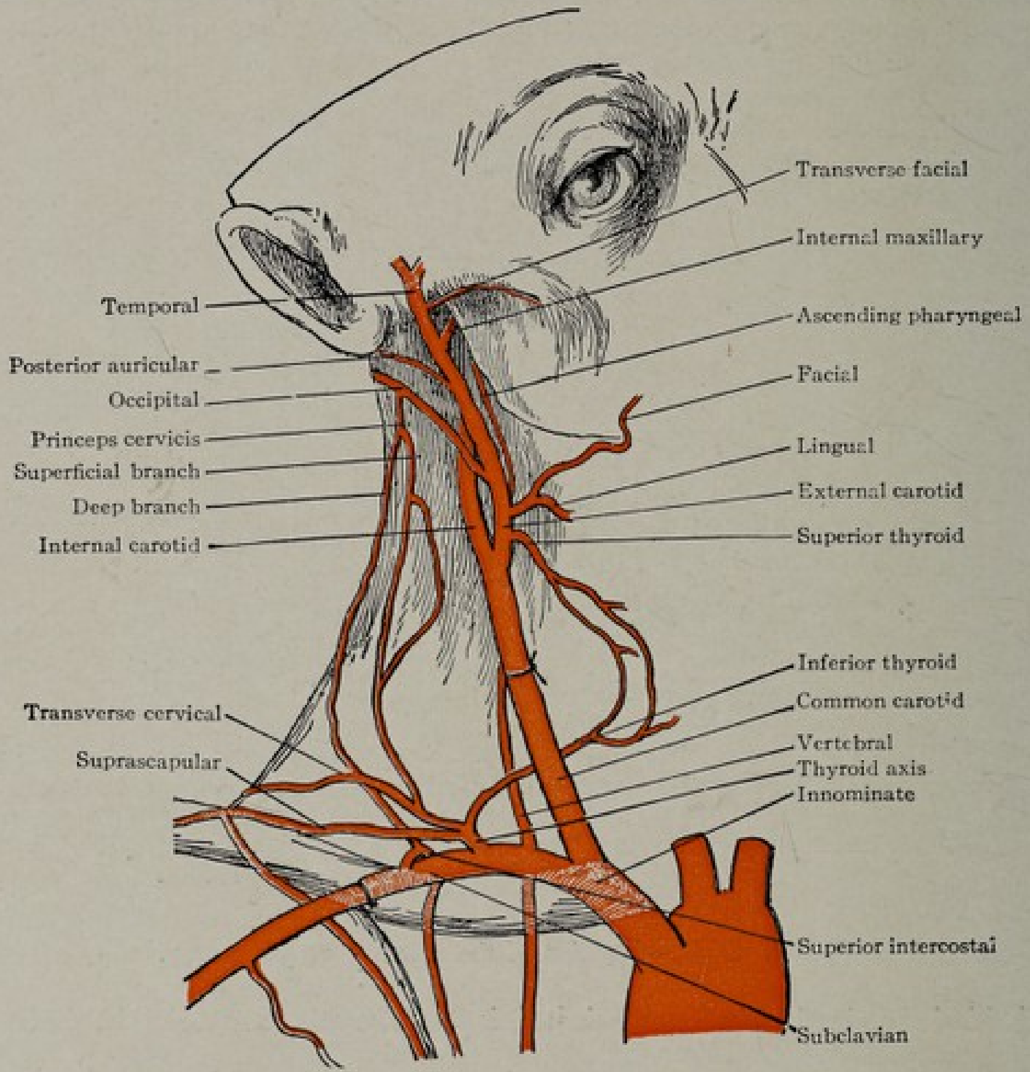


FIG. 186.—Collateral circulation after ligation of the common carotid artery.

least resistance, when the vessel becomes tortuous it bulges into it, and on examination through the mouth a pulsating swelling can be distinctly seen in the pharynx just posterior to the tonsil. The finger introduced can feel the pulsations, and pressure on the carotid in the neck below causes the pulsations to cease. Thus the character of the pulsating swelling can be recognized. This artery is rarely ligated, but if it is desired to do so it can readily be reached through an incision 6 or 7 cm. long behind the angle of the jaw. Aneurism or wounds may necessitate its ligation. At its commencement it is comparatively superficial, but as it ascends it gets quite deep, passing beneath the digastric and stylohyoid muscles. It should therefore be ligated below the angle of the jaw and not over 3 cm. from its origin at the upper border of the thyroid cartilage. It will be necessary to push the sternomastoid muscle posteriorly, as its anterior margin overlies the vessel. The *internal jugular* vein is to its outer side and between the two and posterior is the *pneumogastric* *nerve*. The *sympathetic nerve* lies behind it but is separated by a layer of fascia and is not liable to be caught up in passing the aneurism needle. The *lingual, facial,* and *laryngeal veins* may be encountered and are apt to cause trouble. They will have to be held aside or ligated and divided. The *ascending pharyngeal artery* may lie close to the internal carotid and care should be taken not to include it in the ligature. The needle is to be passed from without inward.

The External Carotid Artery.—Of recent years the external carotid artery has been ligated far more often than formerly, as it was customary to ligate the common carotid instead. The external carotid runs from the upper border of the thyroid cartilage to the neck of the mandible. It supplies the outside of the head, face, and neck. These parts are the seat of various operations for tumors, especially carcinoma of the mouth and tongue, diseased lymph-nodes, and other affections, and the external carotid and its branches are not infrequently ligated in order to cut off their blood supply.

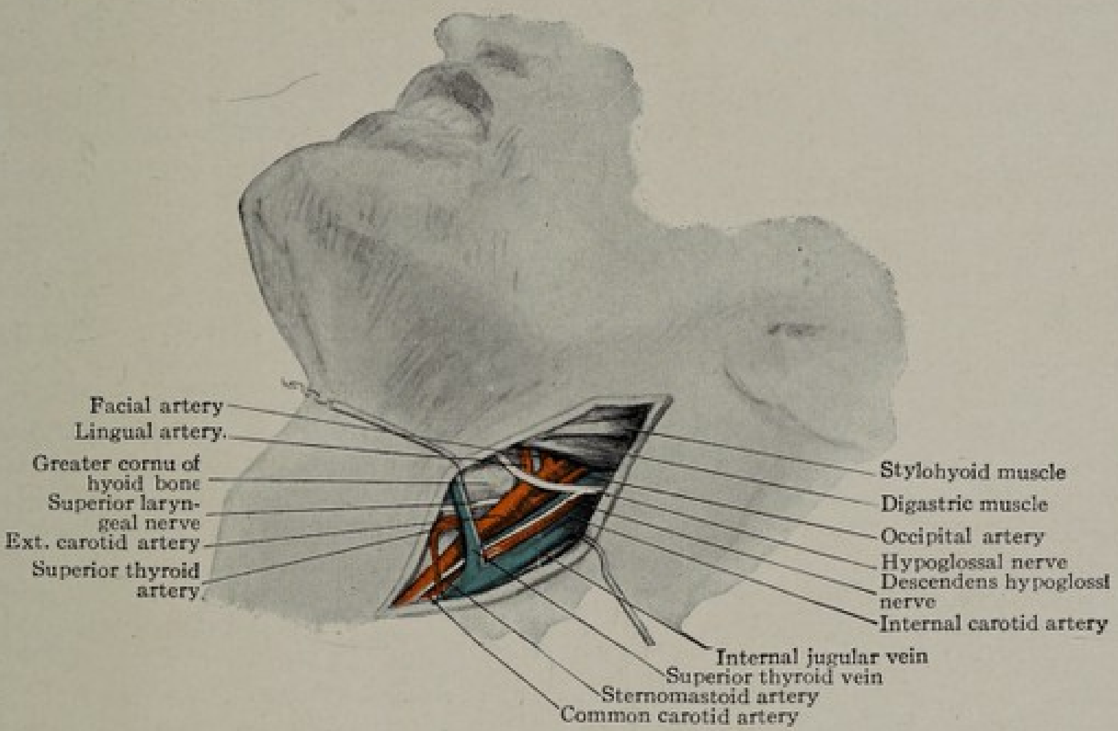


Fig. 187.—Ligation of external carotid artery and its branches.

Unlike some other arteries the external carotid sometimes seems to have no trunk, consisting almost entirely of branches. Therefore in ligating it one should not expect to find a big artery the size of the internal carotid, but often one only half as large. The branches of the external carotid artery are the *superior thyroid, lingual,* and *facial,* which proceed anteriorly toward the median line; the *occipital* and *posterior auricular,* which supply the posterior parts; the *ascending pharyngeal,* which comes off from its deep surface and ascends to the base of the skull; and the *temporal* and *internal maxillary arteries,* which are terminal. It is ligated either near its commencement just above the superior thyroid artery or behind the angle of the jaw above the digastric muscle.

Ligation of the External Carotid Artery above the Superior Thyroid.—At its commencement at the upper border of the thyroid cartilage the artery is quite superficial, being covered by the skin, superficial fascia, platysma, deep fascia, and overlying edge of the sternomastoid muscle. It is to be reached through an incision 5 cm. in length along the anterior edge of the sternomastoid muscle in a line from the sternoclavicular joint to midway between the angle of the jaw and the mastoid process. The middle of the incision is to be opposite the thyrohyoid membrane. The bifurcation of the common carotid artery is an important landmark.

The superior thyroid artery is given off at the very commencement and sometimes even comes from the common carotid just below. The ascending pharyngeal is the next branch, about 1 cm. above the superior thyroid. It comes off from the deep surface of the artery; almost opposite to it and in front is the lingual. It will thus be seen that the distance between the lingual and the superior thyroid, where the ligature is to be placed, is quite small. The superior thyroid is about opposite the upper border of the thyroid cartilage, while the lingual is opposite the hyoid bone. Beneath the artery is the superior laryngeal nerve, but it is not liable to be caught up by the needle in passing the ligature because it lies flat on the constrictors of the pharynx and is apt to be a little above the site of ligation.

The veins are the only structures liable to cause trouble. They are superficial to the arteries. On account of their irregularity more may be encountered than is expected. The superior thyroid and lingual veins both cross the artery to empty into the internal jugular. The facial vein is also liable to be met, as the facial artery frequently springs from a common trunk with the lingual. The communicating branch between the facial and external jugular vein is another one that should be anticipated. These veins, when it is possible, are to be hooked aside; otherwise they are to be ligated and cut. Great care should be taken not to mistake a vein for the artery. It might appear an easy matter to readily recognize the artery and distinguish between it and the veins, but this is not always the case in the living subject. The veins may have some pulsation transmitted to them from the adjacent arteries and the artery may temporarily have its pulsations stopped by pressure from the retractors. The living artery touched by the finger seems soft and does not give the hard, resisting impression felt in palpating the radial in feeling the pulse. The difference in thickness of the coats is also sometimes not apparent at a first glance.

The ligature is to be passed from without inward so as to guard against wounding the internal carotid.

Ligation of the Superior Thyroid Artery.—The superior thyroid is the first branch of the external carotid and is given off close down to the bifurcation or even from the common carotid itself just below. It lies quite superficial but of course beneath the deep fascia. At first it inclines upward and then makes a bend and goes downward to the thyroid gland. It gives off three comparatively small branches, the hyoid along the lower border of the hyoid bone, the sternomastoid to the muscle of that name, and the superior laryngeal to the interior of the larynx. The larger portion of the artery goes downward to supply the thyroid gland and muscles over it, therefore the artery is to be looked for at the upper edge of the thyroid cartilage, and not near the hyoid bone. The incision is the same as for ligating the external carotid low down, viz., 5 cm. along the anterior edge of the sternomastoid muscle, its middle being opposite the upper edge of the thyroid cartilage. Veins from the thyroid gland—superior thyroid—will probably cover it. After the deep fascia has been opened, the external carotid is to be recognized at its origin from the common carotid and then the superior thyroid artery found and followed out from that point. The ligature is to be passed from above downward to avoid the superior laryngeal nerve. This nerve lies distinctly above the artery and is not liable to be injured if the thyroid artery is followed out from its origin at the external carotid. (See Fig. 187.) The ligation of the superior thyroid artery for toxic goiter is rarely done at the present time. If done the ligation should be performed close to the superior pole with two ligatures and the artery divided between them. If this is done the branches from the cervical sympathetic, which enter the gland at the superior pole, are also sectioned.

Ligation of the Lingual Artery.—The lingual artery may be ligated for wounds or as preliminary step to excision of the tongue or to prevent hemorrhage from malignant growths of the mouth, tongue or lower jaw, especially when these are treated by fulguration where the tendency to hemorrhage, when the desiccated slough separates, is great.

The lingual artery springs from the external carotid opposite the hyoid bone about 1 cm. above the bifurcation of the common carotid. It is composed of three parts: the first, from its point of origin to the posterior edge of the hyoglossus muscle; the second, the part beneath the hyoglossus muscle; and the third, the part beyond this muscle to the tip of the tongue.

The artery is usually ligated beneath the hyoglossus muscle in the second part of its course, although it is sometimes desirable to ligate it in the first part of its course.

The *first part* inclines upward and forward, above the greater horn of the hyoid bone, to the hyoglossus muscle, beneath which it passes in a direction somewhat parallel to the upper edge of the hyoid bone. It lies on the middle constrictor of the pharynx and superior laryngeal nerve and is covered by the skin, platysma, and fascia. It lies immediately below the stylohyoid and digastric muscles and is crossed by the hypoglossal nerve and some veins. This portion frequently gives off a hyoid branch which runs above the hyoid bone. It is often missing, in which case the parts are supplied by the hyoid branch of the superior thyroid. From either the end of the first part or the beginning of the second part, the dorsalis linguæ branch arises.

The *second part* of the lingual lies on the superior constrictor and geniohyoglossus muscles and is covered by the hyoglossus. It runs in a direction somewhat

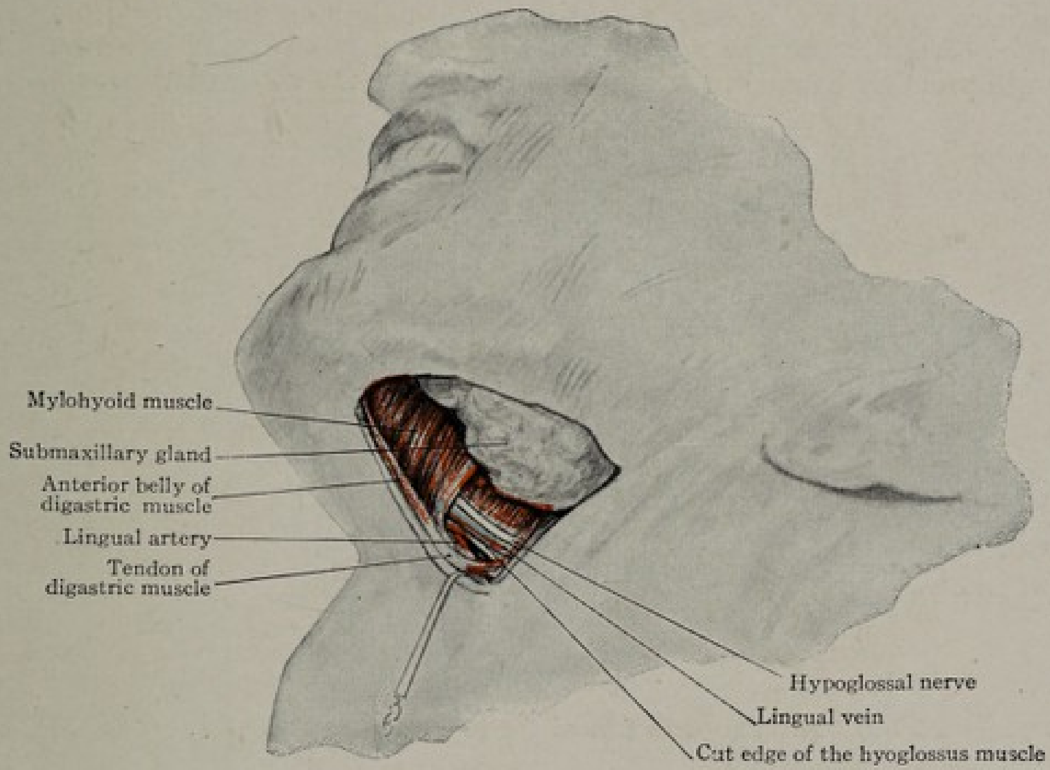


FIG. 188.—Ligation of the lingual artery in Lesser's triangle.

parallel to the upper edge of the hyoid bone and from 0.5 to 1 cm. above it. In this part of its course it is usually accompanied by one or two veins and the hypoglossal nerve is superficial to it, the hyoglossus muscle separating them. This is the part of the artery chosen for ligation. An incision is made, convex downward, running from below and to one side of the symphysis nearly down to the hyoid bone and then sloping upward and back, stopping short of the line of the facial artery, which can be determined by the groove on the mandible just in front of the masseter muscle. The skin, superficial fascia, and platysma having been raised, the submaxillary gland is seen covered with a comparatively thin deep fascia. Some veins coming from the submental region may then be encountered. They may be ligated and divided. The submaxillary gland is next to be lifted from its bed and turned upward against the mandible, carrying with it the facial artery, which is alherent to its under surface. The tendon of the digastric will now be seen with the anterior and posterior bellies of the muscle forming an angle with its point toward the hyoid bone. These with the hypoglossal nerve form what has been called the *triangle of Lesser*. It is in this space that the artery is ligated. The floor of the space posteriorly is formed by the hyoglossus muscle, while anteriorly is seen the edge of the mylohyoid muscle. Through the thin fascia overlying the hyoglossus muscle can be seen the hypoglossal nerve, and below it, sometimes a vein. The artery lies under the muscle, while the veins may be either on or under the muscle or both.

The apex of the angle formed by the tendon of the digastric muscle is held down to the hyoid bone by a slip of fascia which is an expansion of the central tendon of the muscle and the tendon of the stylohyoid muscle. The distance at which the central tendon of the digastric is held away from the hyoid bone varies in different individuals and is an important fact to bear in mind in searching for the artery. If the tendon rests high above the hyoid bone the artery must be looked for low down, sometimes even under the tendon; if, on the contrary, the tendon is low down the artery may be 0.5 to 1 cm. higher up. The hypoglossal nerve lies on the muscle and nearer to the mandible than the artery. If there is a vein on the hyoglossus muscle it is apt to be below the nerve, that is, nearer the hyoid bone, and may lie directly over the artery. The vein and the nerve are to be displaced up towards the jaw and an incision a centimetre long made through the hyoglossus muscle a short distance above the digastric tendon and parallel with the hyoid bone. This incision should not be deep, as the muscle is only 2 or 3 mm. (1/8 in.) thick. The edges of the incision being raised and displaced upward and downward, the artery will probably be seen running at right angles to the fibres of the muscle and

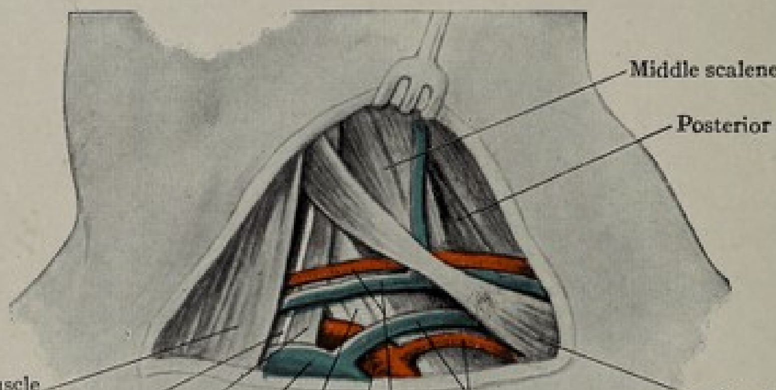


FIG. 189.—Ligation of the subclavian artery.

parallel to the hyoid bone. If not seen at once it should be looked for below the incision, nearer to the hyoid bone. Care must be taken not to mistake the vein for the artery. That this is not an unlikely thing is shown by its occurring in the hands of a distinguished surgeon who had had exceptional experience in this same operation. The ligature needle may be passed from above downward to avoid including the hypoglossal nerve. In ligation for malignant lesions I ligate the lingual at its origin and dissecting upwards isolate and ligate the facial at its origin, since the anastomosis between the two is sufficient to allow for extensive hemorrhage if both are not ligated. If it is preferred to ligate the lingual in Lesser's triangle the submaxillary gland is replaced, the skin flap elevated and the facial can be found and ligated as it passes up over the mandible just anterior to the masseter muscle.

Subclavian Artery.—The right subclavian artery runs from the sternoclavicular articulation in a curved line to the middle of the clavicle. It rises 1.25 cm. above the clavicle. The innominate bifurcates opposite the right sternoclavicular joint. The left subclavian springs directly from the arch of the aorta, therefore it is longer than the right by 4 to 5 cm., this being the length of the innominate. As the subclavian artery passes outward it is crossed by the scalenus anticus muscle, which divides it into three parts: the first part, extending to the inner side of the muscle, gives off three branches, the *vertebral, internal mammary,* and *thyroid axis;*

the second part, behind the muscle, gives off the *superior intercostal;* the third part has no branches.

The *first portion of the subclavian* lies very deep and as it is frequently involved in aneurisms its relations are worth studying. In approaching the artery from the surface it is seen to be covered by the sternomastoid, the sternohyoid, and the sternothyroid muscles. The outer edge of the sternomastoid muscle corresponds with the outer edge of the scalenus anticus. The three first-named muscles having been raised, the artery is seen to be crossed by the internal jugular, the vertebral, and perhaps the anterior jugular veins. The anterior jugular above the clavicle dips beneath the inner edge of the sternomastoid muscle to pass outward and empty into the external jugular or subclavian. The pneumogastric nerve crosses the artery just to the inner side of the internal jugular vein. Below, the artery rests on the pleura, and on the right side the recurrent laryngeal nerve winds around it. Behind the artery are the pleura and lung, which rise somewhat higher in the neck than does the artery.

On the *left side* the phrenic nerve leaves the scalenus anticus muscle at the first rib, crosses the subclavian at its inner edge, and passes down on the pleura to cross the arch of the aorta. To the inner side of the artery runs the thoracic duct, which, as it reaches the upper portion of the artery, curves over it to cross the scalenus anticus muscle and empty into the junction of the internal jugular and subclavian veins. The trachea and œsophagus are likewise seen to the inner side of the artery. The thyroid axis comes off its anterior surface, the vertebral from its posterior, and the internal mammary below.

The *second portion of the subclavian artery* lies behind the anterior scalene muscle. In front of the anterior scalene is the *subclavian* vein. The *phrenic nerve* runs on the muscle and at the first rib leaves it to continue down between the right innominate vein and pleura. Behind and below, the artery rests on the pleura and the middle scalene muscle is to its outer side. Thus it is seen that the artery passes through a chink formed by the anterior scalene muscle in front and the middle scalene behind. They both insert into the first rib. The posterior scalene is farther back and inserts into the second rib. Above the artery are all the cords of the brachial plexus. One branch of the subclavian, the *superior intercostal artery* (costo cervical trunk) is given off near the inner edge of the anterior scalene muscle.

The *third portion of the subclavian* runs from the outer edge of the anterior scalene muscle to the lower border of the first rib. This part of the artery is the most superficial. The only muscle covering it above is the thin sheet of the platysma, lower down the subclavius muscle and clavicle overlie it; but the operations on the vessel are done above these structures, hence they do not interfere. There are apt to be a number of veins in front of the artery. The external jugular and transverse cervical veins are certain to be present and perhaps the suprascapular and cephalic, which may enter above instead of below the clavicle. These veins may form a regular network in the posterior cervical triangle above the clavicle and prove very troublesome. Above is the brachial plexus and transverse cervical artery and still higher is seen the omohyoid muscle. The suprascapular artery is lower down and usually concealed just below the upper edge of the clavicle. The lowest cord of the brachial plexus, formed by the first dorsal and last cervical nerves, may be posterior to the artery. The nerve to the subclavius muscle passes down in front of it.

Ligation of the First Part of the Subclavian Artery.—If an aneurysm involves the first portion of the subclavian obviously nothing can be done on the left side except a distal ligation of the subclavian and a ligation of the carotid. If the aneurysm involves the second or third portions the first part may be ligated. A good exposure is necessary and this is attained by resecting the median third of the clavicle after dividing the inferior attachments of the sternocleidomastoid, sternothyroid and sternohyoid muscles. The carotid artery, jugular vein and vagus nerve are exposed and retracted mesially and by using the carotid artery as a guide the junction with the aorta locates the origin of the subclavian. Careful dissection avoids injury to the dome of the pleura and the thoracic duct. The transverse scapular artery will be ligated. The vessel should be ligated mesially to the origin of the vertebral artery.

A dorsal approach has been advocated by Henry (1913). A curved incision is made over the second rib posteriorly. After raising the flap of skin the origins of the trapezius, rhomboids, and serratus posterior superior are cut. Three inches of the second rib are bared including the transverse process and the latter divided and removed. The rib is then retracted (better removed for three inches) and the pleural dome pushed down and retracted. A branch of the superior intercostal artery will be met and should be divided. The ansa subclavian should be avoided. The artery can then be isolated and ligated. Any of the branches except the thyro-cervical trunk can be ligated.

Ligation of the Third Portion of the Subclavian Artery.—The head is to be turned strongly to the opposite side and the shoulder depressed. An incision 7.5 cm. long is made on the clavicle. The middle of the incision should be a little to the inside of the middle of the clavicle. The deep fascia is to be incised and the clavicular origin of the sternomastoid and trapezius muscles cut to the same extent as the superficial incision.

The clavicular origin of the sternomastoid extends out on the clavicle one-third of its length. The trapezius inserts into the outer third. This leaves the middle third or 5 cm. of the clavicle on its upper surface free from muscles. As the incision is 7.5 cm. long this necessitates the division of 2.5 cm. (1 in.) of muscle, and as the middle of the incision is a little to the inner side of the middle of the clavicle this will make it necessary to divide more of the clavicular origin of the sternomastoid than of the trapezius. After the division of the deep fascia, fat and veins are encountered. The scalenus anticus muscle has the subclavian vein in front of it and the artery behind, therefore the vein must be attended to before a search is made for the edge of the scalene muscle. The veins to be encountered are the external jugular vein, which empties into the subclavian in front of or to the outer side of the anterior scalene muscle, and its tributaries, the suprascapular and transverse cervical veins, as well as the anterior jugular and a communicating branch from the opposite side of the neck. The cephalic vein not infrequently sends a communicating branch over the clavicle to empty into the external jugular. The fat is to be picked away with forceps; the veins are to be held out of the way with a blunt hook or ligated and cut. The suprascapular artery may be seen close to or under the clavicle. The transverse cervical artery may perhaps be above the level of the wound. The omohyoid muscle may or may not be seen, as its distance from the clavicle is quite variable. The transverse cervical and suprascapular arteries are not to be cut, as they are needed for the collateral circulation. As was mentioned in speaking of the ligation of the external carotid artery, so also here it is not always easy to distinguish between arteries and veins. The veins being disposed of, the anterior scalene muscle is to be sought at the internal portion of the wound. It runs somewhat like the lower portion of the sternomastoid, the posterior edges of the two muscles coinciding. The phrenic nerve runs down first on the anterior surface and then on the inner surface of the scalenus anticus. The edge of the muscle being recognized, by following it down the finger feels the first rib. The artery lies on the first rib immediately behind the muscle and the vein immediately in front of the muscle. The tubercle on the first rib may not be readily felt because the muscle is inserted into it. The greatest care should be exercised in passing the aneurysm needle around the artery. The vein is not so much in jeopardy as are the pleura and lowest cord of the brachial plexus, hence the needle is passed from above down between the nerve and the artery and brought out between the artery and vein.

Wounding of the pleura may cause collapse of the lung and later a septic pleurisy, while including the nerve will cause severe pain, etc.

Collateral Circulation after Ligation of the Third Portion of the Subclavian Artery.—(1) Internal mammary with superior thoracic and long thoracic. (2) The posterior scapular branch of the suprascapular with the dorsalis branch of the subscapular. (3) Acromial branches of suprascapular with acromial branch of acromial thoracic. (4) A number of small vessels derived from branches of the subclavian above with axillary branches of the main axillary trunk below (Gray).

Ligation of the Inferior Thyroid Artery.—The inferior thyroid artery, unlike the superior, lies deep from the surface, and it is a far more difficult vessel to reach. It is a branch of the thyroid axis, the other branches being the transverse cervical and suprascapular. The thyroid axis comes from the first part of the subclavian just a little to the inner side of the edge of the scalenus anticus muscle. The inferior thyroid artery ascends on the longus colli muscle, just to the inner side of the scalenus anticus and almost in front of the vertebral artery. When it reaches about the level of the seventh cervical vertebra it bends inward and behind the carotid artery to reach the lower posterior edge of the thyroid gland. The transverse process of the sixth cervical vertebra, called the *carotid tubercle of Chassaignac,* is above it. As it bends to go inward it gives off the ascending cervical artery. In front of the artery are the internal jugular vein, common carotid artery, pneumogastric nerve, and the middle ganglion of the sympathetic. The recurrent laryngeal nerve usually passes upward behind the branches of the artery just before they

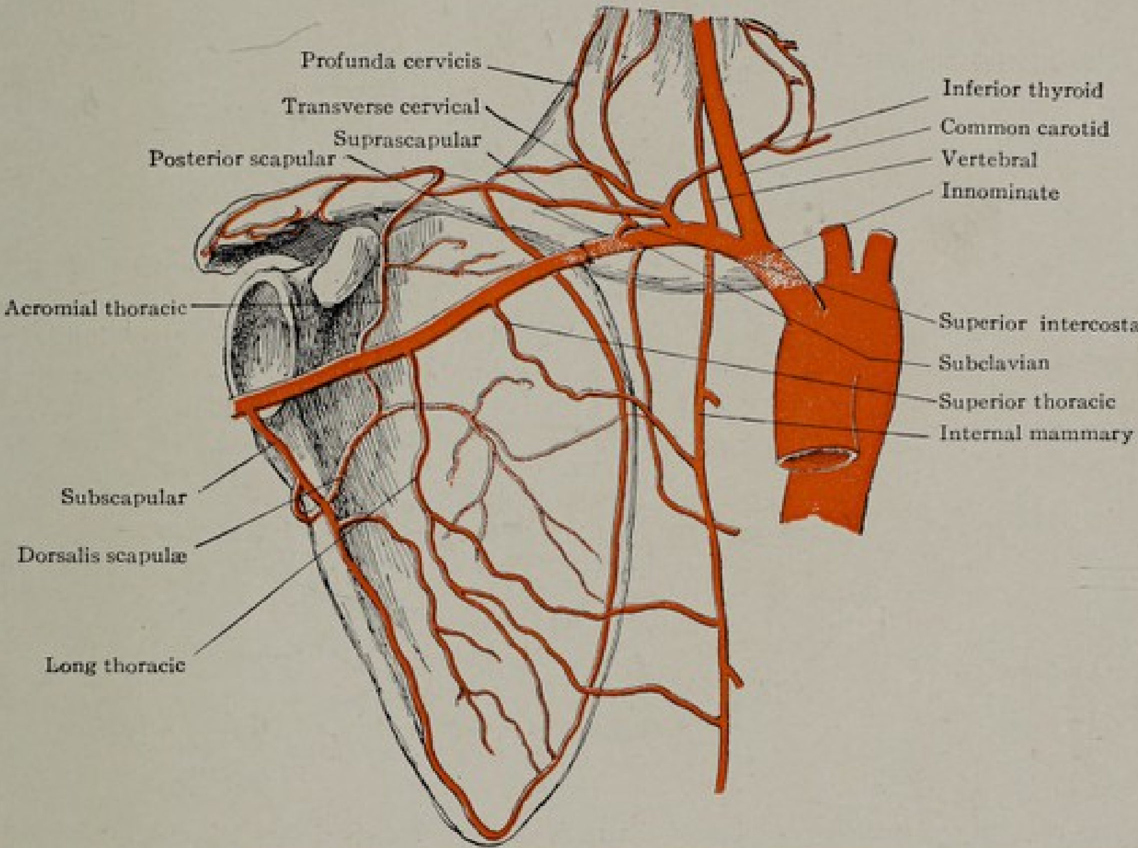


FIG. 190.—Collateral circulation after ligation of the third portion of the subclavian artery.

enter the thyroid gland. The thoracic duct on the left side passes over the front of the artery low lown.

Operation.—An incision 7.5 cm. long is made along the anterior border of the sternomastoid muscle, extending upward from the clavicle. This will bring the upper extremity up to, or even above, the cricoid cartilage. The anterior jugular vein will have to be ligated and the muscle displaced outward. The common carotid artery should then be isolated and it, together with the pneumogastric nerve and internal jugular vein, drawn outward. The omohyoid muscle may appear at the upper edge of the incision. Feel for the carotid tubercle on the sixth transverse cervical process: the artery lies below the omohyoid muscle and cricoid cartilage and below the tubercle and beneath the sheath of the carotid. If the trunk of the sympathetic or its middle cervical ganglion, which lies on the artery, is encountered, it should be pushed to the inner side, the artery isolated outwardly and ligature applied. Do not go too far out or the scalenus anticus will be reached and the phrenic nerve may be injured, nor too far in, to avoid wounding the recurrent laryngeal.

The *thyroidea ima* (*inferior thyroid*) *veins* do not cross outward nor accompany the artery, but proceed downward on the trachea to empty into the innominate veins.

THE CERVICAL FASCIAS

There are two fascias in the neck, the *superficial* and the *deep*. The superficial fascia has blended with it anteriorly the platysma muscle and the termination of the nerves, arteries, and veins. The main trunks of these structures lie for all practical purposes beneath the superficial fascia and adherent to the surface of the deep fascia. It is for this reason that in raising the superficial structures the larger trunks remain applied to the deep fascia and are thus less liable to be injured in the living and mutilated in the dead. In the superficial fascia and on the deep fascia are the superficial lymphatics.

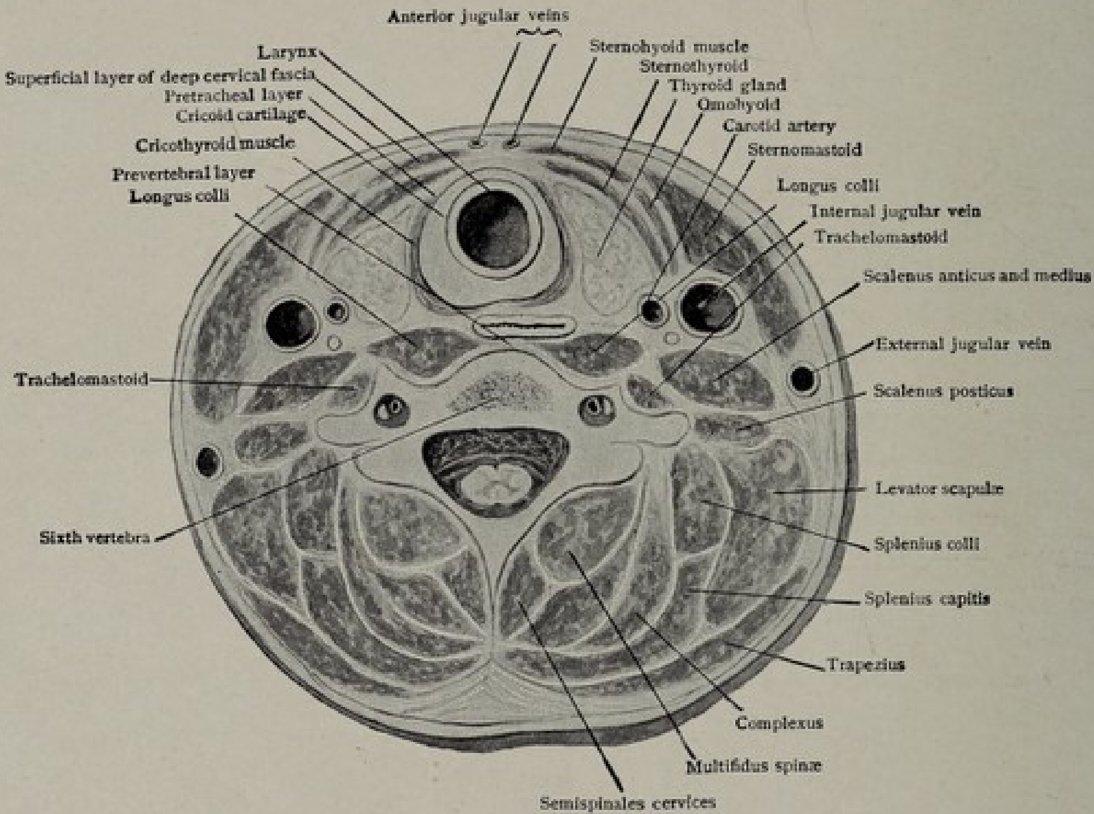


FIG. 191.—Transverse section of the neck through the sixth cervical vertebra.

The superficial lymphatic nodes frequently suppurate. When they do the abscess so formed is prevented by the deep fascia from reaching the parts beneath, so the pus works its way out through the skin. As the superficial fascia is loose, if the abscess is slow in formation, it may extend for a considerable distance under the skin.

Sebaceous cysts are common in the neck. As they are superficial to the deep fascia, which is not involved, they can be removed without fear of wounding any important structures. The veins do not overlie them; they are always superficial to the veins, therefore there is no danger of wounding the external jugular.

The Deep Cervical Fascia.—The deep cervical fascia completely envelops the neck and sends its branches in between all its various structures. It is the fibrous tissue that both unites and separates all the different structures to and from each other. Where this fascia is abundant it forms a distinct layer, but where it is scant it is simply a small amount of connective tissue between two adjacent parts. To follow all the processes of the deep fascia through the neck between its innumerable structures is impossible—nor is it necessary. The main reason for studying the deep cervical fascia and its various parts is to understand the course pursued by abscesses and infections. This is best done by limiting oneself to the main superficial layer and some of the larger layers crossing from side to side.

The principal layers of the deep cervical fascia are the *superficial layer,* which completely encircles and envelops the neck, the *prevertebral layer,* which passes from side to side in front of the spinal column, and the *pretracheal layer,* which passes from side to side in front of the trachea.

The Superficial Layer.—The superficial layer of the deep fascia envelops the whole of the neck, with the exception of the skin, platysma, and superficial fascia. It is attached above to the occipital protuberance, the superior curved line of the occiput, the mastoid process, then blends with the capsule of the parotid gland, then passes to the angle of the jaw and along the body of the mandible to the symphysis, whence it proceeds around the opposite side in the same manner. Below it is attached to the sternum, upper edge of the clavicle, acromion process and spine of the scapula, thence across to the vertebral spines, to which and to the ligamentum nuchæ it is attached up to the occipital protuberance. In the front of the neck it passes from the mandible down to be attached to the hyoid bone and thence downward to the sternum and clavicle.

From the under side of this superficial layer processes of fascia come off and envelop the various structures of the neck. Every separate structure of the neck is covered by it and therefore separated from the adjacent parts by a more or less distinct layer of the fascia. In many places it is quite thin or almost imperceptible, amounting to but a few shreds of fibrous tissue, in other places it is more distinct, forming more or less marked capsules, as in the case of the thyroid and submaxillary glands, or fibrous layers, as in the case of those in front of the vertebræ and trachea. Posteriorly in the median line the superficial layer of the deep fascia sends a process which covers the under surface of the trapezius muscle. Anteriorly another process is given off to cover the under surface of the sternomastoid muscle. The superficial veins of the neck, the anterior, external, and posterior jugulars, lie on or in the deep fascia, being stuck to or blended with its upper surface.

About 3 cm. (1¼ in.) above the sternum the deep fascia splits into two layers, one to be attached to the anterior and the other to the posterior edge of the sternum in front of the sternohyoid and sternothyroid muscles. Between these two layers is the *space of Burns;* it contains the lower ends of the anterior jugular veins with the branch that joins them, some fatty tissue and lymphatic nodes, and the sternal origin of the sternomastoid muscle. Sometimes a vein comes up from the surface of the chest below to open into the anterior jugular vein.

The *prevertebral layer* passes from side to side directly on the bodies of the vertebræ. It covers the muscles attached to the spine, as the scalene, longus colli, rectus capitis anticus, and also the nerves, as those of the brachial plexus, coming from the spine. On reaching the carotid artery and jugular vein it helps to form their sheath. Its upper edge is attached to the base of the skull at the jugular foramen and carotid canal and thence across the basilar process to the opposite side. Inferiorly it passes down on the surface of the bodies of the vertebræ into the posterior mediastinum.

From the sheath of the vessels outward, beyond the posterior edge of the sternomastoid muscle, the prevertebral fascia covers the scalene muscles, the brachial plexus of nerves, and the subclavian artery. On reaching the clavicle the fascia is attached to its upper surface, blending with the superficial layer; it is then continued down over the subclavian muscle, forming its sheath, and ends as the costocoracoid membrane. The part over the subclavian artery and vein is continued over them and the brachial plexus and follows them into the axilla. This fascia forms the floor of the posterior cervical triangle; the roof is formed by the superficial layer of the deep fascia. It is between these layers that the suprascapular artery and veins run. The descending branches of the cervical plexus, the spinal accessory nerve, omohyoid muscle, and some fat and lymph nodes are also found there.

The *pretracheal layer* passes from side to side in front of the trachea. Laterally it too blends with the sheath of the vessels and is continued posteriorly behind the pharynx and œsophagus as the *buccopharyngeal fascia.* In front it blends in the median line with the superficial layer and is attached to the hyoid bone and cricoid cartilage. It splits to enclose and form a capsule for the thyroid gland, and below encloses in its meshes the inferior thyroid veins, and thence passes to the arch of the aorta to be continuous with the pericardium. Laterally it passes under the sternohyoid, omohyoid, and sternothyroid muscles to blend with the sheath of

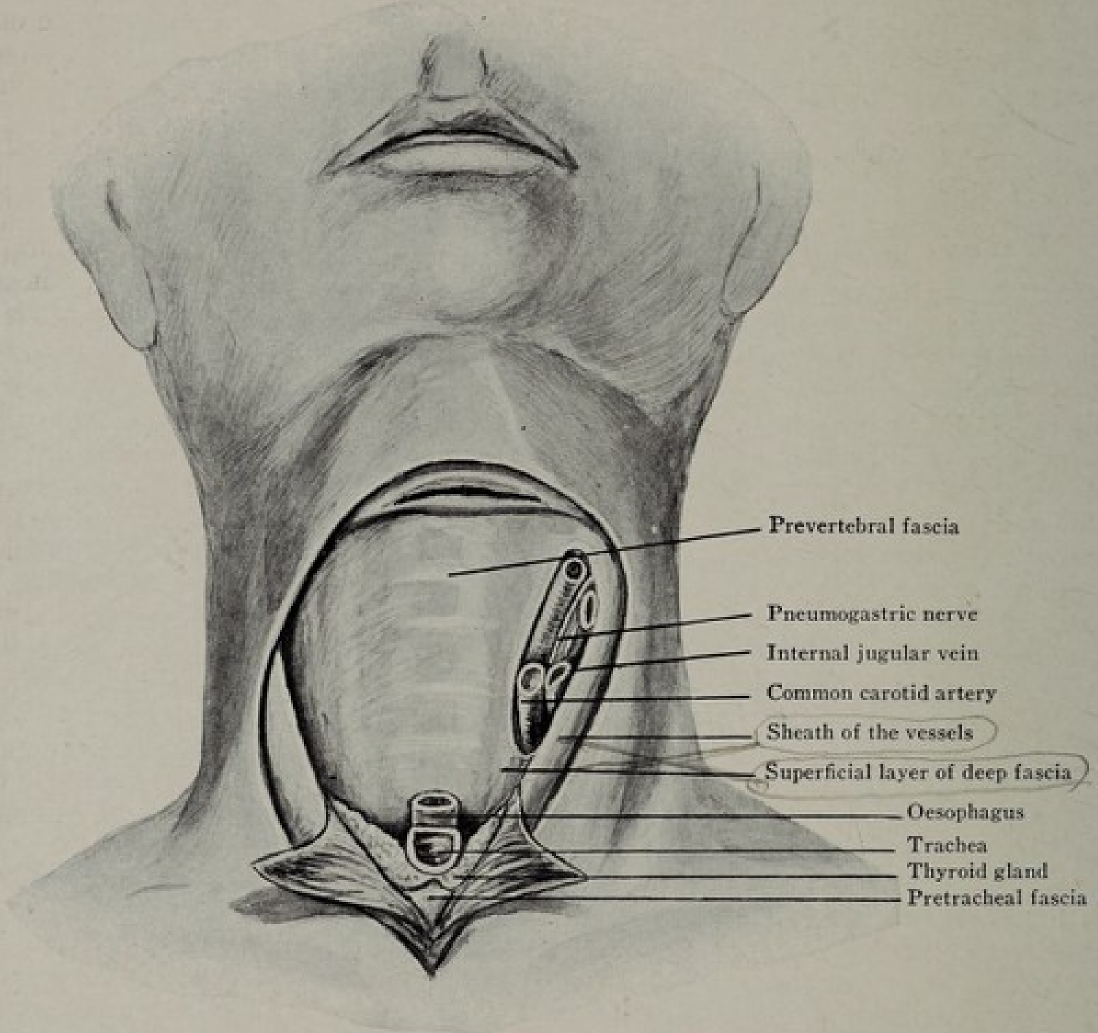


FIG. 192.—Deep cervical fascia. The pharynx and larynx have been cut away, exposing the prevertebral and pretracheal layers.

the vessels and the layer on the posterior surface of the sternomastoid muscle. This is its lateral limit. Underneath the sternomastoid muscle a loop of fascia proceeds downward from the omohyoid muscle to the first rib. This is derived from the sheath of the vessels beneath and the layer on the under surface of the sternomastoid superficially.

The *sheath of the vessels* envelops the carotid artery, jugular vein, and pneumogastric nerve. Thin layers of fascia pass between these structures, separating one from the other. The sheath is formed by the union of the outer edge of the pretracheal fascia and the prevertebral fascia, with the fascia lining the under surface of the sternomastoid muscle. This sheath follows the vessels down into the chest and out into the axilla.

The *capsule of the parotid gland* is formed by the splitting of the superficial layer of the deep cervical fascia as it passes from the mastoid process to the angle of the jaw. Its superficial portion is attached to the zygomatic process. Its deep portion passes from the styloid process to the angle of the jaw and is known as the stylomandibular ligament.

The *capsule of the submaxillary gland* is formed by a splitting of the superficial layer at the hyoid bone. It forms the covering of the gland and from the hyoid bone sends a process upward which lies on the digastric and mylohyoid muscles and follows the latter up to be attached along the mylohyoid ridge of the mandible. It proceeds with the submaxillary gland around the posterior edge of the mylohyoid muscle to cover its upper surface. The stylomandibular ligament alluded to above separates the parotid from the submaxillary gland.

The *capsule of the thyroid gland* is not very thick and the gland is readily separated from it, as is also the case with the submaxillary gland. It is continued downward in front of the trachea as the pretracheal layer and laterally it blends with the sheath of the vessels. It follows the vessels downward into the chest and is continuous with the pericardium. The veins of the gland, which are at times very large, run beneath the capsule and bleed freely if wounded. Tillaux has attempted to clarify the complex arrangement of the cervical fascia by picturing the three chief layers as separating the neck into four anatomical spaces: (1) Subcutaneous—between the skin and the superficial fascia. (2) Intra-aponeurotic—this space does not exist above when only one layer is found but below when the superficial layer of the deep fascia splits, it is equal to the thickness of the sternum, Burns' space. (3) Visceral—between the pretracheal and prevertebral layers. Here are found the principal structures in the neck. The space communicates with the mediastinum and the axilla. (4) Retrovisceral—between the prevertebral fascia and the spinal column. It is in this space and just anterior to it that retropharyngeal collections may arise.

The Buccopharyngeal Fascia.—Between the pharynx in front and the vertebral column behind is the retropharyngeal space. The fascia forming the posterior wall of this space is the prevertebral fascia already described. Forming its anterior wall is a thin layer of connective tissue called the buccopharyngeal fascia. It invests the superior constrictor of the pharynx and is continued forward on the buccinator muscle. It is continued downward behind the pharynx and œsophagus into the posterior mediastinum: laterally it blends with the sheath of the vessels and is continuous with the pretracheal fascia around the larynx, trachea, and thyroid gland (Fig. 193).

Abscesses of the Neck.—Abscesses of the neck usually arise in connection with the lymphatic nodes. They may also start from infected wounds, carious teeth, suppuration of the thyroid gland, and other causes. They may have their course influenced by the various layers of the deep fascia.

Pus in the Submaxillary Region.—As the submaxillary space has the mylohyoid muscle as its floor, abscesses here show below the body of the mandible between it and the hyoid bone. Usually they point towards the skin. Infection of this space may occur from the teeth. Tillmans saw a case in which in four days the pus caused death from infection of the mediastinum and pleura. This proceeded downward from the badly extracted tooth and thence under the deep fascia of the neck to the chest.

The pus, filling the submaxillary space, as can also occur in Ludwig's angina, which is an infective inflammation of the submaxillary and sublingual regions, may follow the lingual and facial arteries to the sheath of the great vessels and down into the superior mediastinum. The infection in Ludwig's angina may pass around the posterior edge of the mylohyoid muscle and involve the structures around the base of the tongue and pharynx, and produce œdema of the larynx and death (see page 229).

Pus superficial to the deep fascia tends to perforate the skin and discharge externally. If it is slow in forming it may sink down and pass over the clavicle onto the upper portion of the chest.

Pus in the suprasternal notch or space of Burns bulges anteriorly but may perforate posteriorly. The sternothyroid and sternohyoid muscles are attached to the posterior surface of the sternum; but the layer of fascia on their anterior surface is very thin, so that pus may either pass between the muscles or perforate them and so pass down in front of the pretracheal fascia close to the under surface of the sternum. It would then tend to show itself in the upper intercostal spaces, close to the sternum.

Pus between the pretracheal and superficial layers, as may occur from abscesses of the thyroid gland, tends to work its way downward rather than laterally. The pretracheal fascia at the sides blends with the sheath of the vessels and the fascia covering the posterior surface of the sternomastoid muscles. In this space lie the sternohyoid, sternothyroid, and omohyoid muscles. The pretracheal fascia is beneath them and the superficial layer of the deep fascia above. Pus can follow the posterior surface of these muscles down behind the sternum in front of the innominate veins and arch of the aorta.

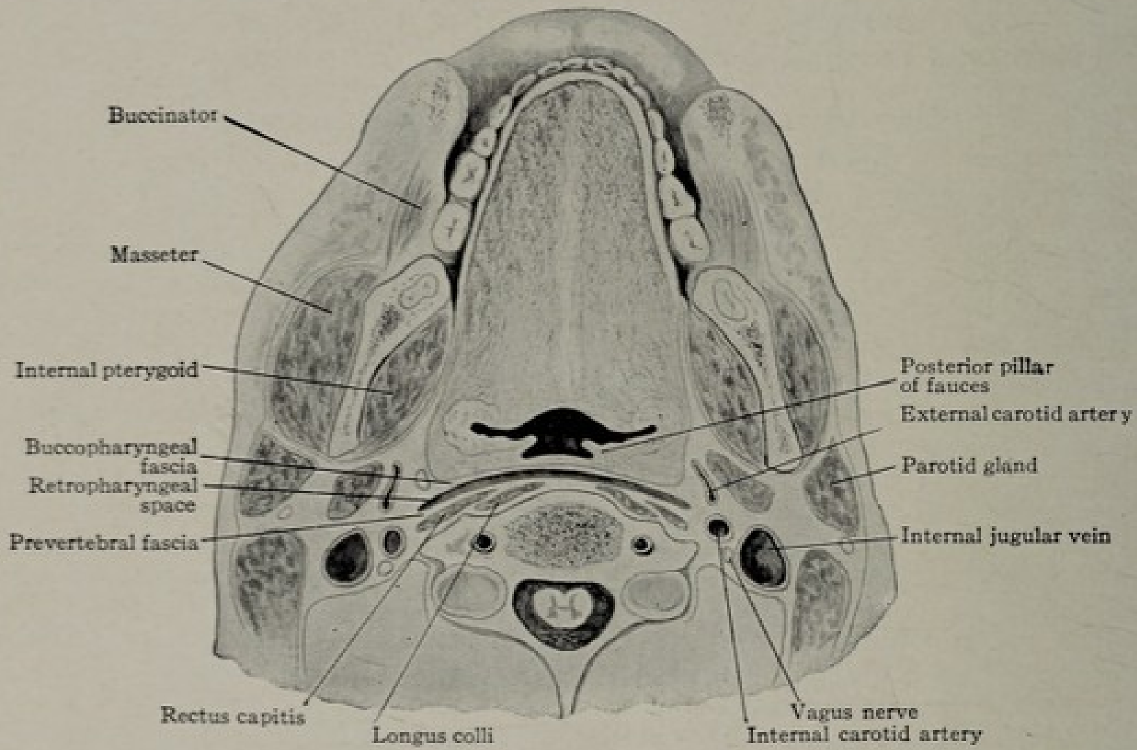


FIG. 193.—Section through the upper portion of the third cervical vertebra, showing the buccopharyngeal and prevertebral fascias and retropharyngeal space.

Pus between the pretracheal and prevertebral layers cannot go further to one side than the sheath of the vessels. Therefore it follows the trachea and œsophagus down into the posterior mediastinum. This space, between these layers, is sometimes called the *visceral space* because it contains the œsophagus, trachea, and thyroid gland. Pus in this space can also perforate into the trachea, pharynx, œsophagus, or even extend laterally and involve the great vessels.

If the anterior portion of the thyroid gland suppurates, the pus may perforate the thin pretracheal fascia covering it and pass down behind the sternohyoid and sternothyroid muscles into the anterior part of the superior mediastinum.

Pus posterior to the prevertebral fascia, as from caries of the vertebræ, if high up may bulge into the pharynx, forming a retropharyngeal abscess. It may follow the scaleni muscles and brachial plexus down around the axillary artery into the axilla. In the neck it shows itself posterior to the carotid arteries and to the *outer* edge of the sternomastoid muscles.

Pus in the sheath of the great vessels, when originating from lymphatic nodes, may first raise the sternomastoid muscle and show itself along its anterior border; it may perforate the lumen of the vessels; it may pass down with the vessels into the superior mediastinum; or it may bulge into the visceral space between the prevertebral and pretracheal layers and follow the trachea and œsophagus down into the chest. Should it tend outwardly it may break into the posterior cervical triangle between the prevertebral and superficial layers and show itself above the clavicle.

Retropharyngeal Abscess.—Pus which tends to point into the pharynx may come from disease of the vertebræ, in which case it is posterior to the prevertebral fascia; or it may originate from the lymphatic nodes in the retropharyngeal space.

When coming from caries of the vertebræ, it may point either in the pharynx or, pushing its way outward, pass behind the great vessels and show itself behind the outer edge of the sternomastoid muscle. I have seen it point in both these

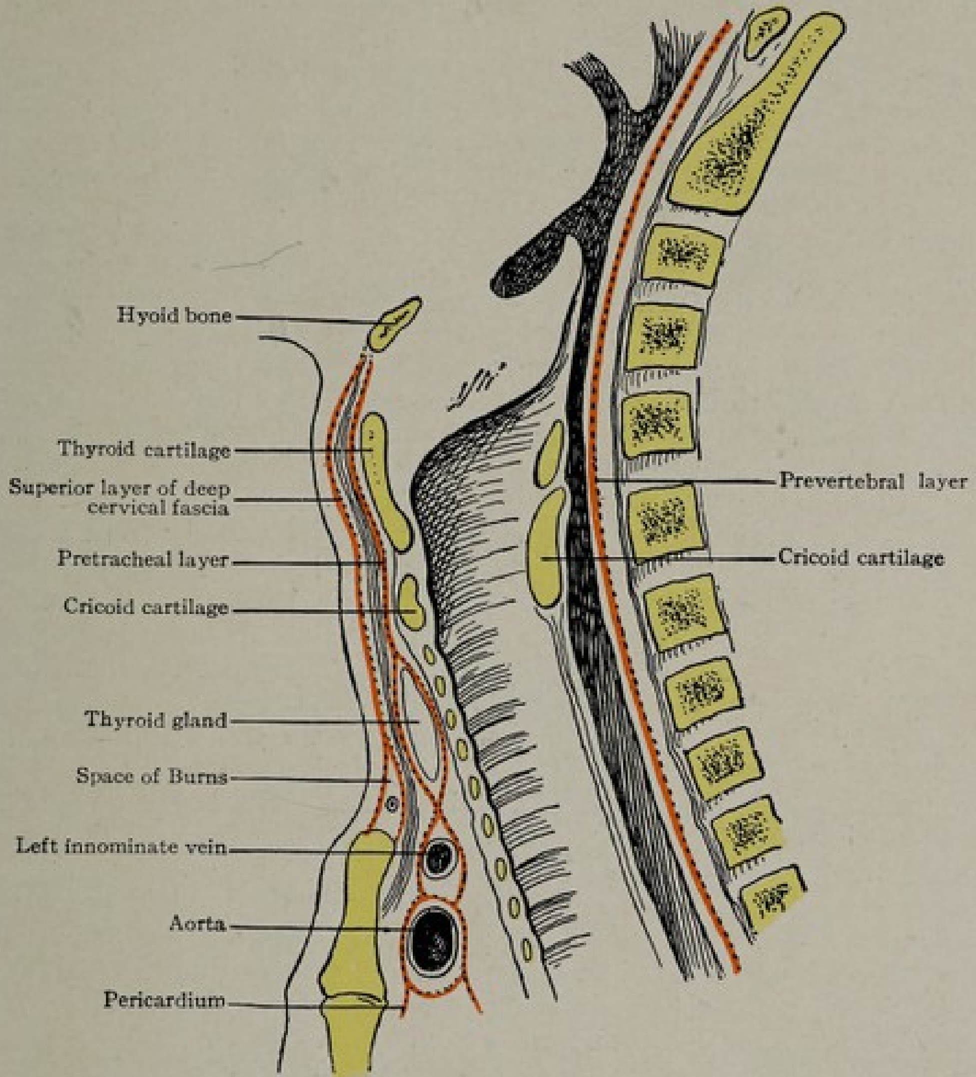


FIG. 194.—The superficial layer, pretracheal layer, and prevertebral layer of the deep cervical fascia.

places in the same case. When originating in the retropharyngeal space it lies in front of the prevertebral fascia and behind the buccopharyngeal fascia. It either points forward into the pharynx or, going down, follows the posterior surface of the œsophagus into the posterior mediastinum. It may also perforate the œsophagus and enter its lumen.

Pus in the Posterior Cervical Triangle.—If above the prevertebral layer this bulges directly forward and tends to open through the skin. Its progress downward is obstructed by the attachment of the superficial layer to the top of the clavicle as it blends with the prevertebral layer. If pus is beneath the prevertebral layer it may then follow the brachial plexus and subclavian artery down beneath the clavicle and appear in the axilla. The attachments of the costocoracoid membrane tend to direct the pus laterally under the pectoralis minor muscle into the axilla rather than to allow it to come forward on the anterior portion of the chest.

LYMPHATICS OF THE NECK

The lymphatics of the neck are both superficial and deep. The superficial nodes communicate freely with and end in the deep ones. For the sake of convenience we may divide them into a *transverse set*, embracing the *submental, submaxillary, superficial upper cervical* (behind the angle of the jaw), *posterior auricular,* and *occipital* nodes; and *two longitudinal sets,* one along the great vessels and another, a posterior set, in the posterior cervical triangle.

The Transverse Lymphatics.—The submental nodes, also called the suprahyoid, lie beneath the chin and drain the region of the lower lip and chin and anterior part of the floor of the mouth. These will be enlarged in children with ulcerative skin affections of these regions. They may also be involved in carcinoma of the lower lip, especially if near the median line. That the submental nodes drain the tissues of the anterior portion of the mouth and probably the tongue itself is shown by Butlin, who states that the submental nodes are frequently affected in carcinoma of the tongue when its tip is involved.

The *submaxillary nodes* are beneath the body of the mandible in the submaxillary triangle. They drain the lips, nose, floor of the mouth, gums, anterior portion of the tongue and side of the face. These are the nodes most frequently affected in carcinomatous affections of the lips and anterior portion of the tongue. Butlin calls attention to the fact that in malignant disease of one side of the anterior portion of the tongue the lymphatics of the opposite side may also be involved, thus showing that the lymphatics of the two sides of the tongue freely anastomose. The lymphatics may cross in the tongue as has been shown by injecting carmine particles in one part of the tongue and finding them later on the opposite side, but there is also an actual decussation of the lymphatic channels in the submental region whereby metastasis may occur on the side opposite to that of the lesion This is contrary to what exists as regards the arteries, which anastomose hardly at all across the median line. He also states that one or more of the lymphatic nodes is frequently imbedded in the substance of the submaxillary gland. Therefore the submaxillary gland is excised at the same time as the affected lymphatic nodes.

The *superficial upper cervical (subparotid) nodes* are just below the parotid lymphatics and behind the angle of the jaw. They drain the region embraced by the masseter muscle as far back as the ear. They may be enlarged in affections of the skin and scalp above. Therefore in children with enlargement of these nodes the source of infection should be sought in those regions.

The *posterior auricular nodes* are behind the ear on the mastoid process and insertion of the sternomastoid muscle. In practice they are encountered as small (1 cm.), round swellings behind the ear, which are usually quite tender to the touch. This is probably due to their being placed on a hard, bony base. When enlarged they are often the subject of operations.

The *superficial occipital nodes* are just below the superior curved line of the occiput or a little lower down in the hollow below the occiput between the posterior edge of the sternomastoid and anterior edge of the trapezius muscles, resting on the splenius. These are the nodes that are enlarged in syphilis and are to be searched for in endeavoring to establish a diagnosis.

Superficial and Deep Nodes.—The five sets of nodes just described, viz., the submental, submaxillary, superficial upper cervical, posterior auricular, and superficial occipital, are all regarded as superficial nodes. As a matter of fact this division of the lymphatic nodes into superficial and deep is not of practical value. The communication between the various nodes is quite free. Adjacent nodes communicate and the superficial nodes communicate with the deep ones below.

On account of this an affection is not always limited to a single node but often involves those to each side and those lying still deeper. In the submaxillary region the nodes will almost certainly be found to lie under the fascia along with the submaxillary gland. When the occipital nodes are enlarged they may not only be found in the space already described but also on the adjacent trapezius and sternomastoid muscle and even beneath the outer edge of the trapezius below the deep fascia.

The Longitudinal Lymphatics.—These are along the great vessels,—the anterior cervical lymphatics,—and in the posterior cervical triangle.

The *anterior cervical lymphatics* is the name given to those which tend to show in the anterior cervical triangle either beneath or in front of the sternomastoid muscle, between it and the median line. There are some nodes in the median line but they are almost all deep down in the neck above the sternum. The other nodes may be either superficial or deep, mostly deep, along the edge of the sternomastoid muscle. They follow the sheath of the vessels. This is a very extensive chain of

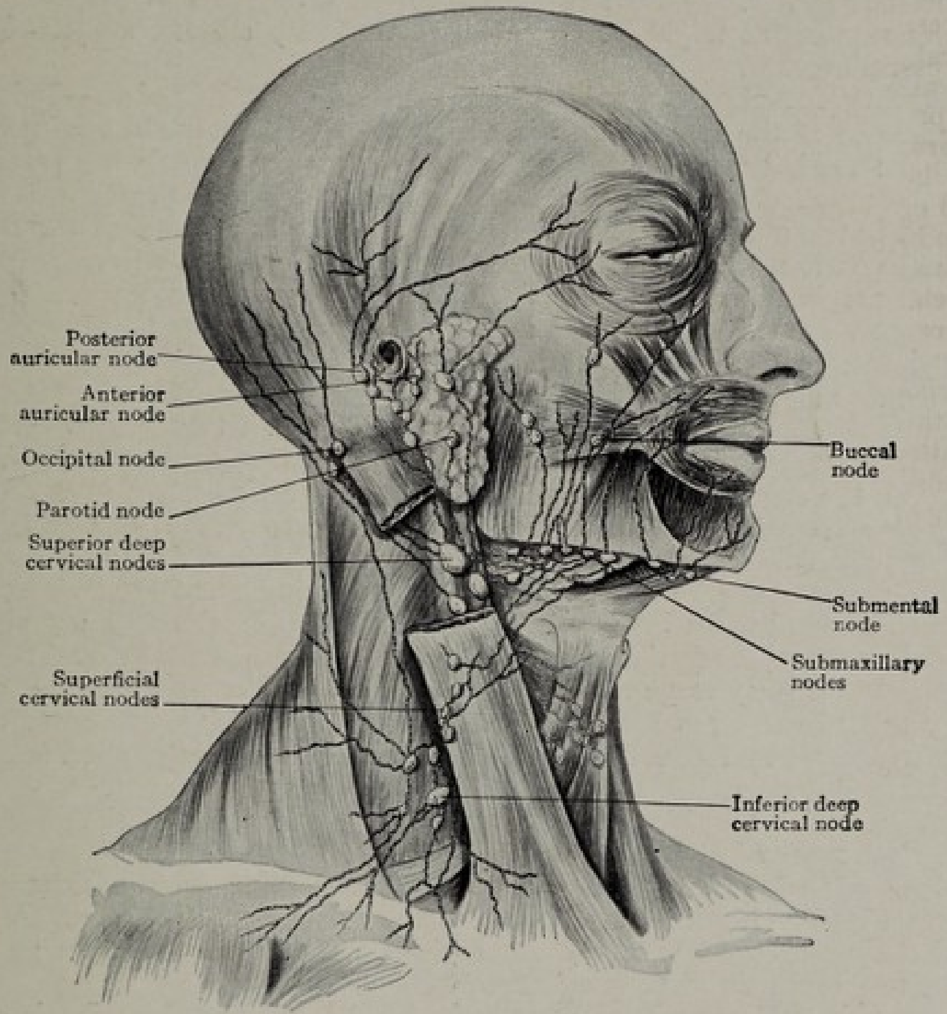


FIG. 195.—Superficial lymphatic vessels and nodes of head and neck: semidiagrammatic. (Piersol.)

nodes. They may extend in all directions. As regards depth they may be on the deep fascia along the edge of the sternomastoid or following the external jugular vein. If deeper they follow the internal jugular vein and carotid artery directly up to the base of the skull, also behind and below the mastoid process and alongside of the transverse process of the atlas (first cervical vertebra). They extend under the sternomastoid posteriorly, deep in the suboccipital region. Should they be enlarged downward they will protrude behind the posterior edge of the sternomastoid into the posterior cervical triangle; if anteriorly they will follow it down into the space of Burns in front of the trachea and thence into the superior mediastinum.

The *posterior cervical nodes* show behind the posterior edge of the sternomastoid, along the edge of the trapezius, and also above the clavicle. They not infrequently fill the posterior cervical triangle and extend beneath the muscles on each side.

Below they may be continuous with enlarged nodes in the axilla and extend anteriorly under the sternomastoid into the pretracheal region and mediastinum. They are frequently excised for both tuberculosis and carcinoma. In so doing particular care is to be taken on account of the transversalis colli and suprascapular arteries and veins, with which they may lie in contact, as well as the terminal portion of the external jugular.

Postpharyngeal Nodes.—In the retropharyngeal space, toward the sides, between the buccopharyngeal fascia in front and the prevertebral fascia behind are located one or two nodes (see buccopharyngeal fascia, page 175, and retropharyngeal abscess, page 177). They seem to be the starting point, sometimes, of retropharyngeal abscess. They do not appear to get enlarged and project into the pharynx as tumors, as might be expected, so that they are not subjected to any surgical procedures.

Operating for the Removal of Enlarged Cervical Nodes.—This operation may be one of the most serious in surgery. Sir Frederick Treves says: "An operation of this kind should not be undertaken unless the surgeon has perfect confidence in his practical knowledge of the anatomy of the neck. Scarcely an instance can be cited in the range of operative surgery where a knowledge of the structure and of relations is more essential than in these excisions." The main difficulties encountered are in the avoidance of nerves and the control of hemorrhage. Air may enter the veins and cause death, and the thoracic duct may be wounded. The latter accident sometimes results fatally. The difficulty of the operation will depend on the size and number of the nodes, their location, and the character of the inflammation or other changes they have undergone. In tuberculous disease the glands most commonly involved are those opposite the angle of the jaw just in front of or beneath the sternomastoid muscle and receiving the drainage from the tonsil. They are also frequently seen in the posterior triangle and in extensive disease large masses are palpable along the trapezius muscle. From the surgical point of view one must remember that when one gland is visibly enlarged many deeper glands will be found to be involved. Gland dissections of the neck are also done for chronic non-specific adenitis, Hodgkin's disease, lymphosarcoma and metastatic carcinoma. In an early stage the nodes may be lying loose in the tissues and can be readily turned out when once exposed. Later they may be matted to the surrounding structures by inflammatory deposits and then their separation is a matter of difficulty and danger.

The direction of the skin incision depends upon the nature of the disease to be attacked. For tuberculosis the transverse incision is best and has been popularized by Dowd; in extensive disease it is better to make two transverse incisions if necessary than a long longitudinal one because of the better cosmetic effect. A natural crease of the neck should be used. In the so-called "block" dissection for cancer the incision of Morestin gives good exposure.

As the skin and superficial structures are cut and the deep fascia opened, the superficial veins will be cut, hence the first anatomical fact to be borne in mind is the probable location of the veins. The most important of these is the external jugular. The internal jugular below the hyoid bone lies under the sternomastoid muscle and therefore is protected until the deeper dissection is begun. The external jugular runs about in a line from the angle of the jaw to the middle of the posterior edge of the sternomastoid muscle and thence downward to about the middle of the clavicle. Therefore an incision along the posterior edge of the sternomastoid will divide it at about the middle of the muscle, and the surgeon should be prepared to guard against an undue loss of blood when it is cut. Opening into the external jugular posteriorly between the middle of the sternomastoid muscle and the clavicle below are the posterior jugular, the transverse cervical, and the suprascapular veins. These latter open into the external jugular 1 or 2 cm. above the clavicle and are almost certain to be cut in operations in the supraclavicular fossa. An incision along the anterior edge of the sternomastoid low down will cut the anterior jugular vein a short distance above the sternum as it winds beneath the sternomastoid to empty into the external jugular. An incision along the anterior border of the sternomastoid from its middle up is bound to cause free hemorrhage. The external jugular behind the angle of the jaw communicates with the facial, which empties into the internal jugular; hence division of the external jugular at this point also drains the blood almost directly from the internal jugular. A carelessly deep incision may wound the internal jugular itself in the region posterior to the hyoid bone. The internal jugular is more superficial at this point than it is lower down. The temporomaxillary and posterior auricular veins will also be cut behind the ramus of the jaw.

Not only are veins cut but also nerves. The middle of the posterior edge of the sternomastoid is the point of departure of several nerves. The superficial cervical runs directly transversely inward toward the thyroid cartilage. The auricularis magnus goes up to the lobe of the ear, and the occipitalis minor follows the posterior edge of the muscle up to the occiput. These three nerves are nerves of sensation and if they are divided only a certain amount of temporary anæsthesia will be produced over the parts they supply, hence their division is not a matter of much moment. The auricularis magnus is the largest of the three. The descending branches of the cervical plexus, which leave the posterior edge of the sternomastoid muscle immediately below the nerves just mentioned, proceed down under the deep fascia and will be seen only in a deeper dissection. The nerve which it is absolutely important to avoid is the spinal accessory. This enters the sternomastoid muscle on its under surface some little distance back of its anterior edge and 3 to 5 cm. below the mastoid process. It sends a branch to the muscle and leaves its posterior edge about its middle. It then passes downward and outward across the posterior cervical triangle under the deep fascia to enter the deep surface of the trapezius. If this nerve is divided, paralysis of the trapezius will certainly follow and as it is a motor nerve the shoulder of that side will drop considerably. This will be a permanent deformity because motor nerves do not seem to have their functions restored by time as so usually occurs when the nerves of sensation are divided.

If the nodes to be removed are superficial ones there are no other structures to be feared and the operation will be an easy one. If they lie deeper, then the sheath of the sternomastoid muscle is to be divided and the muscle pulled outward. Just above the level of the cricoid cartilage a small artery, the sternomastoid branch of the superior thyroid, enters the muscle and it will be divided. As the sternomastoid is raised and pulled outward care must be taken to avoid wounding the spinal accessory nerve. As this nerve enters the muscle from 3 to 5 cm. below the mastoid process and some distance back from the edge of the muscle, if it is necessary to divide the muscle it is best done high up above the entrance of the nerve, or low down. By so doing the nerve supply (from the spinal accessory) and blood supply are not interfered with and the function of the muscle is not so much impaired as it would be if divided near the middle. The nodes not only possess their own capsule but also a covering from the connective tissue in which they lie. Therefore to remove them they must be detached and separated from it usually by blunt dissection. When these strands of fibrous tissue from the nodes to the surrounding parts are strong they have to be caught with forceps and cut. They are to be clamped, to avoid possible bleeding. When the angle of the jaw is reached the communicating branch between the facial and external jugular veins must be clamped and cut. The parotid gland is to be pulled upward and inward. The nodes may stick to the jugular vein and carotid artery. The vein is on the outside and is likely to be the first encountered. When distended it overlies the artery. If collapsed its presence may not be suspected. Feel for the pulsation of the carotid artery and avoid the structure just to its outer side. The jugular vein may be so involved in the mass as to necessitate its removal. In such a case remember that posteriorly between it and the carotid artery is the pneumogastric nerve.

The sympathetic nerve lies deeper in the fascia toward its posterior surface and is not so likely to be wounded. Its superior cervical ganglion lies opposite the second and third vertebræ. Working still higher, the transverse process of the atlas or first cervical vertebra will be felt and seen below and to the inner side of the mastoid process. The connective tissue adherent to the nodes is attached to this transverse process and may have to be cut loose or scraped away. In doing so keep to the outer edge because the jugular vein and internal carotid artery lie on its anterior surface.

Beneath the sternomastoid runs the anterior scalene muscle and on it, coming from the third, fourth, and fifth cervical nerves, is the phrenic nerve; so that it is not permitted to dig into and disturb the muscular mass to the outer side of the common carotid artery on which these nodes frequently lie.

In operating *in the submental region* there is nothing to fear. The space between the two anterior bellies of the digastric muscles on the sides, the hyoid bone below, and down to the anterior surface of the mylohyoid muscle beneath, can be cleared out with impunity.

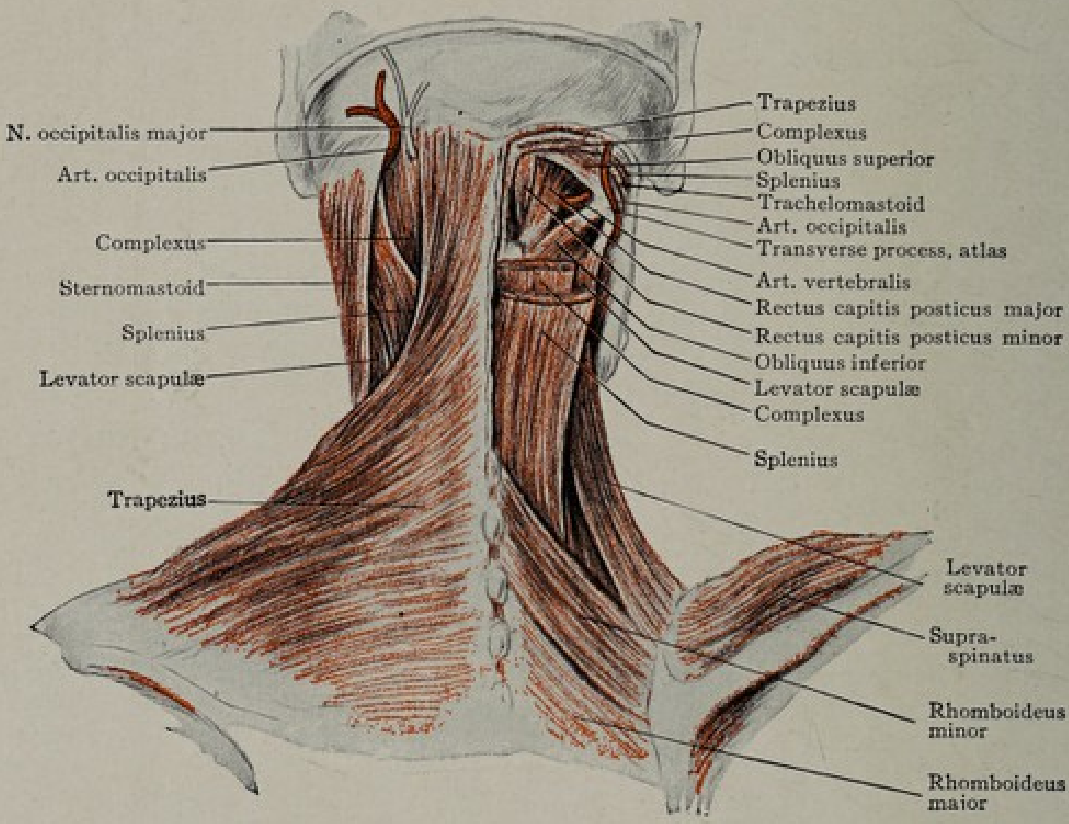


Fig. 196.—Superficial and deep structures of the back of the neck, showing the sub-occipital triangle, formed by the rectus capitis posticus major, obliquus superior and obliquus inferior: the suboccipital nerve emerges from just beneath the art. vertebralis.

In the submaxillary region remember that the fascia covering the submaxillary gland is thin, so that the gland will probably be exposed as soon as the superficial structures are raised. As the facial (ext. maxillary) artery and vein cross the mandible just in front of the masseter muscle, the vein is posterior. The artery goes under the gland and is adherent to it, so that as the gland is raised the artery is brought up also. The facial and lingual veins usually empty into the internal jugular, but, as shown in Fig. 168, they may receive a communicating branch from the external jugular and the anterior jugular and continue down as the anterior jugular to empty into the external jugular low down in the neck, below the sternomastoid muscle. The hypoglossal nerve will be seen lying on the hyoglossus muscle, but it is readily avoided. The lingual artery is beneath the hyoglossus muscle anteriorly but both it and the facial must be looked for as one nears the posterior belly of the digastric.

In the lower cervical region, opposite the cricoid cartilage, the omohyoid muscle will be met. It will sometimes be necessary to divide it. The sternohyoid and sternothyroid muscles and the thyroid gland are to be drawn inward and the sternomastoid outward. One should always keep away from the thyroid gland, as the recurrent laryngeal nerve runs behind it and on the œsophagus near the trachea. Cutting it will probably cause a permanent alteration in the voice. If the internal jugular vein has been removed, as it may be on one side, but not on both, beneath it one is liable to encounter the inferior thyroid artery below Chassaignac's tubercle on the sixth cervical vertebra, and further out the phrenic nerve on the scalenus anticus muscle, and lower down the transverse cervical and suprascapular arteries. The inferior thyroid veins usually run downward to empty into the innominate veins, but the lower portion of the anterior jugular vein and the middle thyroid veins will probably have to be ligated. The course of the various veins is quite irregular and large venous branches may be encountered at any place.

In the posterior cervical triangle the spinal accessory nerve must be avoided as it runs down and back from the middle of the posterior edge of the sternomastoid muscle. The external jugular, posterior jugular, transverse cervical, and suprascapular veins may all require ligation. Beneath the deep fascia (superficial layer) are the descending or supraclavicular branches of the cervical plexus from the third and fourth cervical nerves. Care should be taken not to mistake them for the spinal accessory nerve. If the nerve has been divided it should be sutured together again at the completion of the operation. It is hardly necessary to caution against wounding the subclavian vein; it is in front of the anterior scalene muscle. The artery is behind the muscle. Do not dig under it. It rests on the pleura, a wound or tear of which may mean a septic pleurisy and death. In the angle formed by the junction of the internal jugular vein and subclavian on the left side is the *thoracic duct.* If wounded death may ensue through persistent leakage of lymph, but not infrequently healing eventually occurs. Wounding of the corresponding lymphatic duct on the right side is not considered so serious, the chyle being carried by the left duct. The cords of the brachial plexus run down and across the posterior cervical triangle above the subclavian artery, but a little care will enable one to avoid them. This is one of the regions of the body in which exact surgery is essential.

Cervical Sympathetic.—The frequency with which the cervical sympathetic is exposed necessitates its inclusion in this text. It has been sectioned or wholly or partially excised for epilepsy, exophthalmic goiter, and more recently for angina pectoris, bronchial asthma and essential hypertension and Raynaud's disease. For much of the early work we are indebted to Jonnesco.

The cervical portion of the sympathetic trunk comes from the upper portion of the thoracico-lumbar outflow. There are, therefore, no white rami communicantes which connect it directly with the spinal cord. The cervical portion of the spinal cord may indirectly add fibres through the spinal accessory nerve and the various vagus connections. Gray rami are sent to each of the nerves of brachial plexus. The trunk extends from the subclavian artery to the base of the skull and lies posterior to the sheath of the great vessels and anterior to the longus capitis and longus colli muscles. The latter separate the trunk from the transverse processes of the cervical vertebræ. It usually has three ganglia, one at each end and one somewhat variable in position and occasionally absent.

The inferior cervical ganglion lies at the root of the neck posterior to the vertebral artery or the first portion of the subclavian and anterior to the space between the transverse processes of the last cervical and the first thoracic vertebræ. Its major branches, from the surgical standpoint, are those to the inferior thyroid plexus, and the inferior cardiac nerve.

The middle ganglion is small and at times absent. Its position is variable, but usually it lies about the level of the cricoid cartilage, just in front of the bend of the inferior thyroid artery. This ganglion when present gives off the middle cardiac nerve, which on the left side courses downward between the subclavian and the common carotid arteries and on the right side it passes downward posterior to the common carotid and anterior or posterior to the subclavian and then along the innominate to the deep cardiac plexus. This branch communicates on both sides with the inferior (recurrent) laryngeal and the external laryngeal nerves.

The superior ganglion is fusiform and must not be confused with the ganglion nodosum of the vagus which also lies near the base of the skull, but in front of the upper part of the internal jugular vein. The superior ganglion is frequently as long as one and one-half inches (2.5 to 3.7 cm.) and lies dorsal to the upper part of the sheath of the great vessels and in front of the transverse processes of the second and third cervical vertebræ. Occasionally the ganglion is split and a ventral portion lies superficial to the carotid sheath. Amongst many branches it gives off the superior cardiac nerve which passes downward and makes connections with the upper cervical cardiac branch of the vagus, the middle cervical cardiac, and the inferior (recurrent) and external laryngeal nerves. On the right side the superior cardiac branch terminates in the deep part of the cardiac plexus while on the left side its destination is the superficial part of the cardiac plexus. The ganglion also gives branches to the superior thyroid plexus.

The incision for exposure may be made anterior or posterior to the sternomastoid muscle. The anterior incision is satisfactory when it is intended only to excise the upper part of the trunk and the superior ganglion. The upper end of the incision must be carried well up to a level at the angle of the jaw with the head extended. The spinal accessory nerve must be recognized and carried outwards with the sternomastoid muscle. The vessels in the sheath are drawn mediad and the longus colli et capitis muscle exposed; on its anterior surface will be found the sympathetic. The posterior incision is necessary if the entire nerve is to be removed. In order to avoid severing the superficial cervical nerves it is better to split the sternomastoid muscle lengthwise a short distance from its posterior border. The posterior sheath is similarly incised and the neuro vascular bundle and sternomastoid muscle retracted inward and upward. The sympathetic will be found on the vertebral plane hidden in its own sheath, a part of the deep aponeurosis of the neck. The operator must not confuse the phrenic, vagus, or a branch of the hypoglossal for the sympathetic. If in doubt the fusiform superior ganglion should be sought as a guide. Jonnesco also advises seeking the anterior process of the sixth cervical vertebra at the level of which the sympathetic is in front or behind the inferior thyroid artery and closely related to it.

The trunk adjacent to and the middle ganglion or the nerve tissue representing it must be separated from the inferior thyroid artery. The inferior ganglion and the first thoracic ganglion are closely related and are deeply placed in the "scaleno-pleuro-vertebral space" (Jonnesco, 1923) close to many large blood vessels especially the superior intercostal artery, vertebral artery and vein, cervical artery and posterior jugular vein. An intermediary ganglion is often present and makes isolation of the vertebral artery most difficult. If complete removal is attempted the anatomy of this area must be thoroughly known and the trunk, severed above, used as the guide.

OPERATIONS ON THE AIR-PASSAGES

The pharynx may be opened just above or just below the hyoid bone,—*suprahyoid and infrahyoid pharyngotomy.* The larynx may be opened in the median line,—*thyrotomy.* The cricothyroid membrane may be opened,—*laryngotomy.* The trachea may be opened,—*tracheotomy.*

Suprahyoid Pharyngotomy.—Jeremitsch and Von Hacker have suggested suprahyoid pharyngotomy for the exposure and removal of new growths situated in the lower pharynx, pyriform sinuses and upper portion of the larnyx. The incision is made just above the hyoid bone. The operation gives an excellent exposure and obviates the danger of injury to the epiglottis and the superior laryngeal nerves. In both this and the succeeding operation tracheotomy had best be performed as a preliminary measure.

Infrahyoid pharyngotomy is the entering of the pharynx by means of an incision below the hyoid bone. It may be performed for the removal of tumors or for strictures. The incision may be made just below the hyoid bone and parallel to its border. This will divide the commencement of the anterior jugular vein, perhaps near the median line, perhaps toward the side. The vessels are clamped and the sternohyoid and thyrohyoid muscles are sectioned, exposing the thyroid hyoid membrane. This membrane is incised horizontally, care being taken to keep close to the hyoid bone so as to avoid injuring the superior laryngeal vessels and nerves which pierce the membrane on either side.

The thyrohyoid membrane being incised, access is obtained to the fatty tissue at the base of the epiglottis. If the incision is carried directly backward the epiglottis will be cut through at its base. If, however, it is kept close to the hyoid bone and made upward, the pharynx will be entered in front of the epiglottis and at the root of the tongue. If the incision is carried too far toward the sides the superior thyroid artery and even the external carotid itself will be cut. Attention has already been called to the thyrohyoid branch.

Thyrotomy (Laryngofissure. Thyrochondrotomy) is the division of the thyroid cartilage to afford access to malignant endolaryngeal growths. The soft part incision should be exactly in the median line to avoid wounding the anterior jugular veins, and should extend from the thyroid notch nearly to the suprasternal notch. The isthmus of the thyroid gland may need to be divided. If the growth as previously seen by laryngoscopy is limited to one cord the cartilage and mucosa may be divided in the median line but if the growth involves the anterior commissure such an incision would cut through the growth. The excision should be planned with the growth as the center of a normal margin with the bottom the internal perichondrium of the thyroid cartilage. The operation is too complicated to describe in this book and the descriptions of such authorities as Chevalier Jackson should be consulted.

Laryngotomy is the opening of the cricothyroid membrane. It is rarely done, but it is of service in cases of choking from obstruction of the larynx by foreign bodies. It is the easiest and quickest way to enter the air-passages. Both the thyroid and cricoid cartilages in the median line are practically subcutaneous. A longitudinal incision of the skin is usually advised, after which a transverse incision is employed for opening the cricothyroid membrane. The cricothyroid artery, running across the membrane, is usually too insignificant to cause any trouble; it is nearer the thyroid cartilage, therefore the cut through the membrane should be close to the cricoid cartilage. This operation should never be used when only tracheotomy is desired. Resulting adhesions limit motion of the vocal cords and impair speech.

Tracheotomy is the opening of the trachea. There are two varieties, the high and the low, according as the tube is inserted above or below the isthmus of the thyroid gland. When in the adult male the neck is in line with the axis of the body the lower border of the cricoid cartilage is about 4 cm. (1½ in.) above the sternum. When the head is tilted far back the larynx is drawn upward and the lower border of the cricoid is 6 cm. (about 2½ in.) above the sternum. Hence in doing a tracheotomy the head is to be tilted far back. The total length of the trachea is 10 to 12 cm. (Morris, Hensman), beginning opposite the sixth cervical vertebra,—upper border in the child and lower in adults,—and ending opposite the fifth dorsal. About half of it is above and half below the top of the sternum. It is composed of 14 to 20 rings. In the adult the isthmus of the thyroid gland covers the second, third, and fourth rings. There are about eight rings above the sternum.

According to Symington and Guersant (Treves) the diameter of the trachea is about as follows:

1½ to 2 years	5 mm.
2 to 4 years	6 mm.
4 to 8 years	8 mm.
8 to 12 years	10 mm.
12 to 15 years	12 mm.
Adults	12-15 mm.

A knowledge of the size of the trachea is necessary in order to select a tracheotomy tube of a size suitable to the particular case. The liability is to select too large a tube for young children, particularly infants. If this is done it may be very difficult to introduce the tube, or the trachea may even be torn in the attempt. In operating, an incision, 2.5 to 3 cm. long is to be made in the median line. This may cut the anterior jugular vein. If carried near to the sternum it will certainly divide the communicating branch between the anterior jugulars at that point. The top of the incision in a child will be over the cricoid cartilage, and as soon as the skin has been divided the finger is to be inserted and the cricoid cartilage felt and recognized. This will show how deep the trachea lies. In very young children the isthmus of the thyroid gland is liable to come up to the cricoid cartilage and the difficulty of displacing it far enough down to allow the tube to be inserted is such that it may be best to divide it. Therefore after the skin and deep fascia have been divided and the cricoid recognized by the finger the soft tissues covering the trachea immediately below the cricoid are grasped on each side with a hæmostatic forceps and divided between them. These tissues may embrace the isthmus of the thyroid gland, the edges of the sternohyoid muscles, some veins, branches from the superior and inferior thyroids, and the fascia covering the gland and overlying the trachea.

The trachea should be cleared before opening it. A sharp hook is inserted into the cricoid cartilage to steady it and an incision is made into the trachea from below

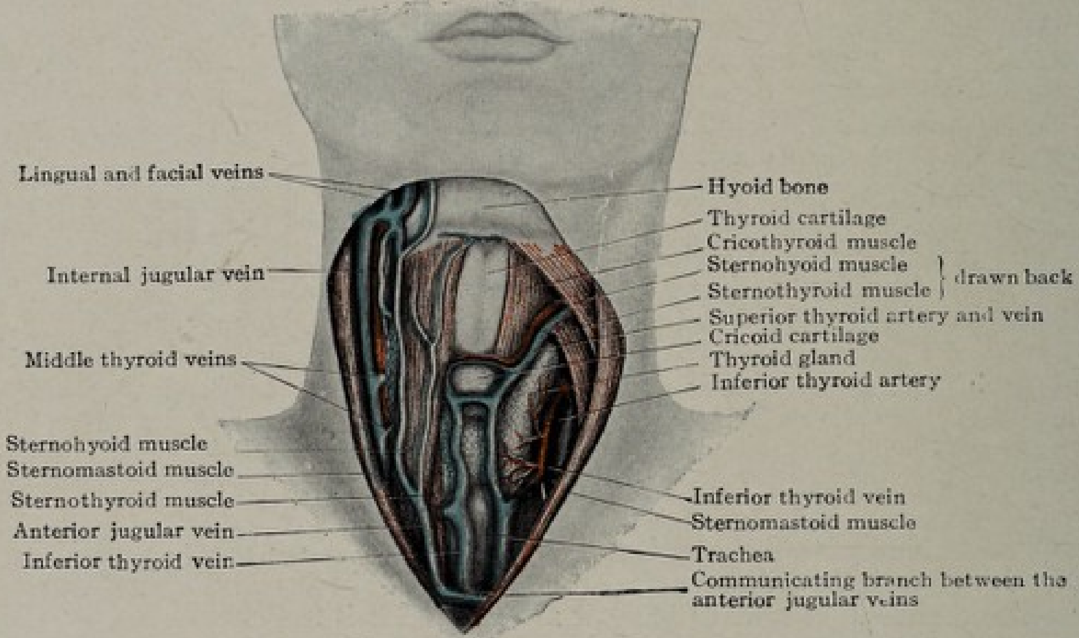


Fig. 197.—Dissection showing the parts involved in operations on the thyroid gland and air-passages.

upward. In making this incision the utmost care must be taken not to cut through the trachea and wound the œsophagus behind. The trachea of a child is not the hard resisting structure of the adult. It is a soft tender tube easily compressed and readily torn by roughness, or punctured with a knife. Forceps do not readily hold in it and stitches through it are liable to tear out. Only the very tip of the point of the knife should be allowed to enter the tube. The utmost care must be taken to keep in the median line. This is to be accomplished by using the cricoid cartilage as a guide and by seeing that the position of the head is straight. Cutting to either side of the trachea will cause wounding of the common carotid arteries. Below the isthmus of the thyroid gland and running down on the trachea are the inferior thyroid veins. The superior and middle thyroid veins empty into the internal jugular vein, but the inferior thyroids go downward to empty into the innominate. These veins will be cut if a low tracheotomy is done. In the infant the innominate artery and sometimes, though rarely, the left carotid encroach on the suprasternal notch and may be wounded if the incision is carried too low. The left innominate vein as it crosses to the right side is liable, especially in very young children, to show quite plainly above the sternum and would certainly be cut if the deep incision was carried as far down as the top of the sternum. An anomalous artery, the thyroidea ima, a branch of the innominate, sometimes passes upward on the trachea. On account of the presence of all these vessels it is not allowable to do any cutting of the deep parts just above the sternum; they are simply to be depressed by blunt dissection and kept out of the way with retractors while the trachea is being incised. The cricoid cartilage is never to be incised. It is far more firm and resistant than the trachea and it serves to keep the trachea from collapsing. The proximity of the tracheotomy tube to the vocal cords result in interference with their function.

Low tracheotomy is preferable in many cases, particularly as a preliminary procedure in operations on the larynx. The incision is made from the thyroid notch to just above the suprasternal notch. The muscles are separated and the isthmus of the thyroid gland displaced upwards or even divided. The corrugated surface of the trachea can then be felt. The incision in the trachea can then be made through the fourth or fifth rings.

THE THYROID GLAND

The operations which are done on the thyroid gland are ligation of its arterial supply and partial or complete removal. These necessitate a knowledge particularly of its blood supply and structure.

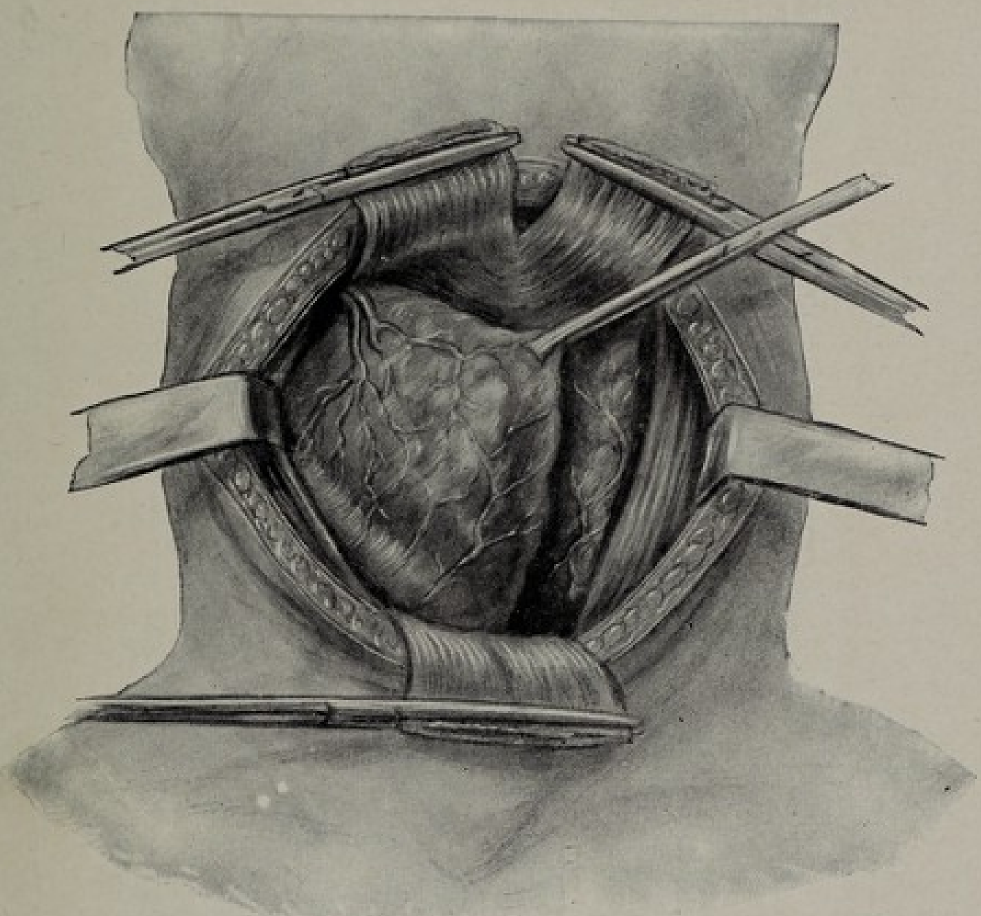


FIG. 198.—Exposure of the thyroid gland.

The *thyroid gland* consists of an *isthmus* and two lateral lobes. The isthmus crosses the second, third, and fourth tracheal rings in the adult. In children it may approach nearer to the cricoid cartilage.

The *lateral lobes* lie under the sternohyoid and the sternothyroid muscles. They rise as high as the oblique line on the sides of the thyroid cartilages which marks the insertion of the sternothyroid muscles. The lobes descend to the level of the sixth ring of the trachea, which is two rings below the isthmus, about two centimetres above the sternum. The inferior constrictor of the pharynx is beneath the gland. The thyroid gland is covered by the *pretracheal fascia* and possesses a *capsule* of its own besides. This fascia envelops the gland and its capsule, and from its posterior surface is prolonged down on the trachea and envelops the vessels coming to and leaving the gland. Therefore we might say that the inferior thyroid veins are *in* the pretracheal fascia.

As the fascia leaves the gland at the sides one portion of it blends with and helps to form the sheath of the vessels. The other or deeper portion continues around the pharynx and œsophagus, forming the buccopharyngeal fascia. In freeing

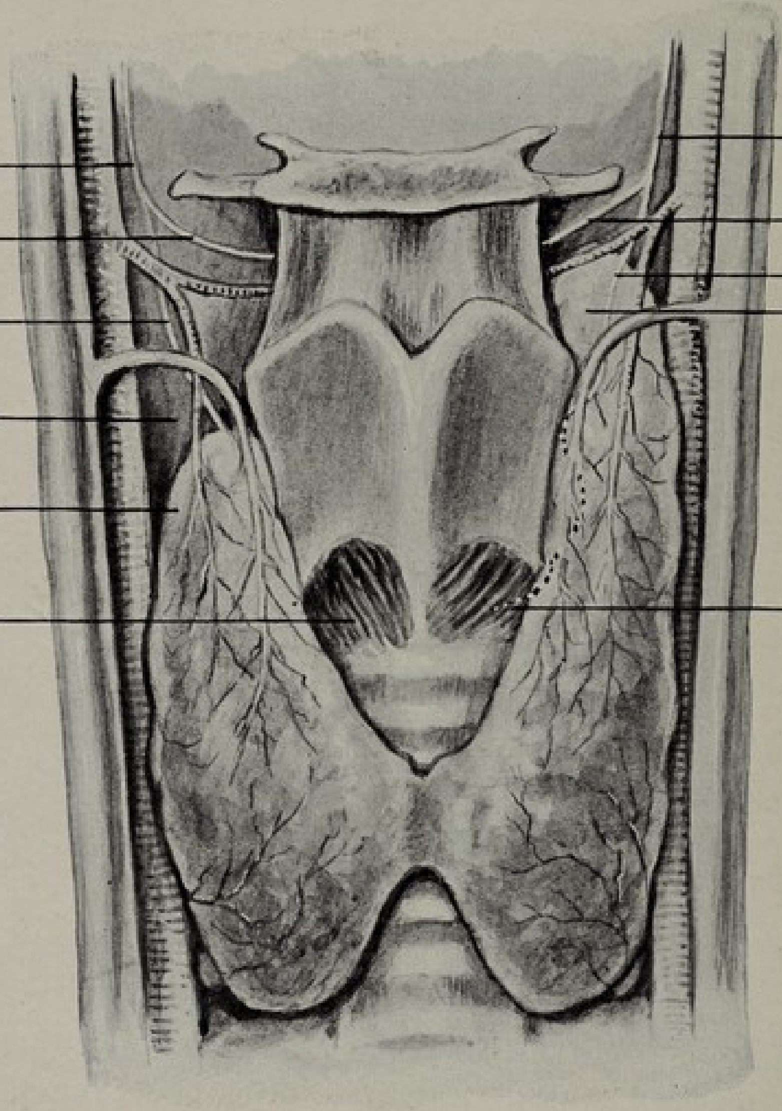


FIG. 199.—Relation of superior laryngeal nerve to poles of thyroid and to the vessels.

the gland and its capsule from the overlying pretracheal fascia care must be taken, not to be led by this fascia too far posteriorly and therefore wound, as has been done, the pharynx or trachea, or recurrent laryngeal nerves.

The *arteries* of the thyroid gland are the superior and inferior thyroids and sometimes the thyroidea ima. The *superior thyroid* comes off the external carotid just above the bifurcation. It rises almost to the greater horn of the hyoid bone and then descends to the thyroid gland, which reaches to the level of the oblique line on the thyroid cartilage; it supplies the upper portion of the gland, particularly the anterior portion, but also sends a branch down the posterior surface. The vessels crossing the median line, contrary to what is often the case in the arteries of the lip and even the scalp, are very small. *Ligation of the Superior Thyroid artery* is practised as a preliminary stage in the complete operation for toxic goitre or to control the vessel's supply in the operation of lobectomy. The ligation should be done close to the pole and yet sufficiently far out to include the branch to the posterior surface of the gland. The vessels should be cut between ligatures to insure division of the sympathetic nerves which accompany the artery. The *inferior thyroid* artery, a branch of the thyroid axis, crosses behind the common carotid artery about the level of the seventh cervical vertebra, about on a line with the lower edge of the isthmus. It enters the gland from the side and not from below and ramifies on its posterior surface often as a single large trunk beneath the capsule giving off branches to the parenchyma. Usually it is in front of the recurrent laryngeal nerve, but the middle cervical ganglion of the sympathetic lies on it. Sometimes the artery breaks into branches before it enters the gland. In such cases the recurrent laryngeal nerve may run between these branches and so be injured in removing the gland. *Ligation of the inferior artery* is rather difficult. It is exposed by an incision about 3 cm. above the clavicle with medial retraction of the sternomastoid muscle. The lower pole of the gland is sought and this also is retracted medial and the carotid laterally. The artery is then located at the medial margin of the scalenus anticus. The jugular vein and phrenic nerve must be avoided. The recurrent laryngeal nerve is behind the artery. The ligation should be done quite close to the gland to avoid the branch of the parathyroids.

The *thyroidea ima* artery when present enters the gland from below, coming up on the trachea usually from the innominate, in which case the innominate is apt to come off more to the left side and so bring the common carotid closer to the trachea than usual. It may also spring from the aorta or from the right carotid artery.

The veins are in three sets, a superior, a middle, and an inferior thyroid, and, as Kocher has pointed out, an accessory thyroid between the middle and inferior ones. The veins ramify under the capsule and form a plexus, which in goitre is much enlarged and communicates freely across the median line at the upper and lower portions of the isthmus. The *superior* and *middle thyroids* pass outward to empty into the internal jugular. Still lower is the *accessory inferior thyroid*, which may empty into the internal jugular, as do the two above it, or it may pass down, as does the inferior thyroid vein, and empty into the innominate. The *inferior thyroid vein* does not follow the artery of the same name but with its fellow of the opposite side passes directly downward in front of the trachea to empty into the innominate vein. Its importance in operations on the trachea has already been alluded to in speaking of tracheotomy. When a goitre dips behind the sternum the presence of the left innominate vein should not be forgotten.

Thyroidectomy is practised for the various forms of goitre. Exposure is often difficult unless the sternohyoid and sternothyroid muscles are divided. The gland should not be dragged or rolled out hastily because this endangers the thin-walled lateral veins. The connective tissue covering of the larynx or trachea should not be dissected off, because this leads to tracheitis. After the arteries are ligated the gland should be taken from the side of the trachea in such a way as to leave, from pole to pole, the intact posterior capsule and a thin shell of thyroid tissue. This insures the safety of the recurrent laryngeal nerve and the parathyroids.

THE PARATHYROID BODIES

The parathyroid bodies are usually four in number, but rarely there may be five or six. They are 6 to 7 mm. long, 3 to 4 mm. broad, and 1.5 to 2 mm. thick. The most constant site of the superior parathyroid is at the middle or junction of the upper and middle thirds of the posterior edge of the thyroid gland opposite the cricoid cartilage. The lower parathyroid is near the lower pole, but may be below it. They are small yellowish-brown bodies in the meshes of the loose connective tissue forming the outer of the gland. Often they are quite distinct from the gland being separated from it by the posterior portion of the thyroid capsule, but sometimes they lie in a cleft in the gland and thereby escape recognition. They possess a separate capsule. They are not only distinct from the thyroid anatomically but they differ from it embryologically since they arise from the third and fourth pharyngeal pouches. The surest means of locating these bodies is by following the small parathyroid arteries to each one of which a parathyroid body is attached. The blood supply is from the inferior thyroid. This latter usually gives off two parathyroid arteries, one to each body. Ginsburg (1908) has demonstrated a free anastomosis with the vessels of the opposite side. Although because of variations in position they are extremely liable to injury they may be avoided by keeping anterior to the posterior capsule and their blood supply is best preserved by ligating the inferior

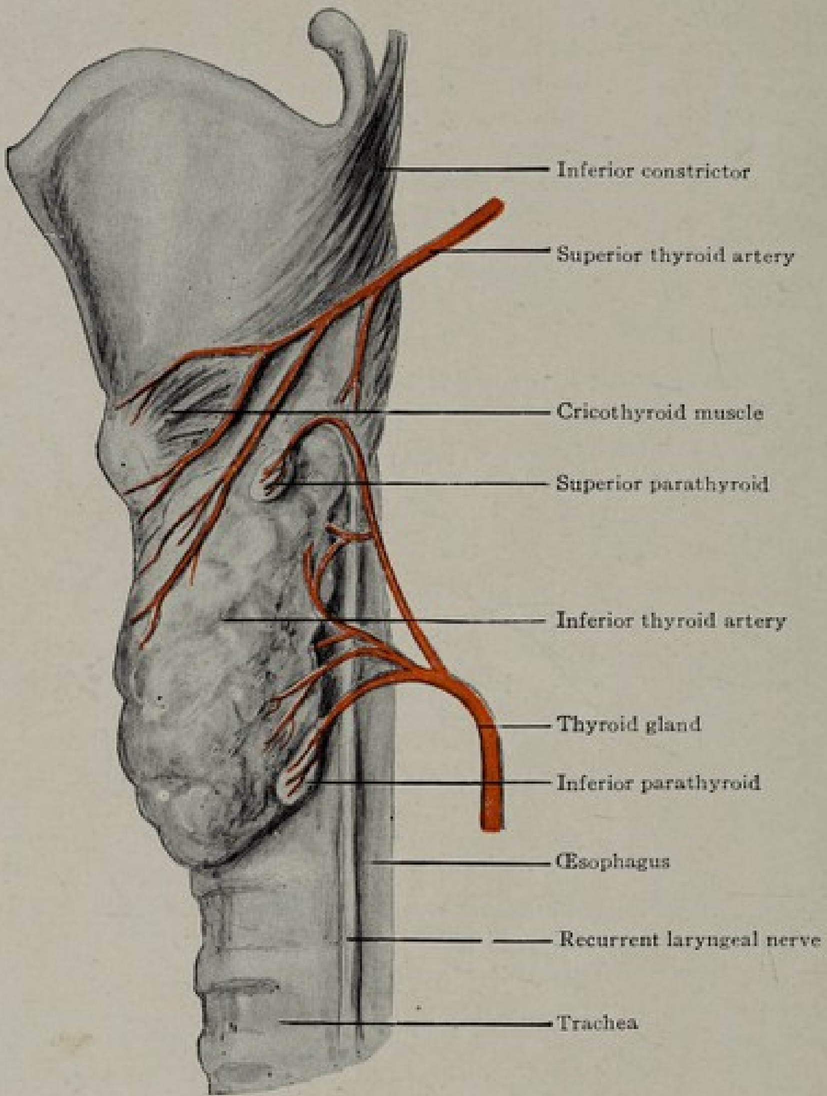


FIG. 200.—Showing the parathyroid bodies.

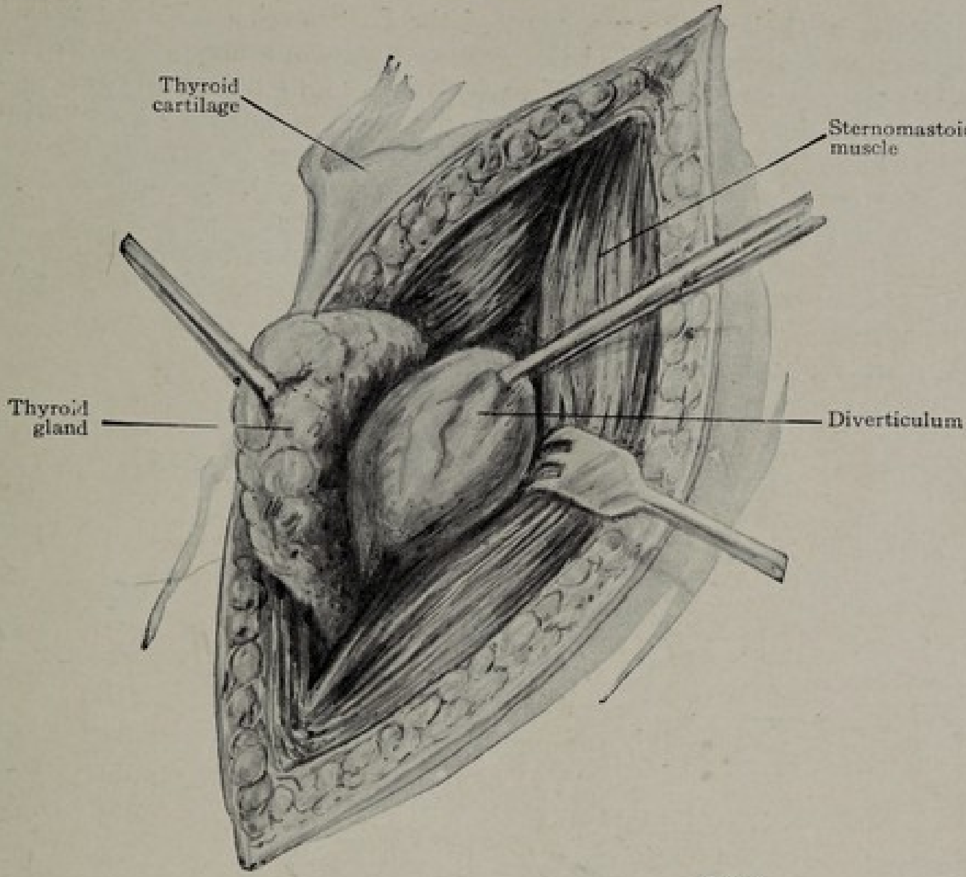
thyroid artery as close as possible to the inferior pole. Their removal during a thyroid operation will result in tetany.

ŒSOPHAGUS—CERVICAL PORTION

The œsophagus begins at the lower border of the cricoid cartilage and after passing through œsophageal hiatus of the diaphragm, opposite the eighth thoracic vertebra, enters the stomach 2 or 3 cm. below this. It is about 24 to 28 cm. in length. The distance from the incisor teeth to the beginning of the œsophagus is about 14 to 18 cm. making the entire distance 38 to 46 cm. The cricoid is opposite the sixth cervical vertebra and the cardiac and œsophageal end of the stomach is opposite the lower border of the tenth thoracic vertebra. It is in the median line above, then curves slightly to the left until the root of the neck is reached, when it returns to the median line opposite the fifth thoracic vertebra.

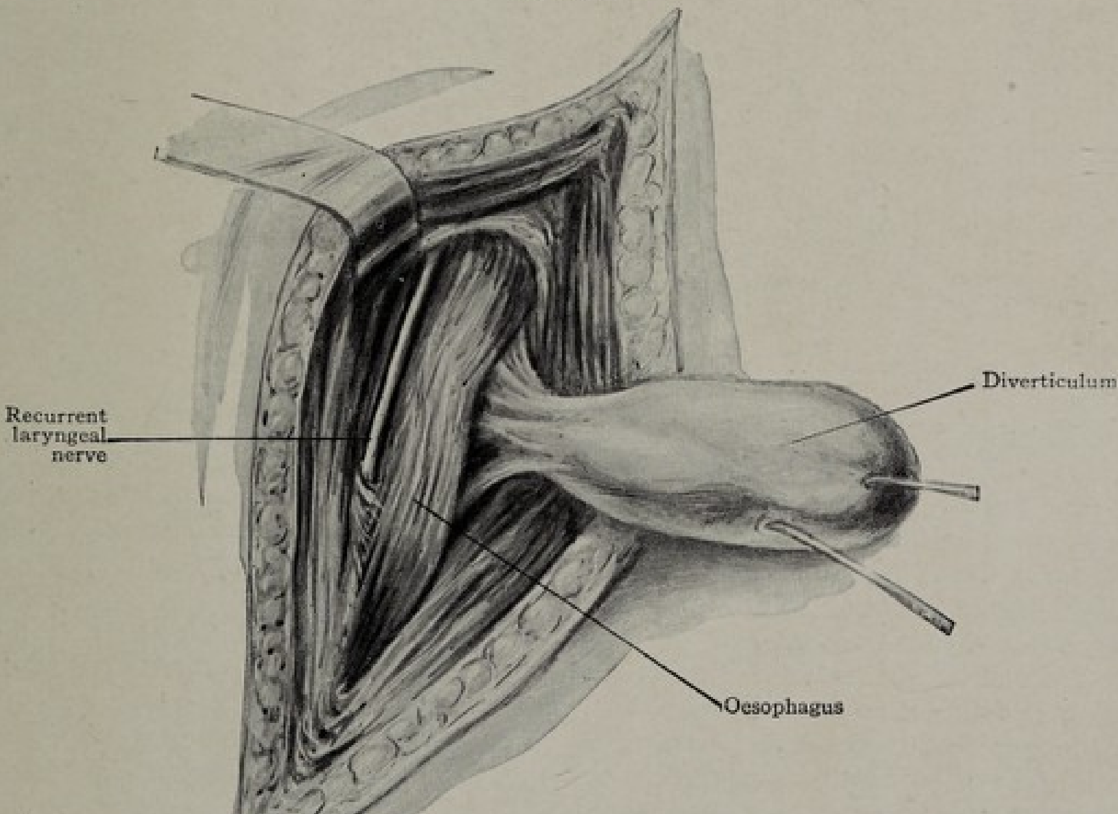
It is in front of the spine and the prevertebral fascia. The layer of fascia between its anterior surface and the trachea is extremely thin. On each side are the common carotid arteries and the sheath of the vessels. The right recurrent laryngeal

FIG. 201.



(Judd.)

FIG. 202.



FIGS. 201 and 202.—Exposure for œsophageal diverticulum.

(Judd.)

nerve winds around the commencement of the first portion of the subclavian, and passes inward and upward behind the common carotid artery to reach the groove between the trachea and œsophagus in which it ascends to the larynx.

On the left side the recurrent laryngeal nerve winds around the arch of the aorta and ascends in the groove on the left side between the trachea and œsophagus. The left carotid artery is closer to the œsophagus than the right. The narrowest point of the lumen is at the cricoid cartilage. Its next narrow point is where it crosses the aorta and left bronchus. This is opposite the upper part of the second piece of the sternum or the upper border of the fifth thoracic vertebra. The third narrow portion is the cardiac opening into the stomach. The œsophagus at each of these three points in diameter is 14 mm.

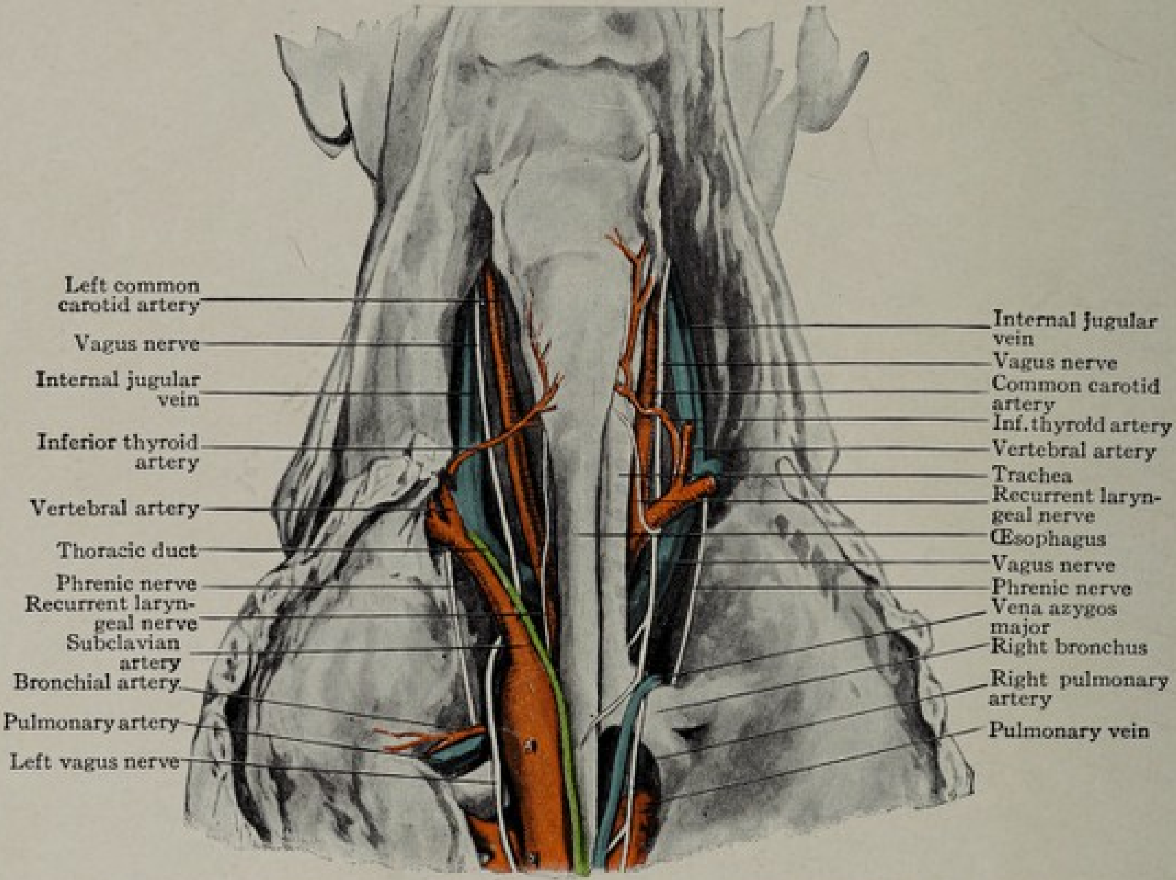


FIG. 203.—Relations of the cervical portion of the œsophagus viewed posteriorly.

Foreign Bodies.—Foreign bodies if they pass the cricoid cartilage are most liable to stop at the aorta and the left bronchus. This is opposite the angle of Ludwig and the second rib, so that the foreign body is either at the root of the neck or just below the top of the sternum. If it passes the two upper constrictions it will probably pass the third, because the cardiac constriction is caused by the diaphragm, which relaxes and allows the body to enter the stomach.

Since the last revision of this book the œsophagus has been more carefully studied and its lesions the object of frequent attack. Jackson and his students have become proficient in the removal of foreign bodies by means of the œsophagoscope. No longer do foreign bodies have to be removed blindly but they can actually be seen and the method of extraction can be carried out with precision. The more extensive use of the X-ray has been also helped materially in diagnosing foreign bodies, strictures, diverticula, and malignant growths in this structure. Biopsy can be performed and strictures dilated by men of the Jackson School almost as simply as the average surgeon performs these procedures in lesions of the rectum.

Mosher has clearly demonstrated various strictures of the œsophagus which are benign and yet not the result of ulceration following the taking of lyes by mistake, or the result of mechanical or thermal causes. The congenital webs or bands occur usually high up and may be associated with a diverticulum. These bands may, however, occur at lower levels.

Many cases of œsophageal stenosis occur following the accidental ingestion of lye. Retrograde dilatation in the cases which have had gastrostomy performed as suggested by Tucker or œsophagoscopic bouginage in the cases without gastrostomy has given very favorable results.

Diverticula may occur in any portion of the œsophagus but they occur more frequently in the upper portion. (Figs. 201 and 202.) This is the weakest portion and is most frequently attacked. However, a dilatation may occur above a stricture at any site. The type which are of most interest to the surgeon are those in the high position. They are called pharyngo-œsophageal or pulsion diverticula and are situated on the posterior wall at the junction of the œsophagus with the pharynx.

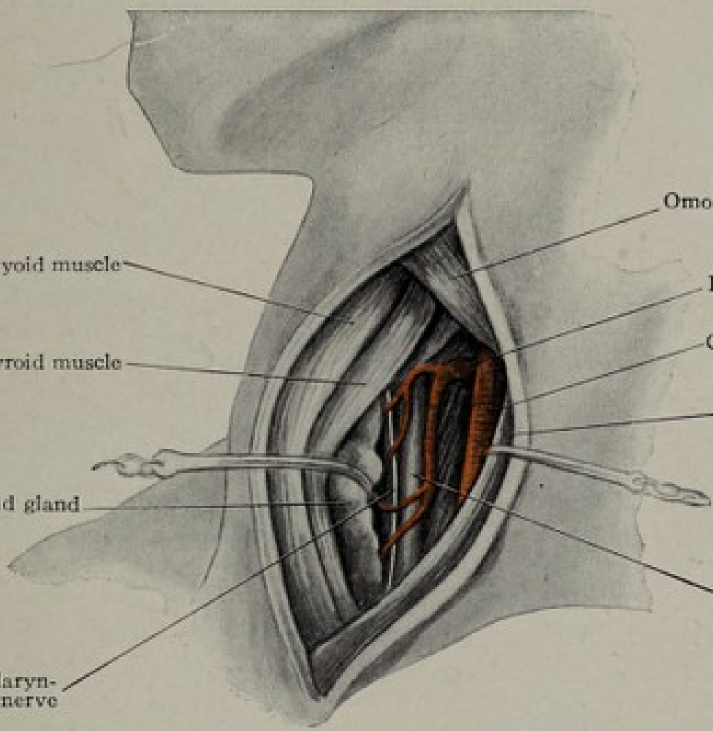


FIG. 204.—Exposing the œsophagus.

Their production is favored by the narrow opening at the level of the constrictor of the pharynx and the hiatus which exists at this point in the longitudinal muscle layer. They may be exposed by the following method.

The œsophagus is recognized by the longitudinal striations of its fibres and its color. It lies behind the trachea and slightly overlaps its posterior lateral edge. Carcinomatous lesions are not so easily attacked. In the cervical portion some success has been attained by resection but more frequently the lesion is just above the diaphragm. An incision is made along the anterior border of the left sternomastoid muscle from the sternoclavicular joint upward. The anterior jugular vein will be cut. After opening the deep fascia the sternomastoid is to be pulled outward. The omohyoid is to be drawn up and out and also the lower portion of the sternohyoid and perhaps the sternothyroid toward the median line.

The middle thyroid and perhaps an accessory thyroid vein are divided and the thyroid gland and trachea drawn inward. The trachea is to be identified by the sense of touch. The inferior thyroid artery is behind the sheath of the vessels and is so high that it is not likely to be injured. The recurrent laryngeal nerve must be looked for between the œsophagus and trachea, and avoided. In going deep down care must be taken not to injure the innominate vein, which comes well up towards the top of the sternum.

CUT THROAT

The most frequent site of the incision in cases of cut throat is between the hyoid bone and thyroid cartilage. *If above the hyoid bone,* the incision will divide the mylohyoid, geniohyoid, geniohyoglossus, and hyoglossus muscles, and perhaps the digastric and stylohyoid. If it goes far back it may wound the submaxillary gland or duct, the facial or lingual arteries and veins, and the hypoglossal nerve. The commencement of the anterior jugular will certainly be divided and the external jugular may also be wounded. The cut passes through the base of the tongue and the upper portion of the epiglottis. The tip of the epiglottis is sometimes entirely cut off. *If in the thyrohyoid space,* the incision passes a short distance above the vocal cords. The sternohyoid, omohyoid, and thyrohyoid muscles are divided. If prolonged backward the pharynx will be opened and perhaps the arytenoid cartilages wounded. The superior thyroid artery is likely to be cut. This is the vessel most often divided in suicidal wounds. The carotid arteries and internal jugular veins are deep and far back, lying under the edge of the sternomastoid muscle, and are rarely wounded.

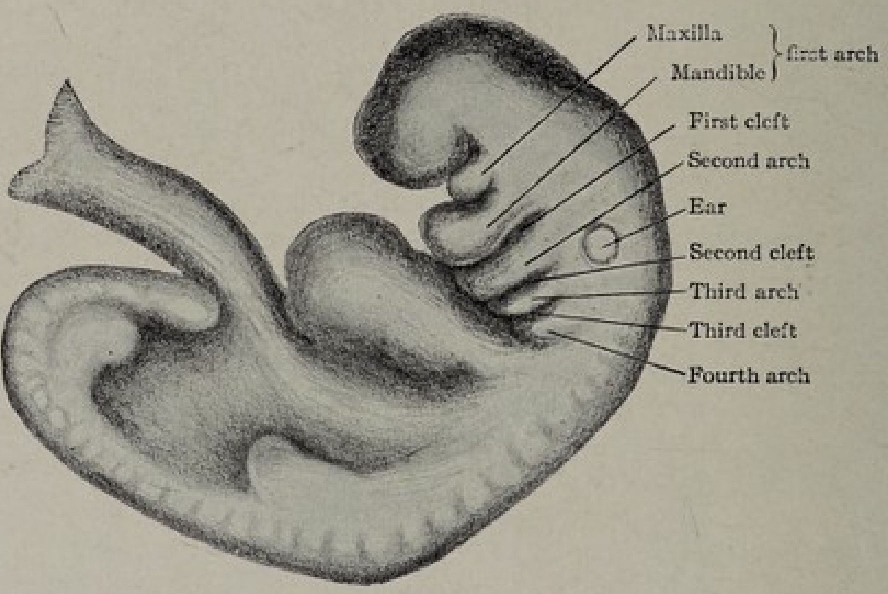


FIG. 205.—Fœtus, 25th day (after His). Showing branchial (visceral) arches and clefts or furrows.

If these are cut, death usually rapidly ensues from hemorrhage. The superior laryngeal nerve may be injured as it pierces the thyrohyoid membrane. This nerve is sensory and its division is followed by anæsthesia of that half of the larynx to which it is distributed. This favors the entrance of food and liquids into the larynx and so may cause a fatal septic pneumonia. *If through the thyroid cartilage* the incision may wound the vocal cords. They lie just beneath the most prominent part of the thyroid cartilage and just below its median notch. *If through the trachea,* the incision may wound the thyroid gland, which reaches from about the sixth ring of the trachea to the oblique line on the thyroid cartilage.

Bleeding from the wounded thyroid, if the gland is normal in size, is not likely to be excessive. Below the cricoid cartilage the œsophagus may be wounded, above it the pharynx may be opened. The two large sternomastoid muscles being put on the stretch tend to protect the large vessels beneath. Suppuration not infrequently accompanies these wounds of the neck in which the air and food passages are involved and may give rise to collections of pus which may travel between the fascias, as previously described. In treatment it is customary to cleanse the wounds and approximate the various injured tissues as carefully as possible, and feed by a stomach tube.

AFFECTIONS OF THE NECK

Cervical Cysts and Fistulæ.—The neck is the seat of some very peculiar cystic tumors and fistulæ which are connected with developmental defects. They are either lateral or median in location. The lateral originate from the visceral (branchial) clefts, while the median are connected with the thyroglossal duct. The visceral clefts are depressions between the visceral arches. These arches, five in number, spring forward from each side of the embryo to form the neck and lower face region. Sometimes these arches are called branchial arches from the fact of their going to form the branchiæ or gills of fishes and some of the other lower orders of animals.

The *first visceral arch* divides into two parts, a maxillary part forming the upper jaw and a mandibular part forming the lower jaw. Defects in the maxillary arch producing harelip and cleft palate have already been described. Two of the ear bones, the incus and malleus, are also formed by the mandibular portion of the first visceral arch.

The *second visceral arch* forms the stapes, the styloid process, the stylohyoid ligament, and the lesser horn of the hyoid bone.

The *third visceral arch* becomes the body and greater horn of the hyoid bone.

The *fourth* and *fifth visceral arches* blend and form the soft structures of the side of the neck, and the thyroid cartilage. The *sixth* forms the cricoid and arytenoid cartilages, trachea and brochii.

The *first visceral cleft*, called the hyomandibular cleft from its being between the hyoid bone and the mandible, forms the middle ear and Eustachian tubes from its inner portion and the external auditory meatus from its outer portion. The membrana tympani is the remains of the membrane which stretched across from one arch to the other. Cervical fistulæ are formed by the persistence of a visceral cleft. As the first visceral cleft persists normally in the structures already named, it in itself does not form pathological fistulæ, but congenital fistulæ are sometimes encountered in the external ear which are the remains of the clefts between the tubercles of which the ear is formed.

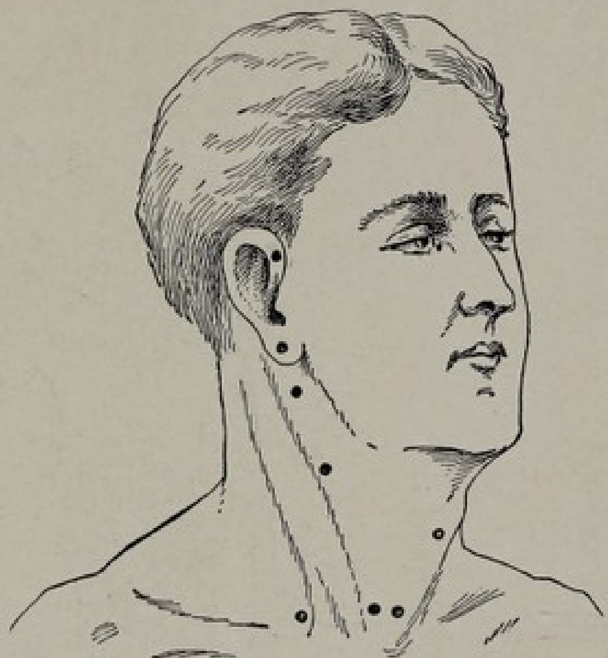


FIG. 206.—Points of opening of sinuses originating from the thyroglossal duct and branchial clefts. (Modified from Sutton.)

Cervical fistulæ or sinuses may extend either completely through, from the surface to the pharynx, or may open internally or externally, or be closed at both ends, in which last case the contents accumulate and form a cervical cyst. The second, third and fourth clefts disappear and leave no traces behind. About the fourth week the second arch grows downward and covers the third and fourth. It finally fuses with the body wall behind the fifth arch. In this way the orifices of the second, third and fourth clefts are covered leaving a space into which they open, known as the "cervical sinus." If this does not disappear, a cyst or a fistula may result. The sinus may open on the neck or into the pharynx or there may be no opening and a cyst result.

Fistulæ arising from the second visceral cleft open externally opposite the thyrohyoid space in front of the sternomastoid muscle. Internally they open into the recess holding the tonsil.

Fistulæ arising from the third and fourth visceral clefts open externally lower down nearer the sternoclavicular articulation in front of the sternomastoid muscle and internally in the sinus pyriformis. The persistence of the third and fourth visceral clefts internally may produce pharyngeal diverticula, as already noted in discussing that region.

In attempting the cure of cysts and fistulæ due to persistence of the visceral clefts it is evident that as they are lined with a secreting epithelium this must be destroyed or removed, or a recurrence will take place. In attempting to dissect them out one must be prepared to follow them through the structures of the neck to the pharynx inside. It is needless to say this may be a serious procedure.

Hueter (quoted by Sutton) followed one between the two carotid arteries into the pharynx. These cysts and fistulæ may be noted at birth or may develop later in life. Thompson believes that a ranula is the remains of a branchial cleft. He even believes that certain of the multiple cervical cysts have a common origin and as he says, "give us the impression of being daughter cysts which have been segregated from a mother cyst and carried by some agency to regions remote from their original home, during which process obliteration of one or more of the daughter cysts or even of the mother cyst has occurred." The persistence of the cervical sinus in whole or in part is probably responsible for all branchial cysts and fistulæ.

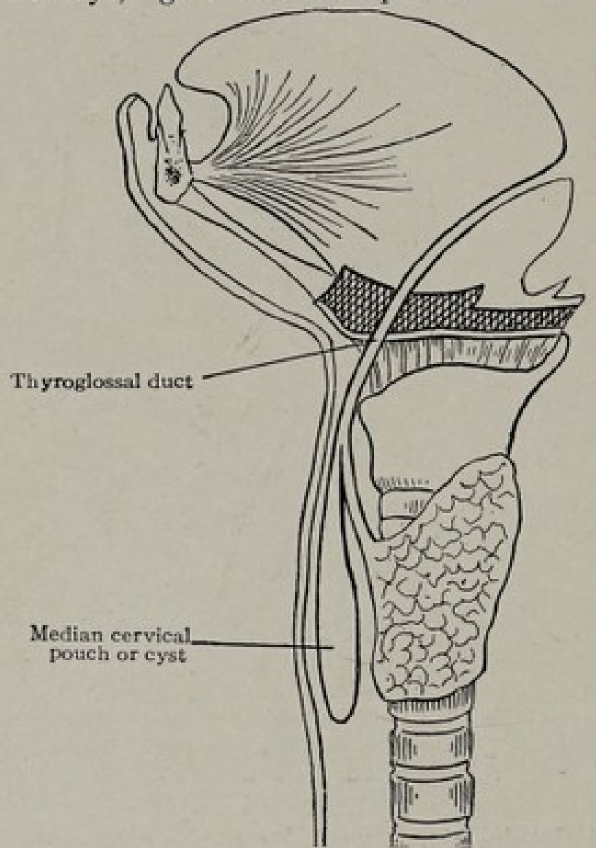


Fig. 207.—Median cervical pouch or cyst arising from the thyroglossal duct.—Marshall's case.

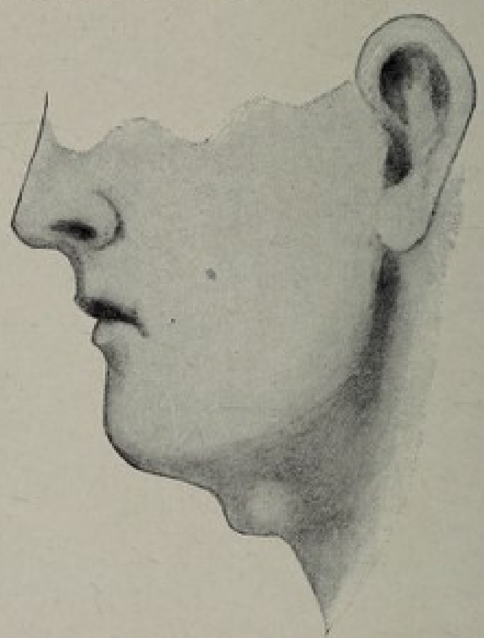


Fig. 208.—Median cervical (thyroglossal) cyst.

Hygroma of the Neck.—There are other cystic tumors of the neck which are congenital, being noticed at birth, and which grow to a large size. They are often wide-spread, extending not only between the tissues of the neck below the deep fascia but even into the axilla. Their walls are thin, consisting sometimes only of a layer of lining epithelium and the surrounding tissues. On this account it is impossible to dissect them out. The use of injections and setons has been abandoned as too dangerous. They rarely require treatment, as they tend to disappear spontaneously. Mr. J. Bland Sutton ascribes their origin *first* to congenitally dilated lymph-spaces; *second* as resembling the cervical air-sacs that exist in the howling monkeys; and *third* that possibly some of them may be related to a persistence of some portion of a branchial cleft. It is more likely that the theory is the true one and that most of the cysts encountered are the remains of a branchial cleft or the cervical sinus. A major portion of the cleft or sinus may have closed leaving only a lateral portion unoccluded just as a portion of the tunica vaginalis may remain and form an encysted hydrocele of the cord.

Median cervical fistulæ and cysts originate in connection with the thyroglossal duct. This, in the embryo, leads from the foramen cæcum at the root of the tongue through to the posterior surface of the hyoid bone and thence downward and forward to the isthmus of the thyroid gland. It begins to atrophy in the fifth week and is obliterated by the eighth. According to Sutton these cysts are never congenital but occur soon after birth or as late as the fourteenth year. They appear as rounded, cystic tumors just below the hyoid bone or over the thyroid cartilage. They either inflame and break of their own accord, discharging externally, or are opened by the surgeon and, contrary to what is the case in hydroceles of the neck, never tend to disappear, but a sinus remains. At times it almost heals, then the contents accumulate and a cyst forms, this again breaks and a sinus results as before. In attempting a cure by operation the sinus should be followed behind the hyoid bone. In one case after two failures of attempted excision a cure was obtained by destroying the tract by introducing a small galvanocautery point. Unless every portion of the lining membrane be completely destroyed the cells will go on secreting and reproduce, in a short time, the original condition. Failure to cure these sinuses and cysts by excision often occurs, notwithstanding the exercise of the greatest care.

The lower portion of the thyroglossal duct may persist in the form of the pyramid or third lobe of the thyroid gland, which arises from the isthmus or from the left side and ascends as far as the hyoid bone, to which it is attached.

THE THORAX

The thorax or chest is that portion of the trunk which lies between the neck and the abdomen. It is composed of a bony framework reinforced by soft parts, and contains the main organs of circulation and respiration. The œsophagus, an organ of the digestive tract, simply passes through it to the regions below. The chest-walls as well as the parts contained within them are affected by wounds and disease, especially the heart and its associated great vessels, and the lungs and pleuræ. These organs are essential to life, like the brain and spinal cord, and like them, are encased in a bony framework. It is an example of bones performing a protecting function in addition to a supporting one.

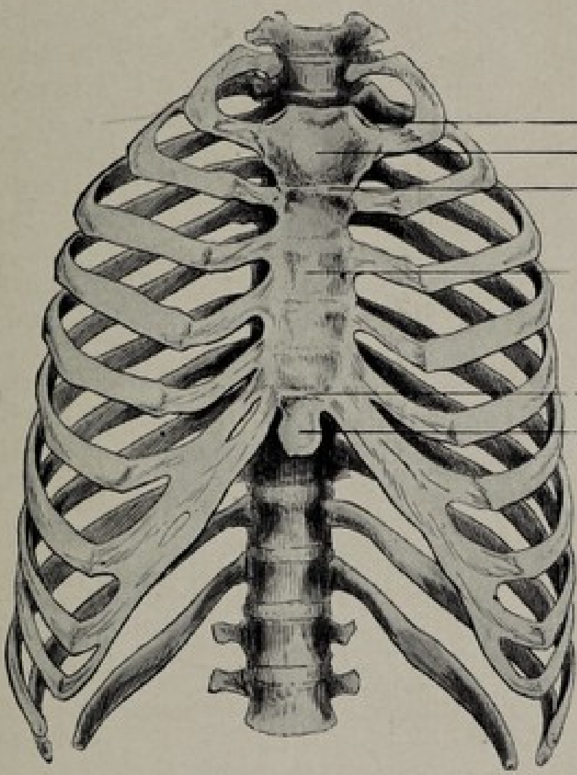


FIG. 209.—The bony thorax.

The functions of the heart and lungs are influenced by constitutional diseases in addition to their own local affections, hence they serve as guides to the general bodily condition, and the condition of the respiration and circulation is continually being examined for the purposes of diagnosis, prognosis, and treatment, even when the heart and lungs themselves are not primarily involved. To make these examinations intelligently, necessitates a knowledge of the organs themselves and their relations to one another and the surrounding parts. This is essential for the physician even more than the surgeon.

The **chest-walls** are composed of a bony framework joined and bound together and covered by soft parts. The **bones** of the chest consists of the *sternum, ribs,* and *thoracic vertebræ*. The clavicle and scapula composed the shoulder-girdle and belong to the upper extremity. The human skeleton is divided into an axial portion and an appendicular portion. The axial portion embraces the skull, the vertebral column, including the sacrum and coccyx, the hyoid bone, the sternum, and the ribs. The appendicular portion consists of the shoulder-girdles and upper extremities and the pelvic girdles and lower extremities.

The bony chest is subject to disease and injury as well as to defects in development, and to deformities due to these causes.

Shape of the Chest.—The chest is conical in shape, being small above and large below. In transverse section it is kidney-shaped, the hilus of the kidney being represented by the vertebræ. In the fœtus the anteroposterior diameter is greater than the transverse, thus resembling the thorax in the lower animals. After birth and in infancy the two diameters are nearly equal, hence we have the rounded chest of the child. As growth and development progress the transverse diameter increases more than the anteroposterior, so that at about the second year the chest has become oval and in adults the transverse diameter is one-fourth greater than is the anteroposterior.

Variations in the shape of the chest are mainly the result of disease. In childhood, rachitic disease (rickets) produces a lateral flattening and a projection of the sternum. If the sternum projects markedly it constitutes what is known as *pigeon breast*, the chest in such a condition being longer from before backward than from side to side. In this disease also there may be a depression on each side of the sternum, the back is rounded owing to the bending of the vertebral column, and the points of junction of the ribs and cartilages are enlarged, this latter constituting what is known as *beading of the ribs*. These beads are felt as rounded enlargements at the sternal extremities of the ribs and form a line parallel to the sternum above and sloping outward below. This line of beads has been called the "*rachitic rosary*." From the level of the ensiform cartilage a groove passes out toward the sides; this has been called "*Harrison's groove*" (see Fig. 210). Sometimes the lower end of the sternum is pressed inward, forming a deep funnel-shaped depression constituting the deformity known as "*funnel chest*" or the "*Trichterbrust*" of the Germans.

Fig. 210.—Child showing Harrison's groove opposite the ensiform cartilage.

This condition of the chest, with the exception of the beading, is also produced in children by obstruction to the breathing from enlargement of the tonsils, from the presence of adenoid growth in the pharynx, and from hypertrophy of the turbinate bones, all of which interfere particularly with nasal respiration.

Diseases of the lungs and pleuræ alter the shape of the chest. In emphysema and when distended by pleural effusions, the thorax becomes more rounded in shape, forming what is called the "*barrel-shaped chest*." In phthisis the wasting of the tissues and contraction of the lungs causes the chest to collapse. The ribs slope more sharply downward and the chest becomes longer and flatter, the anteroposterior diameter being diminished. The angle made by the lower ribs as they ascend to the sternum is called the *costal angle*; this becomes decreased in phthisis. This form of chest is known as the "*phthisical chest*." When the flatness is marked it is sometimes called the "*flat chest*." When the scapulæ project like wings it is called "*alar*" or "*pterygoid chest*."

In *Pott's disease*, or caries of the spine, as the kyphosis develops the chest falls forward and its anteroposterior diameter is increased. The abdominal contents are crowded up into the chest and push the sternum and lower ribs forward. Associated with this deformity is oftentimes a lateral deviation of the parts above the site of the disease.

In *scoliosis*, or *lateral curvature* of the spine, the distortion is uneven, being a compression of the thorax from above downward and a twisting around a vertical axis. The deformity is frequently so severe as to cause the lower ribs to rest on the iliac crests. It is in order to detect these diseases in their early stages that a knowledge of the shape of the normal chest is so essential.

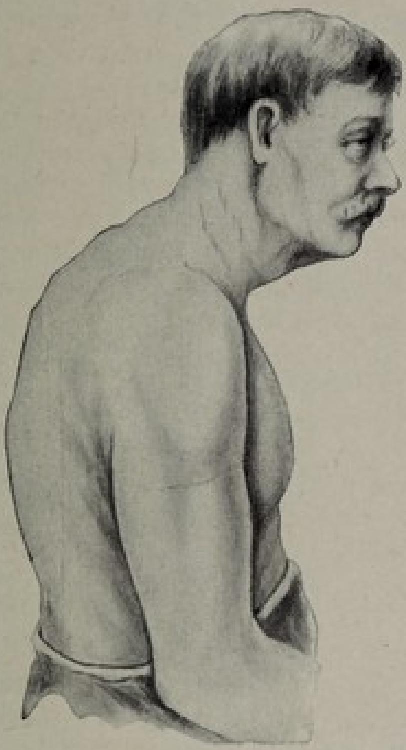


FIG. 211.—Barrel chest of emphysema.

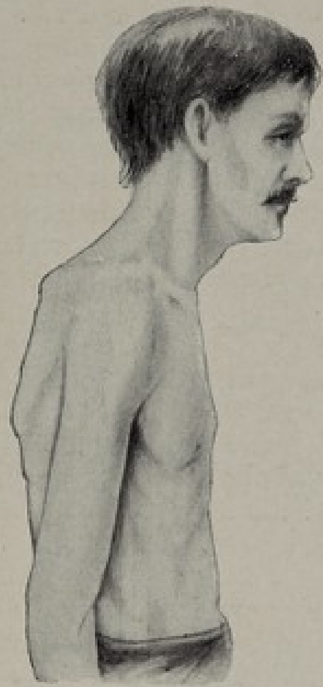


FIG. 212.—Flat chest of phthisis.

FIG. 213.—Kyphosis from Pott's disease, or caries of the lower thoracic vertebræ. The curvature is an angular anteroposterior one.

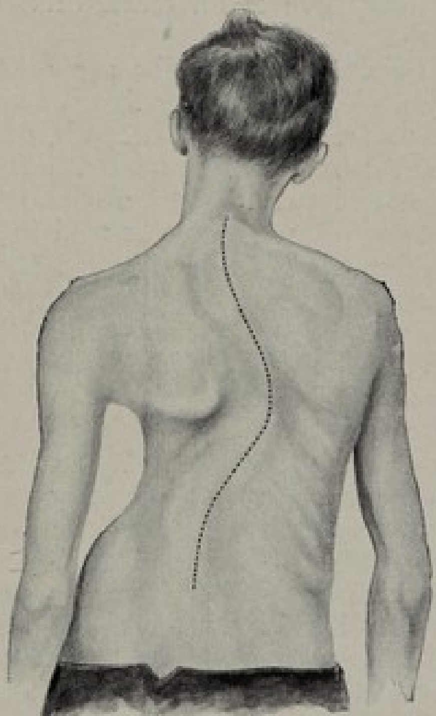


FIG. 214.—Scoliosis, or lateral curvature of the spine.

THE STERNUM

The sternum consists of three pieces: the *manubrium* or *presternum*, *gladiolus* or *mesosternum*, and *xiphoid cartilage* or *metasternum*. It is developed in two lateral halves. Should these fail to unite, an opening is left in the bone through which the pulsations of the heart have been seen and felt. The upper end of the manubrium is on a level with the second thoracic intervertebral disc and the line between the manubrium and the gladiolus is opposite the fifth thoracic verterbra and on a level with the second rib. The seventh is the last rib to articulate with the sternum directly.

The first and second pieces of the sternum are connected by a joint which persists to advanced age. The projection caused by this joint is called the *angulus sterni* or *angle of Louis.* Fractures pass either through this joint, opposite the second rib, or through the bone just below it. They are produced by both direct and indirect force. Usually the upper fragment is beneath the lower one. It is however more true to state that the lower fragment is displaced anteriorly. Any marked posterior displacement of the upper fragment would tend to press on the trachea and interfere with breathing; the trachea bifurcates opposite the joint. As the pleuræ and lungs of the two sides almost or quite touch behind the second piece of the sternum, they may be wounded and emphysema may occur. The heart also may be wounded. Suppuration has followed these injuries, in which case it will be necessary to trephine the sternum to give exit to the pus. The necessity of avoiding wounding of the pleuræ in such a procedure is evident, as it would be followed by collapse of the lung and empyema.

THE RIBS AND COSTAL CARTILAGES

The ribs are frequently fractured, sometimes they become affected with caries, and in operating the chest is frequently opened between them or portions of them are excised. They are both elastic and movable, and difficult to break; hence fracture is almost always due to direct violence, and this violence may be so great as sometimes to cause death. Normally there are twelve ribs on each side, but sometimes there is an extra cervical or lumbar rib. These are both rare, the latter the more so.

The seven upper ribs are called *true ribs* because they articulate with the sternum. The remaining five are called *false ribs*, the eleventh and twelfth being *floating ribs.* The eighth, ninth, and tenth ribs each articulate by their cartilages with the rib above. The tenth forms the lower margin of the thorax. The eleventh and twelfth ribs are attached only by their posterior extremities, their anterior portion being imbedded in the soft parts; hence they are called floating ribs. The ribs slope downward and forward. This obliquity increases until the ninth rib, after which it decreases. The first rib in front corresponds to the fourth behind, the second, third, fourth, fifth, and seventh in front correspond each to the fourth rib lower behind. The first rib is the nearest horizontal in regard to its surface and, being well protected by the clavicle, is rarely broken. The intercostal spaces are broader in front than behind and broader above than below. The third is the largest. The oblique elevations of the ribs can best be seen in the axillary region. Anteriorly they are covered by the pectoralis major and minor, the lower border of the former following the direction of the fifth rib and its costal cartilage. Below this the sixth to the tenth ribs are plainly visible.

The groove on the lower surface of the ribs holds the intercostal artery, but only as far back as the angle, from which point it occupies the middle of the space.

The extent of the intercostal spaces is considerably influenced by position—flexion of the body brings the ribs together, extension and bending to the opposite side separates them. This point is of importance in reference to the operations of paracentesis and empyema. In counting ribs it is best to begin with the second, since this can always be located opposite Ludwig's angle.

A line carried transversely around the thorax and passing through the angle of the scapula, passes through the sternum between the fourth and fifth ribs, the fifth rib in the mammary line, the seventh rib at the angle of the scapula and the ninth rib at the vertebral column.

The first costal cartilage unites directly with the sternum, there being no joint present. The second and sometimes the third cartilage is joined to the sternum by a ligament with a synovial joint above and below it. The other costal cartilages are united by a joint with a single cavity. These joints may be the seat of metastatic abscesses in pyæmic infections.

Cervical Ribs.—The costal process of the seventh cervical vertebra, usually represented by a mere vestige, may develop into a rudimentary or even a fully formed rib which reaches to the sternum. If the extremity of the anomalous rib reaches far enough forward, the subclavian artery and brachial plexus pass over the rib in which instance symptoms of compression may occur at any time. Law (1920) has called attention to the presence of an adventitious ligament attached from the tip of the cervical rib to the first rib or sternum. Surgeons excise this rib when symptoms of vessel or nerve compression are present. Perhaps the best operation is that devised by Taylor (1922). The incision starts at the posterior edge of the insertion of the sternocleidomastoid muscle into the clavicle, and passes upward and outward to the border of trapezius muscle, making an angle of about 45° with the clavicle. The transversalis coli vessels are tied and divided, the fat pad in front of the plexus is mobilized at its outer edge and retracted inward, and then the brachial plexus is completely exposed. The cervical fascia is divided along the outer edge of the plexus which is then separated from its bed posteriorly sufficiently to expose the rib and is then very gently retracted forward. Once the rib is definitely made out, its muscular and ligamentous attachments are divided by sharp dissection so as to leave all periosteum on the rim. The last portions of the rib to be free and removed are the neck and head. These are in the centre of the danger zone. After the outer portion of the rib has been dissected free from its attachments, it is grasped by small bone forceps and manipulated as convenience dictates, while its inner portion is dissected free. During all this dissection the plexus must be held slightly forward on a blunt flat retractor, with the edges rounded so as to avoid the pressure of any sharp edge on the retracted nerves. The amount of functional loss in the nerves as a result of operation is almost entirely dependent upon the skill, gentleness and continuing thoughtfulness of the assistant holding the retractor. One must make frequent remissions in this part of the procedure with removal of the retractor to avoid too prolonged continuous compressions of the nerves. Toward the end of the procedure annoying hemorrhage is apt to result from injury of some of the veins forming a plexus about the vertebral artery. Packing controls this type of bleeding in a few moments. The rib having been removed and hemostasis secured, the fat pad is replaced in front of the plexus, and the wound is closed without drainage.

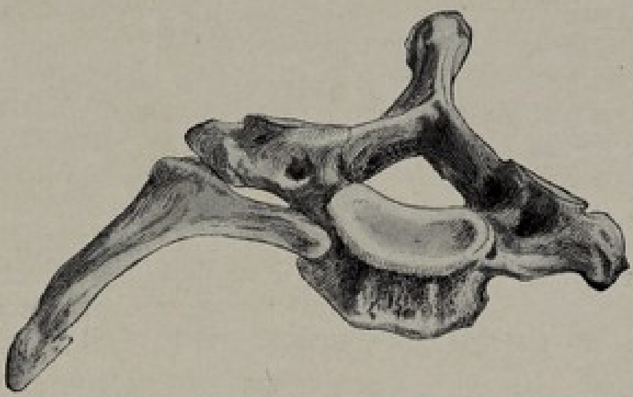


Fig. 215.—A cervical rib attached to the right side of the seventh cervical vertebra.

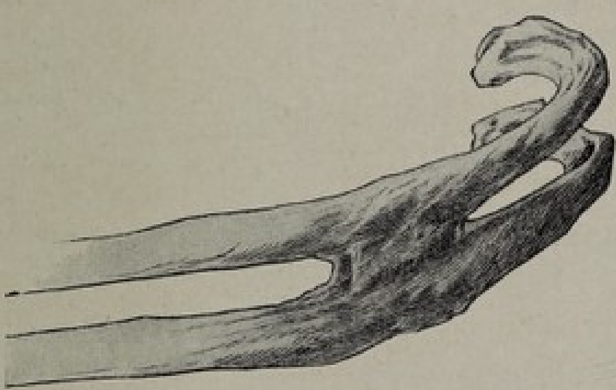


Fig. 216.—Fractured ribs; fusion of callus.

Fracture of the Ribs.—The ribs are almost always broken by direct violence; fractures from indirect force, as from coughing, sneezing, and other forms of muscular exertion, are rare. Fracture from compression of the chest is also rare. The site of the fracture is most frequently on the anterior portion of the chest and not the sides or back. The fourth, fifth, sixth, and seventh ribs are most often broken. The twelfth rib is the least frequently so. In one case we saw the eighth, however, has shown that it can be broken by pressure of the clavicle when the shoulder is depressed. The eleventh and twelfth, being floating ribs, are rarely broken. The twelfth rib is the last frequently so. In one case we saw the eighth, ninth, tenth, eleventh, and twelfth all broken by the passage of a wheel. The soft parts attached to the fragments prevent much displacement, but there is always some, due to the respiratory movements. Hence callus is always present and it may be so abundant as to join adjacent ribs (see Fig. 216). As already stated, death frequently follows fracture of the ribs and is due to wounding of the chest contents. Rarely the intercostal arteries may be wounded and produce hæmothorax. Wounding of the lung is frequent. Emphysema of the surface of the body may ensue, but is not dangerous. Pneumothorax, which may be accompanied by infiltration of air into the lung issue, is more dangerous, favoring collapse of the lung. The object of treatment is to keep the chest-walls from moving. This is accomplished by strapping the chest with adhesive plaster, which is usually laid on almost in the direction of the ribs; but as the chest moves with respiration, the ribs rising, and as they slope downward and forward, I have preferred to lay the straps on from in front downward and backward, this tends to prevent the ribs from rising in inspiration.

THE THORACIC VERTEBRÆ

The thoracic or dorsal vertebræ are twelve in number and are so articulated with one another as to form a single, regular curve with its concavity forwards and convexity backward. Any sudden change in the direction of the curve is an evidence of disease; this is seen in the angular curvature of Pott's disease or caries of the spine. The ribs are connected with the vertebræ by the articulation of the head of the rib with the body of the vertebra, and the tubercle of the rib with the *transverse process*. The transverse process is connected with the body by the *pedicle* and with the spinous process by the *lamina*. The spinal cord is exposed in operations by removal of the spinous process and laminæ, hence the name *laminectomy*.

The spinous processes are the guides which indicate the position and condition of the vertebræ. Their tips are not covered by muscles but lie close beneath the skin and are readily felt and any abnormality detected. In the normal body the grooves on each side of the spinous processes are filled up with the erector spinal muscle, but in certain diseases, as in infantile paralysis and lateral curvature, they become atrophied and the spine becomes twisted, hence on the convex side of the abnormal lateral curve, to the outer side of the spines, the projection formed by the transverse processes and tubercles of the ribs can be both seen and felt.

The external curve formed by the tips of the spinous processes of the thoracic region in the normal person is not so great as is the curve formed by the anterior portion of the bodies of the thoracic vertebræ. This is because the spinous processes at the upper and lower portions of the chest project out almost at right angles to the long axis of the body, while those of the middle portion slope downward. Hence the tips of the spinous processes of the seventh cervical, first dorsal, and twelfth dorsal vertebræ are opposite the bodies of the same vertebræ, while the others are opposite the bodies of the vertebræ next below. (The spine will be considered more at length in the section devoted to the Back.)

Paravertebral Block.—Paravertebral nerve block by injecting an anesthetic solution close to the vertebral column at the emergence of the nerve roots from the intervertebral foramina. Each thoracic or intercostal nerve emerges from its intervertebral foramen and after giving off a meningeal branch divides into an anterior and posterior division. The anterior division is the intercostal nerve proper while the posterior supplies the muscles and skin of the back. The thoracic nerves are blocked (Labat) at a point 3 to 4 cm. from the line of spinous processes. After emerging from the intervertebral foramina the nerve lies midway between the transverse processes and courses obliquely upward to the costal angle of the rib above it.

Labat has the patient lie on the side opposite the one to be injected. The spine is arched, the face and knees approximated. This widens the intercostal spaces. A cushion is placed under the loin to straighten the vertebral column and relax the erector spinæ muscle. The twelfth rib is defined and traced to the midline posteriorly. A perpendicular line is measured off for 5 cm. and this marks the spinous process of the twelfth dorsal vertebra. A wheal is raised as a landmark. Any other spinous process can be distinguished from this. The midline is carried upward. The area for anesthetization is selected and at a point 4 cm. from the midline opposite each spinous process a wheal is raised. A needle (No. 3-8 cm. Labat) is inserted through the wheal and carried forward perpendicularly to the skin toward the posterior surface of the rib just above the space to be injected. After touching the rib the needle is slightly withdrawn and the hub is inclined at an angle of 45° outward and upward, and the needle carried downward and inward to meet the lower border of the rib. When this is met it is carried into the intercostal space for 2 cm. in the same direction. This carries the needle half way between the two ribs and 1 cm. in front of the transverse process. Five or six cc. of 1 per cent. novocaine are then injected.

SOFT PARTS

The bony thorax is lined by the pleuræ, the ribs are united to each other by the intercostal muscles, and over all are muscles, superficial fascia, and skin. In addition, in front are the mammary glands and behind are the scapulæ.

The Intercostal Muscles and Arteries

The intercostal spaces are occupied by the two intercostal muscles, with a fascia above them, one below, and one between them.

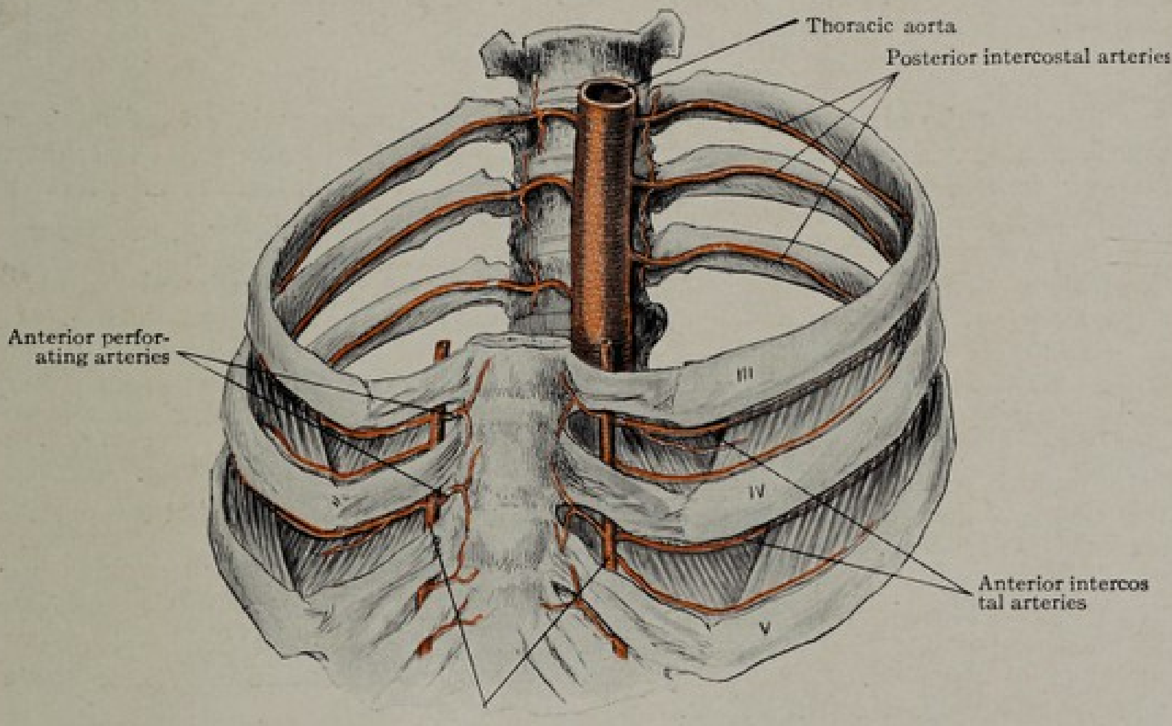


Fig. 217.—Course and distribution of the intercostal arteries.

The *external intercostal muscles* run downward and forward. They begin at the tubercles of the ribs posteriorly and end at the costal cartilages anteriorly. They are continued forward to the sternum by the anterior intercostal membrane, formed by the fusing of the outer and middle intercostal fascias. The *internal intercostal muscles* go downward and backward. They begin at the sternum and end at the angles of the ribs. They are continued to the spine by the posterior intercostal membrane, formed by the fusing of the middle and internal intercostal fascias. The *intercostal arteries* come from both anteriorly and posteriorly. The *anterior intercostals* come from the internal mammary for the upper five or six spaces and from the musculophrenic artery for the remainder. They arise either as a single trunk or as separate superior and inferior branches. At first they are between the pleura and internal intercostal muscle, but they soon perforate that muscle and run between it and the external intercostal, the superior branch running along the lower edge of the rib and the inferior branch running along the upper edge of the rib below. The aortic or posterior intercostal arises as a single trunk which passes between the external intercostal muscle and the pleura. Arriving opposite the angle of the ribs it divides into superior and inferior branches which unite with those from the internal mammary (*arteria mammaria interna*).

From the vertebræ out to the angle of the ribs the intercostal artery lies about midway between the ribs, hence it is liable to be wounded in paracentesis if the puncture is made too far back. It is for this reason that operations for draining the pleuræ are performed anterior to the costal angles. The superior intercostal branches are larger than the inferior ones. They run under the lower edge of the rib above the space and are therefore protected from injury, particularly stab-wounds.

In opening the chest for empyema it is best to go about midway in the intercostal space and not too close to the lower edge of the rib on account of the liability of wounding the superior intercostal. Another method of avoiding the artery is to cut down directly on the rib to be excised and remove the section subperiosteally. This keeps the vessels and nerve attached to the periosteum. The nerve can then be injected with alcohol to lessen post-operative pain and the vessels ligated before opening the pleura. The inferior is usually quite small and causes no serious hemorrhage. Intercostal bleeding may cause a hæmothorax if the wound is small.

MUSCLES

Covering the chest anteriorly are the *pectoralis major* and *pectoralis minor muscles*. The *serratus anterior* (*s. magnus*) winds around its side and posteriorly, above is the *trapezius* and below the *latissimus dorsi*. Beneath them are the *erector spinæ* (*sacrospinalis*) *muscles* on each side of the spinous processes.

The **pectoralis major** muscle arises from the sternal half of the clavicle, from the sternum and costal cartilages as low as the sixth or seventh rib, and from the aponeurosis of the external oblique muscle and sheath of the rectus muscle. It inserts into the outer lip of the bicipital groove. It is to be noted in regard to this muscle that it is attached to the inner half of the clavicle and that the clavicular and sternal parts are separated by a cleft. When removing it in excision of the breast for carcinoma one separates the muscle by passing through this cleft and detaching the part below. It forms the anterior fold of the axilla and by following this fold to the chest-wall it leads to the fifth rib, as it is at that rib that the muscle leaves the chest-wall.

The pectoralis major is covered by the *pectoral fascia*. When in removal for non-malignant growths the breast is raised, the muscle beneath is seen to be covered with a thin fascia continuous with the fascia of the axilla. Beneath the pectoralis major is the *clavipectoral fascia* continuous with the costocoracoid membrane above and the axillary fascia at the sides.

The **pectoralis minor** passes from the third, fourth, and fifth ribs to the caracoid process. Its origin is well forward toward the anterior extremities of the ribs and, as it is not attached so low on the chest as is the pectoralis major, it is hidden by the latter and does not aid in forming the anterior axillary fold. This muscle is frequently removed in operations for carcinoma of the mammary gland.

The **seratus anterior (s. magnus)** muscle (Fig. 219) passes from the side of the chest to the vertebral or posterior border of the scapula, arising by nine or ten digitations from the eight or nine upper ribs, the second having two. The slip arising from the sixth rib is the one most prominently seen on raising the arm away from the side, it passes the farthest forward. The slips into the fifth, seventh, and eighth ribs may also be seen. This muscle passes across the axilla from in front backward, lying on the chest-wall. It is supplied by the *posterior thoracic nerve* from the fifth, sixth, and seventh cervicals. This nerve is also called the

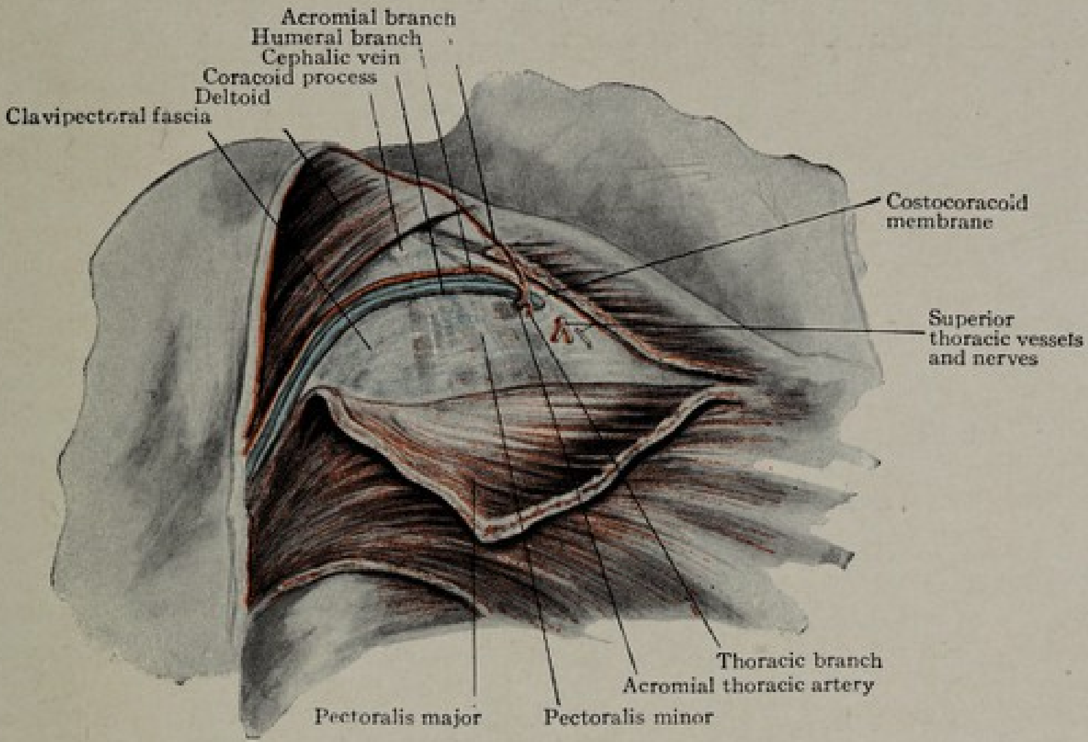


FIG. 218.—The clavipectoral fascia.

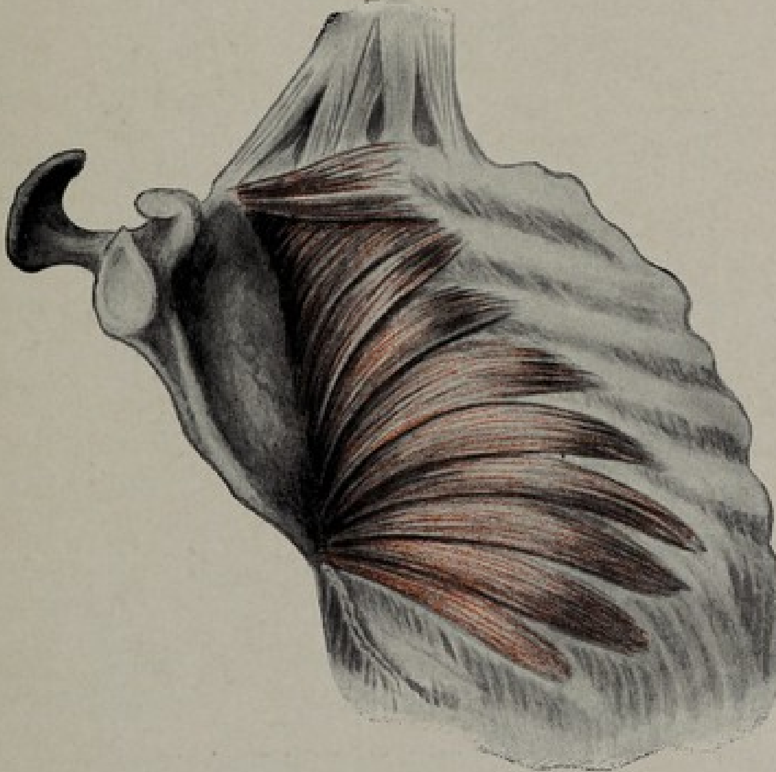


FIG. 219.—The serratus anterior muscle arising by ten digitations from the nine upper ribs.

long external respiratory nerve of Bell. The *internal respiratory nerve* is the *phrenic*, which comes from the third, fourth, and fifth cervical nerves. One of the main functions of this muscle is to keep the scapula applied to the chest and to aid in rotating it in elevation of the arm. When it is paralyzed the arm cannot be raised beyond a right angle and the scapula projects, particularly at its lower angle and posterior edge. This condition is called "*winged scapula.*"

The **trapezius** muscle (Fig. 220) has the shape of a triangle, its apex being out on the acromion process and its base in the median line. It arises posteriorly

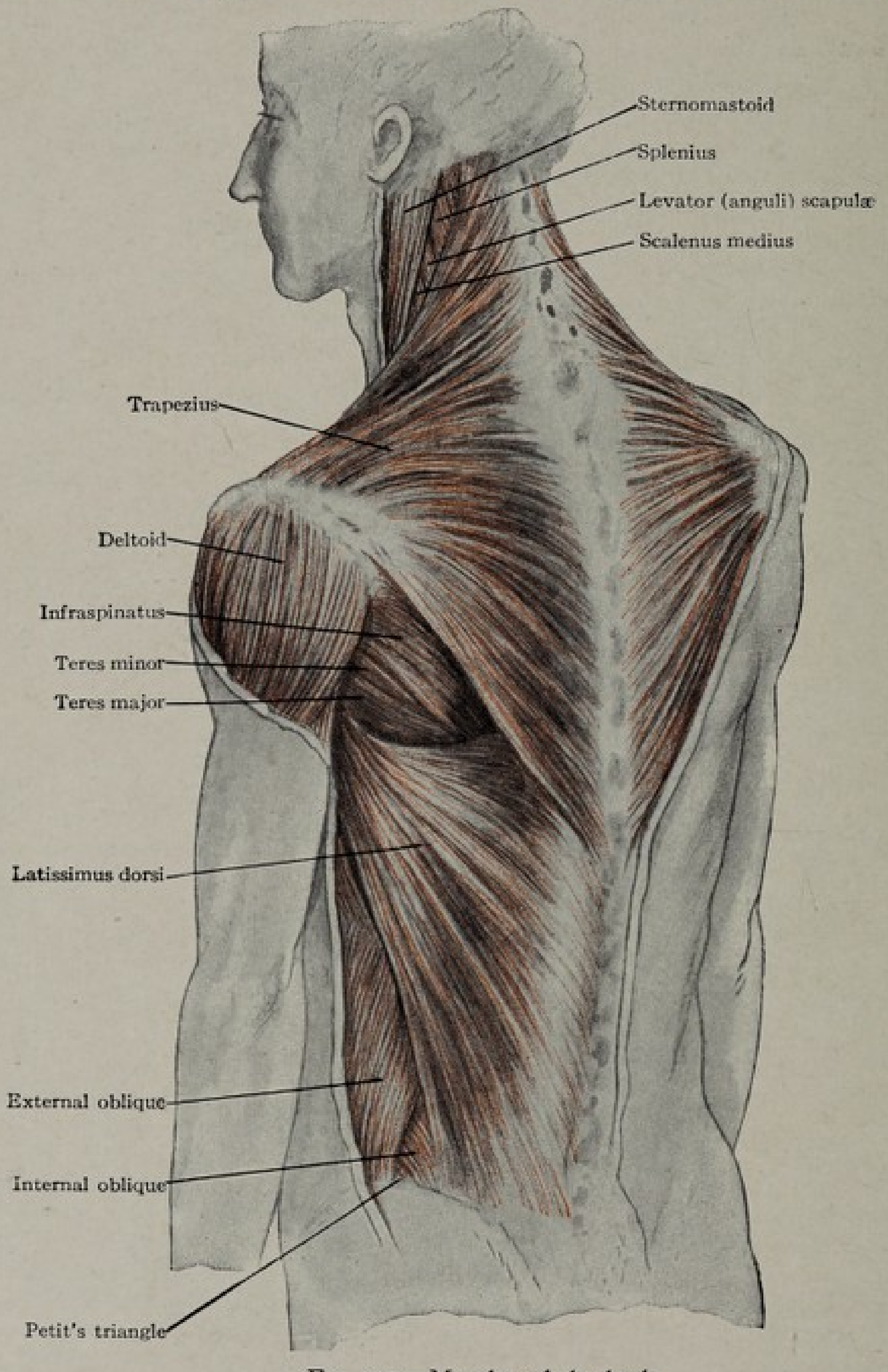


Fig. 220.—Muscles of the back.

from the inner third of the superior curved line of the occiput, the occipital protuberance, ligamentum nuchæ, and the spines of the cervical and all the thoracic vertebræ.

It inserts into the outer third of the clavicle and the acromion and spinous processes of the scapula. It aids in rotating the scapula and elevating the shoulder; its paralysis is followed by marked dropping of the shoulder. It is supplied by the *spinal accessory nerve*, which is sometimes injured in operations for tumors involving the posterial cervical triangle. Branches of the second, third and occasionally the fourth cervical nerves assist in this innervation and help to form the subtrapezial plexus.

The **latissimus dorsi** muscle arises from the spinous processes of the lower six thoracic vertebræ, from the posterior layer of the lumbar fascia, the outer lip of the posterior third of the iliac crest and by digitations from the lower three or four ribs. Sometimes it is attached to the angle of the scapula. It unites with the tendon of the teres major muscle to be inserted into the bottom of the bicipital groove and extends somewhat higher than the tendon of the pectoralis major. A bursa, which may become inflamed, sometimes lies between the muscle and the inferior angle of the scapula. The latissimus dorsi and teres major muscles form the posterior axillary fold.

The **erector spinæ** (sacrospinalis) muscle fills up the hollows on each side of the spinous processes. As the various muscular bundles are inserted into the vertebræ by innumerable small tendinous slips, in exposing the vertebræ in performing laminectomy it is necessary to cut them with a knife or scissors. One should not attempt to separate them by blunt dissection. These muscles become atrophied in cases in which the spine becomes distorted.

SURFACE ANATOMY OF THE THORAX

On looking at the chest one should note whether or not it appears normal. It may show the rounded form of emphysema or the flat form of phthisis. One side may be larger than the other, suggesting pleural effusion. The intercostal spaces

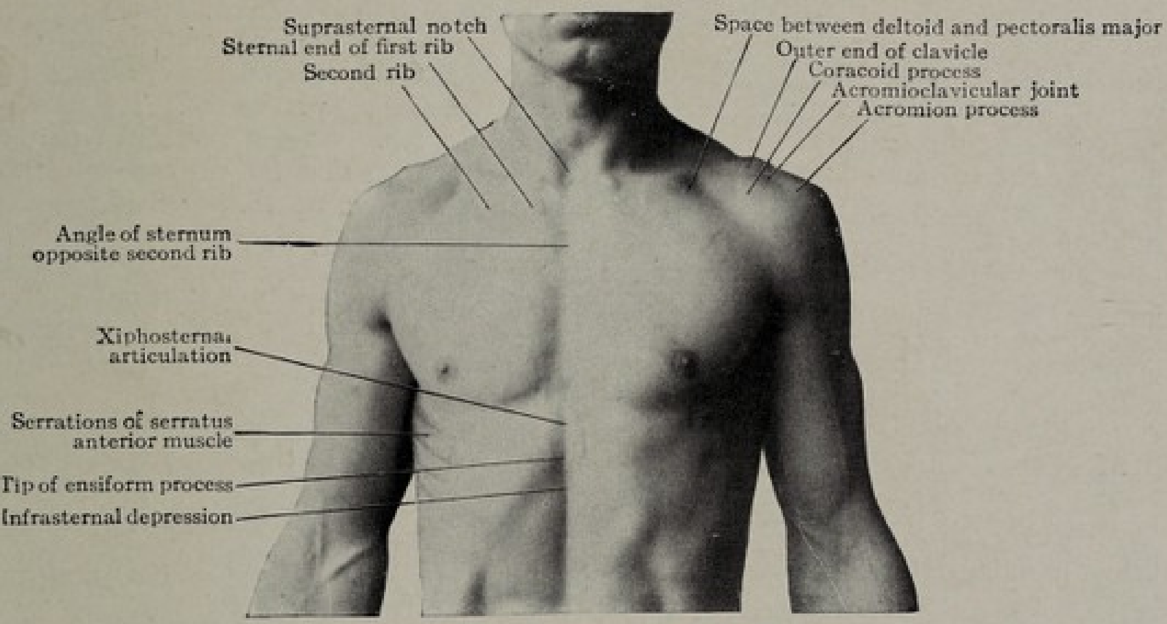


FIG. 221.—Surface anatomy of the thorax.

may be obliterated, indicating the same conditions. This may be local instead of over the whole chest. Note whether Harrison's groove, funnel and pigeon breast, or beading of the ribs, already described, are present. Aneurism affecting the great vessels may cause a bulging in the upper anterior portion, and cardiac disease may produce marked changes in the apex beat. This may be displaced to the right side by pleural effusion.

The clavicle belongs to the shoulder-girdle and hence will be described with the upper extremity. Both it and the sternum are subcutaneous and can readily be felt beneath the skin. The point of junction of the first and second pieces of the sternum is opposite the second costal cartilage. It forms a distinct prominence, which is readily felt and is a most valuable landmark. It is called the *angulus sterni* or *angle of Louis*. There is usually a palpable depression at the junction of the second piece of the sternum and the xiphoid cartilage.

The tip of the xiphoid or ensiform cartilage can be felt about 4 cm. below the joint between it and the second piece of the sternum. The top of the sternum is opposite the lower edge of the second thoracic vertebra. The angulus sterni is opposite the fifth vertebra, the lower end of the second piece of the sternum is opposite the tenth, and the tip of the ensiform cartilage is opposite the eleventh thoracic vertebra. There is usually comparatively little fat over the sternum, so that in fat and muscular people its level is below that of the chest on each side. Above its upper end is the *suprasternal notch or depression,* below its lower end is the *infrasternal depression* or *epigastric fossa,* sometimes called the *scrobiculus cordis.*

With the upper end of the sternum articulate the clavicles. The sternoclavicular joint possesses an interarticular cartilage between the clavicle and the sternum. This separates them sufficiently to allow the formation of a distinct depression, which can readily be felt. From the sternum to the acromion process the clavicle is subcutaneous. Below the inner end of the clavicle the first rib can be often seen and felt. At the middle of the clavicle it is so deep from the surface as not to be accessible and here the second rib is the one which shows just below the clavicle. In children the point of junction of the cartilages and ribs can often be distinguished; this is particularly so in cases of rachitis.

The line of junction between the body of the sternum and the ensiform cartilage can be distinguished, and to each side of it is felt the cartilage of the seventh rib, the last that articulates with the sternum. The tenth rib is the lowest which is attached anteriorly, the eleventh and twelth being shorter and floating ribs. The intercostal spaces are wider anteriorly than posteriorly and the third is the widest.

The nipple is usually in the fourth interspace or on the lower border of the fourth rib and on a line a little to the outer side of the middle of the clavicle. In women its position is variable, owing to the breasts being pendulous. The mammary gland reaches from the third to the seventh rib. As the pectoralis major muscle does not arise lower than the sixth rib it is seen that the mammary gland projects beyond it, an important fact to be remembered in operations for removal of the breast.

Immediately to the outer side of the upper edge of the pectoralis major, beginning at the middle of the clavicle and below it, is a hollow. This is the interval between the pectoralis major and deltoid muscles. At is upper end it is equal in width to one-sixth the length of the clavicle, because the deltoid is attached only to the outer third of the clavicle. Immediately beneath the edge of the deltoid muscle and about 2.5 cm. below the clavicle is the *coracoid process.* On abducting the arm the scapula is rotated and the serratus anterior muscle is put on the stretch; this makes its four lower serrations visible. The serration attached to the fifth rib is the highest, the sixth is the most prominent and extends farthest forward, while below are the last two attached to the seventh and eighth ribs. The operation of paracentesis, or tapping for pleural effusion, is most often done in the sixth interspace in the mid-axillary line. This will be about on a level with the nipple. The apex beat of the heart is felt in the fifth interspace, about 2.5 cm. (1 in.) to the inner side of the line of the nipple.

Running down behind the costal cartilages and crossing the intercostal spaces about a centimetre from the edge of the sternum is the *internal mammary artery.* When it reaches the sixth interspace it divides into the *superior epigastric,* which goes downward in the abdominal walls, and the *musculophrenic,* which passes to the attachment of the diaphragm along the edge of the chest.

THE MAMMA OR BREAST

The name mammary gland is often given to the breast, yet the latter is composed not only of glandular tissue but also of fibrous and fatty tissue, with the usual vessels, nerves, and lymphatics. In the male the glandular portion is undeveloped, the fat is relatively scanty, and the breast as a whole is insignificant and flat. In the virgin female adult it is more spheroidal. Above the nipple it is flattened and below it is rounded. Its general shape is circular and it covers the chest-wall from the upper border of the third rib to the sixth interspace. Laterally it reaches internally almost to the sternum and externally it overlaps the edge of the pectoralis major. It lies embedded in the superficial fascia. At an early period in the development of the embryos of pigs, cats, rabbits and many other mammals a slight ectodermal ridge can be seen, running along the side of the body from axilla to the groin. In 1905 Kallius and Brouha demonstrated these in the human embryo of 9 to 15 mm. At 26-60 mm. these lines disappear, being broken up into a series of points each forming a minute elevation through the accumulation of the ectodermal cells. These constitute the "anlagen" of the future mammary gland. The number of these "anlagen" in the human is always in excess of the number of mammary glands normal to the species, but a persistence of one may account

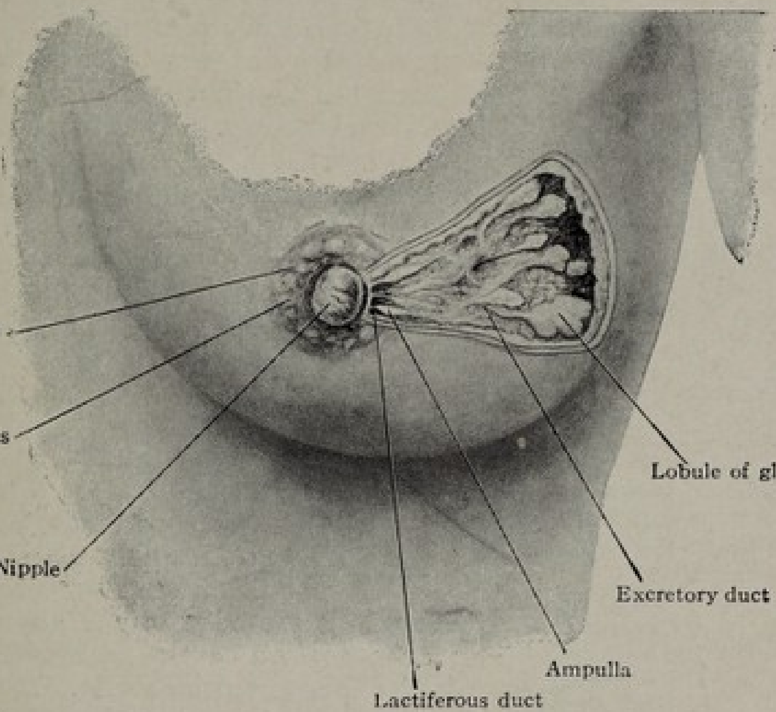


FIG. 222.—The secreting structure of the breast. (Piersol.)

for the supernumerary gland (polymastia) occasionally seen, while if the suppression of the "anlagen" be excessive there may be an absence of the gland (amastia). The mammary glands are included among the cutaneous glands and were formerly looked upon as enlarged and modified sebaceous glands. This conception has now been discarded and they are regarded rather as analogues of the sweat glands. Beginning by a finger-like growth from the skin it burrows its way into the superficial fascia. It becomes compound and sends its branches in various directions, especially does it extend deeper until finally it pushes away most of the fat and rests on the fascia covering the pectoralis major muscle. This is why we find almost no adipose tissue beneath the gland but mostly between the glandular structure and the skin and around its edges. The shape of the virgin breast is due mainly to its adipose tissue and not to its glandular structure. In those who have borne children the breasts become enlarged, lax, and pendulous. After lactation is completed they again retract but rarely regain their former shape. During lactation the fatty portion of the breast may disappear and leave it apparently in a shriveled condition, yet such a breast may be functionally quite active. Therefore the size of the breast is no criterion of its milk-producing powers.

The **secreting structure**, racemose in character, is divided into ten to sixteen lobules each of which has its duct. These lactiferous ducts begin in the acini and end in the nipple. Beneath the nipple they are dilated, each forming a sinus or ampulla. While the shape of the breast is regular in its outline the glandular tissue is not so. It possesses three projections or cusps. One of these projects inward nearly or quite to the sternum, while the other two project toward the axilla and side, one being lower than the other. These are the most common directions in which the glandular tissue is prolonged, but it may extend farther than usual in any direction; hence the wide incisions made in cases of carcinoma.

According to H. J. Stiles (1892), the secreting structure may extend posteriorly into the retromammary tissue between the layers of the pectoral fascia. Anteriorly it is prolonged with the fibrous tissue (*ligaments of Cooper*) almost to the skin.

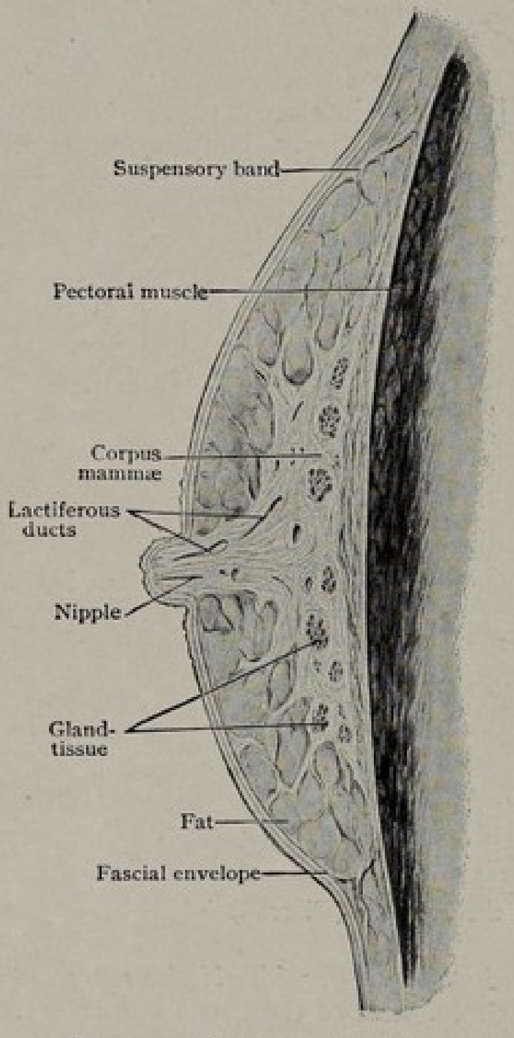


FIG. 223.—Sagittal section of mamma of young woman who had never borne children; hardened in formalin. (Piersol.)

The **nipple**, located below and to the inner side of the centre of the gland, has connected with it some circular and longitudinal unstriped muscular fibres. The longitudinal ones are attached to the lactiferous ducts and serve to retract the nipple, the circular ones to erect it. The erection of the nipple has no connection with the blood supply. The erection is frequently compared with the erection of cavernous tissues, but it is entirely due to the contraction of the circular muscle fibres at the base. Surrounding the nipple is the *areola*. It is pink in the virgin and about 2.5 cm. in diameter. After pregnancy its hue becomes brownish. The *tubercles of Montgomery* are the numerous elevations found on the areola. They are more or less modified sebaceous glands and enlarge during pregnancy. As they secrete a milky fluid, they are often regarded as accessory milk ducts. There is no fat in the nipple or areola.

The **fibrous structure** of the gland envelops the adipose and glandular tissue. It is simply a continuation of the fibrous septa of the superficial fascia. These septa are attached to the skin above, envelop and pass between the fatty and glandular lobules, and form a thin covering for the under surface of the gland. The breast is sometimes spoken of as having a capsule, but that simply refers to the fibrous tissue just described. Each duct is surrounded by a zone of connective tissue, the "peri-ductal tissue." This surrounds the ducts individually and collectively in each lobule. When carcinomatous invasion occurs in the region of the nipple these connective tissue strands are shortened and the nipple becomes retracted. The fibres that go to the skin have been named the ligaments of Cooper. The fibrous tissue forms a net-work which forms a support for the parenchyma, the blood vessels and lymphatics. The peri-ductal tissue is loose, soft and elastic which gives the firmness and shape to the virgin breast. In lactation, the fibrous tissue softens and stretches to accommodate the increase in the glandular structure and this, with the loss of fat, causes the breast to become lax and pendulous. In palpating a normal breast between the fingers and the thumb, this firmness may feel like a foreign growth; hence this method of examination is not to be relied on. A better way is to have the patient recline, and lay the fingers flat on the breast, compressing it on the chest-wall beneath. This flattens the glandular structure and any mass can be more surely detected.

The fibrous tissue between the glandular structure and the pectoralis beneath is quite thin and loose, with large spaces in it which have been called the *submammary bursa.* Pus readily spreads in this loose submammary tissue, but in the gland itself only with difficulty.

Blood Supply.—The breast is supplied with blood from above by the *pectoral branch of the acromial thoracic artery,* which leaves the axillary artery at the inner border of the pectoralis minor muscle. The pectoral branch descends between the pectoralis major and minor and anastomoses with the intercostals and long thoracic. It sends branches through the pectoralis major muscle, and in carcinoma of the gland it may be seen much enlarged running downward on the chest-wall beneath the muscle. From the inner side come the *perforating branches of the internal mammary artery* from the second to the sixth rib; the second, third, and fourth are the largest and may bleed freely in detaching the pectoralis major. To the outer side and below is the *long thoracic artery,* also called the deep external mam-

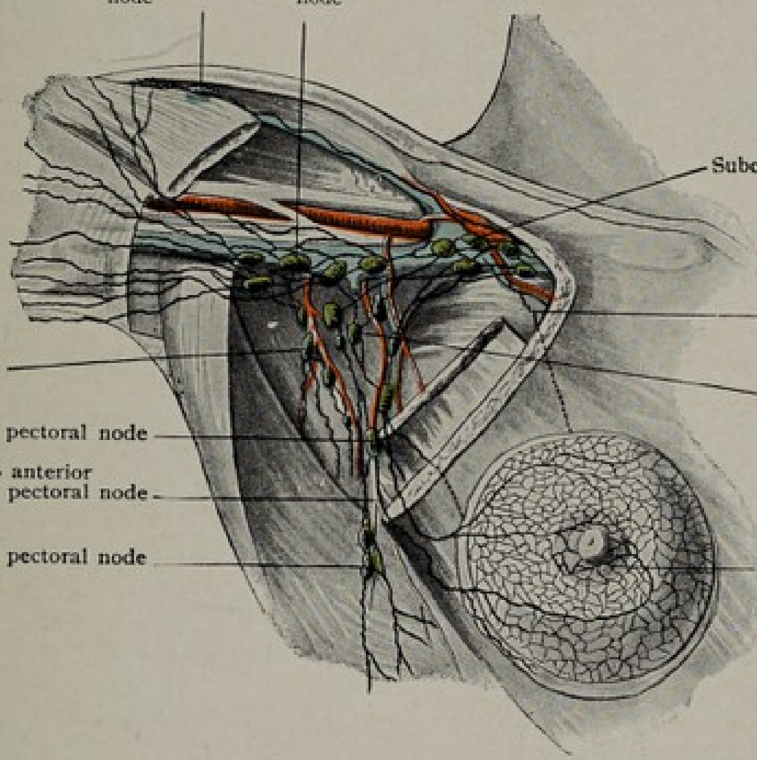


FIG. 224.—Lymphatics of the breast. (Poirier and Cunéo.)

mary; it descends along the outer edge of the pectoralis minor, sending branches inward around the edge of the pectoralis major to the mammary gland. The short thoracic or superficial external mammary and the superior thoracic also send branches to the gland. The *upper five* or *six anterior intercostal arteries* also contribute somewhat to the blood supply of the gland.

Lymphatics.—The breast is exceedingly well supplied with lymphatics. They are composed of a *deep* set around the lobules and ducts, and a *superficial* set which together with the deep lymphatics forms a plexus around the nipple called the *subareolar plexus.* They drain mainly toward the axilla into the lymph-nodes along the edge of the pectoralis major but also communicate with the nodes around the subclavian artery and those in the anterior mediastinum which accompany the internal mammary artery.

The *axillary nodes* are in three sets: one along the edge of the pectoralis major muscle (*pectoral nodes*), another further back along the anterior edge of the scapula (*scapular nodes*), and a third following the course of the axillary artery (*humeral nodes*). In addition to these there are some *infraclavicular* or *subclavian nodes* between the deltoid and pectoralis major and at the inner edge of the pectoralis minor muscles; these are comparatively rarely involved primarily. The axillary nodes are continuous and communicate with the subclavian and supra-clavicular nodes, and these latter are frequently enlarged subsequent to the axillary infection. The anastomosis of the lymphatics across the median line has been thought to account for the occurrence of the disease in the opposite breast or axilla. As shown by Sappey, some if not all of the lymphatics of even the sternal portion of the breast drain into the axilla and not into the anterior mediastinum, thus accounting for the axillary involvement when the inner portion of the breast is affected. These five sets of nodes communicate with each other, and any one may be alone involved. The supraclavicular set do not become involved primarily because no vessels run directly from the breast to them; they are affected secondarily to involvement of the axillary or subclavian sets. Mornard's investigations on the relation of the breast lymphatics are important. His deductions were drawn from fifty bilateral injections done by the Gerota method. Five types of lymphatic drainage to the sub- and supra-clavicular and axillary nodes were distinguished.

Fig. 225a illustrates the method which is usually spoken of as the classical pathway. In this type three to five lymphatic trunks leave the outer and lower border of the breast and reach the central set of nodes along the axillary vein. To reach these nodes the trunks pass through a set of nodes along the lower border of the pectoral muscles. Mornard found that when his injections reached beyond the pectoral and humoral nodes the injecting fluid sometimes reached the subclavicular or at times the supraclavicular nodes, but this was not frequent by this route. Furthermore, although this route is looked upon as the usual avenue for metastasis Mornard was only able to demonstrate it twelve times in both breasts and forty-five times in the hundred breasts.

Fig. 225b illustrates the second type demonstrated. Here the trunks lead to the humeral or outer axillary chain. In twelve of the hundred injections a direct trunk from the outer lower border of the breast passed along the lower edge of the pectoralis major muscle and emptied into one of the central nodes.

Fig. 225c demonstrates a third type where two lymphatic trunks, the axillary and subclavian were found. These may be completely independent. This was the most frequent type demonstrated, being found on both sides in twenty-seven of the fifty subjects. One of the trunks is the so-called classical one, while the other consists of two or three small trunks which arise from the superior and medial aspects of the breast and proceed to the subclavicular nodes beneath the pectoralis minor. In this type the only barrier to the supraclavicular metastasis is the few subclavicular nodes.

Fig. 225d shows the lymphatic trunks which run between the pectoralis major and minor. This type resembles type 3 but differs from it in that the trunks to the subclavicular lymph nodes pass between the muscles instead of under them.

Fig. 225e illustrates type 5. It is rare, being found in only three of the 100 injections. It, however, demonstrates that the supraclavicular nodes occasionally have a direct connection with the breast. By this route, supraclavicular metastasis may occur even before axillary metastasis.

The deep lymphatics of the breast, according to Sappey, follow the ducts to the areola, there anastomosing with the superficial lymphatics to form what he called the *subareolar plexus*, which drains by two trunks into the axilla. The lymphatics of the breast anastomose with those of the surrounding structures; hence in certain cases the pectoralis muscles and even the pleura may be affected, and when the disease is widely disseminated by the lymph-channels on the chest-walls there is produced the thickened, brawny, infiltrated condition known as the cancer *"en cuirasse"* of Velpeau.

Nerves.—The breast and the skin over it are supplied from the descending branches of the cervical plexus, by thoracic branches from the brachial plexus, and by the anterior cutaneous branches of the third, fourth, and fifth intercostal nerves and the anterior divisions of the lateral cutaneous branches of the same nerves. These are not of so much practical importance as the lateral branches of the second

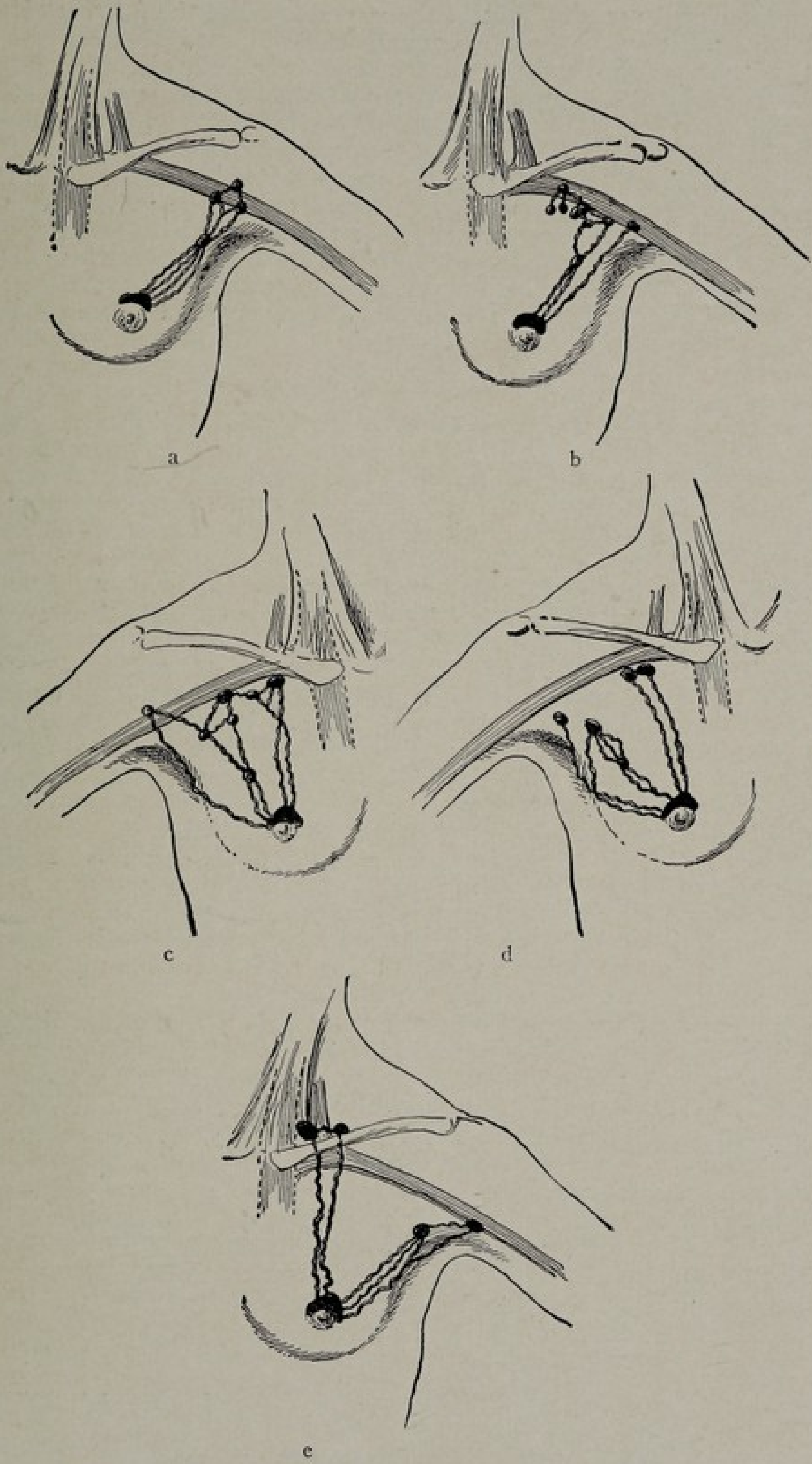


FIG. 225.—Five variations of the classical pathway. (Mornard.)

and third intercostal nerves. That of the second is called the *intercostobrachialis* (*humeral*) *nerve;* it crosses the axilla, anastomoses with the *medial brachial* (*lesser internal*) *cutaneous nerve,* and supplies the skin of the inner and upper portion of the arm. The third intercostal anastomoses with the second and gives a branch to the arm and to the dorsum of the scapula. It is this connection of the intercostals with the median brachial which accounts for the radiation of pain, in breast lesions, down the inner side of the upper extremity. Such pain frequently denotes axillary involvement. These nerves are certain to be seen in clearing out the axilla. Their division is accompanied by no paralysis, but disturbance of them accounts for some of the pain and discomfort following the operation. The parenchyma is poorly supplied with sensory nerves which accounts for the absence of pain in early breast tumors. The nipple is highly supplied thus explaining the severe pain associated with fissured nipple.

Abscess of the Breast

Suppuration in the mammary gland is usually due to infection which has entered the gland either through the lymphatics or the lactiferous ducts. The starting point of the infection is thought to be an ulcerated crack or fissure of the nipple. Infection travelling into the gland by way of the lymphatics would cause pus primarily in the pericanalicular tissue but it would soon involve the lactiferous ducts and then pus might exude from the nipple. Infection travelling up the ducts might reach the ultimate lobules and therefore give rise to widespread and multiple abscesses. Suppuration in this gland resembles that in the parotid gland, already described. When the body of the gland is involved it is apt to be so in more than one spot. The infection follows the branching of the ducts and usually there are several small abscesses instead of one large one. If there is a large collection of pus it is not contained in one cavity but more likely in several. This is so often the case that in treating these abscesses it is advised that they should not only be incised but the finger should then be introduced and the partitions separating the various abscess cavities broken through.

In its incipiency a lymphatic infection may cause a single collection of pus, but this soon breaks through into the canaliculi and infects and involves the glandular structure. In an early stage of duct infection several inflammatory areas may start up about the same time. The pus soon breaks through the canaliculi and involves the periglandular tissue so that in each mode of infection the condition soon becomes the same. It is for this reason that it is difficult to say whether the infection originated in the lymphatics or the ducts.

When the ducts are inflamed the pus often finds a vent at the nipple. The frequency of this is the reason why direct infection of the ducts is regarded as the more common mode. In incising a mammary abscess the incisions should follow the course of the ducts, that is, they should be made in a direction radiating from the nipple towards the circumference and not transversely, otherwise healthy ducts will be divided.

Submammary Abscess (for subpectoral abscess see page 302).—As has been pointed out some of the glandular tissue dips down to the pectoral fascia, hence when some of these deepest lying lobules are inflamed the pus instead of breaking laterally into the adjoined lobules or tissue breaks into the submammary tissue and bursa. Here it spreads rapidly beneath the gland and raises the gland above it. As the pus accumulates it sinks downward and works its way outward to the lower outer quadrant along the edge of the anterior axillary fold. Here is where it should be opened. As the cavity is single one incision is sufficient to drain it.

Tumors of the Mammary Gland

Benign Tumors.—The benign tumors of the mammary gland are mostly either fibrous or cystic. The former are usually called *fibro-adenomata* and consist of a more or less circumscribed mass of periductal connective tissue enclosing typical acini. A true *adenoma* is quite rare. Sometimes cysts are encountered which contain in their walls papillary ingrowth. These are termed *papillary cystadenomata.*

Cystic growths may result from retention of secretion of the ducts and then occur as small rounded tumors painful and tender to the touch. More usually, however, such cysts are part of a diffuse disease usually termed *chronic cystic mastitis*, or better, *abnormal evolution.* The disease results from the failure of the lactating breast to involute properly after the milk secretion has ceased or in the case of the non-lactating woman, to some local stimulus which provoks evolution. The entire breast is studded with small shot-like cysts, both breasts are frequently involuted, and pain is often experined. Th *blue-domed cyst* of Bloodgood belongs to this group. The affection in itself is not malignant but is usually believed to be precancerous.

Malignant Growths.—The malignant growths of the breast are either carcinomata or sarcomata.

Carcinomata originate from the epithelium lining the ducts and acini, and spreads in a radiating direction but most rapidly along the lines of least resistance.

Handley (1904) claims that the principal method of dissemination of carcinoma of the breast is not by the lymph stream or blood current but by spreading peripherally along the coarser meshes of the lymphatic channels which exist in the deep pectoral fascia. These are continuous downward with the surface of the recti muscles. The gross pathologic appearance depends to a large extent upon the degree of *fibrosis present.* Scirrhous cancer is that form in which the fibrosis is developed to the greatest extent. Medullary or encephaloid is that in which the tumor is made up almost exclusively of cancer cells. Between the two, pathologists are accustomed to group the carcinoma *simplex.* Colloid (mucoid) degeneration may be seen.

As breast cancer extends in a radiating direction it sooner or later involves not only the axillary lymph nodes but also readily involves the pectoral fascia covering the pectoralis major muscle. Anteriorly, the ligaments of Cooper may become contracted producing the well-known retraction of the nipple and dimpling of the skin.

The most important aspects of the spread of breast cancer are the lymphatic routes. These follow the fibrous and canalicular structure, therefore on section the cancerous tissue can be seen extending like roots into the surrounding gland. This tissue shrinks, contracts, and becomes harder as the disease progresses, that is why retraction of the nipple and dimpling of the skin occurs. The most free lymphatic drainage occurs toward the axilla, not toward the mediastinal nodes. The first nodes to show infection are those lying along the edge of the pectoralis major muscle about the level of the third rib. Later, the nodes at the anterior edge of the scapula accompanying the subscapular artery become involved, or those along the axillary vessels. Still later those along the subclavian vessels may be enlarged and may be felt above the clavicle and further inward behind the sternomastoid muscle low down.

In rare instances the disease may be carried superficially to the subclavian nodes in the infraclavicular triangle between the deltoid and pectoralis major muscles. Should the disease spread, it may be carried by the lymphatics to the opposite breast directly across the median line. If it involves the lymphatics of the chest-wall generally there is produced the brawny condition of the skin called cancer *"en cuirasse"* of Velpeau already alluded to. A cancerous nodule beyond the edge of the pectoralis major muscle is not necessarily an enlarged node, but may be due to the involvement of one of the cusps of the gland, which sometimes extend even into the axilla.

Removal of the Cancerous Breast.—Theoretically, a patient suffering from breast cancer could be cured always if the primary growth and its extensions were completely removed. This has led to the performance of very extensive operations.

The type of incision is unimportant provided that it is so planned as to give access to the axilla and allow closure at the completion of operation. The oblique incisions of Halsted, Handley, and others share popularity with the incisions of Rodman, Jackson and Stewart. The circle of skin removed need not be more than five inches in diameter centered on the growth, but the underlying fascia must be removed for a distance equivalent to a ten inch circle centred on the growth.

Usually both the pectoralis major and minor muscles are removed. In excising them the slight interspace between the clavicular and sternal fibres of the pectoralis major muscle is entered and the muscle detached from the anterior extremities of the ribs and sternum. In so doing the anterior intercostal arteries, particularly those of the second, third, and fourth spaces, are liable to bleed freely. As the pectoralis major is detached and turned outward, the acromial thoracic artery is seen at the inner edge of the pectoralis minor muscle with its pectoral branch running down the surface of the chest. This may be ligated, the finger slipped beneath the pectoralis minor, and this muscle cut loose from the caracoid process above and the third, fourth, and fifth ribs below. At this stage some operators clear the subclavian and axillary vessels of all loose tissues and lymph-nodes.

The vessels are followed out on the arm. When the insertion of the pectoralis major is reached it is detached and the whole mass turned outward and pared loose along the anterior edge of the scapula. Thus it is removed in one piece. The part of the chest-wall which has been cleared off embraces from the middle or edge of the sternum to the anterior edge of the scapula and from near the lower edge of the chest below to the clavicle above. Handley advised that the lower end of the usual skin incision be prolonged downward and inward so "that every particle of the origin of the great pectoral from the rectus sheath, and the surface of the latter, on both sides of the middle line, should be most carefully cleared" as far as two or three inches below the tip of the ensiform cartilage. The vessels have been cleared off from the insertion of the axillary folds on the arm to underneath the clavicle. Some operators make an additional incision above the clavicle and clear out the supraclavicular fossa even if no enlarged glands can there be detected. Sometimes the long thoracic artery and thoracicalis longus (long external thoracic) nerve of Bell may be wounded, but they need not be.

Two nerves will be seen crossing the axilla from the chest to the arm. They are the lateral branches of the second and third intercostal nerves. The second is called the intercostobrachialis (humeral) nerve. If they conveniently can be spared it should be done, otherwise they are divided. In clearing the axillary vessels, small veins and even arteries may be divided close to the main trunks. These may be expected to bleed freely but are usually readily secured. Care should be taken not to wound unnecessarily the subscapular artery and particularly the vein as they wind around the anterior edge of the scapula 2 to 3 cm. below its neck.

THE MEDIASTINUM

The mediastinum is the middle space of the chest between the spine behind, the sternum in front, and the pleuræ to each side. It is subdivided into a *superior mediastinum*, which is the part above Ludwig's angle, between the first piece of the sternum in front and the vertebræ from the first thoracic to the upper portion of the fifth behind. The part below is divided into the *anterior mediastinum*, the *middle mediastinum*, and the *posterior mediastinum*.

Superior Mediastinum.—The upper level of the superior mediastinum is oblique, as it runs from the upper edge of the sternum to the first thoracic vertebra. The lower level of the superior mediastinum runs from the junction of the first and second pieces of the sternum to the upper border of the fifth (or lower border of the fourth) thoracic vertebra. Laterally it is bounded by the pleuræ and apices of the lungs.

The distance from the anterior surface of the spine to the posterior surface of the sternum is quite small, being only 5 to 6 cm. (2 to 2¼ in.). Through this pass most important structures. The *trachea* and *œsophagus* are in the median line as well as the remains of the *thymus gland*. To each side are the great vessels, the *innominate artery* being on the right and the *subclavian* and *carotid* on the left. The *left innominate vein* crosses transversely just below the top of the sternum to meet the *innominate vein of the right side* and form the *superior vena cava*. Into the innominate veins empty the *inferior thyroid, vertebral, superior intercostal, internal mammary* and *pericardial veins;* and into the descending vena cava empties the *vena azygos major*. On the posterior surface of the œsophagus and afterwards to its left side passes the *thoracic duct*. The trachea bifurcates opposite the junction of the first and second pieces of the sternum, and the transverse portion of the arch of the aorta rises as high as the middle of the manubrium. The *phrenic nerves* lie against the pleura, the right having the vena cava to its inner side.

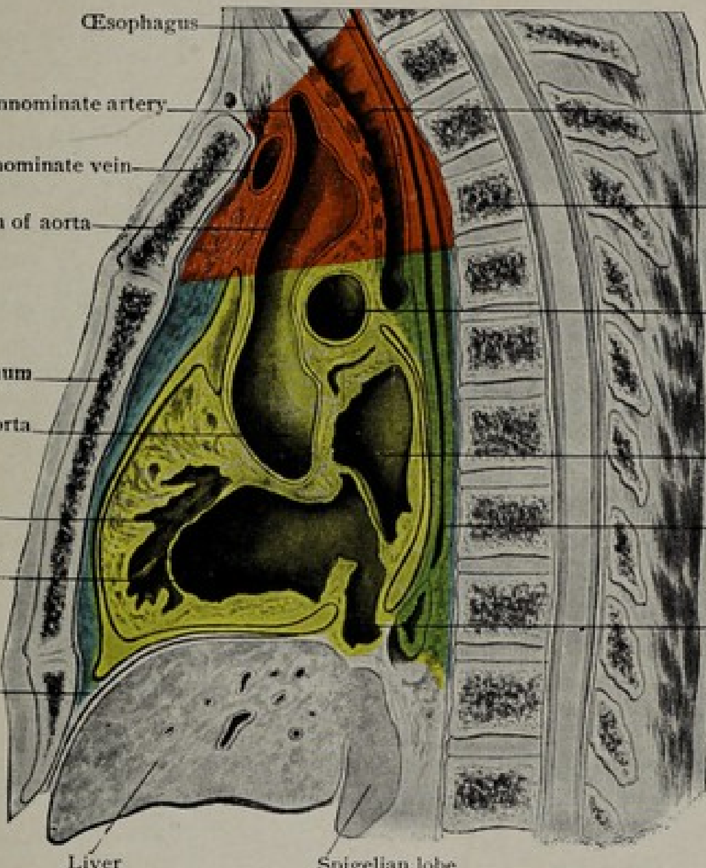


FIG. 226.—The superior (red), anterior (blue), middle (yellow), and posterior (green), mediastina. (Modified from Piersol.)

The *right vagus (pneumogastric) nerve* comes down between the innominate artery and vein and passes downward on the posterior surface of the œsophagus. It gives its recurrent laryngeal branch off at about the right sternoclavicular joint. The *left vagus nerve* comes down to the outer side of the left carotid artery and goes over the arch of the aorta, giving off its recurrent laryngeal branch, and thence proceeds to the anterior surface of the œsophagus. The presence of the trachea in the median line and the edges of the lungs which meet opposite the second rib give a resonant percussion note to the first piece of the sternum. With all these important structures crowded in the small space between the vertebræ and sternum it is easy to see why tumors in this region should cause serious symptoms. Notwithstanding this I have within the last year successfully removed several tumors in this region.

Aneurism involving the arch of the aorta and the great vessels is common. *Tumors,* such as sarcoma, carcinoma, and glandular, though rare, do occur. *Abscess* from high dorsal Pott's disease has been known to cause serious effects.

The symptoms of all these affections resemble one another to a considerable extent. Interference with the blood-current, usually in the veins, almost never in the arteries, is marked. Alteration in the voice is produced by pressure on the recurrent laryngeal nerves. Dyspnœa from the pressure on the trachea and difficulty in swallowing also occur, as well as interference with the circulation and the action of the heart. The presence of growths in this region is indicated also by the presence of dulness over the region of the manubrium.

Anterior Mediastinum.—This is the space below the second costal cartilages, between the sternum in front, the pericardium behind, and the two pleuræ on the sides. It is only a narrow slit in the median line above from the second to the fourth costal cartilage; from here the right pleura is prolonged obliquely down and outward to the seventh costal cartilage, which it follows. On the left side the pleura

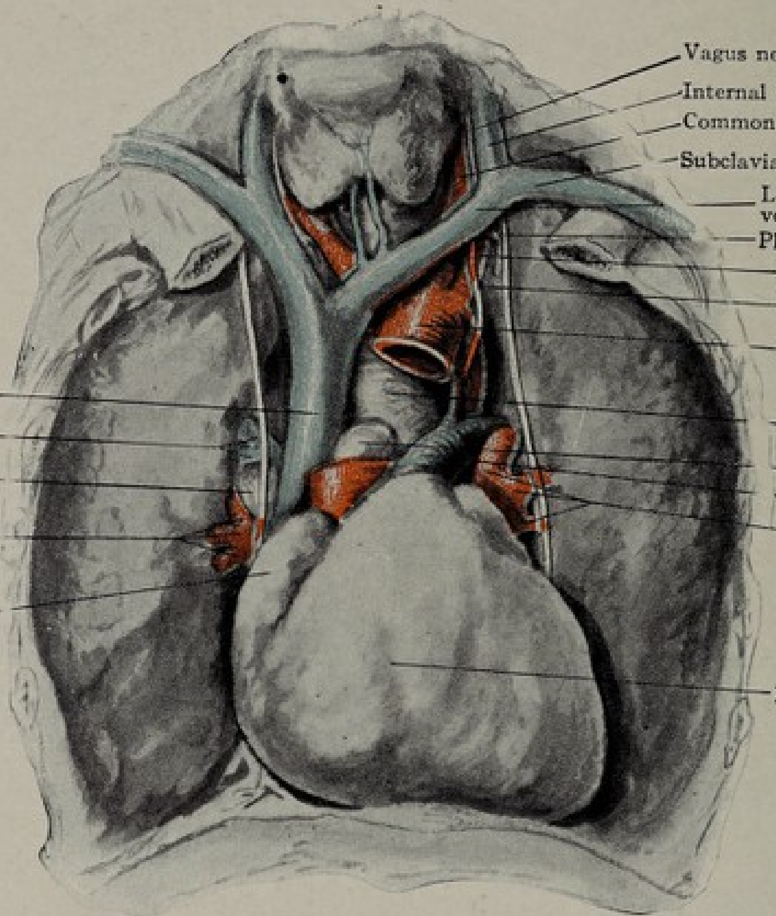


FIG. 227.—Contents of the mediastina viewed from the front.

leaves the median line about the fourth cartilage and passes out about 2 cm. to the left to the sternum and then down to the seventh costal cartilage, which it follows. The *triangularis sterni muscle* arises from the under surface of the lower third of the sternum and from the xiphoid cartilage and passes upward and outward to insert into the costal cartilages of the second to the sixth ribs inclusive. The *muscle* lies in front of the anterior mediastinum and the *internal mammary artery* runs down between it and the bone about 1 cm. distant from the edge of the sternum. There are a few lymphatic nodes in the anterior mediastinum on the diaphragm below and in the superior mediastinum on the arch of the aorta and left innominate vein above. A chain of nodes also accompanies the internal mammary artery along the edge of the sternum between the pleura and chest wall.

Abscess of the anterior mediastinum may result from infection due to injury to punctured wounds. It may break into the pleuræ on the sides, into the pericardium posteriorly, work its way down toward the abdomen, or point in the intercostal spaces at the edge of the sternum.

Paracentesis pericardii is performed in the sixth innerspace close to the sternum; also, the fifth and sixth cartilages may be resected, the internal mammary artery ligated, and the pericardium opened and even drained.

If one attempts to pass a trochar into the pericardium by a puncture through the fifth or sixth innerspace sufficiently far out to avoid wounding the internal mammary artery the pleura is apt to be wounded, as it passes further toward the median line than does the lung.

The Middle Mediastinum.—The middle mediastinum is limited in front by the anterior wall of the pericardium and behind by the posterior wall of the pericardium and roots of the lungs. It contains the *heart* with the lower half of the *descending vena cava* and the *vena azygos major* emptying into it, and the *ascending aorta;* also the structures forming the roots of the lungs, viz., the *right* and *left bronchi,* and the *pulmonary arteries* and *veins.** The *phrenic nerves* lie between the pericardium and pleuræ anteriorly.

The *bronchial lymphatic nodes* are numerous between the structures forming the roots of the lungs. It is these nodes that are so often enlarged in diseases of the

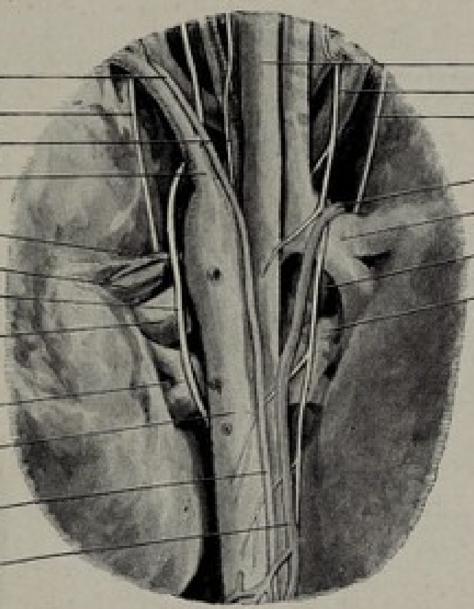


FIG. 228.—Contents of the mediastina viewed from the rear.

lungs. They are affected in malignant disease as well as in tuberculosis, etc. Enlargements of the heart pressing on the vessels, particularly the vena azygos major, are sometimes thought to cause pleural effusions, especially if one-sided.

When the pericardium is distended with fluid it enlarges more in an up and down direction, but when the heart is enlarged its size increases mainly laterally—from side to side.

Posterior Mediastinum.—The posterior mediastinum extends from the pericardium and roots of the lungs anteriorly to the vertebræ posteriorly. The pleuræ are on each side. Behind the pericardium runs the *œsophagus,* lying in front of the *aorta,* which rests on the vertebræ. In the chink between the aorta and bodies of the vertebræ lies the *thoracic duct* and immediately to its right side is the *vena azygos major.* The *vena azygos minor* is on the left side of the vertebræ and crosses the sixth to join the vena azygos major. The *descending portion of the arch and the thoracic aorta* are not infrequently the seat of aneurism.

Mediastinal Tumors.—Malignant growths are more common than benign and secondary tumors more common than primary. Hodgkin's disease, tuberculosis and syphilis, may occur also. These tumors give rise to pressure symptoms. Dyspnœa

* The mediastina are arbitrary divisions, and it is a question as to whether the roots of the lungs should not be included in the posterior instead of the middle mediastinum.

may be due to pressure on the trachea or heart and great vessels. The circulation may be so much impeded that the enlargement of the collateral veins, especially those of the surface, may be very marked. There may also be difficulty of swallowing due to pressure on the œsophagus. Their removal is now a surgical possibility.

THE CHEST CONTENTS

For the sake of convenience in description and record, the chest has been divided into various regions and marked by certain longitudinal lines.

The Longitudinal Lines

Seven longitudinal lines are used. They run parallel with the long axis of the body.

1. The **median line** means the midline of the body. This runs down the middle of the sternum anteriorly and the middle of the back posteriorly.
2. The **parasternal line** runs parallel to the edge of the sternum and midway between it and the midclavicular line.
3. The **midclavicular line,** also called the **mammary line,** is a longitudinal

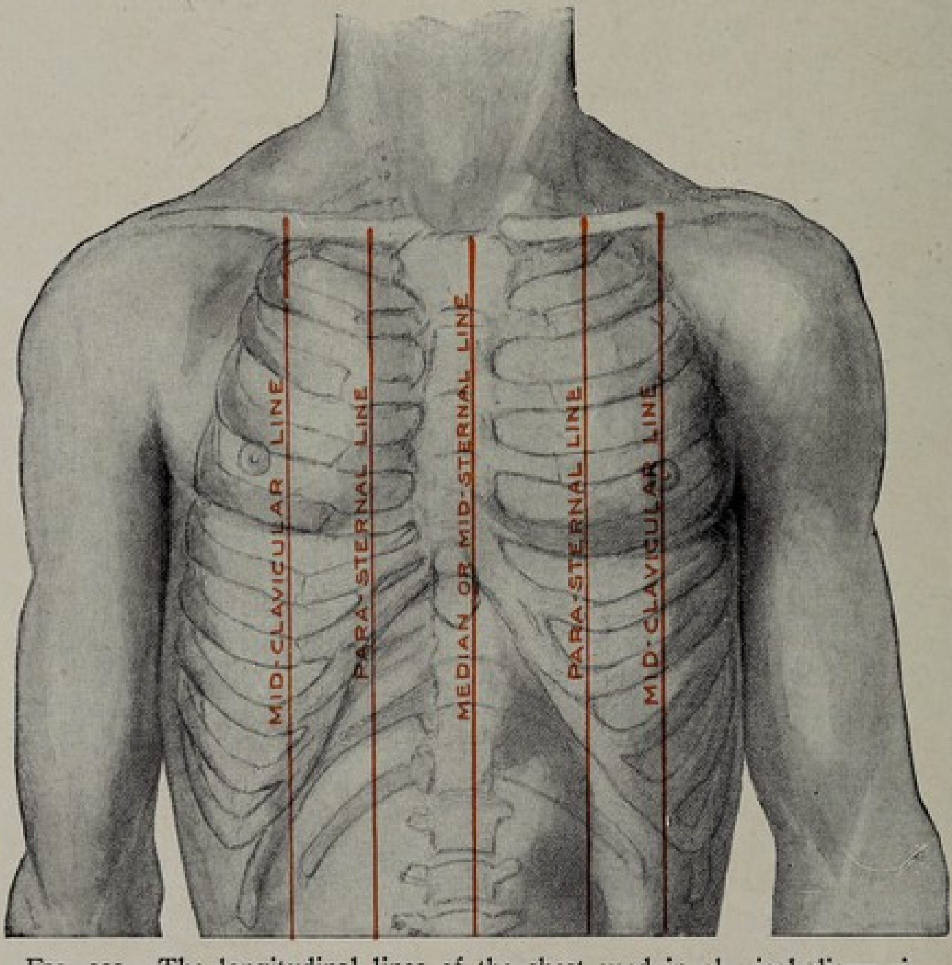


Fig. 229.—The longitudinal lines of the chest used in physical diagnosis.

line passing through the middle of the clavicle. This usually passes 1 to 2 cm. internal to the nipple.

4. The **anterior axillary line** passes through the anterior fold of the axilla.
5. The **midaxillary line** passes through the middle of the axilla.
6. The **posterior axillary line** passes through the posterior fold of the axilla.
7. The **scapular line** passes longitudinally through the lower angle of the scapula.

The Regions of the Chest

In the middle of the surface of the chest anteriorly there are three regions:

1. The **suprasternal region** is the part above the sternum between the sterno-mastoid muscles. It is the suprasternal notch.

2. The **upper sternal region** extends from the suprasternal notch to a line drawn opposite the third costal cartilages.

3. The **lower sternal region** is behind the second piece of the sternum from the third costal cartilages down.

Anteriorly on the chest there are four regions (Fig. 230):

1. The **supraclavicular region**, above the clavicle. This includes the supra-clavicular fossa.

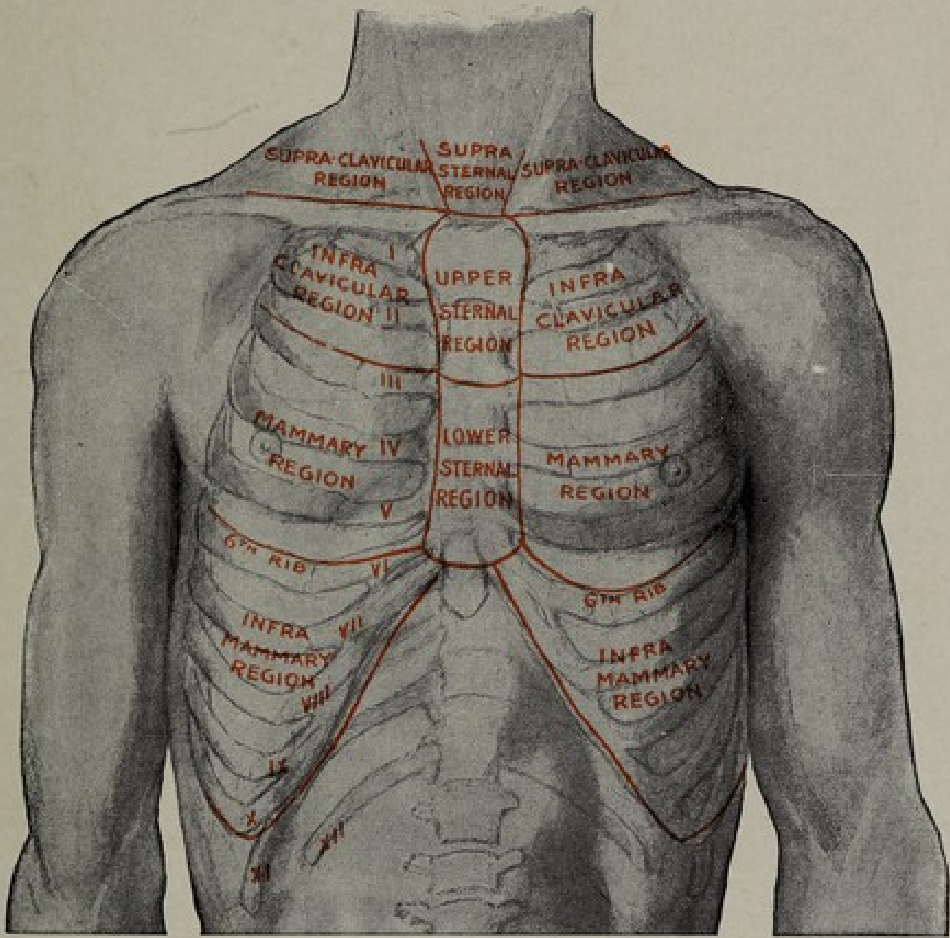


Fig. 230.—The anterior regions of the chest.

2. The **infraclavicular region**, below the clavicle down to the upper edge of the third rib.

3. The **mammary region**, from the upper edge of the third to the upper margin of the sixth rib. This extends from the edge of the sternum to the anterior axillary fold and has the nipple nearly in its centre.

4. The **inframammary region** extends from the upper margin of the sixth rib to the lower margin of the thorax.

Laterally on the chest between the folds of the axilla there are two regions:

1. The **upper axillary region** extends down to the upper border of the sixth rib.

2. The **lower axillary region** extends from the upper border of the sixth rib to the lower edge of the thorax.

Posteriorly there are four scapula regions (Fig. 231):

1. The **suprascapular region** is above the spine of the scapula.

2. The **scapular region** is the part covered by the body of the scapula below its spine.

3. The **infrascapular region** is the part of the chest below the scapula between its angle and the lower edge of the chest.

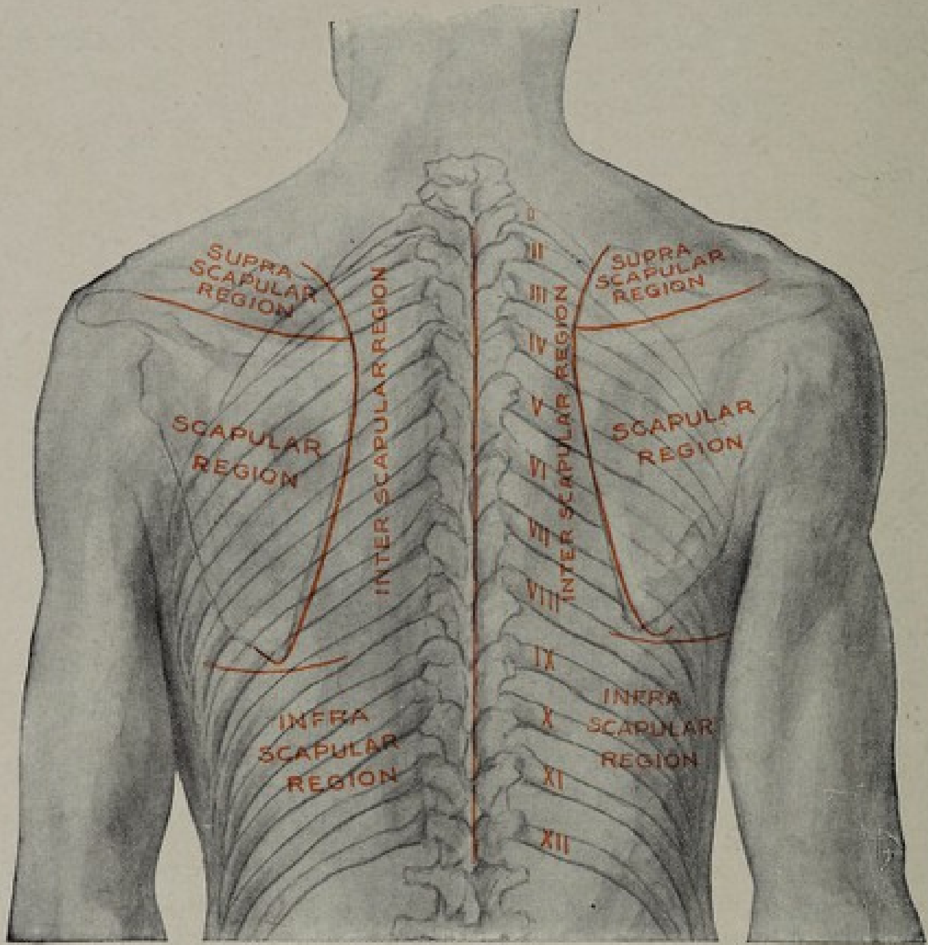


FIG. 231.—The posterior regions of the chest.

4. The **interscapular region** is the part between the posterior edge of the scapula and the median line.

THE PLEURÆ

The pleuræ form closed sacs which line the thorax (parietal pleura) and cover the surface of the lungs (visceral pleura). As the lungs expand and contract, the pleuræ are only completely in contact with the lungs when the latter are fully distended. In ordinary breathing the lungs are not completely expanded, hence the edges of the pleuræ fall together and so prevent the formation of a cavity. This collapsing of the pleuræ takes place mainly along its anterior and lower edges. The apex of the pleura is prevented from collapsing by its attachment to the first rib, and also, as pointed out by Sibson, by the attachment to it of an expansion of the deep cervical fascia and some fibres of the scalenus anticus muscle. Posteriorly the chest wall is unyielding. Anteriorly when the lungs are collapsed they fill out the pleuræ as low down as the fourth costal cartilage; below that, in front of the heart, a space or sinus is left unoccupied by lung. It is called the *costomediastinal sinus*. Likewise between the diaphragm and chest-walls is another space, in which the parietal or costal and visceral layers of the pleura are in contact, called the *costophrenic sinus* or *complemental space of Gerhardt.* From these facts it follows that the outlines of the pleuræ and lungs are identical posteriorly, superiorly, and anteriorly, as low as the fourth costal cartilage. Here they diverge, the pleuræ descending lower than the lungs.

The top of the pleura is about on a plane with the upper surface of the first rib. This makes its posterior portion at the head of the first rib 5 cm. higher than its anterior portion at the anterior end of the first rib. The upper border of the clavicle is level with a point midway between the anterior and posterior ends of the first rib. This, therefore, shows the pleura to extend 2.5 cm. (1 in.) above the level of the upper surface of the clavicle.

The top of the pleura does not project into the neck in the form of a cone, but resembles a drum-head, being stretched in the form of a plane almost or quite level with the top of the first rib. Its upper surface is strengthened by fibres from the

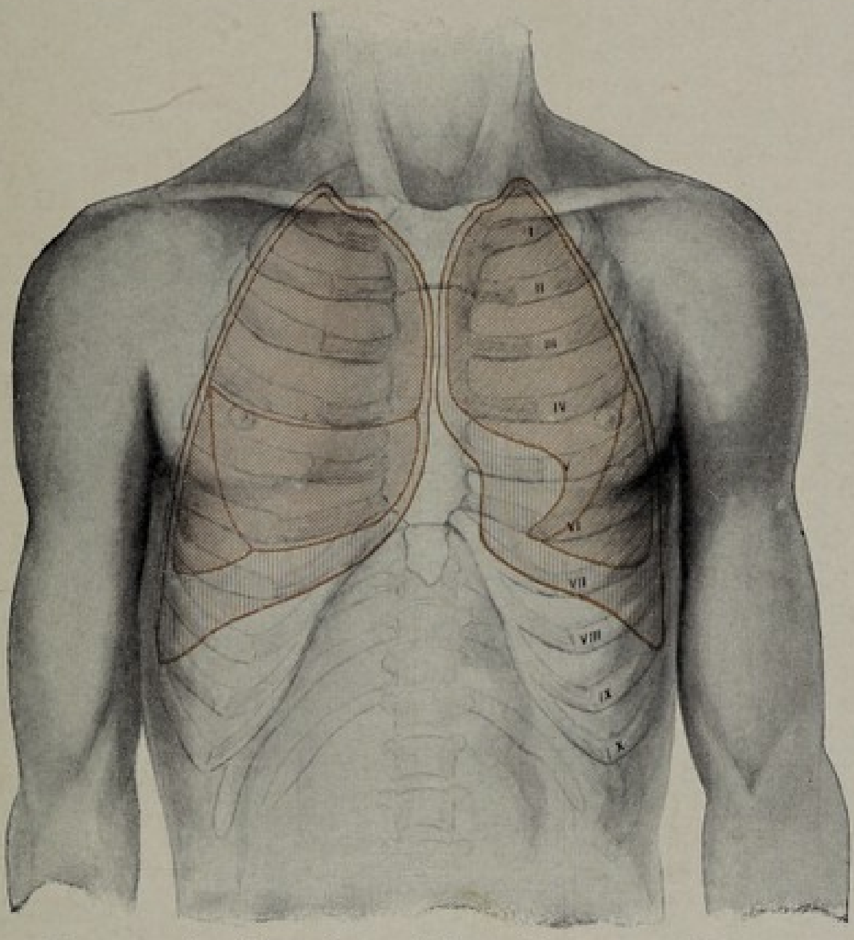


Fig. 232.—Anterior surface relations of the lungs and pleuræ.

deep fascias of the neck and, according to Sibson, by some fibres from the scalene muscle.

The pleura then slopes forward behind the sternoclavicular joint to meet the pleura of the opposite side at the level of the second costal cartilage, a little to the left of the median line. They then descend until opposite or a little below the fourth costal cartilage, when they each diverge toward the side, reaching the upper border of the seventh costal cartilage near its sternal junction. They then slope down and out, reaching the lower border of the seventh rib in the mammary line, the ninth rib in the axillary line, and the twelfth rib posteriorly. The scapular line intersects the lower edge of the pleura at about the eleventh rib.

In operations involving the lumbar region, if the incision is carried high up posteriorly the pleura may be opened along the lower border of the posterior portion of the twelfth rib. It soon recedes from the costal margin and in the axillary line is about 6 cm. (2 2/5 in.) above it.

A heavy body, as a bullet, gravitates to the lowest portion of the pleural cavity, hence it can be removed through an incision in the eleventh interspace posteriorly.

(Paracentesis and empyema will be alluded to after the lungs have been described, see p. 230.)

THE LUNGS

The lungs entirely fill the pleural sacs when completely distended, but only partly so in quiet, ordinary respiration. They are encased in a bony cage that is open below, on account of which, when the lungs distend, they expand mostly downward. To a less extent they expand, in forced respiration, both laterally and anteroposteriorly, due to the elevation of the ribs owing to the traction of the

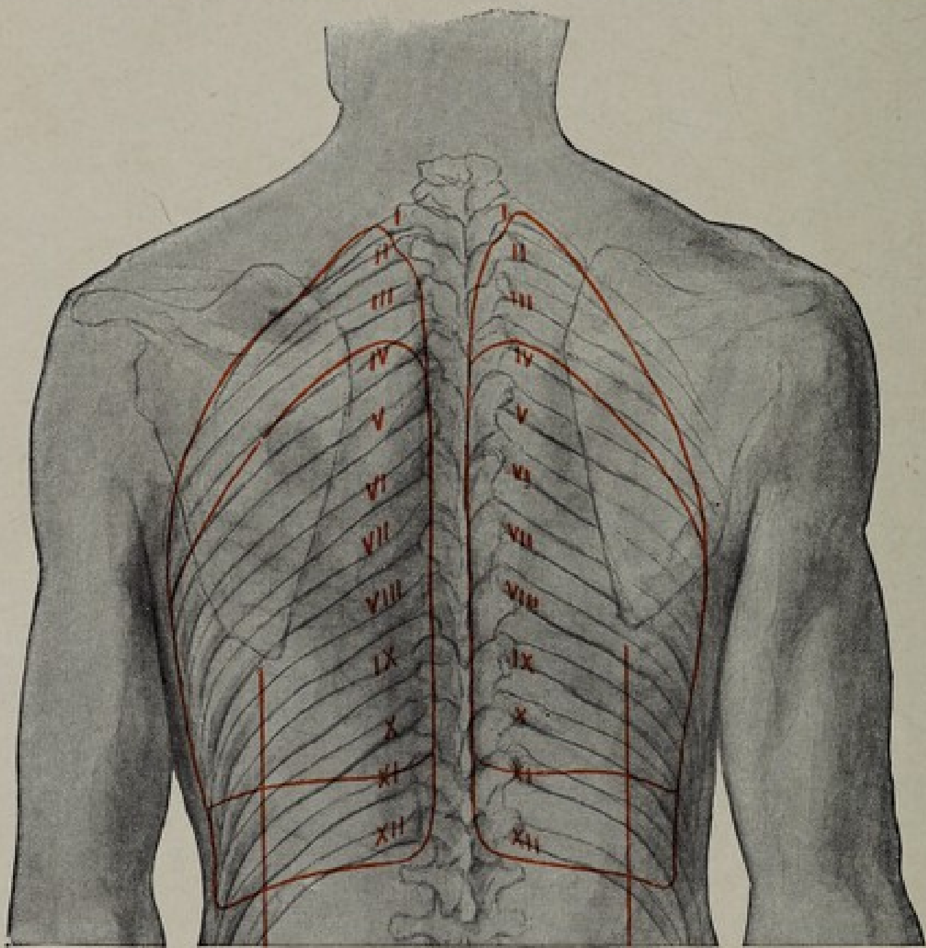


FIG. 233.—Posterior surface relations of the lungs and pleuræ.

muscles upon them. Ordinary breathing is performed mainly by the diaphragm. It acts like the piston of a cylinder and as it descends the air is drawn into the trachea and lungs. As the diaphragm falls a negative pressure is produced within the chest and were it not for its bony framework, it would collapse. The framework is sufficiently strong to retain its shape in spite of this pressure if the breathing is normal and the chest-walls are healthy. When, however, obstruction of the air-passages is present, perhaps from enlarged pharyngeal or faucial tonsils or nasal hypertrophies, then the deformities known as funnel-breast, pigeon-breast, etc., already described, arise. They are also produced if there is no obstruction to the breathing but only a weakness in the bony thorax, as occurs in rickets.

Two of the most common of the diseases of the lungs produce changes in the shape of the thorax; they are emphysema and phthisis. Pneumonia, though a frequent enough disease, does not produce any changes, as it is too short in its duration.

In emphysema the lungs are in a state of hyperdistention, hence they fill the chest to its greatest capacity and tend to make the soft parts bulge between the ribs. In phthisis the lungs are contracted, hence the intrathoracic pressure becomes a negative one and the soft parts sink in between their bony support. In emphysema the anteroposterior diameter increases and the chest assumes the barrel-form already described. In phthisis it becomes lessened in its anteroposterior diameter and we have the flat chest. Enlargement of the chest posteriorly is impossible on account of the support of the ribs, vertebræ, and strong back muscles. Enlargement downward is allowed by a descent of the diaphragm; hence the fulness of the abdomen in those affected with emphysema and conversely the flatness of the abdomen in those having phthisis. In the region of the apices the thorax is closed by the deep fascia, which spreads from the trachea, œsophagus, muscles, and great vessels and blends with the pleura to be attached to the first rib. In the normal condition this is level with the plane of the first rib and rises little if at all above it. Even in disease it is not materially altered. This is certainly so in phthisis and probably

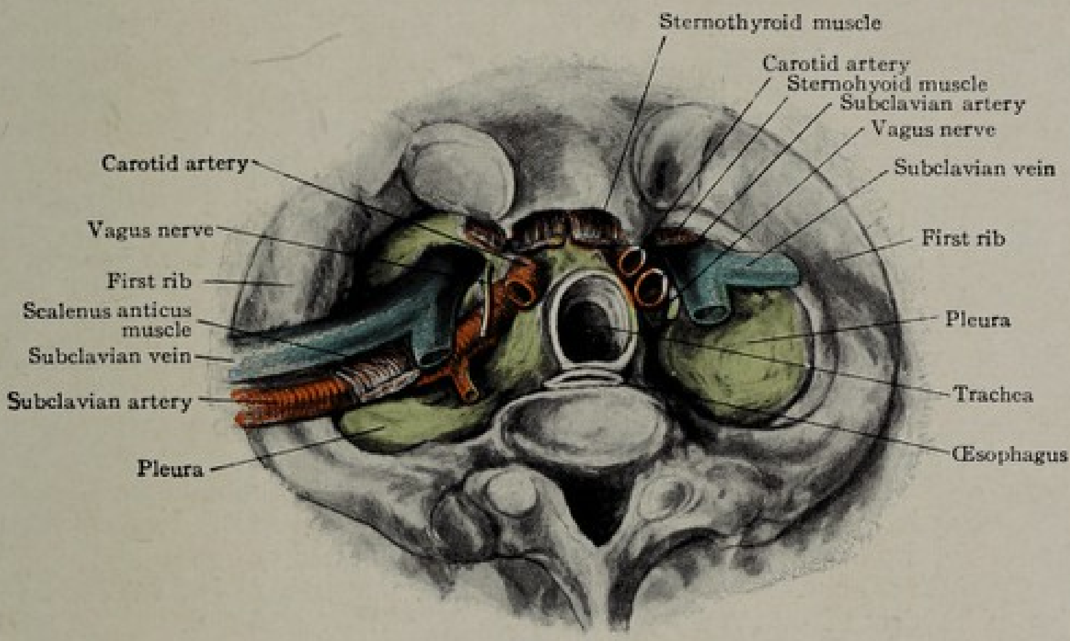


FIG. 234.—Upper end of the thorax, at the level of the first rib.

so in emphysema. The apparent fulness of the supraclavicular fossæ and intercostal spaces in emphysema and the increased depth of these hollows in phthisis are not due so much to a bulging or to a retraction of the lungs at these points as to the atrophy of the fatty and muscular tissue in phthisis and to the muscular tension in emphysema.

In coughing, the apex of the lung does not jump up into the neck above the clavicle as it appears to do, but remains nearly or quite below the plane of the top of the first rib. The appearance of bulging is caused by the movements of the trachea in the median line and the muscles laterally. This is noticeable particularly in the case of the platysma and omohyoid muscles. In quiet breathing the posterior belly of the omohyoid lies about level with the clavicle, but in coughing it rises 1 or 2 cm. above it. The intercostal membranes and muscles are kept tense by the constant elevation of the ribs due to the muscular tension.

OUTLINE OF THE LUNGS

Apex.—The apex of the lung has its highest point opposite the posterior extremity of the first rib. It then follows the plane of the top of the first rib down to the sternoclavicular joint, immediately above the junction of the cartilage of the first rib with the sternum. The anterior end of the first rib is 5 cm. lower than the posterior. The upper edge of the clavicle is 2.5 cm. or one inch, above the anterior end of the first rib and 2.5 cm. below the head of the first rib, hence the apex of the lung rises 2.5 cm. (1 in.) above the clavicle, and it lies behind its inner fourth. This distance will vary in different individuals with the obliquity of the ribs. The more oblique the ribs the greater will be the distance between the level of the top of the clavicle and that of the neck of the first rib. The top of the lung, however, never is above the level of the neck of the first rib. There is no appreciable difference in the height of the right and left lung.

Anterior Border.—From the sternoclavicular joint the borders of the lungs pass downward and inward until they almost or quite touch in the median line at the angle of Ludwig opposite the second costal cartilage. Below this the right lung extends a little across the median line and the left recedes slightly away from it. The right lung leaves the sternum opposite the sixth costal cartilage to which it has gradually descended.

The left lung on reaching the level of the fourth costal cartilage curves outward and downward across the fourth interspace to a point about 2.5 cm. to the inner side of the nipple in the fourth interspace. From this point it goes downward and inward across the fifth rib and interspace to the top of the sixth rib about 3 cm. to the inner side of the nipple line. This forms the lingula of the left lung. This isolated tip of lung just above the sixth rib over the apex beat of the heart is called the lingula.

Lower Border.—The lower edge of the lung varies in different individuals and in the same individual according to the amount of inflation. In quiet respiration it is about opposite the sixth cartilage and rib from the sternum to the mammary line, opposite the eighth in the midaxillary line, the tenth in the scapular line, and the eleventh near the vertebræ. The lowest part of the lung is on the side at the midaxillary line or a little posterior to this, but the line from here posteriorly although rising slightly, is nearly horizontal.

The Fissures and Lobes of the Lungs.—The left lung has one fissure and two lobes, an upper and a lower. The right lung has two fissures and three lobes, an upper, a middle, and a lower.

The relations of the fissures to the surface are variable. They generally appear posteriorly at different levels, the right main fissure being lower than the left. The fissure of the left lung appears at the side of the vertebral column at a variable point extending from the third rib to the upper border of the fifth. In the axillary line it is at the fifth rib, although it may be slightly higher or lower and it ends beneath the sixth rib or the interspace above or below, anywhere from 6 to 11 cm. from the midline shut it in the neighborhood of the para-sternal line.

The main fissure of the right lung leaves the vertebral column opposite the fifth rib or at the root of the spine of the scapula. The fissure tends to follow the fifth rib being beneath the rib or beneath its interspace in the midaxillary line and ending at the sixth rib in the mammary line.

The subsidiary fissure of the right lung leaves the main fissure in the posterior axillary line opposite the fifth rib and running horizontally forward ends near the sternum at any point between the third and fourth interspace.

In order to recognize and appreciate the changes which occur in the lungs in *lobar pneumonia* it is necessary to know the outlines and limits of the various lobes of the lungs. A knowledge of the exact course of the fissures of the lungs is not only necessary to outline the lobes, but it is of service in the diagnosis of pleural effusions. These effusions often are limited to certain localized areas instead of being general.

Pleurisy may affect the lung bordering the fissures. When such is the case, the effusion, serous or purulent, may be in the fissure itself and embrace but little of the general pleural cavity. Dry taps from failure to hit the purulent or serous collection are not infrequent, and the possibility of its being interlobar should be borne in mind.

GENERAL CONSIDERATIONS

From what has been said it follows that a knowledge of the extent and outlines of the lungs and of the location and course of the fissures is essential to the proper diagnosis and treatment of affections of both the lungs and pleuræ.

The extent of the lungs is determined in the living by percussion. The apex of the lungs forms an oblique plane running upward and backward from just below the lower edge of the inner extremity of the clavicle to the neck of the first rib above and posteriorly. The level of these two points will vary according to the inclination of the ribs, which in turn is influenced by the direction (vertical) of the spine. Ordinarily the distance is 5 cm. (2 in.). It may be even as much as 7 or 8 cm. The top edge of the clavicle passes across the middle of this distance so that the top of the lung is about 2.5 cm. (1 in.) above the clavicle. The highest point of the lung is not in the middle of the space enclosed by the first rib, but is at its posterior border, at the neck of the first rib.

In percussing, do not strike directly backward but downward and backward.

If the patient is standing erect the first rib will slope downward and forward at an angle of 65 degrees, or more, with a vertical line. The spine will slope downward and backward from the same vertical line in a normally straight back about 20 degrees.

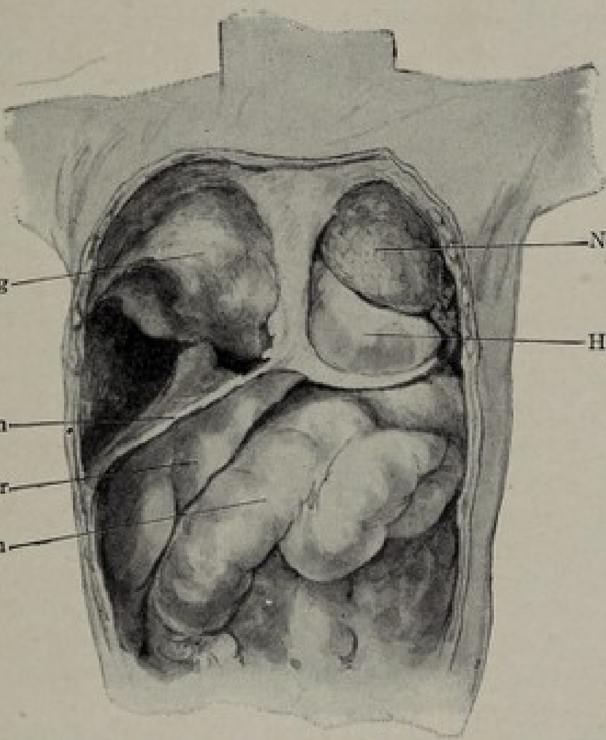


FIG. 235.—Formalin-hardened body, showing the right lung collapsed and compressed by a large pleural effusion.

In people with straight backs and flat chests (often seen in phthisis), the sloping downward of the ribs is marked; in those with rounded backs the chest is apt to be round, as in emphysema, and then the ribs are more horizontal.

Another point to be noticed is the lateral extent of the apex of the lung in relation to the length of the clavicle. The lung does not extend farther out on the clavicle than one-fourth its length. The clavicular origin of the sternomastoid muscle extends out one-third of the length of the clavicle, so that the lung is behind the clavicular origin of the sternomastoid and care should be taken not to percuss too far out. If the finger is laid in the supraclavicular fossa in percussion it should be pressed downward and inward, not backward.

Posteriorly the scapula rises to the second rib and its spine has its root opposite the fourth rib or spinous process of the third thoracic vertebra. Therefore a small portion of the lung is above the upper edge of the scapula and percussion in the supraspinous fossa gives a clear resonant note.

Behind the middle of the first piece of the sternum passes the trachea, crossed by the left innominate vein. The trachea of course contains air; the lungs slope inward from the sternoclavicular joints to meet nearly or quite in the median line and so continue to the level of the fourth rib; hence it follows that the percussion note on the sternum nearly down to this point is resonant and if it be found to be dull one should look for an aneurismal or other tumor which is displacing or covering the lungs and trachea at this point and thereby subduing their resonance.

Below the fourth rib the area of the absolute heart dulness becomes evident. (This will be alluded to in describing that organ later on.)

In performing abdominal operations, as those involving the gall-bladder and kidney, the surgeon may be tempted to prolong his incision upward into the lower edge of the chest-walls, and it is necessary to know how far he can proceed without opening the pleural cavity. This necessitates his knowing how far from the lower edge of the chest the pleura lies. It reaches to the seventh rib in the mammary line, the ninth in the axillary line, and the twelfth posteriorly, extending to its extreme lower edge.

In the axillary line the pleura is about 6 cm. (2 2/5 in.) away from the edge of the thorax. This distance gets less as one proceeds forward to the sternum and backward toward the spine.

In emphysema the lung, being distended, occupies more nearly the outlines of the pleura and its area of resonance is increased. In pleural effusion it is compressed and even sometimes collapsed. As it shrinks it recedes inward and backward and is pushed from the chest-wall by the layer of fluid (Fig. 235). The pressure of the fluid within causes the intercostal spaces to be obliterated and sometimes even to bulge instead of being depressed. As the expansion of the lung is prevented, the chest does not move on the affected side, or expand with the respiration, as it does on the healthy side. This can be demonstrated by measuring the two sides of the chest. At the end of expiration the affected side will be from 1 to 3 cm. greater in circumference than the healthy one. If the pleural effusion is on the right side it may push the heart to the left and raise its apex beat and cause it to pulsate beyond the nipple line and even in the axilla. If it is on the left side the costomediastinal sinus (page 220) becomes distended with fluid or plastic lymph and this obscures or conceals the heart's impulse. If the effusion is very large the heart is pushed over toward the right and its apex beat is seen in the third or fourth interspace on the right side even so far over as the mammary line.

Should the effusion be purulent it may perforate the chest-wall, or open into the pericardium anteriorly, the œsophagus posteriorly, and into the stomach or peritoneal cavity below. If it perforates the chest-wall it usually does so anteriorly between the third and sixth interspaces, most often in the fifth.

Paracentesis.—Where the pleural effusion is serous it is usually drawn off by an aspirating needle or trocar.

For diagnostic purposes a hypodermic syringe with long needle is often used, as the chest-walls are usually thin enough to allow this to be done, particularly if a suitable spot is chosen and the patient is a child. Care should be exercised not to strike a rib. The spot chosen for puncture may be indicated by dulness on percussion. It may be anywhere, but when a choice is permissible the puncture should be made in the sixth interspace about the middle of postaxillary line. Another preferred spot is in the eighth interspace, below the angle of the scapula. The sixth interspace may be determined in several ways, viz.:

1. Begin at the angulus sterni (angle of Louis) and follow out the second rib to the parasternal or midclavicular line, thence count down to the sixth rib and follow it to the midaxillary line.

2. The nipple is in the fourth interspace, follow it to the axillary line and count two spaces down.

3. The apex beat of the heart is in the fifth interspace, follow it around to the axillary line and take the next space below.

4. Find the last rib that articulates with the sternum—it is the seventh; follow it around and take the space above.

5. With the arm to the side the inferior angle of the scapula marks the seventh interspace; take the interspace next above.

6. A horizontal line at the level of the nipple cuts the midaxillary line in about the sixth interspace.

7. The lower edge of the pectoralis major touches the side of the chest at the fifth rib. Follow it to the axillary line and go two spaces lower.

8. By raising the arm the serrations of the serratus anterior muscle attached to the fifth, sixth, seventh, and eighth ribs become visible; that attached to the sixth rib is the most prominent and is attached farthest forward.

Empyema.—When the pleural effusion is purulent, tapping is not sufficient, and drainage is resorted to. It is not considered necessary to open the pleural cavity at its lowest part, that is the costo-phrenic sinus, but the sites chosen are usually the sixth or seventh interspace in the mid- or postaxillary line. The movements of the scapula are apt to interfere with drainage immediately below its angle, hence the opening is usually made farther forward. The surgeon may or may not resect a rib.

The ribs may lie so close together as to compress the drainage-tube; in such case a resection is done if the patient's condition permits.

Incision for Empyema.—In certain cases the condition of the patient may demand that as little as possible be done, and that quickly. The point of operation is selected by one of the guides already given, perhaps the level of the nipple.

While the finger of one hand marks the interspace, an incision 4 cm. (1½ in.) long is made above the upper edge of the rib. A trocar and cannula is then carefully pushed into the pleural cavity between the ribs. As the pus makes its appearance the trocar is withdrawn and the finger is laid on the opening. A drainage-tube held in a curved forceps is then slid along the cannula into the chest. Any bleeding will be from the small intercostal branches and can readily be stopped by gauze packing.

The incision is made above the upper edge of the rib because the intercostal artery running along the lower edge of the rib is the larger.

Resection of a Rib for Empyema.—For the removal of a part of a rib a more formal operation is necessary. The incision is made directly on the rib down to the bone and five or more centimetres in length. The skin being retracted, the periosteum is incised and detached from the rib with a periosteal elevator which is passed down its posterior surface, pushing the pleura away from the rib. When the elevator reaches the lower border of the rib an incision is made down on it through the intercostal muscles, keeping as close to the rib as possible to avoid wounding the intercostal artery, which lies close to its lower edge. The rib is then divided with a cutting forceps. The rib, having been divided at one end of the incision, is then lifted up, the pleura stripped off, and divided at the opposite end.

Should the intercostal artery bleed, and it is often sufficiently large to spurt quite actively, it can be caught with a hæmostatic forceps and secured with a ligature if necessary. This is safer than to trust to packing, on account of the lack of support due to the removal of the rib. After the incision is completed, the pleura is incised and the tube introduced. In ligating the intercostal artery, care should be taken not to include the nerve which lies close to but below it; that is, farther away from the rib.

THE PERICARDIUM

The pericardium is composed of fibrous tissue lined with a serous membrane.

When affected by inflammation the amount of fluid contained in it becomes increased and it becomes distended and may interfere with the functions of the heart and adjacent structures.

If the effusion is serous it is sometimes drawn off by puncture; if it is purulent drainage is instituted.

The pericardium in shape is somewhat conical. Its base rests on the central tendon of the diaphragm and its apex envelops the great vessels, as they emerge from the base of the heart, for a distance of 4 to 5 cm. The attachment to the diaphragm is most firm at the opening of the inferior vena cava. As the fibrous layer of the pericardium proceeds upward it becomes lost in the fibrous tissue (sheath) covering the great vessels. This is continuous above with the deep cervical fascia, especially with its pretracheal layer. Anteriorly the pericardium is attached above and below to the sternum by the so-called *sternopericardiac ligaments* (Fig. 218).

In front of it above are the remains of the *thymus gland* and triangularis sterni muscle of the left side from the third to the seventh costal cartilages. The *internal mammary arteries*, running down behind the costal cartilages about a centimetre from the edge of the sternum above and somewhat more below, are separated from the pericardium by the edges of the lungs and pleuræ, these latter reaching nearly or quite to the median line. The triangularis sterni muscle also lies beneath the

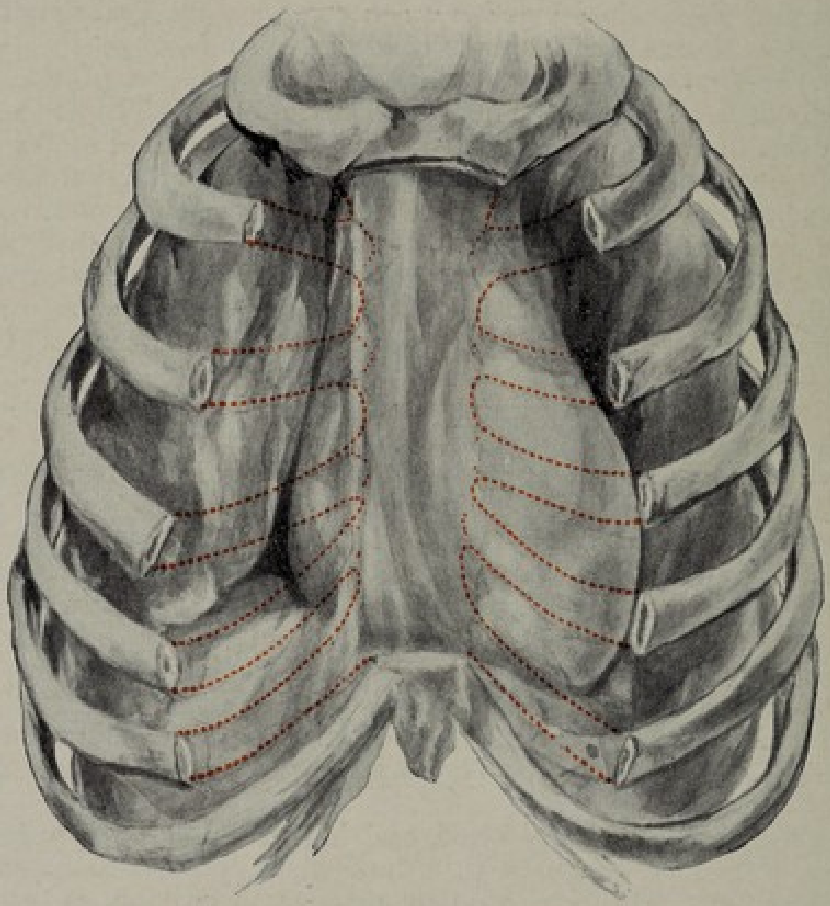


Fig. 236.—View of the pericardium, slightly distended, and its relations to the bony thorax.

artery and farther from the surface. As the left pleura slopes more rapidly toward the side than does the right there is a small portion of the pericardium uncovered by the pleura at about the sixth intercostal space close to the sternum. The incisura of the left lung leaves a space where the pericardium is separated from the chest-walls only by the pleura.

On each side the pleura and pericardium are in contact, with the phrenic nerves between them. Posteriorly the pericardium lies on the bronchi, the œsophagus, and the thoracic aorta.

Owing to the fibrous nature of the pericardium it will not expand suddenly. While only about a pint of liquid can be injected into the normal pericardial cavity after death, if a chronic effusion exists in a living person as much as three pints may be present. Williamson (1921) believes that the exudate first appears in the costo-diaphragmatic angle, the left lobe of the liver being pushed down and rotated in such a way as to push down the anterior margin most, the right lobe remaining in its normal position.

Sudden effusion occurring in the living patient will cause obstruction of the circulation at the base of the heart; it may by pressure on the bronchi at the bifurcation produce suffocative symptoms and by pressure on the œsophagus difficulty in swallowing. The lungs are displaced laterally, and the stomach and liver downward. The largest effusions are slow in their formation.

Pressure on the left recurrent laryngeal nerve as it winds around the aorta sometimes produces alterations or loss of the voice.

In children, according to Osler, the præcordia bulges and the anterolateral region of the left chest becomes enlarged as does also the area of the cardiac dulness.

Paracentesis of the Pericardism.—Tapping the pericardium by means of a trocar or aspirating needle must be carefully done, or the pleura may be punctured. Matas states, "in preparing to puncture or tap the pericardial sac, the operator

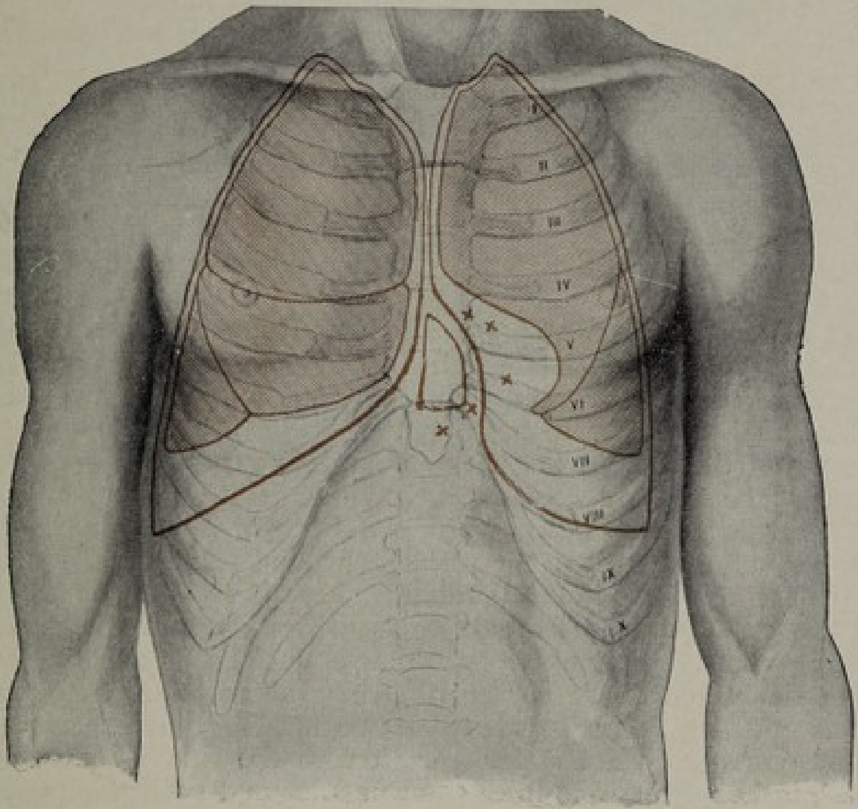


FIG. 237.—Paracentesis of the pericardium.

should select that site for the introduction of the exploring needle which will give the patient the greatest security from: (1) Injury to the mammary vessels; (2) injury to the pleura; (3) injury to the heart itself; and (4) provide a certainty of reaching the largest collection of fluid in the most favorable position for aspiration and drainage, or if necessary incision."

The part of the pericardium in contact with the chest-wall which is never covered by pleura is small. It embraces the space between the two pleuræ from the fourth to the seventh ribs. This may be defined by three lines, one in the midline, another from the middle of the sternum opposite the fourth rib to the costosternal junction of the seventh rib, and a third joining these two passing through the articulation of the xiphoid cartilage (Fig. 237).

The left pleural sac may be 1 cm. distant from the left edge of the sternum. Thus it is seen that there is hardly a point where a needle can be introduced with the certainty of avoiding the pleura. The safest point is probably close to the left edge of the sternum in the sixth interspace. This interspace may not extend to the sternum, but even if the cartilages are in contact a needle could probably be introduced at this point. As the pericardium is distended it carries the lungs and to a less extent the pleura outwards and increases the area available for puncture both upward and downward as well as to the sides. When greatly distended the pericardium may reach to the first interspace above, 2.5 cm. (1 in.) to the right of the sternum, to the seventh cartilage below, and to the left nipple line or even beyond. The arching of the diaphragm causes a sternophrenic sinus behind the sternum analogous to the costrophrenic sinus at the lower edge of the chest. This becomes distended by pericardial effusions in the same manner as does the costophrenic sinus in pleural effusions. A puncture in the sixth space close to the left edge of the sternum enters this sinus. The increased area in cases of distention from pericardial effusions has led Osler to advise tapping in the fourth interspace, either at the left sternal margin or 2.5 cm. from it, or at the fifth interspace 4 cm. (1½ in.) from the sternal margin; or by thrusting the needle upward and backward close to the costal margin in the left costoxiphoid angle. Dieulafoy's method is considered the classical method. The patient is put in the semi-recumbent position. The fourth or fifth interspace, preferably the latter, is selected. The needle enters the thorax at a point 6 cm. from the left border of the sternum.

It is important to avoid wounding the internal mammary artery, which is usually nearer to the sternum above (0.5 to 1 cm. to its outer side) and farther from it (2 to 3 cm.) below. The importance of avoiding these has been so universally recognized that two methods are advocated according to its position;—puncture inside or outside of the internal mammary vessels.

The danger of wounding the pleura in aspirating with a needle has probably been overestimated, but when drainage is to be employed the danger is certain.

Drainage of the Pericardium.—A number of methods have been advocated to afford drainage of a suppurative pericarditis. We advocate the method of Pool (1921). The incision begins at the middle of the sternum at the level of the lower margin of the fourth costal cartilage, it passes downward curving to the left to the upper margin of the chondrosternal junction of the fifth; then downward close to the left edge of the sternum, crossing the fifth and sixth cartilages to the middle of the seventh cartilage; curving outward, it follows the seventh cartilage. The soft parts are freed and retracted, the resulting wound being an ellipse. The seventh costal cartilage is divided at the sternum. The soft parts are detached along its borders and the cartilage is lifted. It is easily freed from the perichondrium posteriorly. A complete subchondral resection is not attempted because the perichondrium anteriorly and at the borders is firmly adherent and is separated with difficulty. The cartilage is fractured about two inches from its sternal end and removed. The same procedure is carried out with the sixth and fifth cartilages. The thin layer, including internal intercostal muscles and posterior perichondrium, is incised vertically and easily separated from the underlying tissues. This exposes the internal mammary vessels. At the upper part of the wound they lie about one-half inch from sternum. They should be ligated above and below to lessen the danger of secondary hemorrhage. The thin triangularis sterni is separated from the sternum, and with finger or blunt scissors the underlying fat, and with it the edge of the pleura, is displaced outward. The pericardium is thus exposed and is opened between forceps, about 1 cm. from the edge of the sternum. The incision should extend downward to the reflection of pericardium to the diaphragm. While the incision is in general vertical, it is advisable that it be slightly curved with concavity toward the sternum. This allows better separation of the edges and favors drainage. If possible, the edges of the pericardium should be sutured to the skin or superficial soft part to diminish the danger of mediastinitis.

THE HEART

In size the heart is somewhat larger than the clenched fist. It measures 12.5 cm. (5 in.) in length, 7.75 cm. (3½ in.) in width, and 6.25 cm. (2½ in.) in thickness. Its weight in the adult male is 250 to 300 Gm. (8 to 10 oz.), in the female it is 60 Gm. (2 oz.) less.

It lies enclosed in its pericardium in the middle mediastinum between the sternum (from the upper edge of the third costal cartilage to the sternoxiphoid articulation) in front, and the bodies of the fifth, sixth, seventh, and eighth thoracic vertebræ behind. Laterally it reaches from two centimetres to the right of the sternum nearly to the left nipple line. On each side of it are the lungs, from which it is separated by the pleuræ and pericardium with the phrenic nerves between. Above are the great vessels and below it rests on the central tendon of the diaphragm.

In shape the heart resembles an acorn, the *atria* (*auricles*), forming the upper right portion and the *ventricles* the lower left portion. It lies with its right side resting on the diaphragm and its apex pointing forward and to the left.

For convenience one speaks of a *base*, an *apex*, a *right border*, a *lower border*, and a *left border*.

OUTLINES OF THE HEART

The base of the heart is opposite the upper border of the third costal cartilage. It is here that the superior vena cava ends and the aorta begins. It extends from 1.25 cm. (½ in.) to the right of the sternum to 2.5 cm. (1 in.) to the left of the sternum.

The right border of the heart extends from 1.25 cm. (½ in.) to the right of the sternum at the upper border of the third costal cartilage in an outwardly curved line to the junction of the seventh rib and the sternum. In the fourth interspace it may reach 2.5 cm. (1 in.) beyond the right edge of the sternum.

The lower border passes from the seventh right chondrosternal junction across the sternoxiphoid joint outward in the fifth interspace to the apex beat, which is 4 to 5 cm. (1½ in. to 1¾ in.) below and to the inner side of the nipple and about 8.75 cm. (3½ in.) to the left of the median line. This marks the extreme left limit of the heart. In children the apex is higher—it is in the fourth interspace. In old people it is lower.

The left border arches upward from the apex beat, as just given, in an inward and upward direction to 2.5 cm. (1 in.) to the left of the sternum at the upper border of the third costal cartilage.

The atrio- (auriculo-) ventricular groove or line of junction between the atria (auricles) and ventricles runs from the sixth right chondrosternal junction upward and to the left to the third left chondrosternal junction. The atria lie above and to the right of this line and the ventricles below and to the left.

The right atrium (auricle) and right ventricle lie anteriorly and the left atrium and left ventricle lie posteriorly. In the right atrioventricular groove runs the right coronary artery. As it lies on the anterior portion of the heart it is liable to be injured in stab-wounds and give rise to fatal bleeding, as may also the interventricular branch of the left coronary artery as it passes down near the left border of the heart between the right and left ventricles.

The Portion of the Heart Uncovered by Lung-tissue.—When the lungs are distended the right lung covers the heart to the median line. The left lung leaves the median line at the level of the fourth costal cartilage and curves outward and downward to about the apex beat in the fifth interspace, 2.5 cm. to the inner side of the nipple line. At this point a small piece of the lung, the *lingula*, sometimes curves around in front of and below the extreme tip of the heart. As the air leaves the lungs they retract and their anterior borders hardly reach the edges of the sternum.

Area of Cardiac Dulness.—The area of cardiac dulness corresponds to the area uncovered by lung and in contact with the chest-wall. This is the area of absolute dulness. It begins opposite the fourth costal cartilage and extends down the sternum, between the median line and left edge, to the liver dulness below opposite the sixth costal cartilage. Toward the left side it arches from the fourth left costosternal junction to the apex beat. The area of so-called relative dulness caused by overlapping of the lungs extends along the right edge of the sternum to opposite the upper border of the third rib above, and to the left follows parallel to the left border of the heart to the tip of its apex. Below it blends with the liver dulness (Fig. 239).

The area of cardiac dulness may be increased not only by the enlargement of the heart itself but by pericardial effusions and disease such as aneurism of the great vessels.

In an early stage of pericardial effusion and also in aneurism there may be an extension of the area of dulness upward. In a later stage of pericarditis the lateral area of dulness becomes increased.

Cardiohepatic Angle (Ebstein).—This is the angle formed by the right border of the heart as it meets the liver. It is a more or less resonant area in the

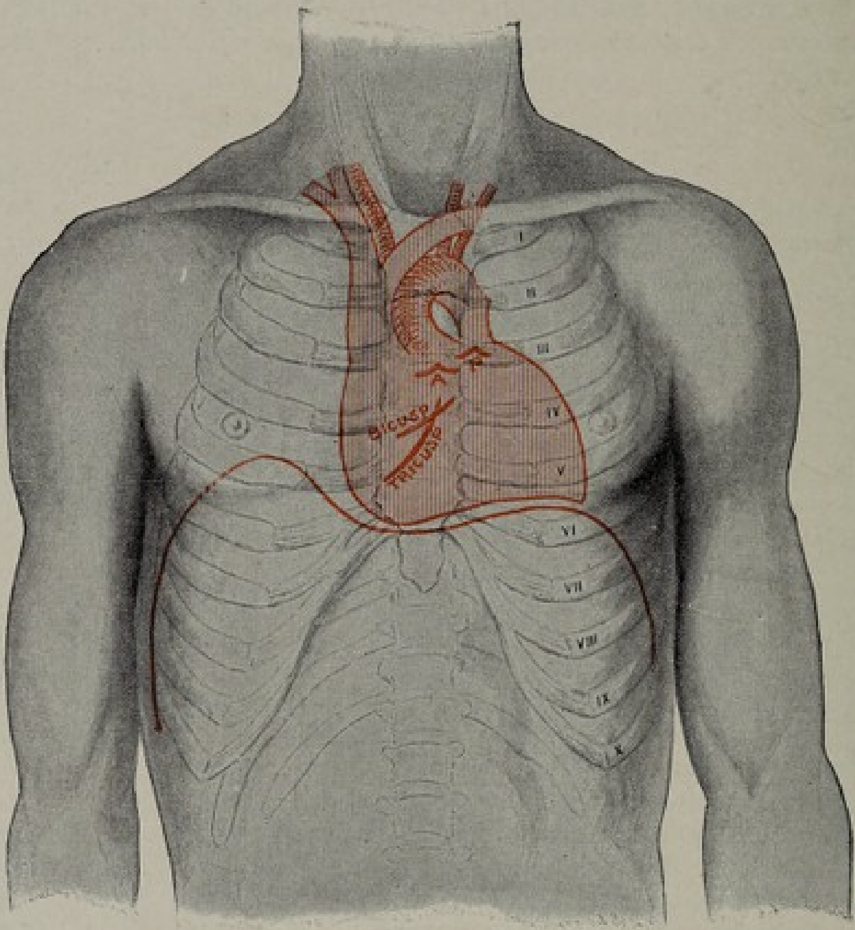


Fig. 238.—Relations of the heart, its valves, and the great blood-vessels to the surface of the chest.

fifth right intercostal space. Below it is the liver dulness and above and towards the median line is the heart.

VALVES OF THE HEART

There are two types of valves in the heart; the *bicuspid* (*mitral*) and *tricuspid* between the atria (auricles) and ventricles, and two sets of *semilunar valves* at the entrance of the pulmonary artery and aorta. (See Fig. 238.)

The **bicuspid valve** is the most important and is the deepest seated. It lies at the edge of the left border of the sternum opposite the fourth costal cartilage. It separates the left atrium and ventricle and lies nearly transversely.

The **tricuspid valve** lies in the middle of the sternum opposite the fourth intercostal space. It runs obliquely downward and to the right from the third left intercostal space to the fifth right costal cartilage. It separates the right atrium and ventricle.

The **pulmonary semilunar valve** lies opposite the sternal end of the third left costal cartilage. It is the most superficial valve and the one highest up on the sternum. It prevents regurgitation of the blood into the right ventricle from the lungs.

The **aortic semilunar valve** lies under the left side of the sternum about level with the lower edge of the third costal cartilage. It is just below and to the right of the pulmonary valve, and above and to the left of the bicuspid valve.

Location of Valvular Sounds

The sounds produced by the closure of the valves do not correspond with the position of the valves, but are as follows.

The **bicuspid sound** is heard most distinctly at the apex of the heart as far inward as the parasternal line and as high as the third interspace. It is transmitted around the chest toward the axilla.

The **tricuspid sound** is best heard at the left sternal border between the fifth and sixth costal cartilages (Tyson).

The **pulmonary sound** is best heard in the second interspace to the left of the sternum; the cartilage above is called the pulmonary cartilage.

The **aortic sound** is best heard in the second right intercostal space and the cartilage above is called the aortic cartilage. The aortic sounds are transmitted up the neck in the direction of the great blood-vessels.

VARIATION IN SIZE AND POSITION OF THE HEART

The heart becomes enlarged both by being dilated and by being hypertrophied, usually both conditions are present; and its position is often changed by disease both of itself and of adjacent organs. It is apt to enlarge unequally. In *emphysema* and *bicuspid regurgitation* the right side becomes enlarged, the pulmonary circulation being impeded. In *aortic disease, arteriosclerosis, muscular exertion*, or any cause impeding the course of the blood through the arteries there is produced an enlargement of the left side of the heart.

The average weight of the healthy heart is in the male 280 Gm. (9 oz.), and in the female 250 Gm. (8 oz.). These may be doubled in cases of enlargement. When the heart is enlarged the apex beat changes its position; it may occupy the sixth, seventh, or eighth interspace instead of the fifth, and may be as far as 5 to 7.5 cm. (2 to 3 in.) to the left of the nipple line.

When it enlarges upward, instead of the absolute dulness beginning opposite the fourth costal cartilage, it is opposite the third or even the second interspace. Toward the right side the absolute dulness may extend a couple of centimetres beyond the right edge of the sternum, instead of being near its left edge as is normal.

The heart is readily displaced by pressure from the surrounding structures. If there is abdominal distention by gas or ascites, or if the liver or spleen is enlarged, the heart is pushed upward. Enlargement of the liver may likewise depress the heart, if the patient is in an upright position, by the weight of the liver dragging it down. Aneurisms of the arch of the aorta, tumors, or emphysema may also depress it. In the aged the apex beat may be normally in the sixth interspace.

Lateral displacement occurs in cases of pleural effusion. Osler says this is not due to a twisting of the heart on its axis but to a positive lateral dislocation of the heart and pericardium. Pneumothorax or tumors on one side may also push the heart toward the opposite side. It may be pulled to one side by pleural adhesions and in those cases of fibroid phthisis in which the lung becomes markedly retracted. Abscess or tumors of the mediastinum also displace it.

The position of the pulsation of the heart is not always an indication of the position of the apex. In pleural effusion the pulsation may be one, two, or three interspaces higher than normal, while the apex itself may not be elevated.

WOUNDS OF THE HEART

Wounds of the heart may be immediately fatal; if not, operation offers a 67 per cent. possibility of recovery. The pleuræ are very liable to be wounded at the same time. The right ventricle, on account of lying anteriorly, is the part most often involved. The atria lie more posteriorly and are most apt to be wounded in stabs through the back. Not only may the substance of the heart itself be injured but also its blood-vessels. The right coronary artery lying in the atrioventricular groove and the anterior interventricular branch of the left coronary running between the two ventricles anteriorly are the vessels most liable to injury. Owing to the heart being enclosed in the pericardium,—a closed sac,—if blood accumulates in it the action of the heart is interfered with. The auricles are compressed and signs of venous obstruction appear; dyspnœa, cyanosis and rapid, weak, muffled heart beats are observed.

Wounds of the heart have been sutured successfully. Suture of the heart necessitates a knowledge of the relations of the pericardium and pleural reflections, and the position of the internal mammary vessels. The operation as usually performed consists in reflecting a trap-door flap of soft parts and portions of the fourth, fifth and sixth ribs with the hinge on the lateral side. An intercostal incision

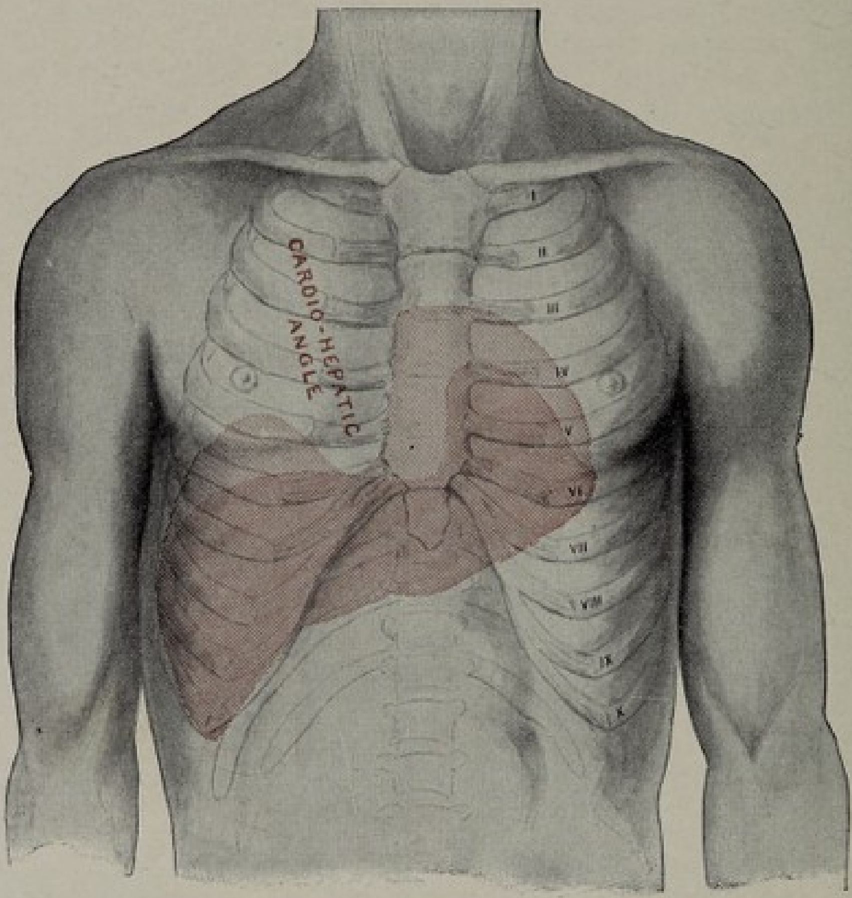


Fig. 239.—Percussion area of the liver and heart. The light shaded area represents the extent of deep or relative dulness and the dark shaded area that of superficial or absolute dulness.

(Spangaro) in the fourth interspace supplemented by division of one or more costal cartilages close to the sternum, also gives an excellent exposure especially when it is desirable to explore the pleural cavity as well as the pericardium. Duval has advocated a median thoraco abdominal incision, the sternum being split longitudinally up to the level of the third costal cartilage at which point a transverse section of the sternum is done. When the latter is sprung apart a perfect exposure of the heart and great vessels is obtained without risks of injury to the pleura.

THE AORTA

The aorta, as it leaves the left ventricle, begins under the left portion of the sternum opposite the lower border of the third left costal cartilage. This is the location of the aortic semilunar valves as already given. It passes upward toward the right for 5 cm. forming an arch, extending backward toward the left, to reach the spine on the left side of the body of the fourth thoracic vertebra. The arch is continued down in front of the spine as the thoracic aorta and pierces the diaphragm in the median line, between the two crura of the diaphragm, opposite the twelfth thoracic vertebra. For convenience of description the arch is divided into three portions—ascending, horizontal and descending.

The **ascending aorta** begins behind the left half of the sternum on a level with the lower border of the third costal cartilage. It proceeds upward, forward and toward the right until it reaches the level of the lower border of the right second costal cartilage, where the horizontal portion of the arch begins.

Immediately above its commencement it has three enlargements, called sinus of the aorta (Valsalva), which corresponds to the semi-lunar valves. There are three semi-lunar valves, one is situated anteriorly and the other two right and left posteriorly. If the plane of the heart is a sagittal one, then have two valves anteriorly, right and left, and one posteriorly. From behind the two anterior valves (as described in the sagittal plane) arise the right and left coronary arteries.

Beyond the valves in the upper right portion of the arch, the aorta is again dilated, forming the great sinus of the arch of the aorta.

The right limit of the aorta is about even with the right edge of the sternum; sometimes it projects slightly beyond. When it does so it is liable to be wounded by a stab in the second interspace close to the edge of the sternum. On account of the proximity of the aorta to the second interspace, it is here that the stethoscope is placed to hear aortic murmurs. The aorta at this point is covered only by the thin border of the right lung and pleura and the slight remains of the thymus gland. Below, its commencement is overlapped on the right by the *auricula dextra* (right auricular appendix) of the atrium and on the left by the root of the *pulmonary artery*. Behind it is the left auricle, the right deep cardiac nerves and the root of the right lung; on the left is the trunk of the pulmonary artery and the branches of the superficial cardiac nerves; and on the right is the superior vena cava and the right auricle.

The ascending aorta is the most frequent seat of aneurism. It may involve either the lower portion in the region of the sinuses or the region of the great sinus at its upper right anterior portion.

If the aneurism enlarges anteriorly it will show itself in the second or third interspace. It will bulge the ribs outward in this region. The right lung will be pushed outward and the two layers of the pleura pressed together. It may break externally through the surface or open into the pleural cavity. If it tends to the right it presses on the superior vena cava and right atrium, thus interfering with the return of the blood from the head and neck and both upper extremities. If it enlarges to the left or backward it may press on the right pulmonary artery and interfere with the free access of blood to the lungs.

The first portion of the aorta is not united with the pericardium, but simply loosely covered by it, so that this portion of the arch is weaker than the other portions, and rupture, with extravasation of blood into the pericardial sac, is not uncommon. An aneurism may also rupture into the superior vena cava.

The horizontal or transverse and descending aorta passes anteroposteriorly from the upper border of the second right costal cartilage in front to the left side of the body of the fourth thoracic vertebra or its intervertebral disc posteriorly. It is about 5 cm. (2 in.) long. Its under surface is level with the angle of the sternum (angle of Ludwig), opposite the second costal cartilage. Its upper surface rises as high as the middle of the first piece of the sternum, which is opposite the middle of the first costal cartilage, about 2.5 cm. (1 in.) below the top of the sternum. It describes a double curve in its course, with one concavity downwards corresponding to the root of the left lung and another to the right corresponding to the trachea.

Relations.—In front of the arch the right lung and pleura cover it slightly, but the left more so; the remains of the thymus gland is between them. The left superior intercostal vein crosses its upper portion to empty into the left innominate vein. The left phrenic and vagus nerves also cross it, the phrenic being the farther forward and the vagus crossing almost in front of the point of origin of the left subclavian artery. Here also are found the superficial cardiac nerves and the left recurrent laryngeal nerve. *Behind* lie the trachea, œsophagus, and thoracic duct, also the left recurrent laryngeal nerve. The bifurcation of the trachea is directly behind and below the lower portion of the arch and the left bronchus passes beneath it. The œsophagus lies compressed between the trachea and vertebræ with the thoracic duct immediately to the left. The left recurrent laryngeal leaves the pneumogastric on the front of the arch, then winds around it and ascends between the trachea and œsophagus to reach the larynx above. *Above,* from the upper

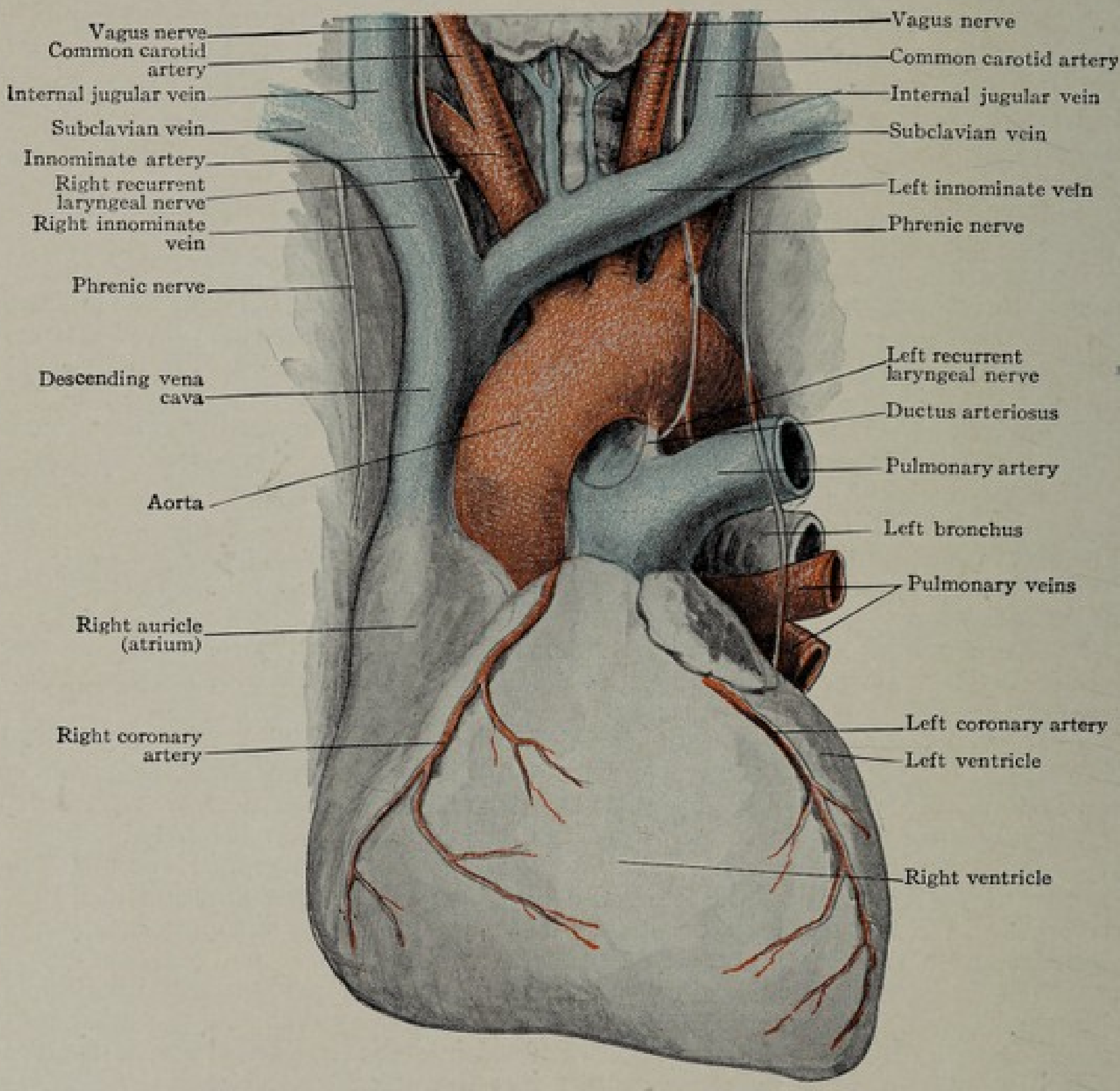


FIG. 240.—Heart and great blood-vessels.

surface of the aorta, are given off the innominate, left carotid, and left subclavian arteries in that order from before backwards and from right to left. The left innominate vein crosses above its upper edge to unite with the right innominate to form the superior cava. *Below* is the left bronchus coming off from the bifurcation of the trachea, and winding around the arch is the left recurrent laryngeal nerve. Beneath the arch and in front of the bronchi are the right and left pulmonary arteries. From the latter the ductus arteriosus goes to the arch. The cardiac branches of the pneumogastric and sympathetic nerves lie on the anterior, inferior, and posterior sides of the arch.

The **ductus arteriosus** at birth is about 1 cm. long and runs from the pulmonary artery near its bifurcation or from the left pulmonary artery to the under surface of the arch a little beyond the point where the left subclavian artery arises from its upper convex surface. It serves in the fœtus to carry the blood from the trunk of the pulmonary artery direct to the aorta instead of passing into the lungs. When, after birth, the lungs are used the ductus arteriosus becomes obliterated and is found later in life as a cord running to the under side of the arch of the aorta. Congenital defects in the heart are a frequent cause of death at birth and in infancy and childhood. They cause an undue mixture of the venous and arterial blood and give the surface a dusky, bluish hue, hence the term "blue baby" as applied to this condition. It is due to an absence of a part or the whole of the septa between the atria and ventricles; to a patulous condition of the foramen ovale of the right atrium; and also to a persistent patulous condition of the ductus arteriosus. Children so affected, if they outlive infancy, usually die before reaching adult age.

Aneurism.—The ascending portion is more often affected than are the others, probably because it is subjected to more traumatism and because it is within the pericardial sac and its walls are not reinforced by blending with the fibrous pericardial tissue. An aneurism of this portion may cause (1) Lividity of the face from pressure on the superior vena cava; (2) dizziness from the same cause; (3) swelling and edema of the anterior thoracic wall from pressure on internal mammary, azygos and hemazygos veins; (4) dyspnœa from pressure on the root of the right lung; (5) aphonia or dysphonia with brassy cough from pressure on the right recurrent laryngeal nerve; (6) ascites and edema of the legs and feet from pressure on the inferior vena cava by a displaced heart; (7) swelling or tumor in the region of the right third interspace; (8) pain which may radiate down the inner side of the arm in the distribution of the fibres of the intercosto-humeral nerve.

An aneurism of the transverse portion may cause:—(1) Dyspnœa; (2) dysphonia or aphonia; (3) dilatation of the pupil (early) and contraction (late) from early stimulation and late paralysis of the upper thoracic sympathetics; (4) inanition from compression of the thoracic duct; (5) venous congestion; (6) variations of the radial pulse especially noted in the left side.

Aneurism of the descending portion of the arch causes:—(1) dysphagia from pressure on the œsophagus; (2) pain which is intensive especially posteriorly; (3) swelling posteriorly from erosion; (4) bronchiectasis from pressure on the left bronchus.

As the aneurism enlarges the symptoms of one part merge into those of the other depending upon the extent of the pressure on contiguous structures.

THE ŒSOPHAGUS

The œsophagus begins at the lower edge of the cricoid cartilage, opposite the lower border of the sixth cervical vertebra, and ends at the cardiac opening of the stomach, opposite the eleventh thoracic vertebra.

It is 25 cm. (10 in.) long and begins 15 cm. (6 in.) distant from the teeth. In the neck it inclines to the left, hence œsophagotomy is performed on that side. It reaches the farthest point to the left at the level of the top of the sternum or opposite the second thoracic vertebra. It then inclines to the right, reaching the median line opposite the fifth thoracic vertebra. It then again inclines to the left, to pierce the diaphragm in front of the aortic opening and to the left of the median line opposite the tenth thoracic vertebra, and ends in the cardiac opening of the stomach entirely to the left of the median line and opposite the eleventh thoracic vertebra or tenth dorsal spine. In its passage through the diaphragm it is accompanied by the continuation of the two vagi nerves. At its termination it grooves or tunnels the posterior surface of the left lobe of the liver. The *structure* of the œsophagus is important from the standpoint of surgery. The submucosa is thick and tough and capable of holding a suture. The muscularis is composed of an inner circular layer and an outer longitudinal layer, the latter predominating in the upper fourth and the circular below. Surrounding the muscular coat is a thin fibrous tunica adventitia which lacks the cohesive healing property of the serous coat of the bowel, thus favoring leakage after end to end suture of the œsophagus.

Lumen.—The lumen of the œsophagus is narrowed at three points, (1) its commencement; (2) where it crosses the aorta and left bronchus; and (3) near its end as it passes through the diaphragm.

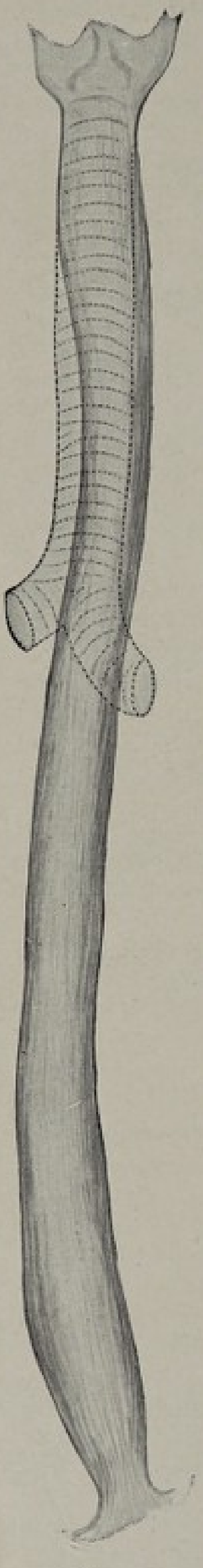


Fig. 241.—The œsophagus. From a plaster cast.

The average diameter of the lumen is 2 cm., which at the upper and lower constrictions is reduced to 1.5 cm. The middle constriction is not quite so marked. The lower constriction is most marked at the point of the passage of the œsophagus through the diaphragm; it enlarges slightly as it enters the stomach. This part of the œsophagus is quite distensible. The next most distensible part is opposite the left bronchus. This is on a level with the middle of the first piece of the sternum and the third thoracic vertebra. The upper constriction at the cricoid cartilage is the least distensible part of the tube, so that a body passing it may pass entirely down.

In both living and dead bodies the lumen of the œsophagus is sometimes open and sometimes closed. In the neck the pressure of the soft parts usually keeps it closed, but frozen sections of the dead body show it sometimes closed and sometimes open. Mikulicz in using the œsophagoscope found the lumen open in the living patient and was able to see down the remainder of the tube when the instrument had only been passed beyond the second constriction.

In passing an œsophageal bougie, do not use one of a larger diameter than 18 mm. (¾ in.). It will enter the œsophagus opposite the lower border of the cricoid cartilage about 15 cm. (6 in.) from the teeth. It will pass the second constriction 7 cm. (2¾ in.) farther on, opposite the middle of the first piece of the sternum or 2.5 cm. (1 in.) below its upper border, and meet the third constriction 15 cm. (6 in.) lower down, or 37 cm. (14.4 in.) from the teeth, and enter the stomach 3 cm. below, or 40 cm. (16 inches) from the teeth and opposite the eleventh dorsal vertebra.

Relations.—*In the neck* the œsophagus rests on the longus colli muscle and vertebræ behind and has the trachea in front. On the left side it lies close to the carotid sheath, the lobe of the thyroid gland, and the thoracic duct. The left recurrent laryngeal nerve is in closer relation to it than the right on account of the latter coming over from the right subclavian artery. The left nerve lies on its anterior surface near the left edge. The right carotid artery lies farther from it than does the left. The left inferior thyroid artery is also in closer relation to it than the right on account of the inclination of the œsophagus to the left side.

In the thorax it passes through the superior mediastinum between the trachea and its bifurcation in front and the aorta behind.

In front it has the bifurcation of the trachea and encroaches more on the left than on the right bronchus. The arch of the aorta and the left carotid and subclavian arteries also pass in front of it and in the posterior mediastinum and pericardium and diaphragm are anterior to it.

Posteriorly, above it rests on the spinal column, but below the bifurcation of the trachea the aorta intervenes.

Laterally it is in relation with the left pleura above and the right below and the vena azygos major runs along its right side posteriorly. The arch of the aorta winds around its left side at the root of the lung. The right vagus nerve runs down posteriorly and the left anteriorly, forming a plexus on its surface.

Blood Supply.—The œsophagus receives its blood supply in the neck from branches of the inferior thyroid arteries; in the chest from branches of the bronchial arteries and from the aorta itself; in the abdomen, from branches of the left gastric artery. The blood is returned through the inferior phrenic veins into the inferior vena cava, others into the venæ azygos major and minor, and directly into the superior vena cava. At the cardiac end there is a communication with portal system through the gastric vein.

Lymphatics.—These arise chiefly in the mucosa and drain into the lower deep cervical, posterior mediastinal and superior gastric nodes. Pressure on the recurrent laryngeal nerve can readily occur causing the aphonia characteristic of advanced carcinoma.

Displacement.—Owing to its loose connection with surrounding structures the œsophagus is readily displaced. Goitre, enlarged lymphatic glands or spinal deformity may affect the cervical portion. Affections of the lung such as tumors or fibrosis, spondylitis, aneurism of the arch of the aorta, enlargement of the heart, etc., may displace the thoracic part. Aneurism of the descending aorta causes marked dysphagia often resembling malignancy.

Dilatation.—Probably most cases of diffuse dilatation of the œsophagus are associated with hypertrophy of the cardiac sphincter (cardiospasm). There is no gross alteration in the contour of the gullet.

Stricture.—Usually the result of swallowing corrosive liquids, particularly preparations of lye. The ulcerated areas heal and scar tissue causes contraction at one or more points. It is important to remember that the wall of the stenosed lumen is not usually cicatrized concentrically, hence rapid dilatation by bougies may perforate the thin side. Preliminary gastrostomy will check the static œsophagitis and enable retrograde dilatation.

Carcinoma.—Any part of the œsophagus may be the site of cancer. The difference is not striking but it seems to occur more frequently in the thoracic part. As a rule the growth does not involve the entire circumference of the gullet and extensive dilatation above the point of stricture is not marked. Dysphagia is the early predominating symptom. Hemorrhage may occur. Lymphatic invasion may cause pain from pressure on intercostal nerve fibres or sympathetic branches of the aortic plexus; also, pressure on the recurrent laryngeal nerve may result in aphonia. Later, perforation into the adjacent trachea may result. Carcinoma of the œsophagus is a deadly disease. Attempts at resection have been done by a transpleural approach or by posterior mediastinotomy. Only one patient has been cured, that of Torek (1913).

Foreign Bodies.—Foreign bodies may become impacted at any part of its course; this is particularly the case if they are hard and rough with irregular outlines. If they are smooth and soft and more or less rounded they are apt to lodge at the constricted parts of the tube. These points are, as already stated, at its commencement, where it crosses the aorta and left bronchus, and where it passes through the diaphragm. The upper constriction is 1.5 cm. (or 3/5 in.) in diameter, and is least distensible. It will dilate to the width of 2 cm., and thus will allow a body of about 3/4 inch diameter to pass. The two lower constrictions are more distensible and a body that passes the œsophagus can usually pass the ileocæcal valve, so that the upper end of the œsophagus acts as a gauge to prevent the entrance of substances too large for the rest of the alimentary tract. The bodies which become lodged are usually those which have been pushed down beyond the opening of the œsophagus by the contraction of the muscles of the pharynx, and then on account of their irregular form become caught by the contraction of the tube below. With the head moderately extended, the first constriction will be 15 cm. (6 in.) from the teeth. A foreign body at this point will be opposite the cricoid cartilage at the level of the sixth cervical vertebra.

The second constriction is opposite the middle of the first piece of the sternum. This is 7 cm. (2¾ in.) below the cricoid cartilage. Therefore a foreign body lodged just above it would be just below the top of the sternum.

It would be felt by the probe 22 cm. (8⅘ in.) from the upper teeth and if œsophagotomy was performed it could usually be reached from the wound in the neck.

The third constriction is 15 cm. (6 in.) below the second, or 37 cm. (14⅘ in.) from the teeth, and is accessible from the stomach. This third constriction is more distensible than the two above it.

Foreign bodies are dangerous on account of the ulceration into the various organs which they cause and also on account of pressure. Pressure on the left bronchus and trachea has caused suffocation.

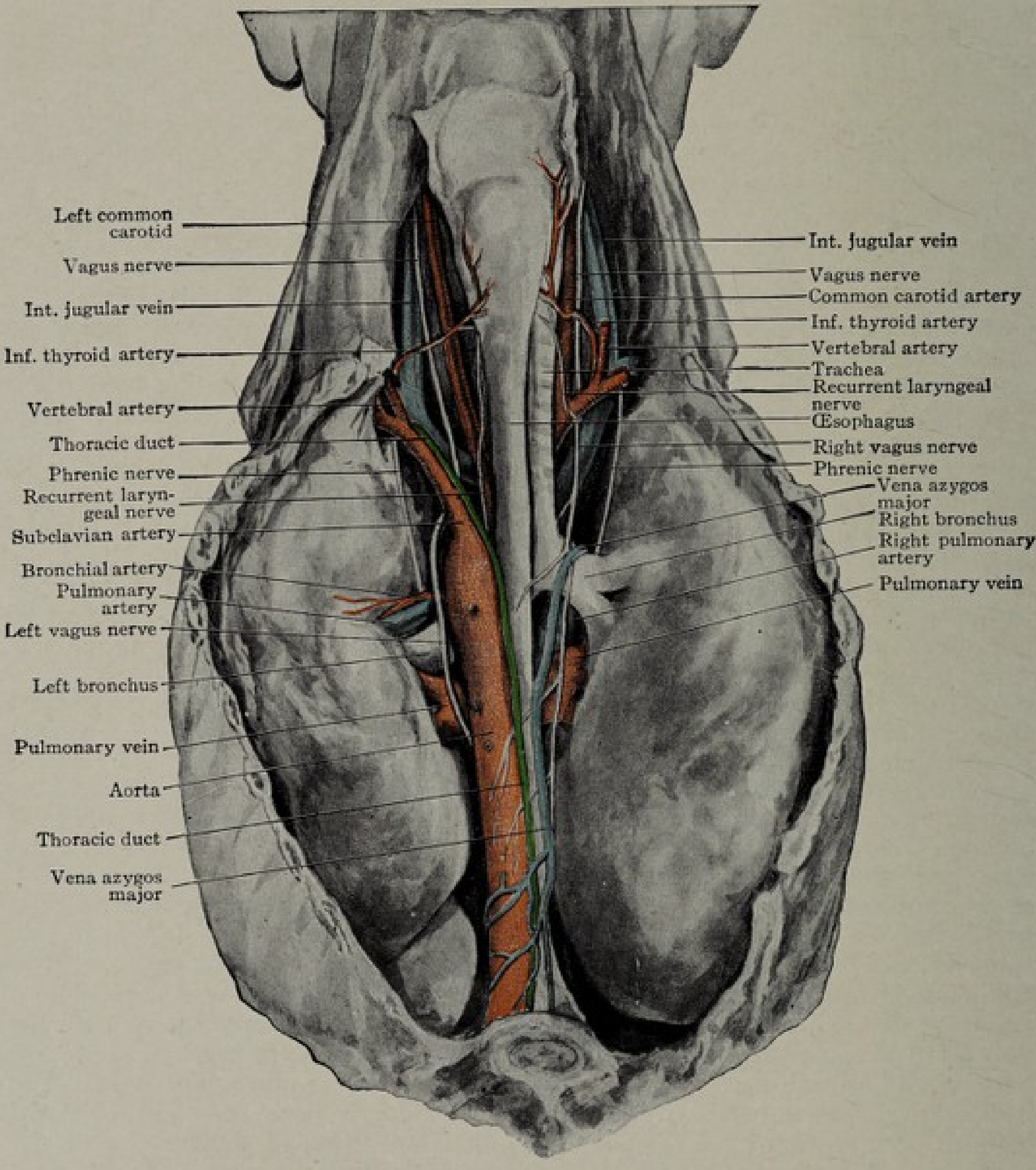


FIG. 242.—Posterior view of the œsophagus, showing its relation to the surrounding structures.

Ulceration may cause fatal hemorrhage by involving the carotid arteries, more likely the left, the inferior thyroids, the innominate, and even the aorta itself lower down. Low down in the chest the pericardium is in front of the œsophagus, and has been perforated. On the left side above and the right side below, the pleuræ have been perforated and the lungs involved. Abscesses may occur from the ulcerative process and they are particularly dangerous, as the distance between the upper portion of the sternum and anterior portion of the bodies of the vertebræ is so small that compression of the air-passages and suffocation is readily produced.

THE THORACIC DUCT

The thoracic duct carries not only *lymph* but also *chyle* which is emptied into the venous system and goes to nourish the body. Therefore a wound of the duct with the escape of its fluid may result fatally from inanition. The lymph coming from all parts of the body is collected into two ducts, the right lymphatic duct and the thoracic duct. Of these two the *right lymphatic duct* is the smaller. It collects the lymph coming from the right side of the head and neck, right upper extremity, right side of the thorax and the upper convex surface of the liver. The several lymphatic branches unite to form a duct one to two centimetres long, which empties into the venous system at the junction of the right internal jugular and subclavian veins. At its point of entrance it is guarded by a pair of valves. As this duct contains no chyle, and lymph of only a portion of the body, wounds of it have not proved serious.

The *thoracic duct* is much larger and more important. It begins on the bodies of the first and second lumbar vertebræ to the right of the aorta in the *cisterna (receptaculum) chyli.*

The cisterna or receptaculum is 5 to 7.5 cm. long and 7 mm. wide. It receives not only the lymph from the parts below but also the chyle from the intestines. The duct passes through the aortic opening in the diaphragm with the aorta to the left and the vena azygos major to the right. In the posterior mediastinum it lies on the bodies of the seven lower thoracic vertebræ, with the pericardium, the œsophagus, and above the arch of the aorta in front. The thoracic aorta is to its left and the vena azygos major and right pleura to its right. Above the fifth thoracic vertebra it ascends between the œsophagus and left pleura, behind the first portion of the left subclavian artery. On reaching the level of the seventh cervical vertebra it curves downward over the left pleura, subclavian artery, scalenus anticus muscle, and vertebral vein to empty at the junction of the internal jugular and left subclavian veins. It passes behind the left internal jugular vein and common carotid artery. At its termination it lies just external to the left sternoclavicular joint and just below the level of the upper border of the clavicle. A punctured wound at this point might injure the duct. It is fortunate that the duct only rarely exends above the level of the junction of the internal jugular and subclavian. It has been known however, to extend as high as 5.5 cm. (2¼ inches) above the upper border of the sternum.

Accompanying the veins of the neck are numerous lymph-nodes which not infrequently become enlarged and require removal. It is in operating on these nodes that wounds of the thoracic duct have been most often produced. When divided, its lumen has appeared to be of the size of a "knitting needle." In some instances the thin walls of the duct have been ligated. In other cases of injury either the oozing point has been clamped with a hæmostatic forceps which has been left in position for a day, or else the wound has been packed with gauze. Recovery usually ensues.

The duct may become obstructed from (1) aortic aneurisms; (2) mediastinal growths either benign or malignant; (3) enlarged mediastinal lymph nodes; (4) large substernal goitres; (5) inflammation of the duct itself; or (6) by worms (filaria).

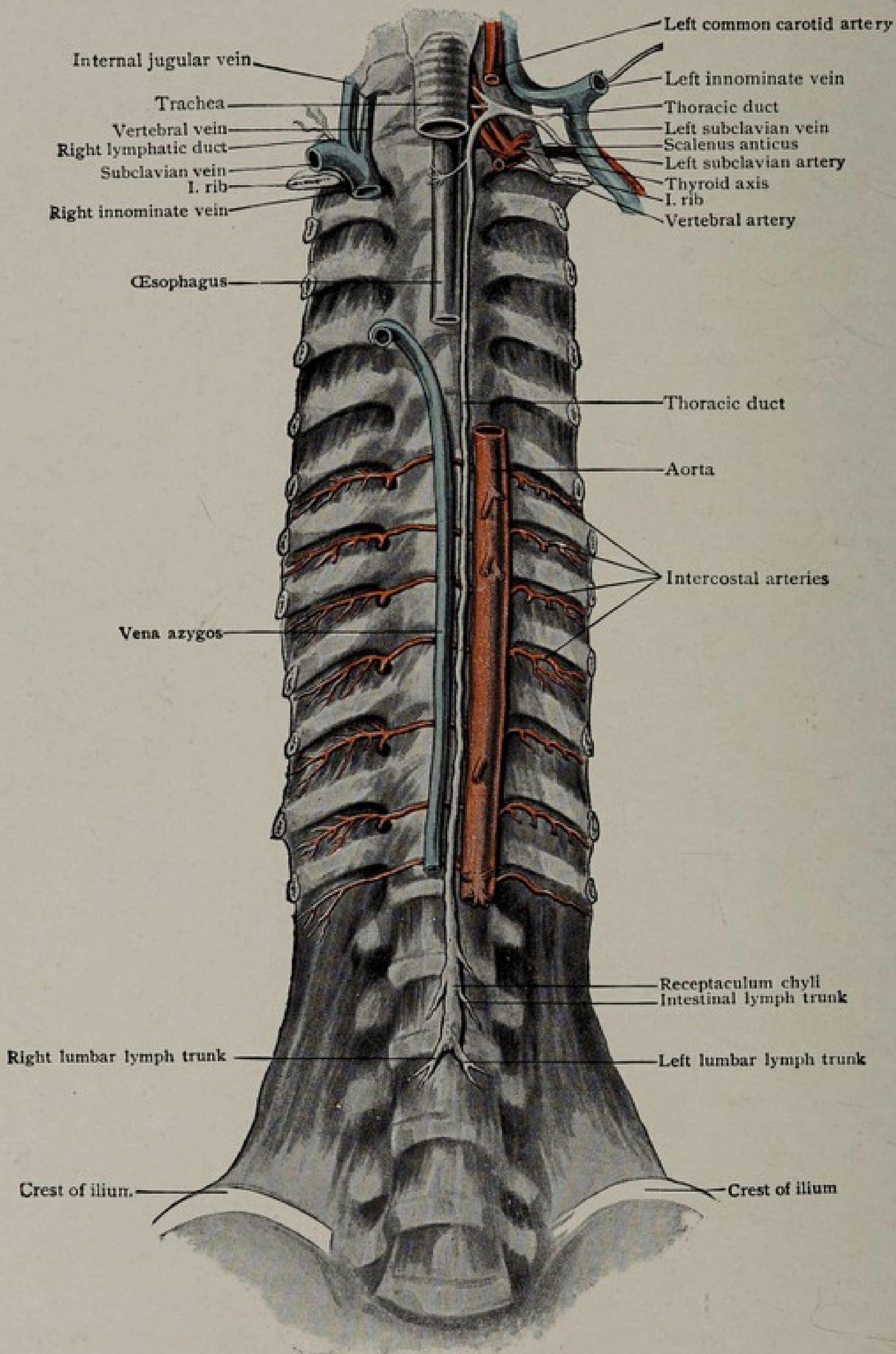


FIG. 243.—Dissection of posterior body-wall, seen from in front, showing thoracic duct and right lymphatic duct veins have been laterally displaced to expose the terminations of the thoracic duct. (Piersol.)

THE UPPER EXTREMITY

Morphology.—The human skeleton consists of two parts, called the axial skeleton and the appendicular skeleton.

The *axial skeleton* embraces the bones of the head, the spine, the ribs, the hyoid bone, and the breast bone. In the spine are included not only the vertebræ of the cervical, thoracic, and lumbar regions, but likewise the sacrum and coccyx.

The *appendicular skeleton* embraces the bones of the limbs, or extremities, including the shoulder-girdle, formed by the scapula and clavicle, and the pelvic girdle, formed by the innominate bone (Fig. 244).

Function.—The upper extremity in man is an organ of prehension. As such, mobility is its chief characteristic. To permit of this mobility the bones and joints are many, and the latter are comparatively loose; the muscles, also, are both numerous and complex. Hence it is that slight injuries are frequently followed by considerable disturbance of function. They are readily produced and with difficulty repaired, either by nature or by art. Orthopædic surgery has done much for the disabilities and deformities of the lower extremities, but comparatively little for those of the upper. An artificial leg in many cases satisfactorily substitutes the natural one, but an artificial arm is comparatively useless.

The hand is the essential part of the upper extremity, and the rest of the limb is subsidiary. If the forearm were lacking and the hand were attached to the end of the humerus it would still be a very useful appendage, far more so than the stump which is left after the hand has been amputated.

The extremities proper are joined to the trunk by what are called girdles. The upper extremity is attached through the medium of the shoulder-girdle and the lower extremity by the pelvic girdle. The interposition of these girdles adds to the mobility of the extremities, and as the upper extremity is more mobile than the lower we find the shoulder-girdle composed of two bones instead of one as in the pelvic girdle; also, as the lower extremity bears the weight of the body it requires strength in addition to mobility, hence we find that it is joined to the trunk by a single big strong bone, the innominate, instead of by two comparatively slight, narrow bones like the clavicle and scapula which form the shoulder-girdle.

The extremities are termed appendicular because they are simply appendages to the essential part, which is the head and trunk; a person *can* live without extremities.

THE SHOULDER-GIRDLE

The upper extremity is joined to the trunk by the shoulder-girdle, which is composed of the clavicle and scapula. The main movements are anteroposterior, as in swinging the arm, those of abduction and adduction, as in raising and lowering it sidewise, rotation and circumduction.

The *scapula* is the more important bone; it is present in all mammals, and the humerus articulates with it. Essentially the scapula provides the shallow socket for the head of the humerus. It also gives attachments to muscles which have humeral attachments and it affords leverage for others in their action on the upper extremity.

The scapula in the mole and many other animals may be a comparatively slender bone, but when, as in man, it is necessary to rotate the arm, then the scapula is large so as to form a strong support for the infraspinatus, supraspinatus, teres minor and major, and subscapularis muscles.

The *clavicle* is developed mainly from membrane, partly probably from cartilage, and is the first bone in the body to ossify. Thus the muscles which arise from the trunk, but insert on the humerus, obtain a maximum of lateral motion. It keeps the shoulder out away from the body, steadies it, and increases the range of motion of the upper extremity. Its one epiphysis, however, at the sternal end, is the last of the epiphyses of the long bones to ossify, appearing about the seventeenth or eighteenth years and joining the diaphysis from the twenty-second to the twenty-fifth years. It owes its existence to the function of abduction. Without a clavicle abduction is practically wanting and when in man the clavicle is broken, he is temporarily reduced to the condition of those animals which have no clavicles; he is able to move the arm backward and forward but not to elevate it properly, and this is an important diagnostic symptom of that injury.

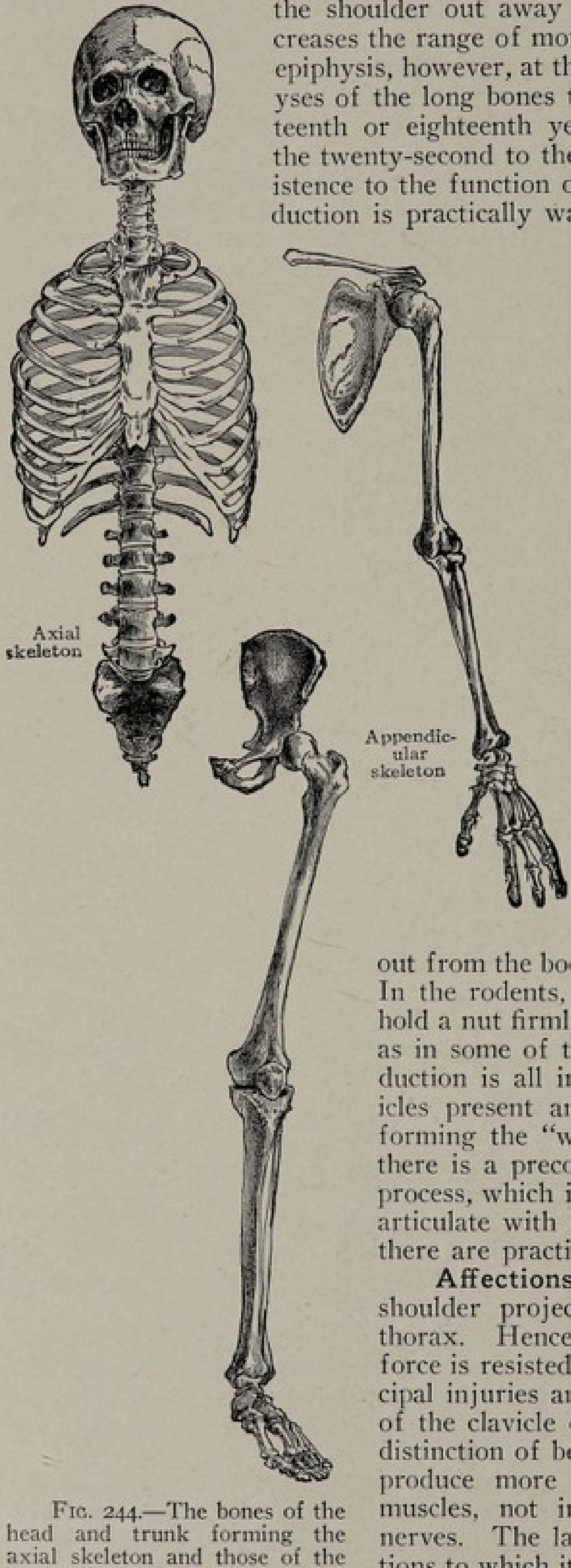


Fig. 244.—The bones of the head and trunk forming the axial skeleton and those of the upper and lower extremities constituting the appendicular skeleton.

The clavicle is lacking in the ungulates or hoofed animals. These have an anteroposterior movement, but little abduction. A horse or cow moves its forelegs back and forward, but not out away from the body. Hence its helplessness when these movements are essential. It is also lacking in seals and whales. In the carnivora, as the lion and the tiger, which possess rudimentary clavicles, sufficient adducting power is present to enable them to hold their food while tearing it apart. In man, apes, bats, rodents, and insectivora the clavicle exists as a well-formed bone; hence they can raise the arm well out from the body and even higher than the shoulder. In the rodents, as the squirrel, they are enabled to hold a nut firmly in the paws while eating it. When, as in some of the lower orders, the function of abduction is all important, we find not only the clavicles present and, as in the common fowl, joined, forming the "wish-bone," but in addition, in birds, there is a precoracoid bone formed by the coracoid process, which is enlarged and continued forward to articulate with the sternum; thus in flying animals there are practically two clavicles on each side.

Affections of the Shoulder.—The point of the shoulder projects well out from the side of the thorax. Hence it is frequently injured. As the force is resisted by the bones, these receive the principal injuries and they are often broken. Fractures of the clavicle dispute with those of the radius the distinction of being the most numerous. Contusions produce more or less complete paralysis of the muscles, not infrequently through lesions of the nerves. The laxity of the joint favors the dislocations to which it is so frequently subject. It likewise becomes the seat of tuberculous disease requiring resection. Crushes of the arm sometimes require its removal at the shoulder-joint, and occasionally as the result of injury or disease operations may be required on the axillary lymph-nodes, nerves, or blood-vessels.

In order to determine the character and extent of injuries to the shoulder, its surface anatomy must be thoroughly known. In order to treat them, a knowledge of the deeper structures and their relation to one another is essential.

The landmarks of the shoulder are formed by the bones and muscles; hence a brief review of their important characters will serve as a basis for the surface anatomy which follows.

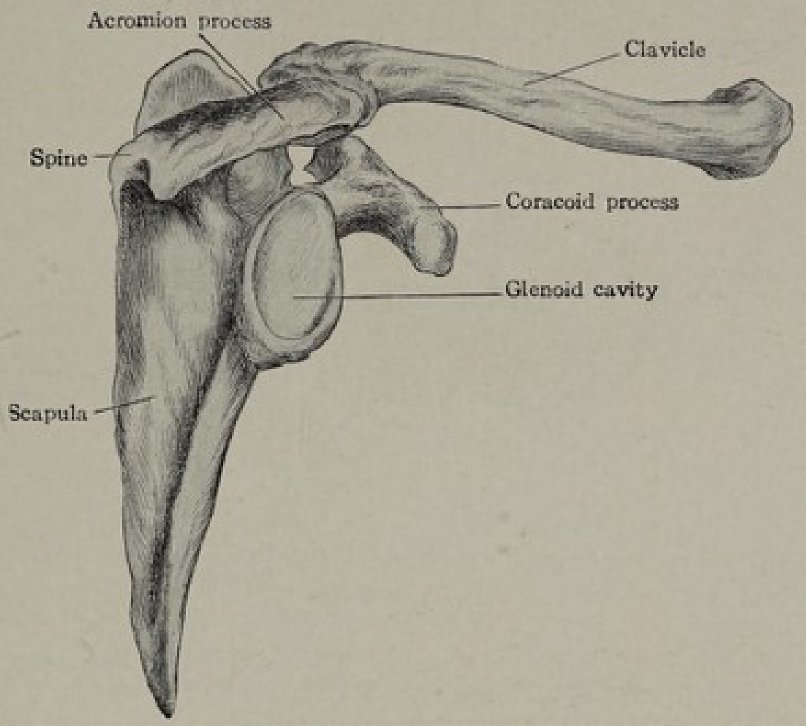


FIG. 245.—Shoulder-girdle of man.

THE BONES OF THE SHOULDER

The bones entering into the construction of, and forming the basis on which the shoulder is constructed are the clavicle and scapula, forming the shoulder-girdle, and the humerus.

The **clavicle** is a comparatively long and slender bone that acts as a prop to keep the point of the shoulder out from the trunk. The inner extremity is large and rests with its flat surface on the upper outer edge of the sternum, with the interposition of a disk of fibrocartilage. Its outer extremity is flattened; it articulates by means of a gliding joint with the acromion process of the scapula, and it is connected with the base of the coracoid process beneath by ligaments. It is double curved, the large curve having its convexity forward and embracing the inner two-thirds of the bone, and the small curve having its concavity forward, forming the outer third.

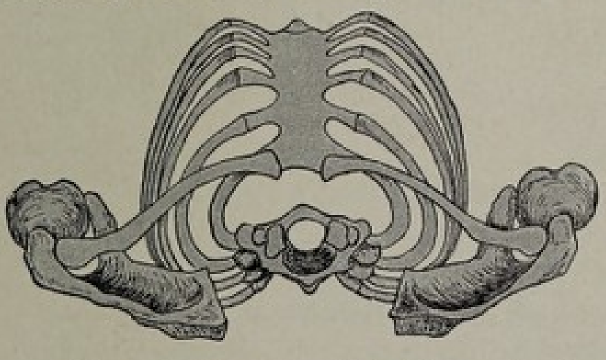


FIG. 246.—Shoulder-girdle of man, showing how the clavicle acts as a prop to keep the shoulder out away from the chest.

At the deepest part of the concavity of the anterior edge, about at the junction of its outer and middle thirds, is a small rough eminence called the *deltoid tubercle* because of the attachment to it of the deltoid muscle. At a corresponding point on the posterior and under surface of the bone is a prominent projection called the *conoid tubercle*; to this is attached the *conoid ligament*. Running forward and outward from this tubercle on the under surface is a rough line which serves as the point of attachment of the *trapezoid ligament*. Both these ligaments are of importance in relation to the fractures of this bone.

The middle third of the bone is its weakest part. Attached to the clavicle on its anterior surface are the *deltoid muscle* on its outer third and the *pectoralis major* on its inner half. On its posterior and upper surfaces are the *trapezius* at its outer third, and the clavicular head of the *sternomastoid* on its inner third. The *subclavius muscle* is attached to its under surface. It will thus be seen that there is a space equal to one-sixth of the length of the bone inferiorly and one-third of the bone superiorly which is free from muscular attachments, and it is here that it is most frequently fractured. The bone would be fractured more frequently if it were not for the elasticity which results from its curves.

The male bone is longer, stronger and more curved than is the female.

The Scapula.—The scapula is spoken of as having a body, neck, spine, and acromion, glenoid, and coracoid processes; an upper, an anterior, and a posterior border; and an upper and a lower angle. It is not often spoken of as possessing a head, the glenoid process or that portion being sometimes so called in which the *glenoid cavity* or fossa for the articulation of the humerus is situated.

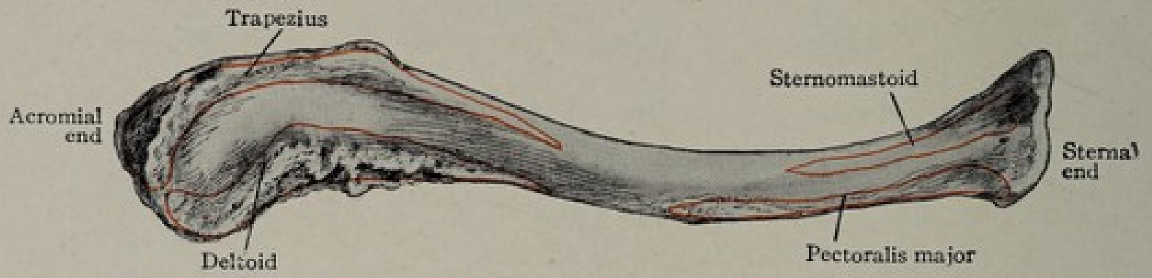


Fig. 247.—Right clavicle, upper surface.

The constriction surrounding the head of the scapula is known as the *anatomical neck*, in contradistinction to the *surgical neck*, which name has been given to that portion indicated by a line drawn through the suprascapular notch and passing beneath the spine and to the inside of the attachment of the long head of the triceps muscle just below the lower edge of the glenoid cavity.

The angles and borders and spine are important landmarks in physical diagnosis and the coracoid and acromion processes in injuries.

In the upper border of the bone at its junction with the base of the coracoid process is a deep notch called the *suprascapular notch* (*incisura scapulæ*), the suprascapular nerve passes through it. The artery passes over it. From the edge

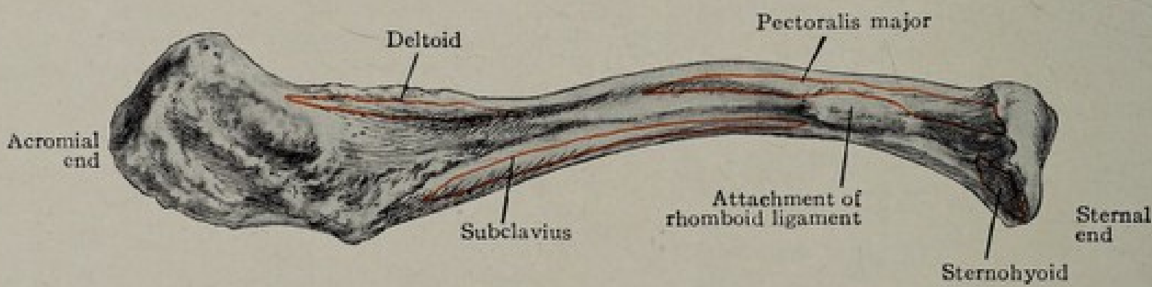


Fig. 248.—Right clavicle, under surface.

of the bone just behind the notch arises the posterior belly of the *omohyoid muscle*, an important guide in operations on the neck.

The body of the scapula on its under surface is flat and rests on the thorax from the second to the seventh and nearly to the eighth rib. Its movements on the chest are free and follow those of the arm. It rises and falls, glides forward and backward, and also rotates on an anteroposterior axis.

When using any portion of the scapula as a landmark it is customary to have the arm hanging by the side; if it is otherwise the position of the bone will be changed, and the relations of its projections to the surrounding parts are altered. The scapula is sometimes fractured directly across its body below the spine. One should endeavor to fix in mind especially the relation of the acromion and coracoid processes to the head, with its glenoid cavity, and the rest of the bone.

The head is comparatively small and cup-shaped, with the glenoid fossa on its surface for the head of the humerus. It is joined to the body of the bone by a narrow constriction called the neck. Fractures through this neck are rare. Above and posterior to the glenoid fossa is the acromion process and spine of the scapula, and above and anterior is the coracoid process.

The spine of the scapula runs upward and forward across the upper and posterior surface of the bone. Its commencement at the posterior edge of the bone is called its root; this is over the fourth rib and opposite the third thoracic spine. The posterior edge of the scapula opposite the root of the spine projects backward, but this is not the superior angle, which is still higher up. The spine of the scapula ends anteriorly in the acromion process. It projects far beyond

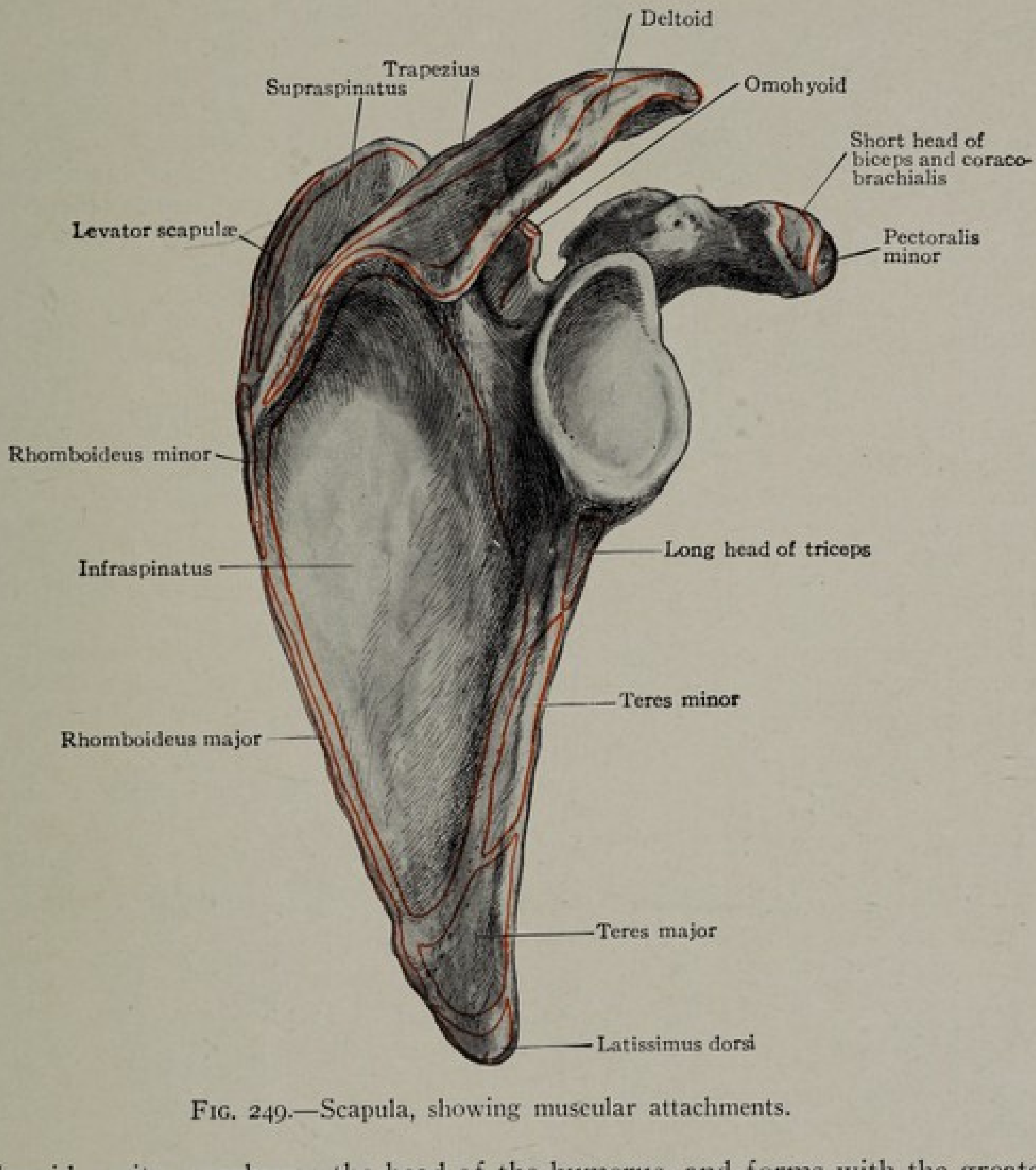


Fig. 249.—Scapula, showing muscular attachments.

the glenoid cavity, overhangs the head of the humerus, and forms with the greater tuberosity the point of the shoulder. It, as well as the rest of the spine, is subcutaneous and is a valuable landmark. Measurement to the edge of the acromion from the suprasternal notch determines shortening in a fracture of the clavicle or in dislocation of the acromial end. The prominence of the acromion is accentuated in shoulder-joint luxations. The length of the arm is usually measured from the junction of the spine of the scapula with the acromion, to the external condyle of the humerus.

The acromion process is not so often fractured as one would expect. Many of the cases which are diagnosed as fractures of the acromion or epiphyseal separations are in reality cases of persistent epiphyses. It articulates with the clavicle and the bones are not infrequently luxated at this point.

The coracoid process projects forward underneath the clavicle to the upper and inner side of the head of the humerus. It is about 2.5 cm. (1 in.) below the clavicle and just to the outer side of the junction of its middle and outer thirds. It lies just underneath the inner edge of the deltoid muscle, hence it is not always easily felt. It is almost never fractured, but is especially valuable as a landmark in injuries and operations on the shoulder.

The two great hollows above and below the spine are the *supra-* and *infraspinous fossæ* for the supra- and infraspinatus muscles. The angles are at the two extremities of the posterior border. The superior angle receives the insertion of the levator scapulæ muscle and is covered by the *Trapezius* which inserts into the spine and thus obscures its outline. The inferior angle is crossed by the upper edge of the *latissimus dorsi muscle*, from which it sometimes receives a few fibres. This angle is rendered prominent when the forearm is flexed on the arm and placed across the back. The centre of ossification of this angle may remain distinct, and connected with the body of the bone by a synchondrosis. Traumatic separation of the angle might therefore occur.

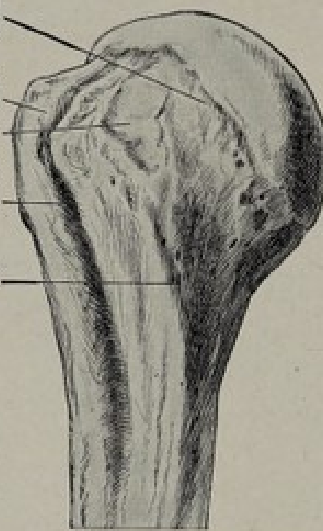


FIG. 250.—Anterior surface of upper end of humerus.

The Humerus.—The upper end of the humerus is composed of a head joined to the tuberosities through the medium of the *anatomical neck*, which is a groove for the attachment of the capsular ligament. The head projects inward, upward and backward from the shaft at an angle of 120° to it. The lesser tuberosity has inserted into it the *subscapularis muscle*; it presents forward. The upper aspect of the tuberosity looks inward and is smooth for the bursa under the subscapular tendon. To its outer side and separating it from the greater tuberosity is the *bicipital groove* for the long tendon of the *biceps muscle*. To the outer side of the groove is the greater tuberosity with its three facets for the *supraspinatus, infraspinatus*, and *teres minor muscles*, from above downward and backward, respectively.

The greater tuberosity projects considerably beyond the acromion process and therefore forms the most prominent part of the shoulder. Immediately below the tuberosities is the *surgical neck*. It is described as being the portion between the tuberosities above and the insertions of the pectoralis major and latissimus dorsi muscles below. It is a common site for fractures. Half way down the shaft on its outer side is the rough *deltoid eminence* for the insertion of the *deltoid muscle*.

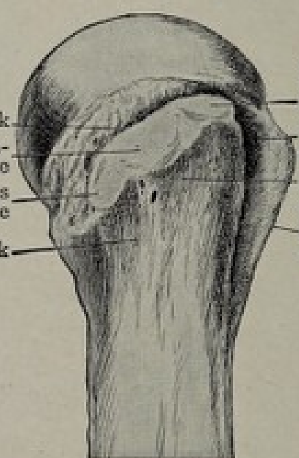


FIG. 251.—Outer surface of upper end of humerus.

Sternoclavicular Joint.—The ligaments uniting the inner end of the clavicle to the thorax at the upper end of the sternum are the *interclavicular*, which passes from one clavicle to the other across the top of the sternum, the *anterior* and *posterior sternoclavicular*, which are really thickened bands of the capsule, and the *rhomboid* or *costoclavicular ligament* which passes from the clavicle downward and forward to the first rib. This last one limits displacement in cases of luxation. There is a fibrocartilaginous disk between the clavicle and sternum, forming two distinct joint cavities. This disk is the chief factor in maintaining the security of the joint. It is thinnest centrally and thickest at its superior border. This is to all intents a universal joint allowing raising, depression, forward or backward motion, air conduction and slight rotation. The joint is strengthened by the muscular arrangement around it which by contraction draws the bones together. The line of the joint slopes downward and outward.

Acromioclavicular Joint.—The outer end of the clavicle articulates with the acromion process by a joint whose surface inclines down and inward, thus favoring displacements of the clavicle upward. The ligaments joining them are called the *superior* and *inferior acromioclavicular*. In reality they are simply the thickened portions of the *capsular ligament*. This capsular ligament is ruptured in the not infrequent cases of luxation which occur here. Running from the under surface of the clavicle, a short distance from its outer end, to the coracoid process below, is the *coracoclavicular ligament*. It is composed of two parts, an antero-external square ligament called the *trapezoid*, and a postero-internal conical one called the *conoid*.

The bone may be fractured just external to these ligaments, giving rise to a peculiar deformity to which attention will be called in describing the fractures of its cartilage.

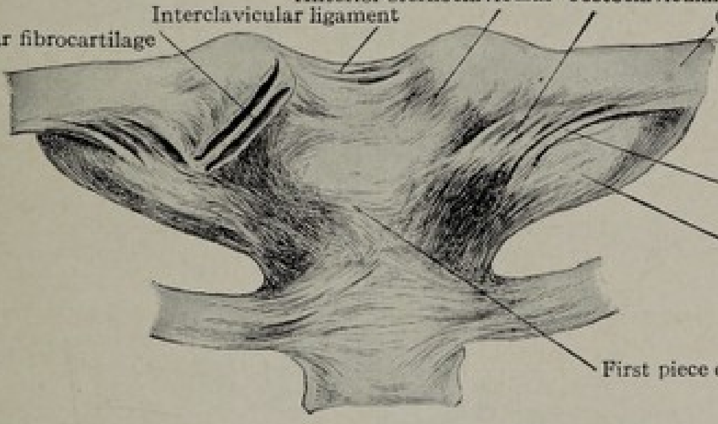


FIG. 252.—Sternoclavicular joint and attachments of the inner end of the clavicle.

From the coracoid process the *coraco-acromial ligament* runs outward and upward to the acromion process, the *coracohumeral* outward and downward to the neck of the humerus, and the *costocoracoid ligament* inward to the first rib at its cartilage.

The Shoulder-joint.—The upper extremity being an organ of prehension and not of support, the shoulder-joint, which is the articulation which connects it with the trunk through the shoulder-girdle, is constructed with the idea in view of favoring and permitting motion, and not of supporting weight or resisting force. Hence we find it to be a ball-and-socket joint, the one which allows of the freest movements.

The glenoid cavity is a shallow excavation, not a deep cup, and therefore there is not the necessity for a long neck as in the femur. The articulating surface of the head of the humerus is extensive but not so large as it would have been had the scapula not been made to move on the thorax. The clavicle keeps the joint well out from the side of the body; hence the neck of the humerus is short. The movements of the arm are so extensive and free that we do not have the tuberosities of the humerus so large and set so far away from the articular surface as is the case with the femur and its trochanters.

If the upper portion of the femur was like the upper end of the humerus, the lower extremity would be continually rolling in or out, making walking or running at least difficult if not impossible. Thus we see that the shape of the bones is dependent on the character of their functions.

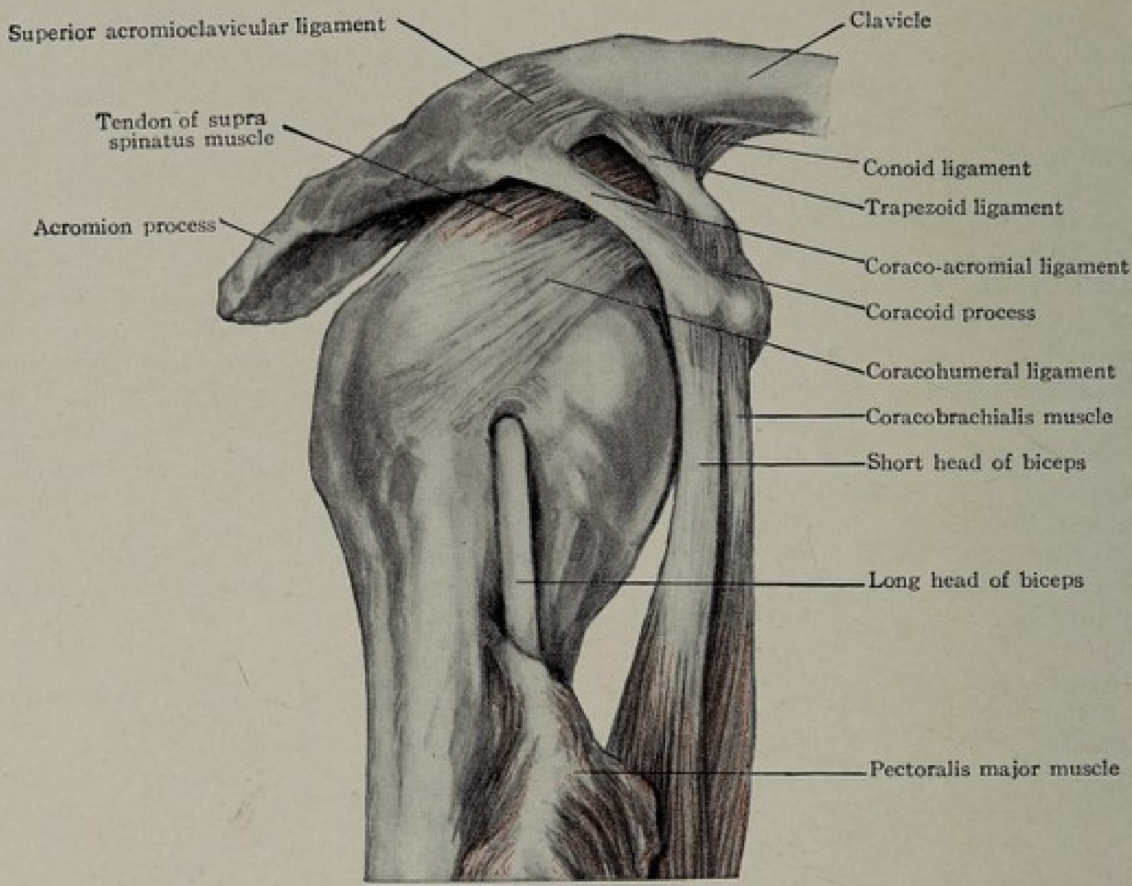


Fig. 253.—Acromioclavicular and shoulder joints.

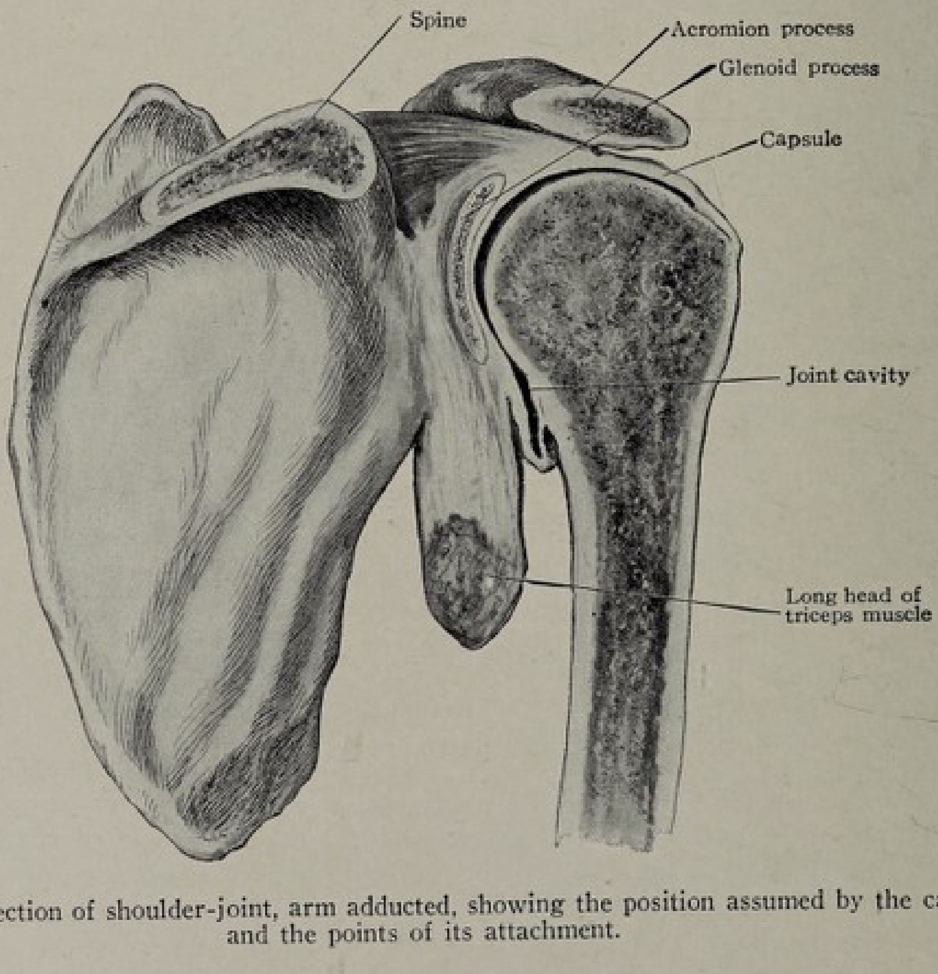


Fig. 254.—Section of shoulder-joint, arm adducted, showing the position assumed by the capsule and the points of its attachment.

The ligaments of the joints are inelastic tissues; hence those that enter into the construction of a movable joint must be loose, and the more movable a joint is, the more does its security depend not on its ligaments, but on its muscles.

The shoulder-joint, like other joints, has a capsular ligament which is attached to the adjacent bones and serves to keep the lubricating synovial fluid applied to the articulating surfaces. In certain positions this ligament may also serve to a limited extent to keep the ends of the bones of the joint in contact.

Besides this capsular ligament there are fibrous bands which strengthen it at certain places as they pass from adjacent processes of bone on one side of the joint to those on the other. The muscles and their tendons pass across the capsule and sometimes blend with it, so that there is an intimate relation between the muscles and their tendons and the ligaments; finally, there is a third structure

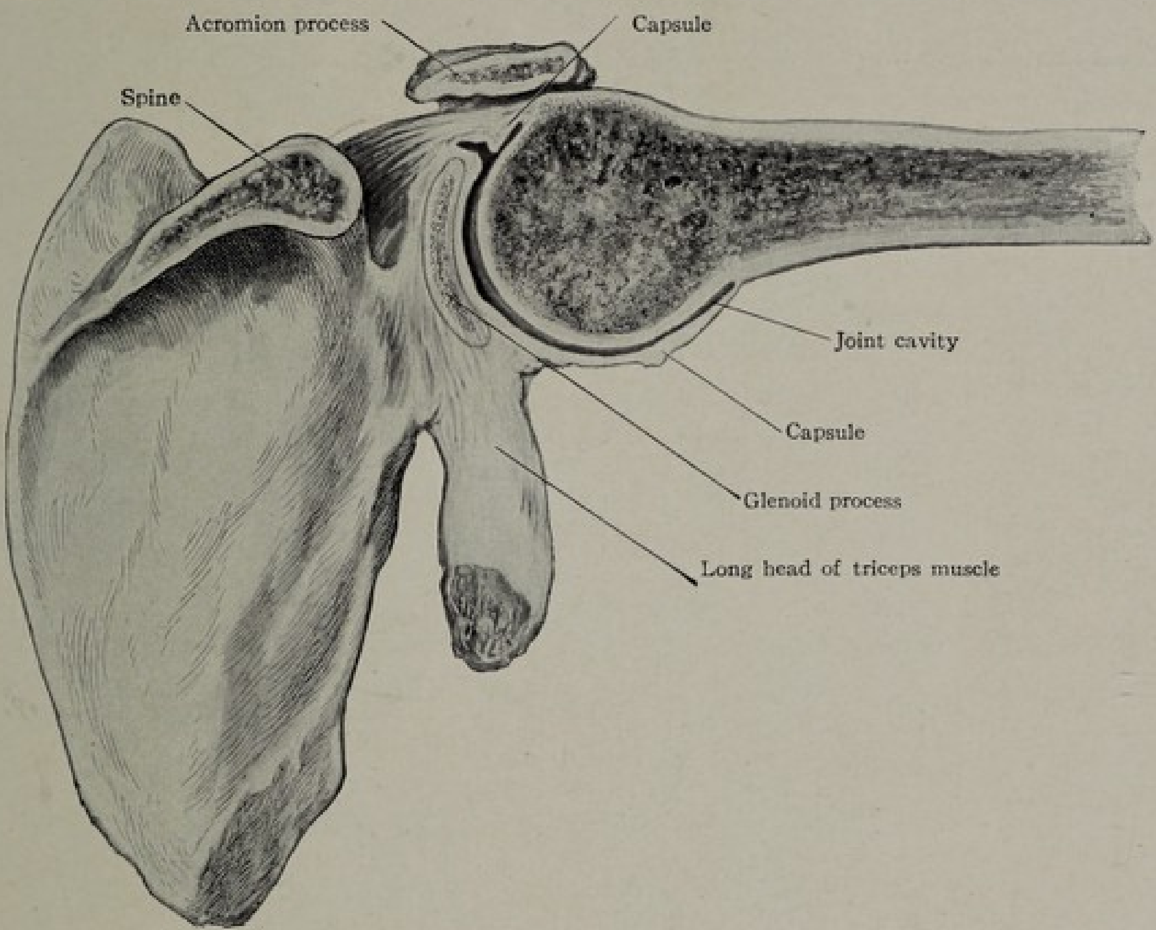


FIG. 255.—Section of shoulder-joint, arm abducted, showing the attachment of the capsule and the position it assumes when the arm is in this position.

called the *glenoid ligament*, which is in reality a fibrocartilage that serves to deepen the glenoid cavity.

The *capsular ligament* is attached on one side to the edge of the glenoid cavity, the anatomical neck of the scapula, and the rim of the glenoid ligament. On the other side it is attached above or externally to the anatomical neck of the humerus just at the edge of the articulating surface, but on the lower or inner surface it is attached some distance below the articular surface (approximately 1 cm.) and then turns upward toward the edge of the articular cartilage. Thus a fracture through the anatomical neck might pass outside of the joint above, and inside of it below. Positions assumed by the capsule in abduction and adduction are shown in Figs. 254 and 255.

The capsular ligament, *per se*, has not much strength. There are two openings in it—one is for the long tendon of the biceps and the other is the opening of the bursa beneath the subscapularis muscle. Sometimes there is a synovial extension beneath the supraspinatus tendon and rarely, in old people, a communication with the subacromial bursa. It is evident that in case of suppuration within the joint the pus would tend to find vent first through these openings.

The laxity of the capsule is such that after the muscles are removed the head can be drawn a considerable distance away from the glenoid cavity. When the muscles are paralyzed the weight of the arm causes the head to fall away and a depression is seen beneath the acromion process. The capsule is strengthened by

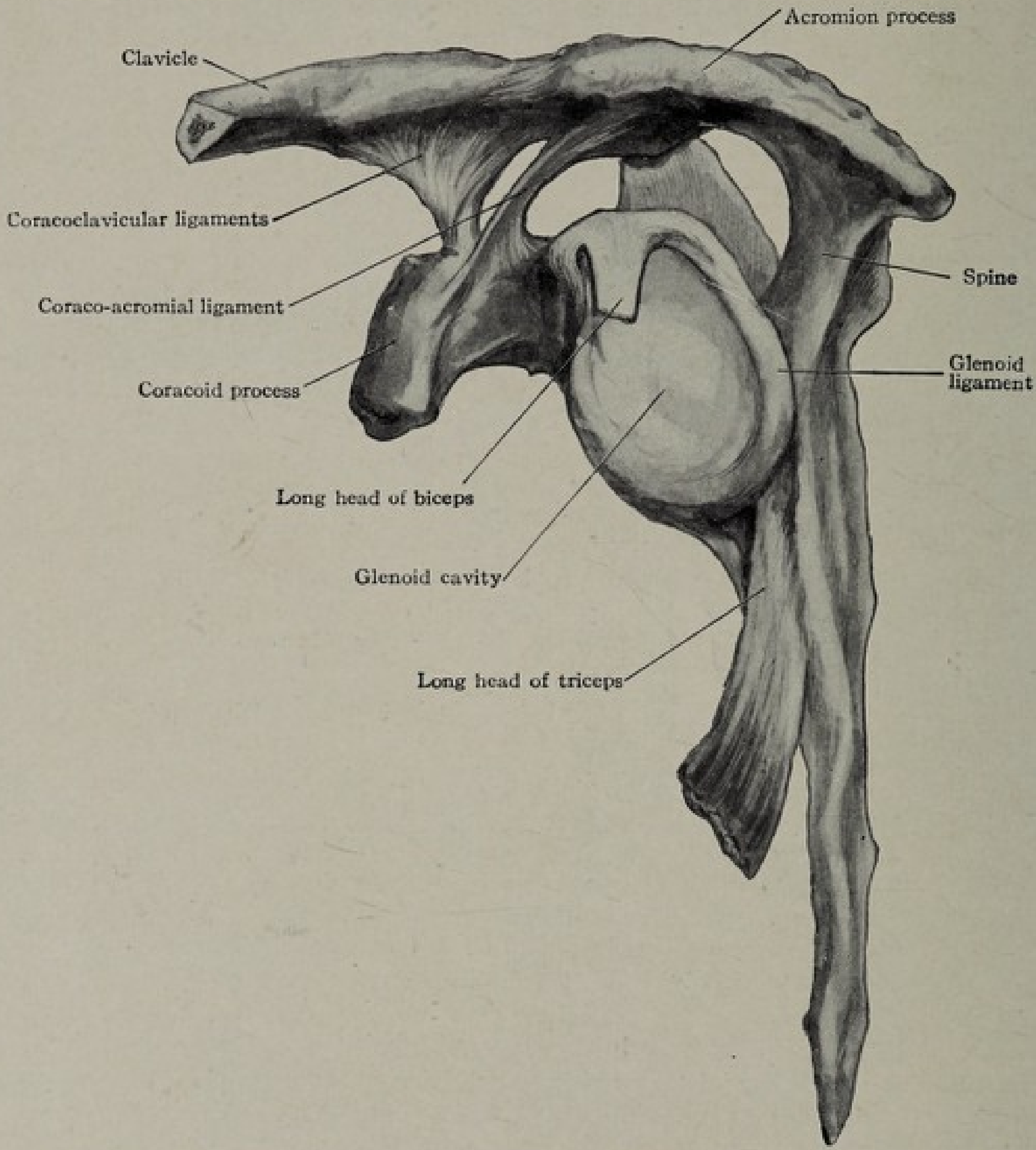


Fig. 256.—View of the left scapula and outer end of the clavicle from in front, showing the ligaments passing from the coracoid process to the clavicle and acromion process, the glenoid ligament, and attachments of the long heads of the biceps and triceps muscles.

two definite and separate ligamentous bands called the coracohumeral and the glenohumeral ligaments.

The *coracohumeral ligament* passes from the root of the coracoid process to the anterior portion of the greater tuberosity. It is supposed by Sutton to be a regression of the tendon of the pectoralis minor muscle.

The *glenohumeral ligament* is a ribbon-like band seen lying alongside of the inner edge of the biceps tendon as it passes through the interior of the joint. It passes from the root of the coracoid process near the edge of the glenoid cavity to a dimple in the lesser tuberosity of the humerus. Sutton considers it a regression of the tendon of the subclavius muscle and homologous with the ligamentum teres in the hip. It is also called the superior glenohumeral ligament, in contradistinction to some bands on the lower anterior part of the capsule which are called by some anatomists the middle and inferior glenohumeral ligaments. Between the superior above and the middle and inferior below is the opening by which the bursa of the subscapularis muscle communicates with the joint.

The *glenoid ligament* is the wedge- or cup-shaped ring of fibrocartilage which deepens the glenoid fossa. It is attached around its edge to the rim of the fossa and at its upper end receives the long tendon of the biceps, which divides and blends with it on each side. At its lower part when it is attached to the bone it blends with the anterior edge of the long tendon of the triceps.

THE MUSCLES OF THE REGION OF THE SHOULDER

The shoulder embraces two sets of muscles: one connects the shoulder-girdle with the trunk and the other the humerus with the shoulder-girdle.

The inner end of the clavicle articulates with the sternum and gives a bony support to the shoulder-girdle at this point. The rest of the shoulder-girdle,

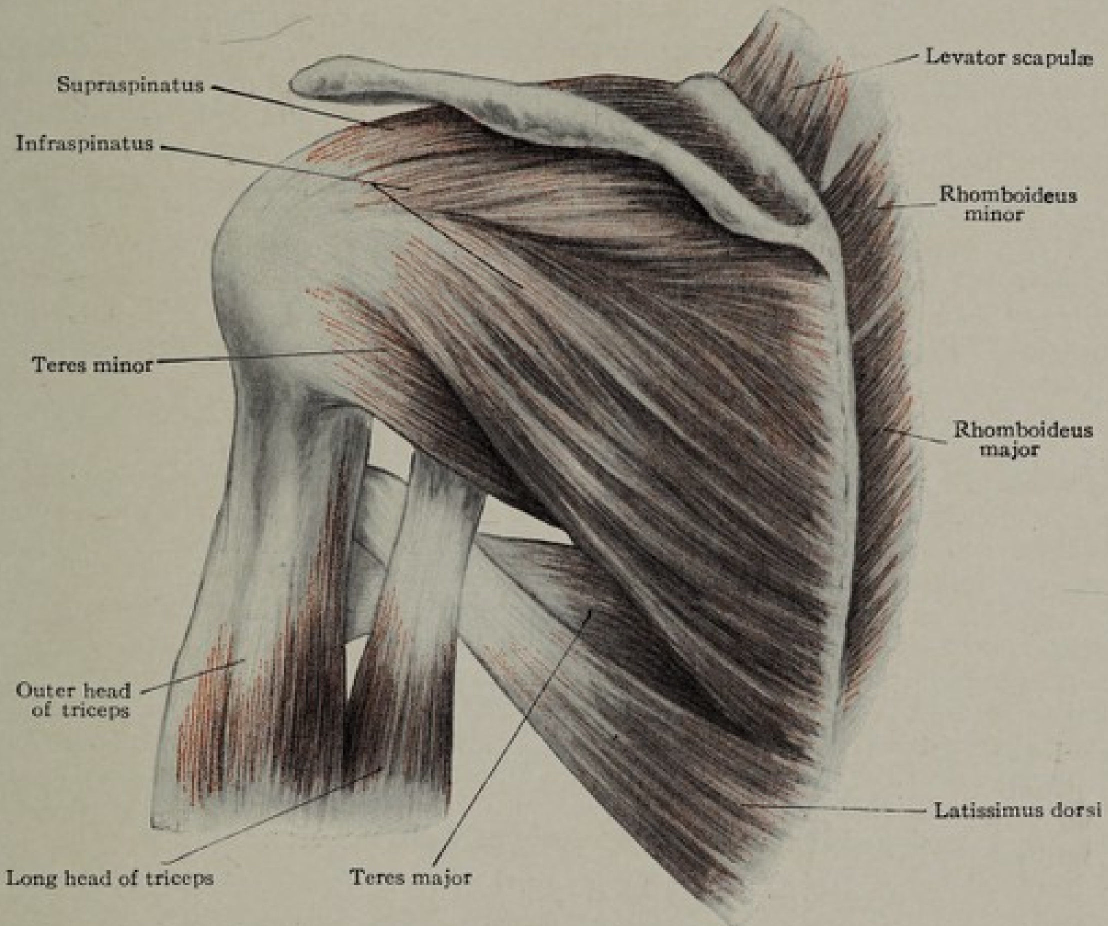


Fig. 257.—Scapular muscles.

comprising the remainder of the clavicle and all of the scapula and bearing the weight of the whole upper extremity, hangs from and is supported and moved by the muscles which pass from it to the vertebræ posteriorly and to the skull, hyoid bone, and ribs anteriorly.

Anteriorly the clavicle has attached to its upper inner third the clavicular origin of the sternomastoid muscle; and on its under surface is the subclavius muscle, which arises from the cartilage and anterior end of the first rib. These muscles aid in moving the clavicle. Running from the third, fourth, and fifth ribs to the coracoid process is the *pectoralis minor muscle*; and on the side of the chest, passing to the posterior edge of the scapula, is the *serratus anterior* (*magnus*) muscle. It will be alluded to again.

Posteriorly is the trepezius muscle superficially, and beneath are the *omohyoid, levator scapulæ,* and the two *rhomboid muscles.*

The **trapezius** arises from the superior curved line of the occiput, the ligamentum nuchæ, and the spines of the seven cervical and all of the thoracic vertebræ. It inserts into the upper surface of the outer third of the clavicle, acromion process, and spine of the scapula to near its root. Its upper fibres directly aid in sustaining the weight of the upper extremity. It is not infrequently paralyzed, and then falling of the shoulder is marked. It also tends to pull the scapula backward toward the spine, and rotates it.

The **levator scapulæ** arises from the transverse processes of the upper four cervical vertebræ and passes downward to insert into the posterior edge of the scapula between its upper angle and the root of the spine of the scapula.

The scapula is supported largely by this muscle; hence when the trapezius is paralyzed, as occurs in division of its motor nerve, the spinal accessory, this muscle is utilized in counteracting its loss.

The **rhomboid muscles** arise from the lower part of the ligamentum nuchæ and the spines of the seventh cervical and upper five thoracic vertebræ and insert into the posterior edge of the lower three-fourths of the scapula.

The **serratus anterior (magnus) muscle** (Fig. 219), lies beneath the scapula and arises from nine slips from the outer surface of the upper eight or nine ribs; the second rib receives two slips. It passes backward and upward and inserts into the posterior edge of the scapula from its upper to its lower angle.

The serration attached to the sixth rib is the one that reaches farthest forward on the side of the chest.

The **omohyoid muscle** arises posteriorly from the upper border of the scapula, just behind the suprascapular notch, and then runs upward and forward to the under surface of the body of the hyoid bone. It is a digastric or two-bellied muscle and its middle tendon is attached by a pulley-like process of the deep cervical fascia to the first rib.

MOVEMENTS OF THE SHOULDER-GIRDLE

While the muscles above enumerated comprise all those directly attached to the shoulder-girdle and trunk, they are of course assisted to some extent by the muscles forming the axillary folds, viz., the pectoralis major anteriorly and the latissimus dorsi and teres major posteriorly.

The shoulder-girdle is elevated by the upper fibres of the trapezius, levator scapulæ, rhomboidei, sternomastoid (clavicular origin), and omohyoid. It is depressed by the lower fibres of the trapezius, latissimus dorsi, lower fibres of the serratus anterior (magnus), pectoralis major, pectoralis minor, and subclavius. It is drawn forward by the pectoralis major, minor, subclavius, serratus anterior, omohyoid, and, if the arm is fixed, by the teres major muscles. It is drawn back by the trapezius, rhomboidei, and latissimus dorsi muscles. Circumduction is effected by a combined action of various parts of these muscles.

SURFACE ANATOMY

On observing the region of the shoulder it is noticed that it projects well out from the trunk, so that the arm hangs free. It has as its framework three bones —the clavicle and scapula above, forming the shoulder-girdle, and the humerus below. They radiate from the region of the joint, the clavicle toward the front, the scapula toward the back, and the humerus downward, forming the basis of the shape of the shoulder, which is modified by the muscles, fat, and skin.

The skin and fat bridge over and tend to obliterate the hollows and to a less extent obscure the prominences. This is more the case as applied to the muscles than the bones, hence the bones form the better landmarks or guides.

Age and sex modify the surface appearances. In children the bones are but slightly developed and their prominences not marked. Fat is usually abundant and it is often no easy task to recognize by the sense of touch the various anatomical parts and determine whether or not they have been injured. For this reason one should endeavor to increase his skill by taking advantage of every opportunity that offers for examination. In the case of women the same thing usually exists, but to a less degree. In the somewhat emaciated adult male the structures can be recognized to best advantage.

The clavicle is subcutaneous, and even in children and fat people can be felt throughout its entire length. Its large, knob-like inner extremity projects considerably above the upper edge of the sternum, which can be felt at the suprasternal notch. Take particular notice of its size and compare it with the one on the opposite side so as not to be misled as to its being diseased or luxated. Follow the bone to its outer extremity, which is higher than the inner, more so when lying down than when standing. A prominent ridge marks its outer extremity; if it is

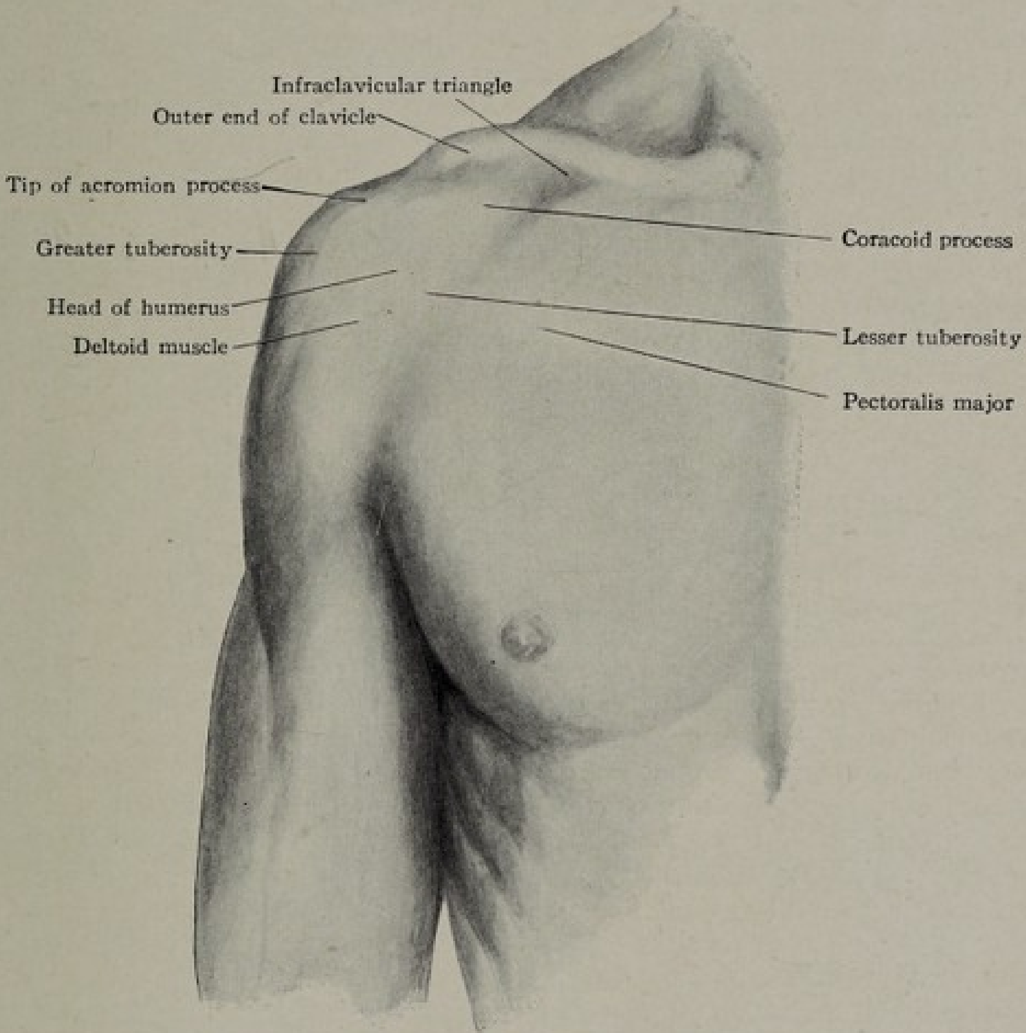


FIG. 258.—Surface anatomy of the shoulder.

difficult to recognize, as will often be the case, then continue directly outward to the point of the shoulder, which is formed by the tip of the acromion process. Having recognized this point, the end of the clavicle will be found about 2.5 to 3 cm. (1 to 1¼ in.) directly inward from it.

In the median line above the sternum is the suprasternal notch with the prominent sternal origins of the sternomastoid muscles on each side. Just to the outer edge of these tendons lie the sternoclavicular joints. The one on the right side marks the ending of the innominate artery and the commencement of the right common carotid and subclavian. That on the left marks the left carotid with the subclavian directly to its outer side and a little posteriorly.

If the head is extended and turned to the opposite side the clavicular origin of the sternomastoid is made visible. It arises from the *inner third* of the bone.

The inner two-thirds of the clavicle is convex forward. Above this portion is the subclavian triangle in the supraclavicular fossa. The *outer third* of the clavicle is convex backward and from its upper surface the trapezius muscle can be felt proceeding upward. This leaves the middle third of the bone free from muscle.

Under the middle of the bone passes the subclavian artery. It curves upward about 2.5 cm. (1 in.) above the clavicle to descend again to the sternoclavicular joint. The arch so formed indicates the apex of the lung because the subclavian artery rests on the pleura. The internal jugular vein passes down opposite the interval between the sternal and clavicular heads of the sternomastoid muscle. Just behind the clavicular head of the sternomastoid lies the scalenus anticus muscles upon the posterior surface of which is found the phrenic nerve.

Just above the clavicle, a little internal to its middle, and behind the clavicular origin of the sternomastoid muscle is seen the external jugular vein. It terminates in the subclavian vein, which lies to the inner (anterior) side of the artery. To the outer side of the artery the cords of the brachial plexus pass upward and inward. They become prominent in emaciated subjects when the head is turned forcibly toward the opposite side. The posterior belly of the omohyoid muscle varies in its position, sometimes it lies behind the clavicle, at others two or three centimetres above it.

Immediately below the clavicle is the infraclavicular fossa. At its inner extremity can be felt the first rib. As it is exceedingly easy to mistake the ribs, it is best, in counting them, to locate the second rib by recognizing the angle of the sternum, (angle of Ludwig) to which it is opposite, on the surface of the sternum about 5 cm. (2 in.) below its upper edge. Attached to the lower edge of the *inner half* of the clavicle is the pectoralis major muscle and to the *outer third* the deltoid muscle.

This leaves one-sixth of the lower edge of the clavicle free from muscular attachments. This forms the base of the subclavicular triangle and its two sides are formed by the adjacent edges of the pectoralis major and deltoid muscles. Beneath this triangle runs the first portion of the axillary artery with the vein to its inner side and the cords of the brachial plexus to its outer side. Deep pressure at this point can compress it against the second rib, but not so effectively as above the clavicle.

Just to the outer side of the junction of the middle and outer thirds of the clavicle, in front of the deepest part of the concavity of the clavicle and about 2.5 cm. (1 in.) below it, is the coracoid process. It is better felt by pressing the fingers flat on the surface than by digging. It is somewhat obscured by the edge of the deltoid muscle, which covers it. Running from the coracoid to the acromion process is the sharp edge of the coraco-acromial ligament. An incision midway between the two processes would open the joint and strike the long biceps tendon as it winds over the head of the humerus to reach the upper edge of the glenoid cavity. The head of the humerus when pressed against this arch communicates motion to the outer fragment in fracture of the clavicle. This is the simplest way to obtain crepitus and preternatural mobility in this fracture.

Beneath the acromion process but covered by the deltoid is felt the greater tuberosity of the humerus. If the arm is placed alongside of the body with the palm facing forward, a distinct groove can be felt to the inner side of the acromion process passing downward on a line with the middle of the arm. It is the bicipital groove for the long tendon of the biceps muscle. The bony process of the humerus to its outer side is the greater tuberosity and that to its inner side, between it and the coracoid process, on a slightly lower level, is the lesser tuberosity. It will be noted that the greater tuberosity projects beyond the acromion process and forms the prominence of the shoulder. On rotating the arm the tuberosities can be distinctly felt moving under the deltoid muscle.

Following the acromion process around toward the back it turns abruptly where it joins the spine of the scapula, forming a distinct angle. This angle is quite prominent, can be readily seen and felt, and can be used as a landmark for measuring the length of the humerus. If the spine of the scapula is followed farther it ends in its root at the posterior border of the bone opposite the upper edge of the fourth rib and third thoracic spine. This marks the upper extremity of the fissure of the lung; with the arm to the side, the lower angle of the scapula lies over the seventh interspace.

Axilla.—On raising the arm directly out from the body the armpit and axillary folds become visible. The rounded edge of the anterior axillary fold is formed by the pectoralis major muscle. It follows the fifth rib and its upper end merges with the lower edge of the deltoid muscle.

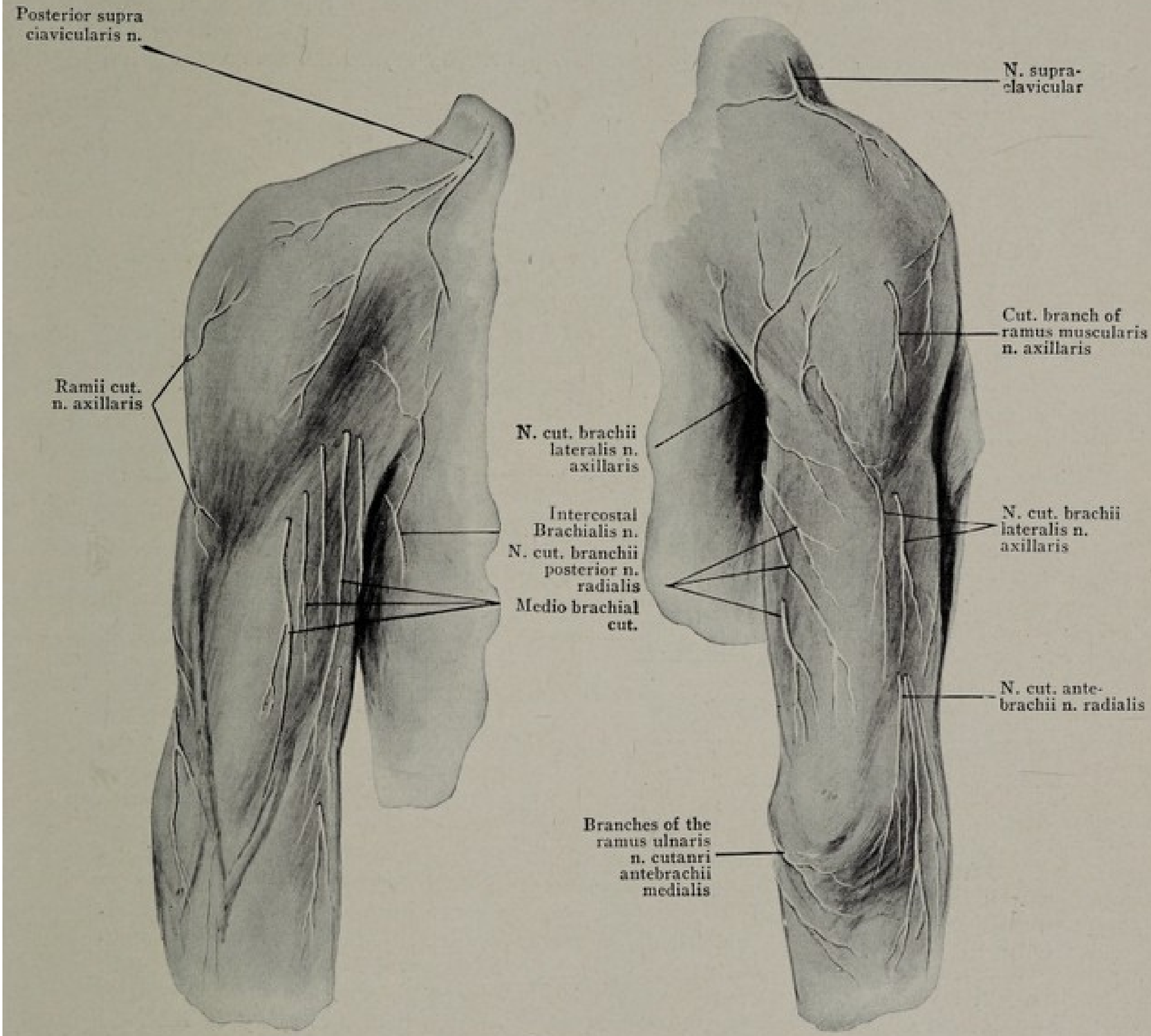


Fig. 259.

Distribution of cutaneous nerves of shoulder and arm anterior. Distribution of cutaneous nerves of shoulder and arm anterior.

If firm pressure is made along the inner or lower edge of the outer extremity of the anterior axillary fold the upper end of the biceps muscle can be felt, and lying along with it, to its inner side, is the swell formed by the coracobrachialis muscle.

Along the inner edge of the coracobrachialis muscle lies the axillary artery with its vein to the inner side. This is a little anterior to the middle of the axilla. The artery can be felt pulsating along the inner edge of the coracobrachialis and can be compressed by pressure made in an outward and backward direction against the humerus. The line of the axillary artery is from the middle of the clavicle down along the inner edge of the coracobrachialis muscle, which will be anterior to the middle of the axilla.

The posterior fold of the axilla is formed by the latissimus dorsi and teres major muscles. By deep pressure in the axilla, posterior to the vessels, the arm being abducted, the rounded head of the humerus can be felt.

When the arm is brought more to the side the tissues of the axilla relax and any enlarged lymph-nodes present may be recognized. When normal they cannot be felt.

Winding around the surgical neck of the humerus from behind forward under the deltoid muscle, just below the surgical neck is the posterior circumflex artery and circumflex nerve. Hence a blow at this point may injure the nerve and cause

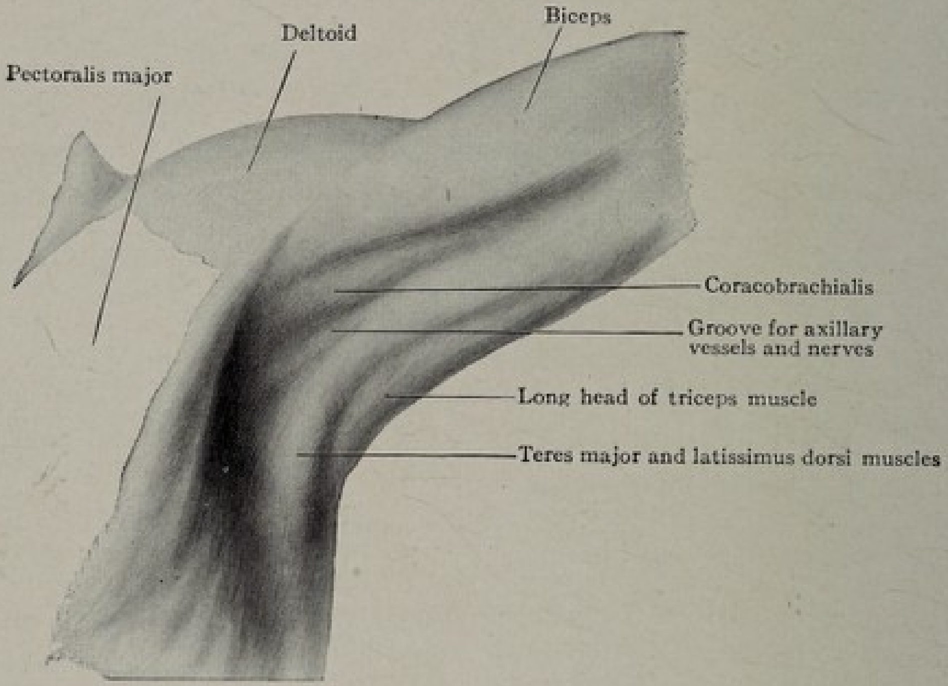


Fig. 260.—Surface anatomy of the axilla.

paralysis of the deltoid muscle. The line of fracture of the surgical neck of the humerus would also lie at this point.

DISLOCATIONS OF THE CLAVICLE

Dislocation of the Sternal End of the Clavicle.—The sternal end of the clavicle is most commonly dislocated forward. Other dislocations, which may be upward or backward, are very rare. The range of movement of the clavicle approximates 60 degrees. All the dislocations are uncommon. The interarticular fibrocartilage acts as a buffer and prevents the clavicle from transmitting to the sternum the full force of blows on the hand or shoulder. The ligaments are stronger than the clavicle which therefore fracture in most cases where an injury is received which threatens the integrity of the joint.

The bone is lowest when the elbow is brought forward across the front of the body and highest when the arm is raised and placed behind the neck. The luxation is produced by the shoulder being violently depressed and pushed backward, as in falling on it; in some cases an inward thrust may be added. As the clavicle descends its under surface comes into contact with the first rib, which acts as a fulcrum, and the inner extremity is lifted upward and forward, rupturing the anterior sterno-clavicular ligament which is the weakest. The rhomboid ligament remaining intact prevents a wider displacement of the bone.

As regards treatment, to reduce the luxation the shoulder should be elevated and drawn outward and backward. While pressure is made on the protruding bone the arm is used as a lever and the bone tilted into place. Usually reduction can be readily accomplished, but most people have found it difficult to retain the parts in place. The only sure way of doing so is to keep the patient in bed on his back.

Stimson, following Velpeau and Malgaigne, advises the application of an anterior figure eight bandage of plaster-of-Paris; Hamilton says deformity remains after any method of treatment, but that function will be but little impaired.

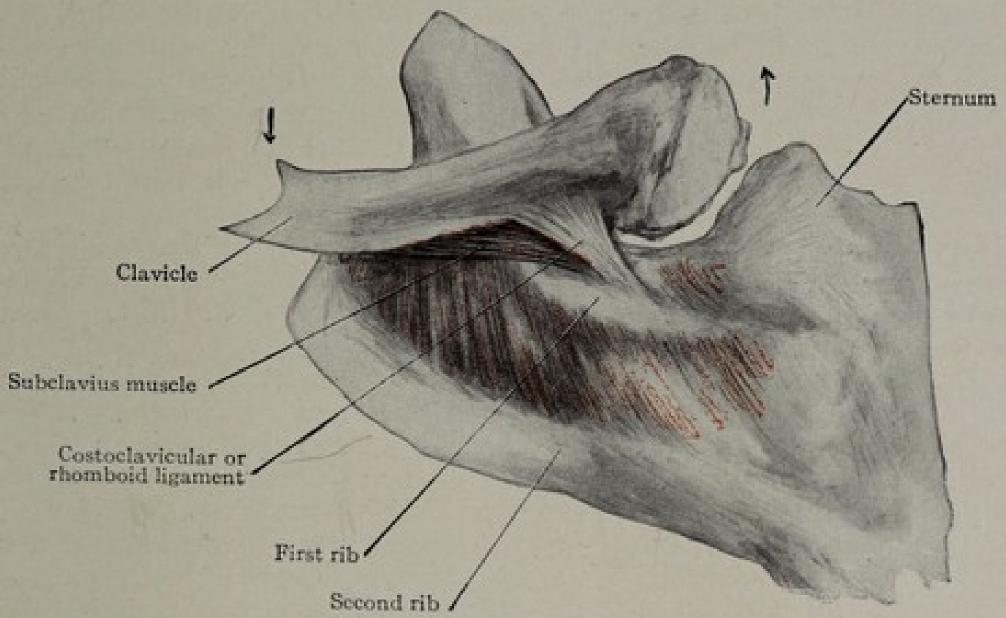


Fig. 261.—Dislocation of the sternal end of the clavicle upward and forward, showing how the first rib acts as a fulcrum and the clavicle as a lever.

In upward dislocations the end of the bone passes behind the sternal origin of the sternomastoid muscle. This dislocation is extremely rare since it is resisted by the wedge-shaped interarticular cartilage and the powerful ligamentous and attachments.

In backward dislocations pressure on the trachea and œsophagus have caused difficulty in breathing and swallowing; cyanosis due to pressure on the internal jugular and innominate veins has been observed in one case. When one recalls the function of the clavicle in keeping the shoulder out from the body, it is readily seen that when the security of its inner attachment has once been destroyed displacement is favored by the weight of the upper extremity as well as by the action of all the muscles which pass from the head, neck, and trunk to the shoulder-girdle and humerus.

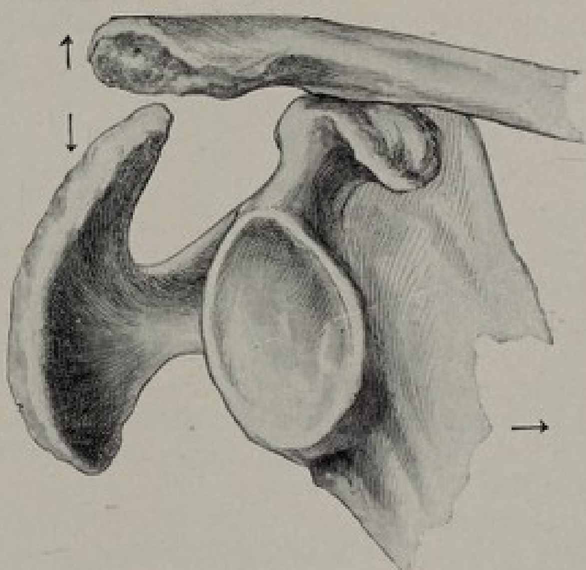


Fig. 262.—Luxation of the outer end of the clavicle upward, showing the coracoid process acting as a fulcrum. As the outer end of the clavicle rises, the lower angle of the scapula is carried toward the median line and the acromion process is depressed and torn loose from the clavicle above.

In these dislocations of the sternal end of the clavicle the fibrocartilaginous disk of the joint sometimes is carried out with the clavicle and sometimes remains attached to the sternum, more often it follows the clavicle.

Dislocation of the Acromial End of the Clavicle.—This articulation is extremely shallow, the clavicle being perched upon the upper edge of the acromion. The powerful conoid and trapezoid ligaments, although they bear an indirect relation to the joint are the most important factors in preserving its integrity. The acromial end of the clavicle may be dislocated either upward or downward. Nearly all the dislocations are upward.

The displacement is usually produced by direct violence, a blow on the top or back of the shoulder driving the acromion down and inward. The clavicle not only rises but also goes backward, or the scapula comes forward, so that the end of the clavicle may rest on the acromion process. In this dislocation the base of the coracoid process, on which the clavicle rests and to which it is bound by the conoid and trapezoid ligaments, acts as a fulcrum. The scapula rotates on an anteroposterior axis, passing through the base of the coracoid process, and as the inner portion of the bone rises, its outer portion,—that is, the acromion process,—descends and is torn from the outer end of the clavicle.

The deformity produced by the upwardly projecting end of the clavicle is typical. The luxation may be complete or incomplete. When incomplete the injury is confined to the acromioclavicular joint; when complete the conoid and trapezoid ligaments are partially or wholly ruptured.

The joint usually possesses a poorly developed fibrocartilage and inclines upward and outward so that the inclination favors the rise of the clavicle. When the conoid and trapezoid ligaments are not ruptured they serve as the axis on which the scapula rotates forward so that the outer end of the clavicle slips backward on the acromion process. This led Hamilton to describe these luxations as backward luxations. In rare instances the end of the clavicle seems to be displaced posteriorly without rising above its normal level. We reported one such case in the *Annals of Surgery* several years ago. Reduction of the displacement is easily effected, but the same difficulty in keeping the bone in place has been experienced in this dislocation as in dislocations of the inner extremity. Bandages going over the shoulder and down the arm and under the elbow are commonly employed. The only sure way of keeping the clavicle in its proper position is to operate and fasten it to the acromion with wire or chromicised catgut. When the patient is put in bed the bones are readily replaced.

Downward dislocation though rare may occur, but as the under surface of the clavicle rests on the coracoid process it is difficult to see how it is possible for this injury to take place. It must take place while the scapula is violently twisted on the clavicle. The displacement is readily reduced and shows but little tendency to recurrence.

DISLOCATIONS OF THE SHOULDER

The dislocations of the shoulder are to be studied from the anatomical and not from the clinical standpoint. A knowledge of the anatomical construction of the various parts involved is to be applied to the explanation and elucidation of the methods of production, the signs and symptoms observed, and the procedures necessary for reduction. J. William White pointed out the following anatomical conditions which are of importance in relation to displacement: "(1) The shallowness of the glenoid cavity. (2) The relatively large size of the humeral head only one-third of which is in contact with the glenoid surface when the arm is by the side of the body. (3) The thinness and great laxity of the capsule, which if fully distended, would accommodate a bulk twice as large as the head of the humerus. This laxity (to permit free elevation of the arm) is greater at the inferior portion of the joint. The primary office of the capsular ligament in this joint is not to maintain apposition, but to limit movement. (4) The maintenance of the contact between the articular surfaces by muscular action, aided by atmospheric pressure, and not by the ligamentous or capsular attachments. (5) The length of the humerus affording a very long leverage, and the exposed portion of the shoulder.

Classification.—For our purpose there are two forms of dislocations of the shoulder—anterior and posterior. These two forms are entirely different and must be studied separately.

Anterior Dislocation.—An anterior luxation is one in which the head of the humerus is either on or anterior to the long head of the triceps muscle at the lower edge of the glenoid cavity.

Posterior Dislocation.—A posterior luxation is one in which the head goes posterior to the glenoid cavity and usually rests beneath the spinous process of the scapula, hence this is called *subspinous dislocation.*

When the head is luxated anteriorly it may pass so far inward as to rest between the coracoid process and the clavicle; hence this form is called *subclavicular.*

When the head does not pass so far inward, but rests on the anterior edge of the glenoid cavity below the coracoid process, it is called a *subcoracoid luxation.*

When it rests on the anterior and lower edge of the glenoid cavity, sometimes on the long head of the triceps muscle or just anterior to it, it is called a *subglenoid luxation.*

ANTERIOR DISLOCATION OF THE SHOULDER

The head of the bone almost always comes out through the anterior portion of the capsule and slips beneath the coracoid process. From this point it may shift its position either a little farther inward, when it is called a subclavicular luxation, or a little farther downward and outward, when it receives the name of subglenoid.

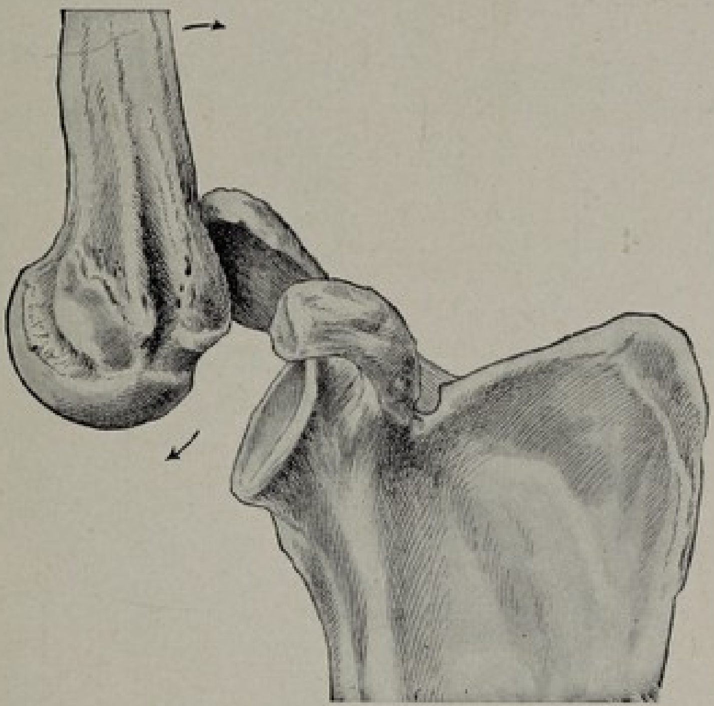


FIG. 263.—Dislocation of the shoulder; action of the bones; by extreme abduction of the humerus over the acromion process as a fulcrum the head is levered out of the socket.

As a matter of fact the head usually comes to rest beneath the coracoid process and permanent fixation of the bone either in the subclavicular or subglenoid positions is very rare. As the symptoms and methods of treatment are identical they will all be included under the one head of subcoracoid luxations. What are commonly regarded as subglenoid luxations are really subcoracoid.

Method of Production of Anterior Luxations.—Anterior luxations are produced by the arm being hyperabducted, rotated outward, and the head of the bone pushed or pulled in toward the body. Rotation may not be essential, but it is largely responsible for the wide detachment of the capsule which is present in these injuries. When the arm is raised from the body much beyond a right angle the greater tuberosity strikes the acromion process. If the hyperabduction is continued the acromion process acts as a fulcrum and the head of the bone is lifted from its socket, tearing away the capsule of the joint in front of and below the glenoid cavity.

If now the arm rotates, the capsule is still farther detached and if the force continues to act, as in those cases in which a person is thrown forward and alights on the outstretched arm, or if the axillary muscles contract, the head is thrust from its socket. After once leaving the socket, subsequent movements may cause the head to assume various positions around the glenoid cavity; as a matter of fact it is almost always below the coracoid process.

Parts Injured.—When the luxation occurs the arm is hyperabducted and, owing to the acromion process being somewhat posterior to the glenoid cavity, pointing backward, this places it up almost or quite alongside of the head. The force which thrusts the bone out acts downward toward the axilla and inward toward the body. The posterior border of the scapula is prevented from descending by the levator

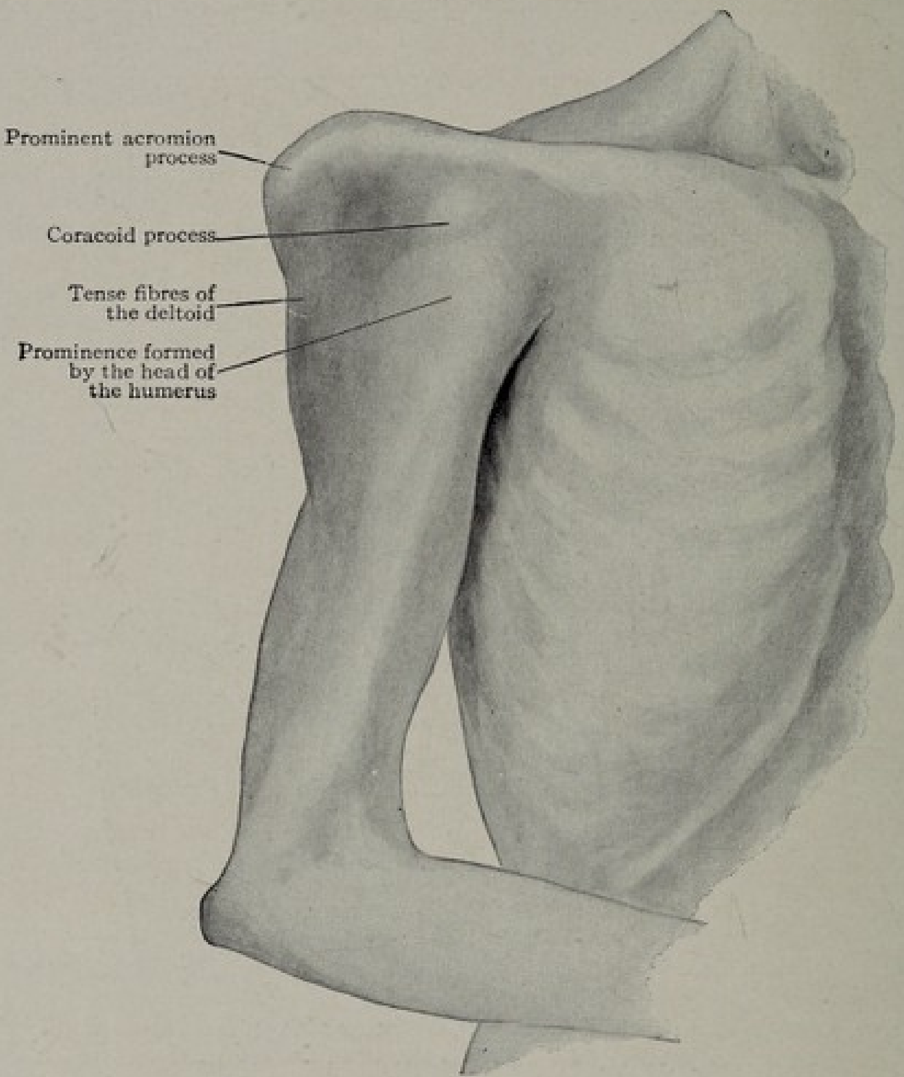


Fig. 264.—Surface view: subcoracoid dislocation of the humerus, showing the elevation of the shoulder, abduction of the arm, prominence of the displaced head below the coracoid process, flattening of the shoulder, and tense fibres of the deltoid muscle.

scapulæ and rhomboid muscles, hence it is the *joint* which descends and tears loose the capsule already stretched tightly over the head of the humerus.

This is the reason why the lower portion of the capsule is torn; it is the longitudinally acting force that does it. When the transverse force acts it is expended on the anterior portion of the joint because the joint is at the anterior portion of the scapula. Posterior to the joint the scapula rests on the chest, so it is its anterior portion which is forced inward, thus rupturing the capsule at this point. The fulcrum, or acromion process, is also posterior to the midline of the joint.

By a combination of these two forces (longitudinal and transverse) the capsule is ruptured at its lower and especially its anterior portion. Its tearing is favored by a twisting or external rotation of the humerus. The attachment of the capsule is torn from the humerus, and a fragment of the bony rim frequently comes with it. The opening is large and embraces nearly or quite half the circumference of the joint. It is limited above by the caracoid process. The coracohumeral and superior glenohumeral ligaments lying in front of the long tendon of the biceps also limit the upward tearing. If the tear does not extend so high it is because the subscapularis muscle, instead of being torn, is wedged in between the head and the coracoid process. Below, the tear is wedged in between the head and the coracoid process and is limited by the insertion of the long head of the triceps. As the head luxates it cannot pierce the triceps tendon, so it slips behind it in a posterior luxation

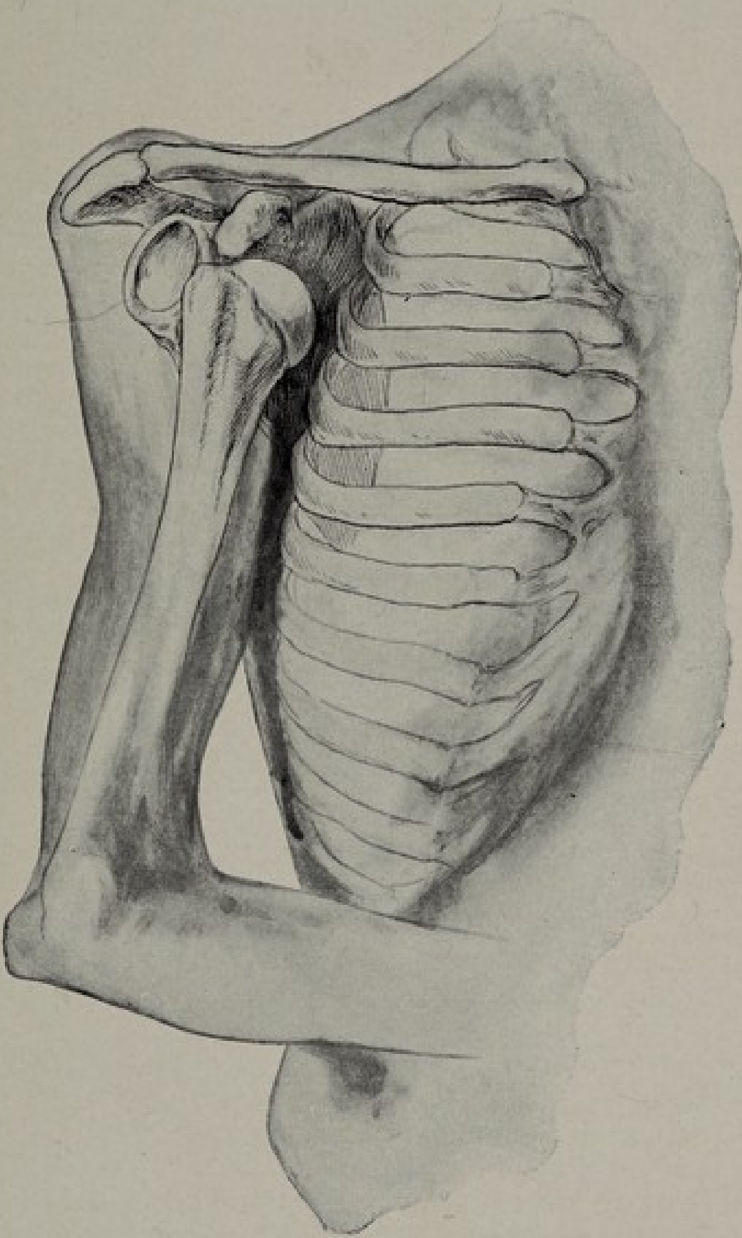


Fig. 265.—Subcoracoid dislocation of the humerus, showing the position of the bones in relation to each other and to the soft parts.

and in front of it in anterior luxation. The supraspinatus, infraspinatus, and teres minor muscles are all posterior; they blend more or less with the capsule and as the head luxates they are stretched with it over the glenoid cavity.

The long tendon of the biceps, while it may sometimes be torn loose from the bicipital groove after rupture of the transverse ligament, is usually so loose that it follows the head without being detached from its connections. The subscapularis muscle not infrequently has its lower edge torn.

The brachial plexus and blood-vessels are pushed inward by the head, but when the arm is abducted they are stretched over it, running close to the coracoid process.

As the circumflex nerve winds around the surgical neck of the humerus, it may be ruptured or tightly stretched over the head of the bone.

Hyperabduction stretches the vessels and nerves so forcibly over the head just prior to its leaving the socket as sometimes to produce serious injury to them.

Signs and Symptoms

There is (1) at first elevation then lowering of the shoulder, (2) flattening of the deltoid muscle, (3) projection of the elbow away from the side. (4) The normal hollow below the outer third of the clavicle is filled up; the head, covered by the deltoid, may sometimes even make a rounded prominence at this point which can frequently be felt. (5) If the elbow is raised and the hand placed on the opposite shoulder and held there the elbow cannot be brought flat on the chest (Dugas's sign), (6) with the arm to the side the distance from the acromion process to the external condyle is increased, with the arm abducted to a right-angle, the same distance is decreased as compared with the previous position as well as when compared with the arm of the opposite side (see Fig. 266).

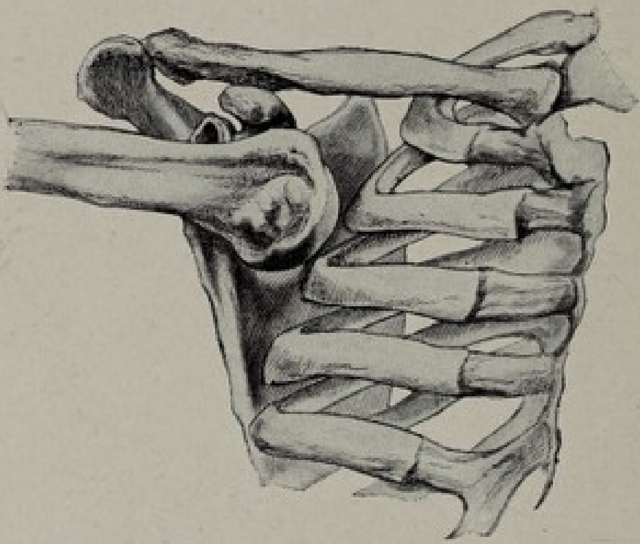


Fig. 266.—Subcoracoid dislocation of the shoulder. The head of the humerus has slipped off its pedestal or shoulder-girdle onto the side of the thorax. This shows how the arm is shortened and why it is necessary to make traction in order to replace the humerus up again on the shoulder-girdle.

1. Lowering the shoulder obviates pain by relaxing the deltoid and preventing it from forcing the head upward in its displaced position.

2. Flattening of the shoulder is due to the head and tuberosities being displaced inward, thus leaving the socket empty. A marked depression can be felt with the fingers below the prominent acromion process.

3. Projection of the elbow from the side is due to tension of the deltoid muscle because the head is lower than normal. In its natural position the top of the head is about level with the coracoid process; when luxated it is below it.

4. The normal hollow below the outer third of the clavicle is lost because here is where the head lies. It may form a distinct prominence and when the arm is rotated if the surgeon lays his hand at this point the tuberosities can be felt to rotate beneath. If the arm is abducted the head can usually be felt in the axilla, where it may even form a prominence.

5. In Dugas's test the elbow cannot be brought to the chest because the outer end of the humerus is held close to the chest-wall. On account of the thorax being rounded like a barrel it is necessary for the outer end of the bone to rise as the inner end falls.

6. The reason for the difference in measurements when the shoulder is luxated is readily seen by the fact that the head is displaced downward and inward as shown in the accompanying figure.

Treatment

Reduction of an anterior luxation of the shoulder can be accomplished in two ways, viz., the *direct*, in which the head is pulled or pushed back into the socket, and the *indirect*, in which it is levered back.

Direct Method.—This consists in first placing the arm in approximately the position it occupied when luxated (abduction) and then pulling or pushing the head toward and into the socket while the arm is rotated to relax the capsule and

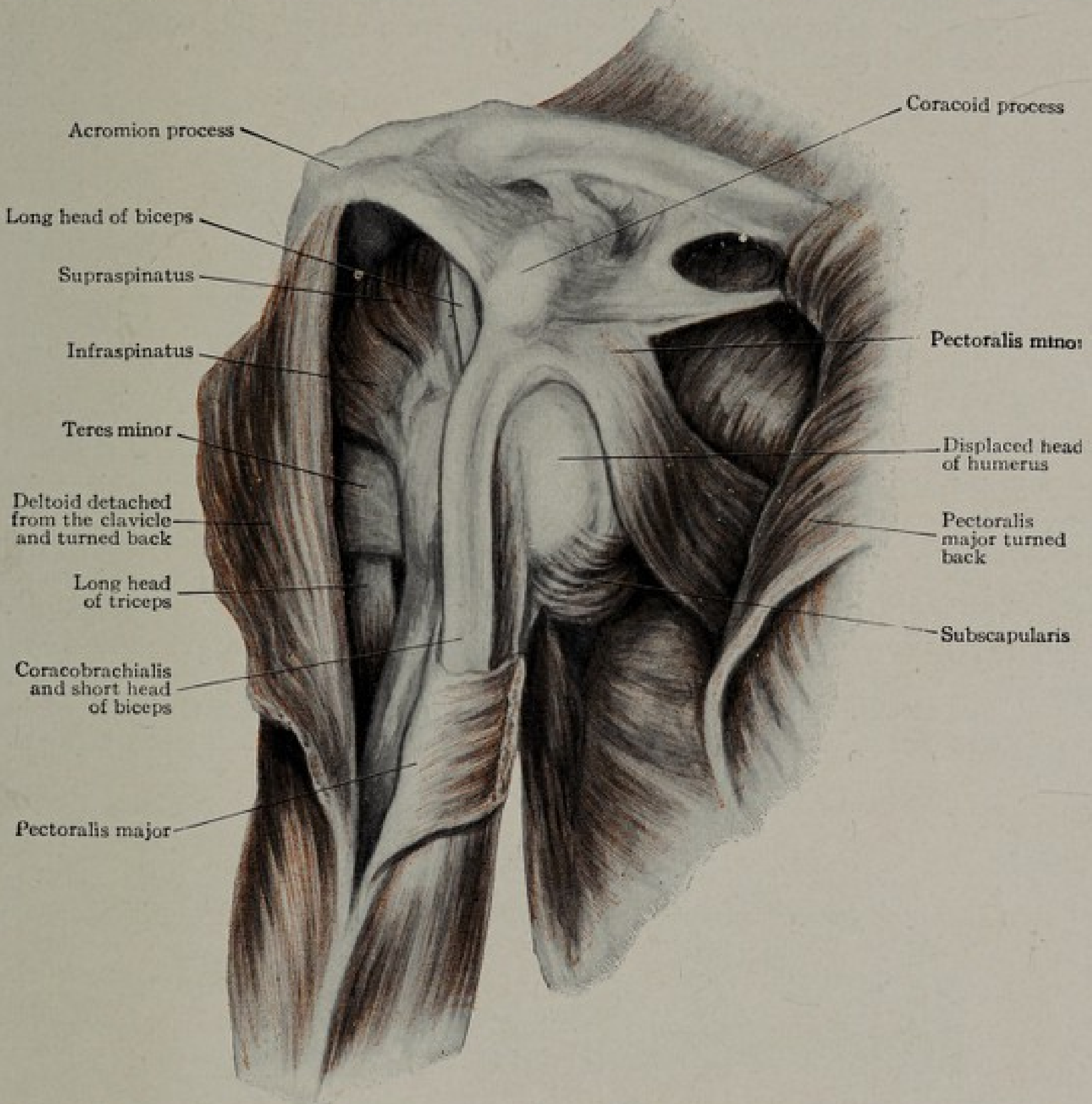


FIG. 267.—Subcoracoid dislocation of the shoulder. Dissection showing the relation of the muscles to the displaced humerus.

allow the head to enter. The usual obstacle to reduction of a recent luxation is muscular contraction. The main muscles acting are the deltoid, pectoralis major, latissimus dorsi, and teres major. To effect reduction the action of these muscles must either be held in abeyance or overcome by force. This may be accomplished in several ways, viz., by the use of general anæsthesia, by such gentle manipulations as will not incite the muscles to contraction, by a quick movement accomplishing the object before the muscles are able to contract, or, finally, by overcoming the muscular action by steady continuous traction. General anæsthesia is the surest way of obviating muscular contraction.

The question of muscular contraction having been solved by one or more of these expedients the actual replacement is to be accomplished by dragging or pushing the head back over the route it took in coming out. The opening in the capsule is below and anterior, therefore the arm is to be strongly abducted, and traction made upward and backward. This drags the head upward and backward over the rim of the glenoid cavity into its socket. If it does not enter readily it is because of tension of the untorn part of the capsule; this is to be remedied by gently rotating the arm, when the proper position will be revealed by the slipping of the head into place. Rotation in either direction beyond the proper point narrows the tear in the capsule and keeps the head from entering. Traction is necessary in order to replace the head of the humerus on its pedestal or shoulder-girdle from which it has fallen onto the side of the chest (see Figs. 266 and 268).

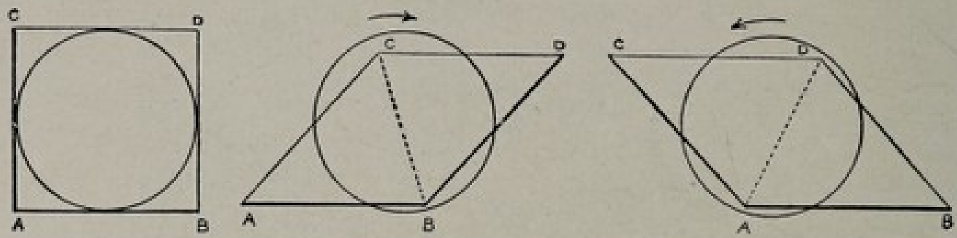


FIG. 268.—Diagram to show how rotation influences the size of the rent in the capsule. The square represents the rent in the capsule and the circle the head of the humerus. If the humerus is rotated too much in the direction of the arrows, either to the right or left, the opening in the capsule is so narrowed as to obstruct the passage of the head.

If it is desired to tire the muscles out, the plan of Stimson is best. Place the patient in a canvas hammock and allow the arm to hang downward through a hole in the canvas. Fasten a ten-pound weight to the wrist and inside of six minutes the weight will have dragged the head of the humerus into place. This same object can be carried out, but not so well, by having the patient lie on the floor and pulling the arm directly upward by means of a rope and pulley. Here the weight of the body acts as the counter force.

Other means, such as the heel in the axilla, etc., may be found described in works on surgery, but it is to be remembered that the objects to be sought are (1) to

FIG. 269.—Kocher's method of reducing dislocation of the shoulder: First step—Flex the forearm at a right angle to the arm; bring the humerus alongside the chest, the elbow nearly touching the side, and rotate outward as far as the arm will go without undue force.

overcome the action of the deltoid by abducting the arm, (2) to overcome the axillary muscles—pectoralis major, latissimus dorsi, and teres major—by traction, and (3) to loosen the capsule and open the tear to its widest extent by rotation while the head is pushed with the hand toward and over the lower and anterior edge of the socket.

Indirect Method.—The indirect or lever method has been best systematized by Kocher of Berne, although Henry H. Smith, a former professor of surgery in the University of Pennsylvania, taught a similar method previously. Kocher's method is as follows: *First Step.*—Flex the forearm until it forms a right angle with the arm, then, with the elbow touching the side of the body, rotate the arm outward 90 degrees until the forearm points directly outward (Fig. 269). This causes the head of the bone to rotate outward and leave the side of the chest to take a position close to the glenoid cavity. *Second Step.*—The arm being held in this position, the elbow is raised forward until it forms a right angle or a little more with the long axis of the body. This relaxes the coracobrachialis muscle, releases the lesser tuberosity, which may be caught against it, and allows the head to pass outward and

FIG. 270.—Kocher's method of reducing dislocation of the shoulder: Second step—Keeping the arm in external rotation, raise the elbow until the humerus reaches the vertical line or a little beyond.

ascend from its low position up into the glenoid cavity (Fig. 270). *Third Step.*—Carry the arm obliquely inward, place the hand on the opposite shoulder and bring the elbow down to the surface of the chest, the humerus pointing diagonally downward and inward as in the Velpeau position for fractured clavicle (Fig. 271).

The mechanism, as readily demonstrated on the cadaver, is as follows: The head lies to the inner side of the glenoid cavity with the tense posterior portion of

FIG. 271.—Kocher's method of reducing dislocation of the shoulder: Third (final) step—Rotate the arm inward and place the hand on the opposite shoulder bringing the elbow down on the anterior surface of the chest.

the capsule passing backward. When external rotation is made the capsule is wound around the head and upper portion of the neck and the head moves out. In some instances the head will not only move out but will likewise move up and be drawn at once into place. Bringing the arm forward and upward relaxes the coracobrachialis muscle, while bringing it across the chest in the last step assists the head over the rim of the glenoid cavity and restores the member to its normal position. Prof. H. H. Smith brought the elbow forward *before* making the external rotation instead of after, as did Kocher. This is probably the better way because persistence in rotating outward when the lesser tuberosity is caught beneath the tense coracobrachialis muscle is one cause of the frequent fracture of the humerus in attempting to carry out Kocher's method; another cause is the fixation due to strong muscular contraction or to jamming of the head between the scapula and side of the chest.

This method can be used without anæsthesia, but it is at times exceedingly painful and savors of cruelty. It is particularly applicable for old and severe cases. It depends for its efficiency on the integrity of the posterior portion of the capsule, if this has been torn loose the method fails and the head simply rotates *in situ*. If this

Fig. 272.—Raising the arm to a vertical line or a little more relaxes the tendon of the coracobrachialis and short head of the biceps muscle and allows the lesser tuberosity of the humerus to pass beneath it when the arm is rotated inward to place the hand on the opposite shoulder.

latter is the case, reduction can readily be effected by direct traction and manipulation.

POSTERIOR DISLOCATIONS OF THE SHOULDER

Posterior dislocations are always beneath some portion of the spine of the scapula, hence they have been called *subspinous*. When the head lies anteriorly under the posterior portion of the acromion process they have been called *subacromial*.

Posterior luxations are rare. They occur either when the arm is abducted with strong internal rotation or by direct violence, such as a blow on the anterior portion of the shoulder, which forces the head out of its socket backward. The posterior portion of the capsule is torn and the head lies posterior to the glenoid cavity with its anatomical neck resting on the rim and the lesser tuberosity in the glenoid fossa. The arm is inverted and abduction and rotation impaired. The capsule is ruptured by internal rotation while the arm is in a position of abduction, and then a push sends the head posteriorly. We have seen it as a congenital affection resulting from injury in childbirth.

The infraspinatus, teres minor, and sometimes the subscapularis muscles are ruptured and frequently there are accompanying fractures of the tuberosities or some part of the scapula. The head makes a prominence posteriorly and the arm hangs to the side and in a position of inward rotation. Reduction, if the injury is recent, is likely to be easily effected by pushing the head directly forward into its socket.

Recurrent Dislocation of the Shoulder.—As a result of repeated dislocations the capsule becomes so enlarged that dislocation may occur from any trivial injury or by mere will of the patient. In these cases the inferior anterior portion of the capsule becomes baggy while the other portions may remain practically normal.

Treatment.—The operation of choice should be one based upon anatomical grounds. That of T. T. Thomas seems to fulfill these demands. An incision is made in the posterior axillary wall and continued inward until the white shining tendon of the latissimus dorsi is exposed. The circumflex (axillary nerve) which winds around the neck of the humerus just above the latissimus dorsi is then isolated. With the arm in full abduction the head can then be palpated against the

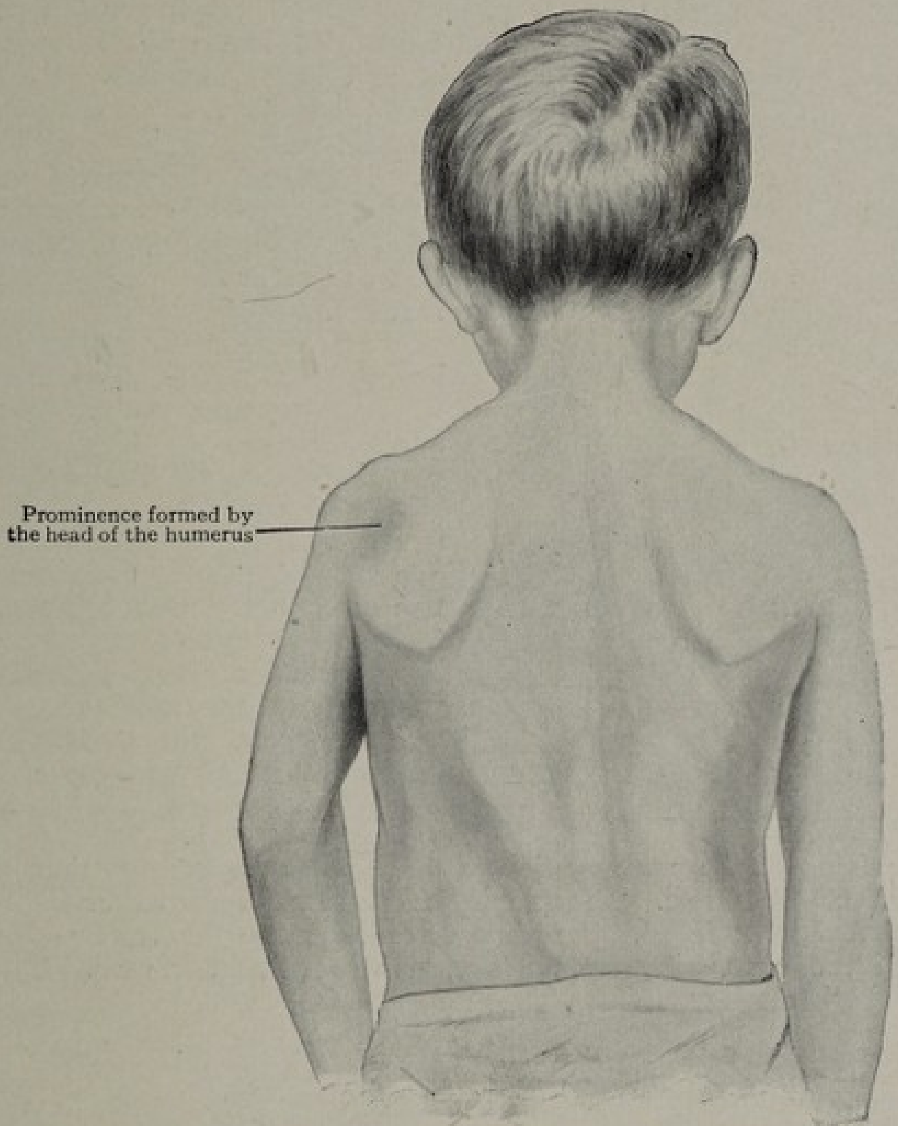


FIG. 273.—Posterior luxation of the shoulder. The head of the humerus makes a prominence beneath the spine of the scapula and the arm is rotated inward. (From a photograph of author's patient by Dr. A. P. C. Ashhurst.)

capsule. An elliptical piece is removed from the redundant capsule, the wound is closed and the arm fixed to the side for six to eight weeks. The posterior circumflex artery accompanies the circumflex nerve in this region. Great care must be exercised so as not to injure the nerve.

The Nicola operation has found much favor with surgeons because of the very satisfactory results. The principle of the operation is to support the humerus in the glenoid cavity with a strong structure, the long head of the biceps, rather than upon the weaker capsular structures reefed as in the older operations. A channel is drilled thru the head of the humerus, the long head of the biceps is divided and the tendon run thru the channel in the head of the humerus after which it is sutured. This insures a strong support for the shoulder joint.

FRACTURES OF THE SHOULDER-GIRDLE AND UPPER END OF THE HUMERUS

FRACTURES OF THE CLAVICLE

Fractures of the clavicle divide with those of the radius the distinction of being the most frequent of any in the body. It is also the most frequent site of "green-stick" or incomplete fracture. About one-half of the fractures occur during childhood and adolescence. The frequency is due: (1) to its exposed position; (2) to its early ossification; (3) to the lack of close attachment of the periosteum; (4) to the unusual thickness of the periosteum, which tends to prevent complete fracture; (5) to the fact that shocks or blows on the outstretched hand are transmitted to the trunk through the clavicle; (6) to the firm ligamentous attachments at its inner and outer end which usually withstand more force than is necessary to produce a fracture.

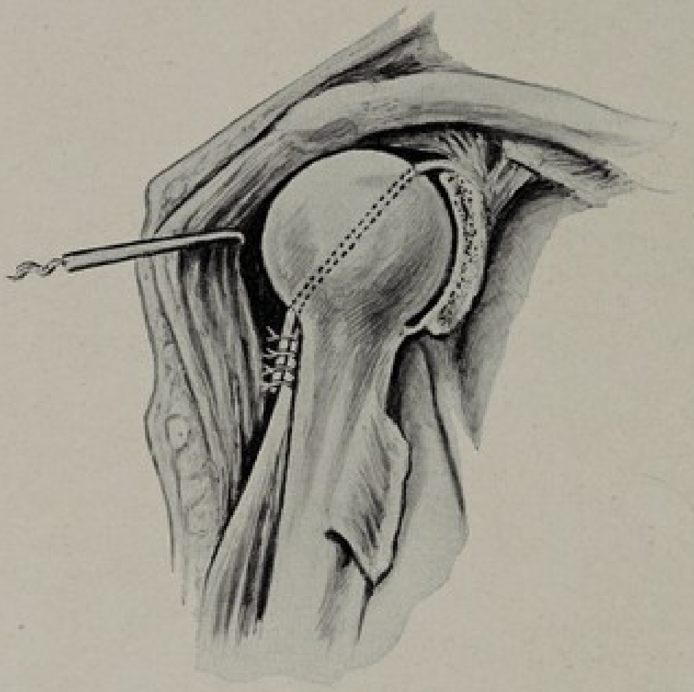


Fig. 274.—Nicola operation for recurving dislocation of the humerus. (After Bickham.)

The clavicle is most often broken in its middle third, next in its outer, and, lastly, in its inner third.

Fracture of the Inner Third of the Clavicle.—This is the rarest fracture of the clavicle and has its main anatomical interest in relation to the costoclavicular ligament. The ligament runs obliquely upward and outward from the upper surface of the cartilage of the first rib to the lower surface of the clavicle, a distance of 2 cm. (4/5 in.).

Immediately in front of the outer portion of this ligament is the insertion of the tendon of the subclavius muscle. The line of the fracture may be either transverse or oblique; if oblique it follows the same direction as do the fractures of the middle third of the bone, viz., from above, downward and inward. The

Fig. 275.—Fracture of the clavicle just outside of the middle, with the customary deformity.

displacement of the inner fragment is upward and of the outer fragment downward. The displacement of the inner fragment upward is promoted by the attachment of the clavicular origin of the sternomastoid muscle; it is opposed by the costoclavicular (rhomboid) ligament and to a less extent by the subclavius muscle.

Fracture of the Middle Third of the Clavicle.—The clavicle is most frequently broken in the outer half of its middle third. The bone at this part is most slender; it is here that the anterior curve passes into the posterior; and, finally, it has fewer muscular attachments at this situation. The upper surface has arising from its inner third the clavicular origin of the sternomastoid muscle. Its middle third has no muscular attachments, and on its outer third is the trapezius muscle. On the lower or anterior surface on its inner half is the clavicular origin of the pectoralis major and on its outer third is the deltoid. This leaves the outer half of the middle third free from muscular attachments, with the exception of the subclavius on its under surface. It is through this part of the bone that fractures occur.

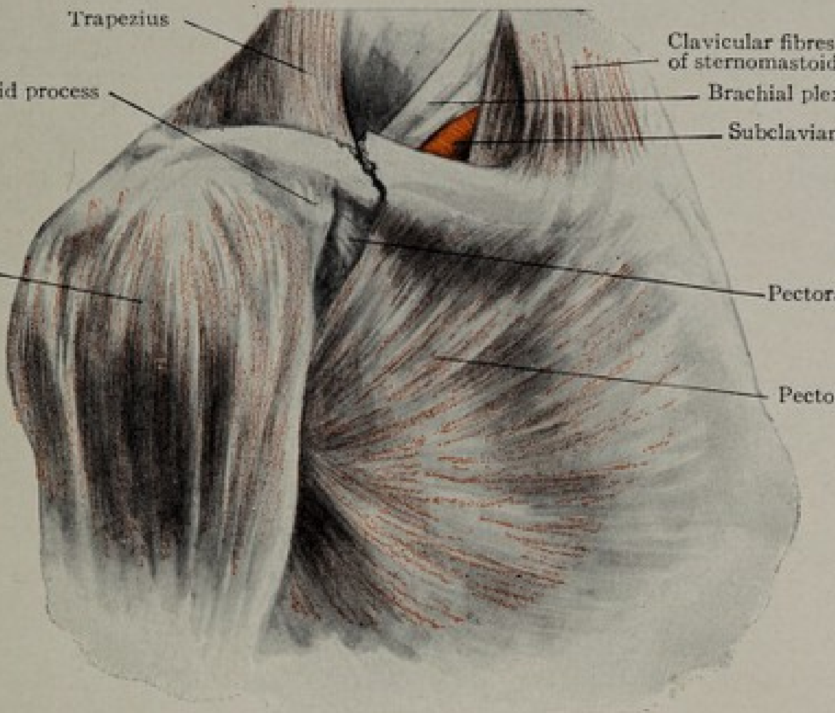


FIG. 276.—Fracture of the clavicle just outside the middle. The outer fragment is displaced downward and inward and the inner fragment upward. The brachial plexus and subclavian vessels are behind the inner end of the outer fragment.

Sometimes in children the line of fracture is transverse, but most often it is oblique and always in the direction from above downward and inward.

The *displacement* of the inner fragment is upward, and of the outer fragment downward and inward. This produces the deformity seen in Fig. 275. The inner fragment is pulled up by the clavicular origin of the sternomastoid muscle. The support of the clavicle being gone, the shoulder falls down and in. It is impelled in that direction first, by the weight of the upper extremity, and, secondly, by the action of the axillary fold muscles, pectoralis major and minor anteriorly and teres major and latissimus dorsi posteriorly, and by the subclavius to some extent. The anterior edge of the scapula rotates inward and its posterior edge tilts outward.

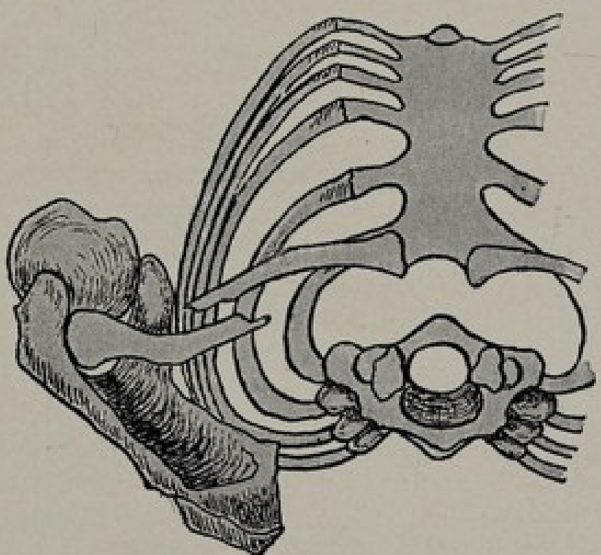


FIG. 277.—Showing how the shoulder falls inward and the posterior edge of the scapula tilts outward when the prop-like action of the clavicle is destroyed by fracture.

In this manner overlapping is produced, and measurements of the injured and healthy sides taken from the sternoclavicular to the acromioclavicular joint will show some shortening on the injured side. As the continuity of the shoulder-girdle has been destroyed and its prop-like action lost, its function of abduction ceases, and the patient is unable properly to elevate the arm. Sometimes the brachial plexus or subclavian vessels are injured by the inner end of the outer fragment. The artery passes beneath the middle of the bone, the vein being to its inner side and the brachial plexus to its outer side. We have operated on one such case of injury to the brachial plexus; and cases of hæmatoma arising from injury to the veins and aneurism from injury to the artery have been recorded.

Treatment.—When the line of fracture is oblique and in an adult, healing with a certain, often considerable, amount of deformity is almost constant, the only efficient way of combating its occurrence is to place the patient in bed on his back. This is the best way of removing the weight of the arm, of quieting the muscles, and by pressure of the scapula close to the thorax of levering the shoulder out (see Fig. 277).

Fracture of the Outer Third of the Clavicle.—Attached to the outer third of the clavicle on its under surface, extending not quite to its end, are the coraco-

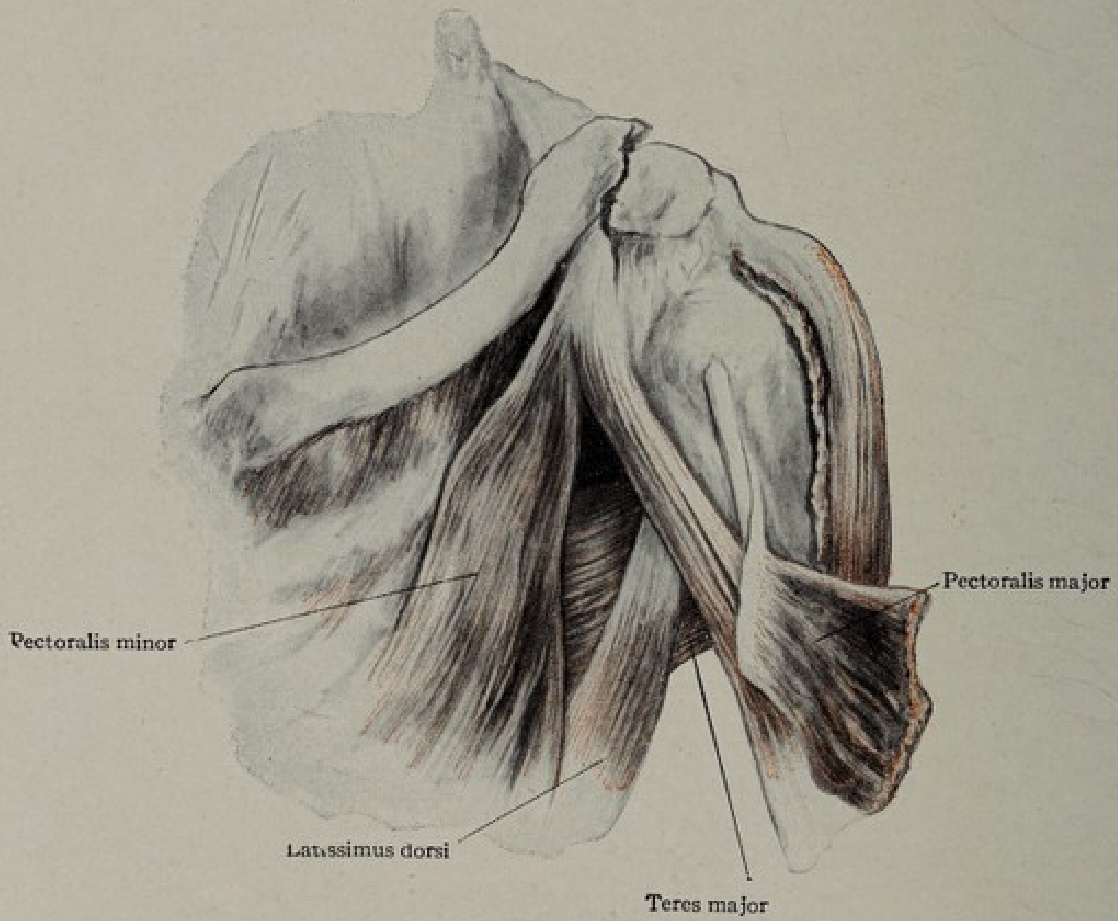


Fig. 278.—Fracture of the outer end of the clavicle. The outer fragment is drawn inward by the pectoralis major latissimus dorsi, and teres major muscles.

clavicular (conoid and trapezoid) ligaments. The conoid inserts into the conoid tubercle near the posterior edge of the clavicle, while the trapezoid is broader and passes from the conoid tubercle outward and anteriorly not quite to the extremity of the bone (see Fig. 287). The bone may be fractured either through the part to which the conoid and trapezoid ligaments are attached, or between them and the end of the bone, a distance of about 2 cm. (4/5 in.). The line of the fracture is either transverse or inclines backward and outward (see Fig. 278).

The displacement of the outer fragment is downward and inward. If the fracture is through the ligaments the displacement is not marked. If beyond the ligaments, the shoulder drops, carrying down the outer fragment, and the inner fragment may be elevated slightly above the outer one, but the up-and-down displacement is not conspicuous. In many cases the anteroposterior displacement is very marked and peculiar. The outer fragment is bent sharply inward at the site of fracture, producing a deformity which is pathognomonic. It is caused by the curved shape of the bone at this point, by the weight of the arm, and by the action of the muscles passing from the shoulder to the trunk, especially the pectoralis major (see Fig. 276).

Treatment.—Manipulation under anæsthesia may be necessary depending upon the degree of displacement. After reduction a Sayre dressing or a clavicular cross should be so applied that the shoulders are pulled upward, backward and outward.

FRACTURES OF THE SCAPULA

While fractures of the scapula are not common, there are a few anatomical facts in reference to the scapula and its muscles which are worth attention.

The scapula is liable to be fractured more or less transversely through the body below the spine; the acromion and coracoid processes have been broken; it has also been fractured through the surgical neck, and the glenoid process has been chipped off.

Fracture Through the Body.—The scapula has attached to its under surface the subscapularis muscle, along its posterior border is the serratus anterior (magnus) and rhomboids, to its dorsum and edge below the spine are attached the infraspinatus, teres minor, and teres major muscles. These are covered by a strong, tough fascia which dips between them to be attached to the bone.

Bearing these facts in mind it is readily appreciated why in many of these fractures, which usually traverse the bone below its spine from the axillary to the vertebral border, the displacement is slight, and why healing occurs with some appreciable deformity but with little disability.

If, however, the fracture is low down, breaking off the lower angle, then the teres major and lower portion of the serratus anterior (magnus) muscles displace the fragment toward the axilla, and this is to be borne in mind in treating the injury.

Fracture of the acromion process is more rare than would be expected. It is the result of direct violence, and the displacement and disability resulting from the injury are slight. The acromion is covered by a dense fibrous expansion from the trapezius above and the deltoid below, and these prevent a wide separation of the fragments.

Fracture of the coracoid process is also rare and may occur from muscular contraction or direct violence, as in luxation of the shoulder. It might be thought that owing to the action of the pectoralis minor, coracobrachialis, and short head of the biceps muscles, which are attached to it, it would be widely displaced, but this is not so, for the conoid and trapezoid ligaments still hold it in place.

Fractures through the surgical neck are not common. They pass down through the suprascapular notch and across the glenoid process or head, in front of the base of the spine and behind and parallel with the glenoid fossa. The tendency of the outer fragment to be dragged down by the weight of the arm is resisted by the coraco-acromial and coracoclavicular (conoid and trapezoid) ligaments as well as by the inferior transverse ligament, which runs from one fragment to the other from the base of the spine, on the posterior surface, to the edge of the glenoid cavity. These ligaments all remain intact. These fractures are best treated with an axillary pad (apex upward) and the arm supported by a sling.

Fracture through the glenoid process, chipping off a greater or less portion of the articular surface, is rarely diagnosed. It occurs sometimes in cases of luxation. The long head of the triceps muscle may be fastened to the detached fragment and is liable to pull it downward and therefore some interference with the functions of the joint would be apt to remain and prevent complete recovery.

FRACTURES OF THE UPPER END OF THE HUMERUS

Fractures of the upper end of the humerus may occur through the anatomical neck, through the tuberosities, detaching one or both, and through the surgical neck just below the tuberosities. These fractures are frequently associated with luxation of the head of the bone.

Fracture through the Anatomical Neck.—This occurs as the result of direct violence and most often, though not always, in old people. The line of fracture does not always follow exactly the line of the anatomical neck, but may embrace a portion of the tuberosities. The fracture may or may not be an entirely intracapsular one. The capsule in its upper or outer portion is thickened at its humeral end by more or less blending with the tendons of the muscles which pass over it. The capsule at this point is attached to the anatomical neck almost or quite up to the articular surface. On the under side to the contrary it passes about a centimetre below the articular surface and doubles back to be attached somewhat closer to it (see Fig. 286, page 288).

In consequence of this arrangement, a fracture which follows the anatomical neck would be within the joint below and just outside of it above. As a matter of fact, some of these fractures are intra- and some partly extracapsular. This influences the amount and character of the displacement and the course of healing. Fractures of the anatomical neck are often associated with impaction. If impaction does not occur and the capsule of the joint is completely detached from the upper fragment, atrophy or necrosis of this fragment must result since there is no direct blood supply to the head of the humerus similar to that which the femoral head receives through the ligamentum teres. Usually, however, portions of the periosteum and the portion of the capsule on the internal side remain, so that union can occur and the blood supply be maintained. The fragment is apt to be much displaced, being tilted and lying to the inner side anteriorly. Sometimes it is entirely extruded from the joint. In one case we have seen it lodged in front under the anterior axillary fold.

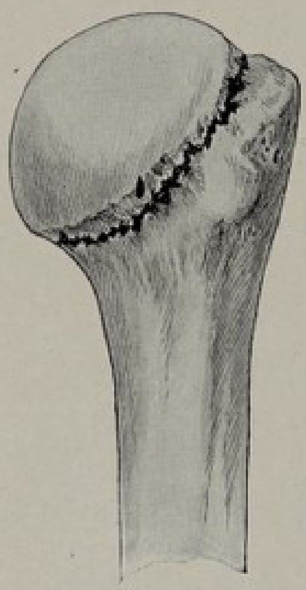


Fig. 279.—Fracture through the anatomical neck of the humerus.

The signs and symptoms vary much, according to the position of the head, and a positive diagnosis may be impossible. A thorough knowledge of the surface anatomy is essential in these cases and a careful comparison should be made with the opposite healthy shoulder. Impaction sometimes occurs, and is most often of the upper fragment into the lower, sometimes splitting it and detaching to a certain extent one of the tuberosities. Sometimes it is the lower fragment which is impacted into the upper.

Fractures through the Tuberosities.—Like the former these are often accompanied by luxation, especially if one or both of the tuberosities is detached. These fractures are frequently blended with fracture through the anatomical neck. In this fracture, however, the influence of the muscles is to be remembered. The supraspinatus, infraspinatus, and teres minor insert into the greater tuberosity, and the subscapularis into the lesser. The line of fracture may pass through their insertions and the displacement may be slight.

The upper fragment is, however, liable to be tilted outward by the contraction of the supraspinatous muscle, which is attached to the upper portion of the upper fragment, while there is no muscle attached below to counteract it. In this case the shaft of the humerus is drawn up and out by the deltoid and is felt beneath the acromion process. There is but little rotatory displacement of the upper fragment because the subscapularis anteriorly is neutralized by the infraspinatus and teres minor posteriorly.

In instances where there is not much displacement of the upper fragment, the lower one may be drawn inward and forward by the action of the muscles of the axillary folds.

Fractures detaching the tuberosities are mostly accompanied by luxation. If the greater tuberosity alone is detached, it is drawn up beneath the acromion by the supraspinatus.

In all these fractures the subsequent disability is often great and the prognosis is unfavorable. They are amongst the hardest in the body to correctly diagnose. They are treated sometimes with a shoulder-cap and sometimes with the arm in the abducted position while the patient is kept in bed. Epiphyseal separation will be alluded to farther on.

Fractures of the Surgical Neck.—These are the most common fractures of the humerus. The surgical neck of the humerus is usually defined as the portion between the lower part of the tuberosities and the upper edge of the tendons of the pectoralis major and latissimus dorsi muscles. Often, however, the tendons of these two muscles continue almost or quite up to the tuberosities, hence there is little

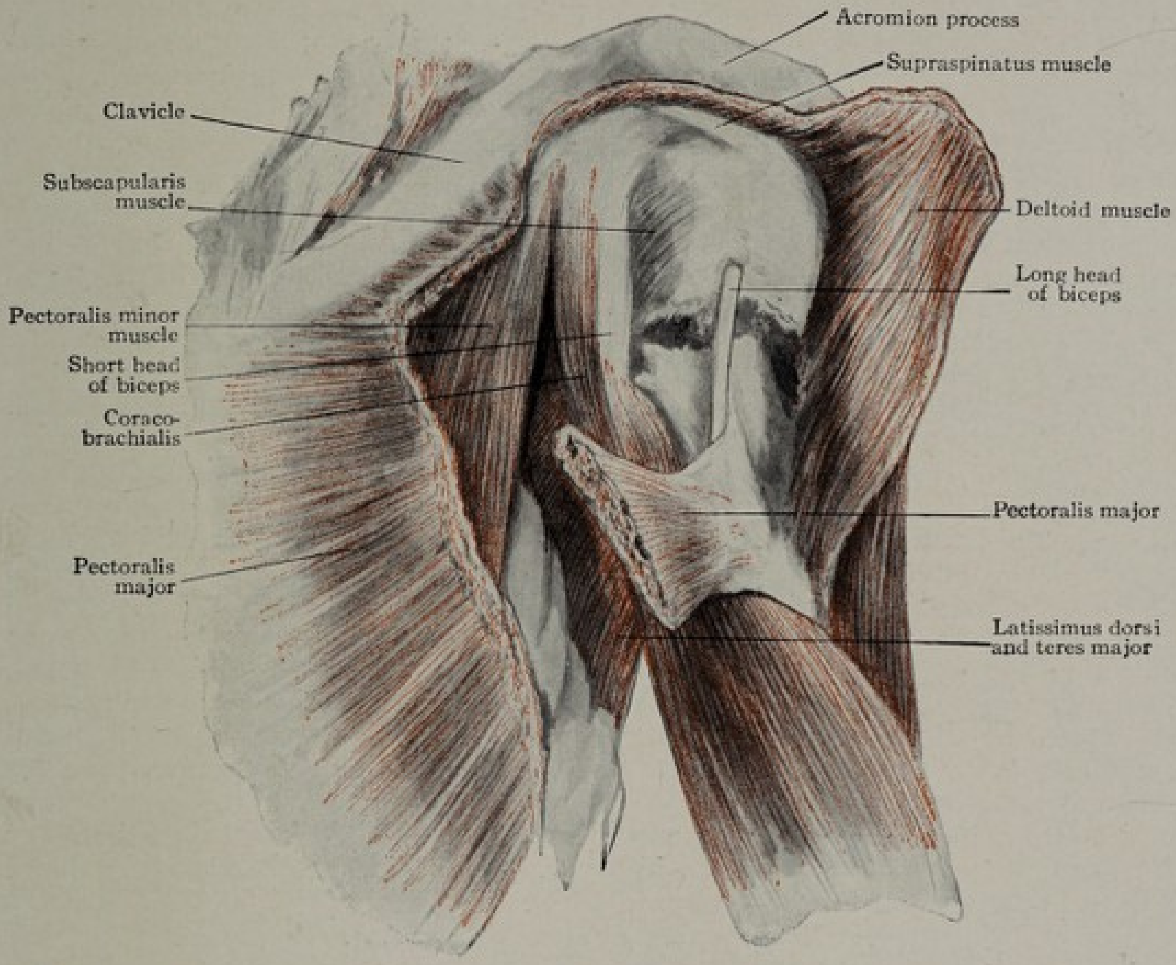


FIG. 280.—Fracture of the surgical neck of the humerus. The upper fragment is held out by the supra spinatus, while the lower fragment is drawn in by the pectoralis major, latissimus dorsi, and teres major muscles and the arm abducted by the deltoid.

or no interval here and the line of fracture then passes through the upper part of the tendons.

The fractures occur both from direct and indirect violence and the direction of the force has probably something to do with the displacement of the fragments.

Displacement.—It can readily be seen that if a blow is received on the humerus below the tuberosities while the arm is in a somewhat abducted position the head will be supported by the glenoid process (head) of the scapula and the bone will be fractured through the surgical neck and driven in towards the body, and, as the scapula is supported posteriorly, the movable lower fragment is displaced anteriorly. After the fracture has occurred, and possibly in some cases aided by the peculiar direction of the fracturing force, the lower fragment is drawn upward by the muscles running from one side of the fracture to the other. These are the deltoid, biceps, coracobrachialis, and the long head of the triceps. The typical displacement is for the upper fragment to be abducted and some say rotated out—this latter is not without doubt. The lower fragment is certainly in front and to the inside of its normal position.

The abduction of the upper fragment is due to the unresisted action of the supraspinatus muscle. The subscapularis in front and the teres minor and infraspinatus behind nearly or quite balance each other, thus causing little or no lateral displacement. The displacement inward and anteriorly of the lower fragment, is due to the action of the violence as already detailed and is aided by the action of the pectoralis major, the teres major, and latissimus dorsi muscles, all of which pass from the lower fragment just below the seat of fracture inward to the trunk. To these muscular actions may be added that of the deltoid which may fix the middle of the bone so that it actually acts as a fulcrum abducting the elbow.

The longitudinal displacement is peculiar. The biceps, triceps and coracobrachialis assist in the displacement aided probably by the traumatic force. As the lower fragment is drawn up its upper end may be felt through the deltoid muscle below and toward the inner side of the acromion. While the displacement in most cases is not marked, in some the lower fragment can readily be felt in the axilla (Fig. 280).

Sometimes instead of the lower fragment being displaced inward it goes outward. In this case as it rises it pushes the head and tilts it inward while it passes farther outward.

The *diagnosis* is to be made by a careful examination and comparison with the opposite healthy member. The head is recognized to be in the glenoid cavity, crepitus is felt, the upper end of the lower fragment can often be palpated, and on rotating the arm the head of the bone is found to lie stationary.

Treatment.—The ideal treatment is extension with the patient in bed and the arm abducted. As the upper fragment cannot be brought in, an effort may be made to bring the lower one out. As these are usually treated as ambulatory fractures various dressings are used, among them being the axillary pad and shoulder cap, the aeroplane splint, the mittledorf triangle, and the Thomas arm splint. That method of immobilization should be used which will keep the fragments together after reduction, the degree of abduction necessary varying in different cases. In cases of fracture associated with luxation of the head of the bone, replacement can sometimes be effected by traction in the abduction position and pressure on the head, general anæsthesia being used (see description of direct method of reduction under dislocation of the shoulder, page 268).

To aid in the reduction McBurney devised a hook which he inserts into the upper fragment, pulling it toward the glenoid cavity. These cases after reduction are best treated in an aeroplane or Thomas arm splint.

EPIPHYSEAL SEPARATIONS

The epiphyses that are liable to separation are those of the coracoid process, the acromion process, and the upper end of the humerus.

Separation of the Coracoid Epiphysis.—The coracoid process has three separate centres of ossification which fuse with the body of the bone from the fifteenth to the twentieth year. Therefore displacements occurring before the latter age may be separations of the epiphysis and not true fractures, particularly if the line of separation runs through the base of the coracoid.

Separation of the Acromion Epiphysis.—The acromion process is cartilaginous up to the fifteenth year. Then two centres appear and the epiphysis unites with the rest of the spine of the scapula about the twentieth year or later. The epiphyseal line runs posterior to the acromioclavicular joint, just behind the angle of the spine of the scapula. It has been suggested that many cases diagnosed as sprains and contusions of the shoulder are really epiphyseal separations of the acromion process.

Separation of the Epiphysis of the Upper End of the Humerus.—The upper end of the humerus has three centres of ossification, one for the head and one each for the greater and lesser tuberosities. These three centres are blended by the seventh year, and the whole epiphysis unites with the shaft at about twenty-five years.

The epiphyseal line follows the lower half of the anatomical neck and then passes outward to the insertion of the teres minor muscle. This brings the outer end of the epiphyseal line some distance away from the joint, while the inner portion of the line is within the joint. Disease of this region may therefore follow the epiphyseal cartilage into the joint. A separation of the epiphysis from injury will implicate the joint.

The surgical neck of the humerus lies a short distance below the epiphyseal line and farther away on the outer side than on the inner. The line of the epiphysis rises higher in the centre of the bone than on the surface, making a sort of cap for the end of the diaphysis. The symptoms of epiphyseal separation are almost exactly the same as those of fracture of the surgical neck (see page 279).

The supraspinatus is the main agent in tilting the upper fragment outward, while the muscles inserted into the bicipital ridges,—the pectoralis major into the outer ridge and the latissimus dorsi and teres major into the inner,—draw the lower fragment inward. The relative position of the fragments when the lower is displaced outward is seen in Fig. 281.

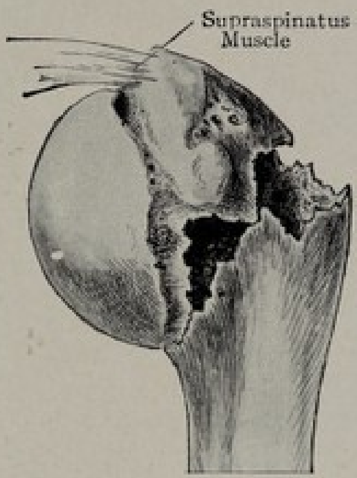


Fig. 281.—Detachment of the epiphysis of the upper end of the humerus.

AMPUTATIONS AND RESECTIONS OF THE SHOULDER

AMPUTATION AT THE SHOULDER-JOINT

The many different methods of amputating at the shoulder may for our purposes be divided into two classes,—the flap method and the racket method.

The Flap Method.—One large flap may be made to the outer side and a short one to the inner side (Dupuytren) or they may be made anteroposteriorly (Lisfranc). The flap operations were done with long knives by transfixion, as they originated before the discovery of general anæsthesia and by them the member was removed with great rapidity (Fig. 282).

In *Dupuytren's method* the arm was raised to a right angle with the body and the deltoid muscle grasped with one hand while the knife was inserted beneath it, entering just below the posterior portion of the acromion process (its angle) then passing under the acromion to emerge in front at the coracoid process. This flap was turned up, the capsule and muscles divided, the bone turned out, and while an assistant compressed the remaining tissues they were divided transversely.

Lisfranc's method consisted in transfixing the posterior axillary fold from below upward, entering the knife in front of the tendons of the latissimus dorsi and teres major muscles and bringing it out a little in front of the acromion. The joint was opened posteriorly, the bone luxated, and an anterior flap cut from within outward. Sir William Fergusson, a noted operator, was partial to this operation.

The Racket Method.—In this method the incision resembles in shape the ordinary racket, such as is used in tennis. The loop encircles the arm, while the handle begins above at the point of the shoulder.

There are two operations by the racket method, which differ as to the position from which the upper portion of the incision starts.

Larrey's Method.—The operation usually ascribed to Larrey consists in starting the incision at the anterior end of the acromion process and continuing it straight down the arm for three centimetres (1¼ in.). It then parts, one branch sweeping gradually in a curved line to the anterior axillary fold and the other to the posterior axillary fold, an incision, through the skin only, passes across the inner surface of the arm joining the two branches. The flaps having been turned anteriorly and posteriorly, the joint is opened by cutting on the head of the bone, first posteriorly, then above, and then anteriorly. Tilting the head outward the inferior portion of the capsule is divided and the bone loosened from the soft parts. These are compressed by fingers of an assistant and cut.

Spence's Method.—A modification of Larrey's procedure, attributed to Spence by the British and to S. Fleury by the French, consists in commencing the incision just outside of the coracoid process in the interval between it and the acromion process. This modification is probably the best form of procedure for this locality and is the one which will be discussed here. It will be noticed, however, that it practically changes the operation of Larrey from one with anteroposterior flaps to one with a single external flap, as in the method of Dupuytren (Fig. 282).

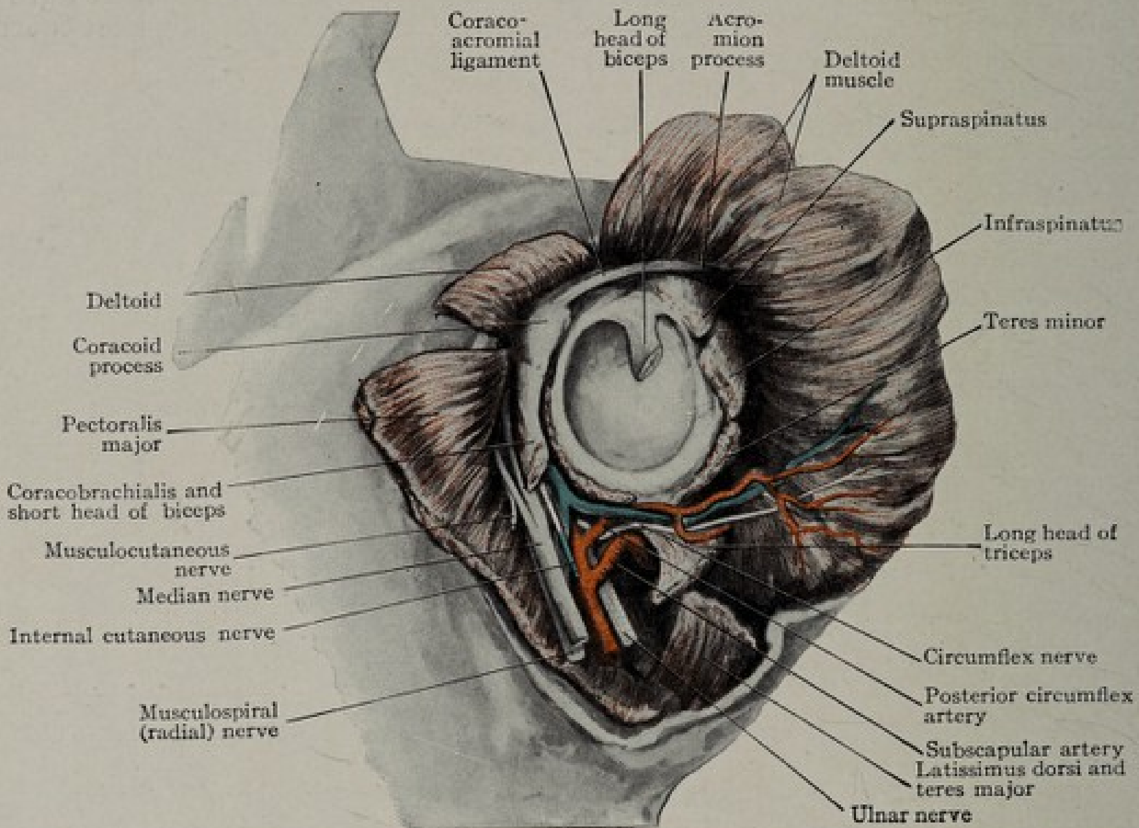


FIG. 282.—Amputation of the shoulder by anteroposterior flaps. The upper extremity of the incision passes between the coracoid and acromion processes. The posterior flap is the larger.

The incision begins just below the coraco-acromial ligament and lies deep in the hollow formed by the anterior concave surface of the outer third of the clavicle. It divides the fibres of the deltoid muscle longitudinally a short distance from its anterior edge. It will be recalled that the deltoid muscle covers the coracoid process and extends just to its inner side to be attached to the outer third of the lower surface of the clavicle. Between it and the adjoining edge of the pectoralis major muscle runs the cephalic vein. This passes downward and outward along the inner edge of the deltoid until it reaches the outer edge of the biceps muscle alongside of which it passes down to the elbow. This vein will be cut as the inner branch of the incision is made. The bicipital groove, when the palm of the hand faces forward, lies almost directly below the coraco-acromial ligament. While the incision is being made the arm is kept rotated slightly outward.

As the knife descends it runs along the inner side of the bicipital groove and divides the tendon of the pectoralis major muscle. As soon as this tendon is cut the incision is inclined laterally. The incision having been carried down to the bone, except on the inside of the arm, the deltoid flap is raised upward and backward. It carries with it the circumflex nerve and posterior circumflex artery.

The disarticulation of the bone is apt to be bungled unless one knows the construction of the parts. It is to be borne in mind that the capsular ligament is to be divided together with the tendons of the muscles inserted into the tuberosities. The capsule does not pass across the anatomical neck to be inserted into the tuberosities beyond, and the mistake is often made of cutting on the anatomical neck and therefore frequently the capsule still remains attached to the proximal side. The cut may be commenced posteriorly and should be made *on the head* of the bone just above the anatomical neck. The arm is to be adducted and rotated inward and the muscles inserting into the greater tuberosity cut in their order, first the teres minor, then the infraspinatus and supraspinatus with the joint capsule beneath them. Then comes the long head of the biceps, and the arm now being rotated outward, the tendon of the subscapularis is divided. In cutting the muscles and capsule across the top of the joint, the arm is to be kept close to the side of the body so as to tilt the upper portion of the capsule out beyond the acromion process.

The head of the bone can now be drawn out sufficiently to allow the knife to be introduced behind it to divide the inferior portion of the capsule. This should be detached close to the bone so as to avoid wounding the axillary artery and especially the posterior circumflex artery and the circumflex nerve, which wind around the surgical neck immediately below and are to be pushed out of the way.

The division is completed by cutting the remaining muscles passing from the trunk to the shaft of the bone. On the inner side may be an uncut portion of the pectoralis major, the coracobrachialis, and short head of the biceps; below is the long head of the triceps and on the outer side are the teres major and latissimus dorsi.

On examining the face of the stump, posteriorly is seen the bulk of the deltoid muscle with the triceps below, and then the latissimus dorsi and teres major tendons lying next to the artery. Anteriorly is the cut edge of the deltoid and pectoralis major with the coracobrachialis and short head of the biceps lying next to the artery.

To the outer side of the artery lie the median and musculocutaneous nerves. To the inner side are the ulnar and lesser internal cutaneous nerves (*cutaneous brachii medialis*) and the axillary vein. Posteriorly are the musculospiral and axillary (circumflex) nerves.

Sometimes the median nerve lies in front instead of to the outer side. The axillary artery is divided below the origin of the anterior and posterior circumflex arteries. The bleeding in the first cut will be from the cephalic vein (which runs between the pectoralis major and deltoid), muscular branches of the posterior and anterior circumflex, a small ascending branch of the anterior circumflex which runs in the bicipital groove, and the humeral branch of the acromial thoracic which accompanies the cephalic vein.

A glaring and common mistake in the performance of shoulder amputations is the making of the flaps entirely too short, especially when a Larrey operation is attempted.

The avoidance of serious hemorrhage is usually accomplished by clamping the small vessels as the operation proceeds, and before the final division of the axillary vessels slipping the fingers behind the bone and compressing them.

Esmarch's tube has been used by encircling the shoulder as close to the trunk as possible, the tube being kept from slipping by a bandage passed beneath it and fastened to the opposite side. Wyeth's pins have been used for the same purpose. One is inserted through the lower edge of the anterior axillary fold a little internal to its middle and brought out above in front of the acromion process, the other is entered at a corresponding point of the posterior fold and brought out above just behind the angle of the spine of the scapula or acromion process.

Interscapulothoracic Amputation.—For malignant growths of the axilla, shoulder, or scapula, and, rarely, for injury, the whole upper extremity with the scapula and part or whole of the clavicle have been removed. Anteroposterior flaps are made.

The greatest danger is death from shock and hemorrhage. In order to obtain some idea of the topography and vessels involved, see Fig. 283.

Excision of the Clavicle.—Excision of the clavicle in the living body, like tracheotomy, is much more difficult than when practiced on the dead body; this is due to the condition of the parts for which operation is undertaken. It has been often excised for malignant growths. On the upper anterior surface are attached the clavicular origin of the sternomastoid, the deep cervical fascia, and the trapezius muscle. Crossing the clavicle near its middle is the jugulocephalic vein which sometimes connects the cephalic with the external jugular. It is likewise crossed by the superficial descending branches of the cervical plexus. The external jugular vein, about 2.5 cm. (1 in.) above the middle of the clavicle, pierces the deep fascia and turns inward to empty into the internal jugular just behind the outer edge of the sternomastoid muscle; just below it empties the thoracic duct at the junction of the internal jugular and subclavian veins. The subclavian vein is directly behind the clavicle and the left innominate vein crosses behind the left sternoclavicular joint and passes across the posterior surface of the sternum just below or on a level with its superior border. The omohyoid muscle, if the shoulder is drawn outward and the head turned to the opposite side, is drawn upward above the clavicle.

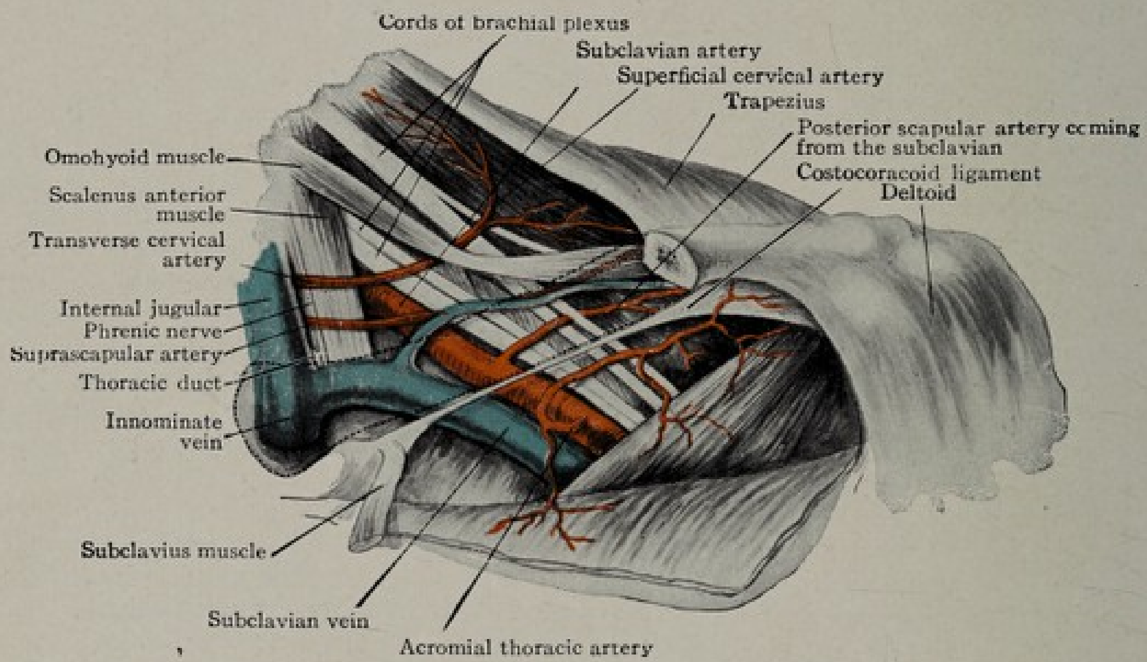


FIG. 283.—Structures exposed by excising the inner portion of the clavicle.

Behind the upper portion of the clavicle is the suprascapular artery and above it runs the transverse cervical artery, a branch of the thyroid axis. Both these vessels cross over the scalenus anterior muscle on which, toward its inner edge, is lying the phrenic nerve. In front of the scalenus anterior runs the subclavian vein and behind it is the subclavian artery with the cords of the brachial plexus above and to its outer side. Below and in front are attached the pectoralis major and deltoid muscles; the space between them forms the subclavicular triangle and occupies the outer half of the middle third of the bone. The cephalic vein pierces the costocoracoid membrane at this point to enter the subclavian vein.

On the under surface of the bone is the subclavius muscle, covered with a strong membrane. To the inner side of this muscle is the costoclavicular ligament. Beneath the clavicle, about its middle, passes the subclavian artery, separated from the vein in front by the scalenus anterior muscle. Below and beneath the subclavian artery, which rests directly on it, is the pleura. The internal mammary artery passes behind the inner extremity of the clavicle opposite the cartilage of the first rib.

The clavicle is the first bone in the body to ossify, and it has one epiphysis at its sternal end which appears about the seventeenth year and joins the shaft from the twentieth to the twenty-fifth year. In removing the bone it is first loosened at its outer extremity by dividing the acromioclavicular and coracoclavicular (conoid and trapezoid) ligaments.

Excision of the Scapula.—The removal of the scapula necessitates the division of a large number of muscles, for which see pages 228 and 229. The subscapular artery at the anterior border, about 2.5 cm. (1 in.) below the head or glenoid

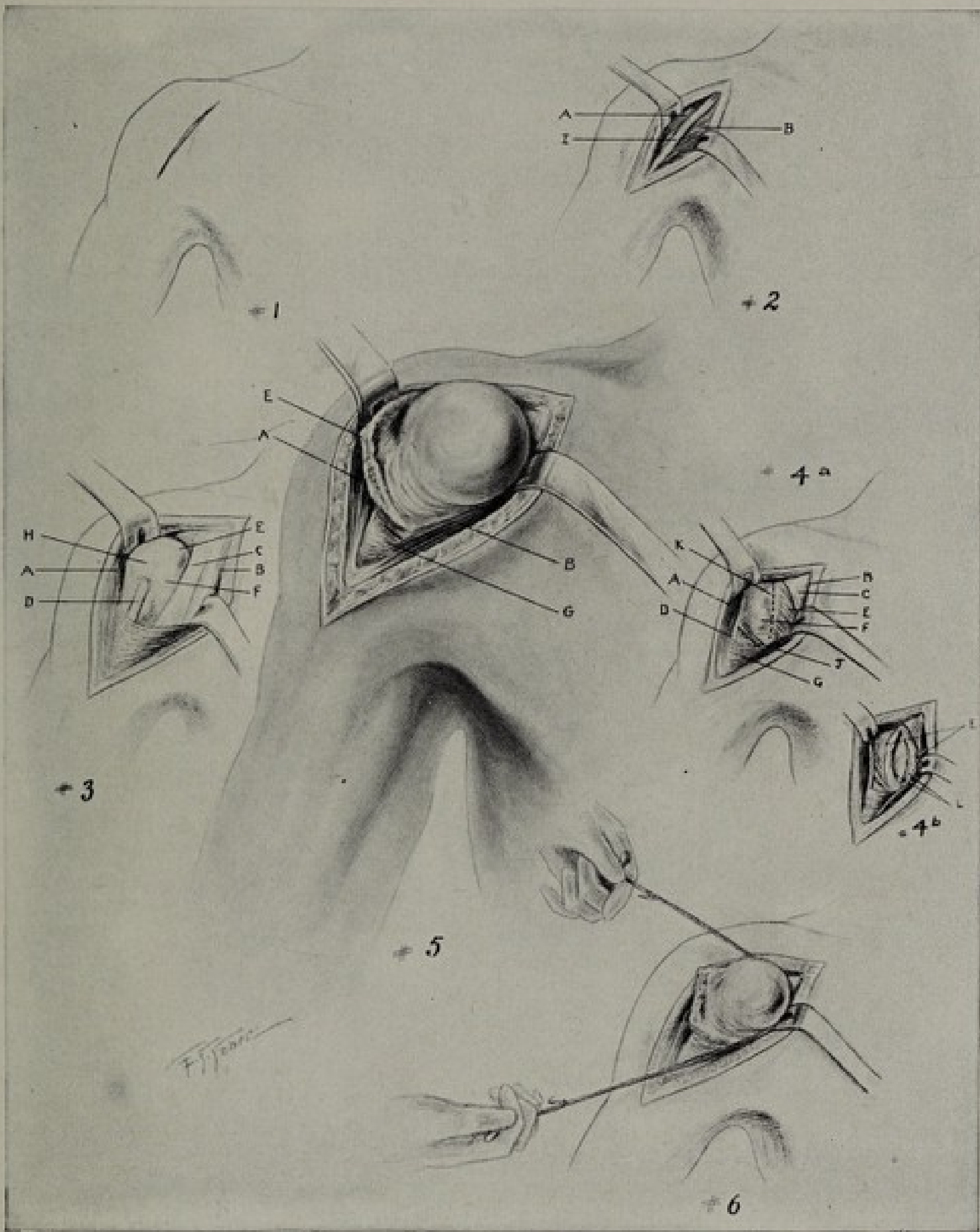


FIG. 284.—Showing the essential features of the operation for the high excision of the humerus or shoulder-joint, and in 4*b* the exposure and incision of the capsule in the deltoid pectoral capsule operation. No. 1, Skin incision. No. 2, Cephalic vein in interval between deltoid and pectoralis major. No. 3, Upper end of humerus exposed in almost full external rotation. No. 4*a*, Humerus in full normal external rotation. Dotted line shows where subscapularis and underlying capsule are divided into joint. No. 4*b*, Subscapularis divided and retracted and capsule divided as in the capsule operation. No. 5, turning out of humeral head through capsule opening. For all figures: *A*. Deltoid. *B*. Pectoralis major. *C*. Short head and biceps and coraco-brachialis. *D*. Long head of biceps. *E*. Subscapularis. *F*. Lesser tuberosity. *G*. Tendon of pectoralis major. *H*. Greater tuberosity. *I*. Cephalic vein. *J*. Anterior circumflex vessels. *K*. Line of division of subscapularis muscle and capsule, and *L*, their division in 4*b*. (T. Turner Thomas, M.D.)

process, and the suprascapular at the suprascapular notch, are to be ligated before removing the bone. Skirting the posterior edge is the posterior scapular, the continuation of the transverse cervical artery; it is to be avoided when detaching the muscles. The acromial branches of the acromial thoracic artery ramify over the acromion process; they are not so large as those already mentioned. If safety permits one should allow the acromion process to remain, as it preserves the point of the shoulder and to some extent, the functions of the trapezius muscle. It is highly desirous to leave the neck of the scapula and glenoid cavity. The coracoid should also be saved if possible by dividing it at its base and leaving it in place.

Excision of the Head of the Humerus (Figure 284).—The incision for the removal of the head of the humerus should be commenced just outside of the coracoid process and be carried 10 cm. (4 in.) downward in a direction toward the middle of the humerus, where the deltoid inserts. This incision may be made while the arm is somewhat abducted but it does *not* go in the groove between the deltoid and pectoralis major muscles. This groove contains the cephalic vein and the humeral branch of the acromial thoracic artery, and hence is to the *inner* side of

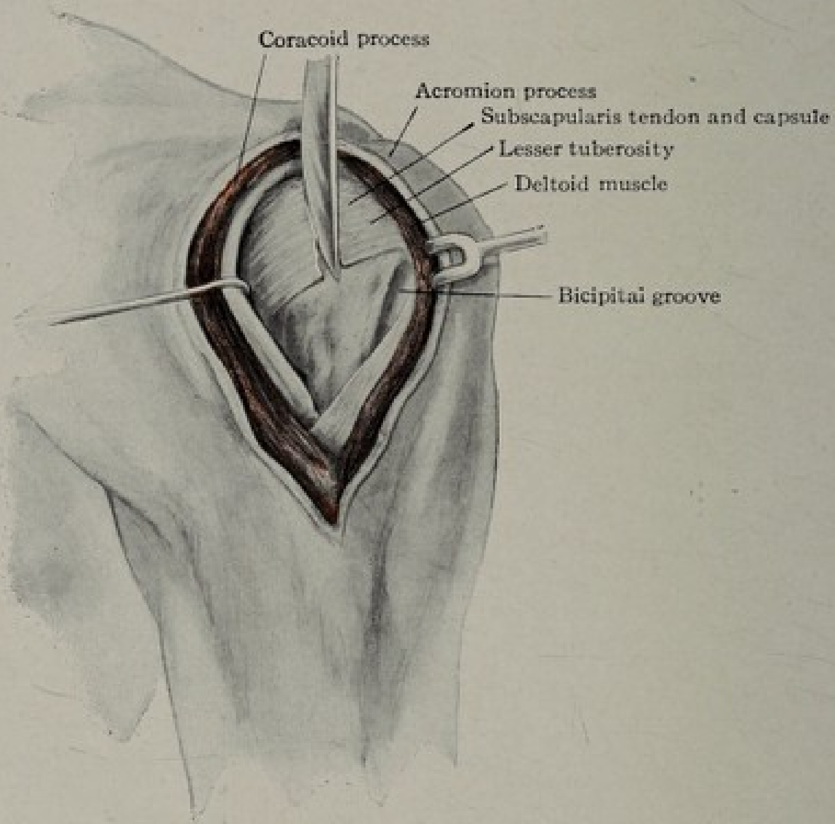


Fig. 285.—Resection of the shoulder-joint. The arm has been rotated outward so as to put the tendon of the subscapularis on the stretch. The long tendon of the biceps has been dislocated from the bicipital groove and is held to the inner side by a hook.

the coracoid process and as the incision is to the *outer* side, it passes through the deltoid near its anterior edge (Fig. 285).

The incision goes through the muscle and exposes the capsule of the joint. The sides of the wound are to be retracted and, if the long head of the biceps muscle is not recognized by sight, the finger is inserted and the arm rotated. The bicipital groove can be felt and the tendon identified.

The capsule is to be incised along the *outer* edge of the long tendon of the biceps and as the arm is rotated inward the supraspinatus, infraspinatus, and teres minor muscles are to be detached from the greater (posterior) tuberosity. The biceps tendon is again brought into view by rotating the arm outward and its sheath (transverse ligament) slit up and the tendon luxated inward.

The attachment of the capsule and subscapularis muscle to the lesser (anterior) tuberosity is then divided while the arm is rotated outward. The biceps tendon lies in the bicipital groove between the two tuberosities. When the arm is lying with the palm upward, in a supine position, the bicipital groove looks directly anteriorly in a longitudinal line passing midway between the two condyles of the lower end. The position of the head and groove can be told by observing the position of the condyles. The head is directly above the internal condyle and the groove is on the anterior surface above a point midway between the condyles. After the capsule has been opened and the attachments of the muscles to the greater and lesser tuberosities divided and the tendon of the biceps luxated inward, the head is thrust directly upward and out of the wound and sawed off as low as desired.

Immediately below the lower edge of the tuberosities is the surgical neck. On it anteriorly winds the anterior circumflex artery, and posteriorly the circumflex (axillary) nerve and posterior circumflex artery. These should not be disturbed, for the artery will bleed and injury of the nerve will cause paralysis of the deltoid muscle.

Posterior and transverse incisions have been suggested for this operation but they are not to be advised. The circumflex nerve and posterior circumflex artery are almost certain to be injured and the functions of the deltoid are liable to be seriously impaired or altogether lost.

If more access is desired than can be obtained by a straight incision as directed, the deltoid can be detached from its orgin along the outer end of the clavicle and acromion process and turned down. This does not interfere with its nerve supply. The circumflex nerve going to the muscle crosses the humerus at about the junction of the upper and middle thirds of the deltoid or a finger's breadth above its middle. After resection of the bone the deltoid can again be brought up and sewed to its previous attachment.

The character of the operation depends on the nature and extent of the disease. The operator should be familiar with the epiphyseal line, which runs from the inside upward and outward in the line of the anatomical neck as far as the middle of the bone, and then slopes slightly downward and outward to reach the surface almost on a level with the lower (inner) edge of the articular surface. As this is the site of most active growth of the humerus in young subjects this epiphyseal cartilage should be spared as much as possible.

The disability arising from a free resection is so great, owing to the loss of movements resulting from the detachment of muscles and interference with the epiphyseal cartilage, that formal resections are rarely performed, but, instead, the diseased parts are simply gouged away and as much allowed to remain as possible.

It is to be remembered that rotation inward is mostly performed by the subscapularis and outward rotation by the infraspinatus and teres minor. The supraspinatus aids abduction. A too free excision is liable to be followed by a flail-joint, in which case the limb hangs helplessly by the side with the dorsum pointing forward.

The axillary fold muscles insert on the anterior surface of the bone and hence turn the arm inward and draw it in toward the body, they do not compensate for the loss of the muscles attached to the tuberosities.

The bleeding in the operation will be mainly from the acromial branches of the acromial thoracic artery and the bicipital branch of the anterior circumflex artery, which runs in the bicipital groove.

A. B. Gill has devised a new operation for arthrodesis of the shoulder useful particularly in shoulder paralysis due to infantile paralysis and peripheral nerve lesions where there is sufficient power in the rotators of the scapula and in the extremity to make the operation worth while. He has not failed to get bony ankylosis with this operation. A horse-shoe incision one-half inch below the border of the acromion is made, a vertical incision two inches long over the greater tuberosity joins the first. The three flaps are then dissected freely from the underlying fascia. A deep incision then separates the deltoid from its attachment to the acromion, the deltoid is reflected sufficiently to expose the capsule of the joint. The capsule is opened and excised over the upper part of the joint from its attachment to the edge of the glenoid fossa to within an inch of its attachment to the humerus, this procedure being facilitated by a longitudinal incision if need be. The subacromial tissue is excised and the periosteum from the under surface of the acromion is reflected proximally as is the periosteum on the superior surface. The articular cartilage, glenoid ligament and the cartilage with a portion of the bone from the head of the humerus are removed. The humerus is split longitudinally with an osteotome so that a thin outer and anterior portion may be reflected slightly outward. A small wedge of bone with the base upward is removed from the remaining portion of the head. With the arm abducted, the acromion fits into the cleft in the humerus and becomes buried for a half-inch or more. The capsule attached to the humerus is then sutured to the reflected periosteum of the acromion, these structures being overlapped to secure greater strength. The arm is then included in a cast extending to the fingers and over the body as far as the pelvis, the arm being abducted at not more than a 45 degree angle and slightly forward. The cast is not removed until the end of twelve or fourteen weeks at which time bone fusion is complete and firm.

DISEASES OF THE JOINT AND BURSÆ

The shoulder-joint, like other joints, is subject to inflammatory and other diseases. These may be (1) traumatic and later septic; (2) rheumatic or gouty; (3) tuberculous, with suppuration.

These affections result in an effusion within the joint-cavity which distends the capsule and finally tends to escape at the weakest points. The joint is not a compli-

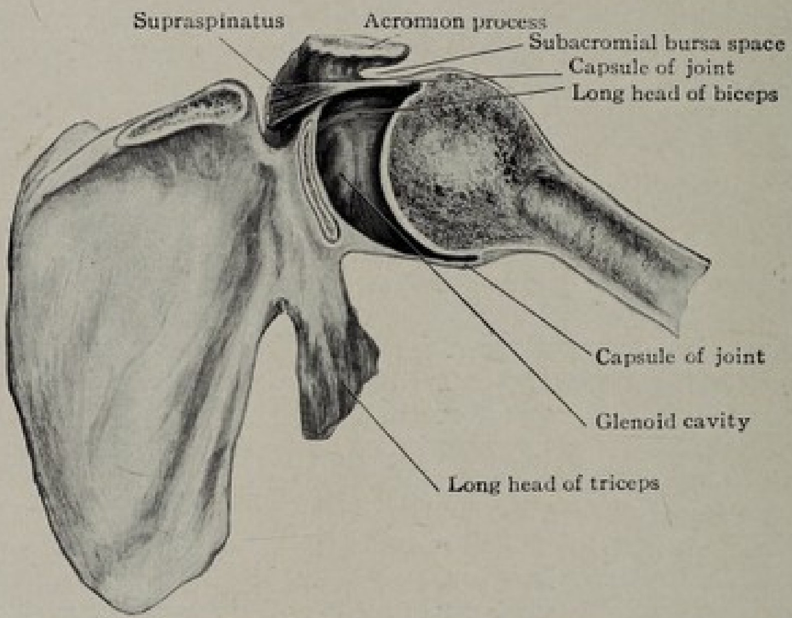


FIG. 286.—Transverse section of shoulder-joint, illustrating the laxity of the capsule of the joint.

cated one, like the knee, and its synovial membrane is neither so extensive nor so elaborate.

Traumatism may give rise to a synovitis, an inflammation of the synovial membrane, or an arthritis involving the entire joint structures. Sprains and other injuries are not uncommon. A sprain will be caused by a force which acts to a greater extent than the normal movements of the joint will allow.

Movements of the Joint.—In abduction the capsule becomes tense at its lower portion when the arm is at 90 degrees to the trunk, greater abduction is resisted by the greater tuberosity impinging on the acromion process and the scapula begins to revolve.

Abduction is resisted both by the muscles and by the ligaments. When the ligaments only remain, the head can be separated for 2 cm. or more from the glenoid cavity (see Fig. 286). Marked adduction is usually limited by the arm coming in contact with the side of the body.

If the humerus is brought diagonally across the chest the scapula begins to move and its posterior edge and lower angle turn forward. As the humerus is adducted the deltoid and supraspinatus are made tense and the head is drawn up in its socket. When the muscles are paralyzed the weight of the upper extremity allows the head to fall and a distinct depression can be seen beneath the acromion process. In paralysis of the deltoid this is particularly noticeable.

If traction is made on the arm, the muscles are the resisting agents. If the arm is in a position of adduction, those going from the humerus to the scapula, as the deltoid, supraspinatus, biceps, and triceps, act. If in abduction, then also those from the humerus to the trunk, like the pectoralis major and latissimus dorsi, are brought into play. The part played by the deltoid and trapezius should be noted. If the arm is down by the side and traction is made on it, the force is transmitted

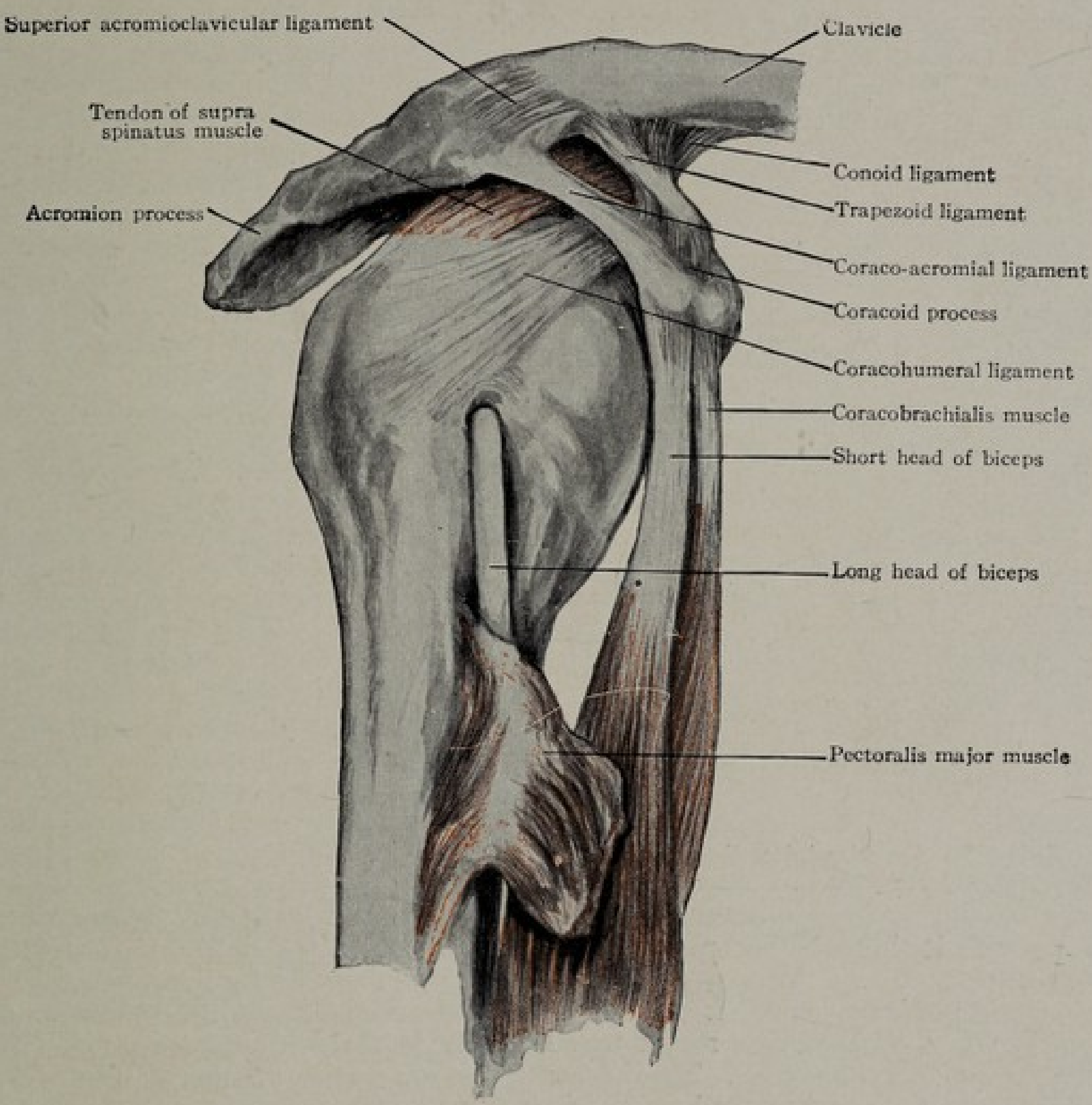


Fig. 287.—Acromioclavicular and shoulder joints.

from the humerus in a direct line through the deltoid and the upper fibres of the trapezius to their attachment to the spine and superior curved line of the occiput. If, on the contrary, the traction is made while the arm is raised above the level of the shoulder, the force is transmitted through the axillary fold muscles as well as by the deltoid and continued through the lower fibres of the trapezius. In either case the muscles are the resisting agents and not the ligaments. Abduction to more than a right angle is resisted by the contact of the greater tuberosity with the under surface of the acromion process and coraco-acromial ligament and the under side of the capsular ligament is made tense. The raising of the arm to 90 degrees is performed by the supraspinatus and deltoid muscles of the scapula and beyond this by the serratus anterior and other muscles.

Inward rotation is limited by the infraspinatus and teres minor muscles and by tension of the upper portion of the capsule. Outward rotation is limited by the subscapularis and upper portion of the capsule. The humerus rotates on its long axis 97 degrees (Macalister).

Subacromial or Subdeltoid Bursa.—Separating the greater tuberosity from the deltoid muscle, the acromion process, and coraco-acromial ligament, is the large subacromial bursa. It does not communicate with the joint, except rarely in old people. Effusions into it cause an increased prominence of the deltoid muscle, and pus seeking an outlet is likely to show itself at the anterior edge of the muscle and less often at its posterior edge. These effusions, which are liable to be present from contusions, sprains, etc., should not be mistaken for intra-articular accumulations. Codman believes this bursa to be the most frequent cause of "stiff and painful shoulder." He divides the lesions into the following types: (1) Acute or spasmodic; (2) subacute or adherent; (3) chronic or non-adherent. When adhesions are present abduction beyond 10 degrees is not possible. In the non-adherent type abduction and external rotation may be limited by spasm and pain. Calcareous deposits in the bursa lining may impede motion. Adhesions may be broken up by forced motion under anæsthesia.

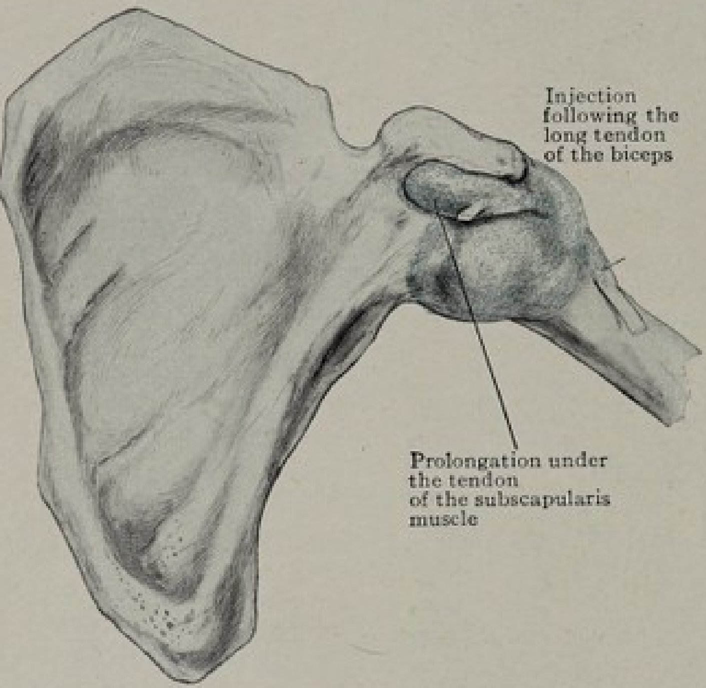


Fig. 288.—Shoulder-joint distended with injection, showing the position assumed by the humerus.

Biceps Tendon.—The long tendon of the biceps muscle enters the joint through the bicipital groove between the two tuberosities. With the arm hanging by the side it points directly forward; it passes over the head of the humerus and under the coraco-acromial ligament about midway between the coracoid and acromion processes to insert into the upper edge of the glenoid cavity. It is covered by a synovial sheath which passes with it through the opening in the capsule and a short distance along the bicipital groove. As this sheath does not communicate with the joint the tendon is in one sense extra-articular. It is held in the groove by a fibrous expansion, extending from the pectoralis major tendon below to the capsule above, called the *transverse humeral ligament*. This ligament is so strong that luxation of the tendon is uncommon; even when the humerus is luxated the tendon is rarely displaced.

Subscapular Bursa.—Beneath the tendon of the subscapularis there is a bursa which frequently communicates with the joint. This opening tends to weaken the capsule and it is at this point and just below that the head bursts through in dislocations.

Infraspinatus Bursa.—The capsule of the joint and the synovial membrane may be prolonged beyond the rim of the glenoid cavity under the tendon of the infraspinatus, or a bursa at this point may communicate with the joint.

Other bursæ may be present, but are unimportant. One is between the coracoid process and the capsule and another under the combined tendon of the coracobrachialis muscle and the short head of the biceps.

Effusions in the Shoulder-joint.—Liquid accumulations occur both from injury and disease. The liability of confounding them with those in the subacromial bursa has been alluded to above. As a result of disease, most often osteo-arthritis or tuberculosis, considerable liquid may accumulate in the joint. As the tension increases the arm becomes abducted about 50 degrees and the effusion tends to escape through the openings in the capsule (Fig. 288).

A distention of the joint will cause the deltoid to be more prominent. If the affection is in an old person, as is liable to be the case in osteo-arthritis, there is apt to be a communication with the subacromial bursa and this will become distended. If the liquid is purulent it has a tendency to work its way laterally under the deltoid and break through at its anterior or posterior borders and show itself at the folds of the axilla.

In osteo-arthritis (*arthritis deformans*) the long tendon of the biceps as it passes through the joint may be dissolved and the belly of the muscle then contracts and forms a lump on the middle of the arm anteriorly.

Pus frequently finds an exit along the bicipital groove and follows it downward and shows itself just at the edge of the anterior axillary fold near the middle of the arm.

If the pus passes out by way of the subscapular bursa it passes below the subscapular tendon and into the axilla anteriorly. If it passes backward it may emerge through the bursa beneath the infraspinatus muscle, and then either work its way downward into the posterior portion of the axilla, or if it works upward may travel either above or below the spine of the scapula and show itself on the dorsum.

THE AXILLA

The axilla is a wedge-shaped space with its apex upward, formed between the arm and chest at their junction. It serves as a passage-way for the arteries, veins, nerves, and lymphatics passing between the trunk and the upper extremity. It is frequently the site of growths and abscesses, requiring operations which necessitate a knowledge especially of its blood-vessels and lymphatics.

Extent.—Its apex lies between the clavicle and scapula above and the first rib beneath. Its base is formed by the skin and fascia stretched between the anterior and posterior axillary folds. It is spoken of as having four walls: inner, outer, anterior, and posterior.

The *inner wall* is formed by the first four ribs and interspaces and the corresponding serrations of the serratus anterior (magnus) muscle.

The *outer wall* is nothing more than the chink formed by the union of the two axillary folds. Above is the lesser tuberosity of the humerus and subscapularis tendon, lower down are the coracobrachial and biceps muscles.

The *anterior wall* is formed by the pectoralis major and minor muscles with the fascia enveloping them.

The *posterior wall* is formed by the subscapularis above and the teres major and latissimus dorsi muscles below.

Axillary Fascia.—The name axillary fascia is given to the fascia which closes the axillary space and forms its base. It is stretched across from the lower edge of the pectoralis major in front to the lower edge of the teres major and latissimus dorsi behind. On the inner wall it is continuous with the fascia covering the serratus anterior (magnus) and side of the chest; when it reaches the vessels at the apex of the axilla it is reflected around them to form the sheath.

On the outer wall it passes from the pectoralis major in front, over the coracobrachialis muscle beneath, blends with the sheath of the vessels, and then passes to the posterior wall, covering the subscapularis above and the teres major and latissimus dorsi below. At the lower edge of this latter muscle, which is a little lower than the pectoralis major, it passes across the axilla (Fig. 289).

Anteriorly the fascia covers the pectoralis major muscle; at its lower edge it splits to cover the pectoralis minor muscle and forms a sheath for it. As the axillary fascia approaches the apex of the axilla where the superficial vessels enter, it becomes cribriform in character, the fascia itself being wide-meshed and containing fat in the interstices.

The fascia on the superficial surface of the pectoralis minor is called the *clavipectoral fascia.* At the upper or inner border of the pectoralis minor it is continuous with the *costocoracoid membrane* which goes up to the clavicle, where it splits to enclose the subclavius muscle and to be attached to the anterior and posterior borders of the clavicle. The upper portion of this costocoracoid membrane is thickened and forms a firm band which runs from the coracoid process to the cartilage of the first rib, and is called the *costocoracoid ligament.*

Between this ligament above and the upper edge of the pectoralis minor below, and piercing the costocoracoid membrane, are the acromiothoracic artery and vein, the cephalic vein, the superior thoracic artery, external anterior thoracic nerve, and a few lymphatics derived from the breast. The superior thoracic artery is often a branch of the acromiothoracic and passes behind the vein to supply the serratus anterior and intercostal muscles and side of the chest.

The fascia on the under surface of the pectoralis minor unites with the layer on its upper surface, and passes upward to the coracoid process and is reflected onto

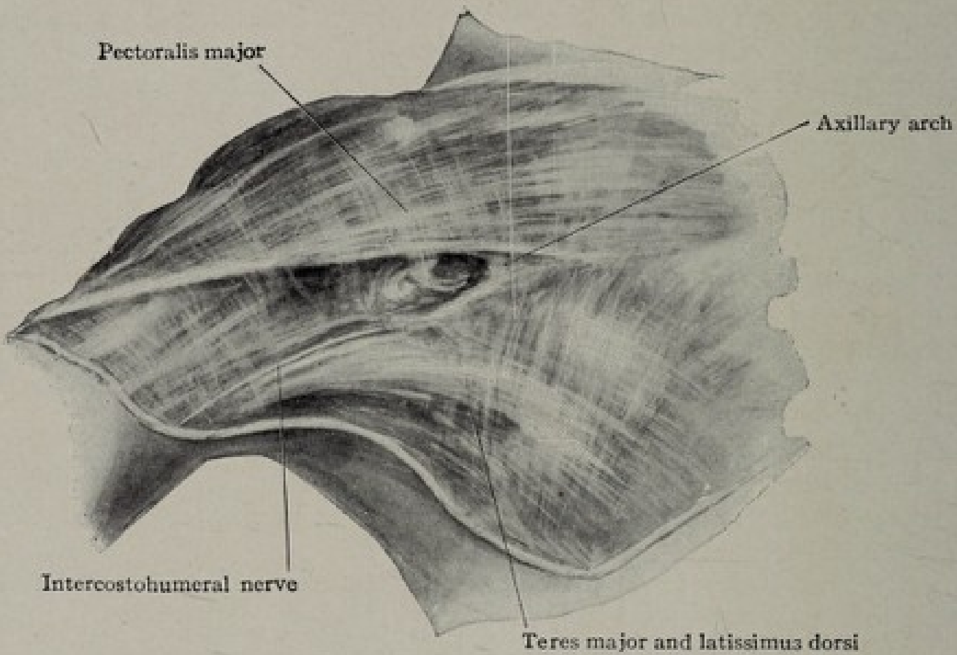


Fig. 289.—Axillary fascia. At the apex of the axilla the fascia is almost lacking, forming a curved arch on the side toward the chest, called the axillary arch or "Achselbogen." The curved edge toward the arm, less distinct than that toward the chest, is called the "Armbogen." (Langer, 1846.)

the vessels to aid in forming their sheath. It is continuous with the fascia on the under surface of the subclavius muscle and the deep fascia of the neck.

This portion of the fascia is not sufficiently strong to form an absolute barrier between the neck and axilla, consequently abscesses forming in the neck will break through it and passing under the clavicle appear in the axilla, and abscesses starting in the axilla may burrow under the clavicle and up beneath the deep fascia of the neck.

THE AXILLARY VESSELS

The axillary artery and vein are both important. The avoidance of hemorrhage in operations in this locality requires skill and knowledge, and venous bleeding is more apt to be troublesome than arterial. Wounds of the vessels, whether artery or vein, of those portions of the body like the axillæ, groins, or base of the neck are particularly dangerous; the blood current is both large and rapid.

The axillary vein drains the whole upper extremity and part of the chest, while the axillary artery carries all the blood going to those parts. The veins being so much weaker and thinner walled than the arteries is the reason of their being more frequently injured. Ligation of the artery, or vein, or both, may cause gangrene of the extremity and require amputation.

The Axillary Artery.—The axillary artery begins at the lower border of the first rib and ends opposite the lower border of the folds of the axilla (teres major). If the arm is lying by the side of the body the artery describes a curve with its convexity outward. If the arm is placed straight out away from the body, the artery is straight. If the arm is abducted above the level of the shoulder, the artery again becomes curved but with its convexity downward.

The *line of the artery* is straight only when the arm is out from the body, when its course is represented by a line drawn from the middle of the clavicle to the anterior surface of the elbow, midway between the two condyles. It passes down along the inner side of the coracoid process and the coracobrachialis muscle about at the junction of the anterior and middle thirds of the axilla. It is divided into three parts by the pectoralis minor muscle (Fig. 290). The chief indications for ligation are wounds, aneurisms, and hemorrhage in association with inoperable axillary growths. Three approaches may be mentioned. The supraclavicular incision for the ligation of the third portion of the subclavian, the infraclavicular incision for the first division of the axillary vessels, and thirdly, the axillary incision for the terminal or third portion are the ones described in text-books on operative surgery. The first two procedures are not practical for ordinary use and should not be used unless necessity demands it. The surgeon is constantly working in a deep cavity and the clavicle offers technical difficulties. The second portion of the axillary is quite inaccessible. A transverse incision gives at best only a small exposure to the first portion. Incision through the delto-pectoral sulcus complicates the operation and the vessels are very deep in this region. Conservative vascular surgery demands adequate exposure and this should be the aim of the surgeon. Ligation of the third portion is simple, and sufficient exposure is always obtainable if an anatomical knowledge of the region is had beforehand.

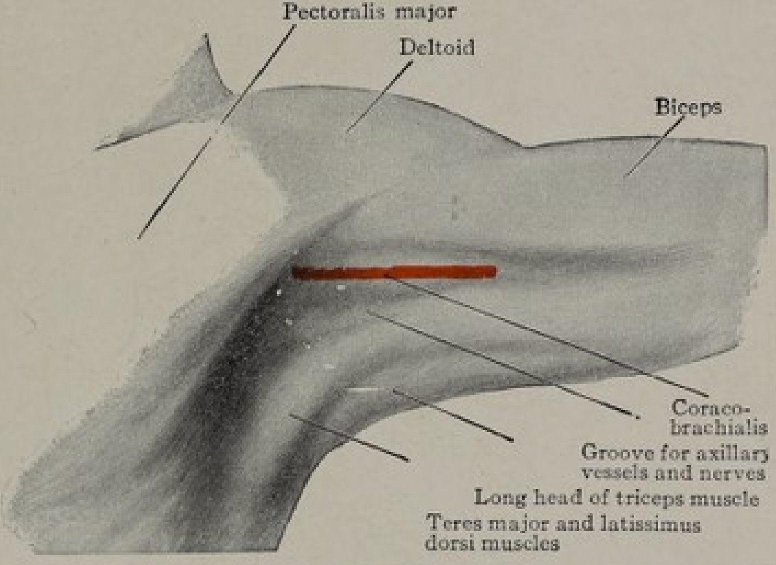


FIG. 290.—Line indicating the course of the axillary artery.

First Portion.—The first portion of the axillary is usually stated to be 2.5 cm. (1 in.) in length, and for surgical purposes we may accept this as a working basis.

A. H. Young has pointed out that, with the arm out from the body, the upper border of the pectoralis minor is nearly or quite level with the lower border of the first rib, but the muscle leaves the side of the chest to go to the coracoid process and that makes an interspace, more than 2.5 cm. long, above its upper edge and between it and the lower edge of the subclavius muscle, in which the artery can be ligated. In the first portion the axillary artery above the pectoralis minor lies too deep to be compressed, being on a lower level than the pectoralis major, therefore it is better to compress the subclavian above the clavicle.

Branches.—The first portion of the axillary gives off two branches, the superior thoracic and the acromiothoracic (thoraco-acromialis) (Fig. 291).

The *superior thoracic* comes off posteriorly and winds around behind the axillary veins to supply the under surface of the pectoralis minor, intercostal muscles, serratus anterior, and side of the chest. It is a small vessel.

The *acromiothoracic* (*thoraco-acromialis*) is a short large trunk which comes off anteriorly, winding around the edge of the pectoralis minor and piercing the costocoracoid membrane to divide into four branches: an acromial, to the acromion process; a humeral, which follows the cephalic vein between the deltoid and pectoralis major; a pectoral, which supplies the under surface of the pectoralis major and gives branches to the mammary gland; and a clavicular, to supply the subclavius muscle.

Relations.—*Posteriorly,* the artery lies on the first intercostal space and muscle, the second and part of the third serrations of the serratus anterior, the posterior thoracic nerve (or external respiratory of Bell), and the internal anterior thoracic nerve to the pectoralis minor and major.

Internally.—To the inner side of the artery and somewhat anteriorly is the *axillary vein*; between the two runs the *internal anterior thoracic nerve.* As the artery and vein ascend they become separated, the artery to pass behind and the vein in front of the scalenus anterior muscle.

Externally.—To the outer side and above the artery lie the cords of the brachial plexus.

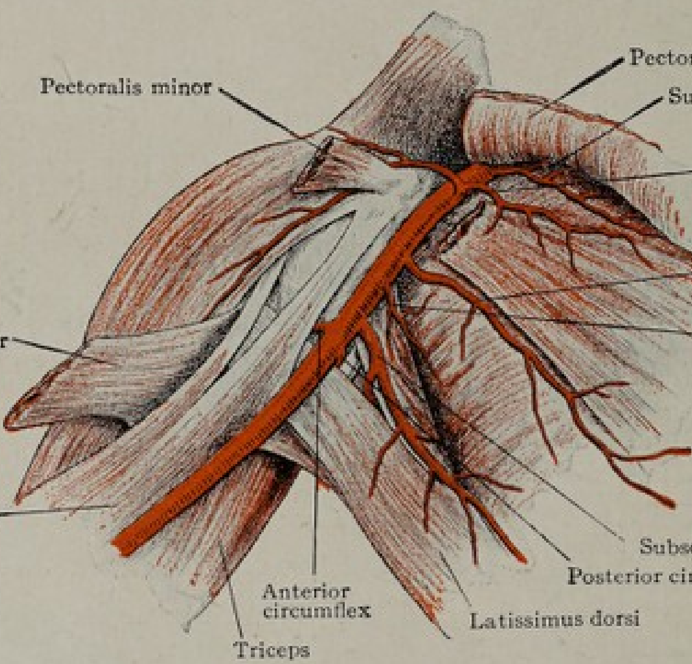


Fig. 291.—Diagrammatic view of axillary artery and its branches.

Anteriorly.—In front of the artery are the skin and superficial fascia, the edge of the pectoralis major muscle and fascia covering it, the costocoracoid membrane pierced by the acromiothoracic artery, cephalic vein, and external anterior thoracic nerve, which goes to supply the pectoralis major muscle.

Ligation of the First Portion of the Axillary Artery.—The artery lies deep in the infraclavicular triangle, between the pectoralis major and deltoid muscles. It can be approached by either a transverse or a longitudinal incision. If the former is used it should be made through the skin only, immediately below the clavicle, reaching from just outside the sternoclavicular joint to the coracoid process.

The pectoralis major is detached from the clavicle and pushed downward, it arises from its inner half. This exposes the costocoracoid membrane. At the outer angle of the wound the cephalic vein and acromiothoracic artery are to be found.

The deltoid muscle is to be detached or pushed outward to expose the coracoid process, this being recognized, the costocoracoid membrane is to be opened to its inner side, between it and the cephalic vein. The acromiothoracic artery if isolated will lead to the artery, while the cephalic vein goes direct to the subclavian vein. The vein and costocoracoid membrane are closely united and great care is necessary to avoid wounding the former in opening the latter. The cords of the brachial plexus are to the outer side of the artery and care is to be exercised not to mistake one of them for the artery. As the vein is the most dangerous structure, it is to be displaced inward and the aneurism needle passed between it and the artery from within outward.

As the external anterior thoracic nerve is a nerve of motion supplying the pectoralis major muscle, if it is seen it should be avoided and not injured.

If it is desired to use a longitudinal instead of transverse incision, it should commence just outside the middle of the clavicle and follow the groove between the deltoid and pectoralis major muscles downward for 10 cm. (6 in.). Great care is then necessary to avoid wounding the cephalic vein and acromiothoracic artery, which lie in this groove.

If sufficient exposure is not given by a single straight incision it can be supplemented by one detaching the pectoralis major from the clavicle.

Second Portion.—The second portion of the axillary lies beneath the pectoralis minor muscle. It is 3 cm. (1¼ in.) long and while never ligated at this point it is nevertheless frequently exposed while clearing out the avilla for malignant

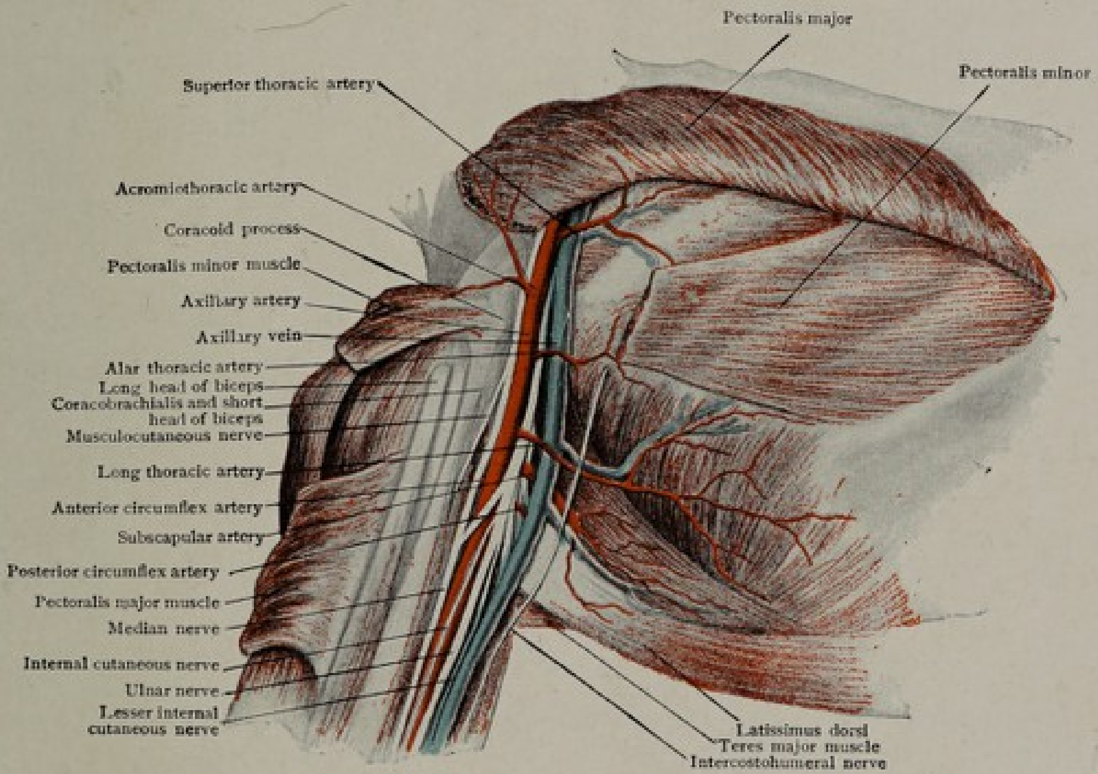


FIG. 292.—Dissection of the axilla.

growths of the breast. Owing to its being covered by the pectoralic minor and major muscles the artery cannot be compressed at this point in its course.

Branches.—Its branches are the alar thoracic and long thoracic. The *alar thoracic* are small branches of little importance supplying the fat and glands of the axilla.

The *long thoracic* or external mammary (Fig. 292) is of considerable importance on account of its size and because it is encountered in operations on the breast and axilla. It passes down along the lower (outer) border of the pectoralis minor, giving branches to it and the pectoralis major; some branches go to the axilla and serratus anterior, and others, which may be of considerable size in the female, wind around the lower portion of the pectoralis major or pierce it to supply the mammary gland. Posterior to it is the long or posterior thoracic nerve, or external respiratory nerve of Bell, going to supply the serratus anterior muscle.

Relations.—*Anteriorly* is the pectoralis minor muscle, superficial to which is the pectoralis major and skin. *Posteriorly* lie the posterior cord of the brachial plexus, the fat of the axilla, and the subscapularis muscle; *internally* is the axillary vein, with the inner cord of the brachial plexus separating the two. *Externally* is the outer cord of the plexus and farther out is the coracoid process.

Third Portion.—This is about 7.5 cm. (3 in.) long and runs from the lower border of the pectoralis minor to the lower border of the teres major. Its upper portion is under the pectoralis major but its lower portion is subcutaneous because the teres major, forming the edge of the posterior fold of the axilla, extends lower than the anterior fold. It is here that the axillary artery is most easily reached and most often ligated.

Branches.—It gives off three branches, the subscapular, the anterior circumflex, and the posterior circumflex.

The *subscapular* artery is of considerable practical importance; it is the largest branch of the axillary and is given off opposite the lower border of the subscapularis muscle. It follows the lower edge of this muscle down the axillary or outer border

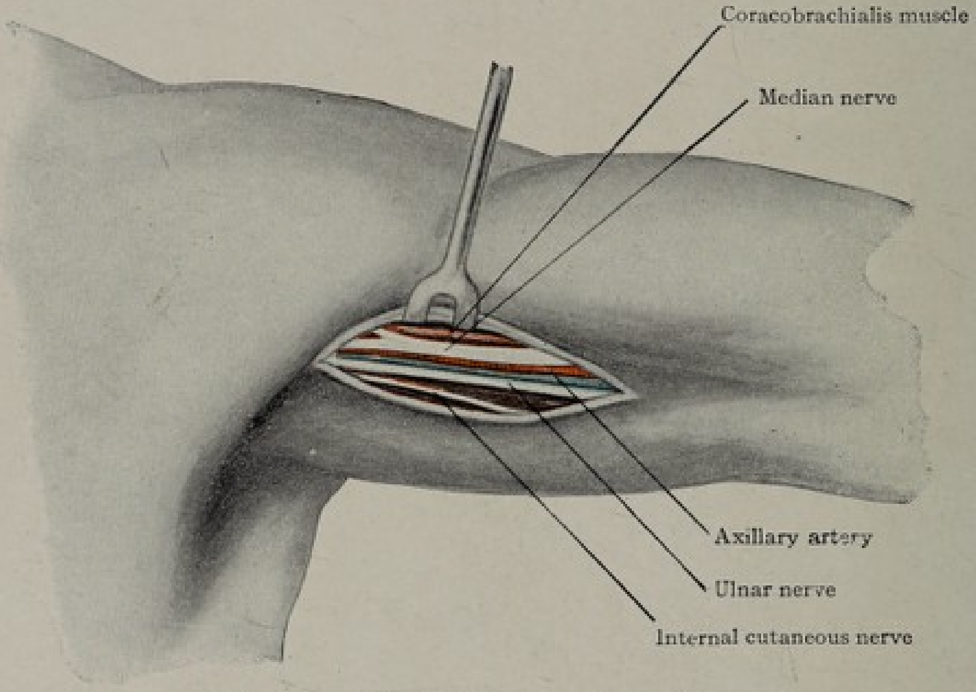


Fig. 293.—Ligation of the third portion of the axillary artery.

of the scapula to its angle, where it anastomoses with the posterior scapular, one of the terminal branches of the transverse cervical from the thyroid axis.

Four centimetres (1½ in.) from its origin the subscapular gives off the *dorsalis scapulæ*, which is as large or larger than the continuation of the artery downward. The position of this artery should be borne in mind in operating. It winds around the outer edge of the scapula between it and the teres minor muscle to supply the muscles posteriorly. The subscapular artery is accompanied by the long subscapular nerve to its inner side. (The first or short subscapular nerve supplies the subscapularis muscle, the second supplies the teres major and the third or long subscapular supplies the latissimus dorsi muscle.)

The posterior axillary chain of lymph-nodes accompanies the subscapular artery, hence it is involved in operations for their removal. The point at which the dorsalis scapulæ winds around the axillary border of the bone is at or just above the level of the middle of the deltoid muscle and below the level of the posterior circumflex artery. The subscapular and dorsal scapular arteries are usually accompanied by a plexus of veins which may cause troublesome bleeding in cleaning the posterior axillary chain of nodes from this region.

The *anterior circumflex* artery is comparatively insignificant. It winds anteriorly around the surgical neck of the humerus beneath the coracobrachialis muscle and both heads of the biceps and gives off an ascending bicipital branch which ascends in the bicipital groove and a small descending branch to the tendon of the pectoralis major. As pointed out by Walsham, the anterior circumflex artery on account of the closeness with which it hugs the bone may be difficult to secure if wounded in the operation of resection of the humerus.

The *posterior circumflex* artery is much larger than the anterior. It runs around the surgical neck posteriorly, below the teres minor, above the teres major, and between the long head of the triceps and the humerus. It is accompanied by the circumflex (axillary) nerve and they run transversely around beneath the deltoid muscle on a level with the junction of its upper and middle thirds. It is to avoid wounding these two important structures that the operation of resection is done anteriorly instead of posteriorly. Being covered only by the skin of the axilla and the superficial and deep fascias, it can readily be compressed by pressure directed outwardly against the humerus along the inner edge of the coracobrachialis muscle.

Relations.—*Posteriorly* the third portion of the axillary artery lies on the subscapularis, the latissimus dorsi, and teres major muscles, with the musculospiral and circumflex (axillary) nerves between the muscles and the artery.

Anteriorly it is covered by the skin and fascia, the pectoralis major above, and deep fascia of the arm below. The inner root of the median nerve crosses it and sometimes the outer vena comes.

Externally is the coracobrachial muscle (which partly overlaps it and forms its guide), the main trunk and outer head of the median, and the musculocutaneous nerves.

Internally is the axillary vein with the ulnar nerve between it and the artery. The internal and lesser internal cutaneous nerves also lie to its inner side with the former the more anterior.

Ligation of the Third Portion of the Axillary Artery.—The arm being placed out from the body, palm upward, the incision for ligating the axillary artery in the third portion of its course is laid along the inner border of the coracobrachial muscle, at about the junction of the anterior and middle thirds of the axilla and on a line joining the middle of the clavicle and a point at the bend of the elbow midway between the two condyles of the humerus.

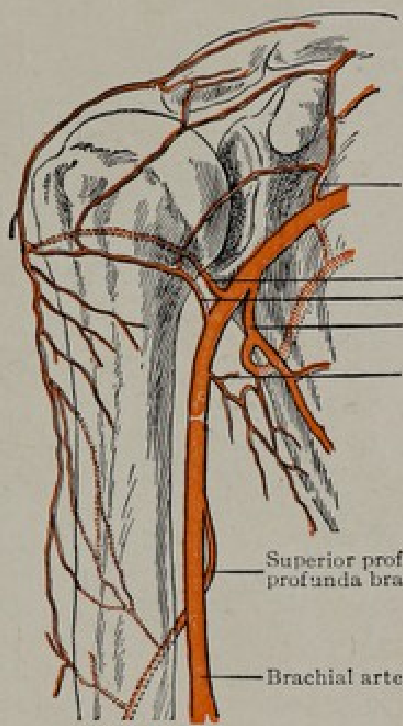


FIG. 294.—Collateral circulation after ligation of the third portion of the axillary artery.

The middle of the incision should be just above the lower edge of the folds of the axilla. The deep fascia having been opened, the coracobrachial muscle with the musculocutaneous nerve piercing it is pulled outward. Lying on the artery to its outer side is the median nerve; it is to be drawn outward. To the inner side lies the axillary vein with the ulnar nerve beneath it and the internal cutaneous nerve (cutaneus antebrachii medialis) in front of it close to the artery.

The needle is passed from within outward. The artery at this point may be crossed by some muscular fibres coming from the latissimus dorsi and crossing the axilla. The axillary vein is the continuation of the basilic from the lower border of the teres major upward.

Of the two venæ comites of the brachial artery the inner one blends with the basilic at the lower border of the teres major; the outer one crosses the artery to empty into the axillary vein on the opposite side.

The axillary vein receives the subscapular, circumflex, long thoracic, acromiothoracic, alar, and cephalic, and contains a pair of valves opposite the lower border of the subscapularis muscle.

Collateral Circulation after Ligature of the Axillary Artery.—If the first portion of the axillary is tied, the acromiothoracic artery comes off so low down (under the edge of the pectoralis minor muscle almost) that the ligature is placed above it, in which case the collateral circulation is similar to that of the subclavian (see page 149). The second portion of the axillary, lying beneath the pectoralis minor, is not subject to ligation. In the third portion the subscapular and anterior and posterior circumflex arteries come off so close together that the ligature will be placed either just below or just above them (Fig. 294).

If below, then the collateral circulation will be between them above and the superior profunda below. If above the subscapular, then the anastomosis would be as follows:

Proximal Vessels.		Distal Vessels.
Acromiothoracic, acromial branch	with	anterior and posterior circumflex
Acromiothoracic, humeral branch	with	anterior and posterior circumflex
Acromiothoracic, pectoral branch	with	subscapular
Long thoracic branch	with	subscapular
Alar thoracic branch	with	subscapular
Posterior scapular (branch of trans. cervical)	with	subscapular and dorsalis scapulæ
Suprascapular	with	dorsalis scapulæ and posterior circumflex

Lymphatics of the Axilla.—The axillary lymphatic nodes are important in that with the exception of a few scattered nodes in the brachial region and an occasional node in the antibrachium, they drain the entire upper extremity. These nodes also receive the afferent vessels from the anterior and lateral chest wall, the breast, and from the scapular region. There are two sets of lymphatic nodes in the axillary region, the axillary nodes proper and the subclavian nodes.

The number of the nodes varies from about ten to thirty or more. When enlarged they are readily seen, but after the surgeon has carefully dissected away all the nodes he can possibly find disease may subsequently reveal the existence of others. Hence it is impossible ever to be absolutely sure that *all* nodes have been removed. The size of the normal gland is usually inversely proportional to the number of glands present. Although they are probably all connected by anastomosing vessels the nodes are divided into groups according to their position and to the origin of their afferents.

The *subclavian nodes* from two to ten in number, lie in the infraclavicular triangle between the pectoralis major, and deltoid muscles and on the front of the subclavian vein above the pectoralis minor muscle. They receive radicles from the mammary gland as well as from the axillary groups. They are important in that they form the terminal station, since they receive, either directly or indirectly, the efferents from the other groups. They may empty through the subclavian trunk into the subclavian near its junction with the external jugular, or into the right jugular trunk or into the thoracic duct. Some also empty into the deep inferior cervical group of nodes.

The *axillary nodes proper* are composed of three sets, humeral or external, thoracic or anterior, and scapular or posterior, accompanying the three vessels, axillary, long thoracic, and subscapular.

The *humeral set*, perhaps eight or nine, accompany the axillary artery and vein and lie along them and in the axillary fat. They receive mainly the lymphatics from the arm. They can often be pared off the vessels with ease, but sometimes are so firmly attached that the vessels are injured in their removal.

The *anterior thoracic and inferior pectoral sets* accompany the long thoracic artery along the lower border of the pectoral muscles. They are not so numerous as the humeral set, perhaps four or five in number, and drain the anterior upper half of the chest above the umbilicus, including the mammary gland (Fig. 295).

The *posterior* or *subscapular set* accompany the subscapular artery along the posterior portion of the axilla. They are about as numerous as the anterior set and drain the upper posterior portion of the chest, the scapula and lower portion of the neck.

The lymphatics of the middle and lower portion of the back as low down as the umbilicus (3 to 4 cm. above the iliac crest) also drain into the axilla.

These lymphatic nodes communicate with one another, so that it does not of necessity follow that if the part ordinarily drained by a certain set is affected the nearest nodes will be involved. It usually is so, but not always. The infection may pass by or through one set of nodes and involve a neighboring communicating set. It happens in carcinoma of the breast that sometimes the posterior or scapular set are involved and the anterior or thoracic set escape. This has already been alluded to in the section on the mammary gland (see page 213). These three sets drain into the subclavian nodes and then empty into the subclavian vein near its junction with the jugular.

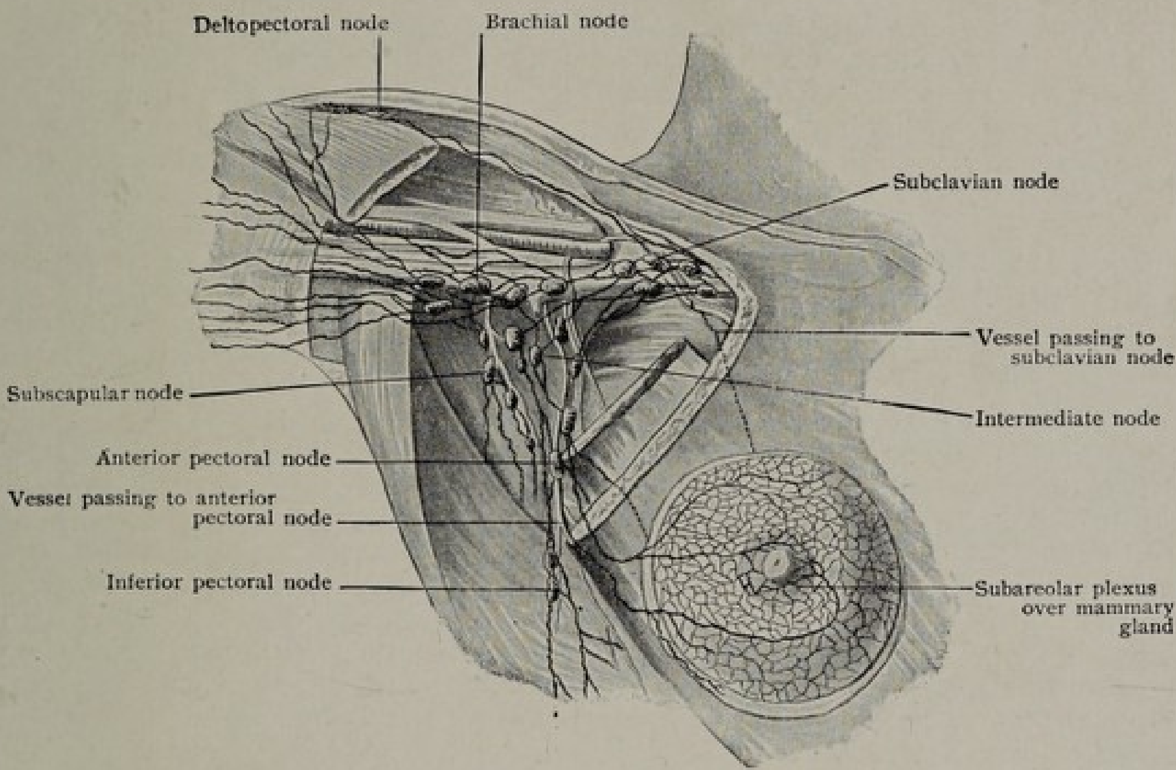


FIG. 295.—Lymphatics of mammary gland, and axillary nodes. (Poirier and Cunéo.)

Abscess of the Axilla.—Pus forms in the axillary region from ordinary pyogenic organisms which may or may not be associated with specific organisms like the tubercle bacillus. Abscesses may be either superficial or deep.

The *skin of the axilla* is thin, loose, and abundantly supplied with sebaceous glands connected with the hair-follicles and sweat-glands. These glands are in the deeper layer of the skin and are superficial to the axillary fascia, hence abscesses originating from them tend to break externally; usually they do not become large nor extend deep into the axilla.

Abscesses originating from the lymphatics, on the contrary, may be either deep in the axilla along the axillary, pectoral, or subscapular vessels, or they may be in the axillary fat and tend to point toward the skin. If the lymphatics along the axillary vessels are the point of origin, the abscess may follow them down under the deep fascia to the elbow. If the nodes high up are involved, the abscess may work up under the clavicle into the neck. If, however, the nodes near the apex of the axilla form the starting-point then the abscess bulges through the cribriform portion of the axillary fascia (between the "Armbogen" and "Achselbogen") into the axilla and tends to discharge through the skin. Abscesses originating in the pectoral group of lymphatics point at the lower margin of the anterior axillary fold. The attachment of the serratus anterior to the side of the chest prevents them from working towards the back.

Abscesses involving the subclavian nodes may cause a *subpectoral abscess* (Fig. 296). The pus collects superficial to the costocoracoid membrane and clavipectoral fascia and pushes the pectoralis major muscle outward, forming a large rounded prominence below the inner half of the clavicle. The pus cannot extend upward or toward the median line on account of the attachment of the pectoralis major muscle. It can burrow through the intercostal spaces and involve the pleural cavity, or break through the fibres of the pectoralis major anteriorly or between the pectoralis major and deltoid, or, as is most commonly the case, work its way under the pectoralis major muscle, over the pectoralis minor, until it reaches the border of the pectoralis major at the anterior fold of the axilla.

In emptying these abscesses an incision is to be made along the anterior axillary fold and a tube introduced beneath the pectoralis major.

Incision for Axillary Abscess.—In opening an axillary abscess one should bear in mind that the important veins and nerves accompany the arteries and that the arteries lie in three places, viz., externally along the humerus, anteriorly along the edge of the pectoral muscles, and posteriorly along the edge of the scapula; therefore these three localities are to be avoided and an incision made in the middle of the axilla and short enough not to endanger the brachial vessels on the outside or the long thoracic or subscapular on the inside near the chest-wall.

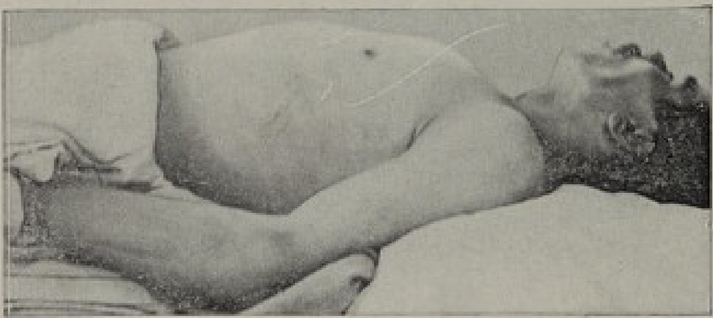


Fig. 296.—Subpectoral abscess.

The incision may divide the skin and if desired the deeper structures can be parted by introducing a closed hæmostatic forceps and separating its jaws.

Axillary abscesses, if of slow formation and unopened, tend to burrow and follow the vessels upward beneath the clavicle and appear in the supraclavicular space beneath the deep cervical fascia, and they may even enter the superior mediastinum. They may also descend the arm under the fascia covering the coracobrachialis muscle.

Axillary Tumors.—Tumors of the axilla are almost always due to involvement of the lymph-nodes. They may be either benign and inflammatory in character, forming the ordinary axillary adenitis, tuberculous, the result of lymphatic disease, or they may be malignant. As they are due to disease of the lymph-nodes, the parts which the glands drain should be searched for the starting-point of the affection. Aneurism or abscess may be mistaken for a new growth and an inflamed aneurism may readily be thought to be an abscess.

The excision of axillary tumors is difficult. If the tumor is of an inflammatory origin it may be closely adherent to the veins or arteries or nerves, and the same condition may exist in malignant cases.

The blood supply of the axilla is so free that nothing is to be gained by saving small vessels, therefore in paring a tumor off the axillary vessels the various small branches are ligated and divided and the main vessels left bare. This applies to the veins as well as the arteries.

The subscapular artery is so large that it is often allowed to remain. When working in the posterior portion of the axilla it is to be remembered that the posterior circumflex artery is opposite the surgical neck of the humerus, above the tendon of the latissimus dorsi muscle, and that the subscapular artery is on the opposite side of the axillary artery a little higher up. The large subscapular vein will bleed profusely if wounded and it should be looked for at the axillary border of the scapula below the subscapularis muscle.

Wounds of the axillary vein are particularly dangerous on account of the admission of air. The attachment of the vein to the under side of the pectoralis minor and costocoracoid membrane keeps it from collapsing; hence the danger.

Nerves of the Axilla.—The *brachial plexus* is above the first portion of the axillary artery. In the second portion one cord is to the inner side, one to the outer, and one behind. In the third portion the *median nerve* is anterior and a little to the outer side of the artery, being formed by two roots, one from the inner and the other from the outer cord of the brachial plexus.

The *musculocutaneous nerve* is to the outer side of the artery, leaving the outer cord to enter the coracobrachialis muscle. The *ulnar, internal cutaneous* (*cutaneus antebrachii medialis*), and *lesser internal cutaneous* (*cutaneus brachii medialis*) come from the inner cord and lie to the inner side of the artery. From the posterior cord come the *axillary* (*circumflex*) and *radial* (*musculospiral*) nerves. On the inner wall of the axilla behind the long thoracic artery is the *N. thoracalis longus* (long thoracic, or external respiratory nerve of Bell); it is a motor nerve and supplies the serratus anterior (magnus) muscle, hence it is not to be injured in clearing out the axilla.

Still farther posteriorly, accompanying the subscapular artery, is the *thoraco-dorsalis* or *long subscapular nerve*. It also is a motor nerve supplying the latissimus dorsi muscle; therefore it is to be spared.

Crossing the axilla from the second intercostal space to anastomose with the cutaneus brachii medialis nerve is the *intercostobrachial* (*intercostohumeral*) nerve. It is a nerve of sensation and need not be spared. Sometimes another branch from the third intercostal nerve also crosses the axilla; it is also sensory and can be cut away.

As the *axillary* (*circumflex*) *nerve* normally winds around the surgical neck of the humerus, when luxation occurs it is stretched over the head and paralysis of the deltoid may ensue.

The various nerves of the brachial plexus are often injured by pressure resulting from the use of crutches ("crutch palsy"). It is liable to affect any or several of the nerves, the radial (musculospiral) probably the most frequently. Neuritis is common and, as in injuries, the nerves affected are recognized by the motor or sensory symptoms produced.

THE ARM

The arm—or upper arm—is formed by a single bone surrounded by muscles, which, with the exception of the biceps, are attached to it. The main vessels and most of the important nerves run down its inner side. It receives from the trunk the insertions of the muscles which move it, and gives origin to the muscles which move the forearm. It is more subject to injury than to disease; infection, caries, and rickets may attack the bone and rarely new growths may occur, but its common affections are wounds involving the muscles, blood-vessels, or nerves, and fractures of the bone. Severe injuries occasionally necessitate amputation.

THE HUMERUS

The humerus is a long bone with a large medullary cavity. Its shaft is composed of compact tissue and its ends of cancellous tissue. In shape it is like the letter *f*, that is, convex anteriorly above and concave anteriorly below. At the middle of the bone on its external surface is the rough deltoid eminence for the insertion of the deltoid muscle. The upper curve ends in the region of the deltoid tubercle. Both curves are accentuated in rachitis. The middle of the shaft where the two curves meet is the smallest, hardest and least elastic portion of the shaft. It is therefore the most frequent site of fracture. Periostitis may cause exostoses most frequently at the site of the insertions of the pectoralis major, latissimus dorsi, and the origin of the outer head of the triceps.

Anterior Surface.—Separating the tuberosities above and running down the anterior surface is the *bicipital groove.* Its external lip receives the insertion of the pectoralis major muscle, its inner lip and floor those of the latissimus dorsi above and the teres major below. On its inner side at and a little below its middle, is the insertion of the coracobrachialis muscle. On the anterior surface from the deltoid eminence to the elbow-joint is the origin of the brachialis anticus; it has two heads, which embrace the insertion of the deltoid, one being in front and the other behind it (Fig. 297).

Posterior Surface.—On the posterior surface, running obliquely across the bone downward and outward, below the insertion of the deltoid, is a shallow groove, called the *musculospiral groove* (*sulcus radialis*). It holds the *musculospiral* (*radial*) *nerve* and the *superior profunda artery.* Above the groove and to its outer side is the origin of the outer head of the triceps extensor muscle and the insertion of the deltoid. To its inner side, below, is the origin of the inner head of the triceps. Therefore the groove separates the inner head of the triceps muscle from the outer (Fig. 298).

MUSCLES OF THE ARM

In order to operate intelligently in this region it is necessary to know the muscles and interspaces, for the latter carry important structures. The arm possesses four sets of muscles. One, a lateral set, abducts it, the *deltoid;* another, or media set, adducts it (and rotates it inward), the *pectoralis major, teres major, latissimus dorsi,* and *coracobrachialis;* another, anterior set, flexes the forearm, the *biceps,* and the *brachialis anticus;* and the last, or posterior set, extend the forearm, the *triceps,* with, sometimes, the *subanconeus* beneath it.

The External or Abductor Set

This comprises only one muscle, the deltoid; the supraspinatus belonging to the shoulder region.

The **deltoid** forms the large rounded prominence of the shoulder. At its insertion the bone is nearest the surface and can be more readily felt. The posterior edge can be plainly seen when contracted running upward and inward and crossing the posterior fold of the axilla at right angles. Its anterior edge blends more or less completely with the pectoralis major (Fig. 299). It is supplied by the circumflex (axillary) nerve.

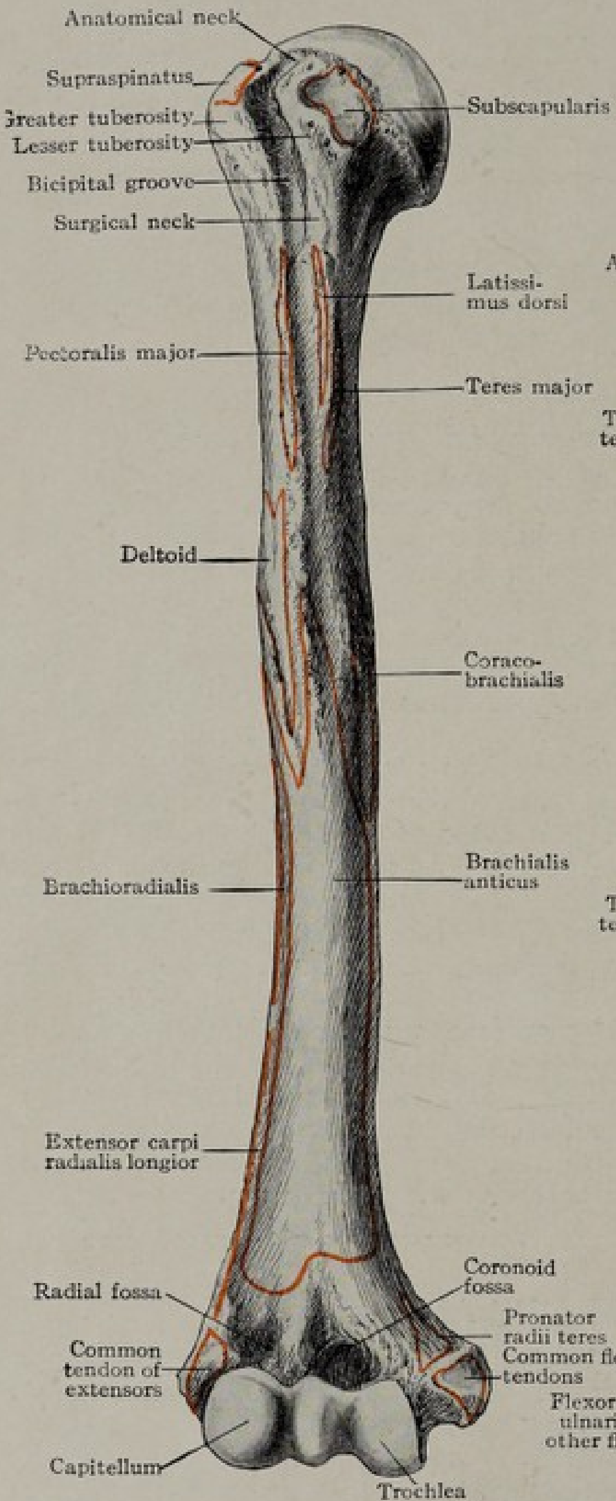


Fig. 297.—Anterior surface of humerus, showing attachment of muscles.

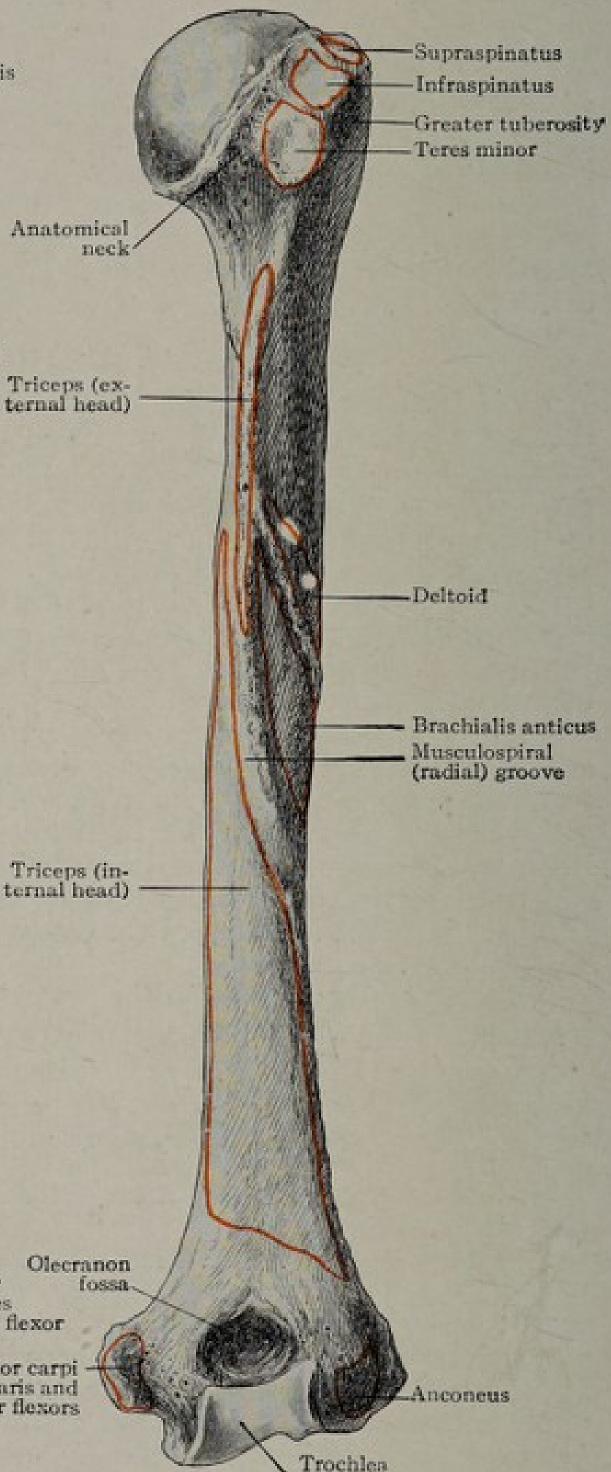


Fig. 298.—Posterior surface of humerus, showing attachment of muscles.

The Internal Set

The internal set includes the coracobrachialis, with the short head of the biceps, and the pectoralis major, teres major, and latissimus dorsi.

The **coracobrachialis** arises from the coracoid process and tendon of the short head of the biceps and inserts on the inner surface of the humerus for a distance 5 to 7.5 cm. (2 to 3 in.) opposite the insertion of the deltoid, but extending a little lower.

In its course from the coracoid process, in its lower part, it is subcutaneous and produces a distinct muscular prominence along the anterior border of the axilla. It occupies about one-third of the width of the axilla and is a guide to the brachial artery. Below the edge of the anterior axillary fold it dips down to insert into the bone and is covered by the biceps muscle. The inner edge of the coracobrachialis is continuous with the inner edge of the biceps. When it contracts it adducts the humerus and brings it forward. It is supplied by the musculocutaneous nerve which traverses its substance from medially laterally.

The **pectoralis major,** forming the anterior axillary fold, inserts into the external lip of the bicipital groove from the greater tuberosity above to the insertion of the deltoid below. The tendon is twisted on itself so that the lowest fibres at its origin are inserted the highest, and the highest in origin are the lowest at their insertion. The posterior surface of the tendon is separated from the anterior sur-

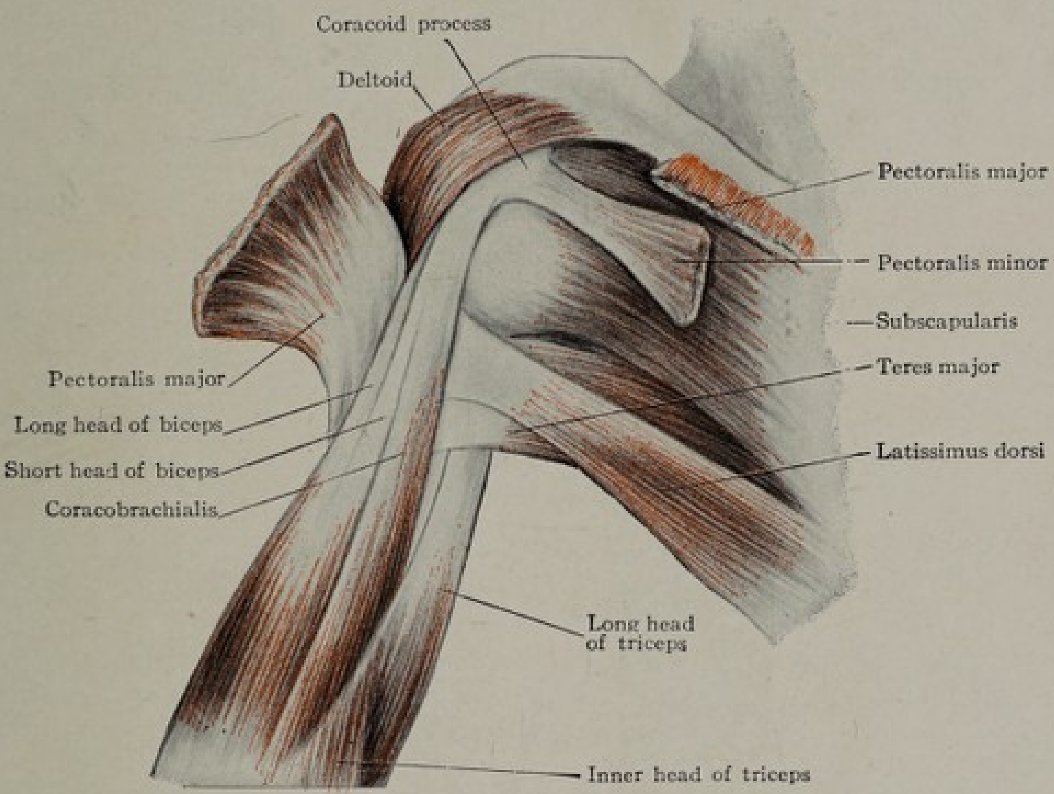


FIG. 299.—Muscles of the anterior and internal aspects of the region of the shoulder.

face of the long head of the biceps by a bursa. The muscle is supplied by the medial and lateral anterior thoracic nerves.

The **latissimus dorsi** and **teres major** form the posterior axillary fold and their manner of insertion resembles that of the pectoralis major. The tendon of the latissimus dorsi inserts into the bottom of the bicipital groove higher up than the teres major. Hence near the humerus the lower edge of the posterior axillary fold is formed by the teres major and its lower border marks the lower limit of the *axillary* and the beginning of the *brachial artery*. The latissimus dorsi is supplied by the long subscapular nerve while the teres major is supplied by the lower short subscapular nerve.

As the pectoralis major, latissimus dorsi, and teres major muscles insert on the anterior surface of the humerus, they tend to rotate it medialward as well as to adduct it. The pectoralis major also pulls the arm forward while the latissimus dorsi and teres major pull it backward.

The Anterior Set

The biceps and brachialis anticus (*brachialis*) form the muscular mass on the anterior surface of the arm.

The **biceps** has no attachment to the humerus. It spans the bone and is attached to the scapula above and to the radius and deep fascia of the forearm below. In the lower half of the arm it lies on the brachialis anticus. The long head runs up in the *bicipital groove*, and is covered by the tendon of the pectoralis major up to the tuberosities, above that by the transverse humeral ligament up to the cap-

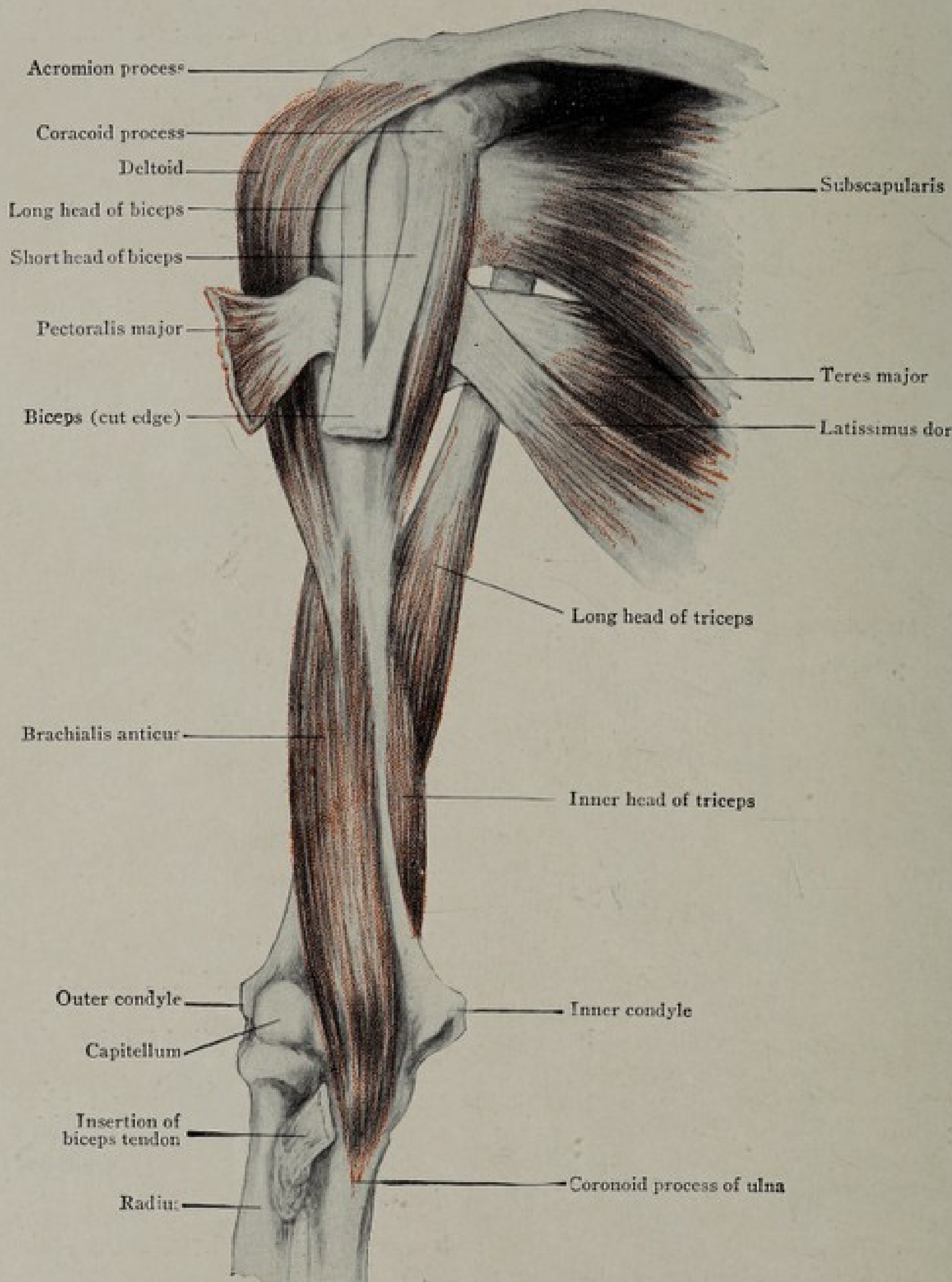


FIG. 300.—Anterior view of muscles of the arm.

sule, which it perforates, and, crossing over the head of the humerus, is attached to the upper edge of the rim of the glenoid cavity (Fig. 300).

The bicipital branch of the anterior circumflex artery accompanies the tendon in the bicipital groove. This tendon is comparatively rarely luxated, because it is firmly held in place by the transverse humeral ligament. Pus, in finding an exit from the joint, follows the long tendon of the biceps and passes under the transverse humeral ligament, then beneath the tendon of the pectoralis major to appear on the anterior aspect of the arm at its lower border. Luxation of the tendon outwardly would be opposed by the insertion of the pectoralis major, therefore it is only displaced inwardly. Rupture of the long tendon may occur from violent muscular

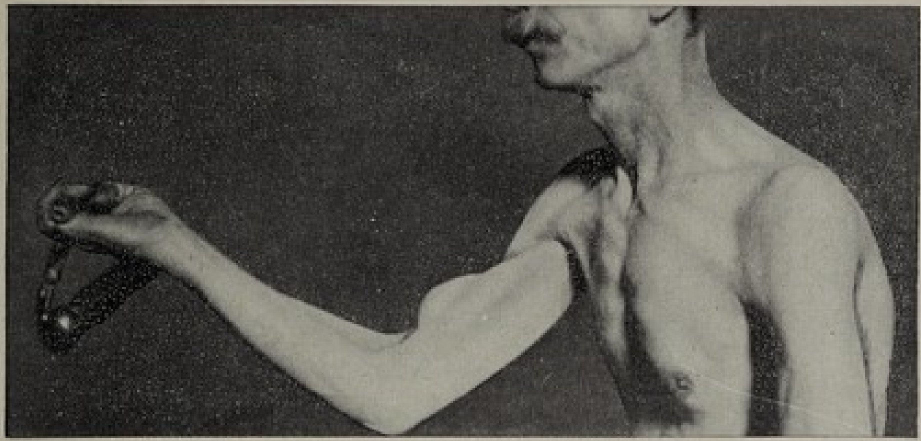


FIG. 301.—Rupture of the tendon of the long head of the biceps muscle, producing a swelling comparatively low down.

contraction. When this occurs the belly of the muscle contracts and forms a large protuberance on the front of the arm (Fig. 301).

The short head of the biceps fuses with the coracobrachialis muscle, to be attached with it to the coracoid process on its outer portion. The pectoralis minor is the third muscle attached to this process.

The biceps forms the large muscular swell on the front of the arm between the anterior fold of the axilla and elbow. At its lower end the biceps inserts by a strong tendon into the posterior border of the bicipital tubercle of the radius. An example of its rupture is shown in Fig. 302. Between it and the bone is a bursa, which does not communicate with the elbow-joint. The *bicipital fascia* is given off from the tendon in the antecubital fossa and passes downward and inward to blend with the deep fascia covering the flexor group of muscles. It separates the superficial veins of the elbow from the brachial artery and the median nerves. The biceps not only flexes the radius on the arm but also acts as a powerful supinator. It is supplied by the musculocutaneous nerve.

FIG. 302.—Rupture of the lower tendon of the biceps. Contraction of the muscle produces a swelling abnormally high up on the arm. (From a photograph.)

The **brachialis anticus** (*brachialis*) covers the lower three-fifths of the humerus and begins with two slips, one on each side of the insertion of the deltoid tendon. It inserts into the inner and lower part of the anterior surface of the coronoid process of the ulna. As the articulation of the ulna and trochlear surface of the humerus is a pure hinge-joint the muscle acts solely as a flexor. It is supplied almost entirely by the musculocutaneous nerve, but the outer fibres which are in contact with the brachioradialis receive a few nerve fibres from the musculospiral (radial) nerves.

The Posterior or Extensor Set

The posterior or extensor set includes the triceps and the subanconeus, when present as a distinct muscle.

The Triceps Muscle.—The muscular mass on the posterior surface of the arm is formed solely by the triceps muscle. It arises by three heads and inserts by a single tendon into the olecranon process of the ulna. Its three heads are the long, external, and internal. The long head arises from the lower edge of the glenoid cavity and the scapular border below it for 2.5 cm. (1 in.). It blends with the capsule of the joint and tends to strengthen it at this point. When the arm is abducted, this tendon is closely applied to the capsule and head of the humerus, and when the head escapes in luxation, it slips out anterior to the tendon. The external head arises from the humerus above the musculospiral groove and from the external intermuscular septum; the internal head arises from the humerus below the musculospiral groove and from the internal and the lower part of the external intermuscular septum (Fig. 303).

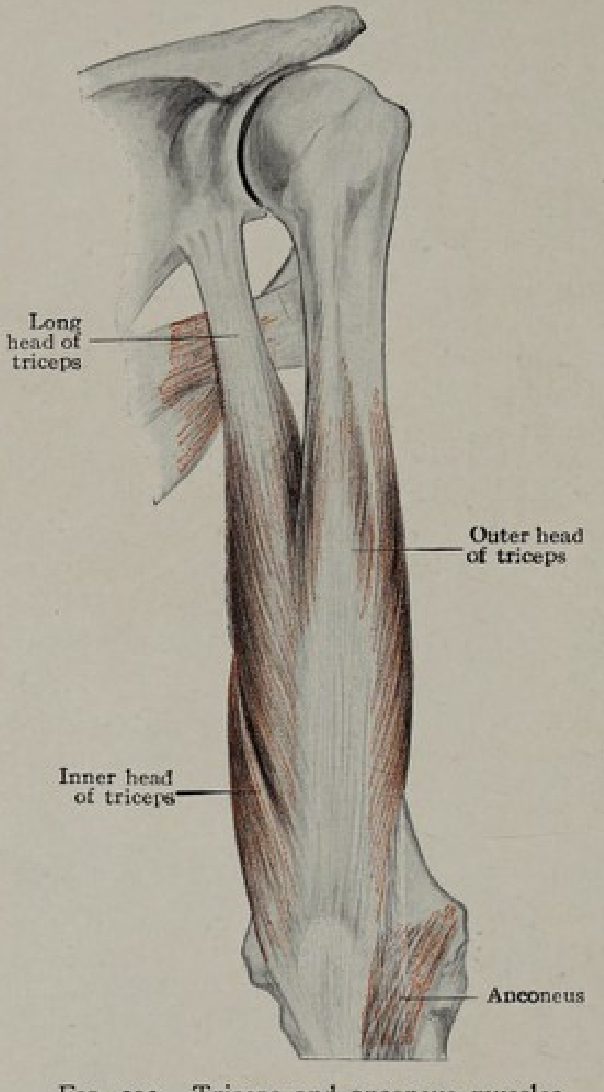


Fig. 303.—Triceps and anconeus muscles.

At its lower end the triceps inserts into the olecranon process, the upper third of the ulna, and the deep fascia of the back of the forearm. The expansion of fascia from the olecranon on the inner side is thin and insignificant, but that on the outer side, on the contrary, is thick and strong, and when fracture of the bone occurs is an important factor in preventing separation of the fragments. It is supplied by the musculospiral (radial) nerve.

THE INTERMUSCULAR SEPTA

The deep fascia of the arm completely encircles it, like a tube. It is continuous above with the fascia covering the deltoid, pectoralis major and teres major muscles, and axillary fascia. Below, it is continuous with the fascia of the forearm and is attached to the olecranon and internal and external condyles. The fascia resists the superficial pointing of subfascial collections which therefore tend to follow the intramuscular septa. Extravasations of blood and collections of pus may point superficially by emerging at the points of entrance and emergence of vessels and nerves through the fascia.

On each side of the lower half of the humerus, extending from the condyles and the bone above outward to the deep fascia, are two fibrous partitions. They are the *internal* and *external intermuscular septa*. These septa divide the space within the brachial aponeurosis into an anterior and a posterior compartment. The space in front of them is filled by the flexors, the biceps, and brachialis anticus, and the space behind contains the triceps extensor. The external septum begins at the external condyle and extends above to the tendon of the deltoid, with which it blends. The internal septum begins below at the internal condyle and extends above to the coracobrachialis. The radial (musculospiral) nerve and anterior terminal branch of the (superior) profunda artery, as they wind around the humerus below the insertion of the deltoid, pierce the external septum. The internal septum is pierced high up by the ulnar nerve, the superior ulnar collateral (inferior profunda) artery, and the anastomotica magna (inferior ulnar collateral) artery as they emerge at about the level of the lower portion of the insertion of the coracobrachialis to pass down behind the internal condyle.

These intermuscular septa are of importance in operative procedures because they indicate the limits of the muscles and position of nerves and vessels. These septa may also limit effusions or extravasations, but the enclosure is not an absolute one since an exit is afforded at the various points of piercing of the septa by the vessels and nerves.

SURFACE ANATOMY

Inasmuch as the movements of the elbow-joint are anteroposterior only and not lateral, the muscles are principally on the front and back and not on the sides.

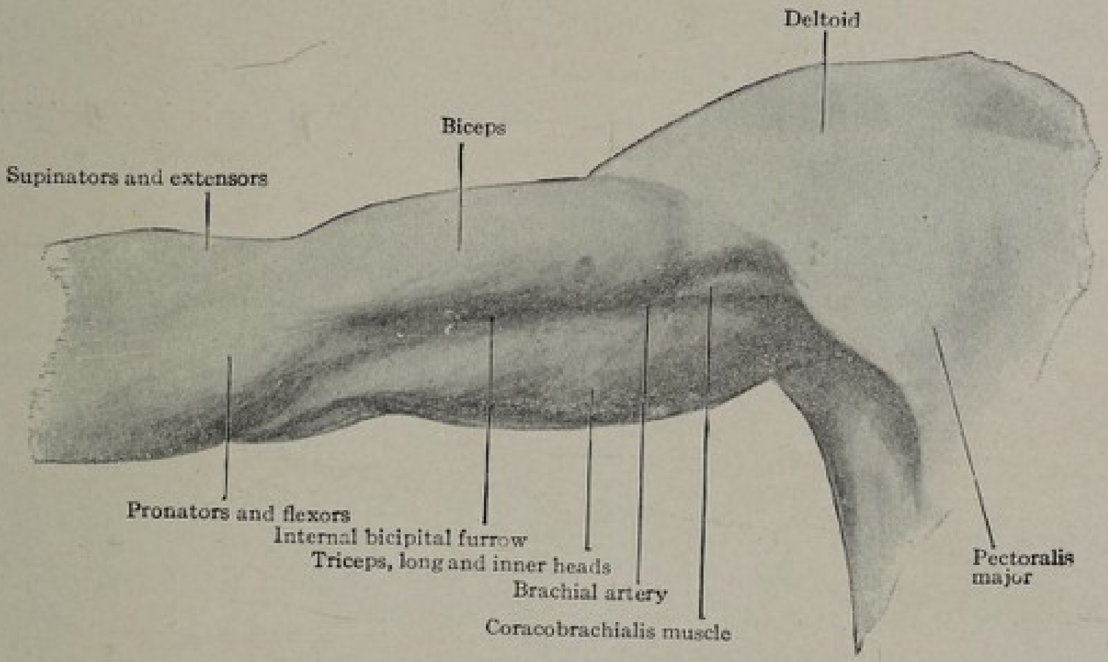


FIG. 304.—Surface anatomy of the arm.

Hence on looking at an arm a rounded mass is seen anteriorly and posteriorly, and separating them on the sides can be seen in a spare, muscular individual, distinct furrows called the *internal* and *external bicipital furrows.* If these furrows are obscured by fat, one can still feel that the bone is nearer the surface at these points than elsewhere. The anterior muscle mass is formed by the biceps and brachialis anticus muscles, the posterior mass by the triceps. The bone is most readily felt at the insertion of the deltoid at the middle of the outer side of the arm. From this point directly down to the external condyle passes the *external* intermuscular septum and external bicipital furrow. Winding around from the posterior edge of the insertion of the deltoid is the *radial* (*musculospiral*) *nerve* and (*superior*) *profunda artery.* They pierce the external intermuscular septum and pass downward in the groove formed by the brachioradialis (supinator longus) and extensor muscles on the outside and the brachialis anticus on the inside. On the inner side of the arm the bicipital furrow, between the biceps in front and the triceps behind, is quite evident and marks the internal intermuscular septum, which extends to the medial (internal) condyle. In front of it lie the *brachial artery* and *veins,* and *median* and *medial antebrachial* (*internal*) *cutaneous nerve.* At the upper portion of the inside of the arm can be seen the swell formed by the coracobrachialis muscle. The inner or posterior border of the coracobrachialis is continuous with the inner border of the biceps, and the brachial artery follows them. The coracobrachialis muscle ends just below the level of the insertion of the deltoid, and, of course, can neither be seen nor felt below that point. It is here that the *ulnar nerve* leaves the artery to pierce the internal intermuscular septum in company with the *superior ulnar collateral* (*inferior profunda*) *artery* to reach the groove behind the internal condyle. The brachial artery is covered only by the skin and superficial and deep fascia, and can be felt pulsating along the inner edge of the biceps muscle and tendon; it can be compressed against the bone by pressure directed outwardly above and inclining more posteriorly as the artery progresses down toward the bend of the elbow. It is on the inner side of the arm in the upper two-thirds, and is more anterior in the lower one-third (Fig. 304).

The *cephalic vein* runs up the external bicipital furrow and the *basilic* up the internal. At the junction of the middle and lower thirds of the arm the basilic pierces the deep fascia and from that point runs up beneath it and joins with the *internal vena comites* opposite the lower border of the teres major or subscapularis to become the brachial vein. (See Fig. 248.)

THE BRACHIAL ARTERY

The arm being abducted, the course of the brachial artery is indicated by a line drawn from the inner edge of the coracobrachialis muscle, at the junction of

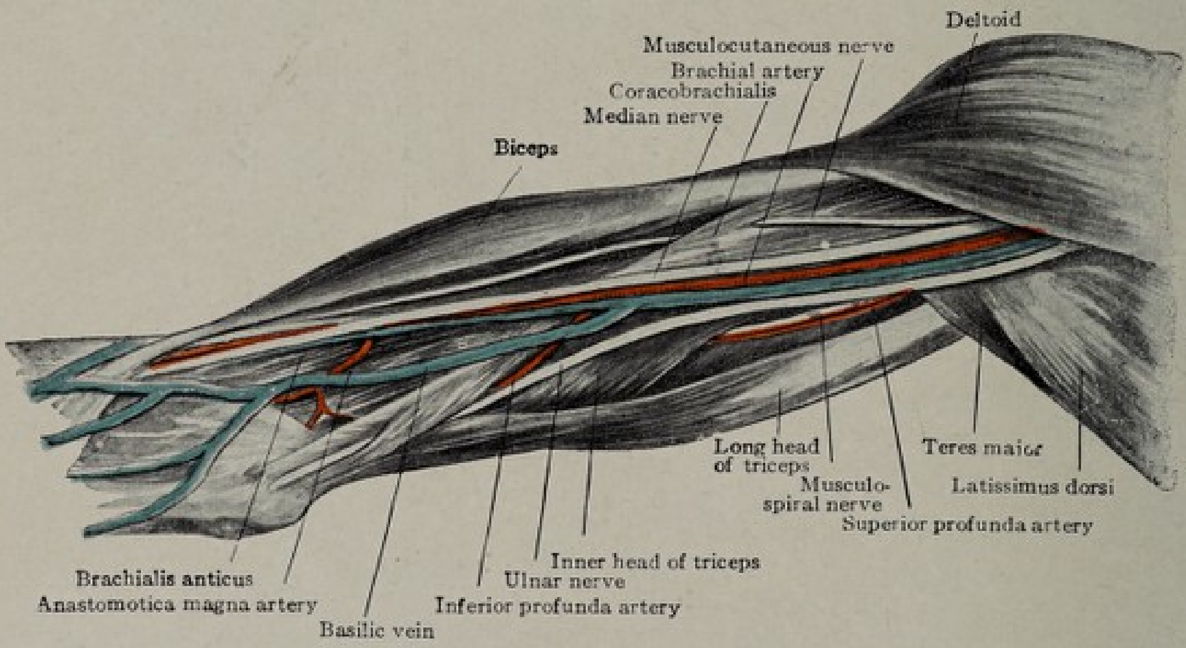


FIG. 305.—Dissection of the arm, viewed from the inner side.

the anterior and middle thirds of the axilla, above, to a point just inside the tendon of the biceps at the bend of the elbow, below, midway between the two condyles of the humerus. This lies in the internal bicipital furrow along the inner edge of the biceps muscle. The artery is superficial in its entire course. It is accompanied by two small venæ comites, which closely embrace it. The basilic vein runs along its inner side. The median nerve lies on the artery to its outer side above, then directly on it and a little to its inner side at the middle, and passes to its inner side at the bend of the elbow. The medial antebrachial (internal) cutaneous nerve, much smaller than the median, passes down along the inner side of the artery between it and the basilic vein to pierce the fascia about the middle of the arm (Fig. 305).

The *ulnar nerve* lies to the inner side of the artery above and is posterior to the basilic vein. About opposite the insertion of the coracobrachialis it diverges from the artery to pierce the internal intermuscular septum.

Relations of the Brachial Artery

In Front

Skin and fascia
Overlapped by coracobrachialis and biceps
Median basilic vein
Bicipital fascia
Median nerve

Outer Side	**Brachial Artery**	*Inner Side*
Median nerve, above Coracobrachialis Biceps Vena comites	*Behind* Triceps (long and inner heads) Radial (musculospiral) nerve (Sup.) profunda artery Coracobrachialis muscle Brachialis anticus muscle	Medial antebrachial (int.) cutaneous and ulnar nerves Median nerve below Basilic vein Vena comites

Branches of the Brachial Artery.—The branches of the brachial artery are the profunda (superior), the superior ulnar collateral (inferior profunda), the nutrient, muscular, and inferior ulnar collateral (anastomotica magna).

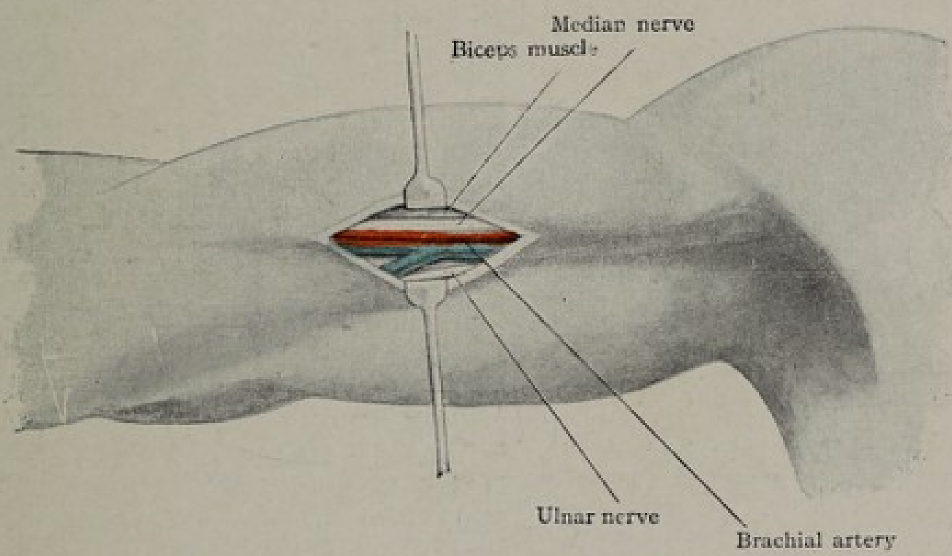


Fig. 306.—Ligation of the brachial artery in the middle of the arm showing the median nerve lying on the artery and the ulnar nerve to its inner side.

Not infrequently the brachial artery instead of dividing into the radial and ulnar opposite the neck of the radius divides higher up even as high as the axilla. The two vessels may follow the usual course in the arm, or the radial may run under the biceps tendon, instead of over it, and the ulnar may accompany the median nerve in front of the medial condyle or the ulnar nerve behind it.

The *profunda* is given off just below the lower edge of the posterior fold of the axilla (teres major). It accompanies the radial (musculospiral) nerve around the arm to its outer side; it sends one branch, the radial collateral, to the front of the elbow and the middle collateral behind it. The *superior ulnar collateral artery* (inferior profunda) comes off about opposite the insertion of the coracobrachialis muscle. It is much smaller than the profunda and with the ulnar nerve pierces the internal intermuscular septum. The *nutrient* artery comes off close to the origin of the superior ulnar collateral (inferior profunda) or is a branch of it. It passes downward in the bone in a direction toward the elbow-joint. The *inferior ulnar collateral* (anastomotica magna) is given off 5 cm. (2 in.) above the elbow and passes inward over the brachialis anticus to divide into two branches, one going down in front and the other behind the elbow.

Ligation of the Brachial Artery.—In ligating the brachial artery, Heath strongly advises that the arm be held by an assistant in an abducted position with the hand supine and not allowed to rest on anything. The object of this is to avoid having the artery overlapped by the triceps being pushed up and thus becoming obscured.

The incision is to be made in the line from the inner edge of the coracobrachialis to a point midway between the tips of the condyles. The deep fascia is to be opened and the inner edge of the biceps muscle is to be sought for, recognized, and held outward. The pulsation of the artery may indicate its position in the living; if not, it is to be sought for to the inner side of the edge of the biceps. The median nerve is not to be mistaken for it. It will lie either over its middle or to its inner side if low down and to its outer side if high up (Fig. 306).

FIG. 307.—Collateral circulation after ligation of the brachial artery at the bend of the elbow.

The ulnar nerve lies on the inner side of the artery as far as the middle of the arm, it then leaves the artery. Below the middle, if the search is made too far posteriorly, the ulnar nerve and basilic vein will be encountered. The ulnar nerve should not be seen, the basilic vein and median nerve—and above the middle of the arm the medial antebrachial (internal) cutaneous nerve—are to be displaced to the inner side.

The aneurysm needle is to be passed from within outward. Care must be taken not to mistake a large superior or inferior profunda for the main trunk. A high division of the brachial may give two vessels of approximately equal size. Of course, in such a case both must be ligated.

Collateral Circulation.—If the ligature is placed above the profunda (superior) branch, the anterior and posterior circumflex will anastomose with the profunda (superior) and superior ulnar collateral (inferior profunda) below. If the ligature is placed between the profunda and superior ulnar collateral arteries, the profunda (superior) will anastomose below with the radial recurrent and posterior interosseous recurrent on the outer side and will also communicate with the inferior ulnar collateral (anastomotica magna) and superior ulnar collateral (inferior profunda) on the inside (Fig. 287). If below the superior ulnar collateral (inferior profunda) then the profunda (superior) would anastomose with the radial and posterior interosseous recurrents on the outside, and the superior ulnar collateral (inferior profunda) with the inferior ulnar collateral (anastomotica magna) and the anterior and posterior ulnar recurrents. The collateral circulation may be assisted by the vasa aberrantia which are occasionally found bridging from the lower portion of the brachial to the radial or ulnar artery or to both of them.

AMPUTATION OF THE ARM

In amputation one has to deal with a part of the body that is approximately cylindrical in shape and that contains only a single bone entirely surrounded by soft parts. The circular method is more applicable to amputation of the arm below the insertion of the deltoid than to any other part of the body, but nevertheless in some cases, particularly in muscular arms, difficulty may be experienced in turning back the cuff. In such cases the cuff is slit by the surgeon and the operation becomes one of square skin flaps. For this reason flap amputations are usually to be preferred.

The arm may be amputated at any place, high up or low down. Artificial appliances for the upper extremity are comparatively useless; hence the height of division of the bone is determined by the injury.

As it is desirable to retain the head of the bone and tuberosities, if possible, in order to preserve the shape of the shoulder and retain the attachment of the muscles, amputation may be done through the surgical neck. This is just below the epiphyseal line. In performing a flap amputation the soft parts should cover

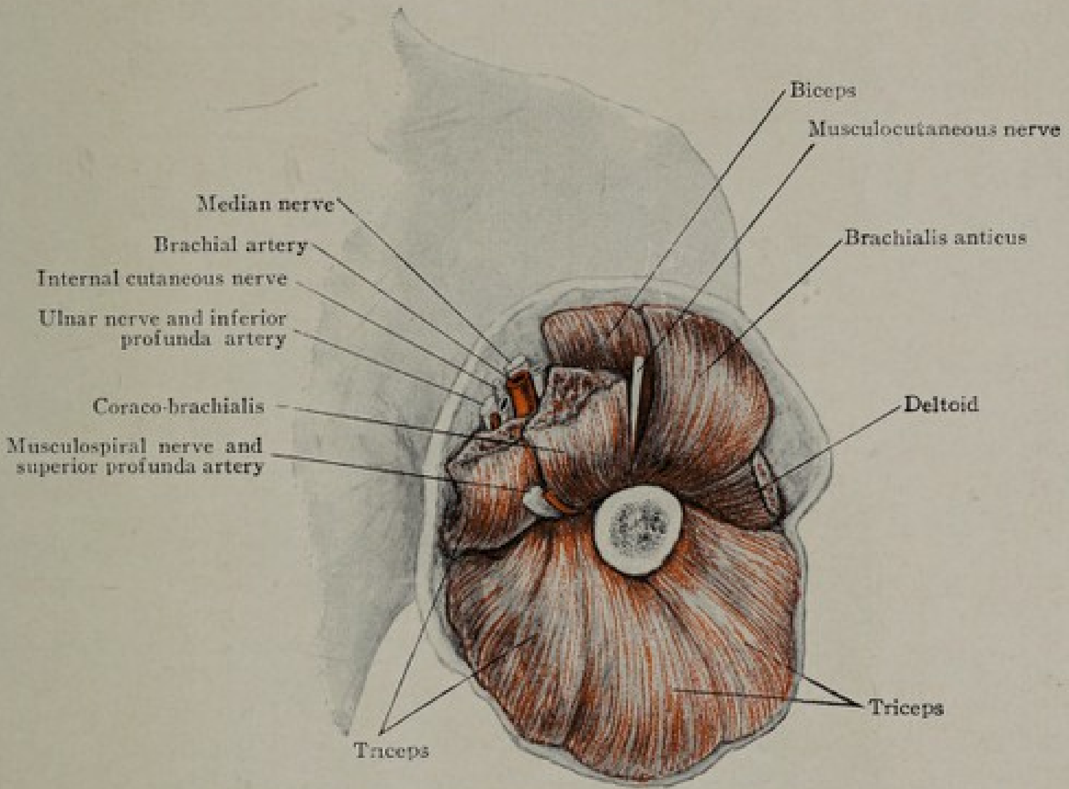


FIG. 308.—Amputation just above the middle of the arm.

or cap the bone like a hemisphere: therefore the total length of the flaps should be equal to one-half the circumference of a sphere whose diameter is the diameter of the limb at the point of section of the bone. If the diameter of the limb is 4 inches, then the total length of the flaps should be approximately 6 inches. If the flaps were of equal length then each would be 3 inches long. If there was only one flap, it would be 6 inches long.

It is an axiom in surgery that in flap amputations the artery should be contained in the shorter flap. The operator should accurately know the course of the artery and avoid making his flaps in such a manner as to bring the vessel in the angle of the wound. Otherwise the artery is liable to be split. In a high amputation the external flap may be long and the internal short. In the middle of the arm anteroposterior flaps are preferred and the artery is included in the posterior flap. If the amputation is in the lower third and the flaps are anteroposterior, then the artery of necessity is in the anterior flap.

Above the middle of the arm the deltoid, coracobrachialis, and biceps muscles are free and therefore retract markedly when cut. In the middle the biceps only is free and the same is the case in the lower third. The triceps and brachialis anticus are attached to the bone and therefore retract but little when cut. Surgeons have called attention to the necessity of being careful to see that the radial (musculospiral) nerve is properly divided, otherwise it may be torn by the saw. The groove in which it lies may be unusually deep and necessitate a special effort to divide it. On the face of the stump the artery is to be looked for to the inner side of the bone in the upper two-thirds of the arm and anteriorly in the lower third. Lying on it will be the median nerve and to its inner side the ulnar nerve. At the level of the insertion of the deltoid the radial (musculospiral) nerve, accompanied by the (superior) profunda artery, will be posterior or toward the outer side. The superior ulnar collateral (inferior profunda) artery is given off at the level of the insertion of the coracobrachialis muscle, which is about opposite the insertion of the deltoid. It accompanies the ulnar nerve. A nerve may be seen lying between the biceps and brachialis anticus. It is the musculocutaneous which becomes superficial just above the bend of the elbow (Fig. 308).

Five cm. (2 in.) above the elbow the inferior ulnar collateral (anastomotica magna) artery may be expected to be encountered passing down and in over the brachialis anticus muscle.

FRACTURES OF THE HUMERUS

Fractures of the Shaft of the Humerus.—There seems to be but little doubt that in many cases the character of displacement of the fragments in fracture of the

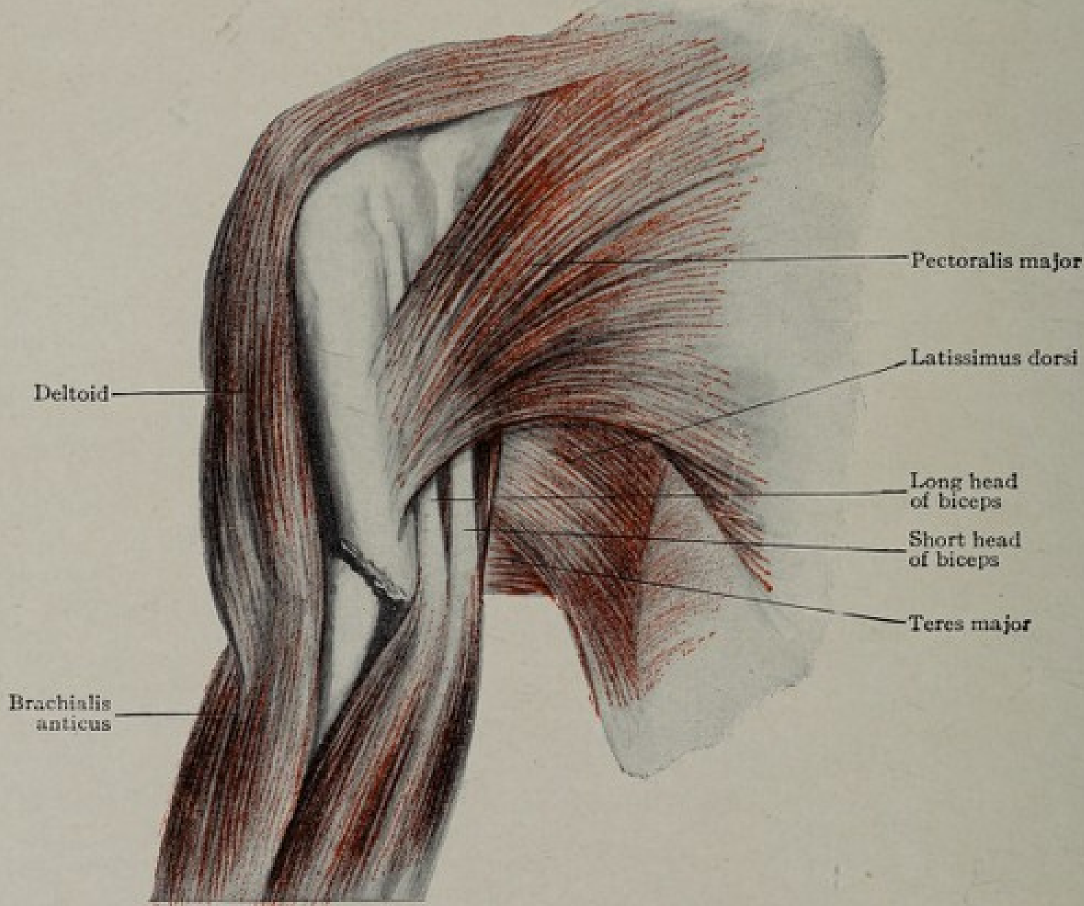


Fig. 309.—Fracture of the shaft of the humerus just above the insertion of the deltoid and below the insertion of the axillary fold muscles. The lower fragment is seen to be drawn outward by the deltoid; the upper fragment is seen to be drawn inward by the pectoralis major, latissimus dorsi, and teres major.

shaft of the humerus is due to the mode of injury and not to muscular action. This accounts for there being less uniformity in these fractures than in those higher up, which have already been considered. There are some cases, however, in which muscular action does play a part and the possible influence of the muscles should be understood.

The line of fracture is usually more or less oblique, in rare cases nearly transverse, but the displacement is often not marked. Nothwithstanding this latter fact, non-union of fracture of the shaft of the humerus is one of the most frequent of any in the body.

Muscular action shows its influence most markedly in producing displacements in three directions, viz., in towards the body, out away from the body, and directly anteriorly.

There are two main points where fracture occurs; immediately above the insertion of the deltoid and below it.

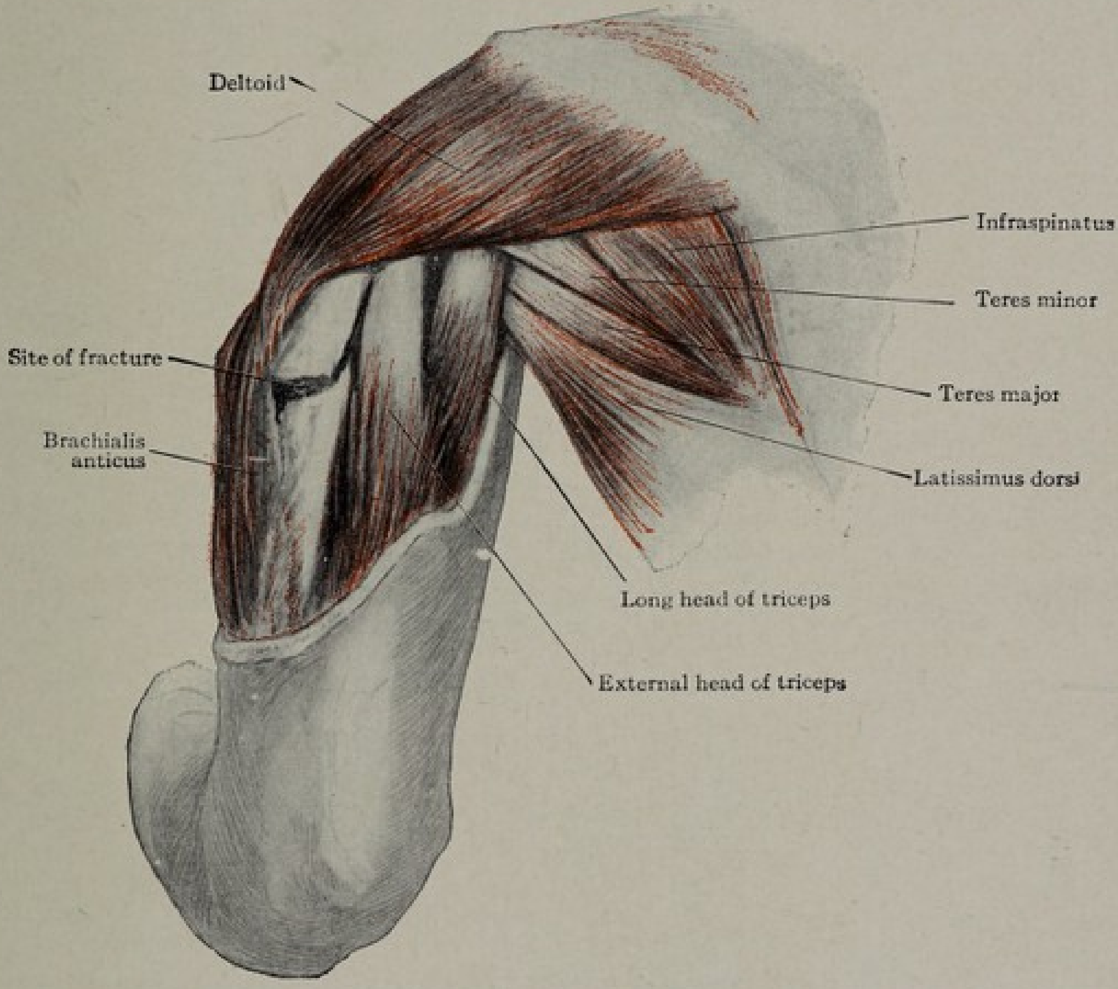


Fig. 310.—Posterior view of a fracture of the shaft of the humerus just below the insertion of the deltoid, showing the influence of that muscle in producing abduction of the upper fragment.

Fracture above the Insertion of the Deltoid.—The bone may be fractured immediately above the deltoid insertion. In this case the powerful axillary fold muscles, pectoralis major, teres major, and latissimus dorsi, being attached to the upper fragment, tend to draw it toward the body, while the deltoid tends to draw the lower fragment out. The influence of the other muscles, biceps, coracobrachialis, and triceps, would be to increase the overlapping (Fig. 309).

Fracture below the Deltoid Insertion.—This is the more common site of fracture. The line of fracture is most apt to be from above downward and outward. The upper fragment is displaced anteriorly by the coracobrachialis and anterior portion of the deltoid and is drawn outward by the deltoid aided by the supraspinatus. To relax the deltoid the arm is sometimes dressed in an abducted position (Fig. 310).

Non-Union.—The humerus has muscles attached to it almost throughout its entire length, and when the sharp ends of the fragments are displaced they probably

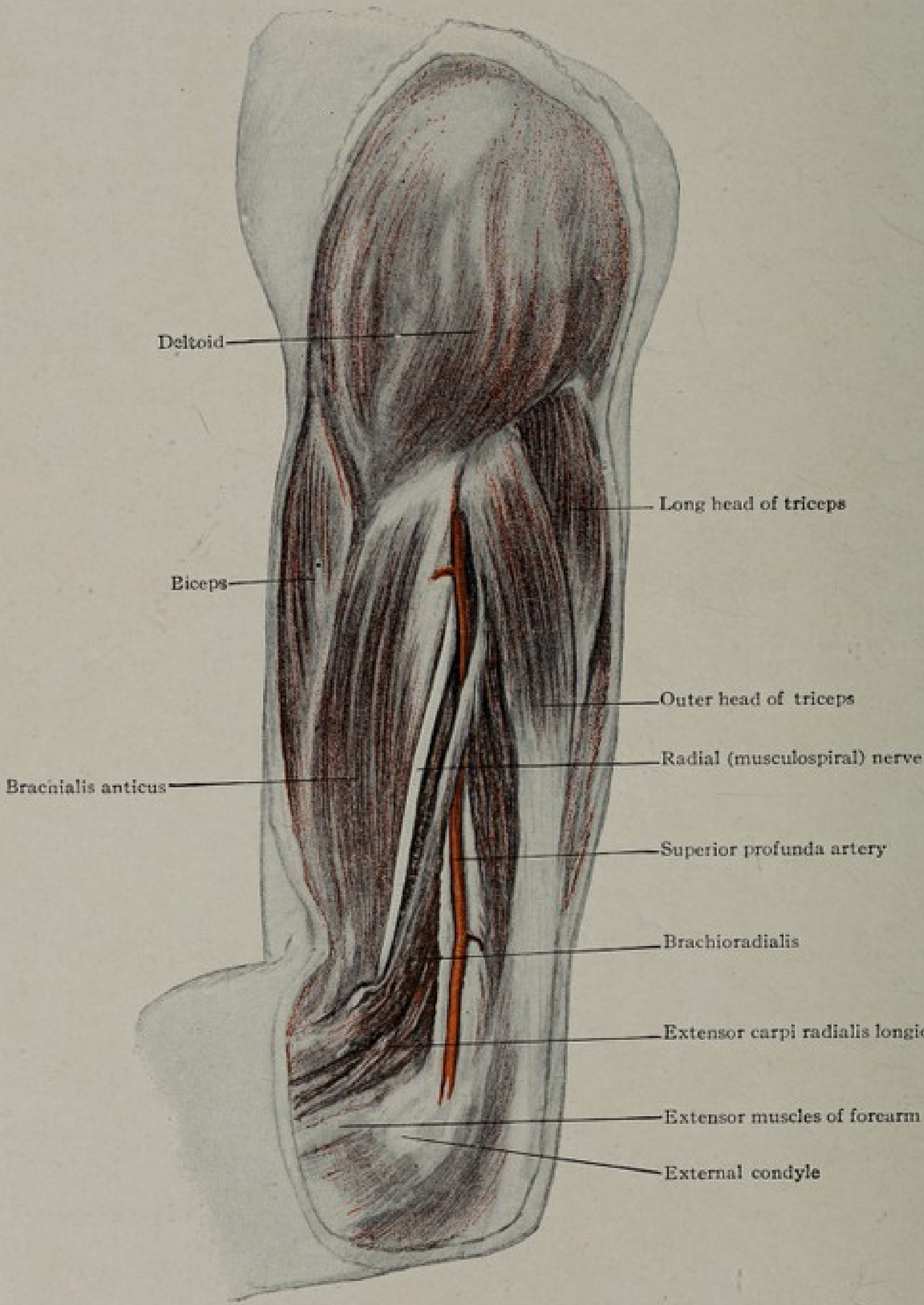


FIG. 311.—The radial (musculospiral) nerve and outer side of arm.

become fixed in the surrounding muscle, and proper apposition of the fragments is prevented, hence non-union. Lack of proper fixation is also a prominent cause. The close attachment of the periosteum at the middle of the bone has also been given as a factor in the production of non-union. It should furthermore be remembered that the nutrient artery enters the bone near the middle of the shaft and interference with the blood supply to the bone by destruction of this vessel may be an added factor. Suffice to say that non-union occurs here more frequently than in the shaft of any other long bone.

The Radial (Musculospiral) Nerve.—In fracture of the shaft of the humerus, paralysis of the extensors due to injury of the radial nerve is comparatively common. It may also occur from pressure due to the use of crutches, to sleeping on the arm or to improperly applied splint. The other nerves are too far removed from the bone to be injured, but the radial (musculospiral) lies on the bone in the radial (musculospiral) groove in approximately the middle third of the bone. It comes into contact with the bone posteriorly above the level of the insertion of the deltoid and leaves the bone on its outer anterior surface to pass between the brachialis anticus and brachioradialis (supinator longus) muscles. Paralysis may be caused (1) by direct injury to the nerve at the time the fracture is received. (2) By subsequent changes in the nerve due to its being stretched over the sharp edge of a fragment. (3) By being included in callus. The last is probably much more rarely the case than the two former (Fig 311).

Paralysis should be examined for early in the course of treatment. It is recognized by wrist drop. Too often it is detected only after the splints have been removed, and then it is apt to be ascribed to improper treatment or to misapplied pressure. The symptoms of involvement of the musculospiral nerve are wrist-drop and diminution of the power of supination, also some sensory changes in the dorsum of the hand and forearm.

This nerve is frequently paralyzed from pressure in cases in which there is no fracture, as from sleeping on the arm, the use of crutches, and also in certain systemic affections, such as lead poisoning. It supplies the triceps, part of the brachialis anticus, brachioradialis (supinator longus), and extensor carpi radialis longior muscles in the arm, and then proceeds to the forearm. The branch to the triceps is given off before the nerve enters the musculospiral groove, hence is not often injured, and loss of extension of the forearm is not often present; even paralysis of the other muscles mentioned is not common, the forearm muscles being mostly affected. The branch to the inner head of the triceps also supplies the anconeus.

OPERATIONS ON THE ARM

Caries or necrosis of the humerus may necessitate operative interference at almost any part of the arm. The same may be said of wounds. In operative procedures it is sometimes desirable to avoid important structures and at others to find them.

The important structures run lengthwise, hence transverse incisions are not to be used. Most of the large vessels and nerves pass down the inner side of the arm, hence this region is usually avoided. The bone can readily be reached by an incision downward from the insertion of the deltoid, but no operation is to be done in this region without a thorough familiarity with the course of the musculospiral nerve. A line drawn on the posterior surface of the arm from behind and above the insertion of the deltoid to the groove on the anterior surface between the brachialis anticus and brachioradialis (supinator longus) just above and to the inner side of the external condyle will indicate its course. If exposed during an operation bleeding from the accompanying (superior) profunda artery may be expected. The median and ulnar nerves give off no branches in the upper arm. The median can be readily located by its relation to the artery. It lies to the outer and anterior side of the brachial artery above, then in front, and then to its inner side below. The ulnar nerve lies to the inner side of the artery and between it and the vein posteriorly. In the middle of the arm, it leaves it to pierce and pass beneath the internal intermuscular septum and thence behind the medial (internal) condyle. Operations involving it would be accompanied by bleeding from its companion the superior ulnar collateral artery (inferior profunda).

In operations on the lower portion of the bone the position of the inferior ulnar collateral (anastomotica magna), 5 cm. (2 in.) above the elbow, should be borne in mind. It runs on the brachialis anticus muscle and towards the inner and not the outer side. Incisions on the outer side will encounter the cephalic vein in the external bicipital furrow. Incisions on the inner side will encounter the basilic vein; at the junction of the lower and middle thirds of the arm it pierces the deep fascia.

REGION OF THE ELBOW

The elbow is so named because at this point the arm is usually bent. A joint is here inserted which permits of flexion and extension; when the arm is fully extended the "elbow" might be said to have disappeared. The lower end of the humerus forms the proximal portion of the joint and the upper ends of the ulna and radius form its distal portion. Ligaments join these bones together to form the joint, and the blood-vessels and nerves change in character in this region as they pass from the arm to the forearm.

The bones are frequently subject to fractures which are of an exceedingly puzzling and disabling character. The joint becomes luxated and the vessels and nerves are not infrequently injured. A thorough knowledge of the anatomy of the region is absolutely essential to the proper treatment of these affections.

BONES OF THE ELBOW

Humerus.—The lower end of the humerus broadens laterally and is slightly concave on its anterior surface; this causes the articular surfaces to look downward and forward and not backward. It carries two articular surfaces: one, the *trochlea,* for the ulna, and the other, the *capitellum,* for the radius. The trochlea, descending lower than the capitellum, causes the line of the joint to incline downward and inward instead of being directly transverse, thus producing the "carrying angle" (Fig. 314). Extending from the edges of the articular surfaces outward, one on each side, are the *condyles, medial* (*internal*) and *lateral* (*external*).

Chaussier gave the name *epicondyle* to the condyles. He called the medial condyle the *epitrochlea* and the lateral (external) condyle the *epicondyle.* Henle called the internal condyle the *epicondylus medialis* and the external condyle the *epicondylus lateralis.* The name epicondyle is now quite generally employed by both surgical and anatomical writers to designate the projecting extra-articular portion of the condyles, so that the terms are practically synonymous (Fig. 313).

From the condyles two ridges run upward. The *lateral* (*external*) *supracondylar ridge* is the more marked of the two and gives origin to the brachioradialis (supinator longus) and the extensor carpi radialis longior muscles, and passes posterior to the deltoid eminence to be continuous with the posterior lip of the radial (musculospiral) groove. The *medial* (*internal*) *supracondylar ridge* is much less prominent than the lateral and soon blends with the shaft of the bone. Above the trochlea and capitellum anteriorly are two fossæ, the *coronoid* and the *radial,* to receive the coronoid process and head of the radius when the arm is in complete flexion. On the posterior surface there is another depression, the *olecranon fossa,* to receive the olecranon process in extreme extension. The projecting hook-like shape of the median condyle causes it to be more frequently fractured than the less prominent lateral condyle. The two condyles are readily felt directly beneath the skin and are the only points of the humerus that are really subcutaneous.

Ulna.—The upper extremity of the ulna articulates above with the trochlea of the humerus and on its outer side with the radius. Its upper end is the olecranon process. The posterior portion of this process is called the tip of the olecranon and is continuous with the posterior surface of the ulna, which is subcutaneous. Immediately in front of the olecranon is a large hollow, which receives the trochlea. It is called the *greater sigmoid cavity.* The anterior margin of the cavity is called the *coronoid process.* On the outer side of the coronoid process is a hollow called the *lesser sigmoid cavity,* which receives the head of the radius. Fracture of the bone frequently occurs through the narrow portion of the olecranon process into the greater sigmoid cavity.

Radius.—The radius ends above in a flat rounded head. The upper surface of this head articulates with the capitellum. The lateral surface articulates internally with the lesser sigmoid cavity of the ulna. The remainder of the circumference of the head is embraced by the orbicular ligament. Immediately below the head is the constricted neck and bicipital tuberosity. To the posterior half of this latter the tendon of the biceps is attached, but its anterior portion is smooth and provided with a bursa. The head of the radius is subcutaneous posteriorly, but the rest is too much covered by muscles to be readily palpated.

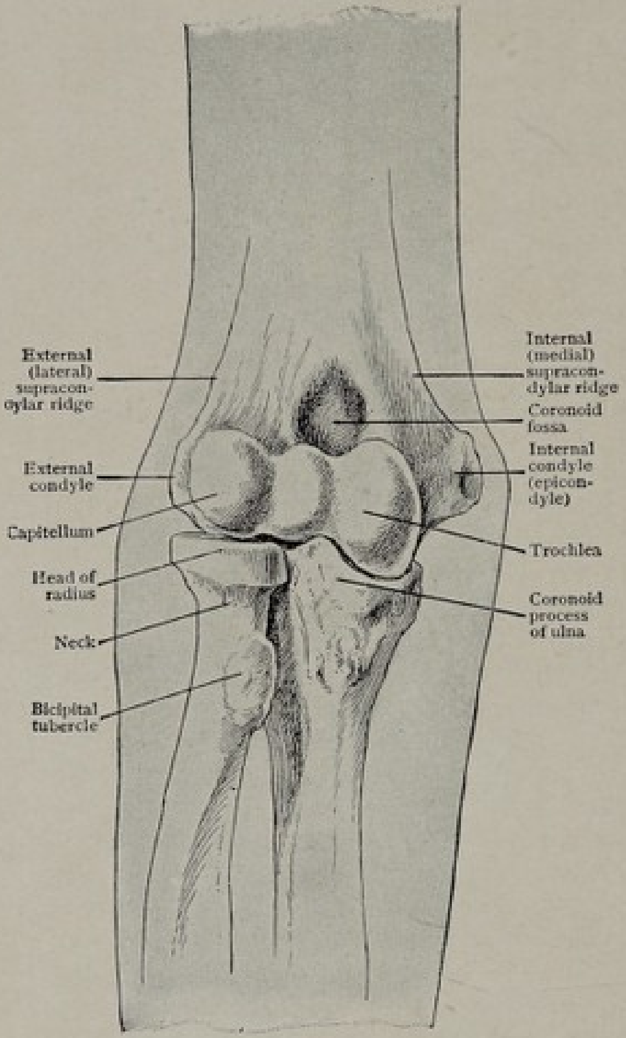


FIG. 312.—Anterior view of bones of right elbow.

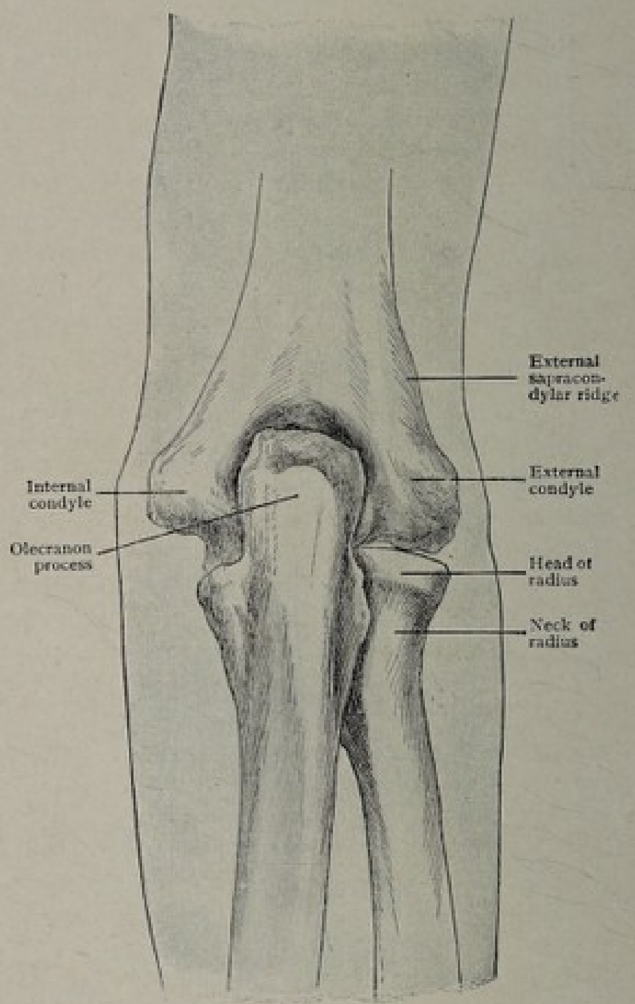


FIG. 313.—Posterior view of bones of elbow.

ELBOW-JOINT

By the term elbow-joint is meant the articulation between the humerus above and the ulna and upper surface of the radius below. The articulation between the upper end of the radius and the ulna forms the *superior radio-ulnar articulation* and does not belong to the elbow-joint proper. As has already been pointed out, the ulna articulates with the trochlea and the radius with the capitellum.

The elbow-joint is a pure hinge-joint. The articulation between the trochlea and ulna is so shaped as to allow no lateral motion, but only an anteroposterior one. The articulation between the capitellum and upper surface of the head of the radius is, on the contrary, a ball-and-socket joint. The socket, it is true, is shallow, but it is perfectly spherical, made so by the rotary movement of the radius in pronation and supination. Hence it follows that the shape and continuity of the upper extremity depends upon the articulation of the ulna with the humerus: it further follows that if the radius be removed from the elbow-joint the forearm would still be held in its proper relation to the arm, but if the ulna be removed the stability of the joint would be lost and the forearm would move in any direction, laterally as well as anteroposteriorly. It is for this reason that injuries involving the medial condyle and trochlea are more liable to be followed by serious disability than are those of the lateral condyle and capitellum.

The movement of the joint takes place around a transverse axis, which passes from side to side below and in front of the condyles. The forearm can be extended to an angle of 180 degrees, or a straight line, with the arm. It can be flexed to an angle of 30 to 40 degrees. Sometimes it cannot be flexed so much, so that if after an injury to the joint the patient can flex the elbow to half a right angle, or 45 degrees, he may be regarded as having regained a normal amount of motion.

Carrying Angle.—The axis of motion of the joint is not exactly transverse, but slopes slightly from the outside downward and inward. The effect of this is to give a slight obliquity to the motions of flexion and extension. This obliquity is not noticeable except in extreme extension and flexion. When the forearm is completely extended it is seen to lie not in the axis of the arm but to bend outward from the elbow at an angle of 170 degrees. This angle is called the "carrying angle," because by resting the elbow against the side, any article which is carried in the extended hand is kept away from the body. Sometimes the line of the forearm is almost straight with that of the arm, at others the deflection may amount to 15 degrees. It may vary on the two sides and 10 degrees may be considered an average; Woolsey gives 6 degrees as the average. This carrying angle becomes lost in certain cases of fracture of the elbow, as will be pointed out later. As the elbow is flexed the carrying angle disappears (see Fig. 314).

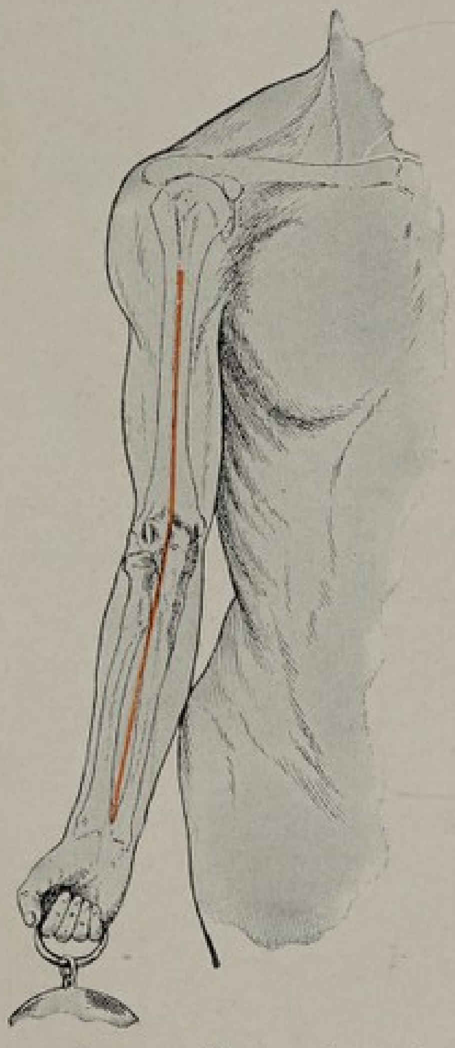


Fig. 314.—The carrying angle; formed by the deviation outward of the axis of the forearm from the axis of the arm.

When flexion is complete the ulna instead of coming up toward the head of the humerus inclines inward at an angle of 10 degrees. Morris states that the hand has a tendency to point to the middle of the clavicle, which would make an angle of 20 degrees. This we believe to be too great.

LIGAMENTS OF THE ELBOW

The ligaments of the elbow-joint are four in number—anterior, posterior, internal lateral, and external lateral.

In all joints there are two kinds of ligaments. One kind serves to retain the synovial fluid; it is a capsular ligament and is usually thin; the other kind is thick, firm, and strong, and is intended to bind the bones together and prevent their displacement and to limit movement. These two kinds of ligaments often blend together so that it is impossible to say where one begins and the other ends; at other places they are quite distinct. If an elbow-joint is distended with effusion (or wax) the distinction is readily seen. The capsule becomes distended in front and behind, while at the sides the ligaments remain closely applied to the bones; hence we learn that the anterior and posterior ligaments are capsular in their function while the lateral ligaments are retentive. These will be considered more in detail later.

Superior Radio-ulnar Articulation.—While the superior radio-ulnar articulation is not considered a part of the elbow-joint proper, it is nevertheless so closely associated with it that it cannot be ignored. The head of the radius, in addition to its movements of flexion and extension on the humerus, possesses a motion of rotation. In order that it may rotate properly the ligaments are arranged in a peculiar

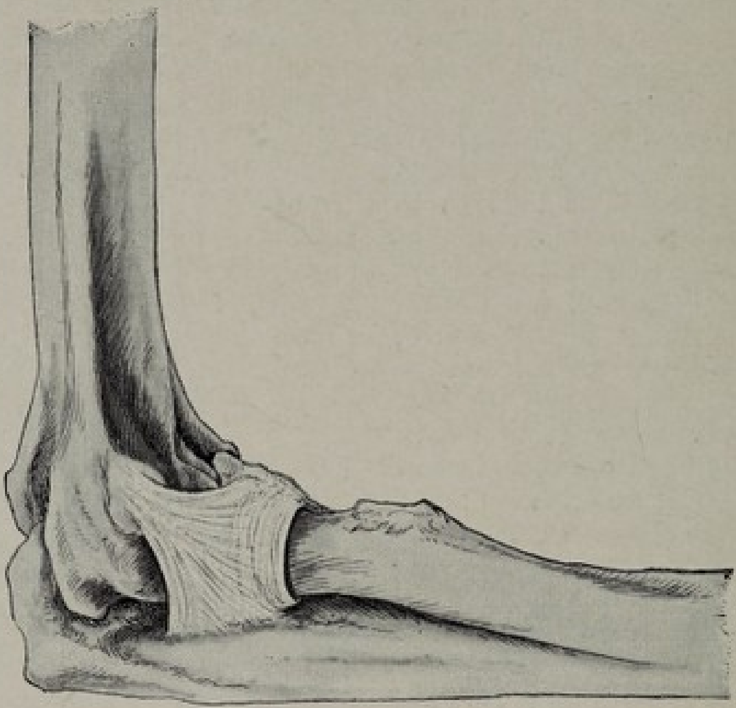


FIG. 315.—The external lateral ligament of the elbow-joint, showing its ⋏ shape. Its upper end is attached to the external condyle of the humerus; its lower ends are attached to the ulna. The circular fibres surrounding the head of the radius are called the orbicular ligament.

manner. Its motion in respect to the ulna is a purely rotary one, so that it is bound to the ulna by a ligament which encircles its head, called the **orbicular ligament.**

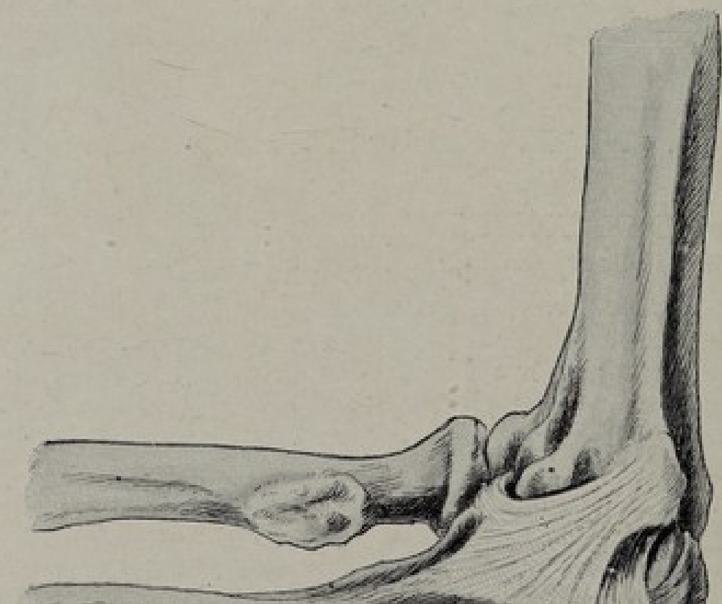


FIG. 316.—The internal lateral ligament of the elbow-joint, showing its fan-like shape.

The bulk of the ligament encircles three-fourths of the head of the radius and is attached at its ends to the anterior and posterior edges of the lesser sigmoid cavity of the ulna. Its lower fibres are continuous below the lesser sigmoid cavity, forming a complete circle. The upper edge of this orbicular ligament blends with the anterior ligament in front, the posterior behind, and the external lateral at the side. We thus see that as the anterior and posterior ligaments are capsular in their function the radius is kept in place by the external lateral ligament, which branches below in the form of the letter Y to blend with the orbicular ligament. When we consider that these fibres are hardly inserted at all into the radius, but pass over it to the ulna, it is evident that this part of the joint is comparatively weak and not an excessive amount of force would be required to pull the head of the radius from beneath the orbicular ligament and so luxate it. The *supinator* (*brevis*) arises partly from the orbicular ligament and strengthens the joint somewhat.

The **external lateral ligament** is a strong band which is attached above to the lower portion of the lateral (external) condyle, blends with the orbicular ligament and is attached below to the ulna along the anterior and posterior edges of the lesser sigmoid cavity (Fig. 315).

The **internal lateral ligament** is a strong band attached above to the lower and anterior portion of the medial (internal) condyle, the groove beneath, and descends in the shape of a fan to insert into the inner edge of the coronoid process and olecranon (Fig. 316).

The **anterior ligament** is capsular in its nature and function, and is a broad, comparatively thin membrane which stretches between the lateral ligaments on the sides and is attached above to the upper edge of the coronoid fossa and below to the coronoid process and orbicular ligament. It sometimes possesses a few coarse fibres passing downward and outward, but it is mostly very thin, in places barely covering the lining membrane.

The **posterior ligament** resembles the anterior. It blends on each side with the lateral ligaments and is attached above across the upper portion of the olecranon fossa and below to the olecranon and posterior portion of the orbicular ligament. It also has some cross fibres; but, especially at its upper attachment, it is very weak.

MUSCLES OF THE ELBOW

The elbow-joint is interposed between the long bones of the forearm below and the long humerus above. The arm muscles come down and pass over the joint to insert close to it in the bones of the forearm. The muscles of the forearm in a similar manner cross the joint and are attached comparatively near to it to the humerus above. Thus we see the joint strengthened by the crossing of the various muscular insertions. The elbow having only an anteroposterior motion, the muscles must of necessity be in two main groups, one in front and the other behind the joint.

Lateral Muscles.—It is true that there are lateral muscles but they have little or no influence on the movements of the elbow-joint. The medial (internal) condyle gives origin to the flexor muscles of the forearm and the *pronator radii teres*, and the lateral (external) condyle gives origin to the extensor muscles; but the bony attachment of both these sets of muscles coincides too closely with the axis of motion to allow of their aiding to any marked extent either flexion or extension of the elbow. Their function as far as the elbow is concerned is to aid and strengthen the lateral ligaments of their special sides.

The Anterior or Flexor Muscles.—These comprise the *biceps*, *brachialis anticus*, *brachioradialis*, and *extensor carpi radialis longior*. It will be observed that the first two muscles come from above and cross the joint, while the last two arise just above the joint to pass down the forearm (Fig. 317).

The *brachialis anticus* arises from the humerus by two heads, one on each side of the insertion of the deltoid, and from the anterior surface to just above the elbow-joint. It passes over the joint and inserts into the base or lower and inner part of the coronoid process. It does *not* insert into the tip, but some distance below it. Its function is purely flexion. The nerve supply is from the musculocutaneous nerve.

The *biceps* arises from the upper rim of the glenoid cavity by its long head and from the coracoid process by its short head. It inserts into the posterior edge of the *bicipital tubercle* of the radius. Between it and the tubercle is a bursa. About 4 cm. (1½ in.) above its insertion its tendon gives off a fibrous expansion which passes inward to blend with the deep fascia covering the flexor group of muscles. This is called the *bicipital* or *semilunar fascia*. The biceps tendon passes almost in the middle between the two condyles. Along its inner side is the brachial artery, which is covered by the bicipital fascia; over this fascia passes the median basilic vein, sometimes used for transfusion. The insertion of the biceps is into the radius, which is the *movable* bone, and not into the ulna, which is less so. As a consequence,

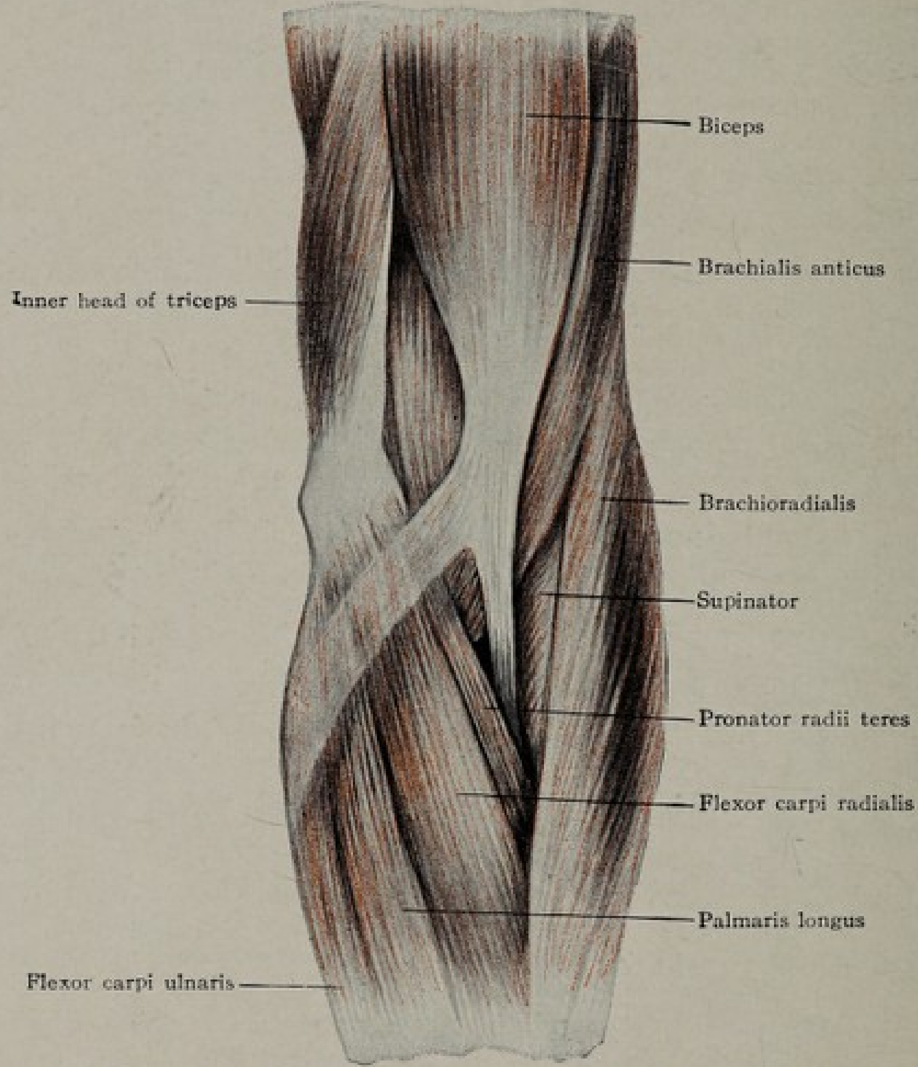


FIG. 317.—View of the antecubital fossa and muscles at the bend of the elbow.

in addition to its function of flexion it acts also as a powerful supinator of the radius. It is supplied by the musculocutaneous nerve.

The *extensor carpi radialis longior* arises from the lateral condyle and lower third of the supracondyloid ridge and inserts into the base of the second metacarpal bone, dorsal surface.

The *brachioradialis* or supinator longus arises from the upper two-thirds of the lateral (external) supracondyloid ridge above the preceding muscle and as high as the insertion of the deltoid. It inserts into the base of the styloid process of the radius.

These two muscles, owing to their high attachment, so much above the axis of motion of the joint, both act as flexors of the elbow-joint. The extensor carpi radialis longior also extends and slightly abducts the hand while the brachioradialis is a partial supinator if the hand is in the position of complete pronation. Both of the above muscles are supplied by the radial (musculospiral) nerve. The brachioradialis also supinates the hand.

The Posterior or Extensor Muscles.—These comprise the *triceps* and *anconeus muscles* (Fig. 318).

The *triceps* arises by its long head from the lower part of the rim of the glenoid cavity and adjoining border of the scapula; by its external or lateral head from the upper outer portion of the humerus from the greater tuberosity above to the radial (musculospiral) groove below; by its internal or medial head from the posterior surface of the humerus below the radial groove. It inserts into the posterior part of the upper surface of the olecranon. Just above its insertion it is separated from the bone by a bursa. It is continuous from the outer edge of the olecranon as a firm fascia which passes down over the anconeus to be attached to the upper fourth of the ulna and the deep fascia. This is an important structure in fractures of the ole-

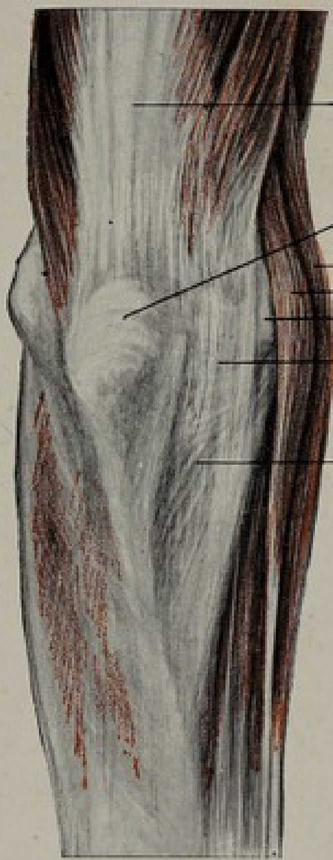


Fig. 318.—Extensor muscles of the back of the elbow.

cranon. Its action is to extend the forearm on the upper arm and to draw the arm backward. The nerve supply is through the radial (musculospiral) nerve.

The *anconeus* passes downward and backward from the lateral (external) condyle to insert into the side of the olecranon and upper fourth of the ulna. Its fibres are practically continuous with the lower fibres of the triceps and it may be considered as a fourth head of that muscle. It covers the posterior portion of the head of the radius and overlaps somewhat the supinator (brevis) muscle. It assists the action of the triceps and receives a similar nerve supply.

SURFACE ANATOMY

Having become acquainted with the bones and muscles, one will be better able to appreciate the surface markings and understand their significance (Fig. 319).

When the elbow is fully extended the bony projections are obscured by the soft tissues, hence in examining an elbow it should be flexed at approximately a right angle. The first object to strike the eye is the prominent olecranon process. It is subcutaneous and the bony ulna beneath can be felt and followed down the back of the forearm. From the tip upward for a couple of centimetres can be felt the upper surface of the olecranon into which the triceps inserts. To feel this distinctly the forearm should be slightly extended to relax the triceps; the outline of the upper portion of the olecranon then becomes perfectly distinct.

Projecting on each side of the elbow are the two condyles of the humerus. These bony projections do not belong to the forearm. The two condyles are nearly on the same level. The medial (internal) is much more prominent and has the appearance of being a trifle higher and slightly anterior. A line joining them crosses the long axis of the humerus at an angle of 90 degrees, but makes an angle of only 80 degrees with the forearm. By deep pressure the lateral (external) supracondylar ridge can readily be felt running up the arm somewhat posteriorly from the lateral (external) condyle. The medial (internal) supracondylar ridge is much less easily felt though the intermuscular septum is more evident on this side. When

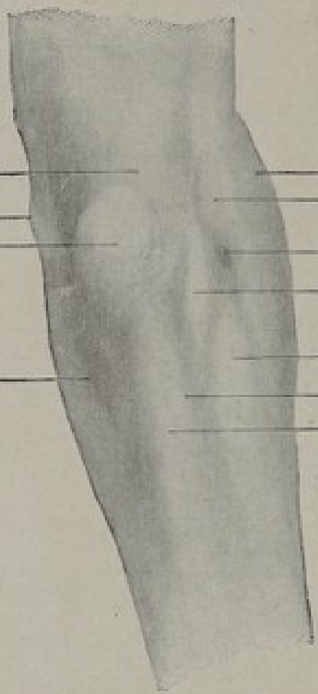


FIG. 319.—Surface anatomy of the back of the elbow.

the elbow is flexed at a right angle a plane parallel with the humerus and passing through the two condyles will cut the tip of the olecranon. If the forearm is extended the olecranon passes slightly posterior to this line; if the forearm is flexed, the olecranon passes somewhat in front of it. Hence in examining the elbow for injury it is desirable to determine the relation of these points when the elbow is bent at a right angle. The coronoid process lies anteriorly, deep in the flexure of the elbow, and cannot be distinctly felt.

If, now, the elbow is extended, the tip of the olecranon can still be felt with the medial (inner) condyle to its inner side. Between the two is a deep groove in which lies the ulnar nerve. To the outer side of the olecranon is a deep pit or short groove; the bone marking its outer edge is the lateral (external) condyle. In the bottom of this pit at its lower portion, about 2.5 cm. (1 in.) below the tip of the olecranon, can be felt the head of the radius. If the thumb is placed on it and the hand rotated, the head of the radius can be felt turning beneath. Immediately above the head of the radius, lying to the outer side of the olecranon, if the elbow be again flexed to a right angle, can be seen and felt the bony projection of the capitellum covered by the strong expansion from the triceps. By careful palpation a groove can be felt between the lower edge of the capitellum and the head of the radius which marks the limits and point of articulation of the two bones.

On the posterior aspect of the joint the ulnar nerve is the most important structure; there is, however, a bursa between the upper or posterior surface of the olecranon and the skin and also another on its inferior surface, extending downward, which from its exposed position is frequently injured and enlarged. Such an enlargement occurs from chronic irritation in certain occupations, hence the name "miners' elbow."

With the elbow flexed at a right angle there is seen on its anterior surface a crease which runs from one condyle across to the other. If a knife were held parallel with the forearm and entered at this crease, it would strike the humerus above the level of the joint line, that is, the line of contact of the bones. This joint line runs from 1.25 cm. (½ in.) below the lateral (external) condyle to 2.5 cm. (1 in.) below the medial (internal) condyle.

Anteriorly the muscular masses form prominent landmarks. In the middle of the crease can be felt the tendon of the biceps muscle. The muscular swell above the crease is formed by the biceps muscle with the brachialis anticus (*brachialis*) beneath. The sharp upper edge of the bicipital fascia can be distinctly felt when the muscle contracts. The limits of the biceps can be felt at two lines, radiating like the letter V from the biceps tendon upward. These are the commencing *bicipital farrows* or *grooves.*

The outer branch marks the depression between the outer edge of the biceps and the swell forming the supinator group of muscles. The inner branch marks the inner edge of the biceps, and between it and the medial condyle can be felt a muscular mass which is formed by the inner portion of the brachialis anticus. In the middle of the flexure of the elbow below the crease is a depression called the *antecubital fossa.* To its outer side is the muscular prominence of the extensors and supinator. To its inner side is the muscular prominence of the flexors and pronator. The inner muscular swell ends at the medial (internal) condyle, but the external one passes well up on the arm. The muscles so prolonged upward are the extensor carpi radialis longior for about 5 cm. (2 in.) above the lateral (external) condyle, and the brachioradialis (supinator longus) for 10 cm. (4 in.) higher. The outer limit of the antecubital fossa is formed by the inner edge of the brachioradialis. The inner side is formed by the pronator radii teres muscle.

To the inner side of the biceps tendon lies the brachial artery, which bifurcates opposite the neck of the radius, approximately 2 cm. or a finger's breadth below the crease of the elbow. Still farther to the inner side lies the median nerve. In the groove between the biceps and brachialis anticus on the inner side and brachioradialis (supinator longus) and extensor carpi radialis longior on the outer side lies the radial (musculospiral) nerve; it divides above or opposite the lateral (external) condyle into the superficial branch and posterior interosseous nerve.

THE VEINS OF THE ELBOW

The flexure of the elbow is occupied by a number of veins which are of importance from the fact that they are frequently used for purposes of saline infusion, blood transfusion, sometimes for blood-letting, and not infrequently they are wounded and give rise to troublesome hemorrhage.

They are made more prominent by allowing the arm to hang and by tying a bandage firmly above the elbow. The larger part of the blood from the parts below is carried by the superficial veins; hence the largest veins lie directly beneath the skin and can be seen through it.

Their arrangement is not always regular but they follow a more or less general plan. The blood from the radial side of the wrist and forearm is carried by the *radial vein.* The *median vein* brings the blood from the anterior surface of the wrist and parts above. There are two veins on the ulnar side, an *anterior* and a *posterior.* The anterior carries the blood from the anterior ulnar aspect and the posterior ulnar from the posterior ulnar aspect of the wrist and forearm. All these veins contain valves at intervals of a few inches. The median vein passes up the middle of the anterior surface of the forearm, and just below the lower edge of the bicipital fascia communicates with the deep veins accompanying the radial and ulnar arteries. This communication is large, distinct, and always present (Fig. 320).

The median vein then divides into the *median basilic* (usually the larger), which passes upward in the internal bicipital furrow, and the *median cephalic,* which follows the edge of the biceps to the external bicipital furrow. Three or four centimetres above the bifurcation of the median, the median cephalic vein is joined by the radial, and from that point up it is called the *cephalic vein.*

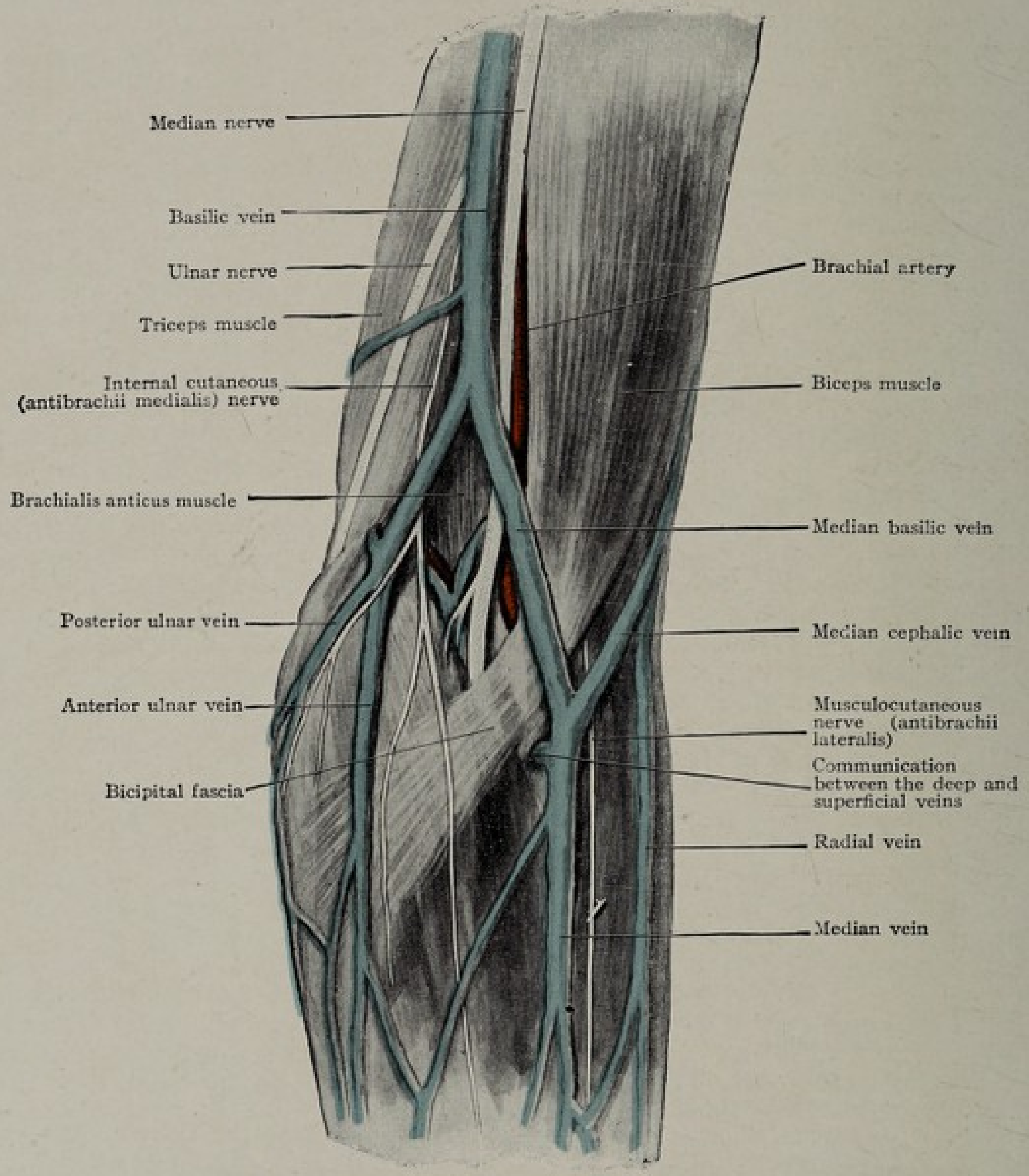


FIG. 320.—Veins at the bend of the elbow.

The two ulnar veins just below the medial (internal) condyle or sometimes just above it empty into the median basilic vein, which from this point is called the *basilic vein.* Sometimes the two ulnar veins, anterior and posterior, unite and empty into the median basilic by a common trunk. The median basilic vein passes over the bicipital fascia, which separates it from the brachial artery which lies directly beneath. The median basilic and cephalic veins are frequently used for intravenous therapy. The median basilic is usually the larger of the two. It lies to the inner side of the biceps tendon and is separated from the brachial artery by the bicipital fascia. If the vessel is small or the arm fat the artery may be exposed by inadvertently severing the bicipital fascia and can be mistaken for the vein. The vein must be thoroughly separated from small terminal nerve filaments of the musculocutaneous which frequently lie on its surface and which if included in the ligature are apt to cause considerable pain. The median vein is frequently large but small valves at its bifurcation and its deep communication are frequently the source of considerable annoyance in introducing the cannula or needle so that an easy flow is quickly established.

When these veins are wounded the bleeding may be very free. Not only are the superficial parts drained but likewise the deep parts through the communication with the median. We saw one case in which death nearly resulted from such a wound made by a piece of tin. When saline infusion is practised the vein selected is made visible by compressing it above. It is then cut directly down upon and isolated, and the cannula inserted. In large veins a needle may be introduced directly without cutting.

BRACHIAL ARTERY

At the bend of the elbow the artery lies to the inner side of the biceps tendon. It is beneath the bicipital or semilunar fascia. The upper edge of this fascia can be felt opposite the crease. In the lower third of the arm the median nerve lies close to the artery, but as the bend of the elbow is reached it diverges and becomes separated from it by the coronoid head of the pronator radii teres muscle. Superficial to the deep fascia is the median basilic vein, crossed at its upper portion by the cutaneous antebrachii medialis (internal cutaneous) nerve. The bifurcation of the brachial artery occurs opposite the neck of the radius, which is approximately a finger's breadth, or about 2 cm., below the crease of the elbow.

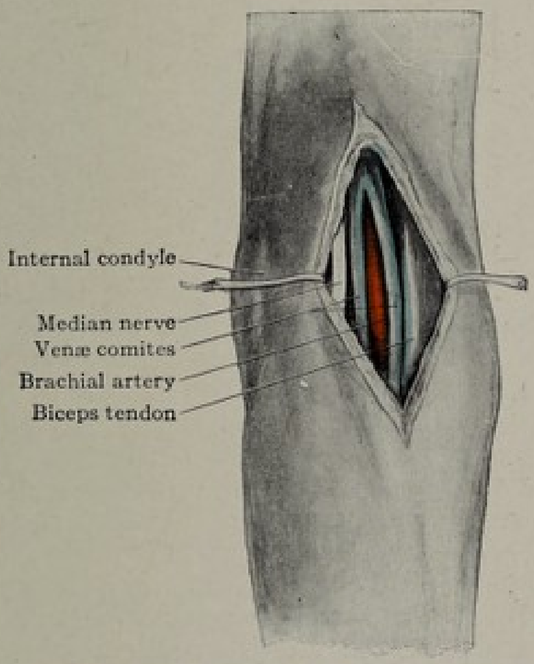


FIG. 321.—Ligation of the brachial artery at the bend of the (left) elbow.

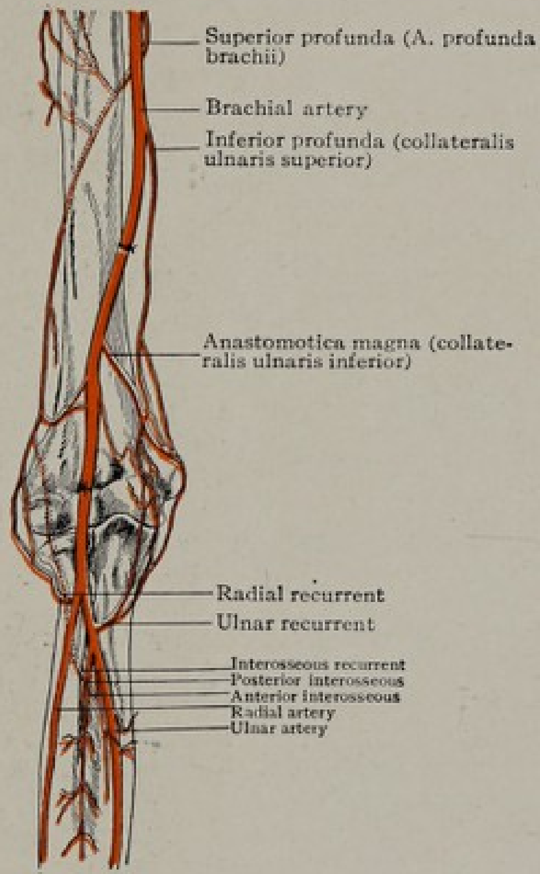


FIG. 322.—Collateral circulation after ligation of the brachial artery at the bend of the elbow.

Ligation of the Brachial Artery at the Bend of the Elbow.—The incision is laid along the inner edge of the biceps tendon. The median basilic vein is usually more prominent than the median cephalic and can be seen obliquely crossing the artery to reach its inner side. This vein is encountered as soon as the skin is divided, hence care is necessary to avoid wounding it. It should be displaced to the inner side along with a filament of the cutaneous nerve if this is present. The incision is then deepened through the upper portion of the bicipital fascia and the artery found beneath, lying in loose fatty tissue and accompanied by two venæ comites. The median nerve lies to the inner side but may be sufficiently removed not to be exposed. The needle is passed from the inner towards the outer side (Fig. 321).

Collateral Circulation.—On the outer side the profunda (superior) anastomoses with the interosseous recurrent (a branch of the posterior interosseous) and radial recurrent. On the inner side the superior ulnar collateral (inferior profunda) and inferior ulnar collateral (anastomotica magna) anastomose with the anterior and posterior ulnar recurrent arteries (Fig. 322).

DISLOCATIONS OF THE ELBOW

The security of the elbow-joint is maintained more by the shape of the bones that take part in the construction of the joint than by the ligaments surrounding it or the muscles overlying it. When man became a biped the joint was no longer necessary for support but increased its use in prehension. Accompanying this change came an alteration in the upper attachment of the radius which is fixed in the quadruped, but movable in the biped. Thus the integrity of the joint came to depend more and more upon the proper alignment of the ulna.

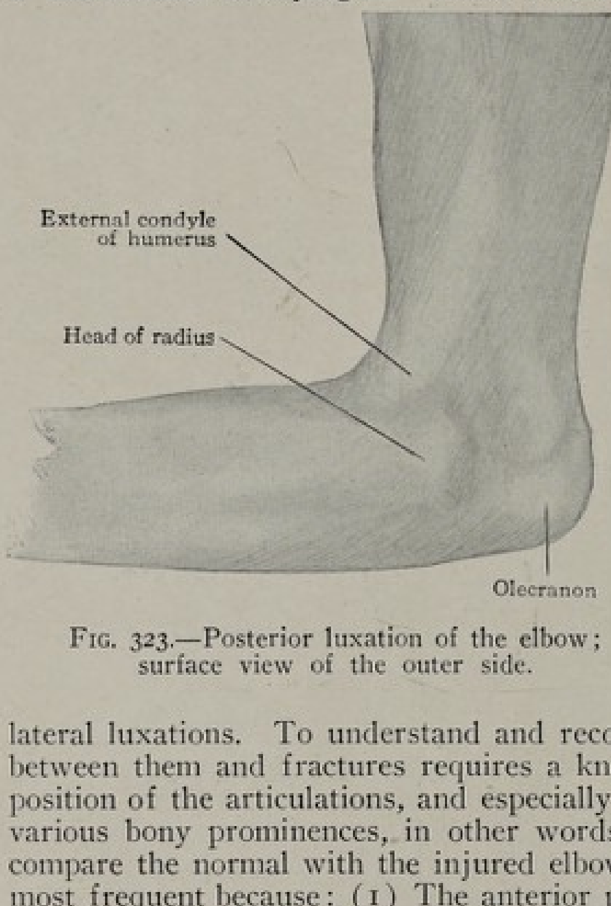


FIG. 323.—Posterior luxation of the elbow; surface view of the outer side.

In dislocation of the elbow the bones of the forearm are most commonly displaced backward. More rarely they may be partially displaced either inwardly or outwardly and with or without an accompanying backward displacement. The lateral ligaments are strong, the anterior and posterior weak. The formation of the bones permits anteroposterior movement and resists lateral movement; hence the frequency of anteroposterior and the rarity of lateral luxations. To understand and recognize these dislocations and distinguish between them and fractures requires a knowledge of the shape of the bones, the position of the articulations, and especially of the relations and significance of the various bony prominences, in other words, surface anatomy. In doubtful cases compare the normal with the injured elbow. Anteroposterior dislocations are the most frequent because: (1) The anterior posterior diameter is much less than the lateral; (2) the lateral ligaments are powerful while the anterior and posterior are comparatively weak; (3) the bony arrangement of the joint allows easier posterior luxation than lateral.

Backward Dislocation of the Elbow.—Posterior dislocation is the more frequent of any luxation at the elbow because: (1) The posterior portion of the capsule is the weakest; (2) the coronoid process which almost exclusively resists luxation is smaller, and is a shallower fossa than the longer olecranon which actively resists anterior displacement; (3) when the joint is hyperextended the coronoid is rocked from its fixation to the humerus and is not in an effective position to resist luxation; (4) in hyperextension the surface contact between the head of the radius and the capitellum of the humerus is diminished; (5) the radius resists the pull of the biceps forward through its powerful ligamentous attachments to the ulna and because of a lack of any intimate connection with the humerus which could fix it temporarily while the ulna goes posteriorly. In backward dislocation the radius and ulna are pushed backward and the lower end of the humerus comes forward, stretching and occasionally rupturing the brachialis anticus over the lower end of the bone. It is most commonly caused by falls on the outstretched hand and not by direct injury to the elbow.

On the cadaver hyperextension with or even without a slight twisting readily produces the displacement.

The internal and external lateral ligaments are torn loose from their respective condyles and the anterior ligament is ruptured. The posterior ligament is stretched from the olecranon process to the humerus, and with the periosteum may be lifted up but not ruptured. This is especially the case with the periosteum above the external condyle, as shown by Stimson.

The amount of tearing of the muscles depends on the amount of displacement. The flexor muscles may be partly torn from the internal condyle or the extensors from the external. The brachialis anticus probably will be somewhat torn near its insertion in front of the coronoid process. The biceps is not torn but may in some cases be caught behind the external condyle. The orbicular ligament remains intact and holds the radius in its proper relation to the ulna.

Signs.—The position assumed by the bones is usually one of slight flexion, approximately 120 degrees (Hamilton).

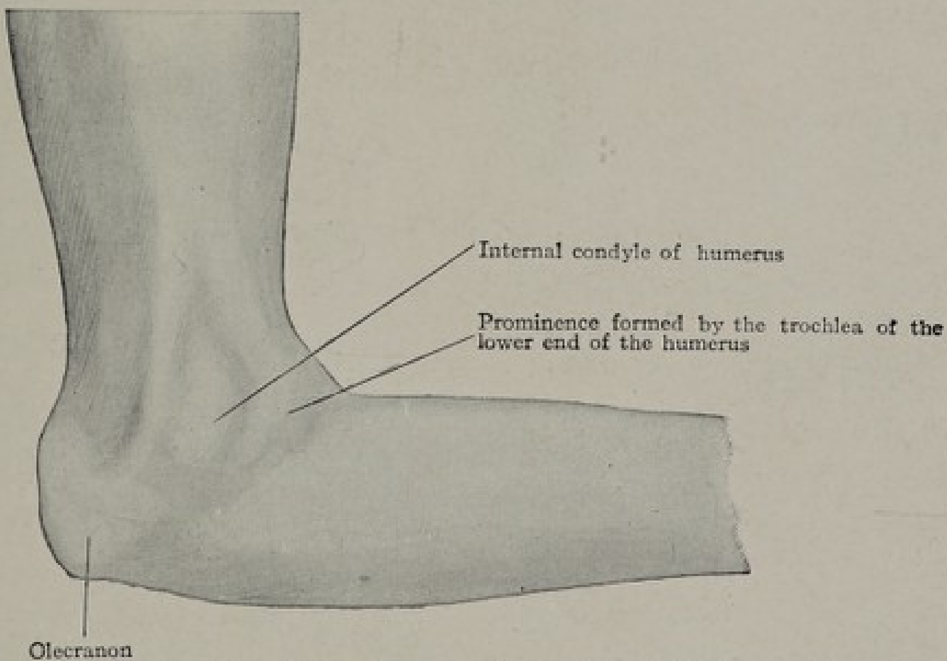


FIG. 324.—Posterior luxation of the elbow; surface view of the inner side.

Viewing the elbow from the side, the anterior portion of arm above the crease is fuller than is normally the case. Posteriorly the olecranon is seen projecting, and above it is a distinct hollow. On the outer side of the joint immediately in front of the olecranon is seen a prominent projection caused by the head of the radius. It is to be recognized by placing the thumb on it and rotating the hand. Almost directly above it may be felt,—though it is not at all distinct,—the external condyle (Figs. 323 and 325). On the inner side are seen two rounded bony eminences. The posterior and upper of these is the larger; it is the internal condyle. Below and anterior to this is another; it is the inner edge of the trochlear articulating surface (Figs. 324 and 326).

Measurements from the condyle to the acromion process show that they are the same on the injured and the healthy sides. Measurements from the condyle to the styloid process of the ulna show shortening on the injured side. As the lateral ligaments are torn there is abnormal lateral mobility. If the forearm is placed at right angles to the arm, it is seen that the tip of the olecranon no longer lies on a plane drawn through the long axis of the arm and the two condyles, but is considerably posterior to it.

The diagnosis as pointed out by Stimson should be based on the positive recognition of the position of the olecranon, the two condyles, and the head of the radius.

Treatment.—The lower end of the humerus rests in front of the coronoid process (rarely fractured). When the forearm is flexed the triceps becomes tense and holds the bones locked in their displaced position. The coronoid process prevents

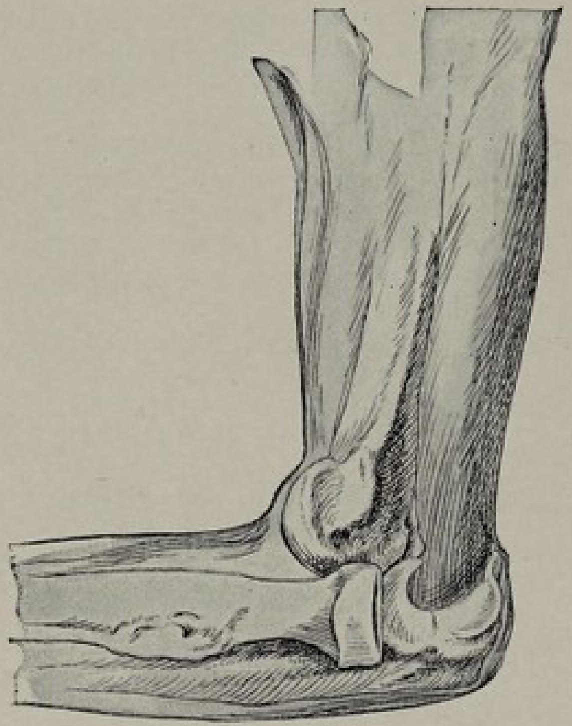


Fig. 325.—Posterior luxation of the elbow, showing the position of the bones as viewed from the outer side.

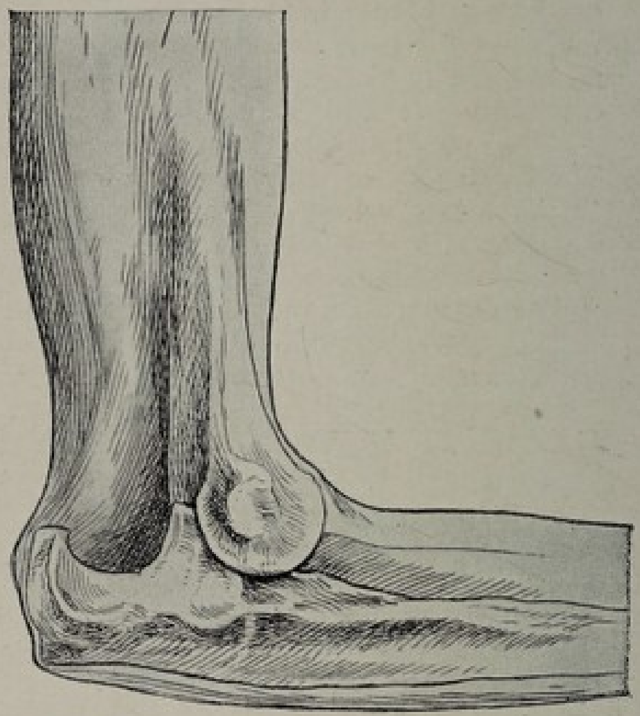


Fig. 326.—Posterior luxation of the elbow, showing the position of the bones as viewed from the inner side.

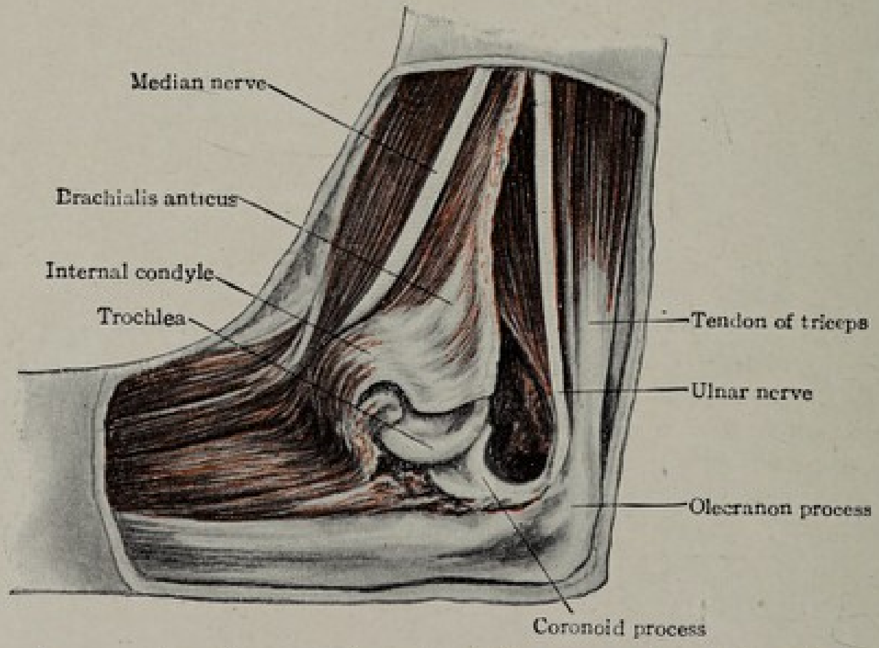


Fig. 327.—Dissected preparation of posterior luxation of the elbow, viewed from the inner side.

the humerus from going back into place. To reduce the dislocation, the triceps is to be relaxed by extending the forearm to an angle of about 120 degrees, thus lowering the coronoid process, and extension is to be made on the forearm and counterextension on the arm. Usually an anæsthetic is not required (Fig. 327).

Lateral dislocations are infrequent on account of the great relative width of the elbow-joint, the irregular lower border of the humerus, the strong lateral ligaments and the presence of strong flexor and extensor muscle groups which originate from the internal and external condyles respectively.

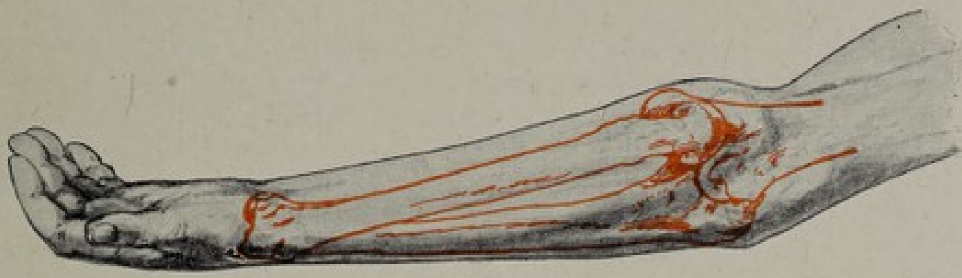


FIG. 328.—Anterior dislocation of the head of the radius. (Sketched by Dr. Davis.)

Inward Dislocation of the Elbow.—An extremely rare dislocation because of the greater projection of the inner border of the trochlea. In inward dislocation the ulna and radius are pushed toward the inner side. The head of the radius leaves the capitellum to rest on the adjacent portion of the trochlea. The olecranon slides from the outer to the inner surface of the trochlea. The outer condyle then becomes prominent while the inner becomes confused with the olecranon. The identity of the condyles is always to be established by tracing them up the humerus. This dislocation is always incomplete.

Treatment.—Extension and counterextension with the arm slightly flexed to release the coronoid process aided by direct pressure on the humerus inward and the ulna outward.

Outward Dislocation of the Elbow.—In outward dislocation the concave surface of the olecranon rests on the capitellum and in the groove between it and the trochlea. The head of the radius projects far to the outer side of the external condyle. The inner condyle and trochlea become quite prominent and can be readily recognized.

Treatment.—Slight flexure of the forearm. Traction and pressure on the radius inward and on the internal condyle and lower end of the humerus outward.

Dislocation of the Head of the Radius.—The ulna alone is rarely luxated (when displaced it would practically be a backward and inward luxation of the elbow) but the head of the radius is not infrequently pulled out of place (Fig. 328). This separate luxation is resisted by the strong ligaments which hold the two bones together, *e.g.*, the triangular ligaments, the interosseous membrane, the oblique ligaments and the orbicular ligament. It is this strong ligamentous attachment between the radius and ulna which prevents dislocation by resisting the powerful forward pull of the biceps. The orbicular ligament offers the chief resistance.

FIG. 329.—Anterior dislocation of the head of the radius. Position of bones when viewed from in front.

The accident occurs in children, particularly young ones who, in walking with their elders, are frequently lifted or helped along by a pull on the hand. The pull, accompanied by hyperextension of the elbow and some adduction of the hand, draws the head of the radius from beneath the orbicular ligament and then the tension of the biceps drags it forward. The displacement may be either marked or slight. A marked displacement in the well-developed arm of an adult is readily recognized, but in the fat, chubby, undeveloped arm of an infant it is overlooked.

Diagnosis.—Pain attracts attention to the part. There is apt to be inability to flex the arm beyond a right angle, due to the radius impinging on the lower end of the humerus. Careful palpation reveals a hollow below the lateral (external) condyle which should be normally occupied by the head of the radius. The outer side of the forearm at the bend of the elbow may be abnormally full and pressure here may detect the head of the radius displaced forward (Figs. 329 and 330).

Treatment.—The forearm is to be extended almost to a straight line. Pressure is to be made with the thumb to force the head of the radius back into place. While this is done the forearm is to be flexed on the arm and if the head is replaced the elbow can be bent to its normal acute angle. On extension being made the radius frequently again jumps forward, hence the injury is to be subsequently treated with the arm in a flexed position. Since the annular ligament is often badly torn it is necessary at times to excise the head of the bone in order to obtain a good result.

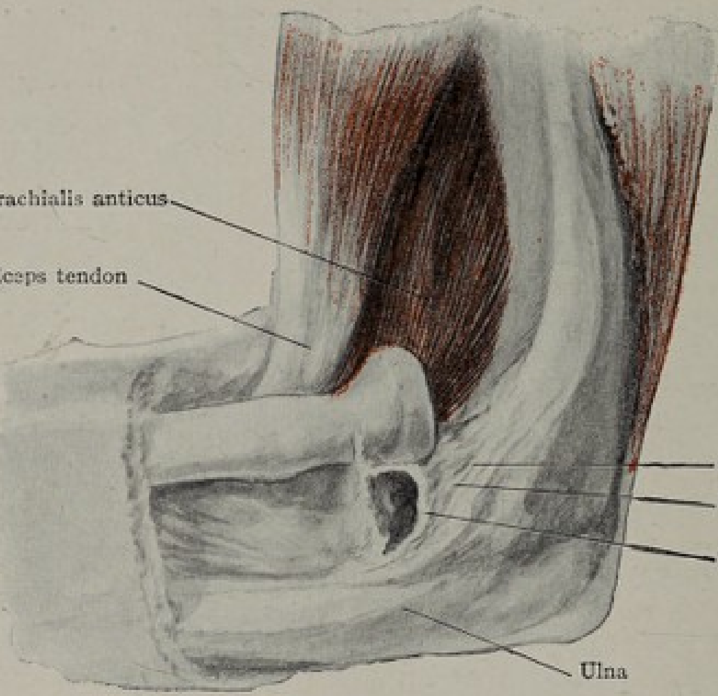


Fig. 330.—Anterior luxation of the head of the radius.

FRACTURES IN THE REGION OF THE ELBOW

The elbow is frequently the seat of fractures, especially in children. Their diagnosis and treatment are both difficult and the result sometimes unsatisfactory.

The bony processes are less distinct in children than in adults and fractures sometimes pass unrecognized, being considered sprains, until the persistent disability or marked deformity betrays their presence. Luxations and fractures are at times mistaken for one another. For these reasons a working knowledge of the anatomy of the region is indispensable.

The fractures that occur in this region are transverse fractures above the condyles and oblique fractures through the condyles, which may either involve the condyles proper (epicondyles so called) and be extra-articular, or involve the articular surface of the trochlea or capitellum. Both condyles may be detached by a T- or Y-shaped fracture: the olecranon may be fractured and also the head or neck of the radius.

Transverse Fracture of the Humerus above the Condyles (Supracondylar).—This is the most frequent fracture of the lower end of the humerus. The mechanism of its production is not settled. There is little doubt but that it can be produced by hyperextension, as the bone fractures at this point when luxation does not occur. Hamilton regarded a blow on the elbow as the cause. The line of fracture runs transversely across the bone just above the condyles and obliquely from behind downward and forward (Fig. 331).

Displacement.—The lower fragment is drawn upward and backward and sometimes there is an angular lateral deformity with obliteration of the carrying angle (see page 321).

Signs.—The overriding of the fragment produces shortening of the humerus as measured from the acromion to the lateral (external) condyle. The olecranon projects backward, causing a hollow above which resembles that produced in backward luxation. The flexure of the elbow is fuller than normal. The relation of the condyles to the tip of the olecranon is not altered. The condyles may, however, lie posterior to a line drawn down the middle of the humerus in its long axis. The sharp edge of the lower fragment can sometimes be felt posteriorly.

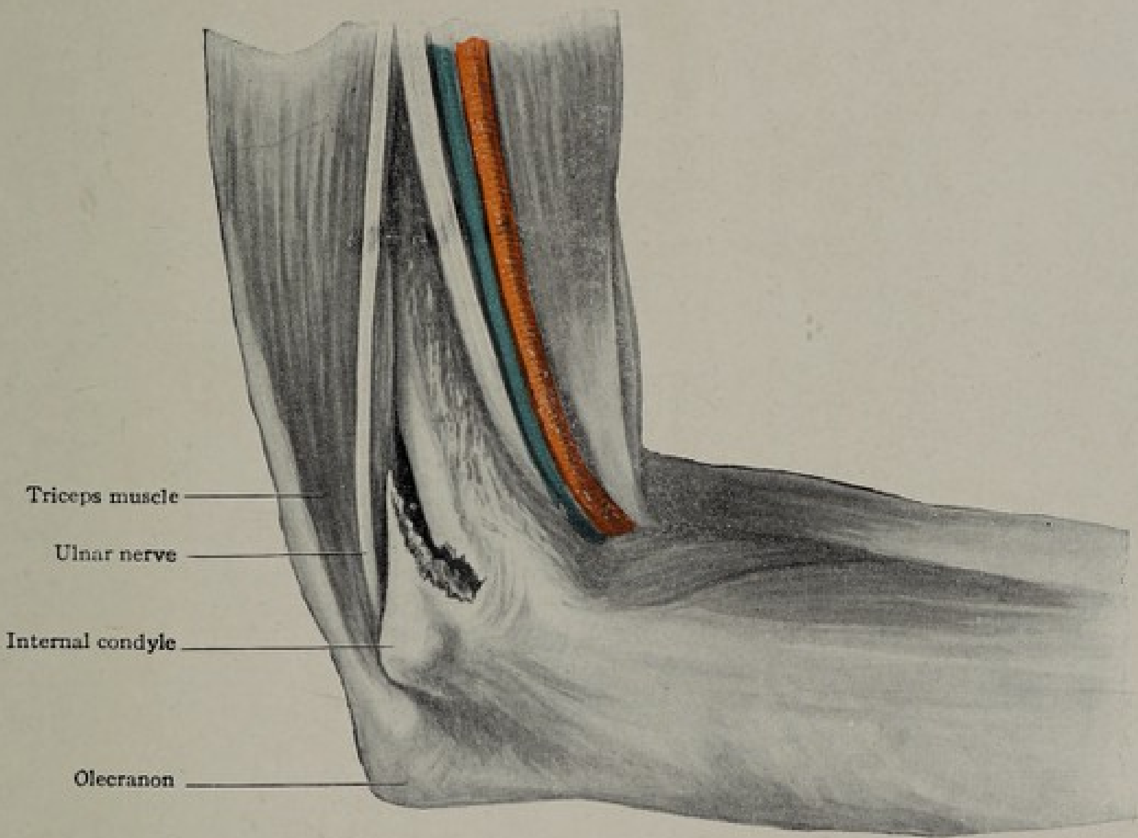


FIG. 331.—Transverse fracture of the lower end of the humerus above the condyles. The upper fragment is seen to be displaced forward and the lower fragment with the olecranon is displaced backward. This posterior displacement is increased by tension of the triceps muscle.

Extension of the forearm causes the fragment to be pushed still farther upward.

Treatment.—There is no single treatment that is applicable to all cases. If the arm is too much extended, the biceps and brachialis anticus are made tense, and tension of either the anterior or posterior muscles tends to favor overlapping and to prevent replacement. Full flexion renders the triceps tense. To relax both sets of muscles a position at about right angles is probably best.

Stimson has shown that gunstock (angular) deformity frequently follows this injury, hence especial care should be taken to guard against it. It is caused by a tilting of the lower fragment. Instead of a line joining the condyles being at right angles to the long axis of the humerus, it may be oblique, owing to one condyle being higher than the other. Practically it is not possible to recognize this displacement when the arm is bent at a right angle. The splints will fit the part and everything appears satisfactory, but on removal of the splints and extension of the forearm it may be found that the carrying angle has been destroyed and that a gunstock deformity is present. This accident is to be avoided by extending the arm during the earlier periods of treatment before the fragment becomes fixed by callus, and seeing that, on extension, the forearm makes the same angle with the arm as does that of the healthy side.

The common mode of treatment of supracondylar fractures is the use of antero-posterior splints with the elbow bent at a right angle or sometimes acutely flexed.

Fractures Involving the Condyles.—The condyles (page 319) have been described as the lateral bony projections of the lower end of the humerus which are extra-articular. Therefore the trochlea and capitellum are not parts of the condyles, and the epicondyles are simply the tips of the condyles.

Bearing this in mind it is evident that fractures involving the condyles may be confined to them and not implicate the articular surfaces. They are then extra-articular fractures of the condyles, or they can with some reason be called fractures of the epicondyles. Other fractures may not only implicate the condyles, but pass through them into the articular surfaces. These will be called intra-articular fractures of the condyles. The internal epicondyle (epicondylus medialis) is sometimes called the epitrochlea.

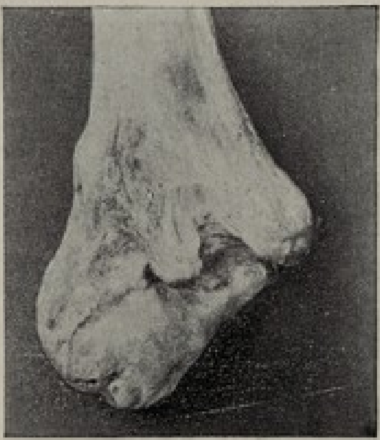


Fig. 332.—Fracture of internal condyle and trochlea, causing gunstock deformity (cubitus varus). From a photograph of a preparation in the Mütter Museum of the College of Physicians.

Extra-articular Fractures of the Condyles or Fractures of the Epicondyles.—The medial (internal) condyle projects far beyond the body of the bone as a distinct bony process, while the lateral (external) condyle is low, flat, and not prominent. For these reasons fractures of the medial condyle not involving the joint are more common than those of the lateral condyle. In fact extra-articular fractures of the lateral condyle (detachment of the epicondyle) are almost unknown, but they have been proven to exist.

In extra-articular fractures of the medial condyle, the fragment has been displaced downward by the flexor muscles which arise from it. To counteract this tendency the arm is treated in a flexed position. As the ulnar nerve runs in the groove on the posterior surface of the condyle it has also been injured, and vesicles and impairment of sensation in the course of the nerve have been observed. As the articular surfaces are not involved, no serious deformity or disability need be expected.

Intra-articular Fractures of the Condyles.—The line of fracture in these injuries usually starts above the epicondyle and passes toward the middle of the bone, chipping off a portion of the trochlear surface or the capitellum. Fractures involving the lateral are probably more frequent than those involving the medial condyle.

Intra-articular Fracture of the Medial Condyle.—The line of fracture passes obliquely through the condyle, entering just above its tip and emerging on the articular surface of the trochlea either in the groove separating the two portions of the trochlea or the groove between the trochlea and capitellum. As already explained (page 319), the integrity of the joint and the line of the arm depend on the trochlea and not on the capitellum, therefore the farther over toward the capitellum the line of fracture goes the more likely is there to be lateral mobility (Fig. 332).

The fragment may be pushed up; this carries the ulna up with it while the radius is prevented from following by the capitellum. Therefore the forearm bends inward, making a lateral deformity. The carrying angle (page 321) becomes obliterated and what is known as *gunstock deformity* or *cubitus varus* is produced. It is mainly to the researches of Dr. O. H. Allis that we are indebted for our knowledge of the mechanism of this deformity. The attachment of the flexor muscles does not keep the fragment from rising. The deformity is difficult to detect when the elbow is flexed. The condyles and olecranon and shaft of the humerus may all be in the same straight line and still the medial (internal) condyle be higher than normal. If the injury is treated with a right-angled splint the radius and ulna remain in their proper positions but the ulna and medial condyle may both be higher than normal. If this is the case, then, when the forearm is extended, instead of it making an angle of 10 degrees outwardly with the line of the humerus, it may incline 10 degrees or even 20 degrees inwardly: thus it may deviate as much as 30 degrees from the normal direction. To guard against this deformity Allis advised treating the injury with the arm in full extension. Any tendency to lateral deformity will then be at once evident and can be corrected by additional lateral support. Certain it is that no serious fracture of the elbow ought to be treated without frequent examinations of the arm in full or almost complete extension from time to time, so as to be sure this deformity is not becoming established.

The treatment of fractures involving the joint by placing the elbow in a position of complete flexion has been strongly advocated and as a rule is best, although it has not entirely superseded other methods in all cases.

Intra-articular Fracture of the Lateral (External) Condyle.—This is also a fairly common injury. The line of the fracture passes from above the tip of the lateral condyle down into the joint through the capitellum or between it and the trochlea. As is to be expected, this does not show the same tendency to lateral deformity as does fracture of the trochlea. When lateral deformity does occur it is because the fracture is so extensive as to also involve the trochlea. This, like the other fractures of this region, is to be diagnosed by grasping the fractured part and detecting crepitus and excessive mobility. The medial (internal) condyle is felt firmly attached to the humerus and the olecranon to the ulna, but the lateral (external) condyle is felt to move independently of the others. It is efficiently treated by an anterior (not internal) angular splint.

FIG. 333.—Intercondylar or T fracture of the lower end of the humerus. Mütter Museum, College of Physicians.

Intercondylar or T Fracture.—When both condyles are detached there is produced what is known as a T fracture. In this injury both condyles are detached from each other and from the shaft of the humerus. The line of fracture may vary. Sometimes there is a transverse fracture above the condyles with a second line passing longitudinally into the joint like the letter T. In other cases the lines may be like the letter V or Y (Fig. 333).

In all these cases the mobility is very marked and the limb can be bent at the elbow in any direction. The diagnosis is to be made by grasping the shaft of the humerus with one hand and moving each condyle separately with the other. Having determined that each is detached from the humerus, then one condyle is grasped in each hand and they are moved on one another, thus establishing the fact of a fracture between them. In cases with considerable swelling it is better not to produce further trauma, but to depend on the X-ray examination.

In treatment the same care must be exercised to detect the occurrence of gunstock deformity as has already been advised in fractures of the medial condyle. In these fractures the fragments are frequently rotated on one another, and disability and deformity so often result that in some cases it is advisable to fix the fragments in place by some operative means. The position of acute flexion which is used in the treatment of the transverse fracture of the humerus above the condyles, or of either condyle itself should not be used in this fracture as the coronoid process would separate the condyles.

Fracture of the Olecranon Process.—The olecranon process may be fractured either close to its extremity near the insertion of the triceps tendon, through approximately the middle of the greater sigmoid cavity, or toward the coronoid process.

The second is the more common. The fracture which occurs nearer the insertion of the triceps is liable to occur from muscular action, the triceps contracting and tearing off the piece of bone into which it is inserted. The shape of the process should be noted. In the bottom of the greater sigmoid cavity near where the process joins the shaft it is constricted and weakened by a groove which sometimes passes nearly or quite across its surface. This is the weakest point and is most often the site of fracture.

The triceps muscle inserts not only into the upper surface of the olecranon but also along its sides. In addition it sends off a fibrous expansion to each side; the one to the medial condyle is thin, but the one to the lateral condyle forms a broad, tough, fibrous band which stretches from the olecranon to the lateral condyle and

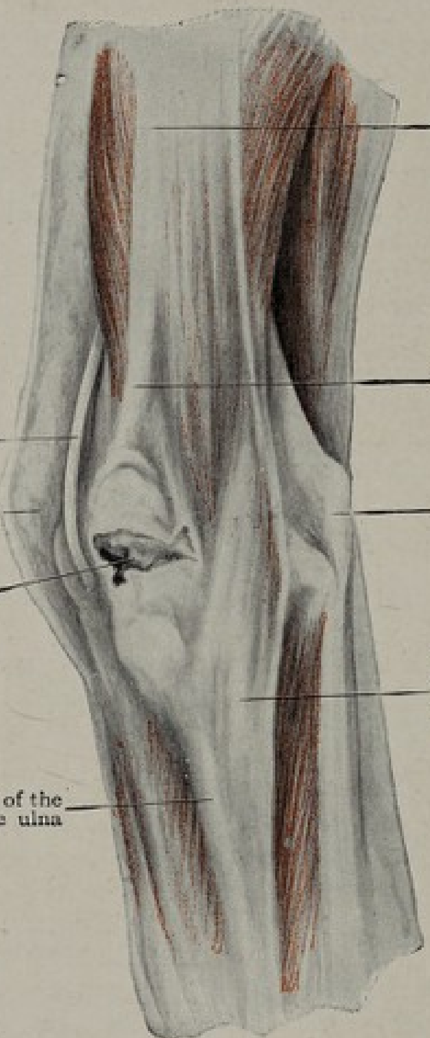


FIG. 334.—Fracture of the olecranon process, showing the insertion of the triceps muscle into the olecranon and upper fourth of the ulna.

passes down over the anconeus to be attached to the outer edge of the upper fourth of the ulna (Fig. 334). In cases of fracture the fragment is only slightly displaced upward by the contraction of the triceps. The reason is that the fibrous expansion of the triceps usually is not sufficiently torn to allow of the retraction of the fragment. The amount of separation of the fragments is directly proportional to the amount of tearing of the lateral fibrous expansion of the triceps tendon. By extending the forearm the triceps is relaxed and by pushing the fragment down crepitus can often be elicited.

Treatment.—Fracture of the olecranon process is usually treated with the elbow slightly flexed. Complete extension is not commonly employed. The slight flexion allows for the effusion into the joint and leaves the arm sufficiently extended to relax the triceps. In cases associated with marked separation open reduction should be practised.

Fracture of the Coronoid Process and Upper End of the Radius.—*Fracture of the coronoid process* does occur but it is exceedingly rare. The brachialis anticus does not insert into its tip, but at the lower part of its anterior surface. The fracture is most liable to occur in cases of luxation, the process being knocked off as the humerus comes forward.

Fractures of the Head and Neck of the Radius.—The head and neck of the radius are rarely fractured. When broken, the line of fracture through the head is usually longitudinal and a portion of the head is chipped off. The fragment is liable to become displaced, and either creates inflammation and suppuration or becomes fixed and greatly interferes with motion. For these reasons the fractured head has been frequently excised. A similar displacement may occur when the neck of the radius is fractured.

In this latter injury an anterior angular deformity is said to have been produced by the action of the biceps pulling the lower fragment, to which it is attached, forwards.

The classical specimen in the Mütter Museum of the College of Physicians of Philadelphia is usually instanced as an example of this action. The possibility of its occurrence suggests the treatment of the injury with the elbow flexed to relax the biceps muscle.

Epiphyses of the Bones of the Elbow.—Traumatic epiphyseal separations are possible, but so rare as to be seldom detected. Supracondylar fractures in children, though not infrequently described as separations of the epiphysis, are probably more often true bony fractures.

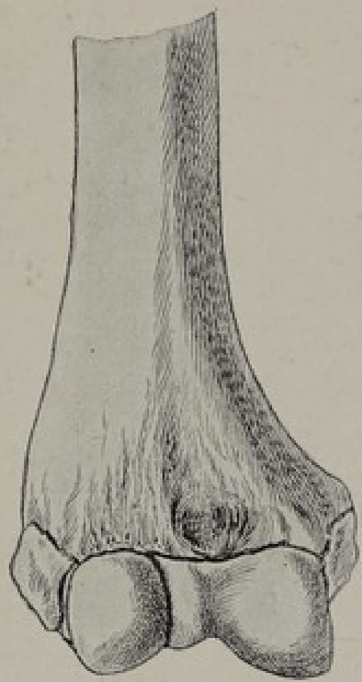


FIG. 335.—Epiphysis of the lower end of the humerus; unites with the shaft at about the seventeenth or eighteenth year.

Humerus.—The lower end of the humerus ossifies by four centres. Three of them, those for the lateral (external) condyle, capitellum and outer portion of the trochlea, and inner portion of the trochlea, appear at the twelfth, third, and twelfth years and fuse and unite with the shaft at about the sixteenth year. The fourth, for the internal condyle, appears at the fifth and unites about the seventeenth or eighteenth year. The epiphyseal line runs close to the edge of the articular surface and is below the level of a transverse line joining the upper edges of the two condyles (Fig. 335). A true epiphyseal separation would thus be intra-articular and would involve comparatively only a thin shell of the articular surface. As already stated most of the cases regarded as epiphyseal separations are probably true supracondylar fractures.

Destruction or removal of the epiphyseal cartilage is, of course, if possible, to be avoided in operations in young children, as otherwise interference with the growth of the bone will occur.

Ulna.—Most of the olecranon process is a direct outgrowth from the shaft of the ulna. At about the tenth year a thin shell forms at its extremity which unites at the sixteenth year. Therefore fractures which pass through the bottom of the greater sigmoid cavity are not separations of the epiphysis but true fractures.

Radius.—The upper articular surface of the radius has a centre of ossification which appears from the fifth to the seventh year, and unites at the eighteenth to twentieth year.

There is also a centre for the tubercle. Surgical writers as a rule do not speak of epiphyseal separations of the upper ends of the radius and ulna.

DISEASE OF THE OLECRANON BURSA

Between the skin covering the olecranon process and the bone is a bursa, which, from its exposed position, is not infrequently diseased. It lies in the subcutaneous tissue and resembles in all respects the bursa in front of the patella. In those whose occupation causes them to rest frequently on the elbow, this bursa becomes enlarged, hence the name "miner's elbow." The bursa lies on the posterior surface of the bone and extends from the tip of the olecranon downward in the direction of the forearm. Excision is the most efficient treatment. There are no dangerous structures to be encountered in the operation because the bursa does not communicate with the joint. The position of the ulnar nerve should be borne in mind. It can readily be avoided and usually is not seen. There is sometimes another bursa on the upper surface of the olecranon just below the insertion of the triceps. It is rarely affected.

DISEASE OF THE ELBOW-JOINT

The elbow-joint, like others, is affected with rheumatoid and tuberculous disease. The former frequently causes ankylosis, while the latter frequently causes suppuration. The joint becomes distended and enlarged. The bony prominences of the elbow, while they may not be visible, nevertheless can usually be recognized by palpation. The lateral ligaments are stronger than the anterior and posterior, hence the swelling is most marked in front and behind the joint. As the internal lateral ligament is stronger than the external lateral, swelling will be more marked on the outer side and the medial (internal) condyle will be more easily recognized than the lateral (external).

Pus first works its way posteriorly up behind the tendon of the triceps and then sideways and along the intermuscular septa. As the external supracondylar ridge is nearer the surface than the internal, pus will show itself sooner above the lateral (external) condyle. It may form a protrusion on each side of the triceps tendon and olecranon process. Although the elbow-joint because of its exposed position is constantly subjected to traumatism, disease of the joint is not as frequent as in the knee-joint. This is partly due to the firm connection of the bones which form the joint preserving its hinge-like character and preventing side strains, and to the protective character of the strong lateral ligaments and muscles, and to the looseness of the capsule which allows moderate distention without undue tension.

Later it may show itself anteriorly; when it does so it appears more to the outer than to the inner side, being deflected outwardly through the antecubital space by the attachment of the brachialis anticus to the coronoid process, by the tendon of the biceps and by the bicipital fascia which passes from the tendon over the muscles attached to the medial (internal) condyle.

RESECTION OF THE ELBOW

A straight incision is made over the point of the olecranon a little internal to its middle. The upper portion of this incision splits the triceps. Its lower part is carried down to the bone on the posterior surface of the ulna. The attachment of the triceps to the inner side is then dissected off and the ulnar nerve raised from its groove without injuring it. The medial (internal) condyle is then to be cleared of the muscles attached to it. The parts external to the incision are now to be raised. By means of periosteal elevators aided by the knife the external part of the triceps is detached from the bone as closely as possible, following exactly the edge of the ulna. The anconeus is raised with the triceps and the broad fibrous expansion passing from the olecranon to the lateral (external) condyle and thence over the anconeus to be continuous with the deep fascia is preserved intact. On the care with which this is done depends the amount of subsequent muscular control. As the triceps is turned aside the muscles attached to the lateral condyle are raised in the same manner. The soft parts being drawn to each side the bones are protruded and the remaining soft parts anteriorly can be detached. A flat spatula is then passed beneath the bones and the humerus sawed through opposite the upper edge of the medial (internal) condyle above and the radius and ulna opposite the lower edge of the head of the radius below. The insertions of the biceps and brachialis anticus are not disturbed.

In raising the supinator (brevis) from the upper portion of the radius care should be exercised not to wound the posterior interosseous nerve. It runs between two planes of muscular fibres in the substance of the supinator (brevis). It is a nerve of motion supplying all the extensor muscles with the exception of the anconeus, brachioradialis (supinator longus), and extensor carpi radialis longior; hence

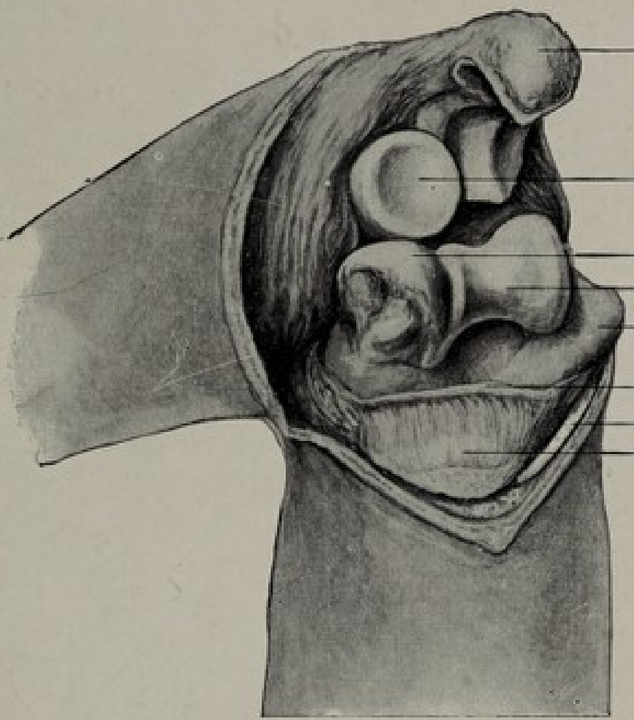


Fig. 336.—Resection of the elbow-joint; the ends of the bones are exposed ready to be removed.

its injury will be followed by serious paralysis. Almost no vessels require ligation (Fig. 336).

AMPUTATION AT THE ELBOW-JOINT

Amputation at this joint is peculiar because of the width of the lower end of the humerus. The skin is loose and shows a marked tendency to retract, especially on the anterior surface. This, combined with the large, expanded end of the humerus, requires ample flaps to be made or difficulty will be encountered in properly covering the end of the humerus. The irregularity of the line of the joint makes disarticulation somewhat difficult (Fig. 337).

A long anterior flap with or without a short posterior one is usually advised. On account of the tendency to retraction the ends of the incision are not carried up to the condyles but are kept at least 2.5 cm. (1 in.) below them.

If the flap is cut by transfixion the line of the articulation must be borne in mind. Inasmuch as the trochlear surface projects farther down than the capitellum it is customary to incline the knife downward and inward. Also, as the trochlear portion is thicker, wider, and projects farther than the capitellum, the inner side of the flap is made longer than the outer.

The skin on the anterior surface is loose and retracts freely as soon as cut; hence the muscles are often cut by transfixion. The skin on the posterior surface is not so loose and does not exhibit the same tendency to retraction. After the anterior muscles have been raised and the short posterior skin flap turned back the joint is to be opened. The line of the joint runs from 1.25 cm. below the lateral (ext.) condyle to 2.5 cm. below the medial (int.) condyle and is most readily recognized on the outer side, hence the division of the ligaments is to be made from the outer toward the inner side. The point at which to enter the knife is to be found by first feeling the head of the radius in the pit below the lateral (external) condyle posteriorly and then by pressure just above the head recognizing the groove between the upper edge of the head and capitellum. The knife passes directly traversely along between the head of the radius and capitellum, then across the inner portion of the trochlea and is then directed downward and inward around the projecting inner portion of the trochlea. Division of the internal lateral ligament allows the forearm to be bent back and the triceps attachment becomes exposed and can be divided from the front.

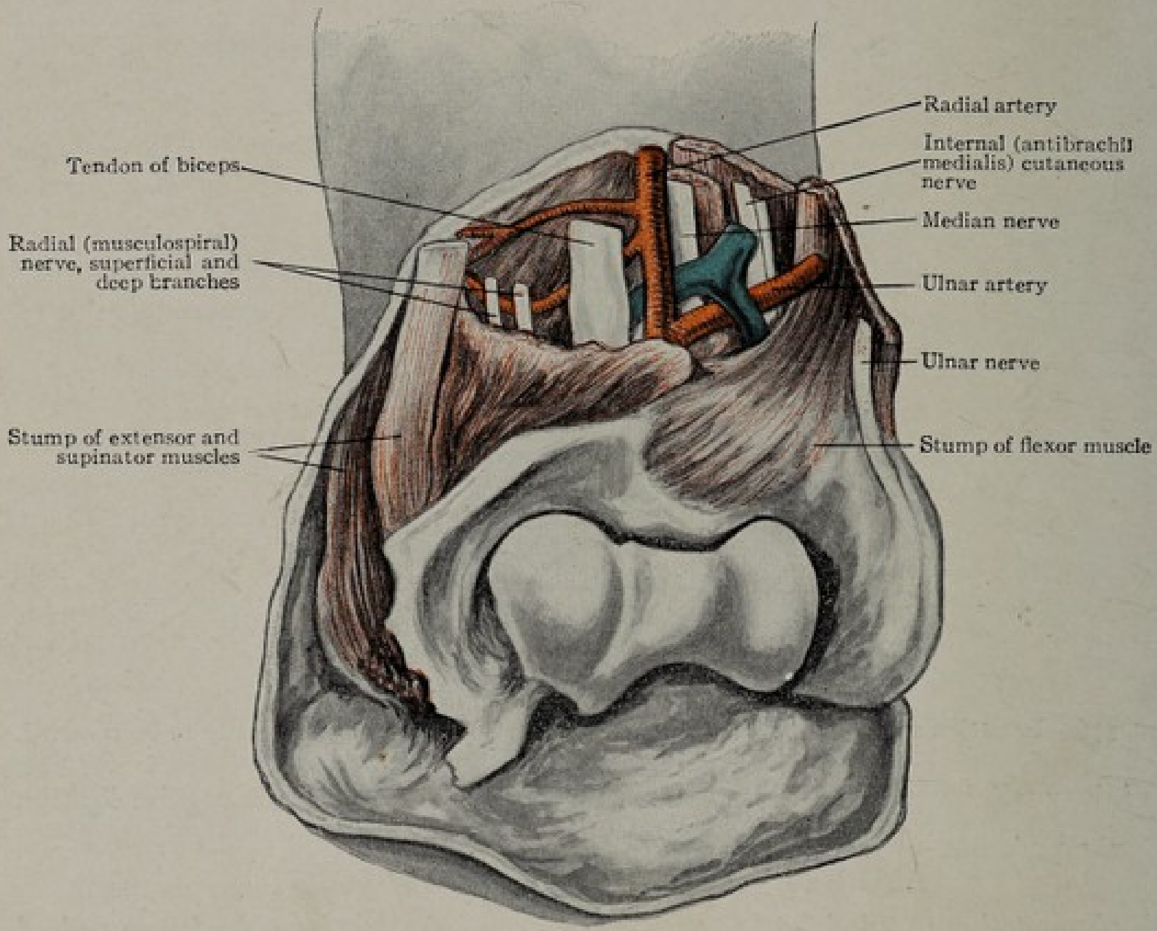


FIG. 337.—Amputation at the elbow-joint.

The appearance of the stump will depend on the manner in which the flaps have been cut.

On each side will be the muscular masses from the internal and external condyles. Between them will be the tendons of the biceps and brachialis anticus. The median and ulnar nerves are to be found, the former to the inner side of the biceps tendon and the latter behind the medial (internal) condyle. They are to be shortened. The radial (musculospiral) has already divided into its superficial (radial) and deep (posterior interosseous) branches.

The ulnar and radial arteries will probably be found divided well anterior on the face of the stump. Some bleeding may be present from the terminal branches of the profunda in front of the lateral condyle, from the superior ulnar collateral (inferior profunda) behind the medial condyle, or from the interosseous or recurrent branches. It is usually not necessary to apply ligatures to the larger superficial veins.

THE FOREARM

The forearm is intimately associated with the functions of the hand. It serves as a sort of pedestal or support, enabling the hand to be carried away from the body, and, by possessing certain movements of its own,—those of pronation and supination,—it increases greatly the range and character of the movements which the hand is capable of executing. The hand is the essential part of the upper extremity and the forearm is subsidiary. Hence we find that, like the neck, the forearm possesses nerves and blood-vessels much larger than its own proper functions would require and which are destined for the more important parts beyond. It is composed of two bones, the radius and the ulna, which act as the bony support of the part, of a few muscles which move these bones and many more which move the hand and fingers beyond, and of certain nerves and blood-vessels that not only supply it but also the parts beyond.

BONES OF THE FOREARM

The forearm contains two bones, instead of one as in the arm. One of these bones, the ulna, is directly continuous with the humerus; the other, the radius, is continuous with the hand. In other words, the ulna is associated with the movements of the arm, and the radius with those of the hand. The large end of the ulna articulates with the humerus and its small end is at the wrist, while the large end of the radius is articulated with the hand and its small end with the humerus.

The **ulna** is the bone which acts mainly as a support. It articulates with the humerus by a pure hinge-joint; hence its only motion is one of extension and flexion. It is the fixed bone and does not take part in the movements of pronation and supination, but serves as an anchoring part for the attachment of the muscles which move the radius as well as the hand. At its upper extremity it has attached to it the *brachialis anticus, triceps,* and *anconeus muscles,* which flex and extend it.

At its upper extremity on its outer side is the *lesser sigmoid cavity* for the articulation of the radius. Its lower extremity ends in a head tipped with a *styloid process.* The ulna gradually decreases in size from above downward until its lower fourth is reached, when it is slightly enlarged to end in the head. At its lower end, the lateral aspect of the head of the ulna rests in a cavity in the radius to allow of the movements of pronation and supination (Fig. 338).

The **radius** is small above and gradually increases in size until its lower extremity is reached, where it is largest. Its upper portion is composed mainly of compact bone with a medullary cavity; lower down as the bone becomes larger it becomes more cancellous. Hence it does not follow that it is strongest where it is largest; on the contrary it is most often fractured at its lower extremity. About two centimetres below the head of the radius is a tubercle. The biceps tendon is inserted into its posterior portion and a bursa covers its anterior part, over which the tendon of the biceps plays. The radius is the movable bone and to it is attached the hand.

Stretched across from one bone to the other is the *interosseous membrane.* Most of its fibres run from the ulna upward and outward, so that the shocks received on the hand are transmitted somewhat to the ulna (Figs. 344, 345, 346). On its anterior surface run the *anterior interosseous artery and nerve.* About 2.5 cm. (1 in.) above its lower end the artery pierces the membrane to go to the back of the wrist.

MOVEMENTS OF PRONATION AND SUPINATION

The radius revolves on the ulna about an axis which passes through the centre of the head of the radius above and the styloid process of the ulna below, which line if prolonged would pass through the ring finger (Fig. 339). In pronation, the hand lies with the palm down and the radius is crossed diagonally over the ulna; the bones are close together (Fig. 340). In supination the hand lies with the palm up, the bones lie parallel to one another and widely separated (Fig. 341). In the midposition the radius lies above the ulna and the space between them is at its maximum. The difference in this respect between midpronation and complete supination is slight. The head of the radius rotates in the orbicular ligament, the lower end of the radius revolves around the head of the ulna and rests on the interarticular triangular fibrocartilage. The range of movement is from 140 degrees to 160 degrees. The radius is pronated by the pronator teres and pronator quadratus muscles. It

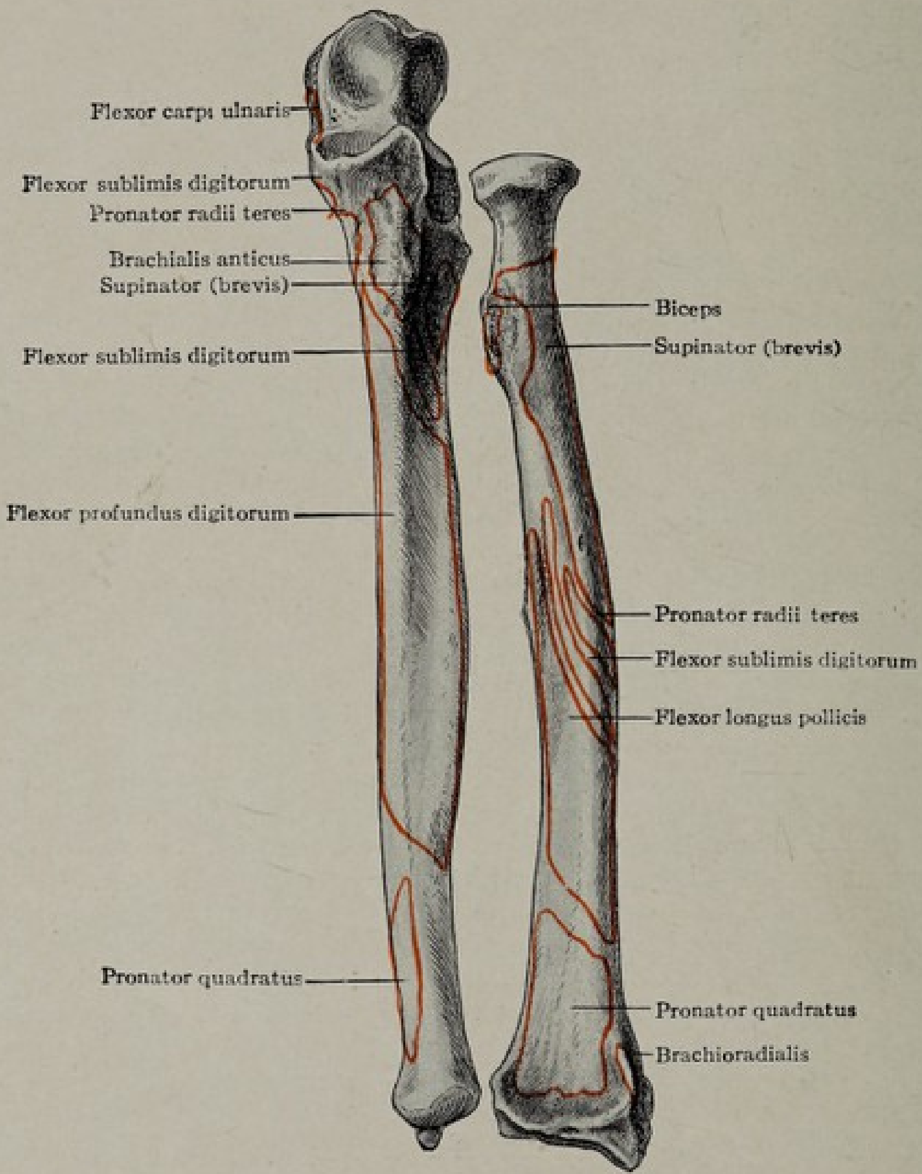


FIG. 338.—Anterior view of radius and ulna with areas of muscular attachments.

is supinated by the brachioradialis, supinator (brevis), and biceps muscles. Some of the other muscles also aid slightly in these movements, especially the flexor carpi radialis in pronation. In fractures the preservation of the interosseous space is essential for the proper performance of pronation and supination; hence anything which tends to encroach on it, as displacement of the fragments or their position as influenced by the position of the hand, is to be guarded against.

The muscles of supination are much stronger than those of pronation; for this reason instruments intended to be used in a rotary manner turn from the inside toward the outside; that is, in the direction of supination. The screw-driver is an example.

MUSCLES OF THE FOREARM

The movements of the hand and fingers are so intricate and complex as to necessitate a large number of muscles for their performance. It is probably easiest in order to understand the construction of the forearm to study these muscles in reference to their functions.

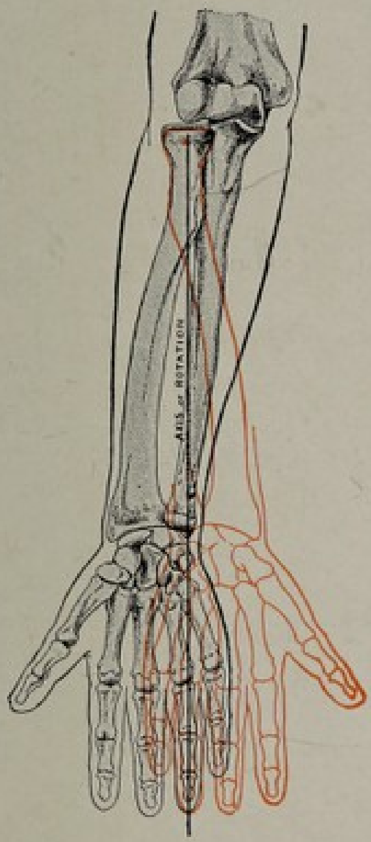


Fig. 339.—The axis of rotation in pronation and supination.

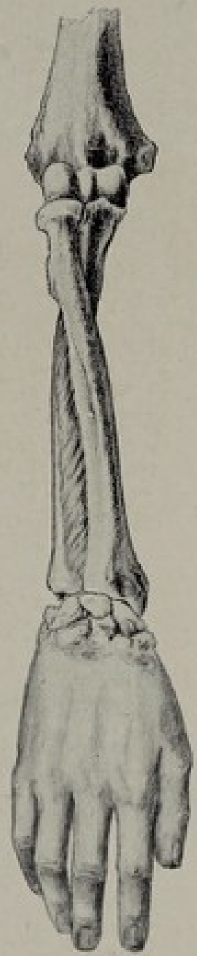


Fig. 340.—Position of the bones of the forearm when the hand is in the position of pronation.

Fig. 341.—Position of the bones of the forearm when the hand is in the position of supination.

The muscles which occupy the forearm form three groups, which have separate functions: (1) to flex and extend the fingers; (2) to flex and extend the wrist; (3) to pronate and supinate the hand.

1. THE FLEXORS AND EXTENSORS OF THE FINGERS

The fingers are moved by two sets of muscles, a long set arising from the forearm and a short set which is confined to the hand. At present we are concerned only with the long extensors and flexors which are found in the forearm.

The Flexors of the Fingers

The flexors of the fingers consist of three separate groups of muscles: (1) the *flexor profundus digitorum* and *flexor longus pollicis,* which insert into the distal phalanges; (2) the *flexor sublimis digitorum*; (3) the *palmaris longus* which, spreading out into the palmar fascia, is attached to the heads of the metacarpal bones and blends with the capsules of the metacarpophalangeal joints. It is an additional perforated flexor muscle (Fig. 342).

1. The **flexor profundus digitorum** is composed of four slips, one for each finger, and the **flexor longus pollicis** (Fig. 343) is a fifth slip that supplies the thumb. The flexor profundus arises from the anterior and outer surface of the ulna and interosseous membrane while the flexor longus pollicis arises from the anterior

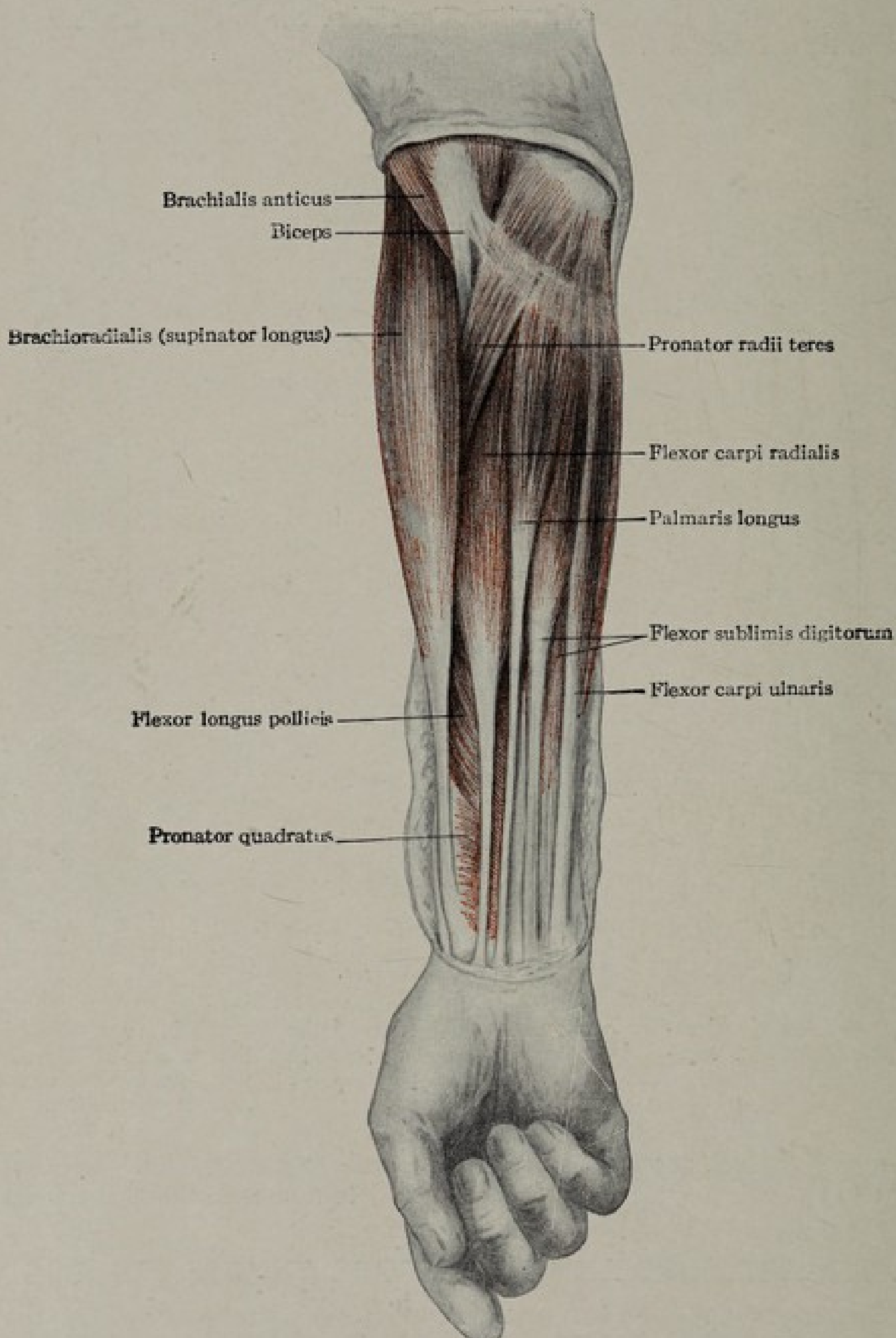


Fig. 342.—Superficial view of the anterior muscles of the forearm.

surface of the radius and interosseous membrane and occasionally a slip may arise from the coronoid process of the ulna and the medial condyle of the humerus. Their tendons pass through slits in the flexor sublimis digitorum opposite the proximal phalanges to insert into the bases of the distal phalanges. The lateral half of the profundus is supplied by the anterior interosseous branch of the median nerve and the medial half of the ulnar. The flexor pollicis longus is supplied by the anterior interosseous.

2. The **flexor sublimis digitorum** arises from the medial (internal) condyle of the humerus, the coronoid process, the intermuscular septa, and the oblique line of the radius and divides into four tendons which split in front of the proximal phalanges to allow the profundus to pass through and then unite again and insert

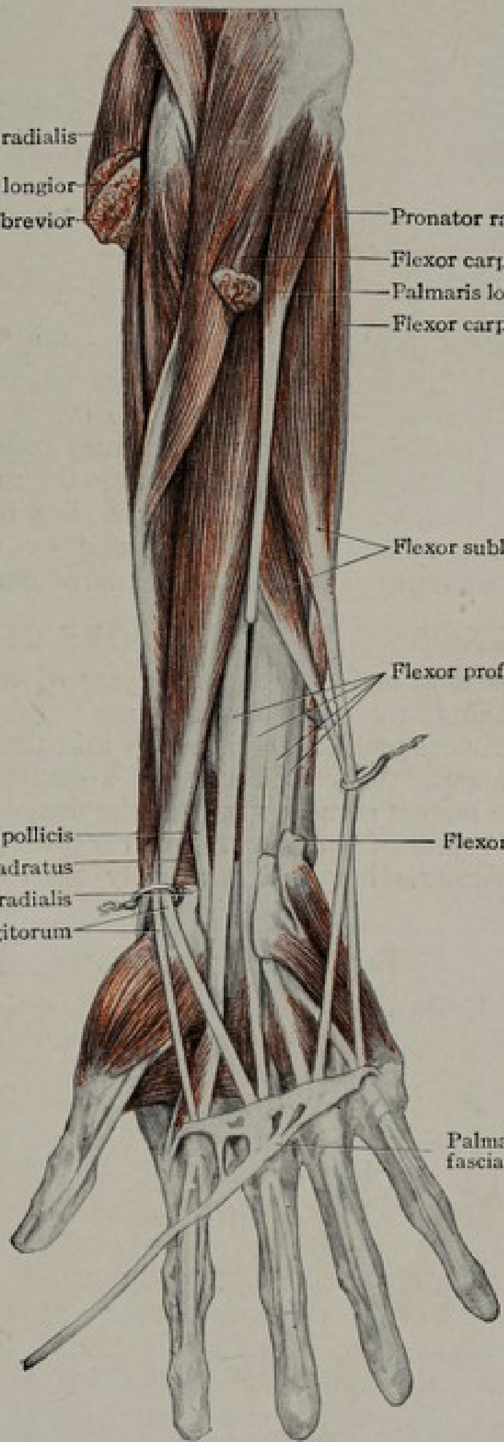


FIG. 343.—Dissection showing the muscles of the forearm, especially the long flexor muscles of the fingers.

into the sides of the middle phalanges. There are only four instead of five slips, because the thumb has no middle phalanx but only proximal and distal ones (Fig. 343). The nerve supply is through the median.

3. The **palmaris longus** arises from the medial (internal) condyle of the humerus and intermuscular septa and inserts into the palmar fascia, which is attached to the base of the proximal phalanges, to the heads of the metacarpal bones,

and blends with the capsules of the metacarpophalangeal joints. It is thus seen to be a perforated muscle exactly like the flexor sublimis, which it also resembles in function; its attachment is not so far forward. Traction on it tends to flex the proximal phalanx and make tense the palmar fascia. The nerve supply is through the median. The palmaris longus is not infrequently absent and sometimes its tendon may be double.

The Extensors of the Fingers

The extensors of the thumb and fingers arise from the lateral (external) condyle and posterior surface of the ulna, radius, interosseous membrane, and intermuscular septa.

Three separate slips forming the **extensor longus pollicis, extensor brevis pollicis,** and **extensor ossis metacarpi pollicis** go to the thumb. The longus inserts into the distal phalanx, the brevis into the proximal, and the ossis into the metacarpal bone of the thumb.

The **extensor communis digitorum** divides into four slips, one for each finger. The slip to the index is reinforced by an additional one called the **extensor indicis proprius muscle.** The slip to the little finger is reinforced by the **extensor minimi digiti (ext. digiti quinti proprius) muscle.** They divide on the dorsum of the proximal phalanges into three parts, the middle one inserts into the base of the middle phalanx, while the two lateral slips insert into the base of the distal phalanx. All these muscles are innervated by the musculospiral, either through the main root or through the posterior interosseous portion of it.

2. THE FLEXORS AND EXTENSORS OF THE WRIST

The muscles which flex and extend the fingers of course also move the hand as a whole, but in addition to these muscles there are five others,—two flexor muscles and three extensor muscles,—which are inserted into the bones of the metacarpus and not into the phalanges. When these muscles contract they tend to move the whole hand and not the fingers alone. They are the *flexor carpi radialis, flexor carpi ulnaris, extensor carpi radialis longior, extensor carpi radialis brevior,* and *extensor carpi ulnaris.* The palmaris longus has already been described as a flexor of the fingers.

Flexors of the Wrist

Flexor Carpi Radialis.—The two flexors of the wrist, the flexor carpi radialis and the flexor carpi ulnaris, are both superficial muscles lying directly beneath the skin. The flexor carpi radialis arises from the medial (internal) condyle of the humerus and intermuscular septa and lies between the pronator radii teres externally and the palmaris longus internally. It runs obliquely across the forearm, striking the wrist at about the junction of the middle and outer thirds. It lies next to and to the outer side of the palmaris longus tendon and to the ulnar side of the radial artery and inserts into the front of the base of the second metacarpal bone (Fig. 344). The nerve supply is through the median. The tendon of the muscle is an important guide to the median nerve at the wrist, the nerve lying between this tendon on its outer side and the tendon of the palmaris longus to its inner side.

Flexor Carpi Ulnaris.—The flexor carpi ulnaris arises by two heads, one from the common tendon of the medial (internal) condyle and the other from the olecranon process and upper two-thirds of the ulna. The two heads are separated by the ulnar nerve, which passes down in the groove between the medial condyle and olecranon process. The muscle passes straight down the anterior and inner surface of the ulna to insert first into the pisiform bone and unciform process and then to continue over to the base of the fifth metacarpal bone. The pisiform bone is a sesamoid bone in the tendon of the flexor carpi ulnaris muscle. The nerve supply is through the ulnar.

Both the flexor carpi radialis and the flexor carpi ulnaris flex the hand at the wrist. When the ulnaris alone acts it tends to tilt the hand inward; when the radialis acts alone it tends to incline the hand outward. Being superficial, these muscles are both important landmarks and guides to the arteries and nerves.

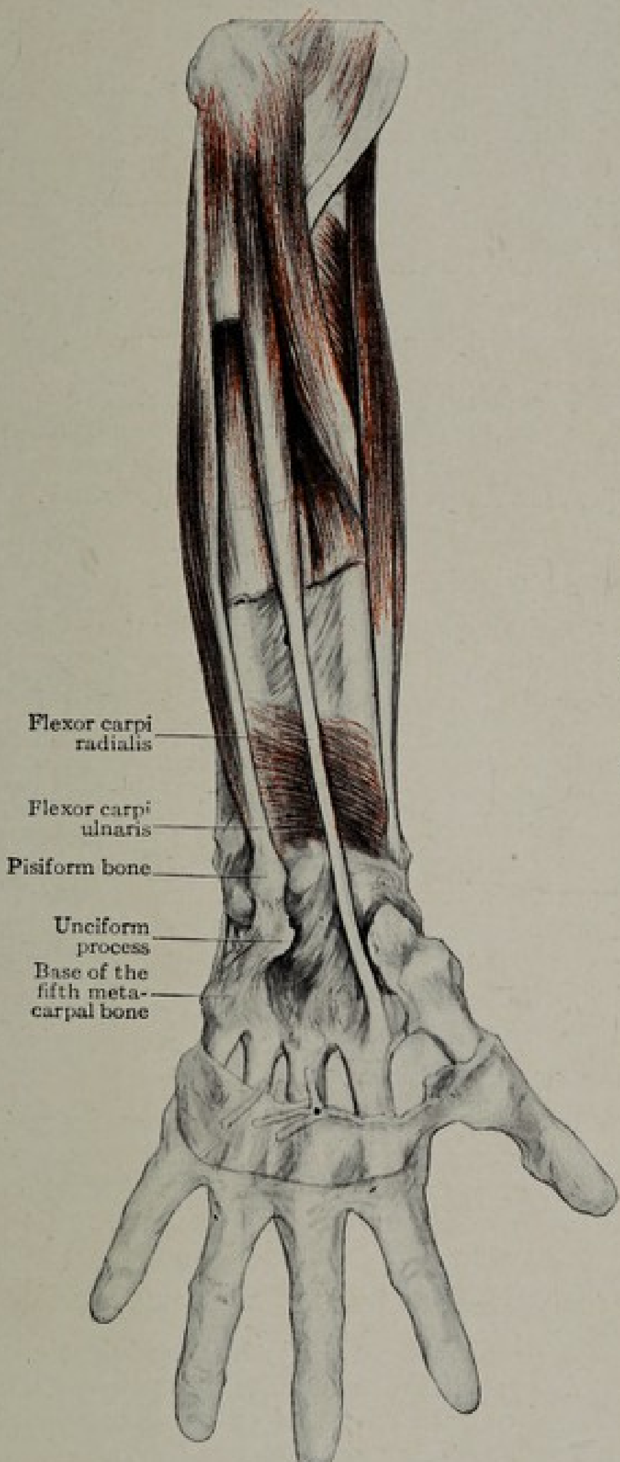


Fig. 344.—The flexor muscles of the wrist.

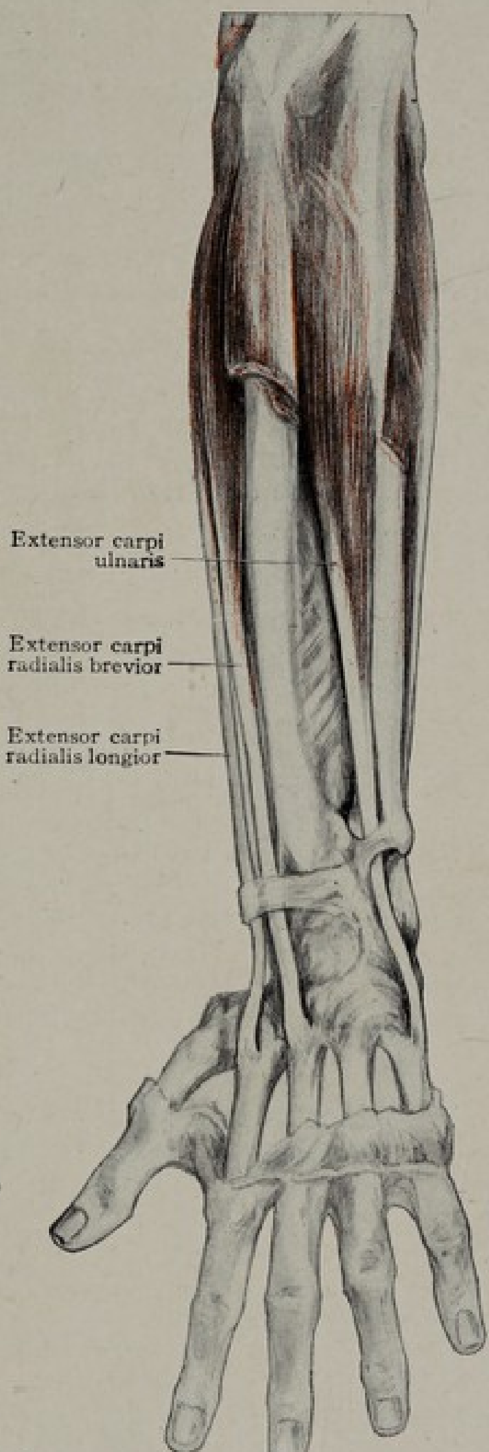


Fig. 345.—The extensor muscles of the wrist.

Extensors of the Wrist

Extensor Carpi Radialis Longior.—The extensor carpi radialis longior arises from the lower third of the external supracondylar ridge and the lateral (external) condyle and inserts into the back of the base of the second metacarpal bone. When it contracts it tends to tilt the hand toward the radial side as well as to extend it, and, being attached to the humerus above the line of the elbow-joint, it also aids in flexing the elbow.

Extensor Carpi Radialis Brevior.—The extensor carpi radialis brevior arises from the common tendon of the lateral condyle and fascia, and running down parallel to the longior muscle, inserts into the base of the third metacarpal bone. It is covered by the extensor carpi radialis longior muscle and lies on the supinator (brevis). It acts as a pure extensor of the wrist (Fig. 345).

Extensor Carpi Ulnaris.—The extensor carpi ulnaris arises by two heads, one from the lateral (external) condyle and the other from the posterior surface of the ulna through the fascia common to it, to the flexor carpi ulnaris, and to the flexor profundus digitorum. It inserts into the base of the fifth metacarpal bone. It extends the wrist and tilts the hand toward the ulnar side.

These extensors of the wrist are supplied with either the radial (musculospiral) nerve or its posterior interosseous branch.

3. PRONATORS AND SUPINATORS OF THE HAND

The movements of pronation and supination have already been described (page 343). They are performed by five muscles, two pronators and three supinators. The pronators are the *pronator radii teres* and the *pronator quadratus*. The supinators are the *brachioradialis* (*supinator longus*), the *supinator* (*brevis*), and the *biceps*.

Pronators of the Hand

Pronator Radii Teres.—The pronator radii teres arises by two heads, one from the medial (internal) condyle and the other, much smaller, from the inner surface of the coronoid process. The median nerve passes between these two heads. The muscle crosses the forearm obliquely and inserts by a flat tendon into the middle of the outer surface of the radius. It rotates the radius inward and tends to draw it toward the ulna and flex it on the humerus. The influence of this muscle is marked in displacing the radius when fractured.

Pronator Quadratus.—The pronator quadratus arises from the volar (palmar) surface of the lower fourth of the ulna and inserts into the lateral and anterior surface of the radius. By its contraction it rotates the radius toward the ulna and in cases of fracture tends to draw the bones together and thus endanger the integrity of the interosseous space (Fig. 346). The nerve supply of both of the above muscles is through the median.

Supinators of the Hand

Brachioradialis (*Supinator Longus*).—The brachioradialis arises from the upper two-thirds of the lateral (external) supracondylar ridge of the humerus and inserts into the base of the styloid process of the radius. When the hand is in a state of pronation, contraction of the brachioradialis will tend to supinate it. It also acts as a flexor of the elbow, as has already been pointed out. It is superficial and is an important guide both to the radial (musculospiral) nerve and to the radial artery. The nerve supply is through the musculospiral.

Supinator (*S. brevis*).—The supinator arises from the lateral condyle, the external lateral and orbicular ligaments, and the triangular surface of the ulna below the lesser sigmoid cavity. It winds around the posterior and external surfaces of the radius and inserts into the upper and outer portion, covering its head, neck, and shaft as low down as the insertion of the pronator radii teres muscle. It lies deep down beneath the mass of extensor muscles and supinates the radius. It is pierced by the deep branch of the radial (posterior interosseous) nerve which bears the same relation to it as does the external popliteal nerve to the peroneus longus muscle in the leg. The nerve supply is through the posterior interosseous branch of the musculospiral.

Biceps Muscle.—The biceps muscle has already been described. Arising by its long head from the upper edge of the glenoid cavity and by its short head from the coracoid process it inserts into the posterior portion of the tubercle of the radius. While its main function is that of flexion of the elbow, still, from the manner in which it winds around the tubercle of the radius, it acts as a powerful supi-

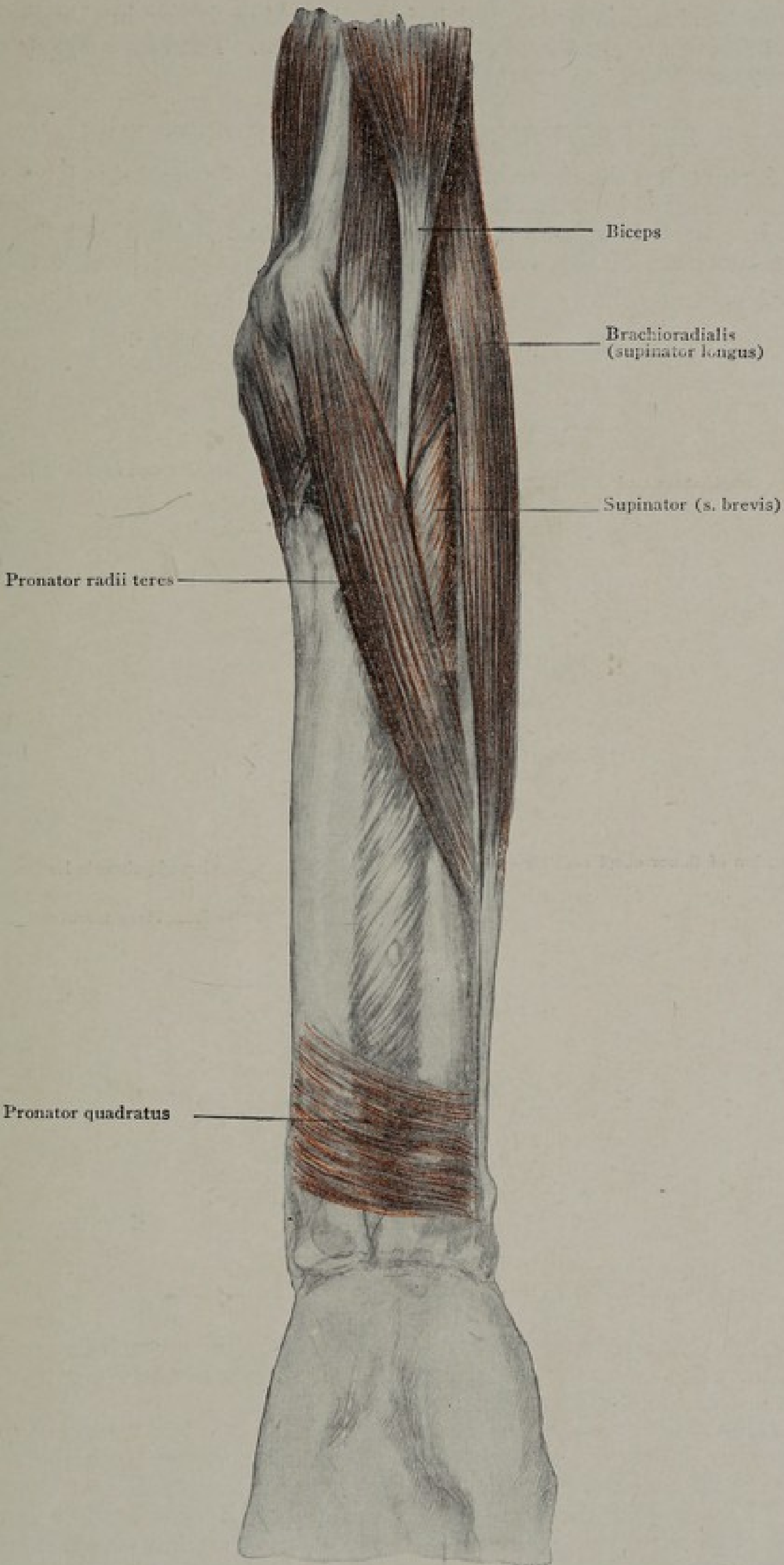


FIG. 346.—The pronator and supinator muscles of the left forearm.

nator when the hand is prone and it is a disturbing factor in the displacements which occur in fractures of the bones of the forearm. The nerve supply is through the musculocutaneous.

SURFACE ANATOMY OF THE FOREARM

The forearm has the shape of a somewhat flattened cone, being large above and small below. This is because the bellies of the muscles lie above and their tendons below. Most of the muscles of the forearm go to the hand and fingers. The prehensile functions of the hand require a strong grasp; hence it is that we find

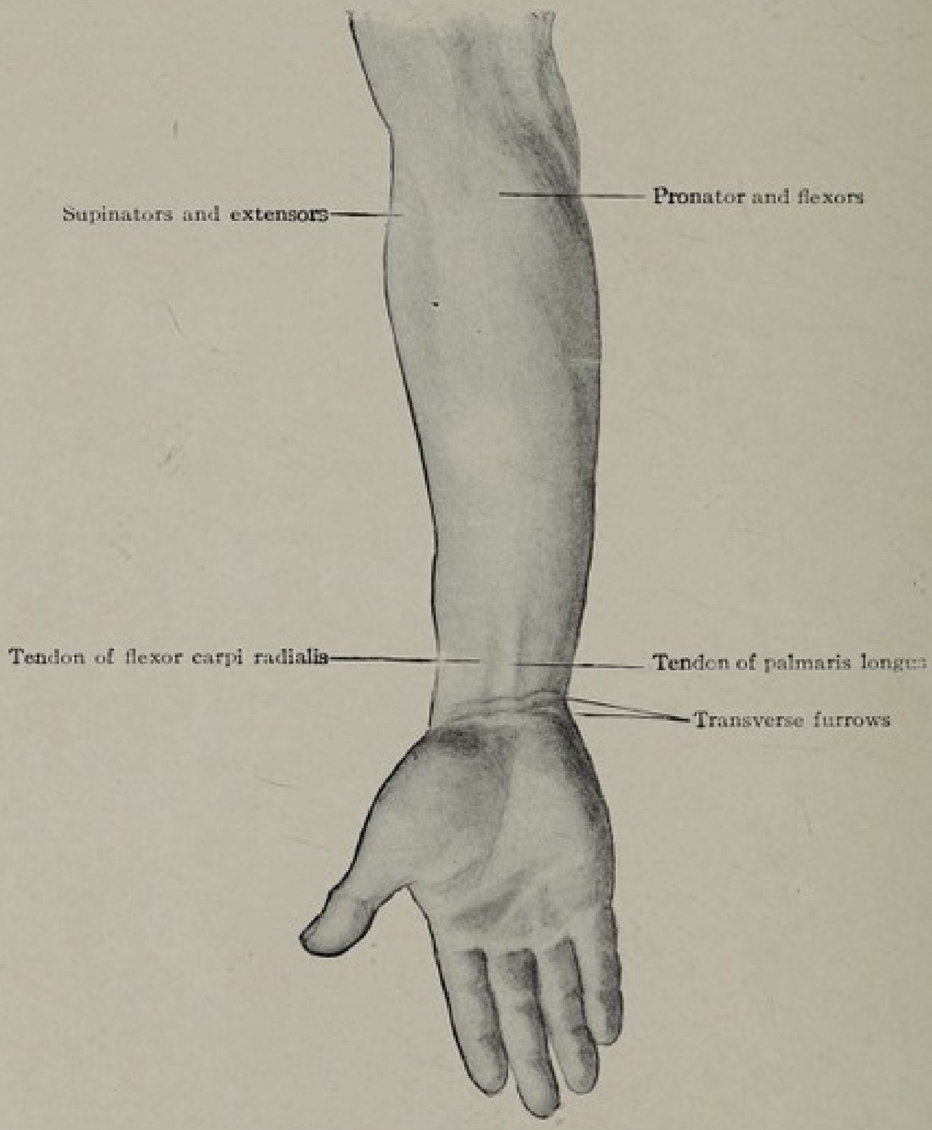


Fig. 347.—Surface anatomy of the forearm.

the flexor muscles on the anterior surface of the forearm much larger and more powerful than the extensors posteriorly, and the bones of the forearm, the radius and ulna, nearer the surface posteriorly.

Anterior Surface.—Anteriorly nothing is to be felt except muscles and tendons. The extent to which these can be outlined depends on the absence of subcutaneous fat and the degree of development and contraction of the individual muscles. The skin of the forearm is loose and thin. Through it can be seen anteriorly, the median vein going up the middle and the radial vein winding around the back of the wrist and crossing the outer edge of the radius about its middle. On the inner side near the elbow the anterior and posterior ulnar veins are visible passing posteriorly.

Sometimes there is a slight depression on the inner side below the medial (internal) condyle which is caused by the bicipital fascia holding the muscle down. The biceps tendon can be felt at the bend of the elbow, and immediately below it for the distance of 5 cm. (2 in.) can be felt a hollow, the antecubital fossa. The mass of muscles between it and the ulna on the inside and posteriorly are the flexors and pronator radii teres; the mass of muscles on the outer side between it and the radius posteriorly are the extensors, supinator (brevis), and brachioradialis. The inner edge of the brachioradialis is indicated by a line drawn from the outer side of the biceps tendon to the outer surface of the styloid process of the radius. A line from the medial (internal) condyle running obliquely across the forearm to the middle of the radius indicates the pronator radii teres muscle. A line from the medial condyle to the middle of the wrist indicates the palmaris longus muscle; it is sometimes absent. Another line from the same point above to a centimetre to the radial side of the palmaris longus tendon at the wrist indicates the flexor carpi radialis muscle. The tendons of both these muscles can readily be seen. A line drawn from the medial (internal) condyle to the pisiform bone at the wrist indicates the anterior edge of the flexor carpi ulnaris muscle.

Having located the superficial muscles the arteries and nerves can be traced. The brachial artery bifurcates about a finger's breadth below the bend of the elbow. A line drawn from the inner edge of the biceps tendon, or a point midway between the two condyles, to the anterior surface of the styloid process of the radius indicates the course of the radial artery. In the upper half of the forearm it is overlapped by the edge of the brachioradialis. In the lower half it is uncovered by muscle and lies in the groove formed by the brachioradialis on the outer side and the flexor carpi radialis on the inner. The ulnar artery describes a marked curve toward the ulnar side until it reaches the middle of the forearm, when it passes down in a straight line from the medial (internal) condyle to the radial side of the pisiform bone.

The median nerve runs down the middle of the forearm, lying beneath the groove separating the palmaris longus and flexor carpi radialis tendons. The ulnar nerve runs from the groove between the medial (internal) condyle and olecranon process above to the radial or outer side of the pisiform bone below. It lies to the ulnar side of the ulnar artery in the lower half of the forearm. The rounded muscular mass between the edge of the flexor carpi ulnaris and the palmaris longus is formed by the flexor sublimis digitorum muscle (Fig. 347).

Posterior Surface.—The posterior surface differs from the anterior in the bones being more conspicuous—they are subcutaneous. Of the two the ulna is the more evident. At the elbow the olecranon and the capitellum to its outer side are well marked and some distance inwardly is the medial (internal) condyle. By palpation the ulna can be traced down the forearm almost subcutaneous, running from the olecranon process, in a gentle curve toward the median line, down to its styloid process at the back of the wrist. It is covered only by the skin and superficial and deep fascias. About 3 cm. (1¼ in.) to the outer side of the olecranon can be felt the lateral (external) condyle and capitellum. If the elbow is extended a dimple is seen just below the capitellum; it marks the position of the head of the radius, and by pressure the groove separating the head from the capitellum can be felt.

By placing the thumb of one hand in the dimple on the head of the radius, and rotating the hand of the patient with the other, one can feel the bone rotate and thus be assured that the radius is intact. Whenever fracture of the radius is suspected this is the procedure resorted to in order to determine whether or not it is broken.

The radius can be followed only for an inch or so below the dimple, when it disappears beneath the muscles to again become subcutaneous on the outer side of the forearm, about its middle, from thence it can be followed more or less distinctly down to the styloid process on the outer side of the wrist.

The ulna being subcutaneous, fracture can be determined by palpating it from the olecranon down the back of the forearm to the styloid process.

The line of the ulna is usually marked by the presence of a groove. To the ulnar side of the groove lie the flexor carpi ulnaris and the other flexors; to the radial side lie the extensor carpi ulnaris and the other extensors (Fig. 348).

From the dimple marking the head of the radius a groove in the muscles can be felt which runs to the middle of the outer surface of the radius. Anterior or to the palmar side of this groove lie the brachioradialis and extensor carpi radialis longior with the supinator (brevis) beneath. The muscles posterior or between the groove and the ulna are the extensor carpi radialis brevior, extensor communis digitorum, and extensor carpi ulnaris. Passing over the lower third of the outer side of

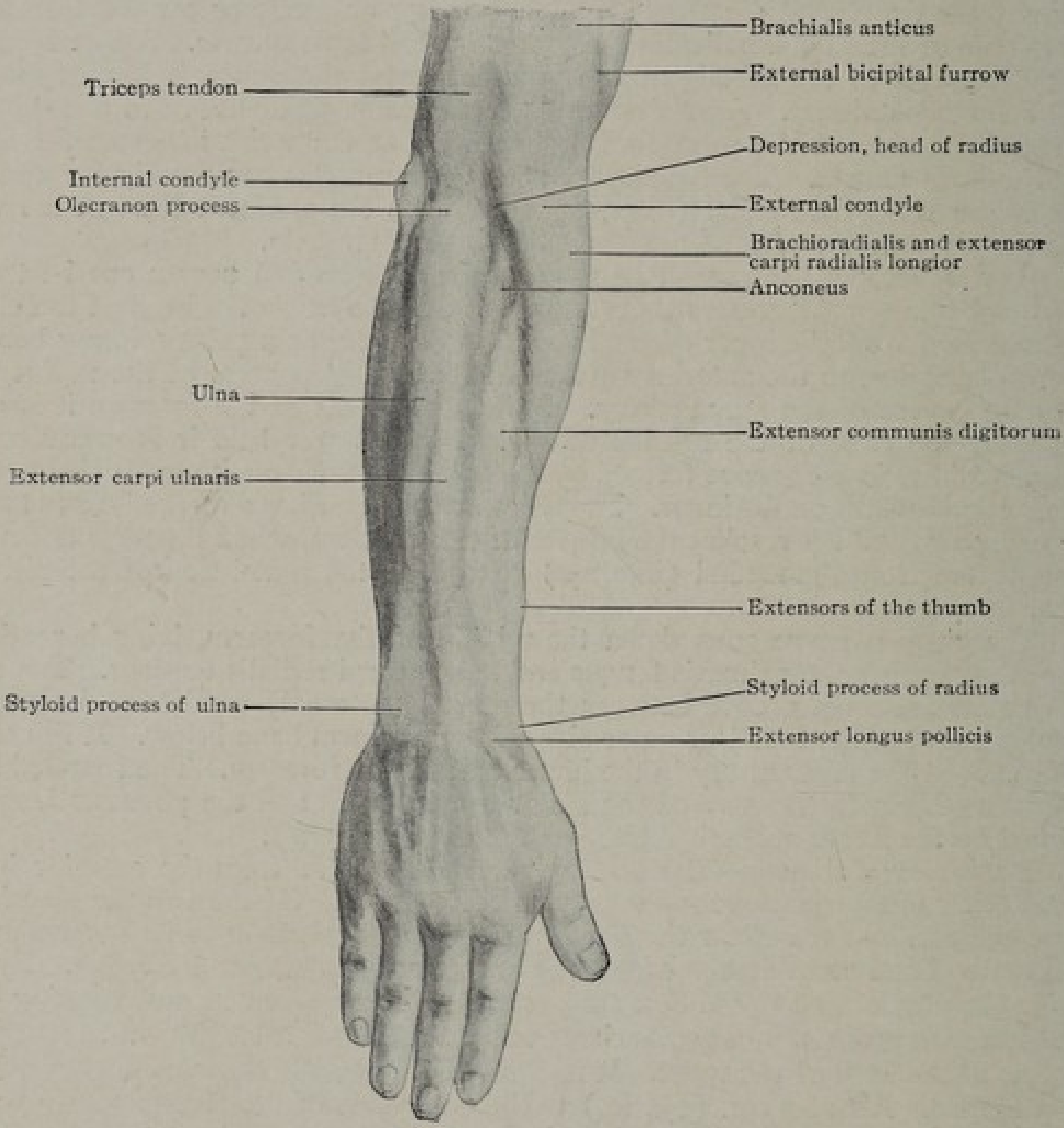


Fig. 348.—Surface anatomy of the back of the forearm.

the radius are the tendons of the extensor ossis metacarpi pollicis and extensor brevis pollicis muscles. As they are here subcutaneous, this is the point at which creaking can be felt when they are affected with tenosynovitis.

ARTERIES OF THE FOREARM

A knowledge of the arteries of the forearm is necessary on account of the troublesome hemorrhage which they cause when wounded.

At the bend of the elbow, a finger's breadth below the crease and opposite the neck of the radius, the brachial artery divides into the *radial* and *ulnar arteries*. These are continued through the forearm to enter the hand, the ulnar anteriorly over the annular ligament and the radial posteriorly through the "anatomical snuff-box," on the dorsal surface of the hand.

The **ulnar artery** is larger than the radial and in its upper half it describes a curve with its convexity toward the ulnar side passing beneath the pronator radii teres and superficial flexor muscles arising from the medial (internal) condyle. It is

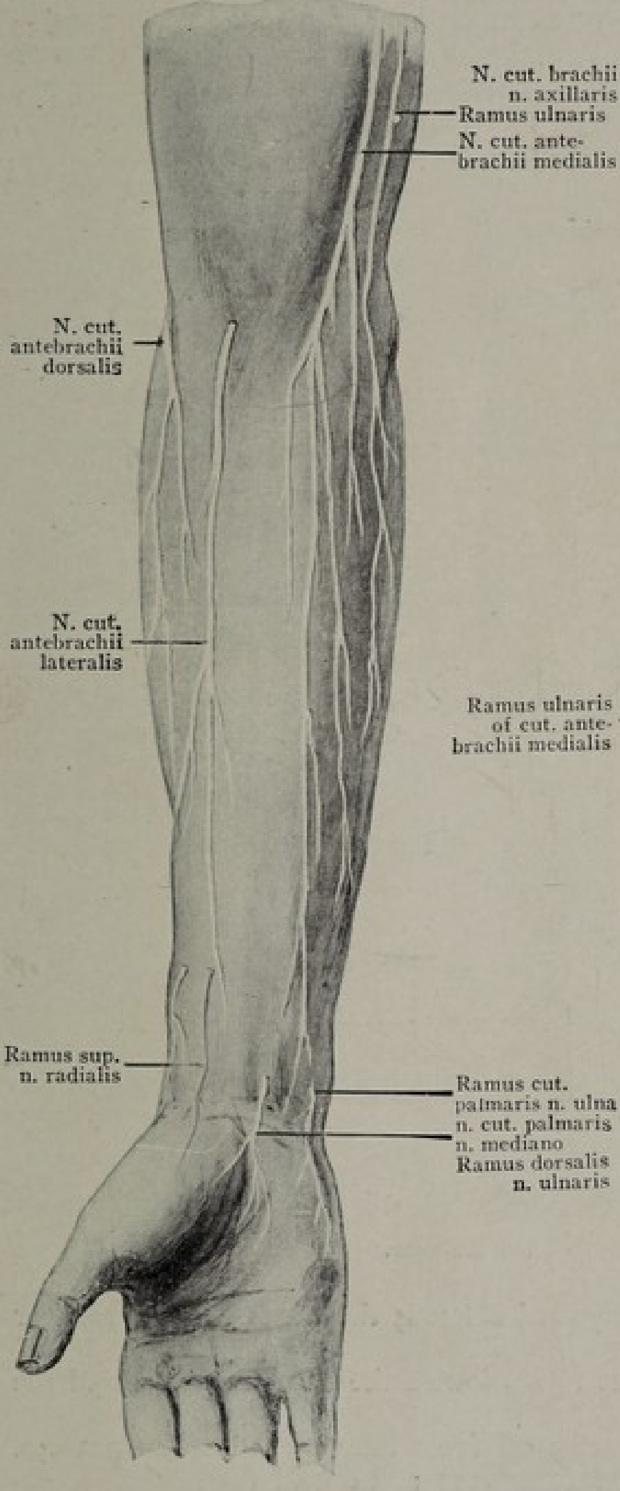


Fig. 349.—Distribution of cutaneous nerves on anterior aspect of forearm.

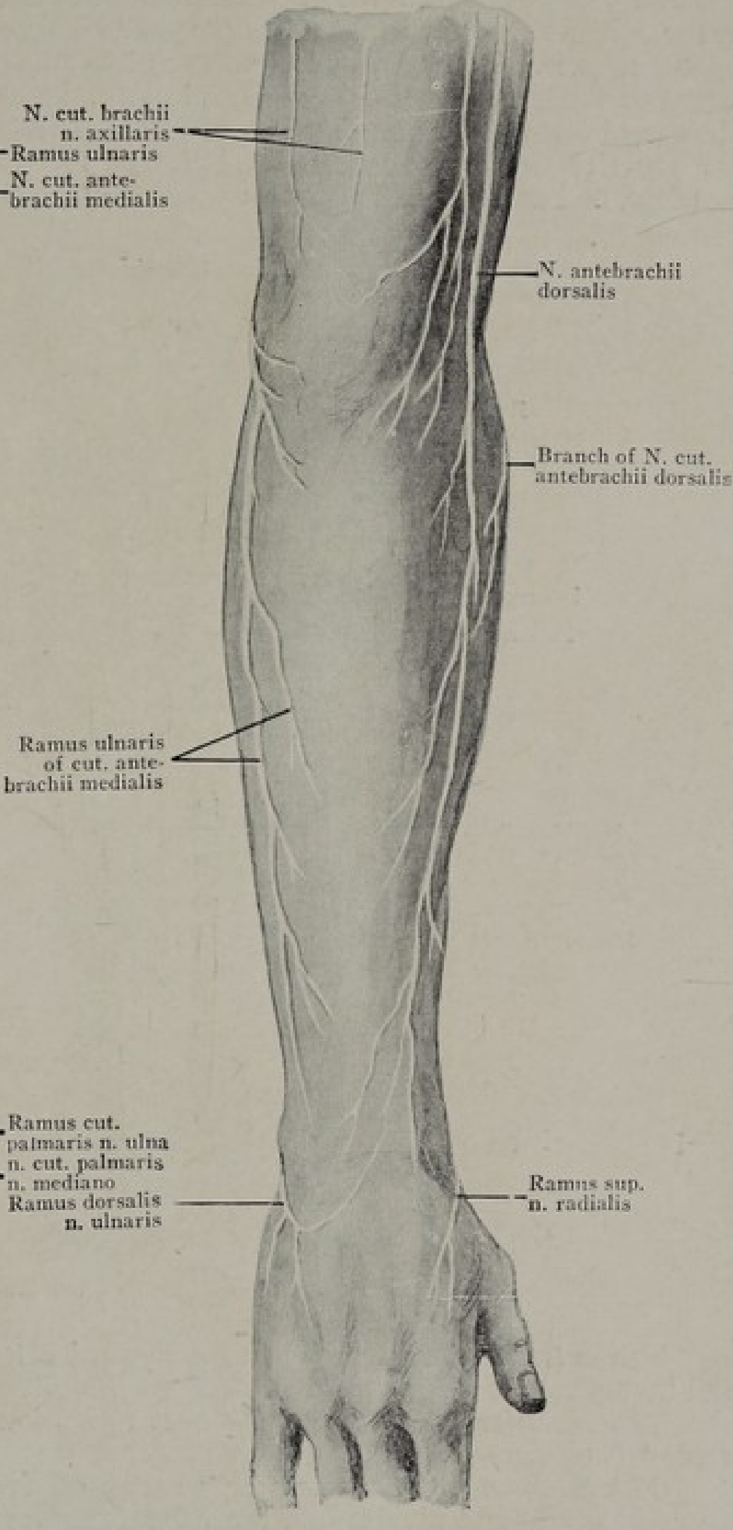


Fig. 350.—Distribution of cutaneous nerves of posterior aspect of arm.

accompanied by venæ comites but not by any nerve in this portion of its course. Just above the middle of the forearm the ulnar nerve joins the artery, lying to its ulnar side, and accompanies it down into the hand. In the lower half of its course the ulnar artery lies to the radial side of the flexor carpi muscle, being slightly overlapped by it. The flexor sublimis on the radial side also tends to overlap it. The covering of the artery, partially at least, by these muscles, together with the thickness of the deep fascia and the lack of a proper bony support beneath, cause the pulse from the ulnar artery to be less distinctly felt than that from the radial. When the artery passes beneath the pronator radii teres muscle it is crossed by the median nerve, which lies superficial to the artery, and is separated from it by the deep head of the muscle. The collateral circulation after ligation is restored by the anastomosis of the branches of the radial and ulnar, the interosseous vessels and those of the carpal and palmar arches. The branches of the ulnar artery in the forearm are the anterior and posterior ulnar recurrents, the common interosseous, muscular, nutrient, and anterior and posterior ulnar carpal branches (Fig. 351).

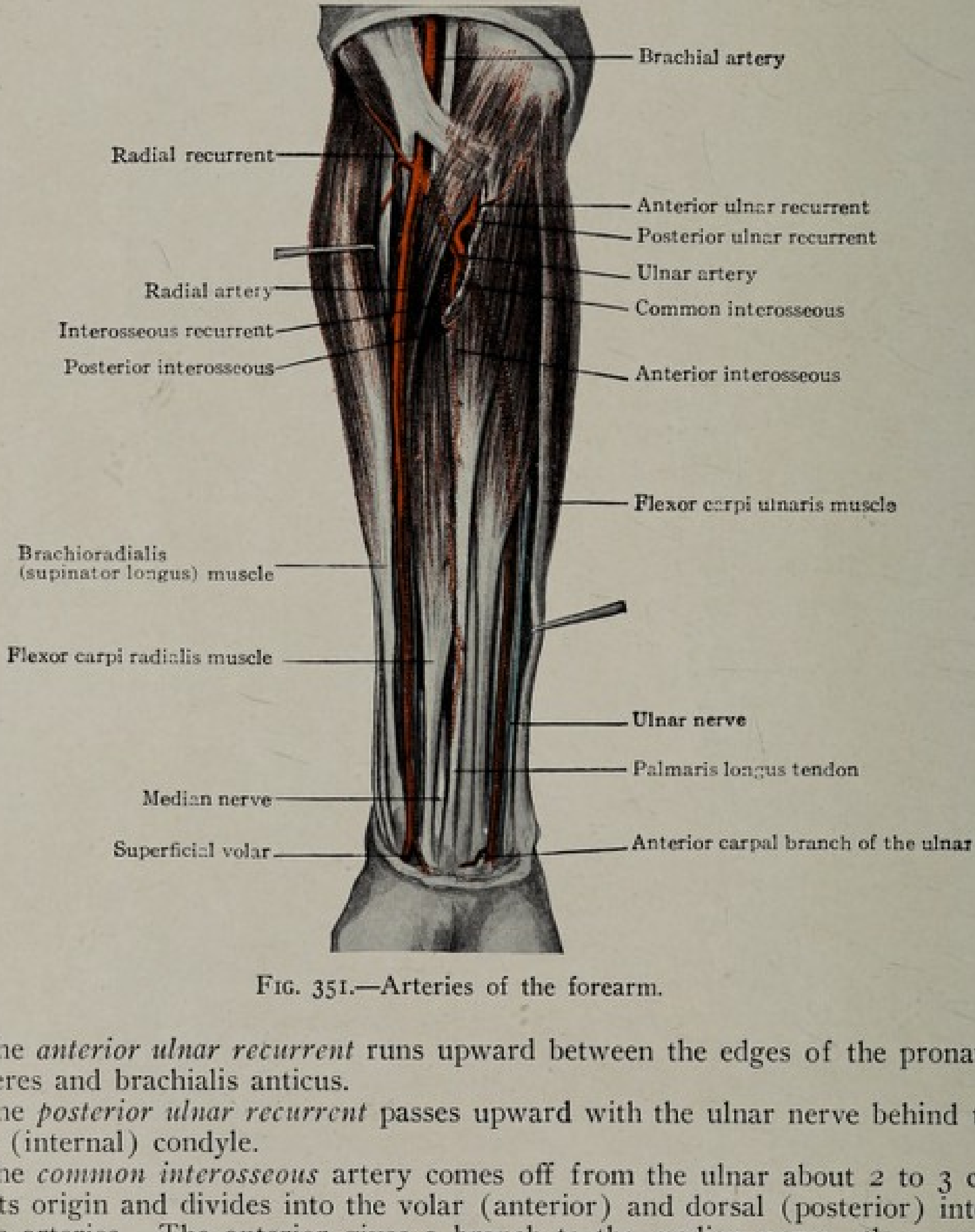


FIG. 351.—Arteries of the forearm.

The *anterior ulnar recurrent* runs upward between the edges of the pronator radii teres and brachialis anticus.

The *posterior ulnar recurrent* passes upward with the ulnar nerve behind the medial (internal) condyle.

The *common interosseous* artery comes off from the ulnar about 2 to 3 cm. from its origin and divides into the volar (anterior) and dorsal (posterior) interosseous arteries. The anterior gives a branch to the median nerve—then comes nervi mediani—a nutrient branch to the radius, and, on reaching the upper edge of the pronator quadratus, sends a posterior terminal branch through the membrane and an anterior terminal branch into the muscle. The posterior interosseous passes beneath the oblique ligament to the back of the forearm and gives off the interosseous recurrent, which runs up between the lateral (external) condyle and the olecranon and then gives branches to the various muscles.

The *anterior ulnar carpal* is quite small. It arises just above the annular ligament and passes under the long flexors to anastomose with the anterior radial carpal and the anterior interosseous to form the anterior carpal network.

The *posterior ulnar carpal*, also small, arises just above the fusiform bone and winds around the ulna under the flexor carpi ulnaris to anastomose with the posterior radial carpal and the posterior interosseous to form the dorsal carpal network.

The **radial artery**, though smaller than the ulnar, seems to be a direct continuation of the brachial because it proceeds in the same general direction while the ulnar branches off to one side. It is divided into three parts according to the region it traverses, viz., the forearm, the wrist, and the hand. It describes a slightly outward curved line from a finger's breadth below the middle of the crease of the elbow to a point on the front of the radius at the wrist, 1 cm. ($\frac{2}{5}$ in.) inside of its styloid process. It is superficial in nearly its entire extent, being overlapped only by the edge of the brachioradialis (supinator longus) in its upper third. This muscle lies to its outer side all the way down to the styloid process. In the middle third the cutaneous branch of the radial nerve lies close to the outer side of the artery, but in the lower third the nerve leaves it to become subcutaneous, passing more toward the dorsum.

To the inner side of the artery is the pronator radii teres muscle in its upper third and the flexor carpi radialis for the rest of its course. At the wrist it rests on the anterior surface of the radius, a centimetre to the inner side of its styloid process. By compressing the vessel against the bone its pulsations can be readily felt, and here is where the finger is applied in taking the pulse.

The branches of the radial artery are the recurrent, muscular, anterior radial carpal, posterior radial carpal and superficial volar.

The *radial recurrent* arises from the radial soon after its origin and follows the radial nerve, in the groove between the brachialis anticus and brachioradialis.

The *anterior carpal* is a small branch which joins with the corresponding branch of the ulnar and anterior terminal branch of the anterior interosseous to form a so-called anterior carpal arch which anastomoses with branches of the deep palmar arch to supply the bones and joints of the carpus.

The *superficial volar* leaves the radial artery just before it crosses the external lateral ligament. It pierces the muscles of the thumb to anastomose with a superficial branch of the superficial palmar arch. Sometimes this artery is so large that it can be seen pulsating as it passes over the thenar eminence from the wrist downward.

The *posterior radial carpal* is a small branch given off as the radial passes beneath the extensor os metacarpi pollicis (abductor pollicis longus). It takes part in the formation of the posterior carpal arch. The collateral circulation after ligation is similar to that given after ulnar ligations.

Ligation of the Ulnar Artery in the Forearm.—The ulnar artery between the elbow and wrist is so large that when wounded it may require ligation in any part of its course. On account of the artery being deep beneath the flexor muscles in the upper part of the forearm, the middle and lower portions are to be preferred for ligation (Fig. 352).

Ligation in the Upper Third.—This is done only for wounds. The superficial incision may be made in a line from the medial (internal) condyle to the middle of the outer border of the radius. The fibres of the pronator radii teres are to be parted, not cut, and the artery searched for crossing the wound almost at right angles, on a line from the bifurcation of the brachial artery to the middle of the inner border of the ulna. The artery is to be found lying between the superficial flexor muscles arising from the medial condyle and the deep muscles arising from the two bones and the interosseous membrane. It lies beneath the ulnar head of the pronator radii teres, which separates it from the median nerve, which is superficial to it and nearer the median line.

Ligation in the Middle Third.—The ulnar artery reaches the inner edge of the ulna at its middle and from thence downward runs in a straight line from the medial (internal) condyle to the radial side of the pisiform bone. It lies directly under the deep fascia and along the radial or outer edge of the flexor carpi ulnaris muscle, which can be made tense by extending and abducting the hand.

In the upper part of its middle third the artery lies under the edge of the flexor sublimis digitorum and the ulnar nerve lies a short distance to its ulnar side. In the lower part of the middle third the artery and nerve lie close together, the nerve being next to the tendon of the flexor carpi ulnaris. The tendon to the radial side of the artery is one of the slips of the flexor sublimis digitorum.

If difficulty is found in recognizing the edge of the flexor carpi ulnaris after the skin incision has been made the hand should be extended and abducted: this may

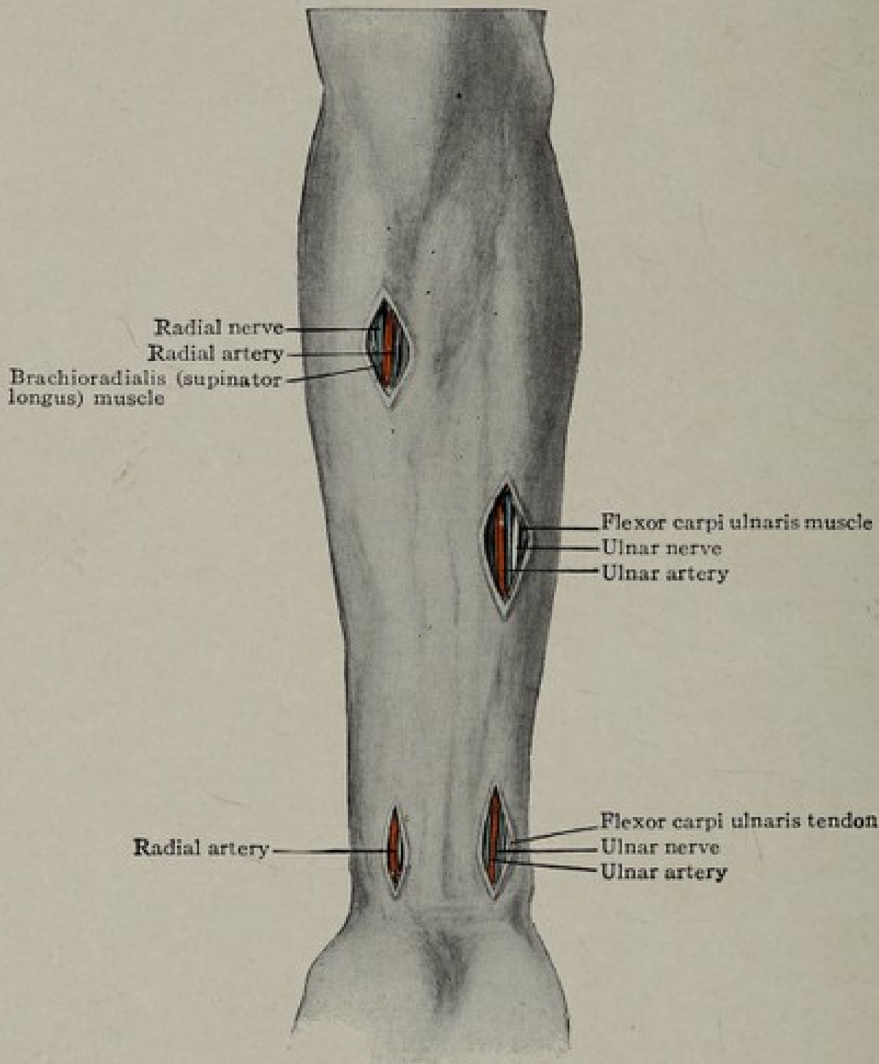


FIG. 352.—Ligation of the radial and ulnar arteries.

make the muscle tense. Sometimes the intermuscular space is marked by a white or yellow (fatty) line or by some small blood-vessels coming to the surface at this point. The edge of the flexor carpi ulnaris is more likely to be to the radial than to the ulnar side of the skin incision. The needle is to be passed between the nerve and artery from the ulnar toward the radial side.

Ligation in the Lower Third.—The relations of the artery are practically the same as in the lower part of the middle third. In the superficial fascia one of the branches of the anterior ulnar vein may be encountered. It should not be mistaken for the artery. The artery lies beneath the deep fascia; the edge of the flexor carpi ulnaris muscle should be clearly recognized. The deep fascia is apt to have two layers, one passing from the edge of the flexor carpi ulnaris over the flexor sublimis while the other, more superficial, goes more to the anterior surface of the annular ligament. Care is to be taken not to work laterally between these layers but to isolate and recognize the edge of the flexor carpi ulnaris muscle.

The nerve lies between the tendon and artery, which latter has venæ comites. The needle is to be passed from the ulnar toward the radial side.

NERVES OF THE FOREARM

Injuries of the large nerves of the forearm are followed by much disability. When these nerves are divided in wounds it is desirable to unite the ends immediately. The reunion of nerve-trunks which have been divided some time previously is also occasionally necessary.

These operations demand on the part of the surgeon an accurate knowledge of the topography of the part. For our purpose we may consider the nerves of the forearm as being of two kinds—trunks and branches. There are two main trunks—

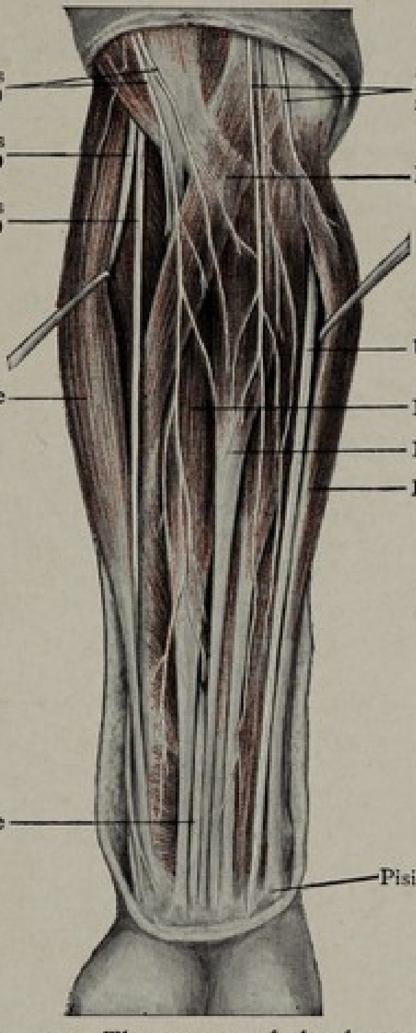


FIG. 353.—The nerves of the forearm.

the median and the ulnar; the superficial (radial), and deep (interosseous) branches of the radial (musculospiral), and forearm branches of the median and ulnar form the second class. The main trunks simply traverse the forearm to be distributed in the hand, therefore injury to them shows itself by disabilities of the hand. The branches supplying the forearm, if of sensation, rarely give rise to any serious effects requiring surgical interference. The motor branches enter the muscles of the forearm so high up that paralysis of the long muscles usually is seen only when the nerves are injured in the region of the elbow or above. Each of these nerves, however, supply some of the intrinsic muscles of the hand and an injury to the nerves in the lower part of the forearm results in loss of the finer movements of the hand. The high entrance is caused by the bellies of the muscles being above and the part below being tendinous (Fig. 353).

The Median Nerve.—The median nerve at the elbow-joint lies internal to the brachial artery, which lies next and internal to the biceps tendon. It lies on the brachialis anticus muscle and under the bicipital fascia. The nerve then enters the forearm by passing between the two heads of the pronator radii teres the deep head of which separates the nerve from the artery. The artery curves to the ulnar side of the forearm while the nerve has a slight curve to the radial side. The nerve then proceeds downward between the superficial and deep layers of muscles. It lies on the flexor profundus digitorum and is covered by the flexor sublimis; about 5 cm. above the annular ligament it becomes more superficial and lies in the interval between the palmaris longus and flexor carpi radialis tendons and touching them. It then passes under the annular ligament to enter the palm of the hand. A branch of the anterior interosseous artery called the *comes nervi mediani* accompanies the nerve in the forearm.

It is frequently injured in lacerations of the wrist. I have seen two cases where its proximal end was sutured to the distal end of the palmaris longus tendon.

Branches.—The median nerve gives off muscular, volar (anterior) interosseous, and palmar cutaneous branches, besides those in the hand.

The superficial flexor muscles, with the exception of the flexor carpi ulnaris, are supplied by branches directly from the main trunk near the elbow; the one to the pronator radii teres usually comes off above the elbow. The deep flexor muscles, with the exception of the inner half of the flexor profundus digitorum, are supplied by the volar (anterior) interosseous branch.

The *volar (anterior) interosseous nerve* leaves the main trunk of the median just below the elbow and accompanies the volar (anterior) interosseous artery, lying on the interosseous membrane between the flexor longus pollicis and the flexor profundus digitorum. It supplies the flexor longus pollicis and radial half of the flexor profundus muscles as well as the pronator quadratus.

The *palmar cutaneous branch* is given off just above the annular ligament and comes to the surface between the palmaris longus and flexor carpi radialis tendons. It passes over the annular ligament to be distributed to the thenar eminence and palm of the hand.

Wounds of the Median Nerve.—The median nerve may be wounded in any part of its course in the forearm, but it is superficial only in its lower portion for about 5 cm. above the wrist. From this point up it is covered by the flexor sublimis, the flexor carpi radialis and the pronator radii teres.

While these muscles tend to protect it from injury, if the traumatism is extensive enough to divide it they render it all the more difficult to treat. Accompanying the nerve, especially in the middle third of the forearm, is the comes nervi mediani artery, which may cause annoying bleeding. Careless attempts to secure the artery may injure the nerve. Should the nerve be divided high up in the forearm, paralysis ensues of all the superficial flexor muscles except the flexor carpi ulnaris, and of the deep muscles, except the inner half of the flexor profundus. This includes the pronator radii teres and pronator quadratus, so that the power of pronating the forearm is impaired as well as the ability to flex the hand. The flexor carpi ulnaris and outer half (that going to the ring and little fingers) of the flexor profundus digitorum are the only flexor muscles not paralyzed, since these are supplied by the ulnar nerve.

The paralyzed flexor muscles atrophy and the size of the forearm is much reduced. There will also be impairment of the functions of sensation and motion in the hand, which will be alluded to later.

Operations.—To find the nerve in the *upper third* of the forearm an incision is made at the inner side of the biceps tendon and brachial artery. The median nerve will be found to the inner side of the artery and followed down. When the pronator radii teres is reached it may be drawn to the ulnar side or divided.

The fascial expansion covering the flexor sublimis is next reached; it must be slit up and the muscular fibres parted to reach the nerve lying between it and the flexor profundus, with the volar (anterior) interosseous nerve alongside.

To reach the nerve in the *middle third* of the forearm the guide should be the palmaris longus tendon. The nerve lies in a line joining the outer edge of the palmaris longus tendon at the wrist and the brachial artery at the inner side of the biceps tendon at the elbow. If an incision is made in the middle of the forearm one comes down on the belly of the flexor carpi radialis muscle and it is necessary to part its fibres as well as those of the flexor sublimis beneath. If one goes a little lower down and places the incision between the palmaris longus and flexor carpi radialis, the latter may be drawn outward, but the fascia covering the flexor sublimis will still have to be incised. The comes nervi mediani artery will be found accompanying the nerve.

To reach the nerve in its *lower third* is the easiest because it becomes superficial about 5 centimetres (2 in.) above the wrist. Here it lies either beneath the tendon of the palmaris longus or between it and the flexor carpi radialis. The incision should be made between the muscles. A layer of deep fascia will be found beneath them, which must be incised. From this point the nerve can be followed up beneath the flexor sublimis or downward beneath the annular ligament. Care is to be taken not to disturb the tendons of the flexor sublimis at the wrist. Care must be taken when suturing wounds in this region to carefully identify every structure. Too often the proximal end of the palmaris longus has been sutured to the distal end of the median.

The Ulnar Nerve.—The ulnar nerve passes downward in the groove on the back of the medial (internal) condyle and between the condyle and olecranon process. It passes between the two heads of the flexor carpi ulnaris muscle, a position it shares with the inferior profunda and posterior ulnar recurrent arteries, and is covered by the above muscle, lying on the flexor profundus digitorum; when half way down the forearm it becomes superficial and lies under or at the edge of the flexor carpi ulnaris muscle with the ulnar artery and flexor sublimis muscle to its outer or radial side. The ulnar artery joins the nerve just above the middle of the forearm. Just below the elbow the artery gives off the posterior ulnar recurrent branch, which passes with the nerve behind the medial condyle. From the middle of the forearm to the wrist the ulnar nerve lies behind and to the ulnar side of the artery. It passes over the anterior annular ligament in the same relation to the artery and to the radial side of the pisiform bone.

Branches.—It gives muscular branches in the upper third of the forearm to the flexor carpi ulnaris and ulnar half of the flexor profundus digitorum muscles. It gives small articular branches to both the elbow-joint and wrist-joint.

It also gives off anterior and posterior cutaneous branches. The anterior, one or two, come off about the middle of the forearm; one supplies the anterior surface of the ulnar side of the forearm, while another called the *palmar cutaneous*, runs down the front of the artery to be distributed to the palm.

The dorsal or posterior cutaneous branch is given off about 5 cm. (2 in.) above the wrist and passes downward and backward beneath the tendon of the flexor carpi ulnaris, across the interval between the pisiform bone and styloid process of the ulna, over the tendon of the extensor carpi ulnaris, and thence to the fingers.

Wounds.—This nerve in the forearm is not infrequently wounded. It is especially liable to injury in resecting the elbow-joint. From what has been said of its course and branches it will be seen that in order for paralysis of any of the muscles of the forearm to be produced it must be injured high up in its upper third. Then the flexor carpi ulnaris and inner half of the flexor profundus digitorum will be paralyzed. If injured lower down the only muscular paralysis which will ensue is that of the short muscles of the hand which it supplies.

If the nerve is divided above the middle of the forearm the anterior cutaneous nerves will be involved. If divided between that point and 5 cm. above the wrist the anterior cutaneous escapes but the dorsal cutaneous branch is paralyzed. Below this latter point the dorsal cutaneous branch escapes and the muscular and sensory disturbances produced are on the palmar surface (except the dorsal interossei muscles).

Because of the situation of the ulnar nerve behind the mesial condyle it is subject to injury by pressure while a patient lies on the operating table. Great care should be exercised that the arms be placed properly and the elbows sufficiently well padded that there will be no pressure on the ulnar nerve.

Operations.—In all operations on the nerve remember that its course is a straight line from the medial condyle to the radial edge of the pisiform bone. In the lower half of its course it lies along the outer (radial) edge of the flexor carpi ulnaris and this tendon will serve as a guide to it. It is here covered only by skin and superficial and deep fasciæ, though it may be overlapped by either the artery or the edge of the tendon. If it is desired to reach the nerve in its upper half it can be followed either from above downward or from below upward, the fibres of the flexor carpi ulnaris muscle which cover it being split to the extent necessary for proper exposure. Below the middle of the forearm the ulnar artery lies to its radial side. Near the elbow the posterior ulnar recurrent artery accompanies it upward, but the nerve is far removed from the ulnar artery in this part of its course.

The Volar Interosseous Nerve and the Superficial and Deep Branches of the Radial (Musculospiral).—In addition to the large nerve-trunks of the median and ulnar the forearm contains the volar (anterior) interosseous, and the deep and superficial branches of the radial (musculospiral) nerve.

The *volar (anterior) interosseous* nerve leaves the median opposite to or below the bicipital tubercle of the radius; it lies on the interosseous membrane to the ulnar side of the accompanying volar interosseous artery. It supplies the outer half of the flexor profundus digitorum and the flexor longus pollicis muscles, between which it lies, and the pronator quadratus muscle. It is rarely wounded alone.

The deep and superficial branches are the continuation of the radial (musculospiral) which divides in the groove between the brachioradialis (supinator longus) and brachialis anticus muscles just above the elbow.

The *deep branch (posterior interosseous)* is the larger and is a muscular nerve; the superficial branch (radial) is smaller and is solely sensory. The deep branch passes down under the brachioradialis and extensor carpi radialis longior and brevior muscles and then enters the substance of the supinator (brevis) through which it passes to supply the extensor muscles on the back of the forearm and terminates in a gangliform enlargement on the back of the wrist. It supplies all the muscles on the back of the forearm except the anconeus, brachioradialis, and extensor carpi radialis longior, which are supplied directly from the radial (musculospiral) nerve. In removing the head of the radius, in resection of the elbow, the supinator (brevis) is to be carefully raised from the bone so as to carry the nerve with it and avoid injuring it. Injury to this nerve causes paralysis of the extensors, and wrist-drop follows.

The *superficial branch (radial)* is purely a nerve of sensation. It passes down almost in a straight line and lies to the outer side of the radial artery at the junction of its upper and middle thirds. It lies alongside of the artery to its outer side in its middle third and then, about 7 or 8 cm. (3 in.) above the wrist, quits the artery, passes beneath the tendon of the brachioradialis, and divides into two branches which supply sensation to the dorsal (radial) side of the hand and fingers.

In operating on the radial artery in the middle third of the forearm care should be exercised not to include the nerve in the ligature with the artery.

FRACTURES OF THE FOREARM

Fractures of the forearm may involve either the radius or ulna, or both. The radius is the bone most often broken. The preservation of the interosseous space and functions of pronation and supination are prominent points in treatment.

Fractures of Both Bones.—These fractures occur either from a direct blow on the part or are due to violence in falling on the outstretched hand. They usually occur in the middle or lower third. The character of the displacement depends more on the manner in which the injury is produced than on the action of the muscles, though in some cases they also have some influence.

The main function of the forearm in addition to that of serving as a pedestal or support for the hand is to perform the movements of pronation and supination. It is these movements that are most apt to be impaired in cases of fracture. When both bones are fractured the interosseous membrane still remains, running transversely from one bone to that of the opposite side. Therefore, while it is common enough to find the fractured ends displaced toward one another, thus narrowing or obliterating the space between them, one never sees a displacement of the fragments producing a widening of the interosseous space. In fracture of both bones four types of deformity or combinations of these types are found.

1. The fractured ends of the distal or proximal fragments may preserve approximately their normal position to one another but be displaced either anteriorly or posteriorly or else to one side. When this is the case the displacement is one simply of overlapping. If the fragments are displaced laterally from one another then the tension of the muscles draws the fragments together and causes them to overlap. There is no special direction which this displacement may take. The lower fragments may be either in front or behind or to either side of the upper ones. The position of the fragments varies according to the direction of the fracturing force.

This displacement is to be remedied by traction on the hand to overcome the muscles and bring the broken ends opposite one another, and then by direct pressure pushing them as completely as possible back into their normal position.

The shafts of both bones have muscles arising from them on both their anterior and posterior surfaces and the sharp fractured ends of the bones not infrequently get stuck in the muscular fibres and so prevent proper approximation; non-union may be produced by this cause.

2. The fractured ends of the distal or proximal fragments may be displaced toward one another, thus lessening or even obliterating the interosseous space. When the bones are intact they rest on one another at their ends, leaving a space between across which stretches the interosseous membrane. The action of this membrane in preventing a separation of the fragments has already been pointed out, and the influence on the fragments of pronation and supination will be discussed further on. The two bones,—radius and ulna,—traverse the forearm from the elbow to the wrist like two bridges, when they are broken they naturally fall inward toward one another. This approximation of the fragments is aided by the muscles, particularly the pronators and the brachioradialis.

The pronator quadratus and teres both pass from the ulna to the radius, the one at the lower and the other at the upper portion of the forearm. When they contrast they naturally tend to draw the bones toward one another. The brachioradialis, arising from the lateral (external) supracondylar ridge of the humerus and inserting into the base of the styloid process of the radius, by its contraction tends to tilt the upper end of the lower fragment toward the ulnar side.

Pressure on the bones by bandages wound around the part likewise causes them to encroach on the interosseous space, hence the desirability of splints which are wider than the forearm so that lateral pressure on the bones by the bandages is prevented.

3. The fragments may be rotated on one another in the direction of pronation or supination and, becoming united in this misplaced position, render the normal movements of rotation either much restricted or altogether impossible.

This axial rotary displacement is due either to the lower fragments being dressed in a position of pronation or to muscular action. As has already been pointed out (see movements of pronation and supination, page 343), in performing the movements of pronation and supination the ulna is the fixed bone and the radius is the movable one. When the hand is pronated the radius crosses the ulna obliquely and lies almost or quite in contact with it, thus obliterating the interosseous space. When the hand is in a position of middle or full supination the bones are widely separated. When fractures are treated in the prone position it is recognized that the callus may bind the bones together in their approximated condition and a loss of motion will result.

This is one reason why it is always required to treat these fractures with the hand midway between supination and pronation or in complete supination, in which positions the bones are widely separated. The influence of the supinator muscles, as was pointed out by Lonsdale, is also important. As has already been stated, the supinators are stronger than the pronators. When the fracture occurs above the insertion of the pronator radii teres the upper fragment is rotated outward by the biceps and supinator (brevis). There are no muscles to oppose them. On this account it is necessary to dress the fracture with the hand supinated. When the bones are broken below the middle of the forearm the pronator radii teres remains attached to the upper fragment and tends to oppose the supinating action of the biceps and supinator (brevis). Therefore the fracture is treated with the hand midway between pronation and supination. A diminution or loss of the power of pronation and supination is a common sequel of fractures of the forearm and is due either to an interference with the movement of the bones by callus or displaced fragments or by supination of the upper fragment. It is favored by treating the arm in an unfavorable position.

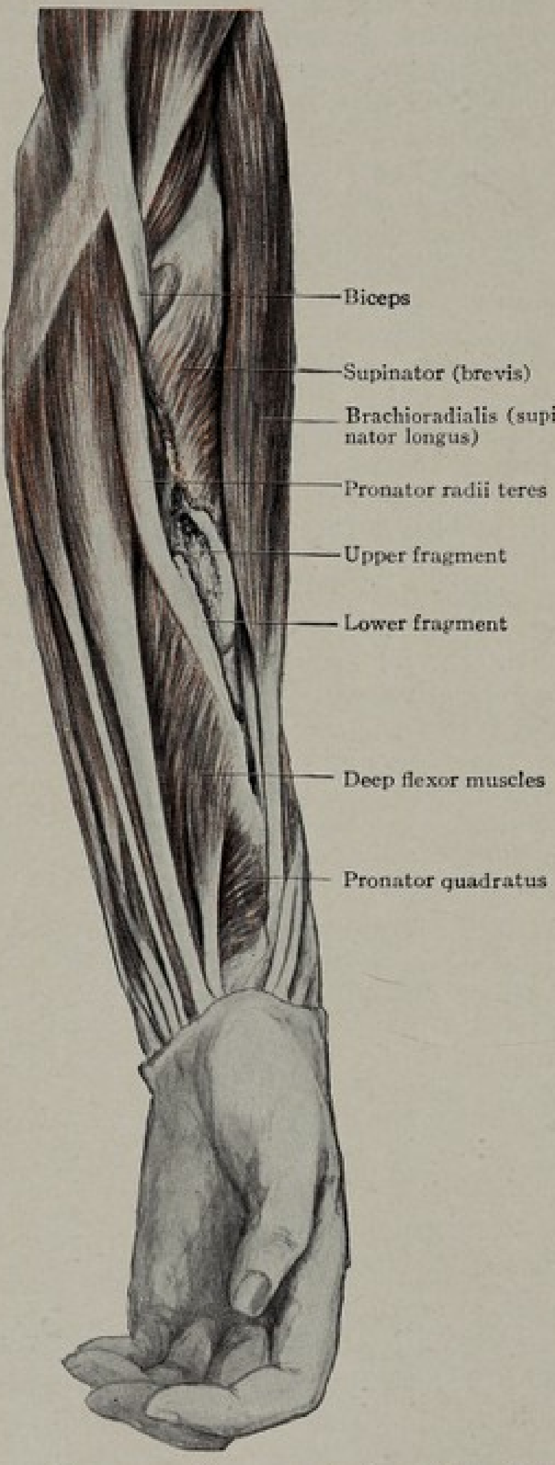


FIG. 354.—Fracture of the shaft of the radius above the insertion of the pronator radii teres muscle. The upper fragment is rotated outward by the biceps and supinator muscles.

4. The fragments may be inclined toward one another, producing an angular deformity. Simple bending at the site of injury produces this displacement. It is liable to occur if a narrow band or sling is used to support the injured member. If the hand is supported by the sling the arm sags at the seat of fracture. If the forearm is supported at the site of fracture the hand falls and an angular deformity again occurs. Treatment of the fracture with the hands in a supine position on a splint with a long sling reaching and supporting the entire length of the forearm will obviate and prevent the deformity.

Fractures of the Shaft of the Radius.—Fractures of the shaft of the radius are produced by both direct and indirect injury. The hand is attached to and articulates mainly with the radius, so that in falls on the hand the force is transmitted to the radius, and the shaft of the bone is not infrequently fractured in this manner.

These fractures are of interest from an anatomical point mainly on account of the influence of rotation and muscular action in displacing the fragments. The forearm possesses the movement of rotation; the radius is the movable bone and rotates around the ulna, hence when it is broken its fractured ends are readily displaced. Fractures of this bone are to be treated with the hand in half or full supination because in these positions the interosseous space is preserved. In pronation the radius crosses the ulna obliquely and lies close upon it and is then most liable to be bound to it by callus. A certain amount of callus or deformity may occur without interfering with the ulna opposite.

It should also not be forgotten that most muscles have more than one action. The biceps is both a flexor and supinator. The brachioradialis flexes, supinates, and exerts a directly upward traction on the outer surface of the lower end of the radius.

The fractures of the shaft of the radius may be divided into those above and those below the insertion of the pronator radii teres. This muscle inserts by a comparatively small tendon into the outer and posterior surface of the middle of the radius. The bone fractures here because it is the point of junction of the two

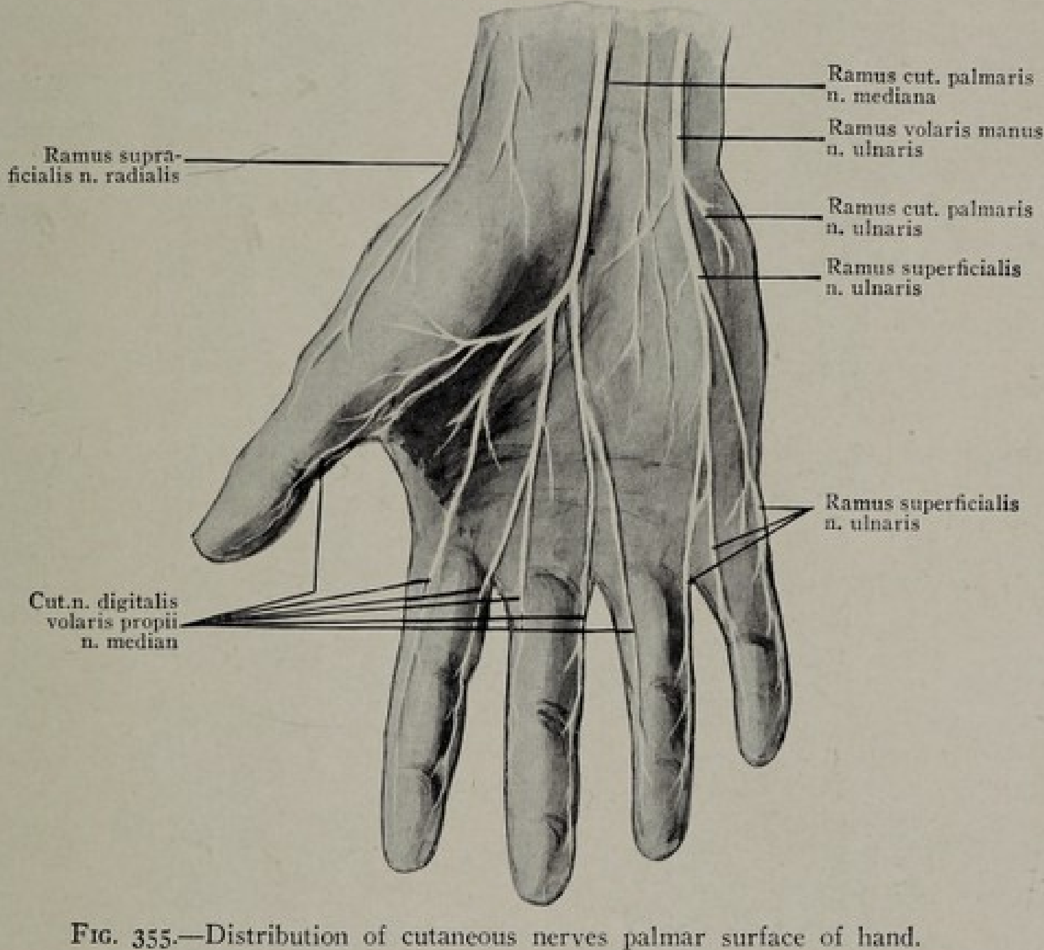


FIG. 355.—Distribution of cutaneous nerves palmar surface of hand.

secondary curves of the radius and the point of greatest curvature in the primary curve of the entire bone.

Fractures above the Insertion of the Pronator Radii Teres.—When the bone is fractured above the pronator radii teres insertion, and below the tubercle, the upper fragment is drawn forward and rotated outward by the biceps. If the fracture is down close to the upper edge of the insertion of the pronator radii teres the supinator (brevis) will assist in the supination. The lower fragment will be pronated by the pronator radii teres and quadratus. It will be drawn toward the ulna by the teres, quadratus, and also by the action of the brachioradialis. The pronator radii teres will also tend to draw the lower fragment anteriorly. The injury is to be treated with the elbow flexed to relax the biceps and in a fully supinated position (Fig. 354).

Fractures below the Insertion of the Pronator Radii Teres.—When the fracture is below the insertion of the pronator radii teres and above the pronator quadratus we have the lower fragment drawn toward the ulna by the pronator quadratus and the brachioradialis. The quadratus also tends to pronate the hand (Fig. 356[a]).

The upper fragment is displaced anteriorly by the flexing action of both the biceps and pronator radii teres. The supinator (brevis) and biceps both tend to supinate it and the pronator radii teres to pronate it. This tends to place the upper fragment midway between pronation and supination. All fractures of the radius

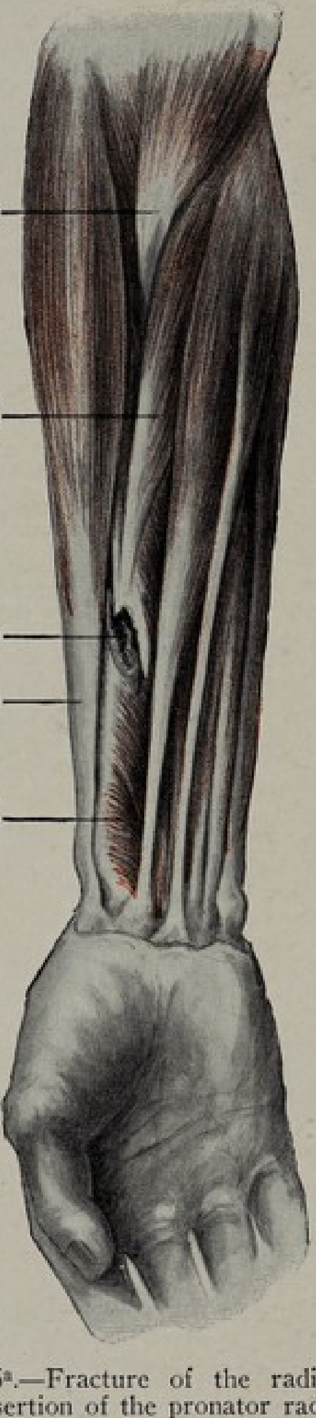


Fig. 356[a].—Fracture of the radius just below the insertion of the pronator radii teres muscle. The upper fragment is displaced directly forward in a position midway between pronation and supination.

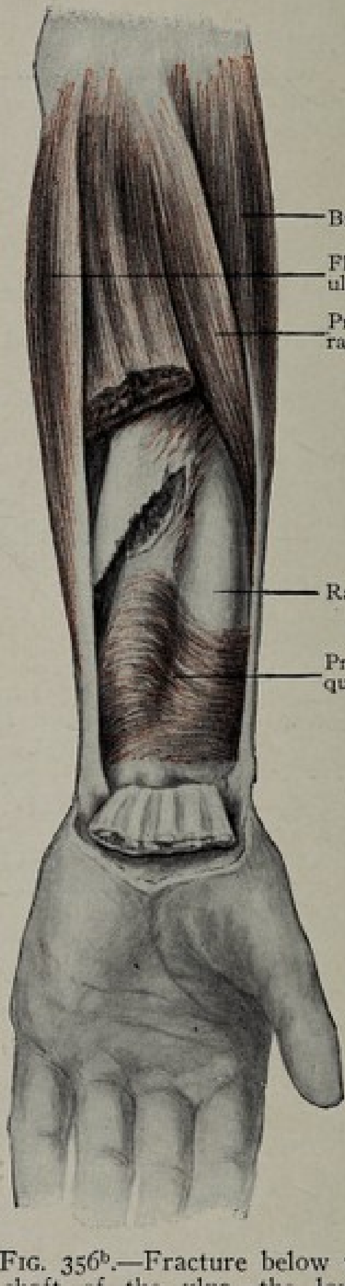


Fig. 356[b].—Fracture below the middle of the shaft of the ulna, the lower fragment drawn toward the radius by the pronator quadratus muscle.

are to be treated with the elbow flexed to relax the biceps muscle. It is to be marked that the position of the lower fragment follows the position of the hand in pronation and supination. Also that by bending the hand toward the ulnar side the lower fragment tendsto be tilted away from the ulna and thus the interosseous space is increased. Pressure with the thumb and fingers between the bones tend to increase the interosseous space and to some extent to counteract the action of the brachioradialis.

On account of the upper fragment assuming a middle position the fracture is dressed in this position with the thumb upward—an internal angular splint is used. Some surgeons prefer using the position of full supination.

The difference in the width of the interosseous space when the hand is in full supination and when it is in semisupination, though it may be slightly in favor of the latter position, is too little to give it any preference on that account.

Fractures of the Shaft of the Ulna.—The shaft of the ulna s more often broken by direct violence than is the shaft of the radius. When the arm is raised to ward off a threatened blow the thumb is toward the body and it is the ulna which is presented externally to receive the impact of the blow, hence its more frequent injury. There are two main sites of injury, one just below its middle and the other a short distance below the elbow-joint, about at the junction of its middle and upper thirds. The former results from the fact that the bone below the middle is smaller and weaker than it is above and is not so well covered by muscles. The latter is not infrequently associated with an anterior dislocation of the head of the radius.

Fractures just Below the Middle of the Shaft of the Ulna.—The bones of the forearm act as props to separate the hand and elbow. The hand is attached to the

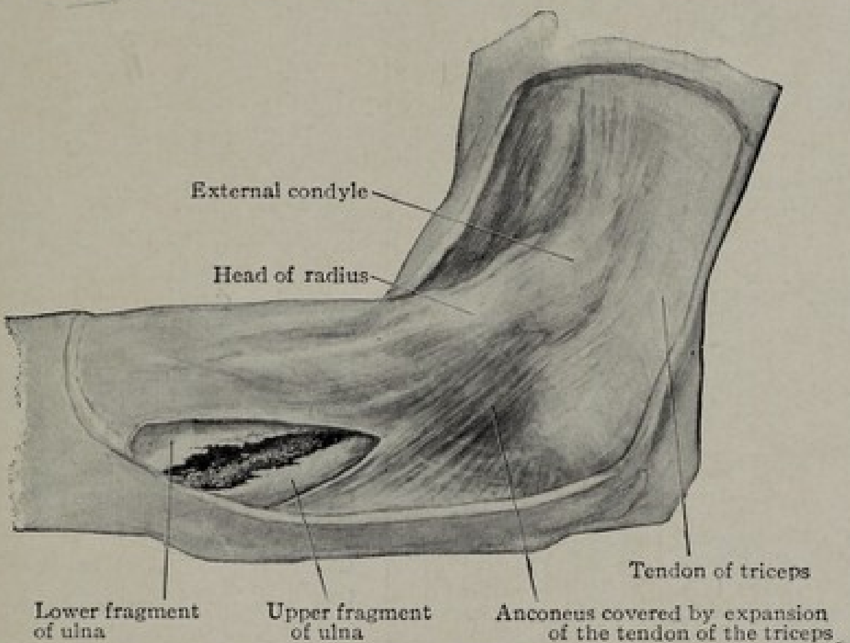


Fig. 357.—Fracture through the upper third of the ulna viewed from the outer side.

radius and the radius rests on the capitellum of the humerus, therefore even when the ulna is fractured as long as the radius and attachments of the hand are intact there is usually but little overlapping of the fragments.

The lower fragment is most often displaced to the radial side. This is due to the action of the pronator quadratus muscle (Fig. 356[b]).

The upper fragment articulating with the humerus by a pure hinge-joint cannot be displaced laterally, but the radius and hand can move bodily toward the ulna, being favored in so doing by the pronator radii teres. Thus it is seen that both upper and lower fragments have a tendency to incline toward the radius and so obliterate the interosseous space and interfere with rotation.

As to whether the lower or upper fragment will be nearer to the radius will depend upon the direction of the line of fracture. If this is from within downward and outward, toward the ulnar side, as is the more usual, then the lower fragment will be to the radial side of the upper one (see Fig. 356[b]).

The treatment of fractures in this locality should be with the hand placed in the position of full supination. Hamilton stated that he had three times seen supination lessened in this injury but never pronation. The ulna is to be pushed away from the radius by pressure made between them with the thumb and fingers and the hand bent toward the radial side.

Fracture at the Upper Third.—The radius articulates with the upper end of the ulna in the lesser sigmoid cavity. Immediately below this is a depression in the ulna called the bicipital hollow, intended to accommodate the bicipital tubercle when the forearm is pronated. At this point the bone is slightly narrowed and then widens again toward the middle. This constricted part is 7 or 8 cm. (3 in.) below the tip of the olecranon process and the spot where fracture is likely to occur. When fracture does occur here, if displacement is marked, it produces characteristic lesions. The upper fragment may be displaced either posteriorly or anteriorly.

The carrying angle (page 319) formed by the line of the arm with the line of the forearm, depends on the integrity of the humerus and ulna and their proper articulation. If the ulna is broken high up the forearm is deprived of its support on the inner side and it sags inward, thus approximating the bones, obliterating the interosseous space, and diminishing the carrying angle. In treatment care should be taken that the forearm be not allowed to incline toward the inner side.

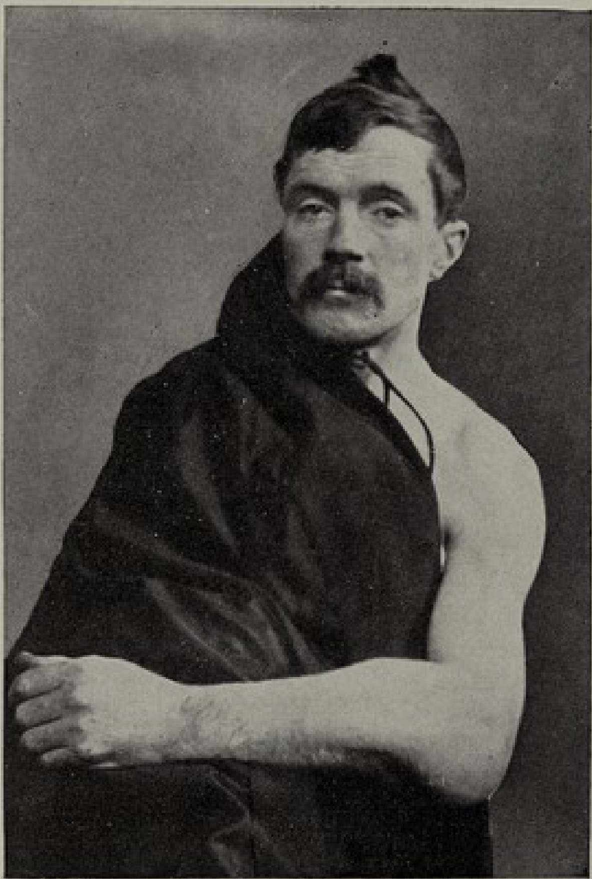


FIG. 358.—Fracture of the upper third of the ulna, with anterior angular displacement of the fragments and anterior dislocation of the head of the radius.

Displacement Posterior.—When the displacement is posterior the lower end of the upper fragment is tilted backward by the contraction of the triceps muscle. This causes a marked projection on the back of the forearm below the elbow (Fig. 357).

In treating this injury the forearm should be placed in at least partial extension (complete extension is usually not necessary) so as to relax the triceps muscle.

Displacement Anterior.—When a person receives a blow in the region of the junction of the upper and middle thirds of the ulna on its posterior surface the fragments are pushed forward and an angular deformity is produced, the apex of the angle pointing toward the anterior surface. The force of the blow is not expended entirely on the ulna but, having broken it, continues and pushes or dislocates the radius forward (Fig. 358).

In these injuries the fracture of the ulna is readily recognized, but the dislocation of the head of the radius is often overlooked. If the dislocation is not reduced subsequent flexion of the elbow will not be possible much if any beyond a right angle. The contraction of the biceps not only favors this luxation by pulling the radius forward but tends to cause it to recur after replacement.

Reduction is to be attempted by supinating and flexing the forearm to relax the biceps and making direct pressure anteroposteriorly on the radius to force the head back into place. The radius may be kept in place by dressing the arm with the elbow in a position of complete flexion.

AMPUTATION OF THE FOREARM

The lower half of the forearm is so largely tendinous that musculocutaneous flaps are unsuitable; by the time the tendons are cut short there is little tissue left but skin, superficial and deep fascia, and a few muscular fibres.

Amputation should be performed as low down as one can so as to save as much as possible. Artificial appliances, so useful in the lower extremity, are, practically of little value in the upper. The preservation of the power of pronation and supination is to be accomplished when the condition permits. The pronator radii teres has its insertion in the middle of the radius and if the division of the bone is below that point rotary movements will be preserved.

The surgeon should be acquainted with the position of the main arteries and nerves. Four arteries will require ligation: the radial, ulnar, volar (anterior), and dorsal (posterior) interosseous. Their position as well as that of the nerves will vary accordingly to the site of the amputation. The median and ulnar are the only nerves that require shortening.

Amputation Through the Upper Third.—The radial artery is to be looked for near the surface under the deep fascia, just beneath the edge of the brachioradialis muscle.

The ulnar artery lies between the superficial and deep flexor muscles somewhat toward the ulnar side of the median line.

The volar interosseous artery lies in front of the interosseous membrane.

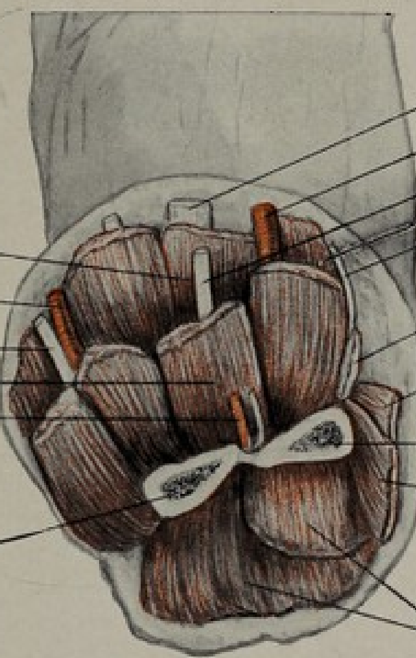


Fig. 359.—Amputation about the middle of the forearm.

The dorsal interosseous lies between the superficial and deep muscles on the back of the forearm more toward the ulnar side.

The median nerve is to be sought in the middle line of the forearm below the superficial flexor muscles.

The ulnar nerve lies to the ulnar side of the ulnar artery on a level with it and beneath the flexor carpi ulnaris muscle.

Amputation Through the Middle Third.—The radial artery lies beneath the deep fascia in front of the radius along the inner edge of the brachioradialis.

The ulnar artery here becomes more superficial and lies beneath the radial edge of the flexor carpi ulnaris muscle.

The volar interosseous is found lying on the anterior surface of the interosseous membrane or the thin edge of the flexor profundus.

The dorsal interosseous lies posterior to the membrane between the superficial and deep extensor muscles.

The median nerve is directly in the midline beneath the flexor sublimis and above the flexor profundus digitorum.

The ulnar nerve lies to the radial side of the ulna, to the ulnar side of the ulnar artery, and under the flexor carpi ulnaris muscle (Fig. 359).

Amputation Through the Lower Third.—The radial artery lies beneath the deep fascia between the flexor carpi radialis and brachioradialis.

The ulnar artery lies to the ulnar side under the deep fascia and at the edge of the flexor carpi ulnaris muscle.

The volar and dorsal interosseous arteries are too small to require ligation.

The median nerve lies beneath the palmaris longus muscle. At the wrist it lies beneath the interval between it and the flexor carpi radialis.

The ulnar nerve is superficial along the edge of the flexor carpi ulnaris and accompanies the ulnar artery along its medial (ulnar) side.

Putti, Vaughetti, Ceci and others have devised and practiced cinematoplastic amputations. The purpose was to devise methods which provide for voluntary motion in the prothesis. The bracemaker will have to improve and augment his knowledge of cinematic prothesis before the procedure can be generally adopted.

OPERATIONS ON THE BONES AND OTHER STRUCTURES OF THE FOREARM

The forearm may require to be operated on for disease or injuries of the bones, tumors, foreign bodies, wounds, etc. In operating on this region of the body it is to be constantly borne in mind that it contains a multitude of structures each of which is essential to the proper performance of some special function. Injury to these structures is followed by a corresponding functional disability. Attempts at brilliant operating are out of place and the surgeon should be exact, careful, and even tender in his handling of the various structures.

The forearm is mainly nourished by the volar and dorsal interosseous arteries; the radial and ulnar pass through it to nourish the hand. These latter are to be avoided.

The nerves that supply the forearm are given off high up near the elbow, hence they are not usually in danger of injury. The median, ulnar, and superficial branch of the radial nerve pass to the hand and must be avoided since the first two supply important muscles of the palm.

It is therefore evident that as far as the arteries and nerves are concerned operations in the lower part of the forearm are less dangerous than those in the upper. With the muscles it is just the opposite. In the lower half the muscles become tendinous and soon form groups or masses of tendons. These tendons are separated by thin connective-tissue sheaths or synovial membrane which allow them to move freely as the muscles contract. Any interference with these sheaths or their contents causes an outpouring of inflammatory material that binds them together and fetters their action. As healing takes place contraction sets in and the patient is left with a useless claw-like hand. For these reasons large incisions and displacements and interference with tendons are to be avoided whenever possible. The sheath of the flexor tendons above the wrist should therefore be carefully guarded. As Kanavel has pointed out, infections should be opened from the side and drained either anterior or posterior to the common flexor group.

As the muscles mostly run longitudinally the incisions should also be longitudinal. Division of the superficial veins is not liable to cause trouble, but the large radial, median, or ulnar veins on the anterior surface may be plainly visible and then the incision should be made so as to avoid wounding them.

The only superficial nerve to be so avoided is the superficial branch of the radial. It is alongside of the radial artery in its middle third, but about 7 or 8 cm. (3 in.) above the wrist it leaves the artery and winds under the brachioradialis to go down the outer and posterior surface of the radius. It is here to be looked for and avoided. On reaching the extensor surface of the forearm it divides into two branches which supply the back of the hand and the thumb, index, middle, and half of the ring fingers.

If it is desired to penetrate the muscles their direction is to be remembered. The superficial flexor muscles arise from the internal condyle, hence, the incision should point upward toward it. The direction of the pronator radii teres is from the internal condyle to the middle of the radius. The deep flexors are parallel with the bones.

Posteriorly the extensor group of muscles tends toward the external condyle. A third group on the radial side comprises the brachioradialis and the extensor carpi radialis longior and brevior. The tendon of the first lies on the outer surface of the radius with the other two immediately posterior to it. Crossing the posterior and outer surface of the radius in its lower third are the extensor ossis metacarpi pollicis and extensor brevis pollicis tendons.

If it is desired to reach the bones the ulna can be exposed posteriorly where it is subcutaneous in its entire length by an incision between the flexor carpi ulnaris and extensor carpi ulnaris. The deep fascia is attached to the bone at this point.

If it is desired to expose the radius, Morris has advised going in between the brachioradialis and the extensor carpi radialis longior. He used the superficial branch of the radial nerve as a guide to the desired interspace.

If an incision were made upward from the outer surface of the styloid process of the radius one would first encounter the tendons of the extensor brevis pollicis and extensor ossis metacarpi pollicus muscles. These being displaced posteriorly would reveal the brachioradialis tendon crossing from beneath the posterior border of the radius; 5 to 7 cm. (2 to 3 in.) above the styloid process would be the superficial branch of the radial nerve. Following the nerve and edge of the brachioradialis tendon would lead to the interspace between it and the extensor carpi radialis muscle posteriorly. When the middle of the forearm was reached the insertion of the pronator teres would be encountered, and from that point up the bone would be covered by the supinator (brevis).

Operations on the median nerve (page 360) and the ulnar nerve (page 361) have already been alluded to.

In operations involving the upper third of the radius the deep branch of the radial (posterior interosseous) nerve is liable to be wounded as it passes through the supinator (brevis) muscle. It is best avoided by elevating the muscle from the bone and raising the nerve along with it, for it does not rest immediately on the bone but has some muscular fibres intervening.

The arteries have already been sufficiently described.

PUS BENEATH THE DEEP FASCIA

The deep fascia of the forearm is continuous with that of the arm. It forms a complete covering for the muscles and sends septa between them. It is especially strong posteriorly. It is attached to the medial and lateral condyles of the humerus, the sides of the olecranon process and the whole length of the ulna posteriorly. Below the medial condyle anteriorly it is strengthened by the bicipital fascia. In the antecubital fossa it is pierced by a large communicating vein which connects the superficial and deep veins. Toward its lower end posteriorly, it is strengthened by transverse fibres and becomes attached to the longitudinal ridges on the radius and blends with the posterior annular ligament. The deep fascia of the forearm gives origin to many muscular fibres. The septa which attach it to the sides of the radius and ulna divide the forearm with the interosseous membrane into two musculo-aponeurotic spaces, one anterior and one posterior. The anterior is more important since besides the muscle bundles it contains the major arteries and nerves.

Below anteriorly it is thin and forms a covering for the tendons of the palmaris longus and flexor carpi radialis muscles and at the wrist blends with the annular ligament beneath. This latter, as pointed out by Colley is a continuation of the layer of fascia covering the flexor sublimis digitorum.

When infection involves the deep tissues of the forearm the pus, being hindered from going externally by the fibrous septa between the various layers of muscles as well as the deep fascia itself, tends to burrow up and down the arm. If in the upper portion of the forearm, it tends to point in the antecubital fossa. If lower down, it tends to come to the surface on the radial side between the flexor carpi radialis and brachioradialis or toward the ulnar side between the palmaris longus and flexor carpi ulnaris.

The three structures,—the tendons of the palmaris longus and flexor carpi radialis and the median nerve,—form a solid barrier anteriorly which inclines the pus to one side. Above posteriorly it may work its way upward behind the internal condyle, following the ulnar nerve.

The fibrous septa of the various muscles hinder the progress of pus laterally, and the attachment of the deep fascia to the ulna prevents its passing around the arm at that point. The many pockets formed by the pus in its burrowing between the muscles render these abscesses difficult to drain and tedious in healing.

Should infection from the thumb travel up the flexor longus pollicis tendon, when it reaches above the wrist it is directly beneath the tendon of the flexor carpi radialis. In such a case an incision should be made along the radial (outer) edge of the tendon, taking care not to wound the radial artery still farther out. If pus infects the forearm by following up the flexor tendons of the fingers beneath the anterior annular ligament, it shows itself above the wrist between the palmaris longus and flexor carpi ulnaris tendons and can here be incised. If it is desired to introduce a drain beneath the flexor muscles, an incision may be made along the side of the ulna and a forceps passed under the flexor tendons and made to project under the skin of the radial side where a counter opening can be made and the drain inserted. (For a discussion of the treatment of purulent affections of the hand and forearm see A. B. Kavanel: "Infections of the Hand.") Suppuration around these tendons is very serious, as the effusion binds together the tendons and irritates the nerves and produces disabling contractures which are exceedingly difficult to remedy.

REGION OF THE WRIST

By the wrist is meant the constricted portion of the upper extremity by which the hand is joined to the forearm. We will include in its consideration the lower

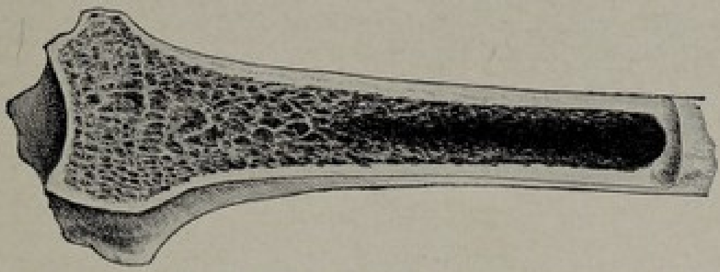


Fig. 360.—Sawn section through the lower end of the radius to show its cancellous structure.

portion of the forearm for about 4 cm. (1½ in.) above the radiocarpal joint, and the joint itself. The wrist is so constructed as to permit of the movements of pronation and supination of the bones of the forearm, to serve as a support for the hand, and to allow movements of the hand in various directions.

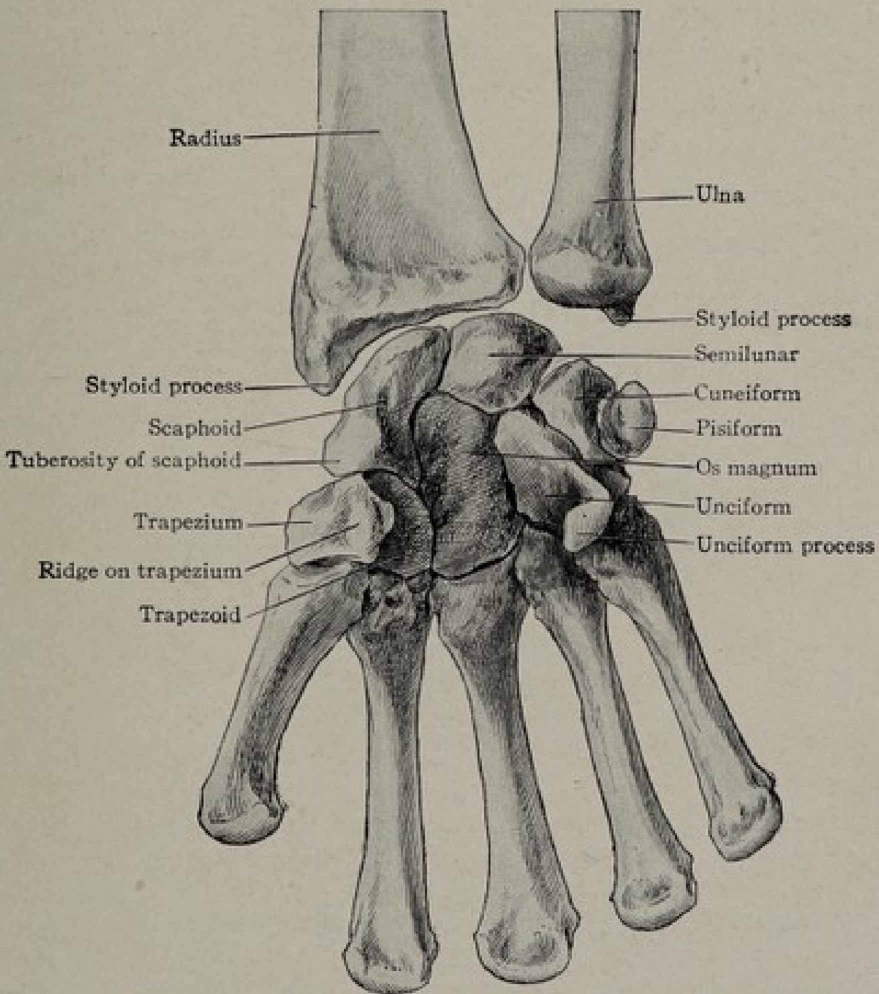


Fig. 361.—Anterior view of the lower ends of the radius and ulna and the carpal bones.

BONES OF THE WRIST

We may include among the bones of the wrist the lower ends of the radius and ulna and the first row of bones of the carpus,—the scaphoid, lunate (semilunar), cuneiform, and pisiform.

Of the bones of the forearm—the radius and ulna—we have seen that at the elbow the ulna is the larger of the two. This is because the main function of the ulna is to act as a support to the parts beyond. The radius is intended mainly as a means of enabling the hand to perform the functions of pronation and supination. At the wrist we find the radius supporting the hand and consequently its lower end is large and well developed. The ulna, on the contrary, contributes but little to the support of the hand and does not even enter directly into the wrist-joint, as does the radius at the elbow-joint, but serves as a fixed point around which the radius rotates. The functional value of the ulna at the wrist is so much less than that of the radius as amply to account for its diminished size.

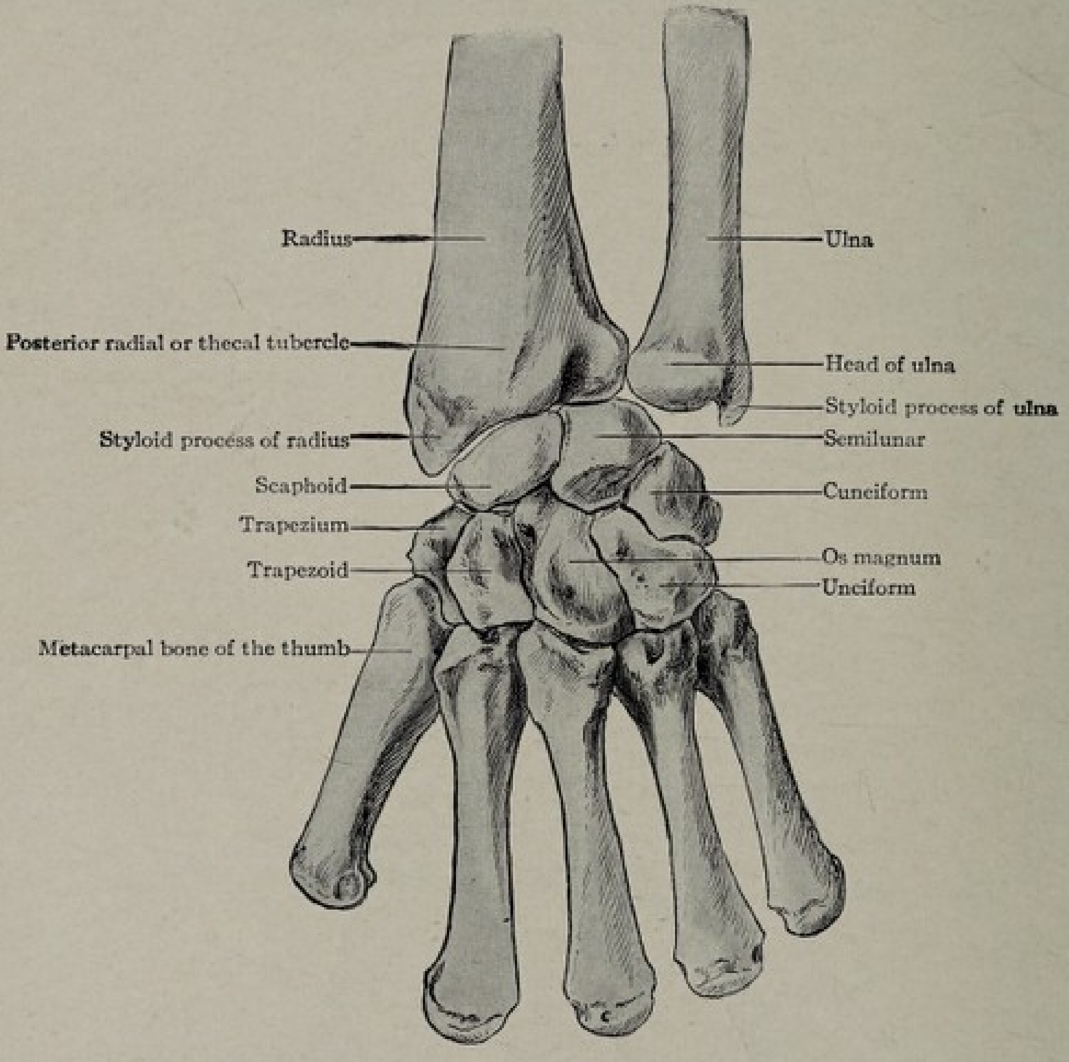


FIG. 362.—Posterior view of the lower end of the radius and ulna and the carpal bones.

Lower end of the Radius.—The lower end of the radius is large and spongy. The compact tissue forms a quite thin superficial layer (Fig. 360). Its anterior surface is hollowed out to receive the pronator quadratus muscle, with a prominent articular edge to which is attached the anterior ligament (Fig. 361).

The posterior surface is convex and marked with a number of ridges with grooves between them which lodge the extensor tendons (Fig. 362). In its middle is a prominence, the *dorsal radial tubercle,* which marks the position of the extensor longus pollicis muscle. On its inner side is a concave articular facet, the *ulnar notch* (*sigmoid cavity*), for articulation with the ulna; it is plane from above downward thus showing that it permits movement in one direction only, like a hinge.

Between the lower edge of the ulnar notch and the articular surface is a rough ridge that gives attachment to the triangular interarticular fibrocartilage.

The lower or radiocarpal articular surface slopes downward and outward to end in the *styloid process*, which is thereby placed lower than the styloid process of the ulna. The articular surface is divided into two facets: the outer is the smaller, is triangular in shape, and articulates with the *navicular* (*scaphoid*) *bone;* the inner or larger is quadrilateral and articulates with the *lunate* (*semilunar*) bone. The styloid process at its base or upper outer portion has inserted into it the tendon of the brachioradialis muscle. To its tip is attached the external lateral ligament.

The Ulna.—The lower extremity of the ulna is rounded in shape, forming its head, with the styloid process projecting downward on its inner and posterior aspect. To its tip is attached the internal lateral ligament. On its outer side is a rounded smooth surface for articulation with the ulnar notch of the radius. The inferior or articular surface is flat and rests on the flat interarticular fibrocartilage.

The **navicular (scaphoid), lunate (semilunar), triquetrum (cuneiform),** and **pisiform bones** form the first row of the carpal bones. The pisiform rests on the anterior surface of the cuneiform and does not enter into the articulations between the hand and bones of the forearm.

The navicular and lunate articulate directly with the lower end of the radius, but the cuneiform articulates with the under surface of the triangular interarticular fibrocartilage.

THE INFERIOR RADIO-ULNAR ARTICULATION

The joint between the lower ends of the radius and ulna embraces not only the portion between these two bones but also that between the lower end of the ulna and

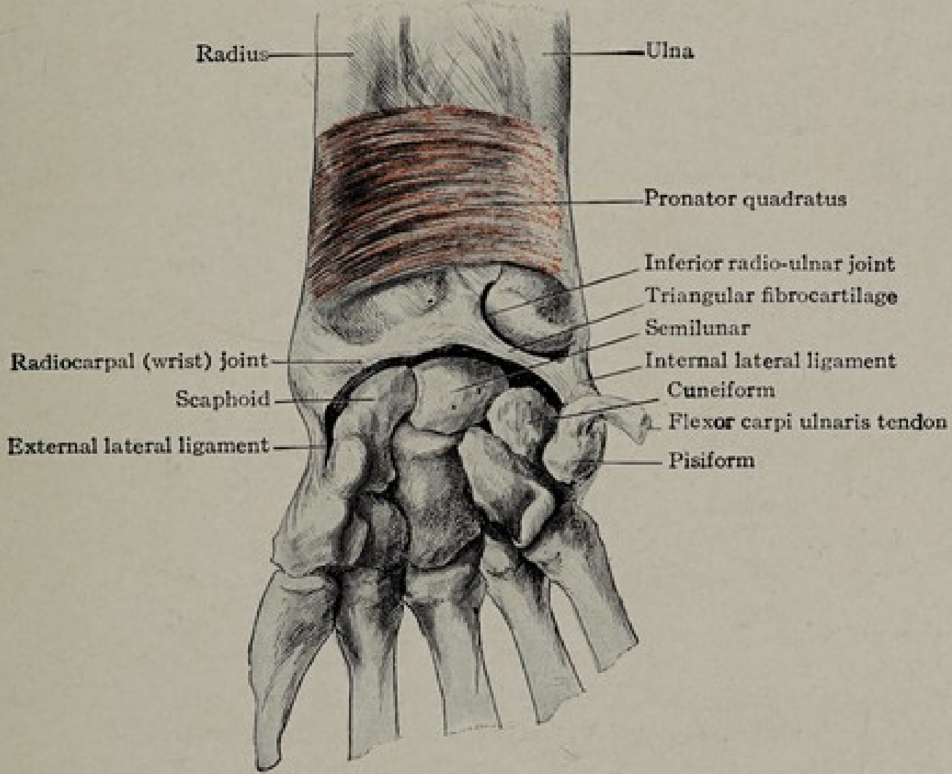


FIG. 363.—The wrist-joint and inferior radio-ulnar articulation.

the upper surface of the triangular fibrocartilage. This latter is attached by its apex to a depression on the outer side of the root of the styloid process of the ulna, and by its base to the rough line on the radius separating the radio-ulnar from the radio-carpal articulation (Fig. 363).

The Interarticular Triangular Fibrocartilage.—This serves as the main bond of union between the lower ends of the radius and ulna. It is strong and blends with the internal lateral ligament. Thus the hand has an attachment to the inner side of the radius by means of the internal lateral ligament and triangular cartilage.

The Capsular Ligament.—The capsular ligament serves to retain the synovial fluid in the joint. It is thin and filmy and possesses no strength, and therefore is useless in limiting movements.

Anterior and Posterior Radio-ulnar Ligaments.—These ligaments are simply a few bands which pass across from the radius to the ulna. They are not strong enough to be efficient in limiting movements of the bones.

Movements.—As has already been pointed out (page 341) the movements of pronation and supination have as their axis a line drawn through the middle of the head of the radius, the styloid process of the ulna, and the ring finger. They embrace in ordinary use a range of about 140 degrees which can be increased by forced effort to 160 degrees (Fig. 364).

These movements are limited by various factors, the most prominent being in pronation the contact of the soft parts and bones, as the radius obliquely overlies the ulna, and in supination by the biceps (the most powerful of the supinators) having reached the dead centre.

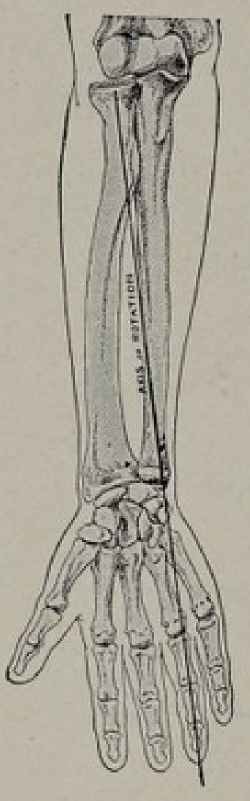


Fig. 364.—Axis of rotation.

There is no communication between the radio-ulnar joint above and the radiocarpal joint below, except when, as occasionally happens, the triangular cartilage has a perforation.

During pronation and supination the lower end of the radius moves with the hand, but the lower end of the ulna remains at rest; hence it is that the styloid process of the radius always retains the same position in relation to the hand. When it is desired to identify the styloid process of the radius, one needs only to follow the metacarpal bone of the thumb up to the snuff-box at the upper edge of which the styloid process can always be felt. Also, to identify the styloid process of the ulna, one must not use the hand as a guide because the hand changes its position in relation to the ulna; but, as the ulna remains quiet, its styloid process can be found by following the posterior surface down to its extremity.

As the interarticular triangular cartilage is fastened by its base to the ulnar edge of the radius and by its apex to the base of the styloid process of the ulna, it travels with the hand in the movements of pronation and supination.

THE RADIOCARPAL OR WRIST-JOINT

The wrist-joint is formed by the radius and triangular cartilage above and the navicular (scaphoid), lunate (semilunar), and cuneiform bones below. These are joined by the anterior, posterior, internal and external lateral, and capsular ligaments. The two lateral ligaments are strong, well-defined bands, the anterior and posterior ligaments are weaker and are fused with the capsular ligament.

The **internal lateral ligament** is attached above to the tip of the styloid process of the ulna and the tip of the triangular cartilage; below it is attached to the border of the cuneiform bone and is continued on to the pisiform bone.

The **external lateral ligament** is attached above to the tip of the styloid process of the radius and below to the base of the tubercle of the navicular (scaphoid) bone.

The **capsular ligament** of the wrist-joint is composed of an anterior and a posterior portion strengthened by the two lateral ligaments just described. The anterior ligament has the bulk of its fibres running downward and inward from the edge of the radius to the palmar surface of the navicular, lunate, and cuneiform bones. It is stronger than the posterior. The posterior ligament likewise has its fibres running downward and inward to be attached to the first row of carpal bones. White thinks that the simplest conception of the capsule is to picture it as passing from the forearm to the metacarpus and attached to each row of carpal bones. Both the anterior and posterior portions are strengthened by the overlying tendons and their sheaths.

Movements.—The wrist is classed as a biaxial diarthrosis or condyloid joint. This means that it is a double hinge-joint having movements around two axes, one anteroposterior and the other transverse. A combination of these movements results in circumduction, but it has at least no voluntary movement of rotation.

Fig. 365.—Position assumed by the carpal bones in flexion of the wrist.

When rotation of the hand occurs it is accomplished by pronating or supinating the forearm. If the wrist-point possessed this latter movement it would be a ball-and-socket or enarthrodial joint. The hand can be flexed and extended through an arc of approximately 140 degrees and adducted and abducted about half as much. The position assumed by the bones in flexion and extension is shown in Figs. 365 and 366.

Adduction or bending toward the ulnar side is much greater than is possible toward the radial side. The fact of the ulna not coming so low as the radius

Fig. 366.—Position assumed by the carpal bones in extension of the wrist.

accounts, at least in part, for this. The lateral ligaments check the movements of abduction and adduction, and in addition the contact of the styloid process of the radius with the trapezium prevents further outward movement.

The extent of the movements of the wrist of course varies much in different individuals. The laxness of the joints in children, women, and those not accustomed to hard manual labor is well known.

The movements of the wrist are performed by two different sets of muscles.

One set comprises the flexors and extensors of the carpus and the other the flexors and extensors of the thumb and fingers.

The first set is composed of the *flexor carpi radialis* and *flexor carpi ulnaris*, with which we may perhaps include the *palmaris longus*,—although it properly belongs with the finger muscles,—and of the *extensor carpi ulnaris, extensor carpi radialis longior*, and *extensor carpi radialis brevior*. If the fingers are clinched and the extensors of the fingers contract they aid the three carpal extensors to bend the hand backward. If the fingers are held extended and the flexors of the fingers contract they aid the carpal flexors to bend the hand forward. Contraction of the flexor and extensor carpi ulnaris adducts the hand and contraction of the flexor carpi radialis and extensor carpi radialis longior and brevior, aided by the short extensor of the thumb and extensor ossis metacarpi pollicis, abducts the hand.

In the affection known as *wrist-drop* all the extensor muscles are paralyzed. It is due to injury, usually from pressure on the radial (musculospiral) nerve, either in the groove of the humerus or in the axilla. Although there are a number of

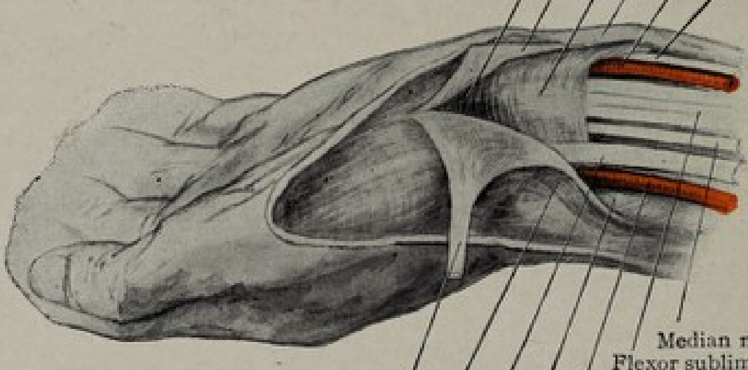


FIG. 367.—Dissection showing the fascias of the anterior portion of the wrist. The superficial layer is continuous with the palmaris longus muscle and palmar fascia; the deep layer is continuous with the anterior annular ligament.

synovial bursæ around the joint in connection with the tendons none communicate with it.

Muscles.—The flexor tendons cover the wrist anteriorly and the extensors posteriorly. With the flexor group we may consider the pronator quadratus. A third or radial group comprises the extensor carpi radialis longior and brevior and the brachioradialis.

Anteriorly.—The tendons on the front of the wrist occupy four different planes or levels. The most superficial layer embraces the flexor carpi radialis, the palmaris longus, and the flexor carpi ulnaris. Of these three the palmaris longus is the nearest to the skin as it inserts in the palmar fascia in front of the annular ligament. The flexor carpi radialis slips under the upper portion of the annular ligament to insert into the base of the second metacarpal bone. The flexor carpi ulnaris inserts into the pisiform bone and continues onward to the base of the fifth metacarpal bone and the unciform process of the unciform bone.

The second layer of tendons is composed of the four tendons of the flexor sublimis digitorum. They fill the space between the palmaris longus and the flexor carpi ulnaris.

The third layer is composed of the four tendons of the flexor profundus digitorum toward the ulnar side and the flexor longus pollicis toward the radial side.

The fourth and last layer is formed by the pronator quadratus. This lies directly on the bones and covers their lower fourth.

It is sometimes necessary to divide these tendons in cases of contraction of the wrist, hence the desirability of being able to recognize and locate them.

The Deep Fascia and Anterior Annular Ligament.—The deep fascia covering the anterior muscles of the forearm is comparatively thin. As it approaches the wrist it divides into two layers. The *superficial layer* is thin and runs over the tendons of the palmaris longus and flexor carpi radialis muscles and the ulnar artery and nerve. It is continuous below with the palmar fascia. To the ulnar side it passes over the flexor carpi ulnaris muscle to be continuous with the posterior annular ligament. It is not attached to the ulna, but slides over it as it follows the movements of the hand in pronation and supination (Fig. 367).

The *deep layer* of the deep fascia covers the flexor sublimis digitorum and passes downward beneath the flexor carpi radialis and brachioradialis muscles. It is continuous below with the anterior annular ligament.

The deep layer blends with the superficial layer to the radial side of the flexor carpi radialis, and then merges with the posterior annular ligament to form the sheath of two of the extensor muscles of the thumb.

On the ulnar side the deep layer passes over the ulnar artery and vein and under the flexor and extensor carpi ulnaris muscles, forming the posterior portion of their sheaths, and then merges with the posterior annular ligament.

The *anterior annular ligament* is attached on the ulnar side to the pisiform bone and unciform process of the unciform bone and on the radial side to the trapezium and tuberosity of the navicular (scaphoid).

Over the anterior annular ligament pass the ulnar artery and nerve, the superficial volar artery, and the palmar cutaneous branch of the median nerve.

Fig. 368.—Muscles of the radial side of the wrist.

The anterior annular ligament is extremely strong. It is similar to a suspension bridge, as it arches over the hollow of the wrist to enclose a canal under which the median nerve, the flexor sublimis, flexor profundus, and flexor longus pollicis tendons pass. These tendons are embraced in two sheaths, one for the flexor longus pollicus and the other for the flexors of the other four fingers, the sheath for the little finger extending to the insertion of the profundus tendon into the distal phalanx. The tendinous sheaths accompany the tendons for a distance of 2.5 to 5 cm. (1 to 2 in.) above the annular ligament.

Posteriorly.—On the posterior surface of the wrist the tendons may be divided into two groups, an extensor group and a radial group. The *extensor group* is divided into a superficial and deep set. The superficial set is composed of the extensor communis digitorum, the extensor minimi digiti and the extensor carpi ulnaris. The deep set is composed of the extensor ossi metacarpi pollicis, extensor brevis pollicis, extensor longus pollicis, and extensor indicis. The *radial group*, on the posterior and outer surface of the radius, is composed of the extensor carpi radialis longior, the extensor carpi radialis brevior, and the brachioradialis (Fig. 368). The first two lie beneath the deep extensor muscles, thus practically forming a third layer. All the tendons of the posterior and radial group of muscles, with the exception of the brachioradialis, pass beneath the posterior annular ligament into the hand. The brachioradialis inserts into the base of the styloid process of the radius.

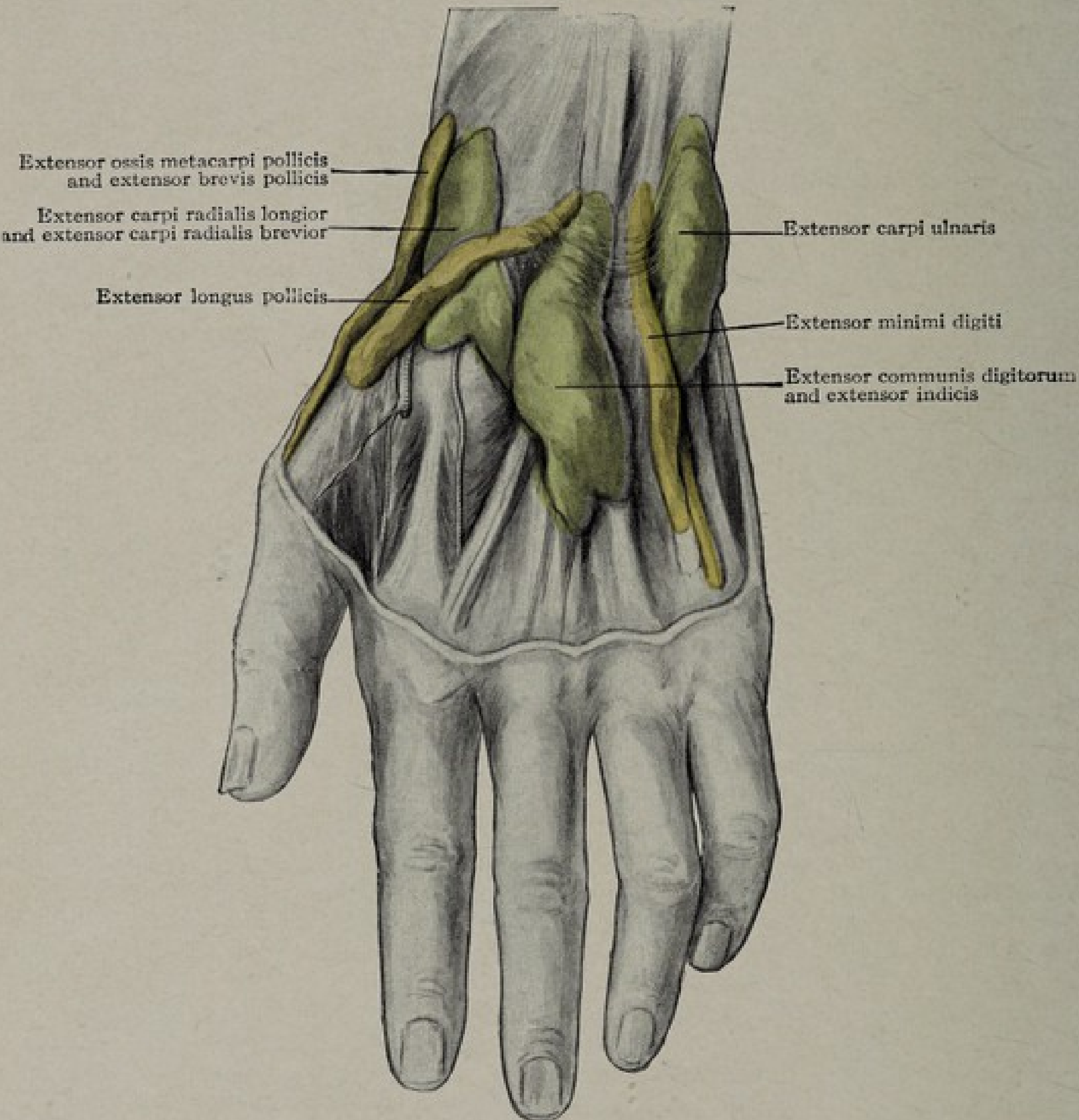


FIG. 369.—The sheaths of the extensor tendons on the back of the wrist distended with wax to show their extent.

Posterior Annular Ligament.—As the tendons pass down over the posterior surface of the radius and ulna they are bound down by processes of the deep fascia which form canals in which they run. The deep fascia of the posterior surface of the forearm in the neighborhood of the wrist is strong, and forms the posterior annular ligament. Its lower border is about level with the upper border of the anterior annular ligament. Thus since it is merely a thickening of the fascia its title to the name of a ligament has been disputed by some anatomists. It is attached externally to the posterior and outer edge of the styloid process of the radius and internally to the posterior surface of the styloid processes of the ulna, the internal lateral ligament, the pisiform, and adjacent carpal bones. Beneath this posterior annular ligament are six compartments. From the radial toward the ulnar side they are: (1) One on the outer side of the styloid process of the radius for the extensor ossis metacarpi pollicis (abductor pollicis longus) and extensor brevis pollicis; (2) for the extensor carpi radialis longior and brevior, then comes the posterior radial tubercle in the middle of the radius, and passing close along its ulnar side is (3) the extensor longus pollicis. To the ulnar side of this tendon is a compara-

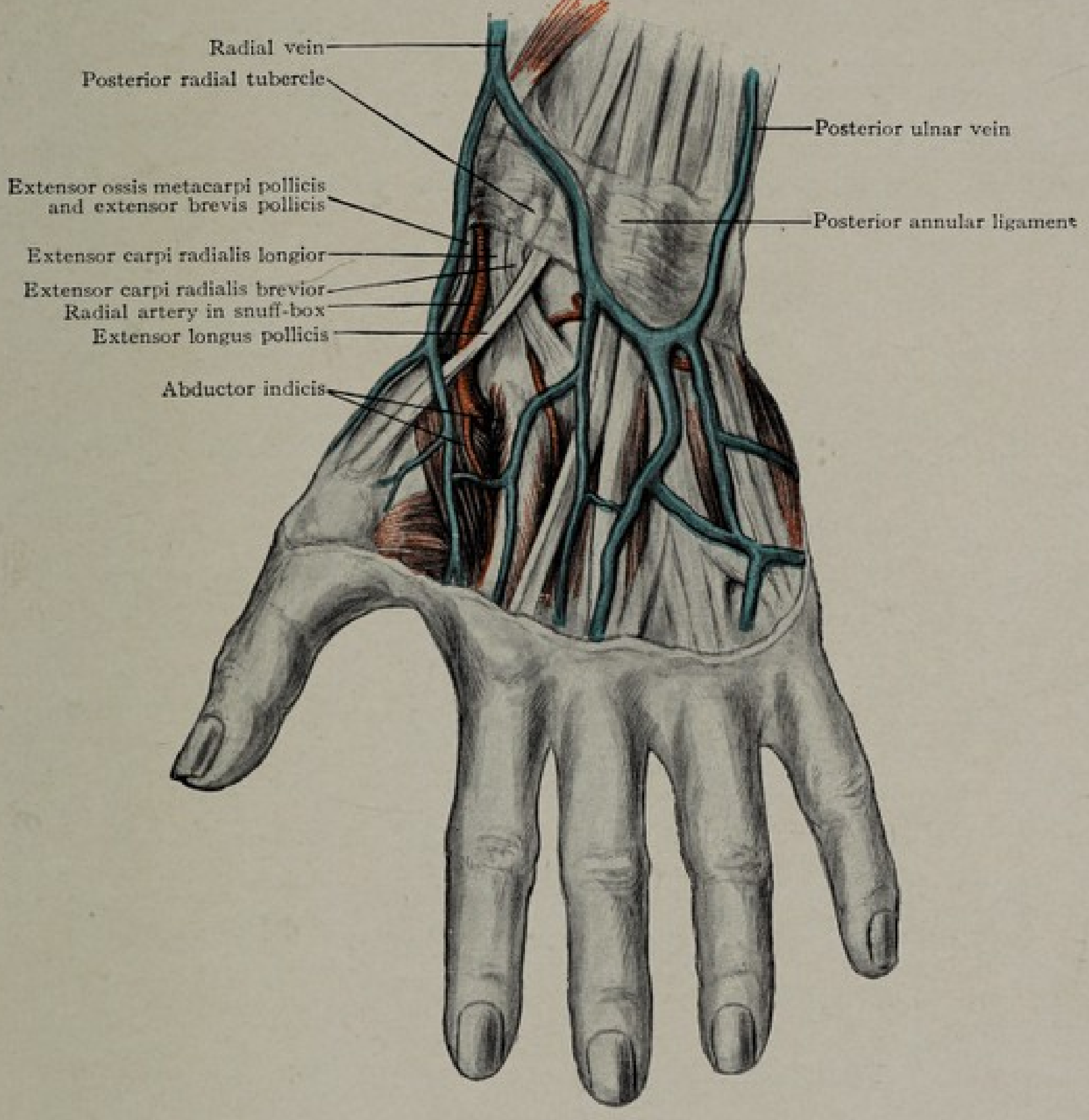


Fig. 370.—View of the anatomical snuff-box and the radial artery passing through it.

tively broad sheath for (4) the extensor communis digitorum and the extensor indicis muscles. In the interval between the radius and ulna lies (5) the tendon of the extensor minimi digiti, and on the posterior side of the styloid process of the ulna is (6) the tendon of the extensor carpi ulnaris (Fig. 369).

Each of these six compartments is lined with a separate sheath which extends under the annular ligament from a centimetre or two above the joint to about the bases of the metacarpal bones on the dorsal surface of the hand.

The Anatomical Snuff-Box (la tabatière anatomique, of Cloquet).— On the outer dorsal aspect of the wrist, just below the radius, is a depression particularly noticeable when the thumb is abducted (Fig. 373, page 384). It is triangular in shape with its base upward. The styloid process of the radius forms its base; the extensor brevis pollicis with the extensor ossis metacarpi pollicis forms its radial or outer side, and the tendon of the extensor longus pollicis (abductor longus pollicis) form its ulnar or inner side. Its floor is formed by the navicular (scaphoid) and trapezium and the articulation between the latter and the first metacarpal bone. Through it, lying on these bones and the external lateral ligament, passes the radial artery on its way to the first interosseous space. Superficial to the artery lies a vein, the cephalic vein of Treves, and some fine branches of the radial nerve. In ligating the artery at this point, care should be taken not to mistake the vein for it; the vein is near the skin, the artery lies deep on the lateral ligament and bones (Fig. 370). When ligating it is highly desirable to avoid opening the sheaths of the tendons to the thumb or the scaphoid-trapezial joint.

SURFACE ANATOMY OF THE WRIST

The bellies of many of the muscles, mainly the superficial ones, cease as they become tendinous about the middle of the forearm. Hence the rapid decrease in

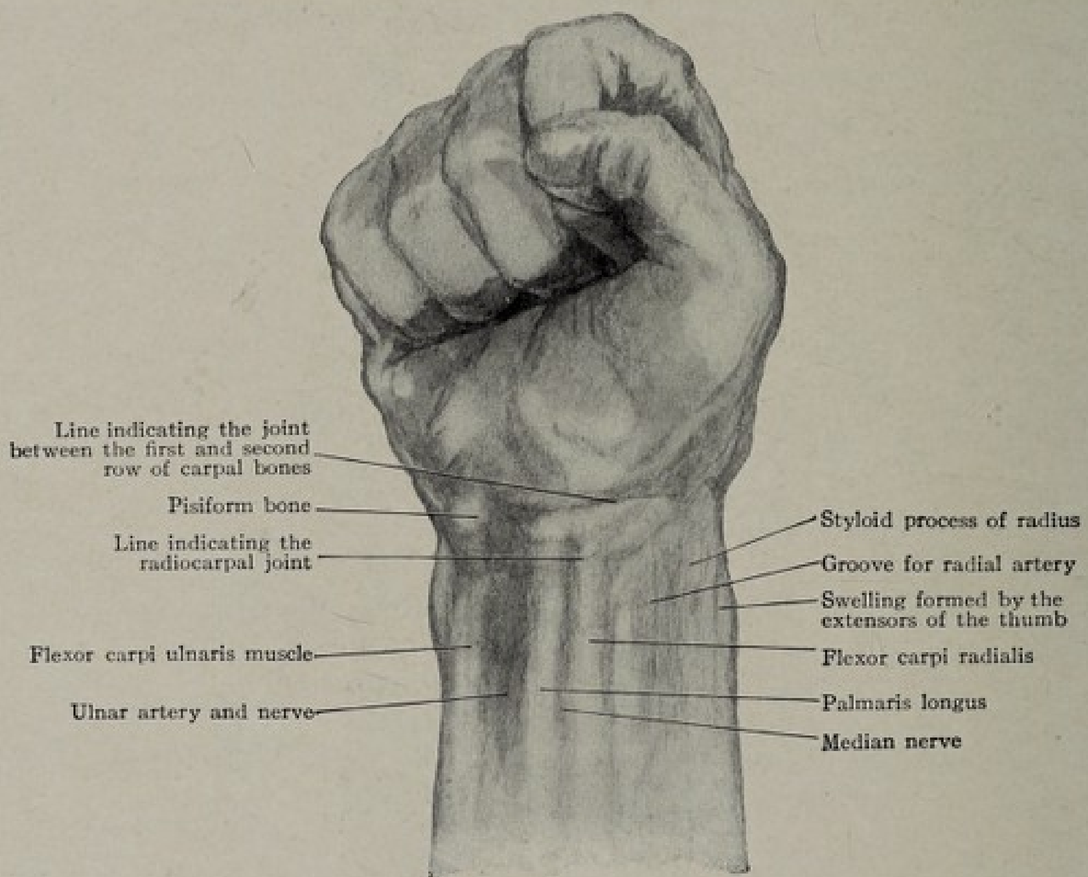


FIG. 371.—Surface anatomy of anterior surface of wrist.

size as one descends. When the wrist is reached there is a swelling on each side caused by the expanded lower end of the radius on the outer side and the head of the ulna on the inner. The medial (inner) prominence is rendered more marked by abducting the hand, the lateral (outer) prominence by adducting it. Just beyond these there is a constriction as the wrist passes into the hand.

Above the wrist on the anterior and outer part can be felt the radius. Its lower 2 or 2.5 cm. (1 in.) is sharp and prominent—this is the anterior border of the styloid process. On the outer side at its base is the point of insertion of the brachioradialis tendon. Following the bone down on its outer side, at the upper margin of the anatomical snuff-box, one feels the tip of the styloid process, a most important landmark.

On the outer surface of the radius beginning below between the tip of the styloid process and its sharp anterior border are the extensor ossis metacarpi pollicis and extensor brevis pollicis tendons. They can readily be seen and felt when the thumb is extended as they cross obliquely over the lower end of the radius. The sheaths of these tendons frequently become inflamed from injuries, causing what is termed *tenosynovitis*. If the hand is laid on the lower portion of the radius of a patient so affected, and he is told to move the thumb, a characteristic creaking can be felt as the tendons move in their inflamed sheaths.

The edge of the articular surface of the radius can be indistinctly felt from the tip of the styloid process to the edge of the flexor carpi radialis internally and across the back of the wrist in an upwardly curved line toward the ulna.

On the inner side of the wrist can be felt and seen the prominence made by the head of the ulna. The ulna is subcutaneous and can be followed up the forearm posteriorly its entire length. It is not covered by muscles on its inner border, but on its anterior surface is the flexor carpi ulnaris tendon beneath which is the flexor profundus digitorum, this latter being separated from the bone by the origin of the pronator quadratus. If the posterior surface of the ulna is followed downward the

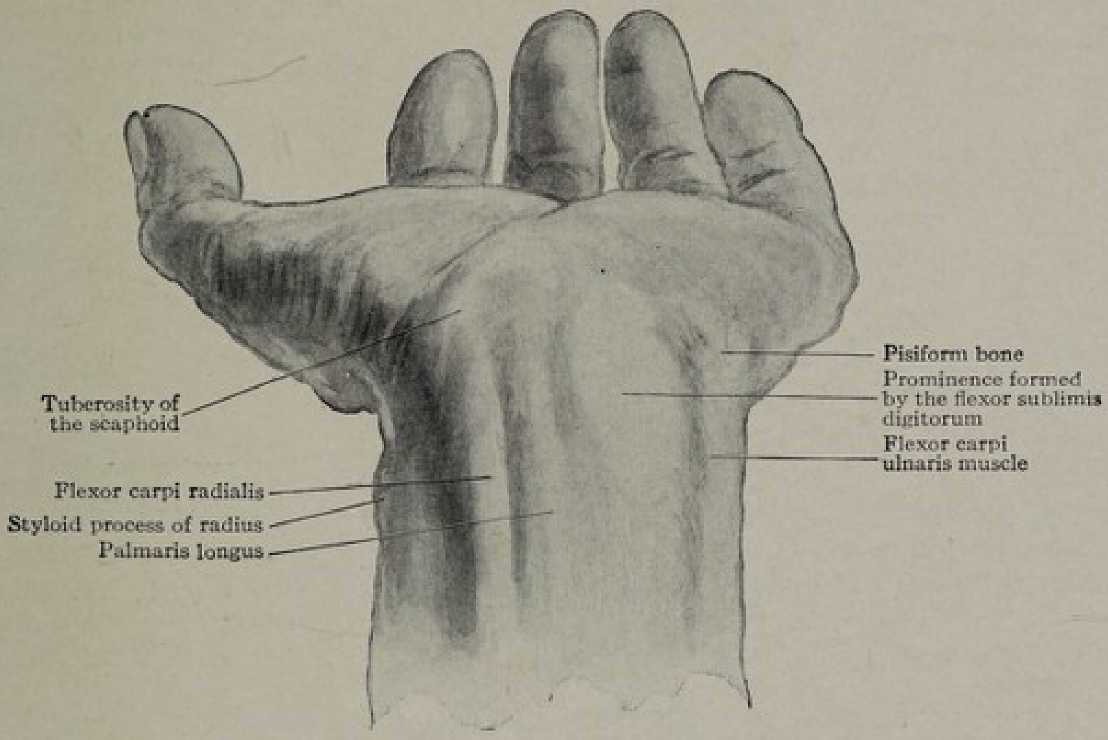


Fig. 372.—Surface anatomy of the anterior portion of the wrist.

styloid process forming its extremity can be distinctly felt, especially if the hand is placed in the supine position and slightly flexed. Overlying the head of the ulna posteriorly is the tendon of the extensor carpi ulnaris muscle going to the base of the fifth metacarpal bone. This tendon follows the movements of the hand in pronation and supination, but the styloid process of the ulna remains stationary. When the hand is pronated the tendon lies to the anterior side of the styloid process, but when the hand is supinated it lies toward its posterior side. This tendon cannot be readily recognized.

The inner and posterior surface of the cuneiform bone can be felt immediately below the head of the ulna. Some difficulty may be experienced in distinguishing one from the other; if, however, the hand is abducted and adducted the cuneiform bone can be felt to move while the ulna remains stationary. On the palmar surface of the wrist, immediately below the ulna, can be felt the distinct bony prominence formed by the pisiform bone. The flexor carpi ulnaris inserts into it.

About 2 to 2.5 cm. (1 in.) below and to the radial side of the pisiform bone is the unciform process of the unciform bone. It is best detected by laying the ball of the thumb over the spot and making deep pressure with a rolling motion. On the radial side of the anterior surface, directly in line with the tendon of the flexor carpi radialis, is the prominent tubercle of the navicular (scaphoid) bone; a centimetre farther on, in line with the thumb, is the ridge of the trapezium. The anterior annular ligament is attached to its outer surface about 2.5 cm. (1 in.) below the styloid process of the radius; a bony prominence formed by the trapezium marks its junction with the metacarpal bone of the thumb in front.

The ability to locate the carpometacarpal joint of the thumb is of importance in reference to the diagnosis of fractures and other injuries. On comparing the two styloid processes it will be seen that the styloid process of the radius extends 1 cm.

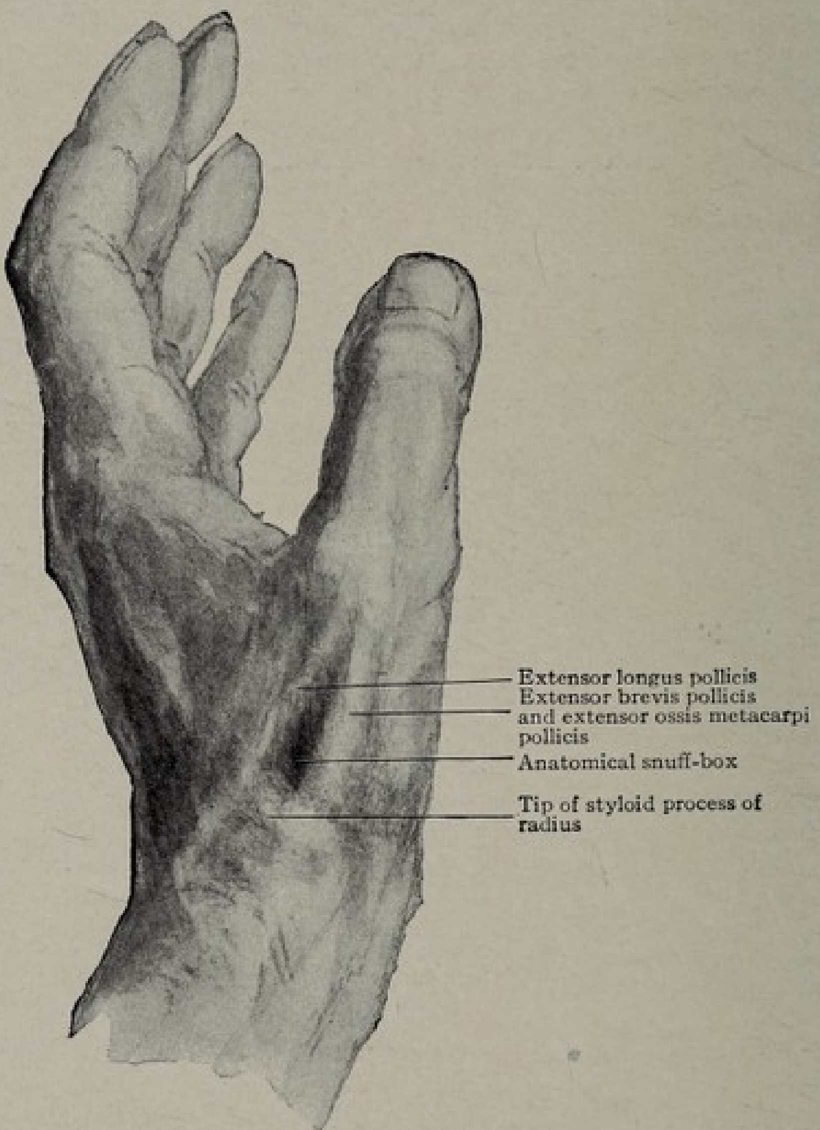


FIG. 373.—Surface anatomy of the outer dorsal portion of the wrist, showing the anatomical snuff-box.

(⅖ in.) lower than that of the ulna. This is best observed with the hand in a prone position. Across the front of the wrist there are two transverse lines. The proximal or upper one corresponds with the radiocarpal joint or wrist-joint. The distal or lower one corresponds with the joint between the two rows of carpal bones and marks the upper edge of the anterior annular ligament.

On the posterior surface of the wrist, one-third of the width of the wrist across from the edge of the radius, can be felt a bony prominence. It is the posterior radial tubercle. If the thumb is extended the tendon of the extensor longus pollicis leads directly to the tubercle and lies along its ulnar border. This tubercle marks the middle of the posterior surface of the radius. The radius passes two-thirds across the wrist and the ulna the other third; by firm pressure the interval between them can be felt.

If the hand is firmly clenched and flexed on the forearm the tendons on the anterior surface of the wrist become prominent. The most evident is the palmaris longus which, though sometimes absent, usually stands out clear and sharp. Lying along its radial border is the tendon of the flexor carpi radialis; between the two on a lower level lies the median nerve. In front of the ulna, and going directly downward to the pisiform bone, is the tendon of flexor carpi ulnaris (Fig. 371).

If the hand is extended the tendon of the flexor carpi ulnaris stands out clearly. In the hollow to its lateral (outer) side lie the ulnar nerve and artery. A rounded muscular swell fills the space between the ulnar artery and the tendon of the palmaris longus,—it is caused by the flexor sublimis digitorum (see Fig. 372). It is here that abscesses show when they travel up from the hand.

Between the outer edge of the flexor carpi radialis tendon and the anterior outer edge of the radius is a groove in which runs the radial artery. The position of the extensor ossis metacarpi pollicis (abductor pollicis longus) and extensor brevis pollicis which run together over the outer surface of the radius can best be determined by abducting the thumb and so making these tendons prominent (Fig. 373).

In the same manner the extensor longus pollicis tendon can be made prominent and followed to the posterior radial tubercle. By firm pressure the upper limits of

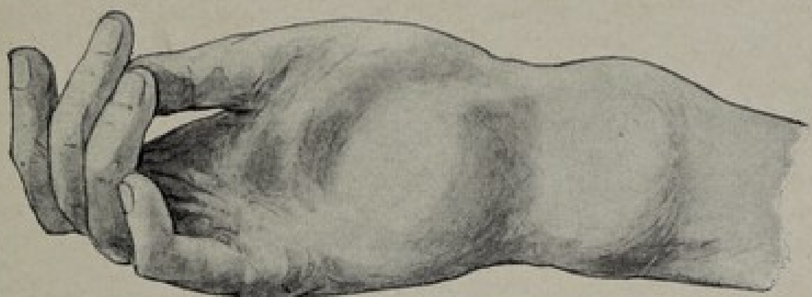


Fig. 374.—Compound ganglion showing swellings above and below the anterior annular ligament. (From author's sketch of a tuberculous case.)

the first and second interosseous spaces can be felt. They mark the bases of the metacarpal bones. The extensor carpi radialis longior passes across the snuff-box to insert into the radial side of the base of the second metacarpal bone. The radial artery as it dips down between the first and second metacarpal bones lies just to its outer side. Crossing under the tendon of the extensor longus pollicis is the extensor carpi radialis brevior, which proceeds to the top of the second interosseous space to insert into the adjoining sides of the second and third metacarpal bones.

In the chink between the radius and ulna lies the tendon of the extensor minimi digiti. Between this tendon and the radial tubercle are the four tendons of the extensor communis digitorum and extensor indicis muscles. Passing over the head of the ulna to insert into the base of the fifth metacarpal bone is the tendon of the extensor carpi ulnaris. It is best felt just beyond the extremity of the ulna when the hand is drawn toward the ulnar side. It inserts into the base of the fifth metacarpal bone.

Compound Ganglion.—Large effusions into the sheath of the flexor tendons of the wrist, usually purulent or tuberculous in character, sometimes cause two swellings, one in the palm of the hand and the other above the wrist. These communicate beneath the anterior annular ligament and form what is called a compound ganglion (Fig. 374). The sheath of the flexor pollicus longus may also be involved, since the two sacs usually communicate with each other above the wrist. The hour-glass appearance is due to the construction of the anterior annular ligament. These ganglia may also communicate with one or more of the joints of the wrist.

FRACTURES OF THE LOWER END OF THE RADIUS AND ULNA

The lower end of the ulna is rarely fractured, but that of the radius vies with fracture of the clavicle in being the most frequent of all fractures.

Colles's Fracture

Fractures of the radius which occur at the wrist possess certain distinct characteristics and were for a long time confounded with dislocations of the wrist. These fractures are generally grouped by modern surgeons under the name of *Colles's fracture*. This fracture was first correctly described, according to both Hamilton and Stimson, by Pouteau ("Œuvres Posthumes," t. 11, p. 251, 1783; also Nélaton, "Chirurgie Path.," t. 1, p. 739). Mr. Colles, a Dublin surgeon, described the injury most carefully in the *Edinburgh Medical and Surgical Journal*, April, 1814, but it is largely due to Robt. W. Smith's "Treatise on Fractures in the Vicinity of Joints," Dublin, 1847, that the name Colles's fracture has become generally accepted. Mr. Colles placed the injury 1½ inches (about 4 cm.) above the joint. Mr. Smith placed it from ¼ in. to 1 in. (6 to 25 mm.) above the joint. Most recent

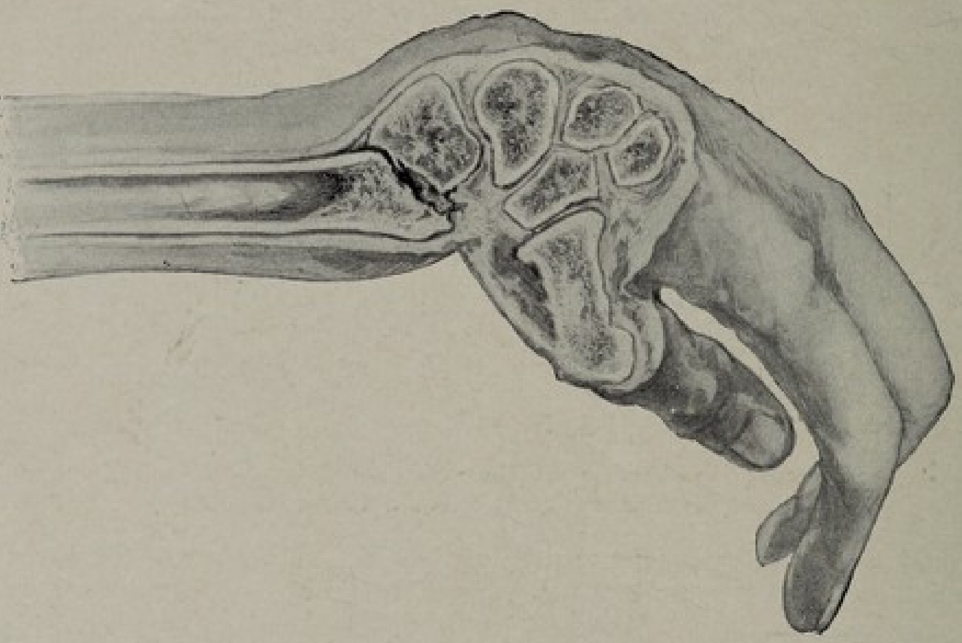


Fig. 375.—Colles's fracture of the lower end of the radius, showing the "silver fork deformity" and displacement of the fragments.

writers include all fractures within 4 cm. (1½ in.) of the lower edge of the radius under this name, though some few go still higher. When the line of fracture lies more than 4 cm. above the joint it loses the characteristics of a Colles's fracture and partakes of those of fractures of the shaft; hence we will not go beyond that limit.

The line of fracture is most commonly found, as stated by Robt. W. Smith, from 6 to 25 mm. (¼ to 1 in.) above the joint. It passes almost transversely across the bone or inclines slightly downward to the ulnar side. It also lies nearer the joint on the anterior surface and inclines backward and upward toward the elbow. Hence the direction is from above downward and forward (Fig. 375).

It is produced while the hand is extended (dorsally flexed) either by direct transmission of the force from the palmar surface of the wrist or by tension of the anterior radiocarpal ligament. The broad attachment of this ligament to nearly the entire anterior tip of the radius distributes the strain equally on the lower end of the bone and the resulting fracture is therefore irregularly transverse. The additional force of the body frequently causes the sharp lower end of the upper fragment to become impacted in the soft spongy tissue of the lower fragment.

The lower fragment is displaced upward and backward on the shaft of the radius. This causes it to be tilted backward so that the articular surface is rotated on a transverse axis more in the direction of the dorsum than normal and the hand is also carried toward the radial side. The ulno-carpal ligament pulls on the lower end of the ulna and either causes an undue prominence of the lower end of that bone or a fracture of the styloid process to which it is attached. The dorsal displacement is due to the direction of the violence and not to muscular action. The radial side of the fragment is displaced upward more than the ulnar because the triangular fibrocartilage retains its radio-ulnar attachments. This prevents the ulnar side from rising, while the radial side is pulled up by the radial flexor and extensor muscles. If the fracture is not extremely close to the joint the brachioradialis will pull the lower fragment toward the radial side and up toward the elbow.

As the hand is attached to the radius it follows the lower fragment; the extensor muscles of the thumb, the flexor carpi radialis, and the two extensor carpi radialis muscles all tend to aid the brachioradialis in producing the displacement toward the radial side (Fig. 376).

The lower fragment is displaced toward the dorsum and the upper fragment toward the palmar surface. The lower end of the upper fragment is found beneath the pronator quadratus or the flexor tendons and the upper end of the lower fragment is found on the dorsum of the wrist. This produces the "silver fork deformity" of Velpeau. This dorsal projection is sometimes increased by the presence of the "carpal tumor," a swelling due to effusion almost directly above the joint. The

Fig. 376.—Colles's fracture of the radius, showing inclination of hand toward the radial side and prominence of the styloid process of the ulna. (From author's sketch.)

projection of the upper fragment toward the palmar surface and the effusion in the sheaths of the flexor tendons cause a protrusion on the anterior surface of the wrist and a marked increase in the lower anterior radiocarpal crease. The styloid of the radius is on a higher level than that of the ulna, while in dislocation of the wrist-joint this is not found.

To reduce the deformity the upper fragment is firmly grasped with one hand while with the other the hand of the patient is forcibly adducted (toward the ulnar side) and then sharply flexed. This drags the distal fragment down and forward off of the proximal one. If the fracture be impacted, hyperextension of the hand to relieve the impaction should preceed the manipulations described above. To retain the fragments in position some surgeons use a pistol-shaped splint to hold the hand turned toward the ulnar side and place a graduated compress on the palmar surface with its base opposite the line of fracture and its apex upward and another pad on the dorsal surface with its apex downward over the hand. Other surgeons place the hand in a flexed position, allowing it to hang.

Separation of the Lower Epiphysis of the Radius

The lower end of the radius is osseous at about the tenth year and it fuses with the shaft at about the twentieth year; therefore epiphyseal separation can occur up to that time. The epiphyseal line passes across the bone from the base of the styloid process to the upper edge of the radio-ulnar joint (Fig. 377). It is an extremely frequent site of traumatic separation. The synovial membrane of the joint does not reach the level of the epiphyseal line which accounts for the fact that the joint is only rarely involved.

The displacement, symptoms and treatment are the same as in Colles's fracture and it is quite possible that many cases diagnosed as Colles's fracture may be epiphyseal separations.

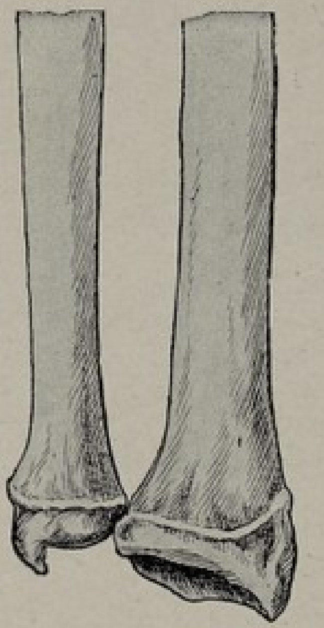


Fig. 377.—Epiphyses of the lower ends of the radius and ulna; union occurs with the shaft of the bones at about the 20th year.

Fracture of the Lower End of the Radius with Displacement Forward

This fracture, though rare, occasionally occurs, and if union has taken place the deformity is marked and the injury is liable to be diagnosed as a luxation. It has been particularly described by Dr. John B. Roberts ("A Clinical, Pathological, and Experimental Study of Fracture of the Lower End of the Radius with Displacement of the Carpal Fragment toward the Flexor or Anterior Surface of the Wrist," Phila., 1897). On account of the difficulties in diagnosis it is well to examine its anatomical peculiarities.

Displacement.—The lower fragment is tilted forward toward the palmar surface of the wrist, carrying the radial side of the hand with it (Fig. 378).

Signs.—The line of the radius can be followed and felt to curve at its lower portion toward the palmar surface. The hand descending with the displaced fragment causes a groove to appear across the dorsum from one styloid process to the other. The dorsal surface of the lower part of the forearm is on a higher plane than that of the carpus. As the hand is lower than normal this causes the lower end of the ulna to project much higher than it should. On account of the tension of the extensor carpi radialis longior and brevior the hand is held level with the forearm and does not droop as in Colles's fracture. Displacement to the radial side may or may not be marked.

Fracture of the Lower End of the Ulna

Previous to the use of the X-rays for diagnostic purposes, fracture of the lower end of the ulna was considered extremely rare. Fractures of the ulna above the head resembled practically those of the shaft.

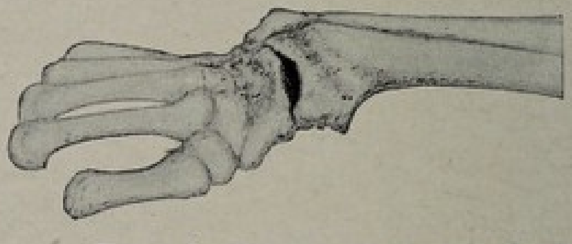


Fig. 378.—Fracture of the lower end of the radius with displacement of the lower fragment toward the palmar surface. (Sketch, by the author, of a specimen in the Mütter Museum of the Philadelphia College of Physicians.)

Fracture of the styloid process was observed by D. H. Agnew in one case which was followed by deformity. Inasmuch as the deep fascia slides over the ulna it is readily seen that if it is perforated one or other of the fragments may be caught in the rent. This is probably the explanation of the deformity which occurred in Agnew's case. He advised treatment with the hand bent toward the ulnar side to relax the extensor carpi ulnaris tendon. Fracture of the styloid process of the ulna has been shown by the X-rays to be a more frequent accompaniment of Colles's fracture than was formerly thought to be the case,—it tends to favor displacement of the hand toward the radial side.

Separation of the Lower Epiphysis of the Ulna.—The lower ulnar epiphysis is concave superiorly to fit into the round lower end of the diaphysis. It is held to the lower radial epiphysis by the ligaments of the inferior radio-ulnar joint and by the fibro-articular cartilage. Because of this and also because the ulna only indirectly takes part in the distribution of a blow on the hand, the epiphysis is only rarely dislocated. The more frequent lesion is a fracture of the radial styloid. However, as the growth of the ulna is almost entirely from the lower epiphysis it is extremely important to recognize and correct the injury.

It is the practise of some surgeons to fix splints with bands of adhesive plaster to fractures of the forearm, arm and hand. As union is largely dependent upon a proper blood supply to the fractured part and the healing of adjacent soft parts likewise if adhesive plaster is used or other unyielding dressing applied, it should be so applied as to allow for swelling of the parts so that undue constriction does not occur which might result in a pressure ulcer, Volkmann's contracture, non-union or long continued edema of the parts resulting in impairment of motion and discomfort. In general it is safer to avoid using these non-yielding dressings and depend upon properly applied bandage which will hold the part in position satisfactorily providing sufficient bandage is applied.

DISLOCATIONS AT THE WRIST

The dislocations at the wrist may be due to traumatism or may occur spontaneously. There may be either a displacement of the carpus at the radiocarpal joint or of the ulna at the inferior radio-ulnar articulation. These luxations are very rare.

DISLOCATIONS AT THE RADIOCARPAL JOINT

It is to Dupuytren that we owe the recognition of the fact that what were previously regarded as luxations of the wrist were really cases of fracture, usually of the radius. True luxations are exceedingly rare; they may be either backward or forward and are often compound. They are usually the result of great violence and the ends of the radius and ulna in many cases protrude on the palmar or dorsal surface.

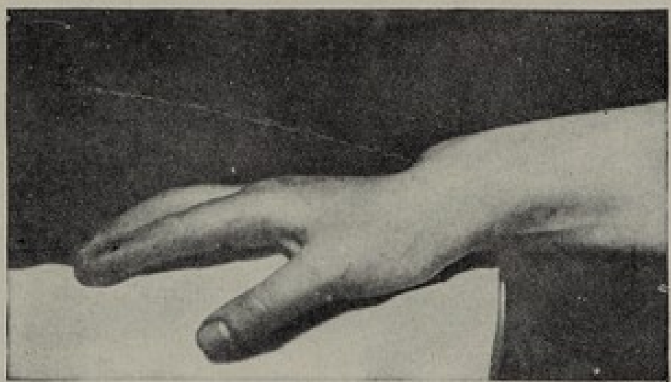


Fig. 379.—Subluxation of the wrist from disease.

Backward luxation is the more common of the two. The question of diagnosis is most important in relation to this injury. Many cases which have been diagnosed as luxations afterwards prove to be fractures. In backward luxation the deformity resembles that of Colles's fracture, with the following differences: the palmar swelling in dislocation extends farther down toward the hand than is the case in Colles's fracture,—this is owing to the displacement occurring at the joint instead of some distance above, as in fracture; in luxation the protrusion forming the hump on the dorsal surface has an abrupt upper edge which is lacking in cases of fracture, and both styloid processes—of the radius and the ulna—remain attached to the shaft of the bones.

Anterior luxation may occur from injury, but more commonly it is seen in the form of a subluxation which occurs slowly and spontaneously usually between the ages of 16 and 25 years. It was first described by Dupuytren and later by Madelung. The ulna projects markedly toward the dorsal surface while the radius is somewhat less prominent; there is a marked hollow on the palmar surface of the forearm just above the hand. Fig. 379, from a girl 18 years of age, shows these points clearly.

DISLOCATION OF THE ULNA AT THE LOWER RADIO-ULNAR JOINT

The ulna may be dislocated forwards or backwards. When associated with fracture of the radius it is not so rare, but otherwise it is seldom seen. Posterior luxation is the most common. The internal lateral ligament and triangular cartilage both usually remain attached to the lower end of the ulna, which projects markedly on the dorsal surface. The injury has been produced by falls on the hand and forced pronation.

In recent cases reduction can usually be accomplished by direct pressure and rotation of the hand, with traction. The secret of success in the diagnosis of these obscure fractures and luxations in the region of the wrist lies in knowing the surface anatomy and in being able to recognize the various deeper structures by the sense of touch.

When the posterior or anterior dislocation of the ulna persists it may be necessary to resort to some operative procedure to correct the deformity. Eliason has modified the operations of others using a fascial sling which encircles the ulna and is threaded through a hole drilled through the lower end of the radius. He reinforces by plication the anterior radio-ulnar ligament and reinforces it further with a transplantation of the lower fibres of the pronator quadratus having their origin from the lower part of the ulna. This operation is useful when there is no shortening of the radius, when the radius is shortened good results have been obtained by resecting subperiosteally the lower end of the ulna leaving the styloid process.

EXCISION OF THE WRIST

Formal excisions of the wrist are undertaken for tuberculous disease. It is desirable that all the affected tissues be removed. To do this is difficult, on account of the number and extent of the various carpal bones and joints as well as the danger of injuring the important arteries, nerves, and tendons by which they are surrounded. To remove the diseased parts without inflicting avoidable injury requires an exact and skilful operator who has a precise knowledge of the anatomy of the region. Interference with the sheaths of the tendons will result in stiffness and loss of control and power in the hand.

Maisonneuve, Boeckel, and Langenbeck operated through a single dorsal incision along the radial side of the extensor indicis tendon. As this incision was found to give insufficient room, Lister, in 1865, advised an additional incision along the ulnar border. Ollier, of Lyons, modified Lister's radial incision by carrying it nearer the extensor indicis tendon to better avoid injuring the radial artery and the insertion of the extensor carpi radialis brevior tendon. Ollier also carried his incision somewhat higher on the wrist and raised the tissues with a periosteal elevator, and divided no tendons.

Ollier's Operation.—*Radial Incision.*—From a point on the dorsum of the wrist midway between the styloid processes, downward and outward alongside of the extensor indicis tendon to the junction of the middle and lower thirds of the metacarpal bone of the index finger (Fig. 380).

Ulnar Incision.—From a point 2.5 cm. (1 in.) above the styloid process of the ulna toward its palmar surface, downward to the base of the fifth metacarpal bone (Fig. 358).

When making the radial incision, branches of the radial nerve may be seen in the lower part of the incision and should if possible be avoided. In making the ulnar incision a cutaneous branch of the ulnar nerve should be avoided as it verges toward the dorsal surface below the styloid process.

The extensor indicis tendon is pulled aside and the extensor carpi radialis brevior beneath detached with the periosteum from the base of the third metacarpal bone. The incision is then extended higher up the wrist, care being taken not to injure the tendon of the extensor longus pollicis at the posterior radial tubercle. The periosteum is to be detached over the lower end of the radius, the radiocarpal joint opened, and the carpal bones removed one after another. The pisiform bone, unciform process, and trapezium are left when possible. In removing the unciform process the deep branch of the ulnar nerve should be avoided. If the trapezium is removed care must be taken not to wound the radial artery as it goes over the bone to dip between the first and second metacarpal bones, and also to avoid the flexor carpi radialis tendon as it crosses to the inner side of the ridge of the trapezium on its palmar surface.

The articular ends of the ulna and radius may be removed with a small saw if necessary. As Jacobson says, this operation is a tedious and difficult one, and we might add that it is liable to be an inefficient one, owing to the inability to remove all of the diseased tissue.

Operations of Studsgaard and Mynter.—Studsgaard of Copenhagen in 1891 suggested, and Mynter (1894) carried out the method of splitting the hand

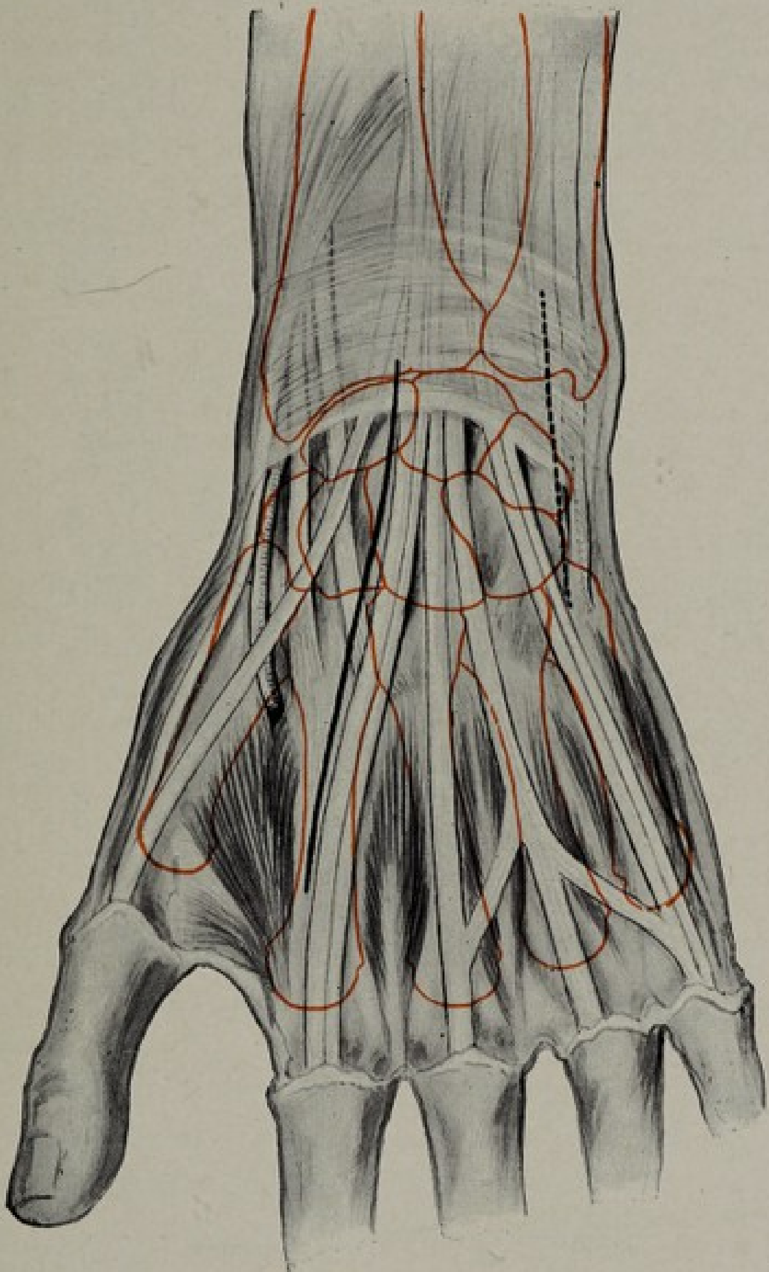


Fig. 380.—Excision of wrist, showing structures involved and Ollier's incisions. The solid line indicates the dorsal radial incision and the dotted line the palmar ulnar incision.

on the dorsum from the web between the second and third fingers to the lower edge of the radius, and on the palmar surface to the base of the thenar eminence.

Wm. J. Taylor (1900) modified the operation by employing only the dorsal incision. This operation gives full access and exposure to the parts, and all disease can most readily be recognized and removed with the scissors or other instruments. It is probably the best method of exposure and operation when simple incision and curetting does not suffice.

AMPUTATION THROUGH THE WRIST-JOINT

When it is possible to do so the interarticular fibrocartilage over the lower end of the ulna is not to be interfered with. The lower radio-ulnar joint is therefore not injured and the movements of pronation and supination are preserved.

The styloid process of the radius is 1 cm. below that of the ulna. It is directly on the outer side of the radius, while the styloid process of the ulna is toward the posterior surface.

On account of the skin of the palm being thick and well adapted for pressure a long palmar flap is preferred.

Incision.—On account of retraction, the knife is entered 1 cm. (2/5 in.) below the radial styloid process—the thumb being abducted to render the tissues tense, and, if the left hand is being operated on, the knife is carried straight down well on the thenar prominence. It is then curved abruptly across the palm on a level almost or

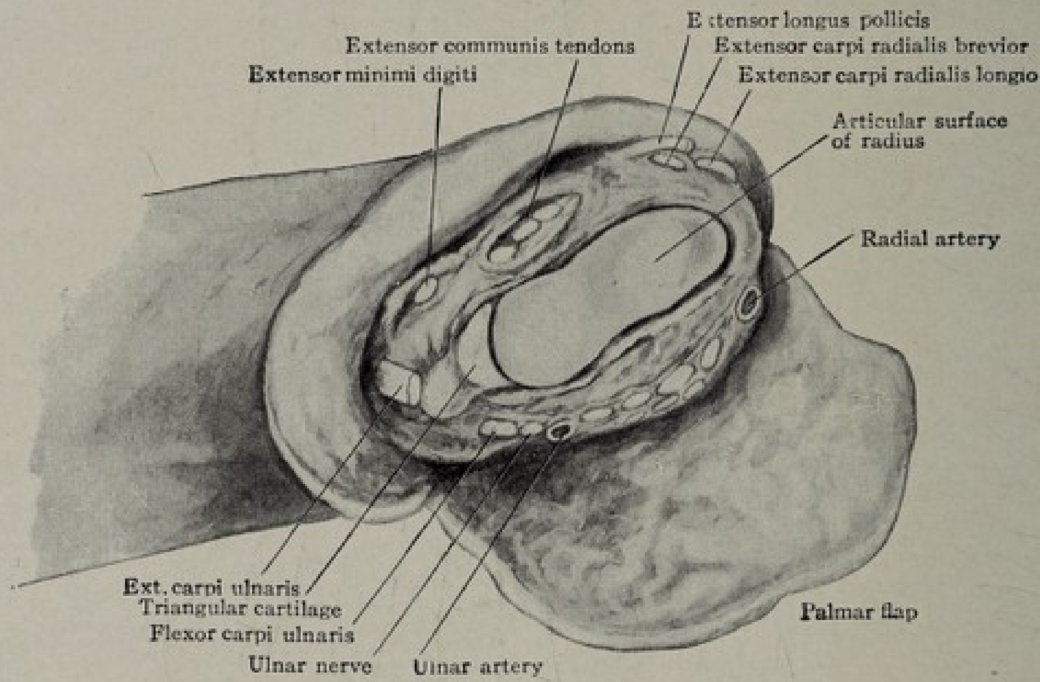


Fig. 381.—Amputation through the wrist-joint of the right side.

quite as low as the web of the thumb. It is continued to the ulnar side and up to within 1 cm. of the styloid process of the ulna. The flap should be an almost square one with rounded ends. The incision goes down to but does not divide the flexor tendons (Fig. 381).

This flap, embracing the palmar fascia and part of the thenar and hypothenar muscles, is at once raised from the flexor tendons, care being taken not to catch the knife on the unciform and pisiform bones.

The hand is now pronated and a dorsal flap 2.5 cm. (1 in.) long is cut. As the skin is loose and elastic this length is needed to provide against retraction.

The flaps being reflected and the hand flexed, disarticulation is begun by entering the knife on the ulnar side of the dorsum, beneath the styloid process. The joint is followed around to the radial side, bearing in mind that it curves markedly upwards.

If the right hand is being operated on and the knife is entered transversely it will strike the scaphoid bone, therefore it must be at once inclined obliquely upward. Section of the flexor muscles and anterior ligament completes the disarticulation. The radial artery will be cut in the snuff-box. The ulnar will be seen on the inner side of the palmar flap, and on the outer side may be seen the superficial volar. Some small branches of the anterior and posterior carpal and interosseous arteries may require ligation.

Some operators remove the styloid processes of the radius and ulna. If this is done, care is to be taken not to go so high as to injure the insertion of the brachioradialis on the radius and the attachment of the triangular cartilage on the ulna. Usually the styloid processes are not interfered with, in order to avoid impairing the movements of pronation and supination.

Ligation of the Radial Artery on the Dorsum of the Hand.—The radial artery can be ligated in the anatomical snuff-box as it crosses the back of the hand to dip between the first and second metacarpal bones and the two heads of the abductor indicis muscle. The course of the artery is indicated by a line drawn from the tip of the styloid process of the radius to the upper end of the first interosseous space (see Fig. 370, p. 381).

The incision is usually made in the direction of the tendons from the styloid process down. As soon as the skin is divided there may be exposed in the superficial fascia some branches of the radial nerve and the radial vein. These being pushed aside, the deep fascia is opened and the artery found with its two companion veins lying deep down on the external lateral ligament and trapezium. The most common error in this operation is mistaking the superficial vein for the artery and not searching deep enough. Care should be exercised so as not to open the tendon sheaths or the carpal joints.

If the radial artery is wounded as it passes through the snuff-box bleeding will be very free. It is almost impossible to ligate the divided ends in the wound because the proximal end retracts under the short extensor tendons of the thumb and the distal end retracts through the first interosseous space deep into the palm of the hand so that they cannot be reached. When such is the case it is necessary either to ligate the ulnar and radial arteries on the anterior surface just above the wrist or, as we did in one case, pack the wound with antiseptic gauze and keep the hand well elevated.

THE HAND

As has already been stated, the hand is the essential part of the upper extremity, and mobility is its main characteristic. It terminates in five digits which possess a bony support or framework. In order that the fingers may perform their many complicated movements numerous joints are inserted which necessitate a still greater number of bones. The movements of the hand and fingers are accomplished not only by the long flexors and extensors of the fingers and the flexors and

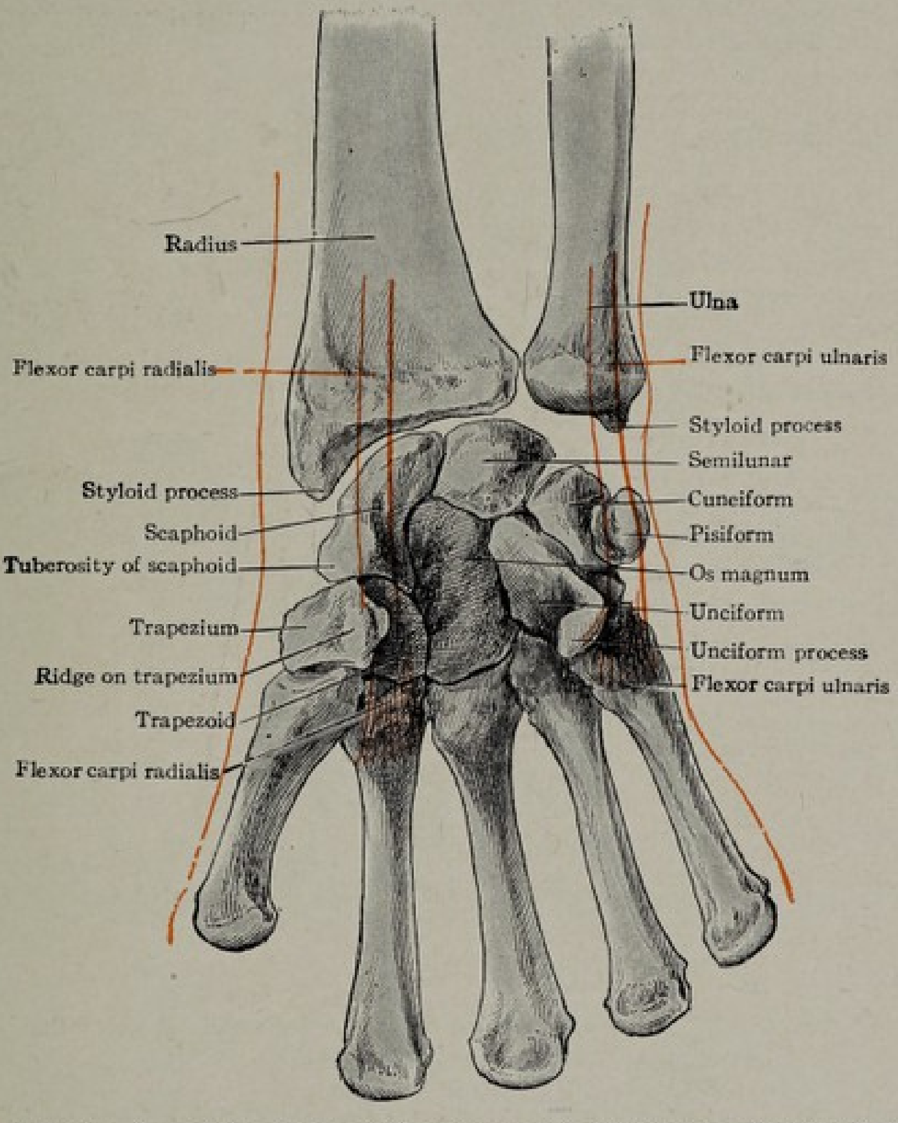


Fig. 382.—Anterior view of the bones of the carpus and metacarpus, showing insertion of the two carpal flexor muscles.

extensors of the carpus, which, as has already been shown, come down from the forearm, but in addition by numerous short muscles situated in the hand itself. An especial peculiarity of the human hand is the ability to oppose the thumb to the other digits.

BONES OF THE HAND

The carpus contains 8 bones, the metacarpus 5, the phalanges 14; 27 bones in all.

The Carpal Bones.—The carpal bones are in two rows. The upper row is convex above and the lower row is convex below.

The upper row, beginning on the radial side, is composed of the *navicular (scaphoid)*, *lunate, cuneiform,* and *pisiform.* The three first-named articulate with the radius and triangular cartilage, forming the *radiocarpal joint,* but the pisiform is separate. It is perched on the cuneiform bone and is practically a sesamoid bone developed in the tendon of the flexor carpi ulnaris muscle. The anterior end of the navicular (scaphoid) has on its palmar surface a tuberosity which can be felt immediately below the flexor carpi radialis tendon at the wrist; this tendon passes along the palmar surface to insert in the base of the second metacarpal bone (Fig. 382).

The lower row, beginning on the radial side, is composed of the *trapezium, trapezoid, os magnum,* and *unciform.* The first three articulate with the first three metacarpal bones but the unciform, like the cuboid in the foot, articulates with two metacarpal bones—the fourth and fifth.

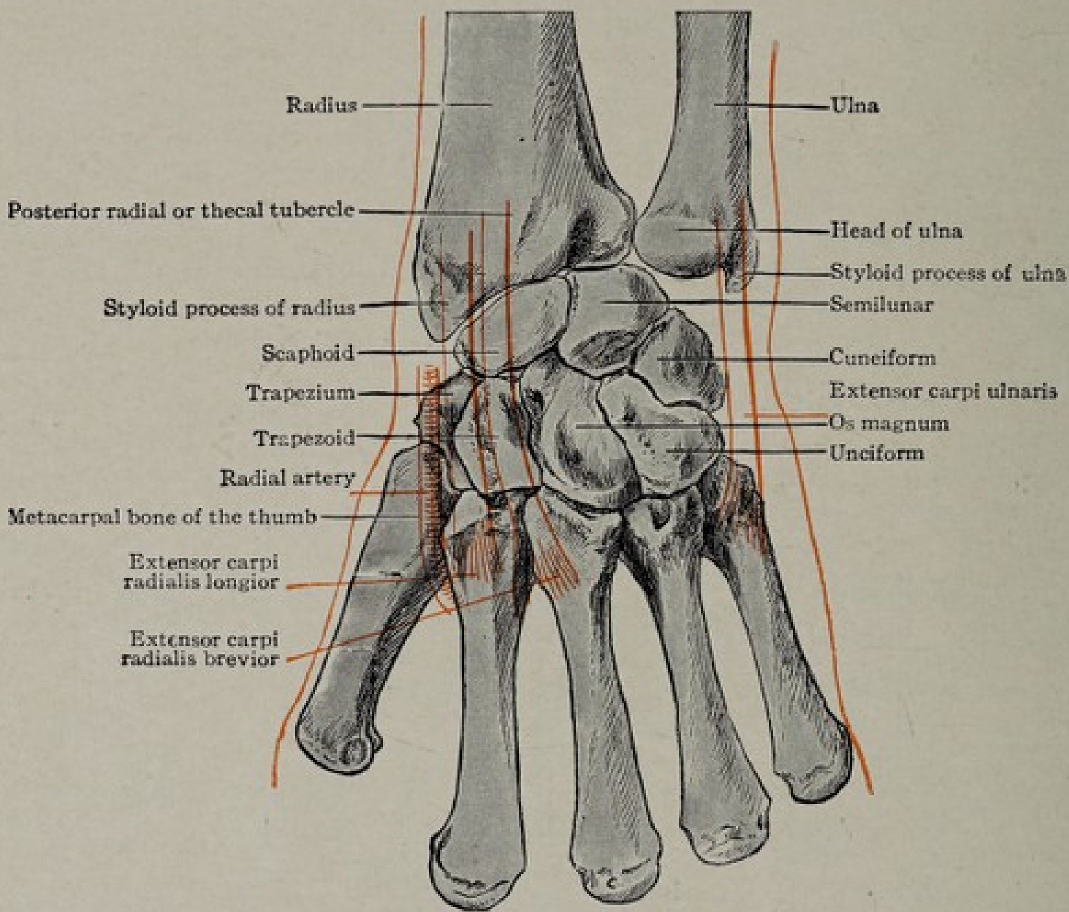


FIG. 383.—Posterior view of the bones of the carpus and metacarpus, showing the insertion of the three carpal extensor muscles.

The trapezium articulates with the first metacarpal bone by a saddle-shaped joint and has on its palmar surface a ridge. Along the inner side of this ridge runs the *flexor carpi radialis tendon.* The ridge of the trapezium and tuberosity of the navicular (scaphoid) give attachment to the radial side of the *anterior annular ligament.*

The unciform bone has a hook-like (unciform) process on its palmar surface. It can be felt by deep pressure 2 cm. (about ¾ in.) below and to the radial side of the pisiform bone. This process and the pisiform bone give attachment to the ulnar side of the anterior annular ligament. Since the inception of the X-ray we occasionally find other bones in the carpus. These may be due to the persistence of centres laid down in early life which usually fuse with other carpal centres and disappear long before the appearance of bone. Thus Pfitzner has placed the number of carpal elements at thirty-three.

The Metacarpal Bones.—The metacarpal bones have their bases at the carpus and their heads toward the phalanges. The shafts are small as compared with the extremities, and hence are not infrequently fractured. On each side of the head is a small projecting tubercle, which, when the bone becomes luxated, catches in the tissues and hinders reduction.

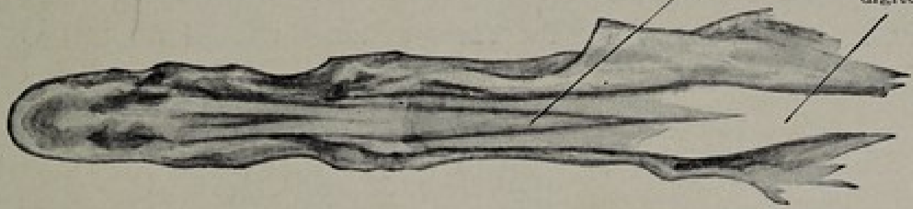


Fig. 384.—Palmar view of the flexor tendons of the finger, showing the insertion of the flexor sublimis into the middle phalanx and the flexor profundus into the distal phalanx.

On the palmar surface of the base of the second metacarpal bone is inserted the *flexor carpi radialis* and into the base of the fifth the *flexor carpi ulnaris*, which is continued onward from the pisiform bone. On the dorsal surface, into the base of the second, is inserted the *extensor carpi radialis longior*; into the base of the third (and part of the second) is inserted the *extensor carpi radialis brevior*, and into the base of the fifth, the *extensor carpi ulnaris* (Fig. 383).

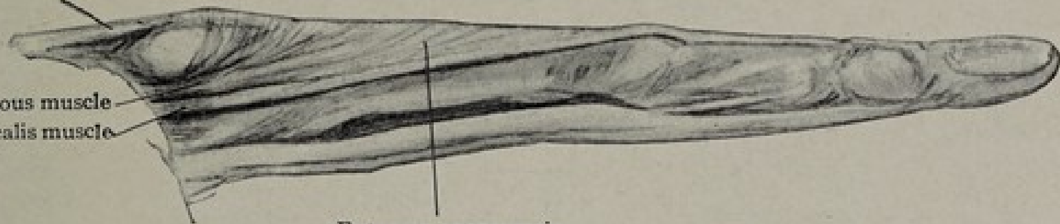


Fig. 385.—Lateral view of the extensor tendons of the finger.

Thus it will be seen that all the flexors and extensors of the wrist have their ultimate insertion into the metacarpal bones.

The metacarpal bone of the thumb has inserting into its base the *extensor ossis metacarpi pollicis* (*abductor longus pollicis*) *tendon*. As this tendon has its origin in the forearm it also acts as a carpal extensor, but owing to the movability of the

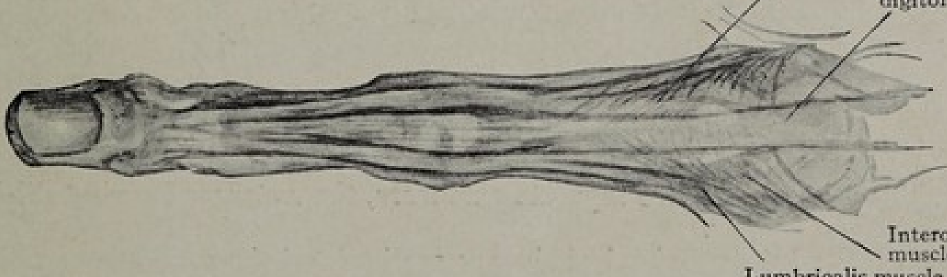


Fig. 386.—Dorsal view of the extensor tendons of the finger.

thumb it acts especially as an extensor of the latter, the carpus remaining immovable.

The Phalanges.—The thumb has two phalanges and the fingers each three. These are called the *proximal*, *middle*, and *distal phalanges*, also the *first*, *second*, and *third phalanges*. The thumb has only a *proximal* and a *distal phalanx*.

Into the middle phalanges on their palmar surfaces are inserted the *flexor sublimis digitorum tendons* and into the distal the *flexor profundus* (Fig. 384). There is only one long flexor to the thumb and it is inserted into the distal phalanx.

The *extensor communis digitorum* opposite the metacarpophalangeal joints sends off a fibrous expansion which blends with the lateral ligaments of the joints (Fig. 385). On the dorsum of the proximal phalanx the tendon splits into three parts. The middle slip inserts into the bases of the middle phalanges, while the two lateral slips, after receiving the insertions of the lumbricales and part of the insertions of the interossei, insert into the bases of the distal phalanges of the fingers

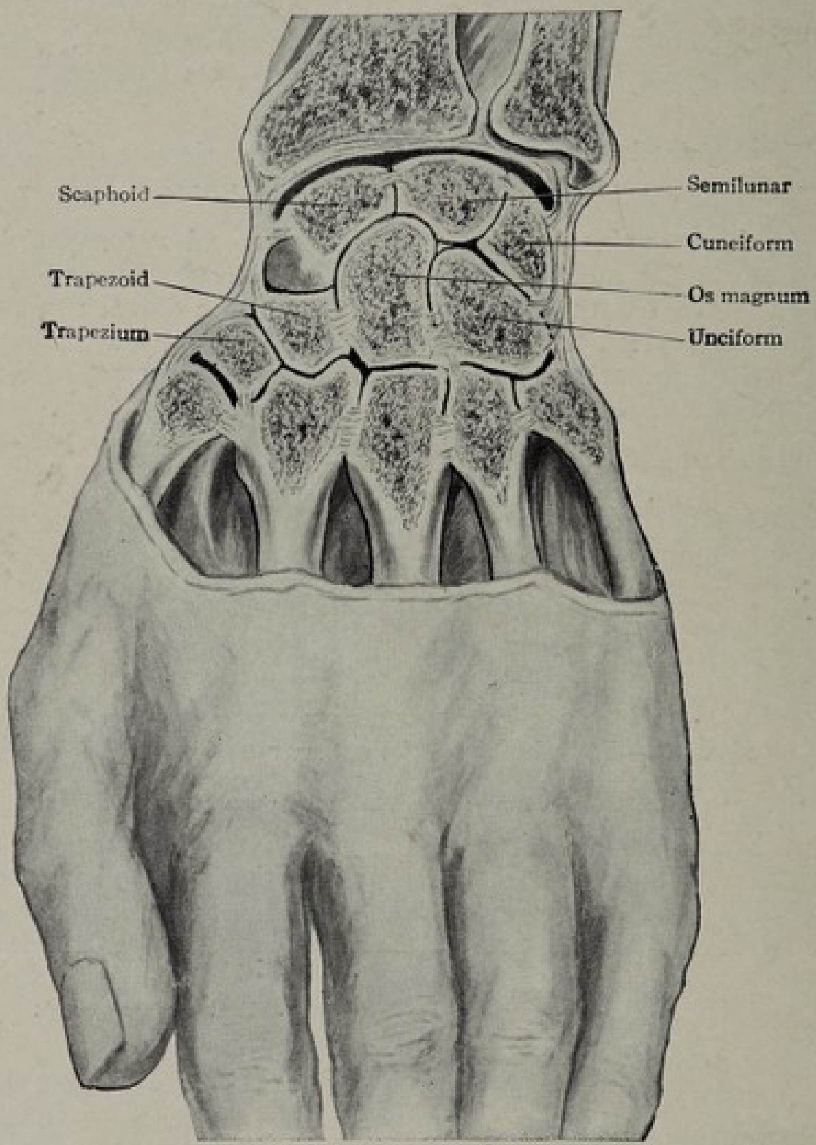


FIG. 387.—The carpal bones and joints.

(Fig. 386). The thumb has two separate extensors, the *extensor brevis pollicis* and the *extensor longus pollicis.*

Into the bases of the proximal phalanges are inserted the remaining portion of the tendons of the interossei muscles, which move the fingers toward and from one another, and slips from the palmar fascia. The main function of the interossei and lumbrical muscles is to extend the distal and middle phalanges and to flex the proximal ones. When, therefore, most of them are paralyzed, as occurs when the ulnar nerve is divided, the distal and middle phalanges are flexed and the proximal phalanges extended, forming the claw-hand (main griffe) of Duchenne.

Rupture of the extensor tendon of the middle finger at its insertion into the base of the distal phalanx frequently occurs as a result of unusual stress placed upon the distal phalanx. Rupture at this joint also occurs either alone or in combination with fracture or dislocation in so called base-ball finger, affecting any of the other fingers. Repair of the tendon should always be attempted otherwise the distal phalanx remains in flexion causing a certain disability. Any associated dislocation should be reduced and if a fracture be present it should receive appropriate treatment.

JOINTS OF THE HAND

The carpal bones besides being connected by short ligaments running from one to another on their dorsal and palmar surface also have their adjacent surfaces connected by interosseous ligaments. The three bones of the first row are joined by two ligaments near their proximal surfaces which prevent any communication of the radiocarpal with the midcarpal articulations. The four bones of the second row are joined together by interosseous ligaments (fibrocartilages, Morris) which are not complete. That between the os magnum and the unciform is attached more toward the palmar surface, while that between the os magnum and trapezoid is more toward the dorsal surface. The interosseous ligament between the trapezium and trapezoid is usually lacking (Fig. 387).

Synovial Membrane.—From the above description it will be seen that the joints of the carpus (with the exception of the pisiform) all communicate with one another and with the carpometacarpal joints, and that the synovial membrane is practically continuous; hence *suppuration* implicating the synovial membrane at any point can travel without hindrance between all the carpal (with the exception of the pisiform) and metacarpal bones.

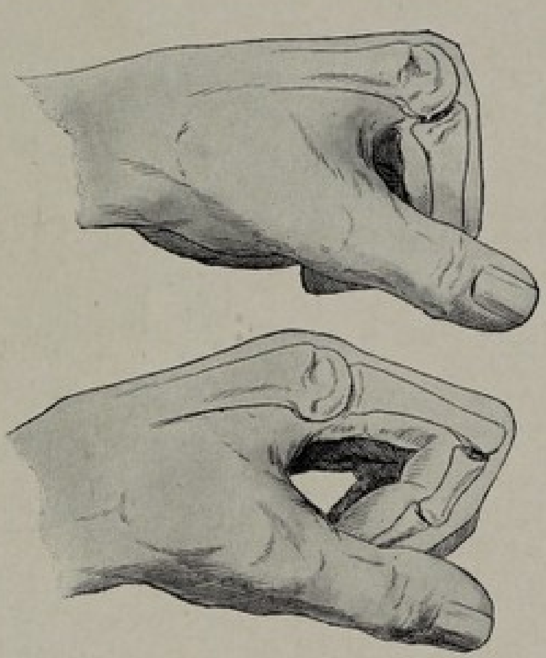


Fig. 388.—Showing how, when the fingers are flexed, the prominence of the knuckles is formed by the projection of the proximal bone.

The phalangeal joints have two strong lateral ligaments and an anterior or glenoid ligament, but no posterior ligament.

Movements.—While the amount of motion between the individual carpal bones is limited to a slight gliding on one another, still, when taken together, a very considerable range of movement is allowed. The hand can be flexed and extended, abducted and adducted, and circumducted, but not rotated. If the bones of the forearm at the wrist are held immovable it is impossible to rotate the hand.

The radiocarpal joint bends more freely posteriorly (extension) than anteriorly, while the midcarpal bends more freely in the opposite direction (Figs. 365, 366, p. 377), adduction (toward the ulnar side) is more extensive than abduction. The movement between the two rows of carpal bones is quite extensive.

The movements of the inner four carpometacarpal joints are both of flexion and extension, mainly toward the palmar surface, and a lateral flexion and extension which enables a person to "hollow" the hand and so grasp round objects. The palmar flexion of the fourth and fifth metacarpal bones is more marked than that of the index and middle ones. The middle metacarpal bone is the least movable. The metacarpal bone of the thumb articulates with the trapezium by a saddle-shaped joint which allows flexion, extension, abduction, adduction, and circumduction, but little or no rotation.

Abduction, adduction, and circumduction of the thumb occur at the carpometacarpal articulation and *not* at the metacarpophalangeal articulation. This latter is a pure hinge-joint and possesses the movements of flexion and extension only.

The metacarpophalangeal articulations of the fingers are practically saddle-shaped joints resembling somewhat the ball-and-socket joints with all their movements except that of rotation. They can be flexed to an angle of 90 degrees. The interphalangeal joints are hinge-joints and capable only of flexion and extension. The second joint can be flexed to an angle of 120 degrees and the end joint to about a right angle.

In flexion the distal phalanx always passes under the proximal bone, thus causing the prominence of the knuckle to be formed by the proximal phalanx or metacarpal bone (Fig. 388).

MUSCLES OF THE HAND

The hand contains not only the tendons of the long muscles which descend into it from the forearm, but also some short muscles. They may be divided into *three*

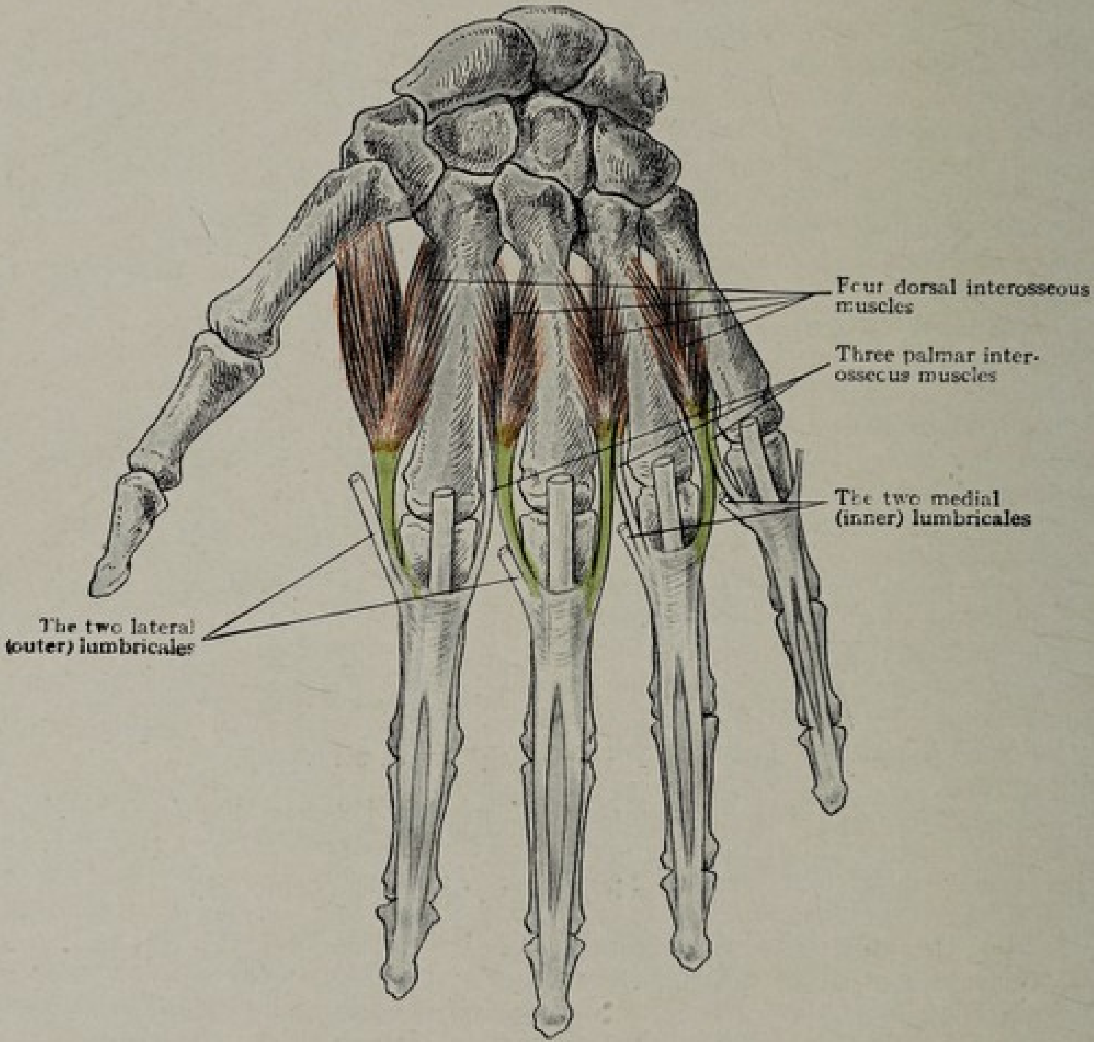


FIG. 389.—Showing the mode of insertion of the interosseous and lumbrical muscles.

sets, viz.: a middle set, embracing the *interossei* and *lumbricales*; an external set, embracing the thumb muscles and forming the *thenar eminence*; and an internal set, embracing the little finger muscles and forming the *hypothenar eminence*.

The Middle Set.—The interossei muscles arise from the adjacent sides of the metacarpal bones; the lumbricales arise from the tendons of the flexor profundus digitorum. They all insert into the fibrous expansion of the long extensor tendons at the sides of the proximal phalanges (Fig. 389). When they contract they flex the proximal phalanx and extend the middle and distal phalanges. The interossei have a second insertion into the sides of the base of the proximal phalanx. By their action the fingers may be separated one from the other, or approximated.

When the fingers are straight the palmar interossei act as adductors, while the dorsal interossei act as abductors. The four volar (four dorsal and the third and fourth lumbricales) interossei are innervated by the ulnar nerve, while the two lumbricales are innervated by the median.

The External Set.—The thenar or thumb eminence has four muscles, the *abductor pollicis, opponens pollicis, flexor brevis pollicis,* and *adductor pollicis.* This latter is usually divided into two parts called the *adductor transversus* and *adductor obliquus* (Fig. 392).

The flexor brevis has two heads, an outer and an inner. The outer head is inserted into the base of the proximal phalanx on its outer side along with the

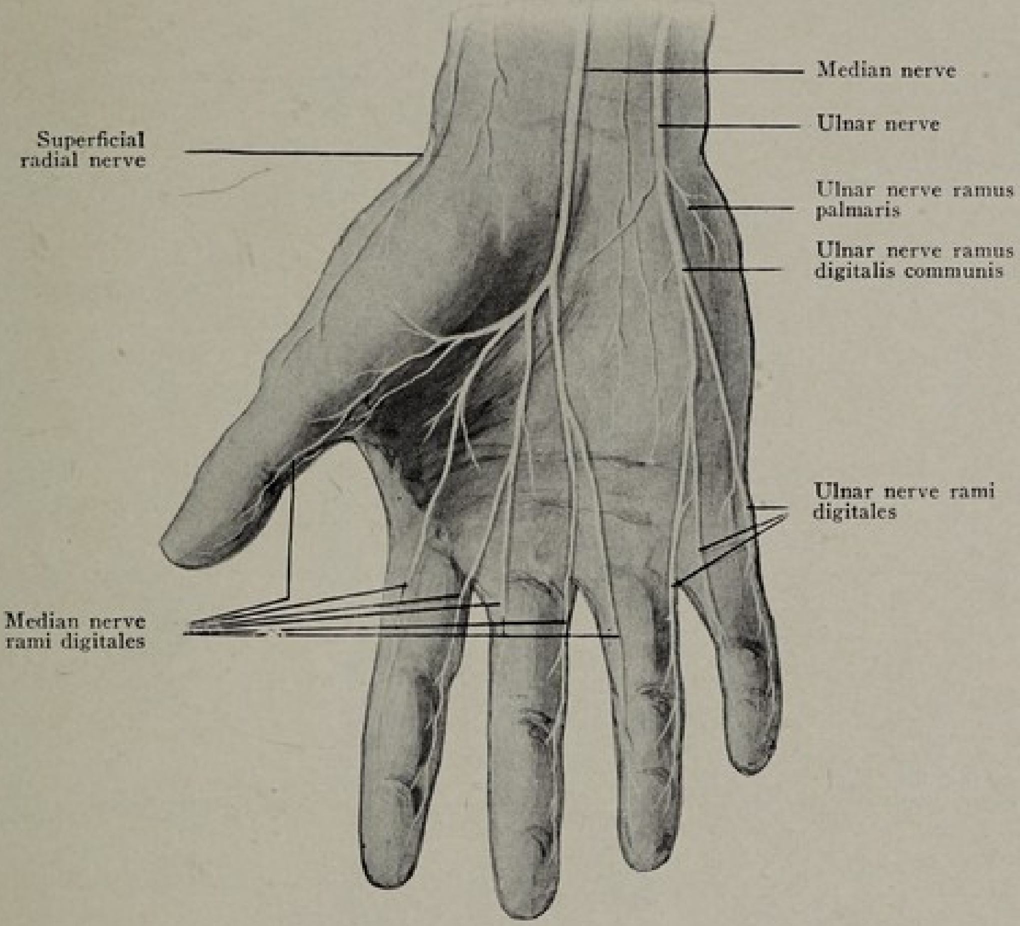


FIG. 390.—Distribution of cutaneous nerves, palmar surface of hand.

abductor. The inner head, called by some the first volar interosseous, is inserted into the inner side along with the adductor; between the two heads runs the tendon of the long flexor of the thumb. The opponens inserts into the outer anterior border of the shaft of the first metacarpal bone. The abductor, opponens, flexor brevis, are supplied by the median nerve. The adductor pollicus receives its innervation from the ulnar.

The Internal Set.—The little finger, like the thumb, has *abductor, opponens,* and *flexor brevis muscles,* but no adductor. There is, however, a short muscle, the *palmaris brevis,* which is superficial to the palmar fascia and, passing transversely across the hypothenar eminence, inserts into the skin. It makes a dimple on the ulnar side when the hand is hollowed. The abductor and flexor brevis minimi digiti muscles insert on the ulnar side of the proximal phalanx, hence when they contract they tend to hollow the hand, as does also the opponens minimi digiti, which inserts on the ulnar side of the fifth metacarpal bone. All the muscles of the internal set are innervated by the ulnar nerve.

SURFACE ANATOMY OF THE HAND

The hand is twice as long as it is broad. The length of the middle finger from the metacarpophalangeal joint to its extremity is equal to the distance from the metacarpophalangeal joint to the radiocarpal joint. If the hand is turned with the palm up, the thumb diverges from the median line at an angle of 40 degrees. The palm is hollow, with a muscular mass on each side. That on the thumb side is called the *thenar* eminence; it is formed by the abductor, opponens, and outer head of the flexor brevis pollicis. The prominence on the ulnar side of the hand is called the *hypothenar* eminence and is formed by the abductor, opponens, and flexor brevis minimi digiti. The palmaris brevis muscle overlies them transversely. The triangle

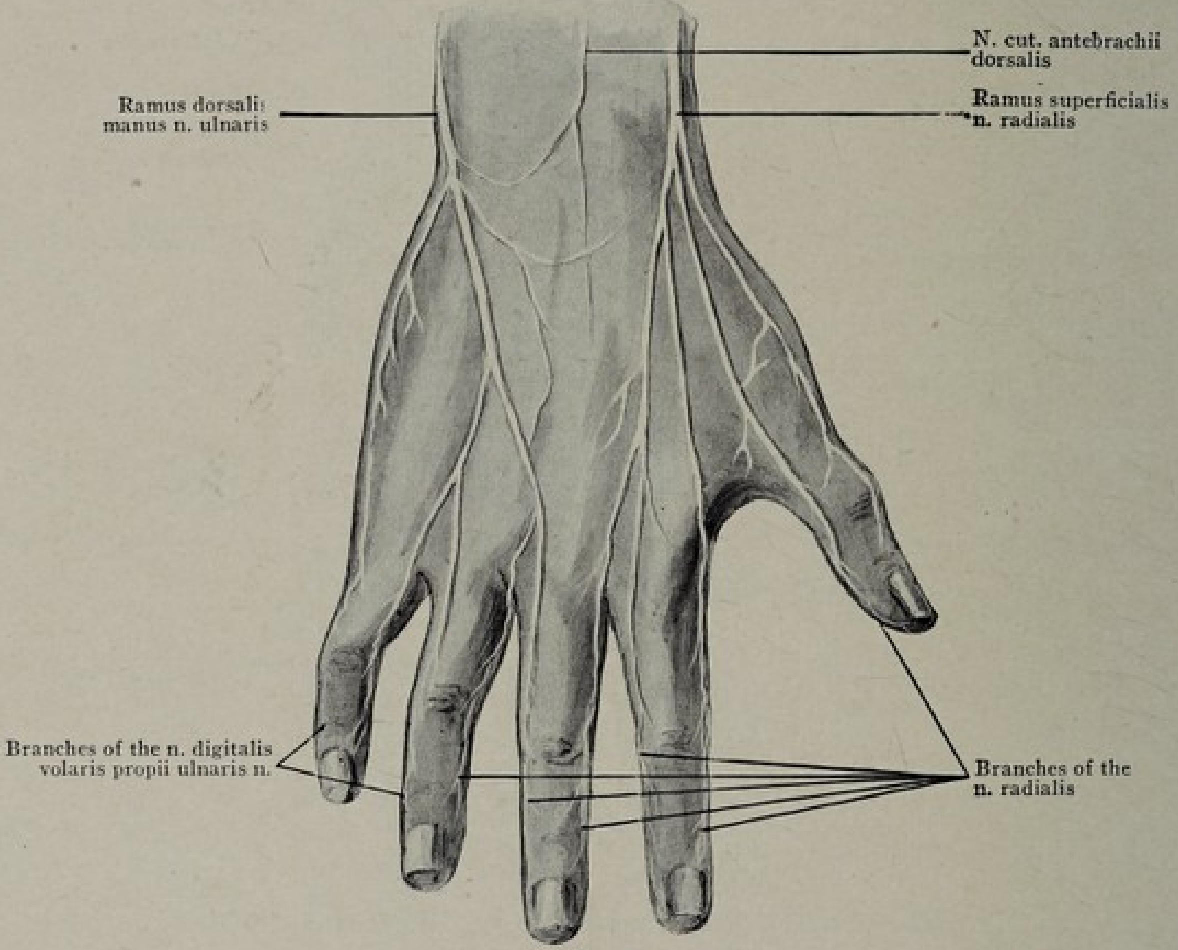


FIG. 391.—Distribution of cutaneous nerves, dorsal surface of hand.

often called the "hollow of the hand" is bounded laterally by these two eminences and its base corresponds to the three elevations opposite the interdigital clefts. The palm is marked by four *creases*, two longitudinal and two transverse. One longitudinal crease begins at the middle of the wrist between the thenar and hypothenar eminences to end on the radial side of the index finger, opposite the head of its metacarpal bone. It is caused by adduction of the thumb. The other longitudinal crease runs somewhat parallel to the first, starting near the wrist and ending in the web between the index and middle fingers. It is formed by hollowing the hand. The upper transverse crease begins on the radial side of the index finger where the first longitudinal crease ends, and runs obliquely across the palm to the middle of the hypothenar eminence. It is formed by the flexion of the fingers, especially the index, and where it crosses a line drawn through the middle of the middle finger marks the lowest point of the superficial palmar arch. The position of the lowest portion of the superficial palmar arch is also indicated by a line drawn across the palm opposite to the web of the thumb and index finger. The lower transverse crease begins on the hypothenar eminence opposite the head of the fifth metacarpal bone and is formed by the flexion of the middle, ring, and especially the little finger. When it reaches the vicinity of the median line it merges with the second longitudinal crease which passes to the web between the index and middle fingers. Midway between the crease and the webs of the fingers lie the joints of the middle, ring, and little finger. More stress is apt to be laid on a knowledge of these creases than they deserve (Fig. 393).

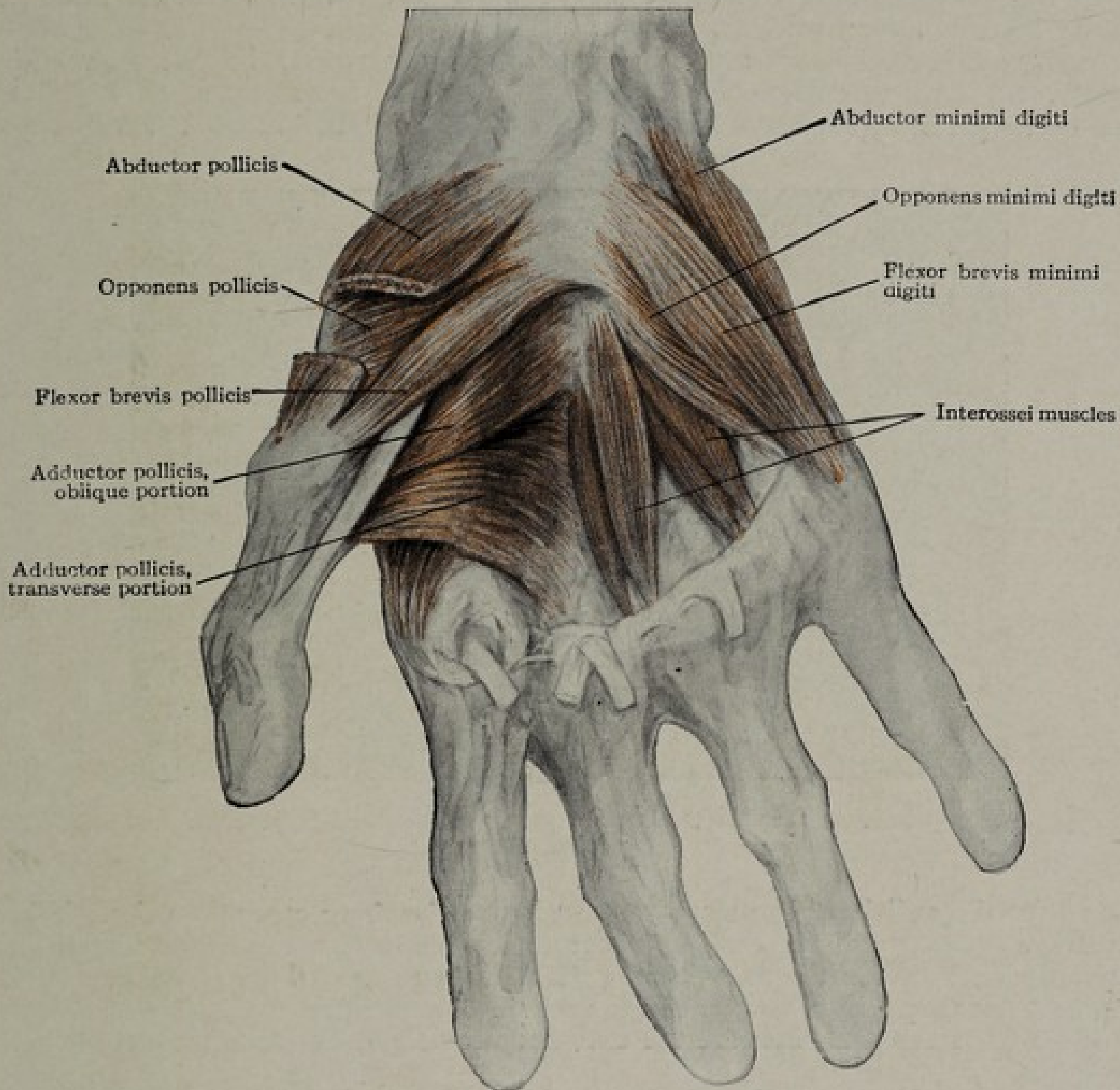


FIG. 392.—Muscles of the hand.

The position of the metacarpophalangeal joints is best determined by feeling for them on the dorsum of the hand and then taking a corresponding point on the palmar surface. They are sufficiently accurately located by taking a point 2 cm. (¾ in.) behind the web of the fingers. The creases for the middle phalangeal joints are directly opposite the articulations. The creases for the end phalangeal joints are to the proximal side of the articulations. The deep palmar arch lies about 1.5 cm. (⅗ in.) closer to the wrist than the superficial.

The digital arteries from the superficial palmar arch pass downward with the digital nerves, superficially, in the spaces between the metacarpal bones, to the webs of the fingers. About 1 cm. (⅖ in.) behind the web they sometimes receive branches from the deep palmar arch, and then divide to go to each lateral palmar side of the fingers. The palmar fascia divides into its four slips just below the line of the superficial palmar arch, opposite the web of the thumb.

On the dorsum of the hand the extensor tendons can be seen. Accessory slips usually connect the tendon of the ring finger with that of the little finger and middle finger. A slip also usually passes from the tendon of the middle to that of the index finger.

The slip from the tendon of the ring to that of the little finger has been thought to restrict the freedom of the movement of the ring finger, hence in musicians it sometimes has been divided. The operation is done by first flexing the fingers, which brings the slip well forward near the knuckle, and then introducing a thin knife longitudinally beneath it and cutting toward the skin. The procedure has not found favor among musicians.

The metacarpal bones are subcutaneous and can readily be felt their entire length. The muscular prominence on the dorsum of the hand seen when the thumb and forefinger are approximated is due to the abductor indicis muscle. At its upper

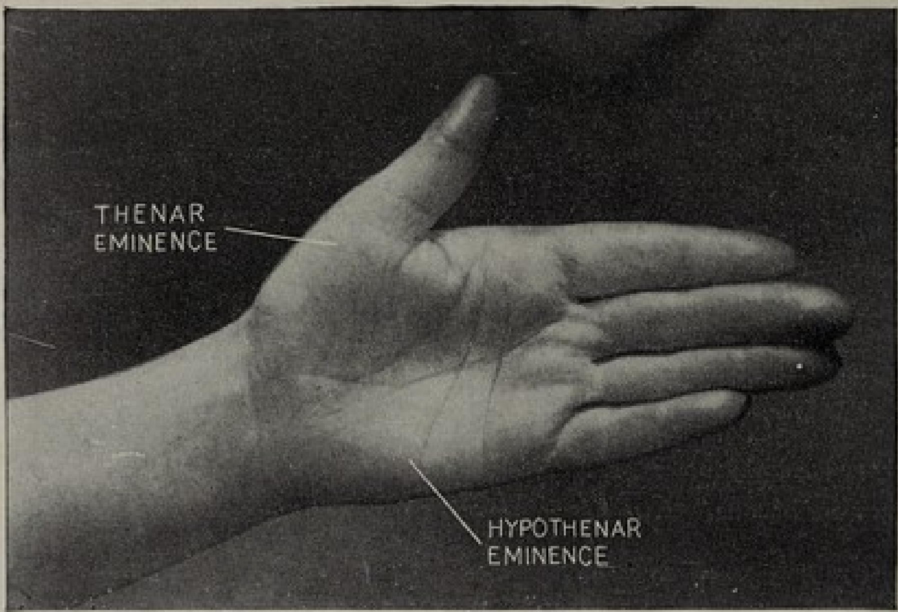


Fig. 393.—The palmar surface of the hand showing thenar and hypothenar eminences and creases.

extremity the radial artery passes between its two heads to enter the palm. When the thumb is extended the snuff-box becomes evident and the extensor longus pollicis tendon is distinctly seen leading to the ulnar side of the posterior radial (thecal) tubercle on the middle of the dorsum of the radius. The tendons on the radial side of the snuff-box are the extensor brevis and extensor ossis metacarpi-pollicis.

When the fingers are flexed, the prominence of the knuckles is formed by the proximal bones; the distal phalanges fold under the proximal ones and the joint line is about 1 cm. ($\frac{2}{5}$ in.) below the dorsal surface of the metacarpal bones (Fig. 388, page 399).

THE PALMAR FASCIA

The palmar fascia or aponeurosis is the deep fascia of the hand. It represents one of the layers of a thick aponeurosis seen in the lower vertebrates which in them receives the antibrachial flexors and gives rise to the digital flexors. It consists of a thick triangular middle portion and two thin lateral portions which cover the thenar and hypothenar eminences. The *triangular middle portion* can be divided into two layers. Its under layer is composed of transverse fibres, and blends with the anterior annular ligament; its upper layer is composed of longitudinal fibres, the continuation of the palmaris longus, and when it reaches the middle of the palm it divides into four slips which blend with the sheaths of the flexor tendons and lateral ligaments of the metacarpophalangeal joints to insert into the sides of the base of the proximal phalanges, and aid in flexing them at the metacarpophalangeal joints and a little below the edge of the fascia the superficial transverse metacarpal ligament which binds the slips together. The digital arteries and nerves lie between these slips on their way to the webs of the fingers. The superficial surface is intimately adherent to the skin above, especially at the webs of the fingers, where its fibres form the superficial transverse ligament. The intimate attachment between the skin above and fascia beneath binds these two structures so closely and firmly together that pus cannot travel for any distance between them. It either burrows

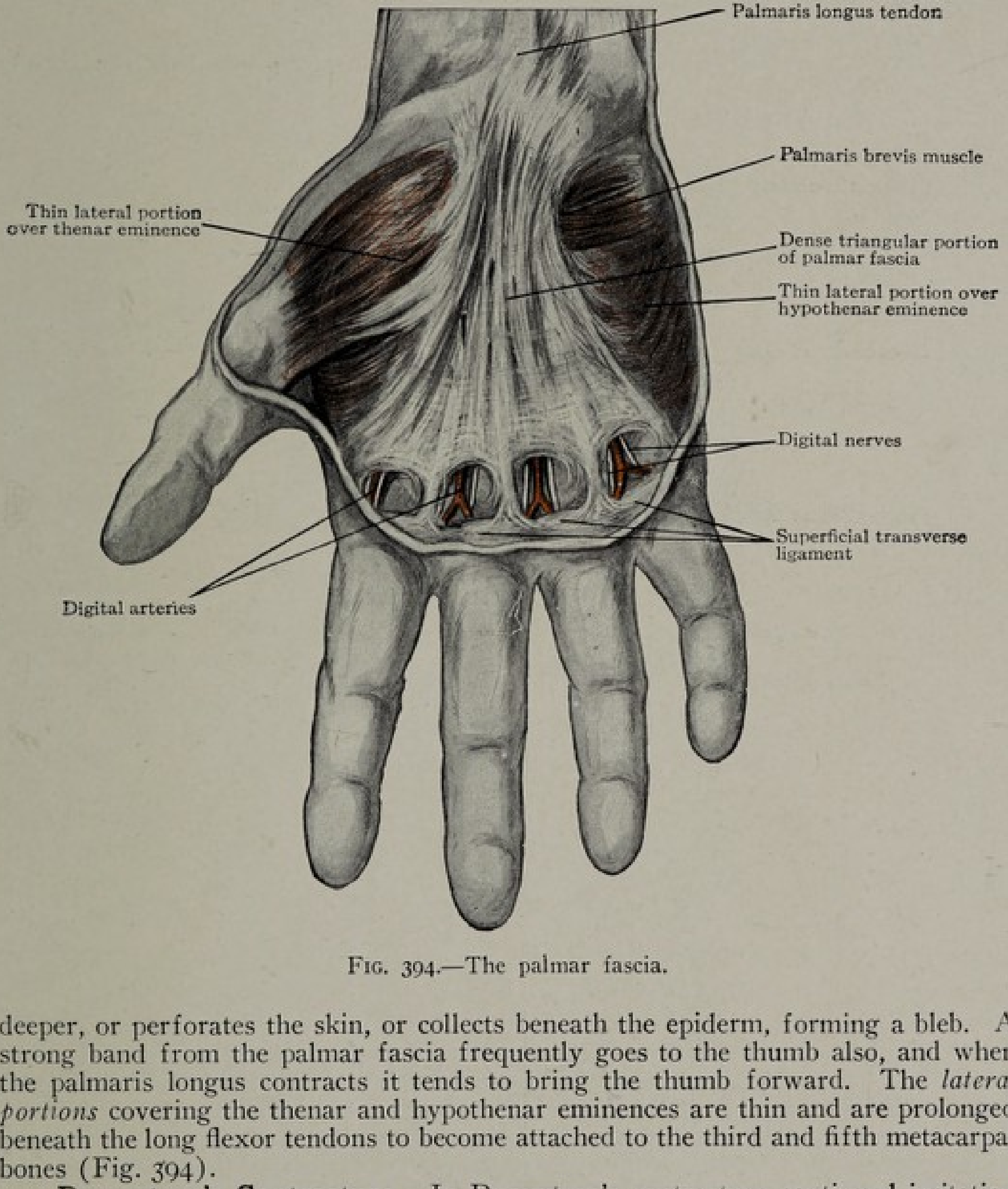


FIG. 394.—The palmar fascia.

deeper, or perforates the skin, or collects beneath the epiderm, forming a bleb. A strong band from the palmar fascia frequently goes to the thumb also, and when the palmaris longus contracts it tends to bring the thumb forward. The *lateral portions* covering the thenar and hypothenar eminences are thin and are prolonged beneath the long flexor tendons to become attached to the third and fifth metacarpal bones (Fig. 394).

Dupuytren's Contracture.—In Dupuytren's contracture continued irritation to the palmar fascia has resulted in a prolific and dense deposit of connective tissue in the palmar fascia often adherent to the overlying skin and tendons beneath. It usually affects the slip of fascia to the ring finger or little finger causing flexion of the affected finger with inability to extend it. Treatment is surgical. That portion of the fascia which is adherent and thickened is excised. Sometimes the attachment between the fascia and skin is so firm that the overlying skin must be removed also. This necessitates grafting of full thickness skin to cover the defect.

ARTERIES OF THE HAND

The hand receives its blood supply mainly from the radial and ulnar arteries, the amount which it receives from the anterior and posterior interosseous being comparatively insignificant. The continuation of the ulnar in the hand forms the superficial palmar arch and the continuation of the radial forms the deep palmar arch (Fig. 395).

Ulnar Artery and Superficial Palmar Arch.—The ulnar artery at the wrist runs along the edge of the flexor carpi ulnaris muscle with the ulnar nerve to its

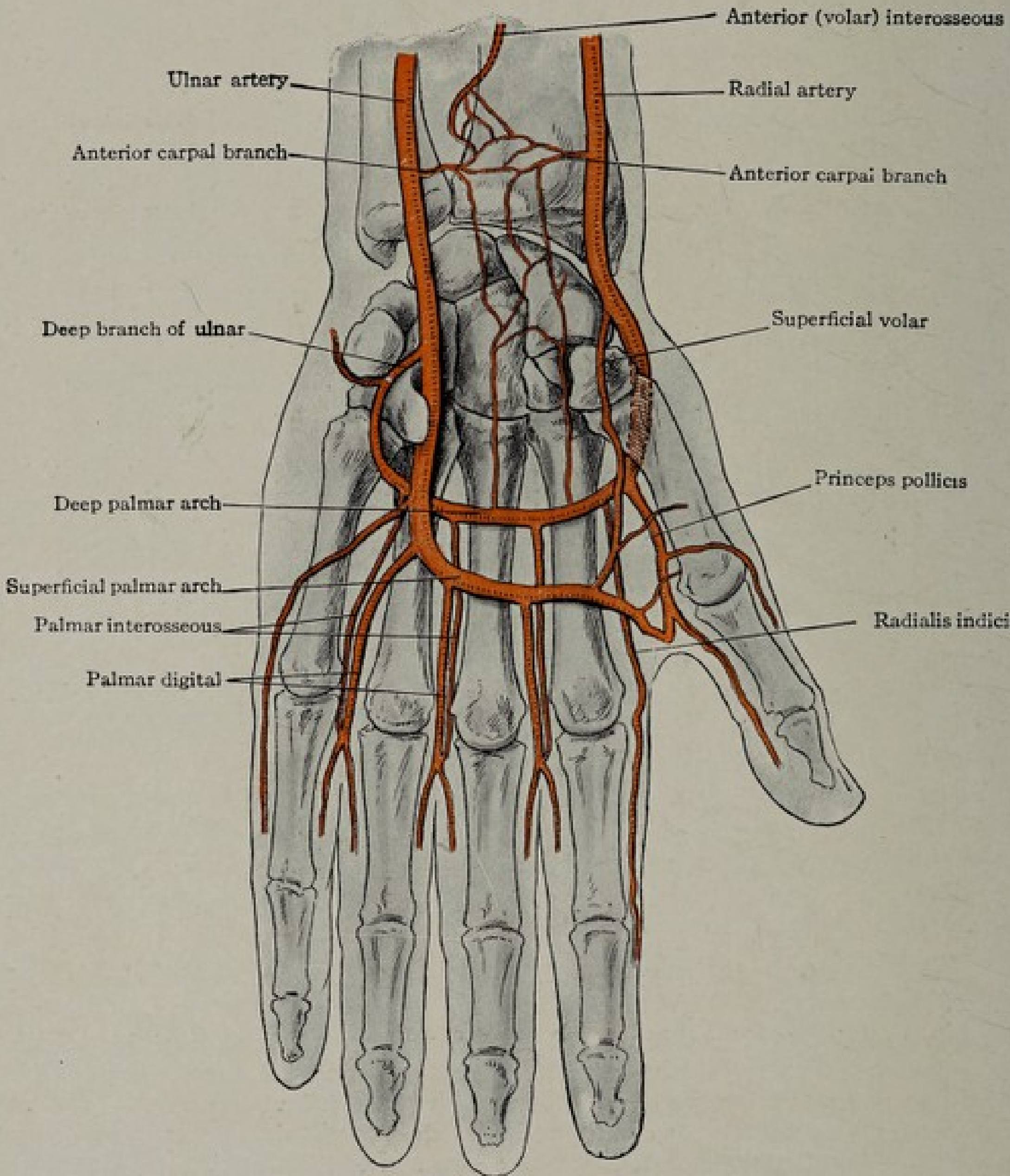


Fig. 395.—The arteries of the hand.

inner or ulnar side. As it enters the hand it lies just to the radial side of the pisiform bone with the nerve intervening. Both the artery and nerve lie *on* the anterior annular ligament. As soon as they pass the pisiform bone they go under the small palmaris brevis muscle and the palmar fascia, and lie on the flexor tendons.

The artery then describes a curve across the palm of the hand toward the web of the thumb. It crosses the middle of the third metacarpal bone at or a little above the level of the web of the thumb and continues on to the radial side of the metacarpal bone of the index finger. Here it receives the superficial volar artery from the radial as well as a communicating branch from the princeps pollicis and radialis indicis. When one of these branches is large the other two are smaller or lacking altogether. Not infrequently the communication with the radial at this point is in the form of a large branch which passes superficially across the web of the thumb and index finger, and its pulsations can be both seen and felt (Fig. 396). Injuries to the superficial arch are frequently troublesome because of the retraction of the divided vessel ends and because of the very free anastomosis of the arch. It should be remembered that the carpal arch sends branches downward to the deep arch and bleeding may thus continue even after ligation of the radial and ulnar arteries.

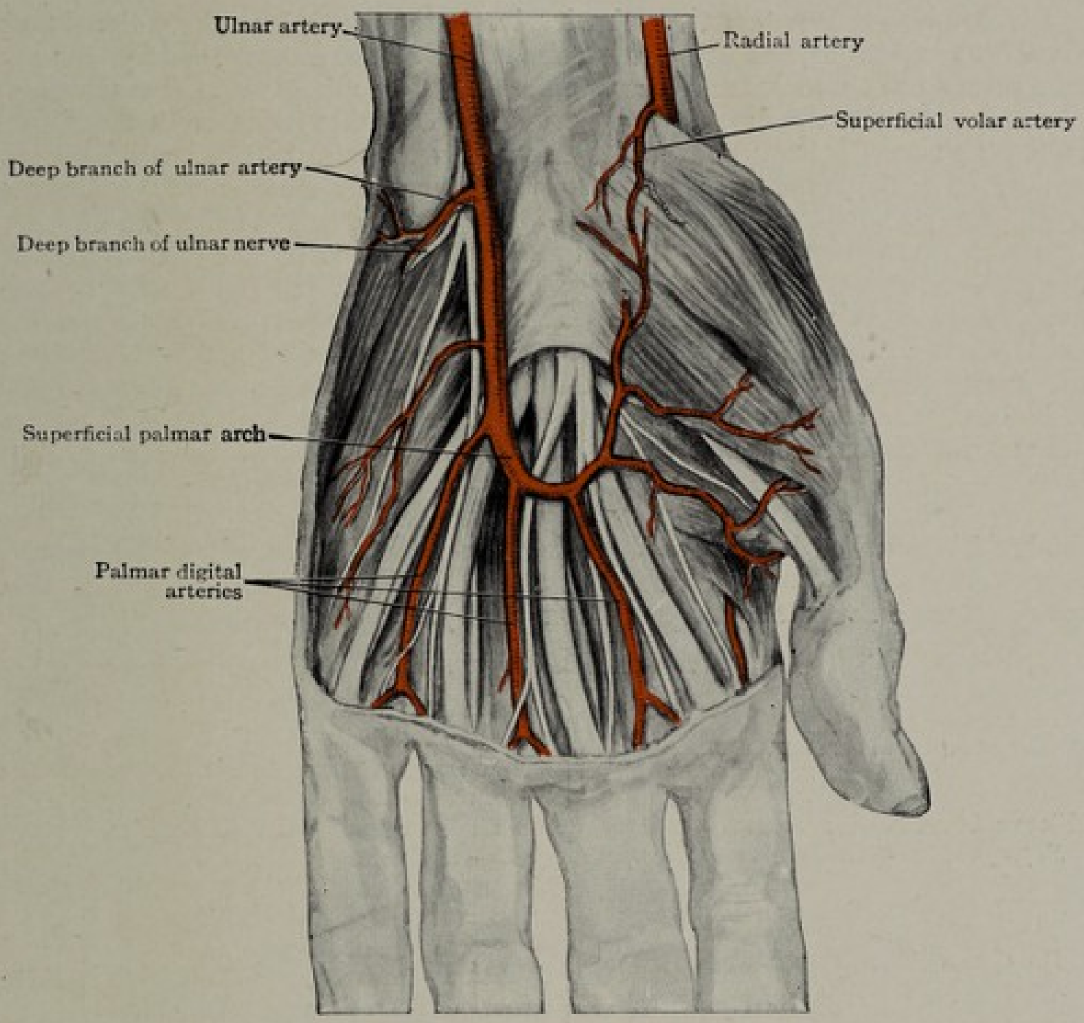


FIG. 396.—Superficial palmar arch.

Branches.—As soon as the ulnar artery passes the pisiform bone it gives off its *deep branch* which passes down between the abductor and flexor brevis minimi digiti to join the termination of the radial and form the deep palmar arch. From the convexity of the superficial arch four palmar digital arteries are given off. One goes to the ulnar side of the little finger while the other three go down between the metacarpal bones to the webs of the fingers. Here they may receive a small communicating branch derived from the deep palmar arch, and about 1 cm. (2/5 in.) back from the web divide into collateral digital branches which run along the palmar sides of the fingers. The digital nerves as they accompany the digital arteries are superficial to them.

The Radial Artery and Deep Palmar Arch.—The radial artery reaches the wrist between the brachioradialis and flexor carpi radialis tendons. It then turns sharply toward the dorsum around the extremity of the styloid process of the radius. It crosses the external lateral ligaments and the scaphoid and trapezium bones to enter the palm between the bases of the metacarpal bones of the thumb and index finger. It then passes across the palm to the fifth metacarpal bone, where it receives the deep branch of the ulnar, which completes the formation of the deep arch. It lies beneath the flexor tendons and on the interossei muscles and bases of the metacarpal bones (Fig. 397).

Branches.—The radial artery at the wrist gives off a posterior carpal branch which anastomoses with the posterior carpal branch of the ulnar to form a posterior carpal arch. From this arch descend three posterior interosseous arteries. The dorsal interosseous artery lying to the radial side of the index finger is called the *dorsalis indicis.* It comes off separately from the radial, and may be a branch from the radialis indicis.

As the radial artery enters the palm it gives off a large branch to the thumb called the *princeps pollicis,* and one to the palmar side of the index called the *radialis indicis.* Farther on, three palmar interosseous branches are given off which communicate at the webs of the fingers with the palmar digital arteries from the superficial arch. The deep palmar arch also sends a few recurrent branches up on the anterior surface of the carpus to anastomose with the anterior carpal arch and three perforating branches between the metacarpal bones to the back of the hand.

Collateral Circulation.—Should the brachial artery be ligated blood will be carried to the forearm through the superior and inferior profunda, the anastomatica magna and the vasa abberentia. These form an anastomosis around the elbow with the anterior and posterior ulnar recurrents, the radial recurrent and the posterior interosseous recurrent. Should the ulnar or radial be ligated the anastomosis between the banches of the anterior and posterior carpal arches and the deep and superficial palmar arches will be called upon to function.

NERVES OF THE HAND

The hand is supplied by the *median, ulnar,* and *radial* (*musculospiral*) nerves. They are of clinical importance on account of the paralysis of the muscles or disturbance of sensation which accompany their injury.

MUSCULAR BRANCHES.

Median Nerve	Abductor pollicis. Opponens pollicis. Outer head of flexor brevis. First and second lumbricales.
Ulnar Nerve	To all the rest of the hand muscles.
Superficial Branch	Palmaris brevis.
Deep Branch	Abductor minimi digiti. Flexor brevis minimi digiti. Opponens minimi digiti. Abductor transversus and obliquus pollicis. Inner head of flexor brevis pollicis. Two inner lumbricales. All the interossei.

CUTANEOUS BRANCHES.

Palmar Surface.

Median Nerve	Entire radial side of the palm over to the middle of the ring finger and the groove at the wrist between the thenar and hypotnenar eminences.
Ulnar Nerve	Ulnar side of the little finger, and adajacent sides of little and ring fingers and hypothenar eminence. The adjacent branches of the ulnar and median nerves anastomose.

Dorsal Surface.

Median Nerve	Ulnar side of thumb and matrix of nail. Distal half of the index and middle fingers and distal half of the radial side of the ring finger.

Ulnar Nerve	Both sides of the little finger and ulnar side of ring finger.
Radial Nerve	Both sides of thumb as far as the nail, anastomosing with the median on the ulnar side. Proximal half of the index and, with the ulnar, the proximal half of the middle and radial side of the ring finger.

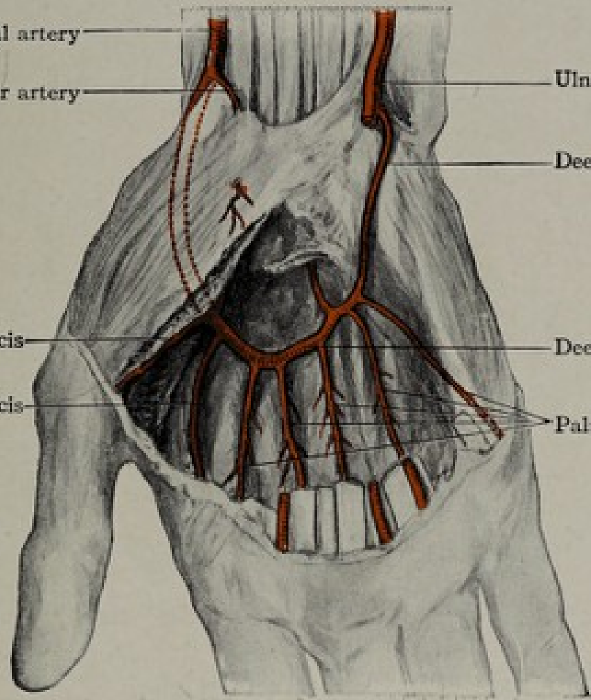


FIG. 397.—The deep palmar arch.

DISLOCATIONS OF THE HAND

The carpal bones are so firmly held in place by their ligaments that they are rarely luxated. Dislocation of the scaphoid and semilunar however are sometimes encountered.

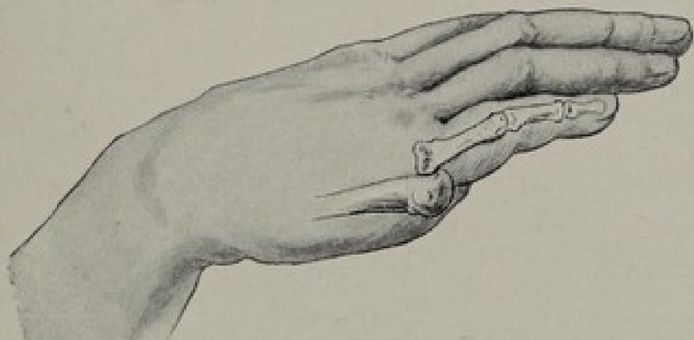


FIG. 398.—Dislocation of proximal phalanx of little finger. (From author's sketch.)

Dislocations of the Bases of the Metacarpal Bones.—Dislocations sometimes occur toward the dorsal surface. The bases of the second and third metacarpal bones in the uninjured hand form a bony prominence on the dorsum of the hand which may be mistaken for a luxation. This prominence lies in a direct line with the posterior radial (or thecal) tubercle and about 4 cm. (1½ in.) below it.

The bases of the metacarpal bones and carpometacarpal joints are best recognized by following up the interosseous spaces by making firm pressure with the fingers between the bones; when the upper limit of the space is reached the joints can be located 1.25 cm. (½ in.) above.

Dislocations of the Phalanges on the Metacarpal Bones.—These dislocations occur with moderate frequency. Dislocation of the thumb occurs most frequently and is well known. The little finger is next in frequency, while the other three are rarely luxated. When luxation of the proximal phalanx of the little finger occurs it acts precisely as does that of the thumb (as I have seen in one case, Fig. 398). As thumb dislocation is the most troublesome it alone will be described.

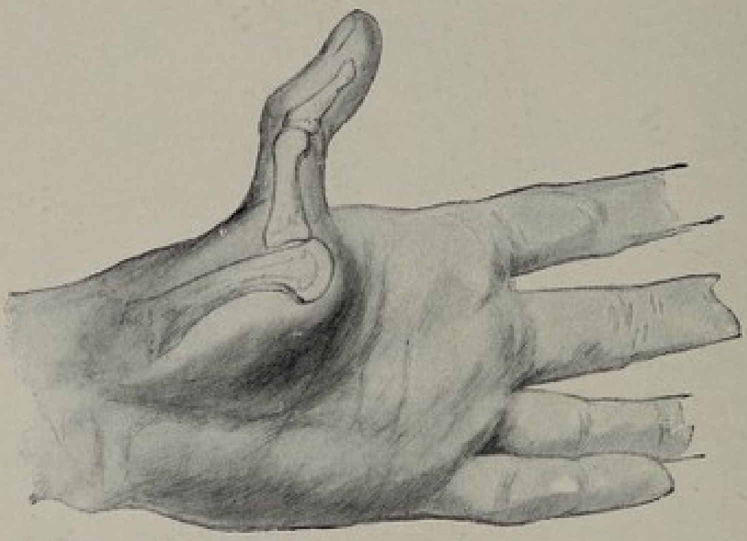


FIG. 399.—Dorsal luxation of the proximal phalanx of the thumb, showing the position of the bones.

Dislocation of the Proximal Phalanx of the Thumb.—This displacement occurs when the thumb is hyperextended on its metacarpal bone (Figs. 399 and 400), and it is often impossible to reduce it without division of the resisting structures. The head of the metacarpal bone is much larger than the shaft immediately behind it and projects especially on its palmar surface toward each side, forming two tubercles.

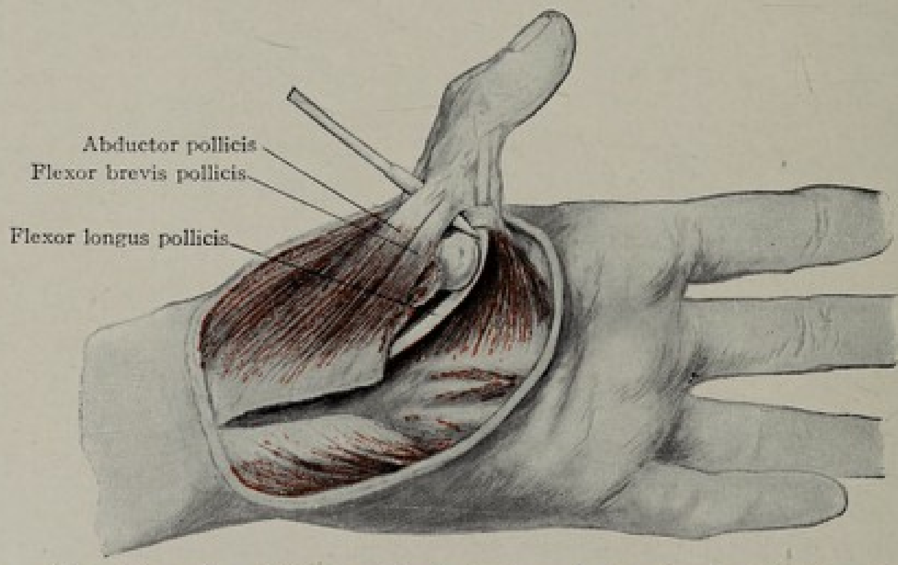


FIG. 400.—Dorsal luxation of the proximal phalanx of the thumb: Division of the tendons of the abductor and flexor brevis pollicis muscles.

The joint has two lateral ligaments and an anterior or glenoid ligament. These are more firmly attached to the phalanx than to the metacarpal bone, so that in dislocation they are torn from the latter permitting the phalanx to pass backwards on the metacarpal (Fig. 400).

Inserting into the outer side of the base of the proximal phalanx are the tendons of the abductor and outer head of the flexor brevis pollicis. They blend with the lateral ligament and have developed in them a sesamoid bone which rides on the tubercle.

Inserting into the inner side of the base of the proximal phalanx are the inner head of the flexor brevis and the adductor obliquus and transversus pollicis muscles. They blend with the lateral ligament and contain a sesamoid bone which rides on the inner tubercle. The flexor longus pollicis tendon passes between the two tubercles and sesamoid bones.

When the thumb is hyperextended the glenoid and lateral ligaments are torn loose from the metacarpal bone and carry with them the tendons and sesamoid bones already described. The head of the metacarpal bone projects forward in the palm and can be felt beneath the skin; the flexor longus pollicis tendon slips to the inner side of the bone. As the head pierces the capsule the latter, strengthened by the tendons of the short muscles of the thumb, contracts behind it like a collar and prevents reduction.

Reduction is to be attempted by extending the phalanx until it is at right angles with the metacarpal bone and dragging its base forward over the head of the metacarpal bone and then flexing.

If this is not successful, then by means of a narrow knife, either through an open wound or subcutaneously, the lateral ligament and tendons on one side (the radial) are loosened from the base of the phalanx, which can then be brought forward. This, of course, divides the tendinous collar which prevents reposition (Fig. 400).

FIG. 401.—Dislocation of the terminal phalanx, showing the position of the bones. (From author's sketch.)

Dislocations of the Middle and Distal Phalanges.—These frequently occur in playing ball games. In attempting to catch the ball the tip of the finger may be struck and the phalanx hyperextended and thereby luxated (Fig. 401).

These luxations are usually readily reduced by simple traction and flexion. Sometimes, however, reduction is not complete, or there is a concomitant fracture, hence the crippled and deformed fingers so often seen in the case of base-ball players.

A tearing loose of the attachment of the extensor tendon allows the distal phalanx to fall, producing what Stern has called drop phalangette.

FRACTURES OF THE HAND

Fractures of the carpal bones are often only suspected or detected by means of a skiagraph. They are quite rare and are almost impossible to distinguish clinically from ordinary sprains.

Special reference should be made to fractures of the naviculare and lunate bones. When these bones are fractured the blood supply to them is often destroyed. This is particularly true in comminuted and dislocation fractures resulting in death of one or more fragments which act as foreign bodies. In recent fracture the hand should be placed in a cock-up position for about six weeks. If this treatment fails or the fracture be comminuted or a fragment or fragments displaced then the initial treatment should be complete removal of the fragments. In old fractures that give symptoms of disability of the wrist joint, the fractured bone should be removed.

Fractures of the metacarpal bones are more common. The bones are subcutaneous on the dorsum of the hand and can be readily felt throughout their entire length. They are not infrequently broken by a blow on the end of the bone in fighting. Hamilton states that in every case in which the fracture has been produced by a blow on the knuckles the distal end of the distal fragment has been drawn toward the palm and its proximal end projected toward the dorsum. This is accounted for by the greater strength of the flexor muscles.

The first, third, and fourth metacarpophalangeal joints have one extensor tendon, the extensor communis digitorum. The second and fifth have in addition the extensor indicis and the extensor minimi digiti. There are two powerful flexors, the sublimis and profundus, and these are aided by the palmaris longus, interossei, and lumbricales muscles. In one case Hamilton saw a dorsal projection of the proximal fragment which he believed to be due to the action of the extensor carpi radialis muscle because the deformity became less marked when the hand was bent backward and the tendon relaxed.

On anatomical grounds one would expect this dorsal displacement to occur in fractures of the third metacarpal bone. It has only one carpal tendon inserting into it, the extensor carpi radialis brevior. The second has the flexor carpi radialis inserting on its palmar surface and the extensor carpi radialis longior on its dorsal surface.

The fifth metacarpal bone has the flexor carpi ulnaris on its palmar surface and the extensor carpi ulnaris on its dorsal surface. Hence it would be expected that the flexor and extensor muscles would neutralize each other.

In order to relax the parts as well as to allow for the concavity of the palmar surface of the metacarpal bones a rounded pad is to be placed in the palm and the hand placed on a splint; sometimes an additional flat pad and small dorsal splint are of service. Care should be taken not to displace the fragments laterally by constricting the hand with the bandage.

Fractures of the Phalanges.—These are frequently compound, necessitating amputation. Fracture of the proximal phalanx necessitates a splint extending into the hand, but for the middle and distal phalanges a short splint is sufficient. The action of the interossei and lumbricales through their insertion into the extensor tendon is liable to draw the distal fragment toward the dorsum if the fracture is left untreated.

A knowledge of the exact position of the joints is essential to avoid mistaking fractures and dislocations for one another.

WOUNDS OF THE HAND

Wounds of the hand, owing to the free blood supply, heal rapidly provided infection does not take place. An exception, however, is to be made in the case of the tendons. These frequently slough. If the tendons are divided they should be immediately united with sutures, otherwise they retract into their sheaths and within a short time may be widely separated.

If nerves are divided where they are large, as near the wrist, they should be sutured, because they are partly motor and supply the short muscles of the hand; but if the digital nerves are divided they need not be sutured as they are only sensory. The median nerve enters the palm to the radial side of the median line, and its position can be determined by following down the interval between the tendons of the palmaris longus and flexor carpi radialis muscles.

The ulnar nerve lies immediately to the radial side of the pisiform bone. Possible injury to this deep branch of the ulnar should be sought for in fractures of the pisiform and unciform bones or wounds on the ulnar side of the hand. This branch of the ulnar supplies all of the muscles in the hand except the abductor, flexor brevis and opponens pollicis and the two lumbricale muscles on the radial side.

Bleeding from wounds of the hand is not infrequently troublesome. The deep arch may be injured in a wound about 2.5 cm. (1 in.) below the lower crease on the anterior surface of the wrist. Its position can also be approximately determined by feeling for the upper end of the first interosseous space on the dorsum of the hand and selecting a spot at a corresponding level on the palmar surface. It lies deep beneath the palmar fascia and flexor tendons and nerves, and necessitates too great a disturbance of the parts to expose it for ligation; hence, when wounded, bleeding from it is checked by packing the wound with antiseptic gauze. A curved line, convex downward, from the radial side of the pisiform bone to the web of the thumb, describes approximately the course of the superficial palmar arch. It lies immediately beneath the palmar fascia, and if it bleeds freely can be exposed by an incision and tied. The incision should preferably be a longitudinal one to avoid wounding the digital arteries and nerves. The superficial palmar arch lies superficial to the tendons and they should not be disturbed. The digital nerves come down beneath the palmar arch, so that they need not be wounded in ligating it. As they reach the webs of the fingers the nerves become superficial to the arteries, and in the fingers they lie anterior and nearer the median line. The fingers are usually supplied with blood from the superficial palmar arch, and the digital arteries between the palmar arch and webs of the fingers may be quite large. Sometimes the fingers are supplied by large digital branches from the deep palmar arch, then those from the superficial will be correspondingly small.

In uniting the several ends of tendons the two ends of the same tendon should be joined and not the flexor sublimis joined to the profundus and vice versa.

ABSCESSES OF THE HAND AND FINGERS

Purulent collections in the palm of the hand are located either beneath the palmar fascia or are connected with the sheaths of the flexor tendons. When the

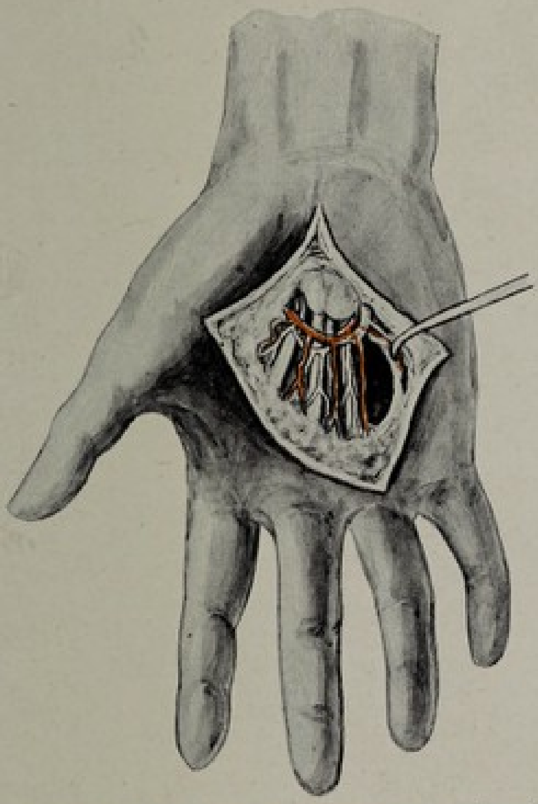


FIG. 402.—Middle palmar space and point of opening for infection.

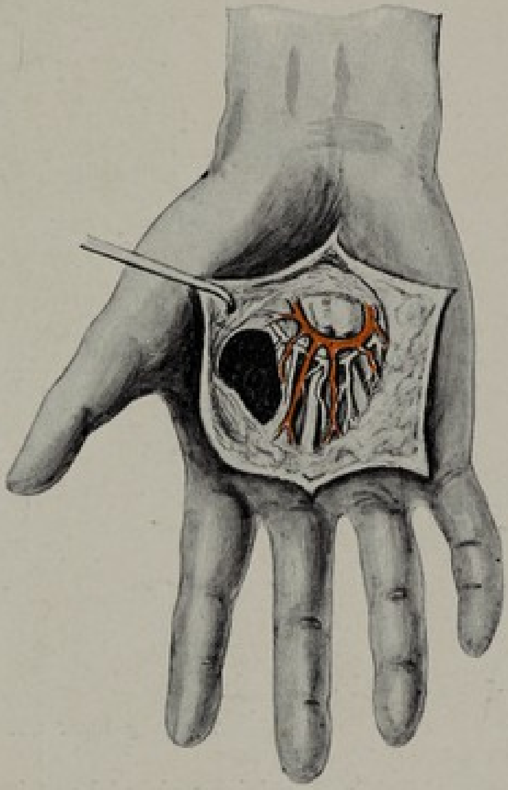


FIG. 403.—Thenar space and point of opening for infection.

fingers are affected the pus may be either in the sheaths of the tendons or in the cellular tissue beneath the skin.

Abscess Beneath the Palmar Fascia.—As a result of infected wounds pus may accumulate beneath the palmar fascia. The construction of this fascia (see page 405) limits the spread of the pus in some directions and favors it in others. Pus originating beneath the thick middle triangular portion will tend to point to either side, and it may show on the inner side at the hypothenar eminence, or work toward the outer side and point in the web of the thumb (Fig. 404).

It may take an upward course and pass under the annular ligament to point on the anterior surface of the forearm above the wrist.

If it tends downward it escapes through the openings for the exit of the digital arteries and nerves, and shows in the webs of the fingers.

If it extends still farther it burrows between the distal extremities of the metacarpal bones and shows on the back of the hand.

Sometimes the pus works directly toward the surface through small gaps in the fascia. In such cases a small amount of pus may accumulate above the palmar fascia and between it and the skin; so that there is a collection of pus both above and below the fascia, and communicating through a hole in the fascia. This is called an hour glass abscess, or the *abcès en bissac* of the French.

In opening such abscesses, if their character is not recognized the surgeon may only incise the superficial of the two collections and fail to evacuate the deeper and more serious one.

In incising palmar abscesses the only safe way is to limit the incision to the skin and open the deep parts by inserting a closed pair of forceps and then separat-

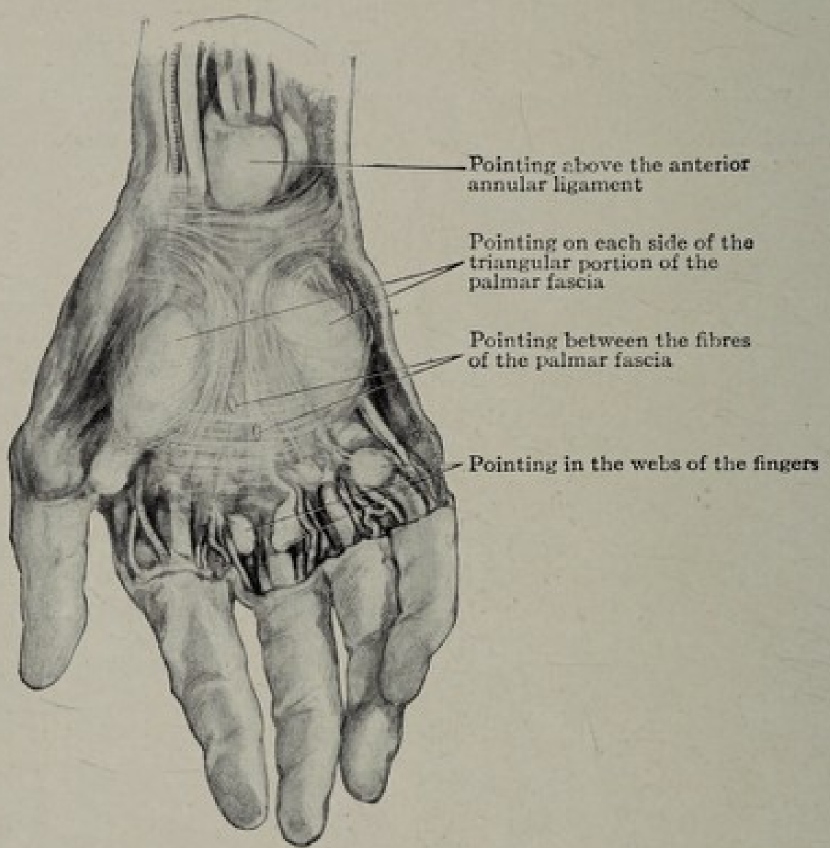


Fig. 404.—Cadaveric preparation with wax injected beneath the palmar fascia to illustrate where palmar abscesses tend to find an exit.

ing its blades. Incisions should not be made nearer to the wrist than on a level with the web of the thumb, or the superficial palmar arch may be cut. The spaces between the metacarpal bones are occupied by the digital arteries and nerves; hence any longitudinal incisions should be made over the tendinous sheaths and metacarpal bones. Usually it is not necessary to carry the incision so deep as to open the sheaths. Incisions over the second, third, and fourth metacarpal bones are tolerably certain to avoid the digital arteries, but an incision over the fifth is liable to wound the artery going to the ulnar side of the little finger as it crosses over from the superficial palmar arch. These arteries of the palm are also liable to be more or less irregular in their location, hence it is better to avoid using the knife in the deeper structures.

Suppuration in the Sheaths of the Tendons.—If the sheaths of the tendons of the hand or fingers become infected, either by being penetrated by a foreign body or by extension from the surrounding tissues, the pus travels along the tendon as far as the sheath extends.

The sheaths of the tendons vary in their extent. The flexor profundus and sublimis tendons lie together in single sheaths, which commence at the base of the distal phalanx. That of the thumb follows the long flexor tendon up the thumb, beneath the annular ligament, to 3 or 4 cm. (1½ in.) above the wrist; that of the little finger passes up to almost opposite the level of the web of the thumb and then spreads over toward the radial side and envelops the remaining tendons of the other three fingers, forming the great carpal bursa which extends up under the annular ligament to 3 or 4 cm. above the wrist (Fig. 405).

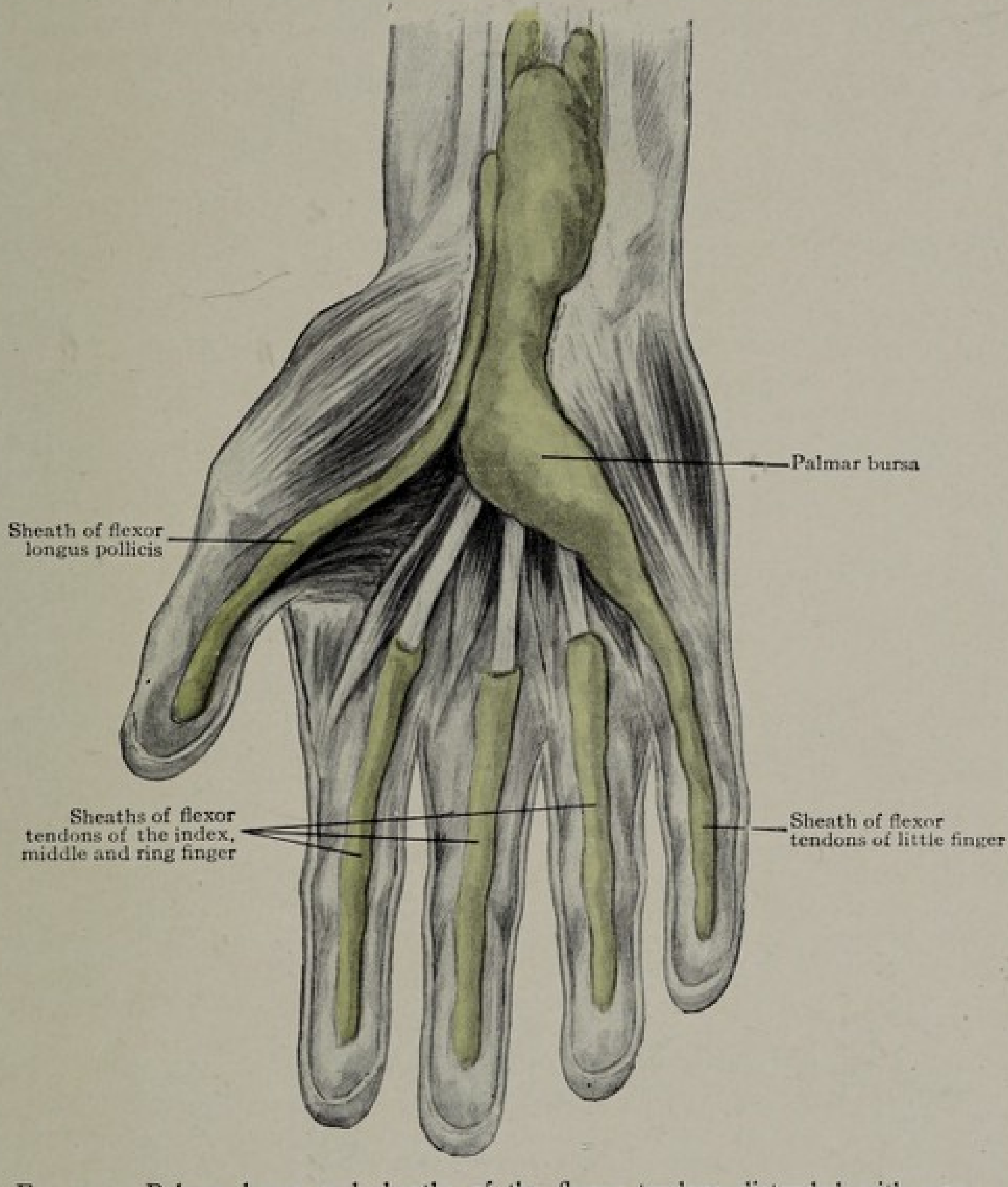


FIG. 405.—Palmar bursa and sheaths of the flexor tendons distended with wax.

The sheaths of the remaining three fingers extend only to the heads of the metacarpal bones, about 2 cm. (¾ in.) above the webs of the fingers. This would leave a space of about 2 cm. (¾ in.) intervening between the proximal ending of the tendon sheaths of the middle three fingers and the great carpal bursa. This is the usual arrangement, but not infrequently the sheath for the little finger ends, as do the other three, opposite the head of the metacarpal bone, or it may go up the entire way to the wrist as a separate sheath, in which case the great carpal bursa envelops only the tendons of the index, middle, and ring fingers.

When suppuration occurs in the sheath of the thumb or little finger it is much more serious than in the other three, because the pus tends to travel directly upward and involve the palm, and go even above the wrist. When suppuration involves the index, middle, or ring fingers it stops when it reaches the vicinity of the metacarpo-phalangeal joints and involves the palm and carpal bursa only by breaking through its own sheath and breaking into the carpal sheath. This it is not likely to do unless the infection is virulent and the suppuration abundant.

Suppuration Involving the Fingers.—When suppuration occurs in the middle or proximal phalanx the pus may occupy the tissue between the skin and tendon and not involve its sheath, hence is not liable to extend rapidly. When the end phalanx is affected the affection is known as *panaris, whitlow, felon,* etc. The pulp of the finger resembles that of the heel, the scalp, the palm of the hand, etc., in the fact

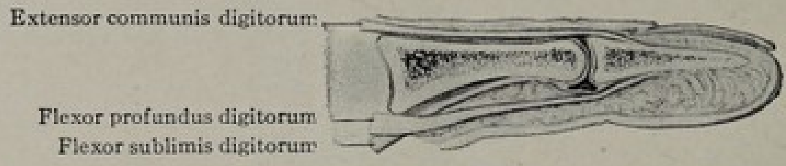


FIG. 406.—Longitudinal section of the end of a finger, showing the pulp and mode of termination of the tendons in the distal phalanx.

that the under surface of the skin sends off firm fibrous bands or fibrils which are attached to the parts beneath. The spaces between these fibrils are filled in with fatty tissue and vessels, nerves and lymphatics (Fig. 406). Infection begins in the skin through some small wound, as the tearing of the nail, pin-punctures, etc., and involves the fatty tissue beneath. If exit is not given to the pus it is often unable to break through the hard skin on the surface. Since the fibrous bands prevent swelling to any extent, it burrows deeper and involves the periosteum along which it proceeds to the region of the joint, here it may enter the sheath of the tendon when it rapidly proceeds upward as far as the sheath extends.

Bone felons are not as a rule primary in their origin, unless syphilitic in character, but arise secondarily by extension from the skin above.

LYMPHATICS OF THE HAND

The hand and fingers are abundantly supplied with lymphatics which begin in a plexus around the matrix of the nail and the pulp of the fingers and unite to form

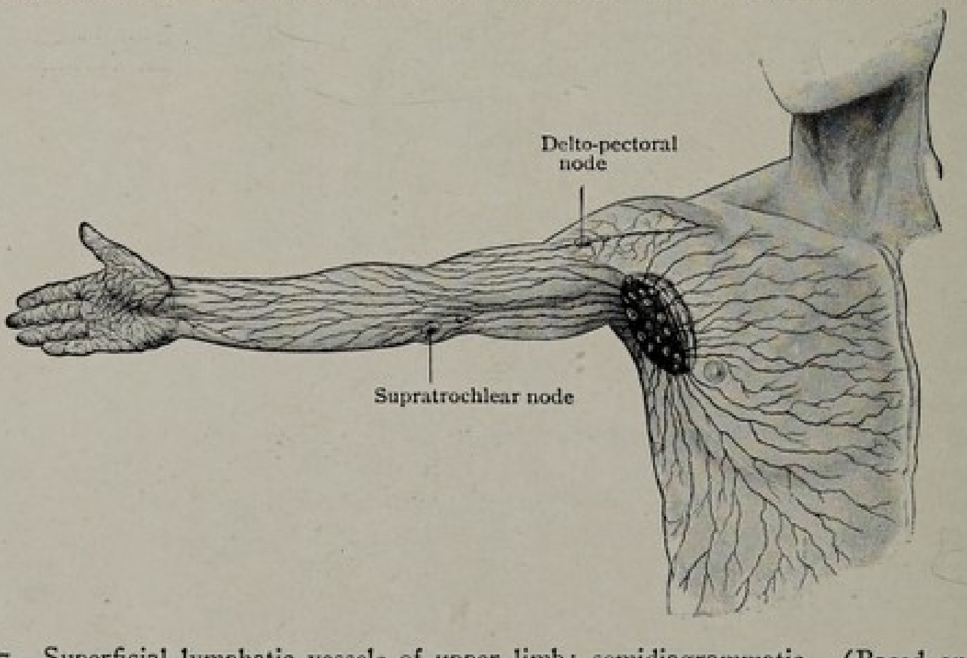


FIG. 407.—Superficial lymphatic vessels of upper limb; semidiagrammatic. (Based on figures of Sappey.)

lymphatic trunks which proceed up the wrist and forearm. There are both superficial and deep sets, which communicate at the wrist.

The deep set follows the arteries of the forearm and arm to the axilla. This set sometimes possesses a few nodes in the forearm and one at the flexure of the elbow.

The superficial set, both anteriorly and posteriorly, concentrates in the supratrochlear nodes and thence proceeds to the axilla. Some of the lymphatic vessels pass by the supratrochlear nodes and empty direct into the axillary nodes (Fig. 407).

In infections of the fingers or hand the infection follows the lymphatic trunks, which can be seen as red lines running up the forearm. Suppuration may involve the supratrochlear and, later, the axillary nodes. As some of the lymphatic trunks pass by the supratrochlear nodes to empty direct into the axillary nodes there may be infection of the latter without any implication of the former. Enlargement and inflammation of the occasionally present deep lymphatic nodes of the forearm is clinically unknown, so it may be said that practically there are no lymphatic nodes below the supratrochlear ones.

AMPUTATION OF THE THUMB AND FINGERS

In these amputations it is particularly necessary to be able to accurately locate the joints. The distal phalanx when flexed always passes under the proximal one. When the flexor and extensor tendons are cut they should be sewed either to their sheaths or united to one another over the ends of the bone.

AMPUTATIONS OF THE THUMB

Distal Phalanx.—In removing the distal phalanx the joint is opened by an incision across the dorsum in a line with the middle of the side of the proximal phalanx. A long flap is to be cut from the palmar surface. As the flexor and extensor tendons are inserted into the base of the distal phalanx, it will be an advantage to retain it if possible. The digital arteries may even here require ligation.

Metacarpophalangeal Amputation.—Lateral flaps are usually used. They are often made too short because the joint is thought to be higher than it really is. By flexing the thumb to a right angle the joint can be felt on the dorsum about 8 mm. (⅓ in.) below the top of the knuckle. The flaps must be cut as far forward as the middle of the phalanx. The two digital arteries on the palmar surface will require torsion or ligation. If the base of the phalanx can be retained the attachments of the short muscles of the thumb are preserved and additional control is given to the stump.

Carpometacarpal Amputation.—The upper limit of the metacarpal bone may often be difficult to recognize. The best way to locate it is to feel for the snuff-box and then feel for the joint a centimetre (say a half inch) in front of it. The dorsalis pollicis artery running on the dorsum of the bone and the princeps pollicis on its palmar aspect may require ligation. In disarticulating, it should be remembered that the joint is curved with its convexity toward the wrist.

AMPUTATIONS OF THE FINGERS

In amputating the fingers, although it is easier to amputate through the joints, it is better to cut through the bone and save part of the phalanx, because much better control over the movements is obtained on account of the insertion of the tendons into the base and sides of the phalanges. Into the base of the distal phalanx is inserted the common extensor and flexor profundus digitorum. Into the base of the middle phalanx on its dorsal surface is inserted the extensor communis digitorum, which is reinforced by the lumbricales and interossei; on its palmar surface is inserted the flexor sublimis digitorum. Into the bases of the proximal phalanges are inserted the interossei muscles. The lines of the joints are to be recognized by remembering that the distal phalanx always flexes beneath the proximal one, therefore the prominence is always formed by the head of the proximal bone.

The joint is to be opened by an incision across its anterior surface when flexed, and not on its top surface. Anterior or palmar flaps are always used, except at the metacarpal joints. The digital arteries lie on the lateral palmar surface on each side of the flexor tendons and may require torsion or ligation. The finger-joints have lateral ligaments and a palmar or glenoid ligament. On the dorsal surface there is no ligament, its place being filled by the extensor tendon (Fig. 408).

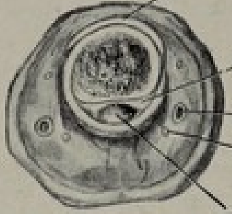


Fig. 408.—A transverse section of the proximal phalanx.

Metacarpophalangeal Amputations.—Lateral flaps are used in disarticulating at the metacarpal joints. In a well-developed hand the line of the joint will be 1.25 cm. (½ in.) below the dorsal surface of the metacarpal bone (Fig. 409).

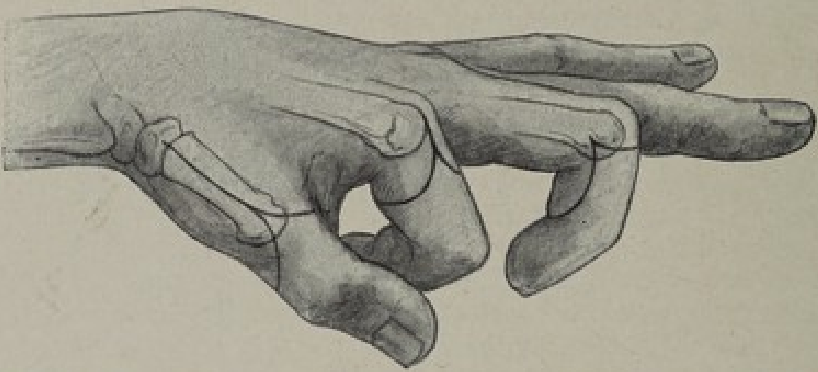


Fig. 409.—Lines of incision for amputations at the carpometacarpal joint of the thumb, the metacarpophalangeal joint of the index finger and between the proximal and middle phalanges of the middle finger.

In consequence of not first recognizing the position of the joint the flaps are often cut too short. The incision must not involve the webs of the fingers but should reach as far forward as the middle of the phalanx. If this is not done it will necessitate resection of the head of the metacarpal bone, which will materially weaken the hand. The two palmar digital arteries will require ligation, and the tendons should be sutured over the face of the bone or to their sheaths, closing them.

THE ABDOMEN

The *abdomen* comprises that part of the body anterior to the spine and erector spinæ and quadratus lumborum muscles, and from the diaphragm above to the brim of the pelvis below. The true pelvis is not included in this definition of the abdomen although many authors include the true pelvis as a part of the abdomen. The *peritoneal cavity* embraces the cavity of the abdomen and also that of the pelvis. An accurate knowledge of the topographical anatomy of the abdomen with its various contained organs is essential to both the physician and the surgeon for diagnostic purposes, and especially to the latter in carrying out operative procedures. The *surface* of the abdomen should be studied with reference to physical diagnosis; its *walls*, because herniæ frequently protrude through them, and because they must be traversed in obtaining access to the structures within; its *contents*, in order properly to carry out necessary operative measures.

SURFACE ANATOMY OF THE ABDOMEN

The form of the abdomen is influenced by its bony support, the lower rib margin above, the pelvis below and the spine posteriorly; by the muscles and fascias attached to these bones, by the organs within and by the fat of the abdominal wall and the tone of the muscles which form its walls. In the upper portion of the abdomen the tip of the ensiform cartilage can be felt—it is opposite the lower part of the body of the tenth dorsal vertebra. Immediately above the ensiform cartilage is its junction with the second piece (gladiolus) of the sternum, which is opposite the tenth dorsal vertebra,—the sixth and seventh costal cartilages meet at this point,—the seventh, eighth, ninth, and tenth cartilages can be followed down to the lower border of the chest; just below this, one free rib, the eleventh, can be distinguished and sometimes in thin people the twelfth; but the twelfth is often not palpable because it is buried beneath the erector spinæ muscles. The most certain way of identifying any particular rib is to count from the sternal (Ludwig's) angle, opposite the second rib. A notch on the costal border indicates the point of union of the tip of the tenth with the ninth costal cartilage.

Below, the crest of the ilium can be followed back to the posterior superior spine of the ilium and in front to the anterior superior spine. The spines of the pubes can be recognized, as well as the upper edge of the pubic bones. The depressions for the linea alba, lineæ semilunares are more marked above the umbilicus and the lineæ transversæ (inscriptiones) of the rectus muscle (tendinal) are of course not found below this point. The *umbilicus* normally lies on the disk between the third and fourth lumbar vertebræ, about 2.5 cm. (1 in.) above a line joining the highest points of the crests of the ilia. It is usually just below the midpoint between the symphysis and ensiform cartilage. The spines of the lumbar vertebræ are easily palpable and are often important landmarks. It should be remembered by the student that varying contours of the abdominal wall result in a shifting of the normal position of the umbilicus. The relations of the various organs in the abdomen are quite variable not alone in different subjects, but in the same individual in different positions and at different periods of life.

Regions.—For clinical purposes the abdomen has been divided into regions, so that the location of tumors, signs, etc., can be readily indicated. The most convenient division is into nine regions by two transverse and two longitudinal lines. The upper transverse line passes from the tip of the tenth rib—which corresponds to the lower end of the thorax—on one side to that of the other. The lower transverse line passes from the anterior superior spine of the ilium on one side to that of the opposite; it is on a level with the second sacral vertebra. The two longitudinal lines pass directly up on each side from the middle of Poupart's ligament. They strike the cartilages of the eighth ribs, but at too indefinite a point to serve as a guide.

The middle regions are the *epigastric*, the *umbilical*, and the *hypogastric*, or *pubic*. The lateral regions are the right and left *hypochondriac*, the right and left *lumbar*, and the right and left *iliac*. The abdomen is sometimes divided into four quadrants by a longitudinal median line and a transverse line through the umbilicus.

The lower transverse line is drawn by Quain and Cunningham from the top of the crest of one ilium to that of the other, but as the umbilicus is often lower than usual this line may pass above it. Anderson suggests using the lineæ semilunares instead of the usual longitudinal lines, but this modification has not been generally accepted.

Harris has suggested using the colon to subdivide the abdominal cavity. By taking the mesial layers of the ascending and descending colon and the inferior layer of the transverse mesocolon there are formed four regions: (1) The antral region surrounded by the mesocolon; ((2) the superior region above the transverse mesocolon; (3) the right posterolateral, and (4) the left posterolateral regions lying outside of and behind the longitudinal mesocolons but the prevalence of ptoses makes this classification even more unwieldy than those now used.

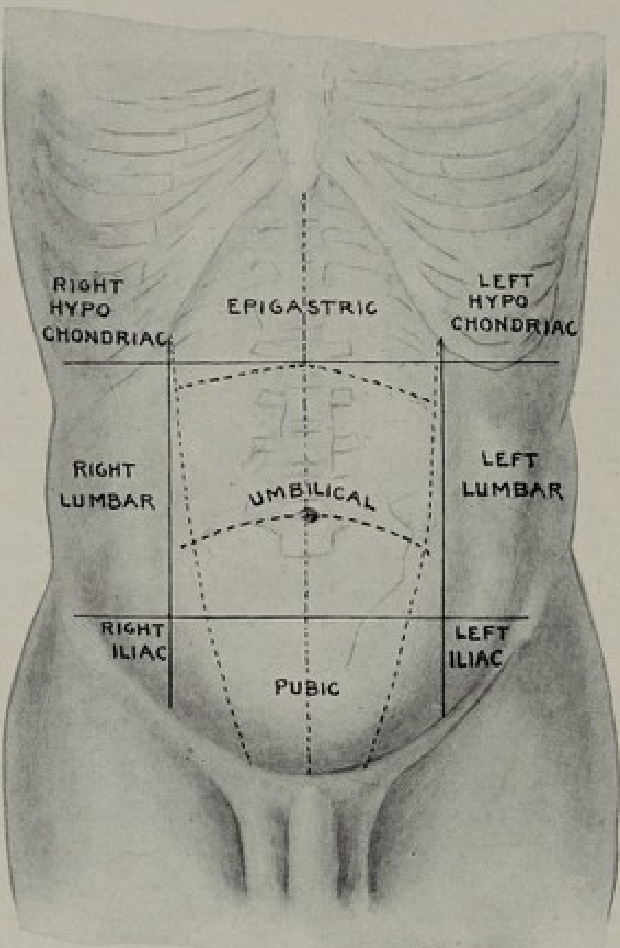


FIG. 410.—Surface anatomy of the abdomen; lines and regions.

Lines, or Lineæ.—There are certain lines on the anterior abdominal wall which serve as moderately good landmarks, the *linea alba, lineæ semilunares, lineæ transversæ*, and sometimes there are present *Lineæ albicantes*.

Linea Alba.—The linea alba passes in the median line from the ensiform cartilage to the symphysis pubis. It is formed by the fusion of the sheaths of the recti muscles. A little over half way down its length is the umbilicus.

The linea alba is broader and distinct more above the umbilicus, separating the recti muscles a half centimetre or more; below, it diminishes and almost or quite disappears, leaving the recti muscles almost in contact with each other. Its fibres run longitudinally, oblique, and transversely. The transverse fibres are the strongest and not infrequently have gaps between them which allow the subperitoneal fat to protrude and form a *hernia* in the median line which can be felt under the skin as a small, firm, rounded body. When these hernias are operated on they are found to be masses of subperitoneal fat with a somewhat constricted pedicle which emerges from a transverse slit in the linea alba. The peritoneum, as a rule does not take part in the formation of this type of hernia. Lewisohn and others have reported cases of epigastric hernia with symptoms stimulating those of duodenal ulcer. Some of the fibres of the linea alba are prolonged into the subcutaneous tissue and skin, thus binding it down and forming a groove distinctly visible above the umbilicus but disappearing below it. It does not long prevent extravasated urine from passing from one side of the abdominal wall to the other (Fig. 410).

The Umbilicus.—The umbilicus lies over the disk between the third and fourth lumbar vertebræ, and 2.5 to 4 cm. above a line joining the tops of the crests of the ilia. In the fœtus it transmits the *umbilical vein*, the two *umbilical arteries*, and the remains of the *vitelline duct* and stalk of the *allantois*. The umbilical vein becomes the round ligament of the liver and is the only structure passing into the upper half of the umbilicus. The umbilical arteries after birth form the obliterated *hypogastric arteries*, being continuous with the *superior vesicals*. The vitelline duct in fetal life passes from the umbilical vesicle to the small intestine. Normally it entirely disappears. If its proximal extremity persists it forms a *Meckel's* (ilei) *diverticulum*, a projection 3 to 7 cm. long from the small intestine 1 to 3 feet proximal to the ileocæcal valve. It may persist up to the umbilicus and cause a fistula through which feces may discharge, it may later be the site of an acute inflammatory process, or it may form a fibrous cord which may cause strangulation of the intestine. The blind diverticulum which is attached at right angles to the ileum, and is of approximately the same diameter as this structure is found in from 1 to 2 per cent of cadavers. The stalk of the allantois ends as a fibrous cord, called the *urachus*, running down to the fundus of the bladder. If the urachus remains patulous, urine may be discharged through the umbilicus while if its proximal portion remains patulous a mucus fistula results. The entire size and shape of the abdomen vary greatly. The above landmarks are for the normal adult male with an irregularly cylindrical boundary, central bulge and an antero-posterior flattening. In the adult with a large pendulous abdomen or in one whose musculature is flabby and relaxed, the lower part of the abdomen is carried downwards and the umbilicus is not a safe landmark.

Lineæ Semilunares.—There are two lineæ semilunares, which pass from the spines of the pubes in a curve upward and outward along the lateral edges of the recti muscles to strike the chest at the ninth costal cartilage. In thin people with little subcutaneous fat their position can be seen, but in fat people, especially females, their location may not be readily recognized. Ordinarily they are 6.25 to 7.5 cm. to the lateral side of the umbilicus and midway between the anterior superior spine of the ilium and the median line. The fibrous tendon of the external oblique muscle passes on to the surface of the rectus muscle to blend with its sheath a short distance internal to its lateral border, while the internal oblique blends with the transversalis in the linea semilunaris; so that an incision through the latter would traverse two fibrous layers—one the expansion of the external oblique and the other the blended internal oblique and transversalis. The upper end of the right linea semilunaris indicates the position of the fundus of the gall-bladder. The point where a line from the umbilicus to the right anterior superior iliac spine is crossed by the linea semilunaris is 2.5 cm. above the root of the appendix and just medial to McBurney's point, or the usual site of greatest tenderness in appendicitis. This line marks the place of limitation of purulent or hemorrhagic extravasations in the lateral intermuscular planes.

Lineæ Transversæ.—In thin muscular people when the rectus muscle contracts grooves are seen on its surface which indicate the position of the fibrous lines called the lineæ transversæ. These tendinous intersections are the remains of the intersegmental septa which separate the original myotomes. One is just opposite the umbilicus, a second opposite the tip of the ensiform cartilage, a third midway between these two, and occasionally a fourth below the umbilicus. The one opposite the umbilicus is the most prominent. They are adherent to the sheath of the rectus anteriorly, but pass only part way through the muscle, so that the rectus muscle can be lifted off the posterior but not off of the anterior portion of its sheath. This fact is to be remembered in making incisions in this region.

Lineæ albicantes are the faint, white, atrophic lines left in the skin of the abdomen after it has been hyperdistended, usually by pregnancy or tumors. The groove formed by Poupart's (inguinal) ligament runs from the anterior superior spine to the pubic spine. Since the ligament is formed by the lowest fibres of the aponeurosis of the external oblique and since the internal oblique and transversalis arise from its lateral half and since the fascia lata of the thigh is attached to it below, flexion at the groin is necessary to relieve abdominal tension and permit of easy examination. Cushing has recently called attention to the very prominent linea associated with pituitary basophilism. These are apt to be purplish but are similar in distribution to the linea albicantes.

THE POSITION OF THE ABDOMINAL VISCERA

Liver.—*Upper Border.*—The highest point of the liver is on the right side just to the medial side of the nipple where it rises to the middle of the fourth interspace. To the left it crosses the xiphosternal articulation to follow the lower border of the heart to a little beyond its apex, but hardly to the nipple line, where it reaches the lower border of the sixth rib. Its highest point on the left side is under the fifth rib posteriorly. On the right side it reaches the upper border of the fifth rib in the mammary line, the eighth rib in the midaxillary line, and the tenth rib in the scapular line. In the median line it is about opposite the tenth thoracic spine (Fig. 386).

Lower Border.—From just below and to the medial side of the left nipple the lower border of the liver passes across the left eighth costal cartilage, then across the median line midway between the xiphoid articulation and the umbilicus to reach the right ninth costal cartilage, and then follows the edge of the ribs posteriorly. In the upright position, and in women, the liver may project a centimetre or two below the rib margin. In the aged it may be slightly retracted and in acute atrophy it may be greatly retracted.

Liver Dulness.—On percussion the liver dulness in the right mammary line extends from the upper border of the sixth rib to the lower rib margin. In the axillary line it reaches the upper border of the eighth and in the scapular line the upper border of the tenth rib. From these limits it extends downward to the edge of the ribs.

Gall-Bladder.—The gall-bladder reaches the surface at the anterior end of the right ninth costal cartilage, just to the lateral edge of the rectus muscle. This is the upper end of the right linea semilunaris.

Stomach.—The *cardiac end* lies under the cartilage of the seventh rib, 2.5 cm. from the edge of the sternum and about 10 cm. from the surface. When the stomach is empty the *pylorus* lies in the median line 2.5 to 5 cm. below the tip of the xiphoid or ensiform cartilage; when distended the pylorus moves 3 to 5 cm. to the right. The *fundus* rises in the left nipple line to the lower edge of the fifth rib. The *lower border* of the stomach crosses the median line 5 to 7.5 cm. above the umbilicus. In the aged it may reach as low as the umbilicus, and when dilated may go far below it.

Pancreas.—The pancreas lies beneath the stomach and transverse colon stretching across from the duodenum on the right of the spine to the spleen on the left. Its body lies over the first and second lumbar vertebræ. This would bring its lower edge about 5 cm. above the umbilicus and its upper edge about 10 cm. above it.

Spleen.—The spleen lies under the ninth, tenth, and eleventh ribs of the left side. Its long axis follows the tenth rib. Its anterior end is at the midaxillary line, while its posterior end reaches to within 4 cm. of the median line.

Kidneys.—The lower edge of the right kidney reaches to within an inch of the level of the umbilicus; this is about opposite the level of the third lumbar spine. The left is 1.25 to 2 cm. higher. This leaves about 4 cm. between the lower edge of the kidneys and the highest point of the iliac crests. Their upper edge is almost or quite up to the level of the tip of the xiphoid cartilage. The pelvis of the kidney and commencement of the ureter are 5 cm. from the median line, about on the level of a line joining the upper ends of the lineæ semilunares. Posteriorly the right kidney rises to the lower border of the eleventh rib, the left kidney to the upper border. The lateral edge of the kidney is a little beyond the lateral borders of the erector spinæ and quadratus lumborum muscles.

Small Intestine.—*Duodenum.*—The duodenum begins at the pylorus and curves first upward and then downward along the right of the spine to the body of the third lumbar vertebra; it then crosses and ascends to the left side of the body of the second. This places it just above the umbilicus in the median line and behind the transverse colon.

Mesentery.—The upper extremity of the root or attachment of the mesentery begins 2.5 cm. (1 in.) to the left of the median line and 7.5 cm. above the umbilicus. It runs obliquely downward and to the right for about 15 cm. to a point below and to the right of the umbilicus, over the right sacro-iliac joint, and 8 to 10 cm. above the middle of a line joining the anterior superior spine and the symphysis pubis.

Jejunum.—The coils of the jejunum lie mostly to the left of the median line, but some are also found in the pelvis.

Ileum.—The coils of the ileum lie mostly to the right of the median line, and also are found in the pelvis.

Large Intestine.—*Cæcum.*—The cæcum lies in the right iliac fossa between the linea semilunaris and the anterior iliac spine.

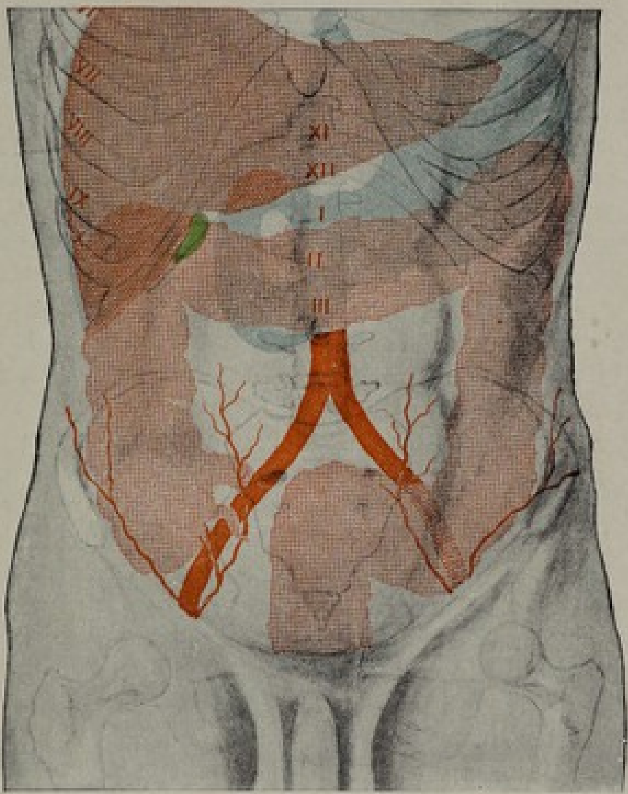


FIG. 411.—Surface anatomy of the abdomen, showing the outlines of the viscera.

The *ileocæcal valve* lies 8 to 10 cm. above the middle of Poupart's ligament.

McBurney's point is 4.5 cm. above and to the medial side of the right anterior superior iliac spine on a line to the umbilicus.

Appendix.—The base of the appendix is 2 cm. below the ileocæcal valve. This is a little below the point where the linea semilunaris is crossed by a line drawn from the anterior iliac spine to the umbilicus, and is opposite the level of the anterior spine.

Hepatic Flexure of Colon.—This lies just to the lateral side of the gall-bladder, under the ninth costal cartilage.

Transverse Colon.—The lower edge of the transverse colon is about at the level of the umbilicus.

Splenic Flexure of Colon.—This rises higher than the hepatic flexure, about to the level of the eighth costal interspace.

Bladder.—When empty the bladder sinks into the pelvis. When distended it rises toward the umbilicus, carrying the peritoneal fold with it so as to leave a space of 2.5 to 5 cm. between it and the top of the pubis.

Abdominal Vessels.—The *aorta* bifurcates on the body of the fourth lumbar vertebra 2 cm. below and to the left of the umbilicus. A line from this point to the middle of one drawn from the anterior superior spine to the symphysis pubis indicates the course of the *iliac arteries.* The upper third of this line is the common iliac and the lower two-thirds the external iliac. The *ureters* cross the points of bifurcation of the common iliac arteries. The *cœliac axis* lies just below the tip of the ensiform cartilage. The *renal arteries* are about 5 cm. lower. The *iliac veins* lie along the inner side of the iliac arteries, and the *ascending cava* runs along the right side of the aorta.

The *deep epigastric arteries* run lengthwise at or a little lateral to the middle of the recti muscles. They pass beneath the edge of the recti a little below the level of a line joining the umbilicus and middle of Poupart's ligament.

THE ABDOMINAL WALLS

The abdominal walls are composed of the skin, superficial fascia, muscles, transversalis fascia, subperitoneal tissue, and peritoneum.

Skin.—The skin of the abdomen is moderately thin and lax. It is adherent at the linea alba. In making incisions care is to be taken not to think it thicker than it is and so open the abdominal cavity and perhaps wound the intestines. This is especially liable to occur in the median line—where the subcutaneous fat is not so abundant as elsewhere—and over hernial protrusions, particularly umbilical, where the thinned and distended skin may lie in direct contact with the peritoneum.

Superficial Fascia.—The superficial fascia is usually described as consisting of an superficial fatty layer (Camper's fascia) and a deeper membranous layer (Scarpa's fascia). These layers, however, can only be satisfactorily demonstrated in the lower anterior abdomen. Above and laterally they lose their distinctness. The deeper layer is connected to the deep abdominal fascia, which covers the muscles of the abdominal wall, by loose areolar tissue. The superficial vessels run on this fibrous layer but are too small to cause troublesome hemorrhage; a few minutes' compression with hæmostatic forceps usually serves to stop bleeding from them. This layer is attached at the linea alba, but not sufficiently closely to prevent extravasated urine from crossing and reaching both flanks. It is also attached to the fascia lata just below Poupart's (inguinal) ligament, and here it *does* prevent urine from passing downward on the thigh. It passes inward over the spermatic cord beyond the external abdominal ring and is continuous with the dartos of the scrotum and its septum and is continuous in the perineum with the deep layer of the superficial fascia (Colles' fascia). It is attached to the spines of the pubes and to the symphysis in the median line. This leaves a space or *abdomino-scrotal opening* over the pubic bone on each side of the median line through which extravasated urine rises from the perineum and scrotum to reach the surface of the abdomen.

MUSCLES OF THE ABDOMEN

The muscles of the abdomen are arranged in two distinct groups: a longitudinal group embracing the *recti* and *pyramidales* and a transverse group embracing the *external* and *internal oblique* and the *transversalis* of each side.

The **pyramidalis** is small, often undeveloped, and sometimes absent; as its direction is not markedly different from that of the rectus it may be considered from a surgical point of view as being a part of it.

The **rectus muscle** lies on either side of the linea alba. It arises from the crest and symphysis of the pubis and inserts into the cartilages of the fifth, sixth, and seventh ribs and sometimes the ensiform cartilage (Fig. 412).

Sheath of the Rectus.—The recti are enclosed in a fibrous sheath formed by the external and internal oblique and transversalis muscles. The anterior layer is attached to the surface of the muscle by the lineæ transversæ already described p. 421). The edge of the sheath on one side blends in the median line with that of the other side to form the linea alba. Above the umbilicus, an incision in the median line passes through fibrous tissues only and the muscles on each side are not exposed, but as they rapidly approximate each other below the umbilicus an incision in this region usually passes either through the edge of one muscle or, if it passes exactly between them, may expose the edges of both.

The lateral edge of the sheath in its upper three-fourths is formed primarily by the splitting of the tendon of the internal oblique muscle, one part going in front and the other behind the muscle. The tendon of the external oblique blends with the anterior layer of the tendon of the internal oblique a little to the medial side of the edge of the rectus, and as the pubes is approached the external oblique has its attachment nearer and nearer to the linea alba, so that close to the pubes the external oblique is separated from the internal oblique and goes to form the medial pillar of the external ring and has the conjoined (falx inguinalis) tendon behind it (Fig. 413).

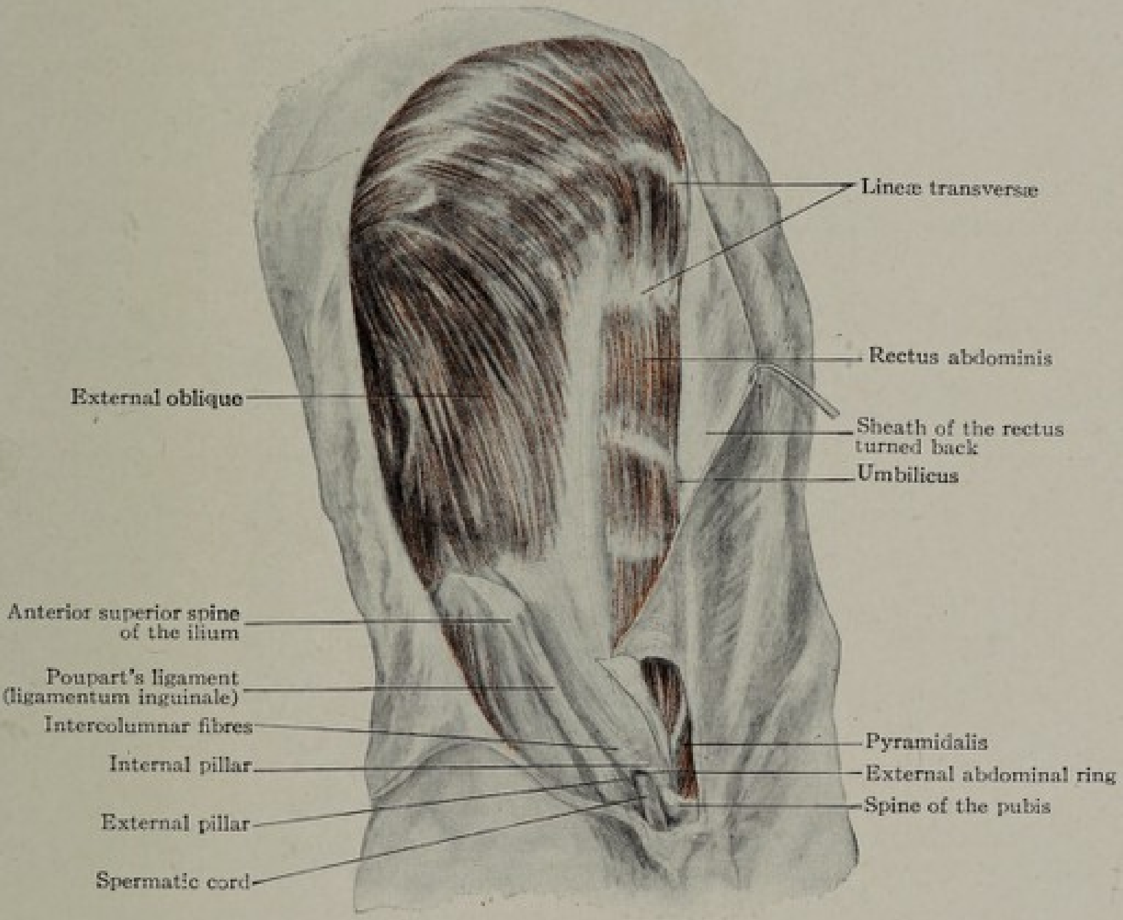


FIG. 412.—The external oblique, rectus abdominis, and pyramidalis muscles.

The tendon of the transversalis muscle blends with the posterior layer of the internal oblique tendon until the lower fourth of the rectus is reached, when they both pass in front of the rectus to form, below, the conjoined-tendon (falx inguinalis). The medial portion of the sheath of the rectus is attached to the symphysis and crest of the pubis; its lateral portion, forming the conjoined tendon (falx inguinalis), is attached from the spine of the pubis along the iliopectineal line for the distance of 4 cm. It lies behind the external abdominal ring.

The lower edge of the posterior portion of the sheath of the rectus is called the semilunar fold of Douglas; the deep epigastric artery ascends beneath this fold about its middle, or a little to its outer side. From this arrangement it will be seen that an incision over or near the lateral edge of the rectus below the umbilicus will pass through two aponeurotic layers, viz., the external oblique and the blended tendons of the internal oblique and transversalis (Fig. 413).

If it is desired to examine the rectus muscle, its sheath can be opened at its edge and the muscle lifted up from the posterior layer, but it cannot be detached from the anterior layer above the umbilicus unless dissected loose from the lineæ transversæ. These lineæ transversæ are found opposite the umbilicus, at the xiphoid and a third midway between the previous two. A fourth frequently limited to the lateral portion of the muscle may be found midway between the umbilicus and the crest of the pubis.

The nerve supply is through the anterior divisions of the fifth to the twelfth thoracic nerves. The recti retract the abdominal wall and flex the vertebral column.

The **external oblique** arises from the eight lower ribs, the upper digitations alternating with those of the serratus anterior (S. magnus) and the lower with those of the latissimus dorsi. Its posterior portion passes almost directly downward to insert into the anterior half of the crest of the ilium. It is crossed obliquely

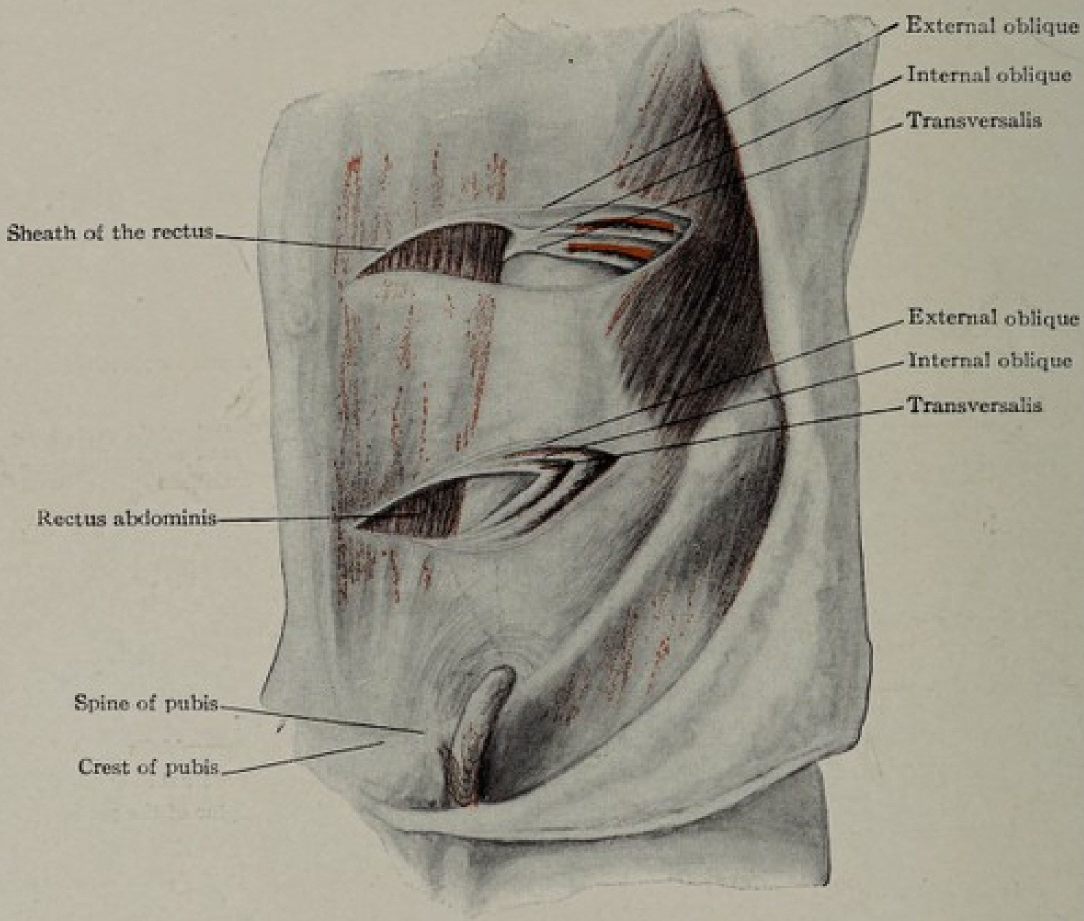


Fig. 413.—Sheath of the rectus abdominis muscle.

by the anterior margin of the latissimus dorsi muscle a short distance above the crest, thus leaving a triangular space between them called *Petit's triangle* (*trigonum lumbale*) (see page 448). As the external oblique approaches the linea semilunaris and anterior superior spine it becomes tendinous, its fibres being nearly but not quite parallel with *Poupart's* (*inguinal*) *ligament*. Its lower edge forms *Poupart's* (inguinal) *ligament*, the convexity of which is continuous with the fascia lata of the thigh. Its medial portion, above and lateral to the spine of the pubis, divides to form the external abdominal (subcutaneous abdominal) ring for the passage of the spermatic cord. The lateral side of the opening is called the lateral pillar or column; it is continuous with Poupart's (inguinal) ligament, inserts into the spine of the pubis, and is prolonged along the iliopectineal line for a short distance (2 cm.) to form *Gimbernat's* (*lacunare*) *ligament*. Sometimes it is continuous upward and medialward to the median line on the sheath of the rectus, forming what has been called the *triangular fascia* (Colles). The medial side is called the medial pillar or column. It inserts into the crest of the pubis. The transverse fibres passing from one pillar or column to the other are called *intercolumnar fibres.* The nerve supply is from the anterior divisions of the eighth to the twelfth thoracic nerves and from the iliohypogastric and ilioinguinal nerves. The external oblique muscles flex and obliquely rotate the vertebral column and retract the anterior abdominal wall.

The **internal oblique** (Fig. 414) arises from the lumbar aponeurosis, the anterior two-thirds of the crest of the ilium, and the lateral two-thirds of Poupart's (inguinal) ligament. It inserts into the lower three ribs and, through the sheath of the rectus and conjoined tendon, into the linea alba, the crest and spine of the pubis, and iliopectineal line for about 4 cm. The fibres arising from the lumbar aponeu-

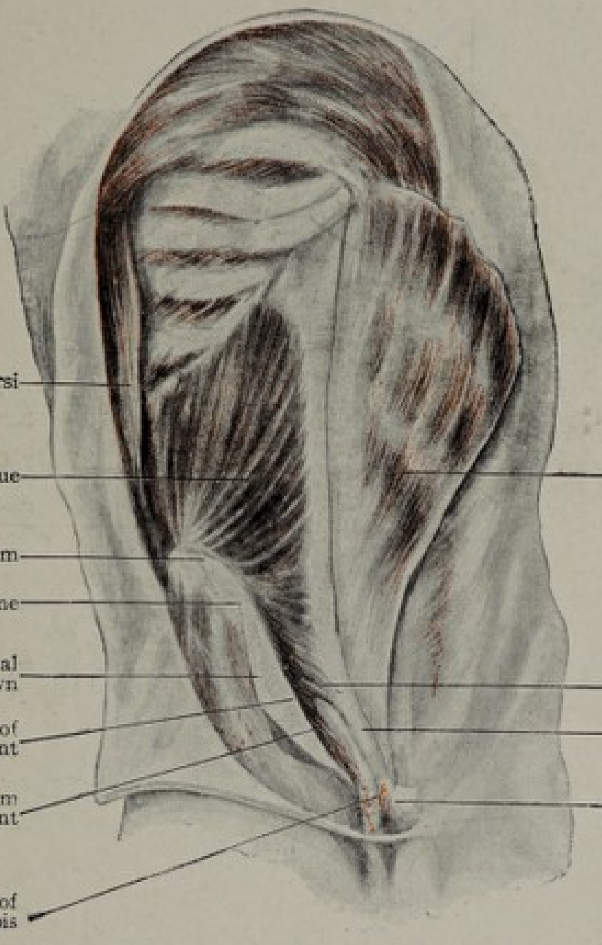


FIG. 414.—Internal oblique muscle.

rosis and the posterior portion of the iliac crest pass upward and medialward. Those from the region of the anterior superior ilias spine radiate like a fan; the lower ones, together with the fibres arising from the lateral half of Poupart's (inguinal) ligament, arch over the cord and end in the conjoined tendon (falx inguinalis). Some fibres are continued down over the cord, forming the *cremaster muscle.* The cremaster muscle usually arises from Poupart's (inguinal) ligament, beneath the spermatic cord, from the lower edge of the internal oblique to near the spine of the pubes, thus obliterating the space usually shown to the under side of the cord, between it and Poupart's ligament. The fibres of the cremaster hang in loops on the cord, and are attached by their distal extremity to the pubic bone in the neighborhood of the spine. The internal oblique has the same nerve innervation as the external oblique while the cremaster is innervated by the genital branch of the genitocrural nerve. Its action is similar to that of the external oblique.

The **transversalis muscle,** which is the deepest muscle of the anterolateral portion of the abdominal wall, arises from the six lower ribs interdigitating with the diaphragm, through the lumbar fascia from the transverse processes of the five lumbar vertebræ, and from the anterior two-thirds of the iliac crest and lateral third of Poupart's (inguinal) ligament. It *inserts* through the sheath of the rectus in the linea alba and crest of the pubis, and through the conjoined tendon (falx inguinalis) into the spine of the pubis and iliopectineal line for about 4 cm. The transversalis does not come down so low as the internal oblique, because it arises from the lateral third of Poupart's (inguinal) ligament instead of the lateral half, as does the internal oblique. As already stated, the blended tendons of the external and internal oblique and transversalis muscles all pass in front of the rectus in its lower fourth. As the umbilicus is below the middle of the linea alba, this point, where the fold of Douglas is formed, is nearer to the umbilicus than it is to

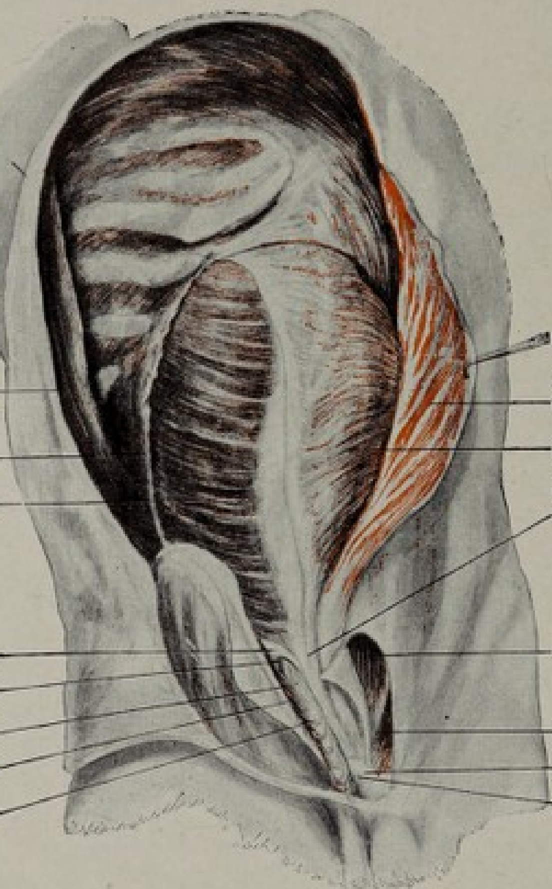


Fig. 415.—Transversalis muscle.

the symphysis. The nerve supply is from the anterior divisions of the seventh to the twelfth thoracic nerves and the iliohypogastric and ilioinguinal nerves.

VESSELS OF THE ABDOMINAL WALLS

The vessels of the abdominal walls comprise arteries, veins, and lymphatics. The *arteries* are both superficial and deep; of these the deep are the more important. The arterial branches in the subcutaneous tissue are small. The superficial epigastric runs in a line from the femoral artery toward the umbilicus. The superficial circumflex iliac runs to its lateral side toward the iliac spine, mostly below Poupart's (inguinal) ligament. Branches of these vessels may require ligation in operations for hernia or appendicitis.

The deep arteries are important: they are the *superior epigastric, deep epigastric, deep circumflex iliac,* (Fig. 416) the last two intercostals and the abdominal branches of the lumbar arteries.

The **superior epigastric artery** is the medial terminal branch of the internal mammary. The other is the musculo-phrenic, which skirts the edge of the thorax. The internal mammary divides opposite the sixth interspace, and the superior epigastric, leaving the thorax at the lower edge of the seventh rib, enters the sheath of the rectus muscle and a few inches lower down enters the substance of the muscle, speedily breaking up into small branches. It is only large in size close to the thorax, where we have seen it cut by a stab-wound, causing dangerous hemorrhage. It may also be wounded during an operation in this locality and is to be sought for between the muscle and its posterior sheath, on a line continued downward from a point one centimeter to the lateral side of the edge of the sternum. It anastomoses with the deep (inferior) epigastric, and with the hepatic arteries.

The **deep (inferior) epigastric artery** arises from the external iliac at Poupart's (inguinal) ligament and curves medialward and upward between the

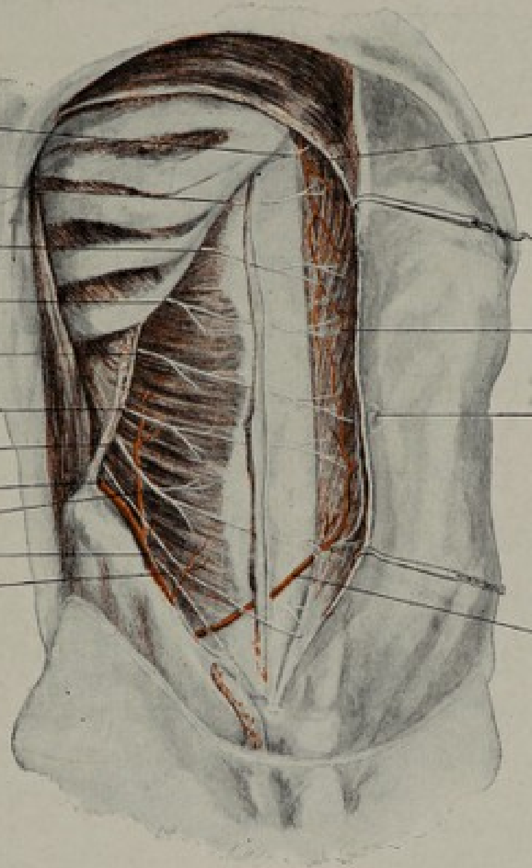


Fig. 416.—The nerves and blood-vessels of the anterior abdominal wall. The nerves are seen piercing the posterior layer of the sheath of the rectus to enter the muscle. The external and internal oblique have been removed exposing the nerves lying on the transversalis.

peritoneum and transversalis fascia. It passes close to the medial side of the internal (abdominal inguinal) ring and may be injured at this point in operations for inguinal hernia. It reaches the edge of the rectus below a line joining the femoral artery at Poupart's ligament with the umbilicus. A line with a slight medialward curve from the junction of the medial and middle thirds of Poupart's (inguinal) ligament to the umbilicus, and which crosses the linea semilunaris about one-third the distance from the symphysis pubis to the umbilicus will approximately indicate the lower course of this vessel. Opposite the fold of Douglas (linea semicircularis) it reaches the middle of the rectus, pierces the transversalis fascia, and enters the substance of the muscle by passing in front of the fold of Douglas. It sends branches to the outer edge of the muscle which are quite large and bleed freely when cut. It anastomoses above with the superior epigastric. It is a most important artery, as it is liable to be wounded in many operations and ligation of the artery and its vein are sometimes the cause of post-operative embolism. If cut it will require ligature, and if pierced by a needle will bleed freely. As it passes upward from Poupart's (inguinal) ligament it lies to the upper and lateral side of the femoral canal and may be wounded if the herniotomy knife is turned in that direction. An oblique or indirect inguinal hernia enters the canal to the lateral side of this artery and a direct hernia to its medial side. The fold of the obliterated hypogastric artery is to its medial side.

The **deep circumflex iliac artery** arises from the external iliac almost opposite the deep epigastric and passes lateralward along the internal side of Poupart's (inguinal) ligament between the transversalis fascia and the peritoneum. When it reaches the anterior superior spine it passes between the transversalis and internal oblique muscles, and just above the crest divides into an ascending branch which goes upward toward the ribs and a posterior branch passing backward to anastomose with the iliolumbar. The ascending branch is large and bleeds freely when cut. It is not infrequently divided in operations for appendicitis in which the incision is carried far back. Its depth from the surface, between the transversalis and internal oblique muscles, should not be forgotten.

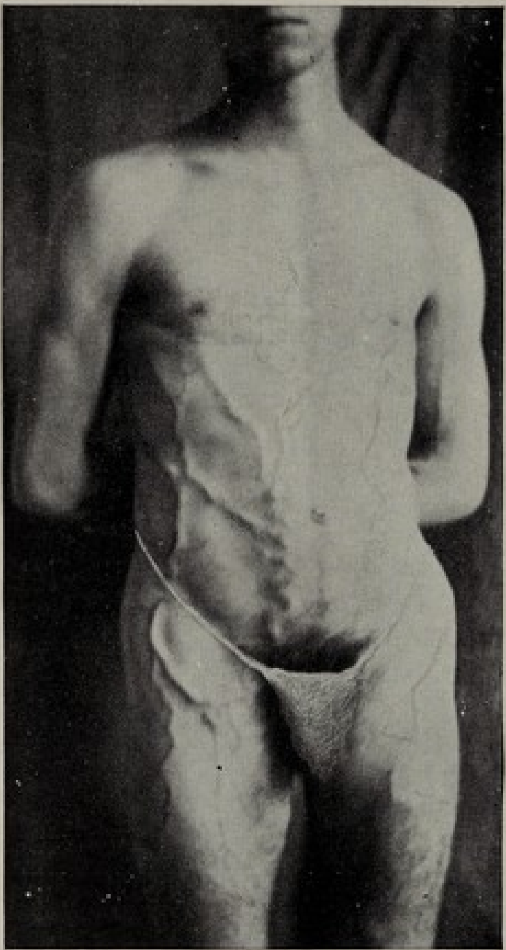


Fig. 417.—Obstruction of the right iliac vein from phlebitis. The vena thoracic epigastrica longa is seen running from the groin up to the axilla.

Superficial Abdominal Veins.—The upper part of the abdomen is drained by small branches emptying into the superior epigastric, the intercostal, and laterally into the axillary veins. With the exception of the above all the other abdominal veins drain into the inferior vena cava and are affected by any condition which interferes with the perfect function of that vessel. Below, there are the superficial epigastric and superficial circumflex iliac veins. In cases of obstruction to the flow of blood in the large deep veins the superficial veins become visible; thus a branch often becomes visible on the side running from the axillary vein to the superficial epigastric or femoral vein,—it is called by Braune the *vena thoracica epigastrica longa tegumentosa* (Fig. 417). Other small veins around the umbilicus become very much enlarged, and, branching in various directions around the umbilicus, have given rise to the term *caput Medusæ*.

Kelly describes two small veins running from the symphysis up to the umbilicus in the subcutaneous tissue on each side of the linea alba, and calls them *celiotomy veins*.

Deep Veins of the Abdominal Walls.—The superior epigastric, deep epigastric, and circumflex iliac arteries are accompanied by veins. There is also a vein in the round ligament of the liver emptying into the portal vein, called by Schiff, and later by Sappey, the *vena parumbilicalis*. In some cases two small veins can be seen on the interior of the abdominal wall, running up to the umbilicus from the symphysis on each side of the median line, and two coming down to the umbilicus on each side of the median line from above.

Lymphatics.—The superficial parts above the umbilicus are drained by lymphatics which empty into the axillary, or occasionally into the supraclavicular nodes; the vessels below the umbilicus empty into the oblique set of nodes in the groin. The lymphatics of the deep surface of the abdominal wall above the umbilicus drain into the mediastinal nodes, while those below drain into the pelvic lymphatics along the iliac arteries.

Nerves.—The front and sides of the abdomen are supplied by the anterior and lateral cutaneous branches of the sixth, seventh, eighth, ninth, tenth, and eleventh intercostal nerves, the twelfth thoracic or subcostal, and the iliohypogastric and ilioinguinal branches of the first lumbar. The sides of the abdomen are supplied by the *lateral cutaneous branches* which supply the skin as far forward as the rectus

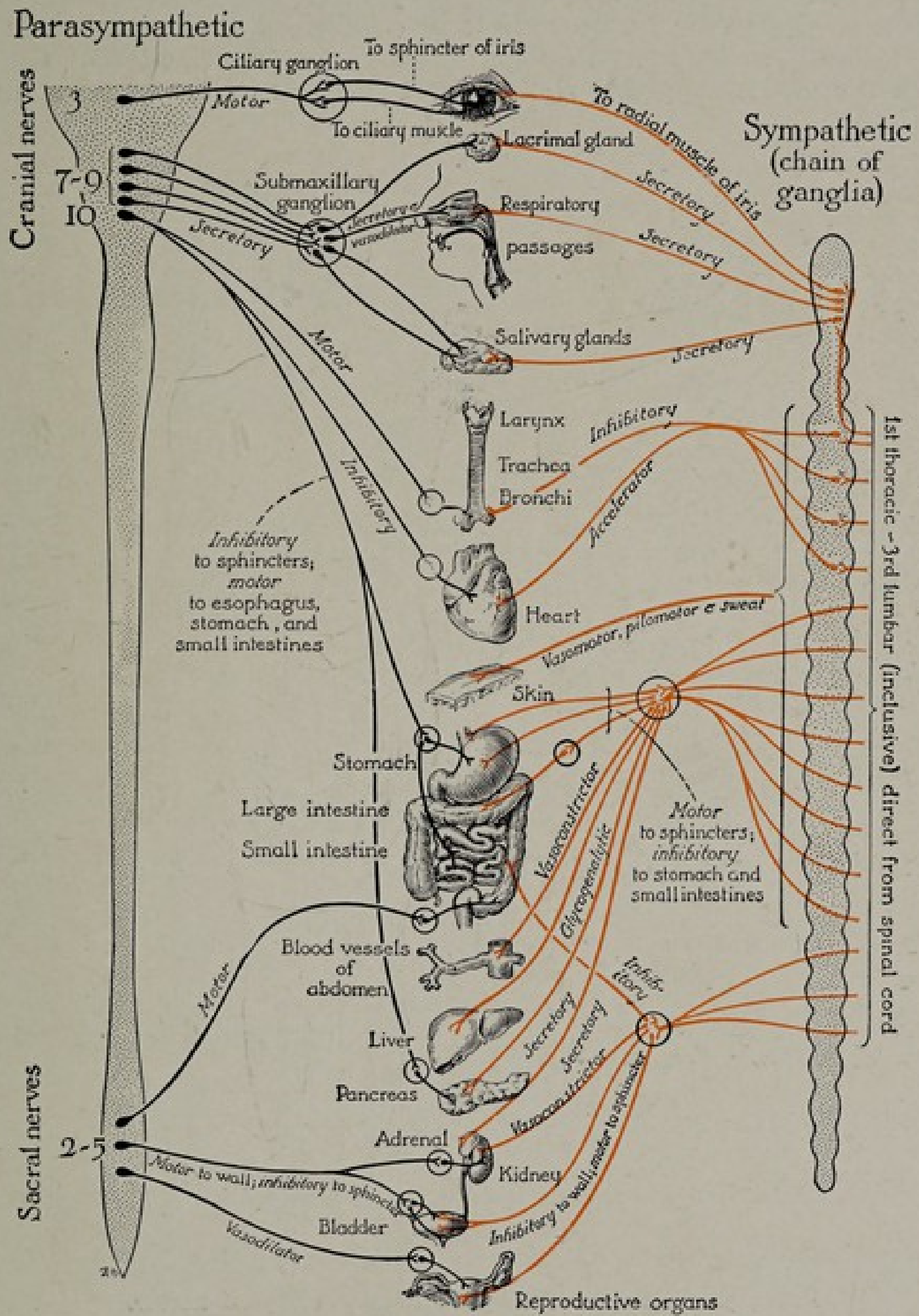


FIG. 418.—Diagram of the autonomic nervous system (visceral efferent). The craniosacral (parasympathetic) division is shown in black; the origin, relay station, and functions are indicated. The thoracolumbar (sympathetic) division is shown in red; the origin in the spinal cord is not shown; the fibers as they emerge from the spinal cord and enter the chain of lateral ganglia are indicated, together with the relay stations and the functions.

muscle. The recti muscles and skin overlying them are supplies by the *anterior branches.* These pass forward between the internal oblique and transversalis muscles to enter the sheath of the rectus, and after supplying the muscle, pierce the anterior layer and are distributed to the integument. The sixth and seventh supply the infrasternal region, the eighth about half way down to the umbilicus, the ninth just above the umbilicus, the tenth the region of the umbilicus, and the eleventh just below,—being about opposite the fold of Douglas (linea semicircularis), while the twelfth supplies the region above the pubes.

The iliohypogastric emerges through the external oblique about 2 or 3 cm. above the external (subcutaneous abdominal) ring, while the ilioinguinal emerges through the external (subcutaneous abdominal) ring and supplies the parts adjacent. From this distribution it is evident why disease posteriorly, such as caries of the spine or pleurisy, will cause pain to be complained of the corresponding distribution anteriorly. Incisions through, or along the lateral edge of the rectus, will divide the nerves supplying it, and cause paralysis of the muscle. Incisions

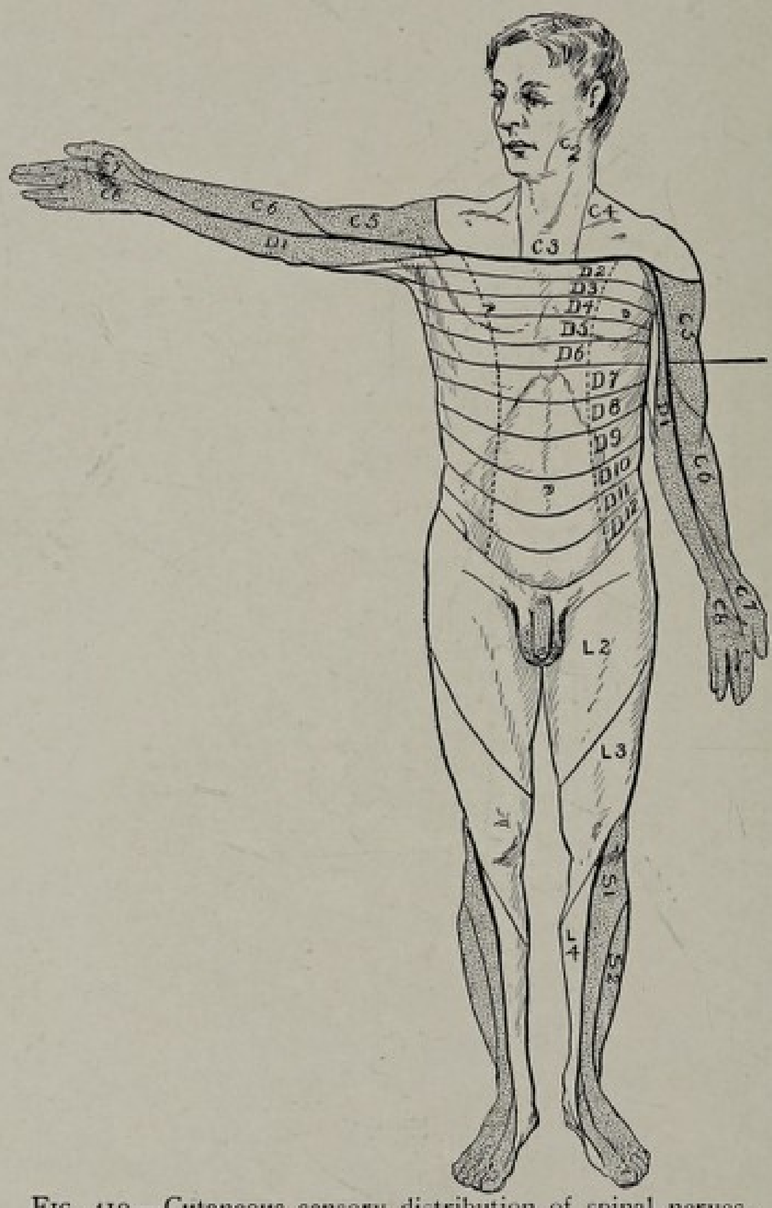


Fig. 419.—Cutaneous sensory distribution of spinal nerves.

made at right angles to the lateral muscles of the abdomen cannot be efficiently repaired by suturing the divided muscles together, because this does not restore the function of the nerves which have been severed.

Besides the muscular innervation of the abdominal wall it is of interest to note the connection of the cutaneous supply and that of the abdominal organs. In order to understand the cutaneous reference of the visceral pain a brief review of the anatomical relations is necessary. The data here given while not universally accepted offers an adequate explanation for the reference of visceral pain. The sympathetic fibres which innervate the abdominal viscera pass from the cord to the sympathetic chain through the white rami communicantes. These white rami consist of both afferent and efferent fibres. The studies of Head concerning the areas of cutaneous hyperalgesia occuring in visceral disease showed that the hyperalgesic areas are identical with the areas which receive their sensory nerve fibres from the spinal segment to which the afferent sympathetic fibres from the diseased viscera pass. This connection is supposedly a constant one. Thus although there may be an irradiation or overflow of the stimulus into an adjoining segment the maximum excitability is in those segments directly involved. The referred pain and hyperalgesia is always referred to the peripheral terminations of the somatic sensory nerves. Head in mapping out the viscerocutaneous reflexes demonstrate that the:—sixth, seventh, eighth and ninth thoracic segments receive afferents from the

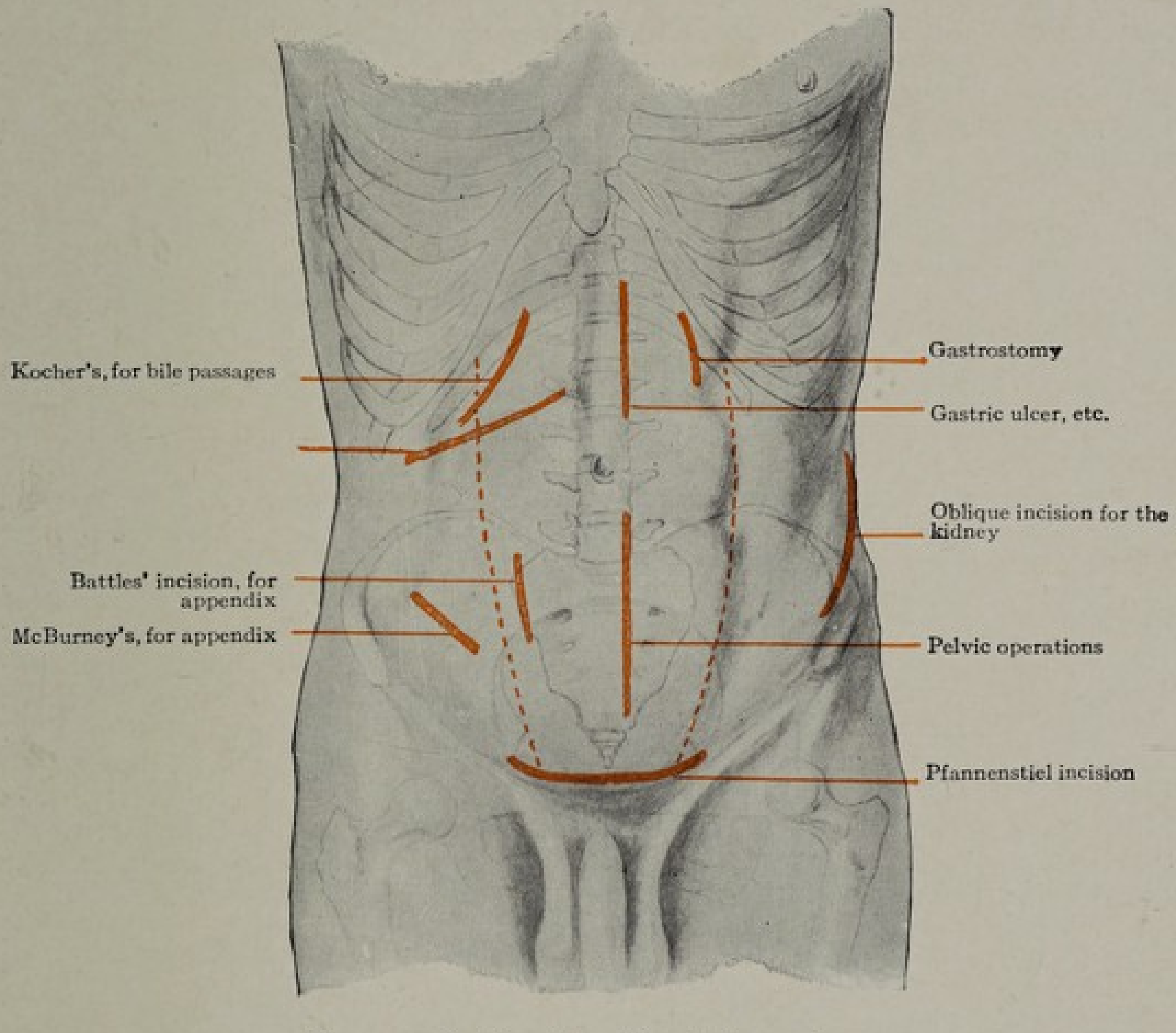


FIG. 420.—Incisions for abdominal operations.

stomach; the ninth, tenth, eleventh and twelfth thoracic segments from the intestinal trace; the seventh, eighth, ninth and tenth thoracic segments from the liver and gall-bladder, the tenth, eleventh and twelfth thoracic and the first lumbar segment with the kidney and ureter; and the second, third and fourth sacral segment with the rectum. The sympathetic segmental connections and the cutaneous reference is charted in figure 418.

ABDOMINAL INCISIONS

These are made through all portions of the abdominal wall according to the organs it is desired to gain access to. They should be so planned as to avoid unnecessarily wounding the muscles, arteries, and nerves. It having been found that incisions through certain fascial structures alone are more liable to be followed by hernia than those through both fascia and muscle incisions, through the lineæ semilunares should be avoided. This does not apply however to incisions through the linea alba or to paramedian incisions where fascia only is divided, the rectus being merely temporarily displaced. Incisions through the recti muscles are best made near their medial edge. If made in the lateral edge the nerves supplying the muscle will be divided, causing subsequent paralysis and weakness. If made through the middle, only the nerves supplying the medial half will be divided, but the main trunks of the deep and superior epigastric arteries will be cut and cause troublesome bleeding. The least harm is done by making the incision through the medial edge of the muscle. If the method of Battles is resorted to, of dividing the lateral edge of the sheath of the rectus longitudinally and displacing the muscle medialward, or of dividing the muscle itself longitudinally, then not only are large branches of the deep epigastric arteries met but in dividing the posterior layer of the sheath the nerves are divided. If the rectus is divided transversely, as Kocher advised in operations on the gall-bladder and numerous surgeons have recommended not only for gall-bladder operations but also for operations on the stomach care should be taken to avoid wounding the nerves. The subcostal incisions have much to command them. Properly placed, one or at most two intercostal nerves are divided. If only one nerve is divided no harm can result since each nerve within the substance of the rectus muscle inosculates with the nerve above and below it. When closing the wound we have as a rule made no attempt to suture the rectus fibres but carefully close the peritoneum, and the posterior and anterior rectus sheaths. The scar in the muscle acts subsequently as an additional linea transversa. Injury to the nerves and rectus muscle both can be avoided by incising the sheath transversely and then pulling the rectus to one side, or by dissecting up the sheaths of both recti transversely and separating the muscles in the median line, a method described some years ago by both Pfannenstiel and Stimson.

Incisions through the transverse muscles if made in the same direction through all three muscles are bound to cut some in a direction more or less transverse to their fibres. The incision of McBurney—for appendicitis—avoids the transverse division of any of the muscle fibres. He separated the external oblique in the direction of its fibres downward and medialward, crossing a line from the anterior superior spine to the umbilicus 4 to 5 cm. to the medial side of the spine. The internal oblique and transversalis are then separated in the direction of the fibres and drawn in the opposite direction. This method is applicable where small openings suffice; but when large incisions are essential, it is customary with many to incise all the muscles in the line of the fibres of the external oblique. Should nerves be encountered they are if possible to be drawn aside. In this incision the internal oblique and transversalis are incised nearly transversely, and bleeding from the deep circumflex iliac artery which runs between them will be encountered.

The Edebohl incision exposes the kidney by incising alongside of the lateral edge of the erector spinæ muscle. The latissimus dorsi is separated in the direction of its fibres, the lumbar aponeurosis is incised and kidney exposed. A normal kidney can be delivered through this incision, but not one much enlarged. When the kidney is much enlarged the incision is to be prolonged anteriorly along the crest of the ilium (see page 450). The relation of the pleura is to be borne in mind: it crosses the twelfth rib about its middle to reach its lower edge posteriorly. Hence the upper end of the incision should always be kept anterior to it (see section on Pleura).

HERNIÆ

Abdominal herniæ, not the result of a defect in wound healing, occur most often in the umbilical and inguinal regions. Sometimes the recti muscles separate and a median protrusion results.

Umbilical herniæ are of three kinds, *congenital, infantile,* and *acquired*.

Congenital umbilical hernia is due to a development defect. In the embryo the umbilicus transmits (1) the vitelline duct, passing from the umbilical vesicle to the small intestine; (2) two umbilical arteries, which inside the abdomen are called the hypogastric arteries and pass to the internal iliacs through the superior vesicals; (3) one umbilical vein passing to the liver through the round ligament; (4) the stalk of the allantois, which, on entering the abdomen, is called the urachus, and passes down to the bladder. At birth these structures, with a myxomatous tissue called Wharton's jelly, are covered with amniotic tissues and form the umbilical cord.

If development is interfered with, a cleft is left in the umbilical region into which intestine or other organs may protrude. If only intestine protrudes, it pushes up into the umbilical cord, and constitutes a congenital umbilical hernia. If the intestine is included when the cord is ligated, death from strangulation will ensue: hence the danger of this form of herniæ. If the urachus remains patulous it may form a *urinary fistula.* The hypogastric arteries become obliterated and, opposite Poupart's (inguinal) ligament, have two fossæ, one to their lateral side and one to their medial side. Through these fossæ direct inguinal herniæ may pass. The persistence of the vitelline duct may cause a finger-like projection, called *Meckel's diverticulum,* on the ileum, about 2 or 3 feet above the ileocæcal valve. Sometimes a band passes from Meckel's diverticulum to the umbilicus and causes incarceration or strangulation of other coils of the intestine. We have operated on one such case. The umbilical vein becomes obliterated and the small vein found in the round ligament of adults, called by Schiff the *parumbilical,* is a new formation, and not the original fetal umbilical vein.

Infantile umbilical hernia is the common form which appears soon after birth and is due to the effect of increases in the intra-abdominal pressure acting on a weak point of the abdominal wall. It does not contain omentum so constantly as does adult hernia, because the omentum does not hang so low, nor is it so well developed.

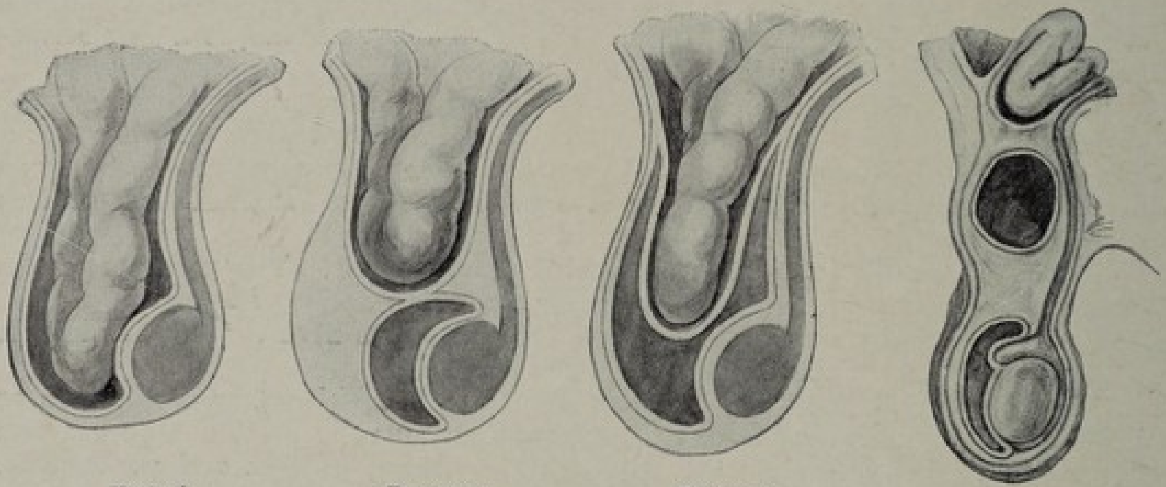
Acquired umbilical hernia is the form seen in adults. The presence of the urachus and hypogastric arteries so strengthens the lower edge of the umbilical ring that hernial protrusions make their exit above, hence the hard edge of the ring is nearly always nearer the lower end of the hernial sac.

These herniæ almost always contain omentum, and either transverse colon or small intestine. The contents of the herniæ are usually matted together and are adherent. The coverings are very thin, consisting of skin and peritoneum, with a small amount of transversalis fascia and scar-tissue between. Unless extreme care is exercised in operating, the first cut will pass into the sac and wound the intestines or omentum. There are several methods of operating on these herniæ. In one operation the sheaths of the two recti muscles are opened and the muscular fibres and sheaths are brought together and sutured in the median line; in the other, two flaps are made from the fibrous walls of the sac and lapped one over the other, thus closing the hernial opening by two fibrous layers. This may be done either longitudinally or transversely. Neither of these procedures had given as satisfactory results as has the Mayo operation. In the Mayo operation transverse elliptical incisions are made around the umbilicus and the hernia. These are deepened to the base of the hernial protrusion. The aponeurotic structures are then exposed for an inch and a half in all directions from the neck of the sac. The fibrous and peritoneal coverings at the neck of the hernia are then divided and the hernial contents exposed. The omental adhesions are carefully divided between double clamps and the clamped omentum ligated. The bowel is freed and returned to the peritoneal cavity. The aponeurotic and peritoneal structures of the ring are incised for a distance of one inch or more transversely to each side. The peritoneum is separated from the under surface of the upper flap. To close the opening introduce mattress sutures so as to overlap the remaining portion of the flaps and suture the lower end of the upper flap to the aponeurosis below. Close the cutaneous incision.

Inguinal Hernia.—Most text-books describe two kinds of *indirect inguinal* hernia, the congenital and the acquired. But we believe that all indirect inguinal hernia are congenital, the degree being only a variation in the quantitative expression of a congenital defect existent at birth.

The *direct inguinal herniæ* may be the result of a developmental defect of the internal oblique and transversalis muscle or more usually of the conjoined tendon (falx inguinalis), or it may be an acquired condition, the result of asthenia and debility.

Development and Descent of the Testis.—The testicle originates in the lumbar region inside of the abdomen, about the third month. It is behind the peritoneum and has a fold of peritoneum, the *plica vascularis* or *mesorchium*, passing upward from it, containing the spermatic artery and veins, and a mesodermal fold passing downward to the inguinal region and into the scrotum called the *gubernaculum*. The gubernaculum does not grow as rapidly as does the trunk and thus becomes relatively shorter. As this occurs the future testicle is pulled downwards. By the fifth or sixth month the genital gland or testicle has reached the abdominal wall at the internal (abdominal inguinal ring) ring, after which it enters the inguinal canal to pass into the scrotum in the eighth or ninth month of fetal life. A process of peritoneum—the *vaginal process*—precedes the passage of the testicle into the scrotum. The neck of the vaginal process is called the *funicular process*. Soon after birth the vaginal process becomes occluded, first at the internal ring, and



Vaginal Funicular Encysted Infantile

FIG. 421.—The various forms of congenital inguinal hernia.

thence downward until the testicle is reached, where the unobliterated portion forms the *tunica vaginalis testis*.

We believe that in the indirect type of hernia the defect is present as a congenital lesion and that the hernia develops in the presence of causative factors.

The Spermatic Cord.—As the testicle descends it carries with and adds to it certain structures which form the spermatic cord. The *vas deferens* is the essential part of the spermatic cord. It carries with it the *spermatic artery*, from the aorta, the *pampiniform plexus* of veins which empty as the spermatic vein into the inferior vena cava on the right side, and the renal vein on the left side, and the *artery of the vas* from the superior vesical. The vas deferens with its artery, a branch of the superior vesical, lies posteriorly and the spermatic artery and pampiniform plexus are anterior. The cremasteric branch of the deep (inferior) epigastric supplies the cremaster muscle. The cord also contains sympathetic nerves, lymphatics, some fibrous remains of the vaginal process, and a few muscular fibres. These structures are imbedded in fatty tissue continuous with the subperitoneal fat and are covered by a fibrous sheath formed by a continuation of the structures of the abdominal walls, viz., the intercolumnar (external spermatic) fascia from the external oblique, the cremasteric fascia from the internal oblique, and the transversalis fascia which in this location is known as the internal spermatic fascia. Accompanying these structures and supplying them are the external spermatic vessels and the genital branch of the genito-femoral (genito-crural) nerve.

The strength of the attachments of the gubernacula to the testis and to the dartos is demonstrated by the fact that in cases of hydrocele and elephantiasis of the scrotum regardless of size the testicles remain in a nearly normal position.

Inguinal Canal (*Canalis Inguinalis*).—This runs from the external (subcutaneous inguinal) to the internal (abdominal inguinal) abdominal ring and is about 4 cm. in length. The *external* (subcutaneous inguinal) *ring* (Fig. 422) barely admits the tip of the finger; it lies immediately to the lateral side and above the spine of the pubis. It is formed by a splitting of the fibres of the external oblique aponeurosis into two columns or pillars. The *external column* (*crus inferius*) blends with Poupart's (inguinal) ligament, passes beneath the cord and inserts into the spine of the pubis. The *internal column* (*crus superius*) inserts into the crest and anterior surface of the body of the pubis. The fibres running across from one column to the other are the *intercolumnar fibres* (*fibræ intercruralis*) and are pro-

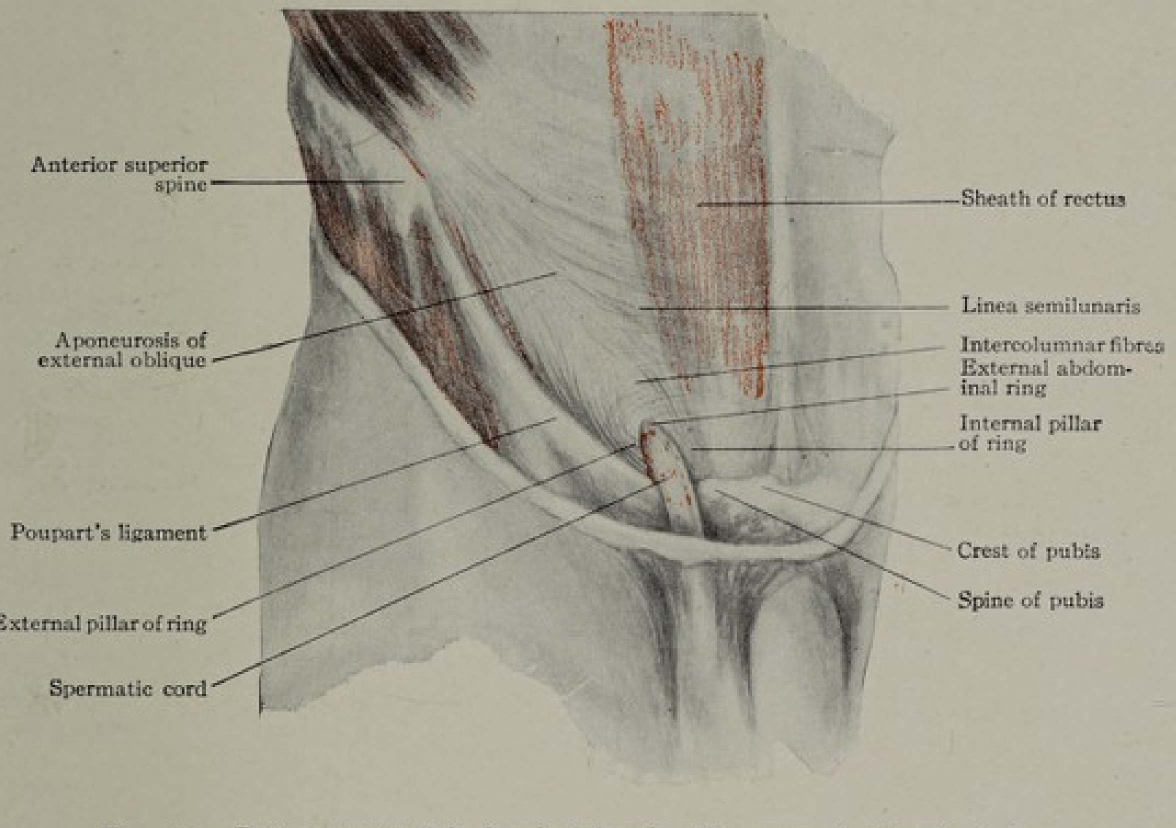


FIG. 422.—Parts concerned in inguinal hernia; the external abdominal ring.

longed over the cord as the intercolumnar (external spermatic) fascia (Fig. 422). The ring is smaller in the female than the male.

The *internal ring* (*annulus inguinalis abdominalis*) is the opening in the transversalis fascia where the cord enters the canal. It is 1.25 to 2 cm. above the middle of Poupart's (inguinal) ligament. This brings it to the lateral side of the external iliac artery. The margins of the fascia are continued over the cord as the infundibulum (internal spermatic) fascia. The deep (inferior) epigastric vessels lie below and medial to the ring.

The body being upright, the inguinal canal has an anterior and a posterior wall and a roof and floor. The *anterior wall* (nearest to the skin) is formed by the aponeurosis of the external oblique, and by the internal oblique muscle for its lateral third and sometimes even its outer half. The *posterior wall* is nearest to the anterior parietal peritoneum. It is formed by the transversalis fascia and at its medial third the conjoined (falx inguinalis) tendon. The *roof*, nearest to the head, is formed by the arching fibres of the internal oblique muscle and—still farther above—the transversalis. The *floor* is nearest to the feet. The cord rests on Poupart's (inguinal) ligament with some of the fibres of the cremaster muscle.

To the medial side of the internal ring and almost midway between it and the external ring runs the deep (inferior) epigastric artery. It is between the transversalis fascia and peritoneum, in the subperitoneal fat.

The various kinds of hernia due to developmental defects have been named as follows: *vaginal*—or *congenital*—*funicular, encysted,* and *infantile.*

Vaginal hernia into the processus vaginalis, commonly known as congenital hernia, is where the vaginal process remains entirely open and the intestine passes down to the testicle. In this form the testicle is found protruding into and at the bottom of the hernial sac. *Funicular Hernia.*—In this form the vaginal process is occluded just above the testicle, but the funicular process above remains open and the intestine descends into it. *Encysted Hernia.*—Here the vaginal process is occluded at the internal ring only, the remainder forming a continuous sac below containing the testicle. When the intestine descends it pushes this septum, like the

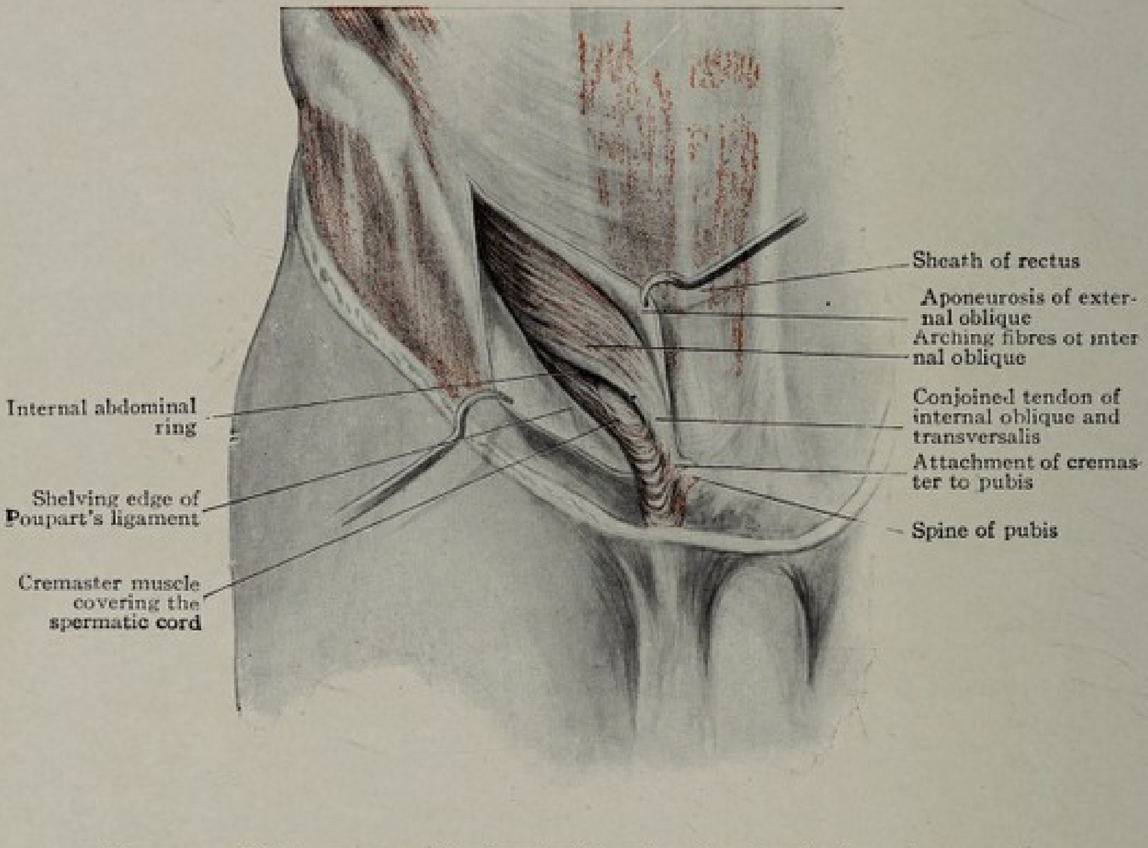


FIG. 423.—Parts concerned in inguinal hernia; the inguinal canal exposed.

finger of a glove, down into the cavity containing the testicle. In operation, two serous layers would be incised, within one of which is the testicle and within the other the intestine. *Infantile Hernia.*—In this form also the vaginal process is occluded only at the internal ring. As the intestine descends it forms a sac posterior to the point of occlusion and vaginal process. Thus in operation three serous layers are divided in exposing the intestine and the sac is posterior to the testicle. It is a rare type of hernia.

Hydrocele.—Hydrocele is an accumulation of fluid in the tunica vaginalis testis. It is usually an acquired affection of adult life, and then does not appear to be dependent on congenital anomalies.

Encysted Hydrocele of the Cord.—This consists of a serous collection in the course of the spermatic cord. It often makes its appearance in infancy and childhood, and is due to some portion of the funicular or vaginal process failing to become obliterated. Serum accumulates in this unoccluded portion, forming a small serous cyst. Sometimes a small opening furnishes a communication with the abdominal cavity, forming a *congenital hydrocele.* In this case the contents of the cyst can be pressed back into the abdominal cavity only to reappear when the individual stands. Should the communicating opening become dilated by a descending coil of intestine, a hernia into the funicular process would be the result.

Hydrocele of the Canal of Nuck.—The inguinal canal in the female transmits the round ligament, and sometimes a finger-like extension of the peritoneum resembling the vaginal process in the male. Accumulation of fluid may occur in this in the same manner as hydrocele of the cord is formed in the male. It is then called hydrocele of the canal of Nuck.

The interparietal (interstitial) hernia is a variety of oblique hernia. It is often associated with anomalies of the testis. It is so called because it does not usually emerge through the external ring, but works its way up between the layers of the abdominal wall. In the type however described by Sultan the hernia insinuates

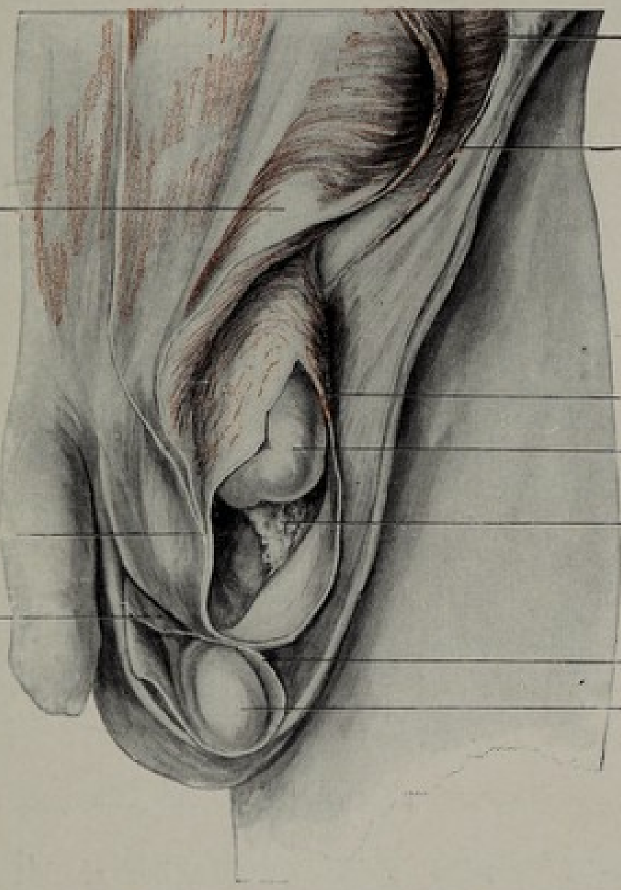


FIG. 424.—The coverings of an acquired oblique inguinal hernia; from an actual dissection. The external and internal oblique have been divided along Poupart's (inguinal) ligament and turned inward exposing the transversalis.

itself between the external oblique aponeurosis and the skin (superficial inguinal hernia).

Coverings of an Indirect or Oblique Hernia.—As the intestine descends to form an oblique inguinal hernia it pushes in front of it the following structures: peritoneum, subperitoneal fat, transversalis (infundibuliform) fascia, internal oblique muscle (cremaster), external oblique aponeurosis (intercolumnal fascia), subcutaneous tissue, and skin. These structures are therefore divided in opening the sac to expose the contents of the sac. The hernia always descends in front of the cord and testicle, hence these are posterior. The site of strangulation may be either at the external (subcutaneous abdominal) ring as the hernia passes through the external oblique muscle or less frequently at the internal (abdominal inguinal) ring as it passes through the transversalis fascia. Strangulation may also occur in the canal from fibres of the internal oblique or transversalis and as frequently occurs from pathological changes in the neck of the sac itself. The deep (inferior) epigastric artery is always along the medial side of the neck of the sac, therefore *divi-*

sion of the stricture must be either upward or up and out, never medialward (Fig. 424).

Operation for Radical Cure.—This has been systematized by Bassini of Padua. The neck of the sac having been exposed by incising the aponeurosis of the external oblique, and the cord separated from it, it is opened and the intestine or omentum is replaced and the sac ligated as high as possible and removed. The cord is then raised and the arching fibres of the internal oblique (and transversalis) are sutured beneath it to Poupart's (inguinal) ligament. The cord is to be replaced, and the divided edges of the external oblique are sutured together down to the external ring, leaving sufficient room for the exit of the cord (Fig. 425).

In large indirect inguinal hernia with weakened surrounding tissues and more especially in recurrent hernia the muscles should be sutured to Poupart's (inguinal) ligament by using fascial sutures after the method of Gallie.

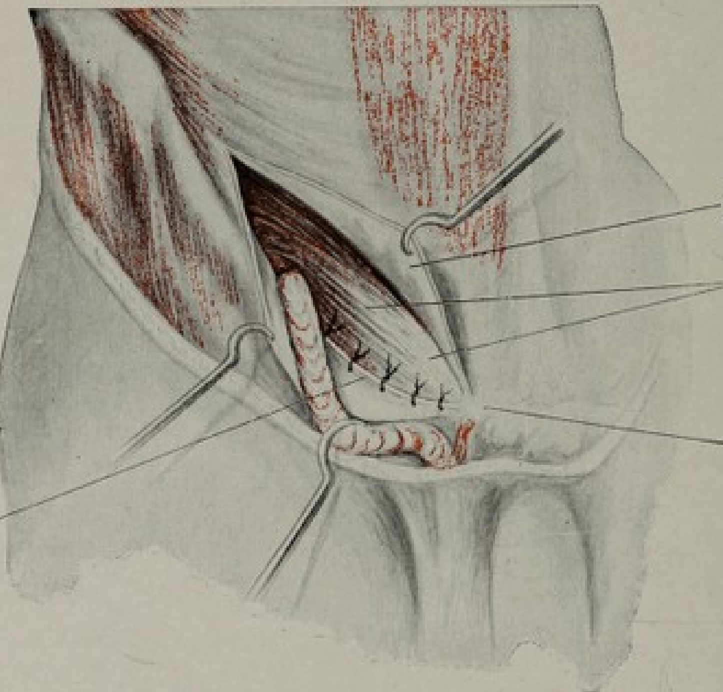


FIG. 425.—Bassini's operation for the radical cure of oblique inguinal hernia.

Direct Inguinal Hernia.—This is so called because it comes directly through the abdominal wall, and not obliquely down through the inguinal canal. It makes its appearance in the neighborhood of the external ring or may cause a protrusion of the abdominal wall just above and to the medial side of the ring. (Figs. 426 and 427.)

Hesselbach's Triangle.—Hesselbach's triangle is seen from the interior of the abdomen; it has on its lateral side the deep (inferior) epigastric artery, on its medial side the edge of the rectus muscle, and as its base Poupart's (inguinal) ligament. Direct inguinal herniæ pierce the abdominal walls through this triangle. On looking at the abdominal wall from the inside, five folds are seen. In the median line the urachus passes from the umbilicus to the top of the bladder; farther out are the folds formed by the obliterated hypogastric arteries (plica hypogastrica); and still farther out the folds containing the deep (inferior) epigastric arteries is called the *internal inguinal fossa* (*fovea supravesicalis*); that between the hypogastric and deep (inferior) epigastric arteries, the *middle inguinal fossa* (*fovea inguinalis medialis*), and that to the lateral side of the deep epigastric artery the *external inguinal fossa* (*fovea inguinalis lateralis*). An indirect or oblique inguinal hernia enters the abdominal walls at the external inguinal fossa, to the lateral side of the deep epigastric artery. A direct hernia almost always enters the middle inguinal fossa between the hypogastric and deep epigastric arteries, or through the lower lateral part of the internal inguinal fossa between the obliterated hypogastric artery and the lateral edge of the rectus muscle. The hypogastric fold passes up behind the middle of the external ring close to the lateral side of the rectus muscle. A direct hernia rarely enters to the medial side of the hypogastric fold (Fig. 426).

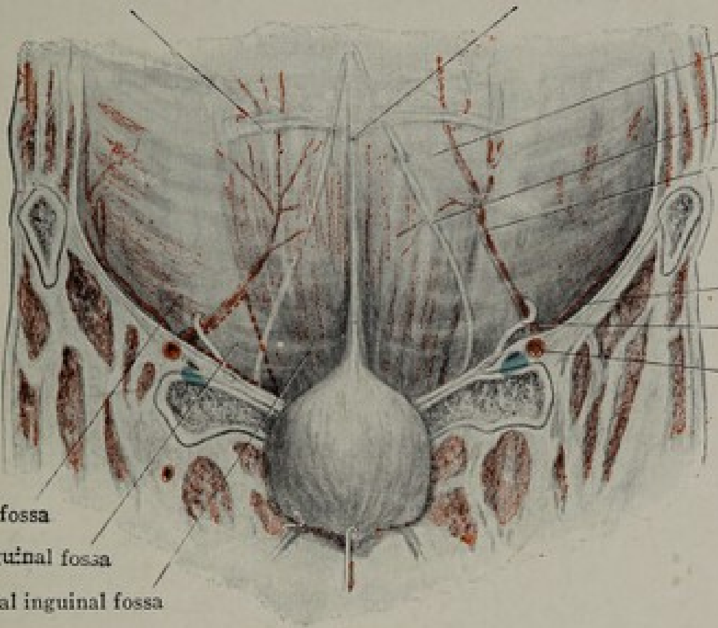


Fig. 426.—View of the posterior surface of the abdominal walls, showing the inguinal fossæ and triangle of Hesselbach (the latter in red).

Coverings of a Direct Inguinal Hernia.—The conjoined tendon (falx inguinalis) is prolonged lateralward from the edge of the rectus muscle two-thirds of the distance to the epigastric artery, and sometimes more. A direct hernia piercing the abdominal wall to the medial side of the hypogastric artery (very rare) will push in front of it the peritoneum, subperitoneal fat, transversalis fascia, conjoined tendon (falx inguinalis), and intercolumnar fascia, making its exit at the

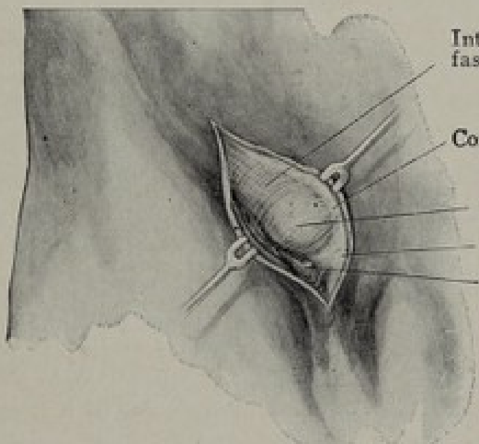


Fig. 427.—Direct inguinal hernia.

medial side of the external abdominal ring. The common site is just to the lateral side of the obliterated hypogastric artery, and it pushes in front of it the conjoined tendon (falx inguinalis) and intercolumnar (external spermatic) fascia, and makes its appearance at the lateral side of, or through, the external abdominal ring (Fig. 427). If it pierces the middle inguinal fossa farther out, and just to the inside of the deep (inferior) epigastric artery, it passes to the lateral side of the conjoined tendon (falx inguinalis), and is covered instead by the cremaster muscle.

Division of the stricture which occurs here must be made upward and medialward, because to its lateral side lie the epigastric vessels, but a direct inguinal hernia rarely becomes strangulated unless it emerges from the external ring.

Radical Cure of Direct Inguinal Hernia.—The repair of this type of hernia from the standpoint of permanency or cure is difficult. There is no true sac, but rather a bulging of the peritoneum and the abdominal wall is usually exceedingly weak. Often the conjoined tendon (falx inguinalis) is absent, the fibers of the internal oblique and transversalis inserting into the rectus sheath.

Recurrence is almost sure to occur in the individual with poorly developed obliques and transversalis muscles or a very weak or deficient conjoined tendon (falx inguinalis). Not only is the roof of the inguinal canal weak, but the floor is formed nearly or entirely by the transversalis fascia and peritoneum. There is one hernia of the so-called "pantaloon" type which may offer better opportunity for cure. This is a coexisting direct and indirect hernia which can be converted into an indirect hernia at the time of operation and then treated as such. When the conjoined tendon is sufficiently thick and strong it is brought down and sutured on Poupart's (inguinal) ligament beneath and behind the cord, thus closing the

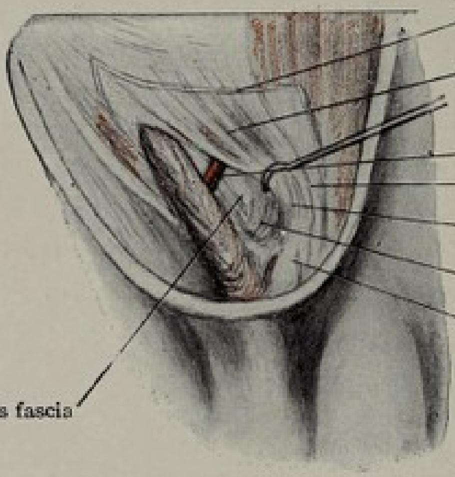


FIG. 428.—The conjoined tendon (falx inguinalis) of the internal oblique and transversalis muscles.

hernial opening. When it is very weak and thin, the edge of the rectus muscle is displaced downward and lateralward and sutured to Poupart's (inguinal) ligament (Bloodgood). The conjoined tendon (Fig. 428) is then brought down in front of these structures and sutured to Poupart's (inguinal) ligament, and the external (subcutaneous abdominal) ring narrowed so as to allow room only for the cord to escape (Fig. 429). The rectus sheath may be divided and turned down to Poupart's (inguinal) ligament. We believe this to be the more rational procedure since it has been demonstrated that muscle does not become firmly attached to fascia. The remainder of the operation can be completed by one of the standard techniques for hernia of the indirect type, or a fascia lata graft may be utilized in place of the weak conjoined tendon (falx inguinalis) before the external oblique is sutured. (The triangular fascia is too uncertain and insignificant a structure to be considered in inguinal herniæ.)

The more recent use of fascial sutures (Gallie) has resulted in better end results. The fact that muscle does not become firmly adherent to fascia is now well established. Gallie has presented a method whereby fascial sutures are passed from the internal oblique and transversalis above to Poupart's (inguinal) ligament below, this providing a strong wall in place of a weak one. The fascial strips are best removed from the fascia lata of the thigh.

Femoral Hernia.—Femoral hernia, although usually considered to be acquired, is probably the result of a congenital defect. It descends through the femoral canal beneath Poupart's (inguinal) ligament to make its appearance at the saphenous opening (fossa ovalis) on the thigh. Beneath the medial end of Poupart's (inguinal) ligament is the iliopectineal line of the horizontal ramus of the pubic bone. The two form an angle with the spine of the pubis as its apex. Gimbernat's (lacunare) ligament is the prolongation of Poupart's (inguinal) ligament from the spine of the pubis for about 2 cm. out on the iliopectineal line. From the iliopectineal line the pectineus muscle proceeds downward and lateralward beneath Poupart's (inguinal) ligament to below and behind the lesser trochanter of the femur.

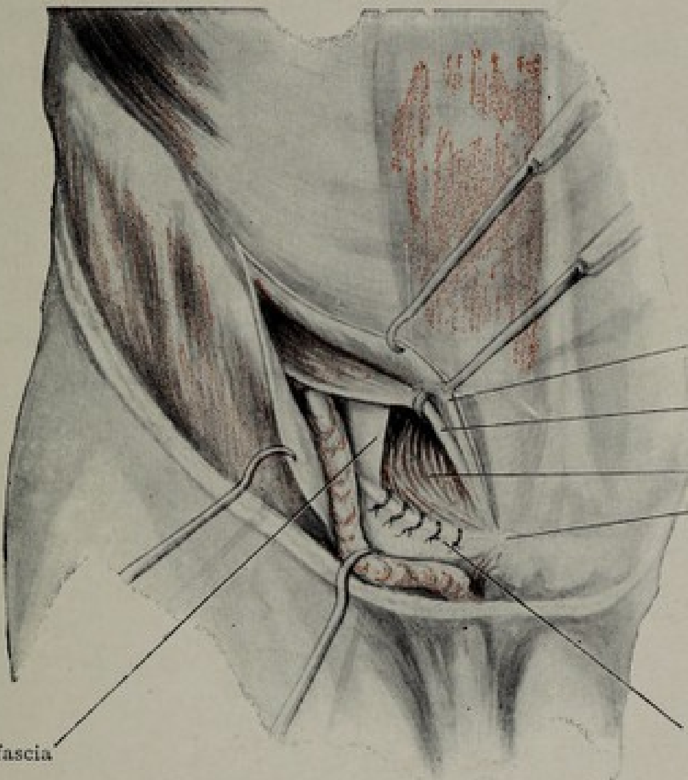


FIG. 429.—Radical cure of direct inguinal hernia. The aponeurosis of the external oblique has been divided and drawn back. The conjoined tendon has been drawn upward toward the median line. The transversalis fascia covering the rectus has been incised and the edge of the muscle has been drawn out and down and sewed to the edge of Poupart's ligament (Bloodgood). The operation is completed by sewing the conjoined tendon to Poupart's ligament, replacing the cord on it, and stitching the edges of the external oblique together down to the external ring.

Farther out beneath Poupart's (inguinal) ligament run the femoral vein and artery, the latter being to the lateral side of the vein. Between the femoral vein and Gimbernat's (lacunare) ligament is left a space 1 to 2 cm. wide. This space is called the *femoral canal*. It is through this canal or opening that a femoral hernia descends. The *femoral sheath* is the continuation downward of the transversalis and iliacus fascia which are prolonged from the interior of the pelvis over the femoral artery and vein and between the vein and Gimbernat's ligament so as to form three compartments. The lateral compartment contains the femoral artery, the middle of the femoral vein, and the medial is the femoral canal. The peritoneum is probably pulled down into this canal as a small nubbin which acts as the nucleus for a sac when the intra-abdominal pressure is exerted against it. The femoral canal is from 1 to 2 cm. long and runs from the abdominal side of Poupart's (inguinal) ligament to the upper edge of the saphenous opening (fossa ovalis) and lies between the femoral vein and Gimbernat's (lacunare) ligament. Its lower extremity is closed by the meeting of its sides. Above, or superficial to it, is Poupart's (inguinal) ligament, and beneath it is the horizontal ramus of the pubis and pectineal fascia covering the pectineus muscle. It is filled with loose connective tissue, fat, and lymphatics, and sometimes contains a lymphatic node, forming all together what has been called the *septum crurale*. It will thus be seen that the septum crurale is continuous with the superitoneal fatty tissue (Fig. 430).

Coverings of a Femoral Hernia.—When a femoral hernia descends, the intestine pushes in front of it the peritoneum septum crurale (subperitoneal tissue), and the femoral sheath (transversalis fascia) and makes its appearance at the saphenous opening. The cribriform fascia closing the saphenous opening (fossa ovalis) gives it a covering, and also the subcutaneous tissue and skin above.

Saphenous Opening (Fossa Ovalis).—This has its centre 4 cm. below and to the lateral side of the spine of the pubis. Its upper margin blends above with Poupart's (inguinal) ligament to proceed to the spine of the pubis. Its lateral and upper edge is marked, forming the *falciform process or ligament* (of Burns). The upper medial portion of the falciform process is attached to the iliopectineal line and spine of the pubis and, blending with Poupart's (inguinal) ligament above, is called *Gimbernat's ligament* (*ligamentum lacunare*) (Fig. 431).

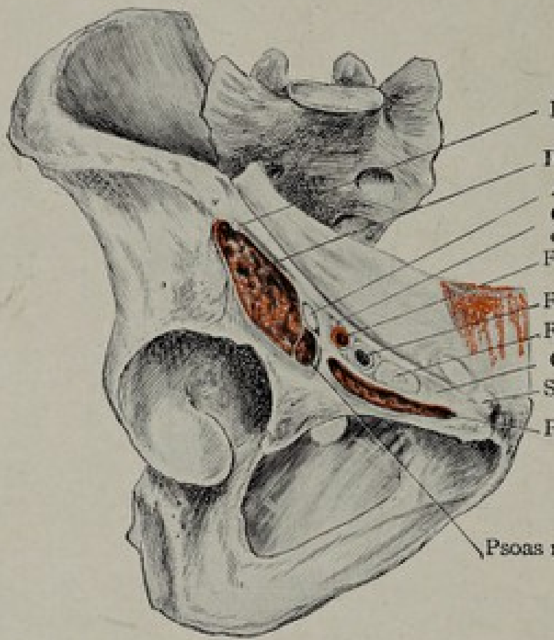


FIG. 430.—The femoral arch and the structures which pass beneath it.

The part of the fascia lata forming the falciform process thins out over the femoral artery and becomes the *cribriform fascia* (*fascia cribrosa*) as it passes from the medial side of the femoral artery on to the femoral vein to blend with the pubic fascia to the medial side. The superficial epigastric, superficial circumflex iliac, and superficial external pudic arteries and veins all pierce the cribriform fascia, as do also the superficial lymphatics and the long or internal saphenous vein. A femoral hernia descends through the femoral canal. As it reaches the superior rim of the falciform ligament it is pressed upon and retarded in its progress. The posterior portion of the hernia turns forward and upward toward Poupart's (inguinal) ligament.

Point of Strangulation.—As a femoral hernia descends it may be strangulated on the sharp edge of Gimbernat's (lacunare) ligament or at the upper portion of the falciform process (Fig. 431).

Division of Stricture.—If Gimbernat's (lacunare) ligament is the constricting band the incision is to be made in an upward and medialward direction. If the upper portion of the falciform process is the constricting part the incision should be made directly upward into Poupart's (inguinal) ligament.

The deep (inferior) epigastric artery lies between the upper portion of the canal and the internal abdominal (abdominal inguinal) ring and the abnormal obturator artery, which when present is a branch of the deep (inferior) epigastric, passes downward along the medical side of the ring. In order to avoid wound-

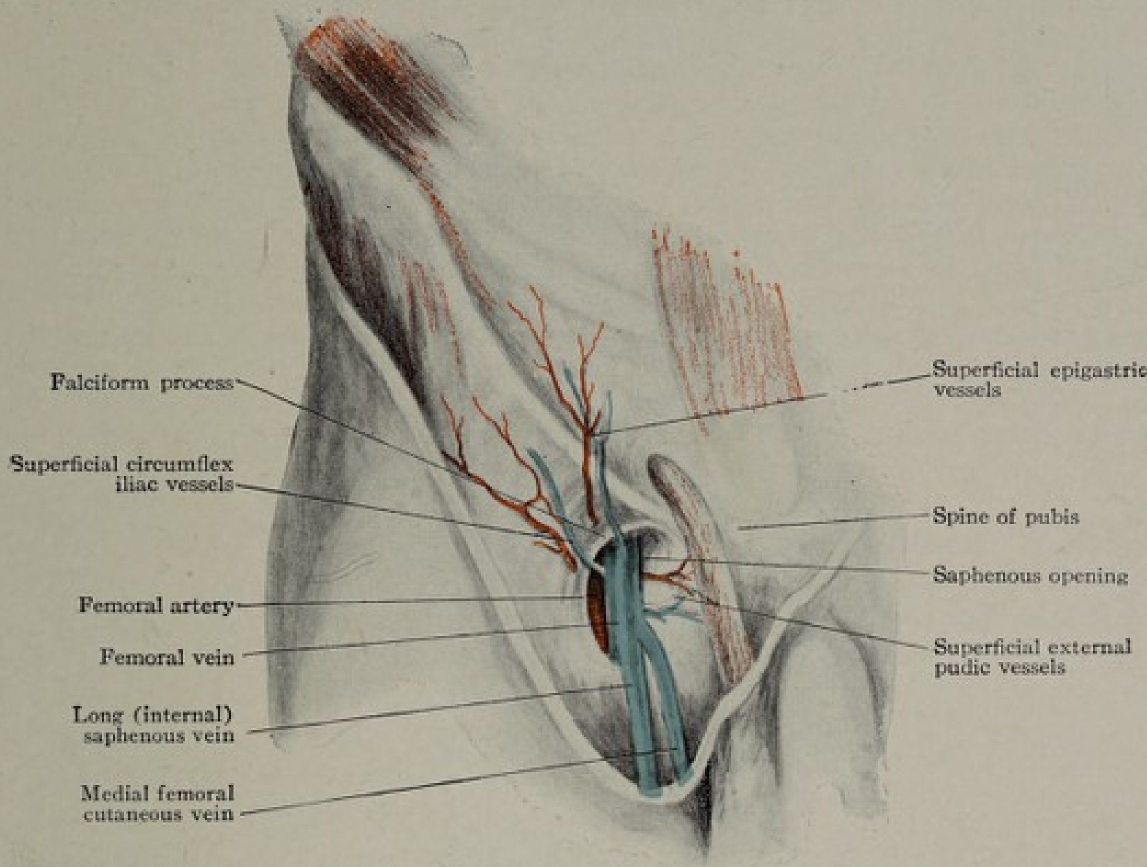


Fig. 431.—The saphenous opening (fossa ovalis).

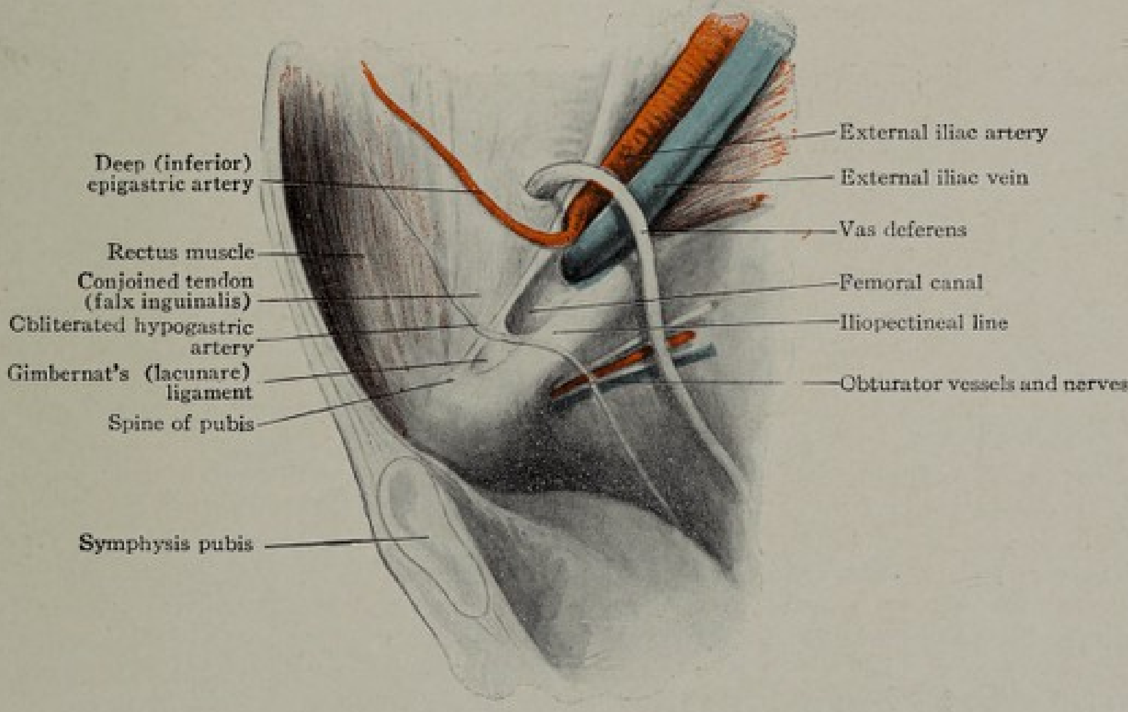


Fig. 432.—View of the inguinal and femoral regions from within; the peritoneum has been removed.

ing this vessel it is best to divide Gimbernat's (lacunare) ligament upward and medialward.

Radical Cure of Femoral Hernia.—The intestine and omentum having been replaced, the neck of the sac is ligated as high up as possible and cut away or, preferably, the two ends of the ligature are brought up through the aponeurosis of the external oblique and tied on its surface just above Poupart's (inguinal) ligament. To close the femoral canal two or three sutures are inserted as follows: If the hernia is on the right side, the needle is passed downward through the inner end of Poupart's (inguinal) ligament, close to the spine of the pubis, into the pectineal or pubic portion of the fascia lata, and brought out alongside of the femoral vein. It is then inserted again through the edge of the falciform process and the suture tied, thus pulling the falciform process and the lower edge of Poupart's (inguinal) ligament down on the fascia covering the pectineal muscle. Two or three sutures are all that are required. Another way of inserting the

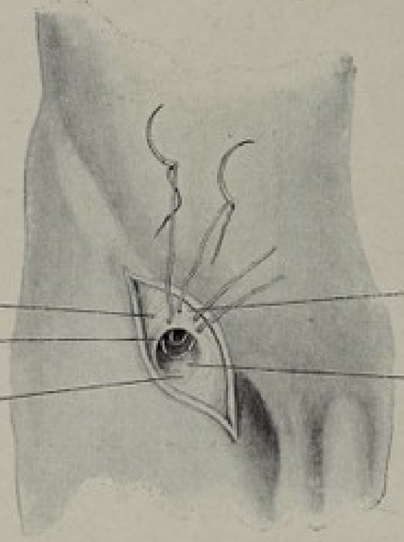


Fig. 433.—Operation for the radical cure of femoral hernia.

sutures is longitudinally, instead of transversely. The first would be close in to Gimbernat's (lacunare) ligament, the second a little farther out, and the third as close to the femoral vein as possible (Fig. 433).

THE LUMBAR REGION

This region is at times affected with abscesses or hernial protrusions and through it incisions are made to reach the kidney (Fig. 434).

Muscles.—The **quadratus lumborum muscle** *arises* from the transverse processes of the lower four lumbar vertebræ, the iliolumbar ligament, and 5 cm. of the iliac crest. It *inserts* into the posterior half of the last rib and transverse processes of the upper four lumbar vertebræ. The **erector spinæ (sacrospinalis)** is the muscular mass which fills the groove to the outer side of the spinous processes. It *arises* from the spines of the lumbar vertebræ, the back of the sacrum, the sacrosciatic and sacroiliac ligaments, and about the posterior fourth of the crest of the ilium. It *inserts* into the posterior portion of the vertebræ and ribs above. The **latissimus dorsi** arises from the spinous processes of the lower six thoracic vertebræ and the vertebral aponeurosis, which is attached to the spinous processes of the lumbar vertebræ, the posterior surface of the sacrum, and the posterior third of the crest of the ilium. It passes upward and forward to insert into the medial lip of the bicipital groove of the humerus.

It will thus be seen that while the direction of the lateral fibres of the latissimus dorsi is from below upward and forward, the direction of those of the quadratus lumborum is upward and backward. It will also be observed that the attachment of the quadratus lumborum is farther out on the crest of the ilium than is that of the latissimus dorsi, reaching to about its middle (Figs. 435, 436 and 437).

Fascias.—The **lumbar fascia (fascia lumbodorsalis),** so called, is the continuation backward of the posterior aponeurosis of the transversalis and internal oblique muscles to the spine. When the aponeurosis, from which these two muscles spring, reaches the lateral edge of the quadratus lumborum, it splits; one thin layer goes on its ventral surface to be attached to the roots of the transverse processes of the vertebræ; the other thicker posterior layer, on reaching the edge of the erector spinæ (sacrospinalis) muscles divides into two, the anterior of which covers the dorsal surface of the quadratus lumborum and the ventral surface of the erector spinæ to attach itself to the tips of the transverse processes, while the posterior layer

Fig. 434.—The lumbar region, superficial view.

passes over the dorsal surface of the erector spinæ to be attached to the spinous processes of the lumbar vertebræ. These three layers are called the anterior, middle, and posterior layers of the lumbar fascia (see Fig. 437).

The anterior layer is attached to the tip of the twelfth rib and arches medialward to the transverse process of the first or second lumbar vertebra, to form the external arcuate ligament (lateral lumbo-costal arch) of the diaphragm. It is practically continuous with the transversalis fascia.

The middle layer is attached above to the last rib, and below to the iliac crest, and is very strong.

The posterior layer is continuous above with the vertebral aponeurosis and gives origin to the latissimus dorsi muscle.

Petit's Triangle (trigonum lumbale).—Above the middle of the crest of the ilium is, as a rule, a small triangular space formed by the edge of the external oblique in front, of the latissimus dorsi behind, and the crest of the ilium below. Its floor is formed by the internal oblique muscle, and it is called the triangle of

Petit or the lumbar triangle. It forms a weak point in this region through which collections of pus or, more rarely, herniæ, may make their appearance (Fig. 434).

Fascial Triangle.—Above and a little posterior to Petit's triangle is another triangular space. Its base is the twelfth rib, its anterior side is the posterior edge of the internal oblique, and posterior side is the outer edge of the quadratus lumborum. It is also called the triangle of Grynfelt and Lesshaft. The lower portion of the kidney lies immediately beneath it and the latissimus dorsi covers it (Figs. 435 and 436).

Lumbar Abscess.—Pus in the lumbar region usually originates from caries of the vertebræ, from renal or perirenal affections, or, on the right side, sometimes from disease of the appendix. Empyemata may likewise point in this region. Pus

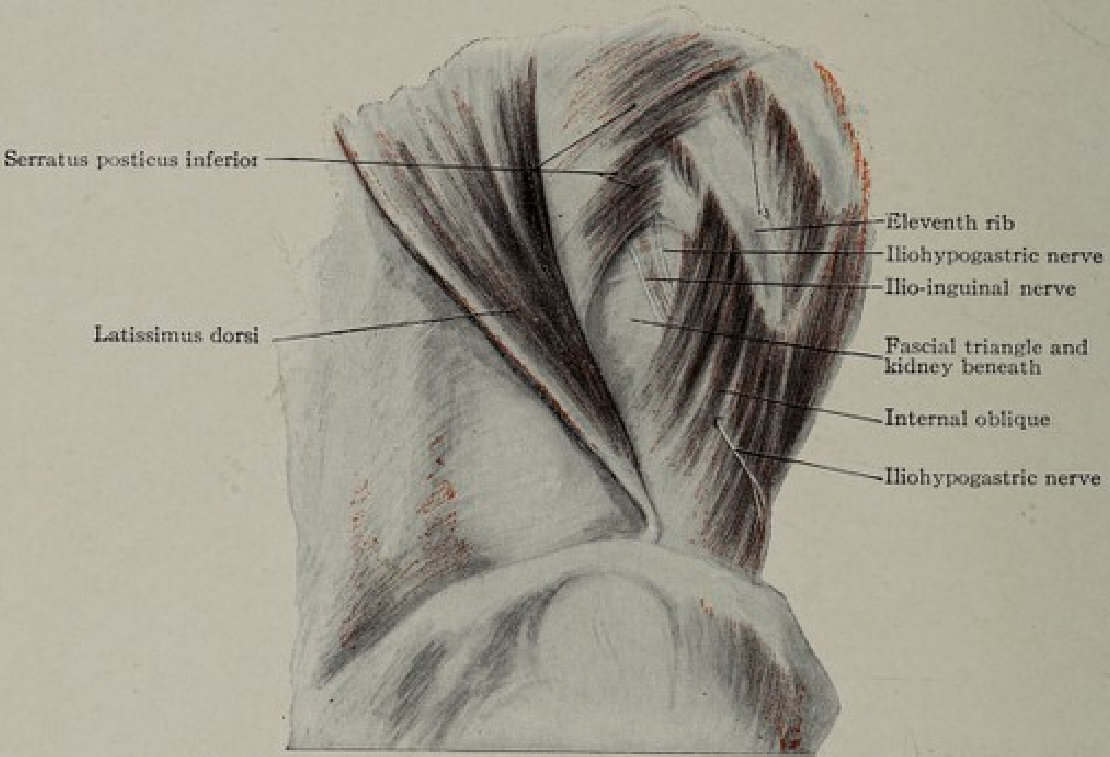


Fig. 435.—The lumbar region; the latissimus dorsi has been turned back and the external oblique cut away, revealing the fascial triangle.

starting from the vertebræ may push its way outward under the transversalis aponeurosis (anterior layer of the lumbar fascia) and perforate the transversalis muscle where the iliohypogastric, ilio-inguinal, and last thoracic nerves enter and thus reach the under surface of the internal oblique and perforate this muscle to find its exit at Petit's (lumbar) triangle. Pus may also perforate the floor of the fascial triangle and follow the anterior surface of the latissimus dorsi down until it points in the angle between the posterior portion of the crest of the ilium and the spine. The quadratus lumborum muscle is thin, and its lateral edge, which is not covered by the erector spinæ (sacrospinalis) muscle, is readily pierced by pus. The *erector spinæ* (sacrospinalis) is a thick muscle covered both anteriorly and posteriorly by the thick middle and posterior layers of the lumbar fascia, hence pus does not pierce it but always goes around its outer side.

Lumbar Hernia.—Lumbar hernia, either the high or low, is an infrequent occurrence. The left side is said to be more often the site than the right. Although they are more apt to occur in elderly individuals, with poorly nourished and relaxed tissues, the lesion may be congenital. Hernial protrusions may also occur in this region as the result of trauma, suppuration or after operative incisions.

Lumbar incisions are made to evacuate pus or to operate on the kidney. Incisions to evacuate pus should be made obliquely from the lateral edge of the quadratus lumborum in order to avoid wounding the nerves. The patient should be placed in that position which increases the distance between the last rib and the crest of the ilium.

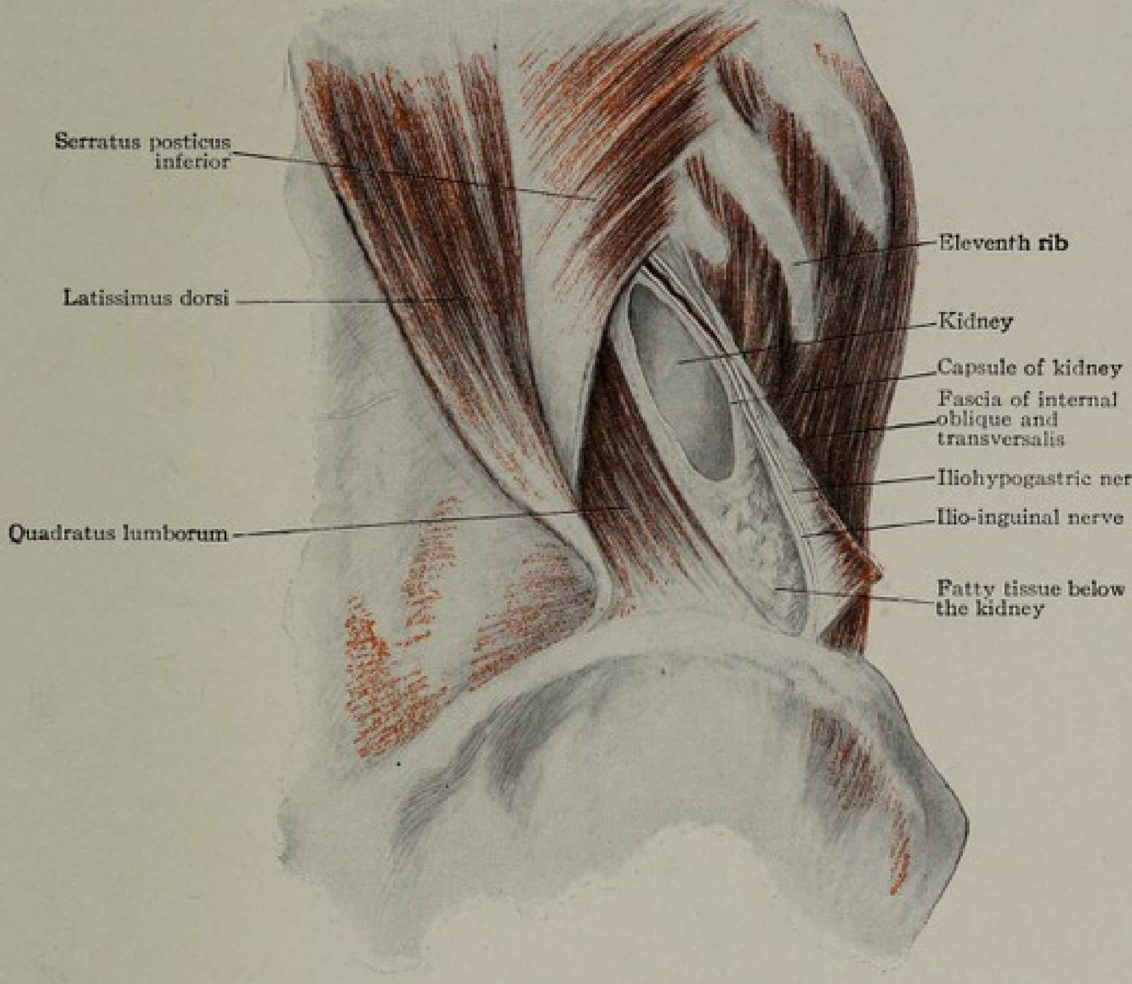


Fig. 436.—Lumbar region, showing the kidney and quadratus lumborum muscle exposed.

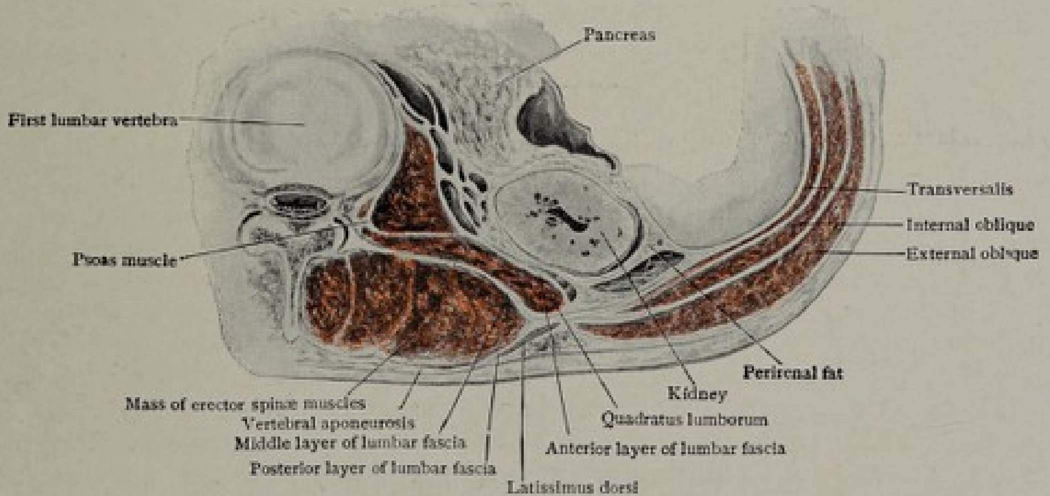


Fig. 437.—Transverse section of the lumbar region, showing the lumbar fascias and muscles.

Longitudinal Incision.—If it is desired to expose the kidney, a straight incision 10 cm. long may be made between the last rib and middle of the crest of the ilium along the lateral edge of the quadratus lumborum. This may sometimes necessitate dividing the last thoracic nerve near the rib and the iliohypogastric and ilio-inguinal nerves near the crest. They should if possible be pulled aside. This gives only sufficient room to bring a normal-sized kidney out of the wound. If the kidney is enlarged, Edebohl recommended prolonging the incision along the crest of the ilium. This longitudinal incision lies just back of the external oblique, traverses in its upper part the latissimus dorsi (the fibres of which may be parted by blunt dissection) then the lumbar fascia or anterior edge of the quadratus lumborum muscle, and lastly the transversalis fascia behind the peritoneum (Fig. 438).

Oblique Incision.—When an incision for an enlarged kidney, or for large tumors, or abscesses is desired, it can be made obliquely downward and forward from the twelfth rib—anterior to its middle—toward the anterior portion of the

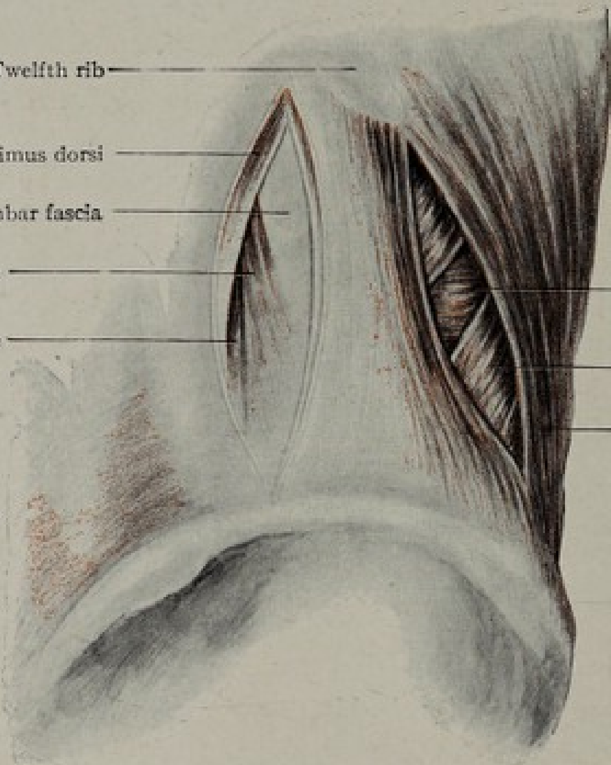


FIG. 438.—Lumbar incisions for operations on the kidney, showing the direction of the muscular fibres.

crest of the ilium. This parts the fibres of the external oblique and divides the fibres of the transversalis muscle obliquely, and those of the internal oblique almost transversely, but the nerves (twelfth thoracic and iliohypogastric) are more readily drawn aside than if the longitudinal incision is used. Care is to be taken not to go farther back than the middle of the twelfth rib, because the pleura usually crosses at that point to reach the lower edge of the rib, or even a little below it at its posterior extremity. As it is sometimes difficult to identify the twelfth rib, because it may be so short as to be hidden beneath the muscles, the most certain way is to count downward from the angle of the sternum opposite the second costal cartilage. There may be some bleeding at the lower portion of the wound from the ascending branch of the deep circumflex iliac artery near the anterior portion of the crest of the ilium.

THE INTERIOR OF THE ABDOMEN

The abdominal cavity proper extends only to the brim of the pelvis while below this is the pelvic cavity. The peritoneal cavity is thus not synonymous with the abdominal cavity: some of the abdominal organs project comparatively little forward into it and, as in the case of the kidneys, may be only partly covered with the peritoneum. The peritoneal cavity includes the pelvis, so that an infection of the pelvic peritoneum of necessity involves a part of the general peritoneal cavity.

The **peritoneum** is a closed sac lining the abdomen and pelvis into which the various abdominal and pelvic organs project. As the organs increase in size they push farther into the abdominal cavity and the peritoneum covers more of their surface, until in some cases the two layers (anterior and posterior) meet; thus the organ is left hanging by its peritoneal pedicle. The peritoneum covering the organs is called the visceral peritoneum, that lining the walls of the abdominal cavity the parietal peritoneum. The visceral and parietal perineum are continuous. Those parts of the peritoneum joining the visceral and parietal layers receive various names. Sometimes they are called ligaments,—thus we have the various ligaments of the liver, the coronary, lateral (triangular), and suspensory (falciform); of the spleen; of the uterus; bladder; etc. Sometimes they are called omenta,—thus we have the greater omentum, the lesser or gastrohepatic omentum and the gastrosplenic omentum. Sometimes they receive the name of mesentery, which is applied to the small intestine, and mesocolon, as applied to the large intestine. From this arrangement it is evident that there is some portion of every abdominal and pelvic organ that is not covered by peritoneum. In some organs, as the small intestines, the uncovered part is very small, being at the attachment of the mesentery. In other organs, as the kidneys and pancreas, it is very large, embracing all their posterior surface. In operating on the abdominal or pelvic organs these attachments are of importance, as a knowledge of them enables the surgeon—for example, in operating on the kidney for renal calculus—to complete his procedures without wounding the peritoneum or opening the peritoneal cavity. The superior and inferior limits of the peritoneum are also important, as they are liable to be wounded in operations on the chest and the organs of the pelvis. The peritoneal sac is entirely closed in the male, but in the female the open end of the Fallopian tube allows for external communication. This has been utilized in producing pneumoperitoneum in the female and has also been used to diagnose obstruction of the tubes as a cause of sterility. The smooth walls of the peritoneal sac secrete a thin fluid which lubricates the surface and reduces friction.

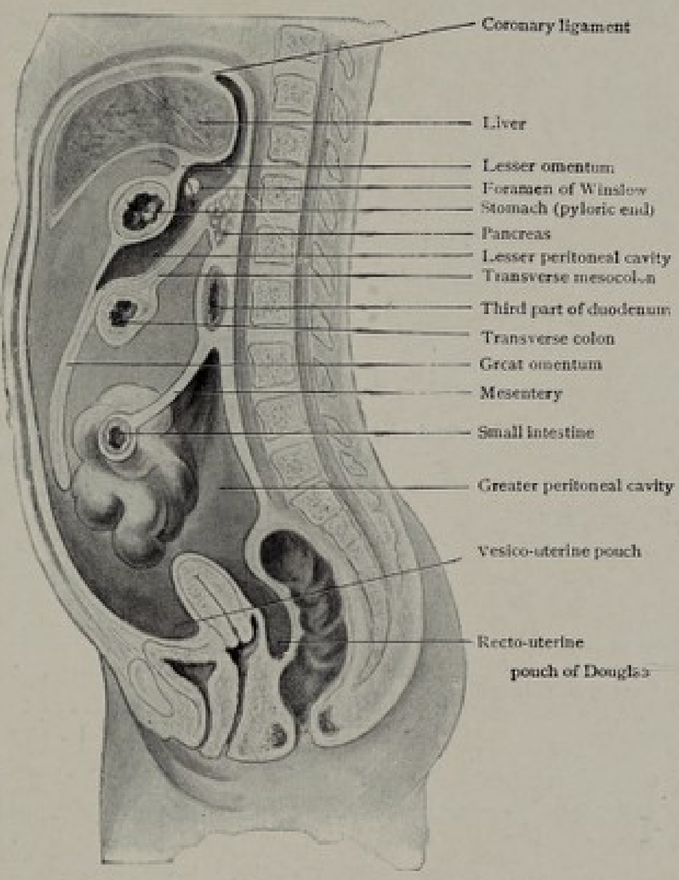


FIG. 439.—Anteroposterior section, showing the peritoneum.

A knowledge of the course pursued by the peritoneum over the various organs is of service both in diagnosis and operative procedures.

Viewing the body in an anteroposterior section (Fig. 439), and beginning at the umbilicus. the peritoneum is seen to pass upward on the posterior surface of the anterior abdominal wall until it reaches the under surface of the diaphragm, which it covers, to the upper posterior surface of the liver, where it forms the *coronary* *ligament* on the right side and the *left lateral* (triangular) *ligament* on the left. It then covers the superior or parietal surface of the liver and curves around the anterior edge and the under or visceral surface as far as the transverse fissure (posta hepatis). Thence it proceeds to the stomach, forming the anterior layer of the lesser or gastrohepatic omentum. After covering the anterior wall of the stomach, it leaves the greater curvature to form the anterior layers of the gastro-colic omentum. Passing over the transverse colon it extends for a variable distance in the abdominal cavity, forming the anterior layer of the great omentum when it turns upward and backward to the transverse colon the inferior surface of which it covers. It passes under the transverse colon, which it covers and passes back to the spine at the lower border of the pancreas. It then goes downward, covering the transverse portion of the duodenum and forming the anterior layer of the mesentery. Having covered the small intestine, it goes back to the spine, forming the posterior layer of the mesentery, and descends until it reaches the rectum. From the rectum it is reflected forward to the upper part of the vagina and uterus in the female, forming the *recto-uterine pouch* (or *pouch of Douglas*) or on the bladder in the male, being at this point about 7.5 cm. distant from the anus. After covering the fundus and body of the uterus, it is reflected at the level of the in-

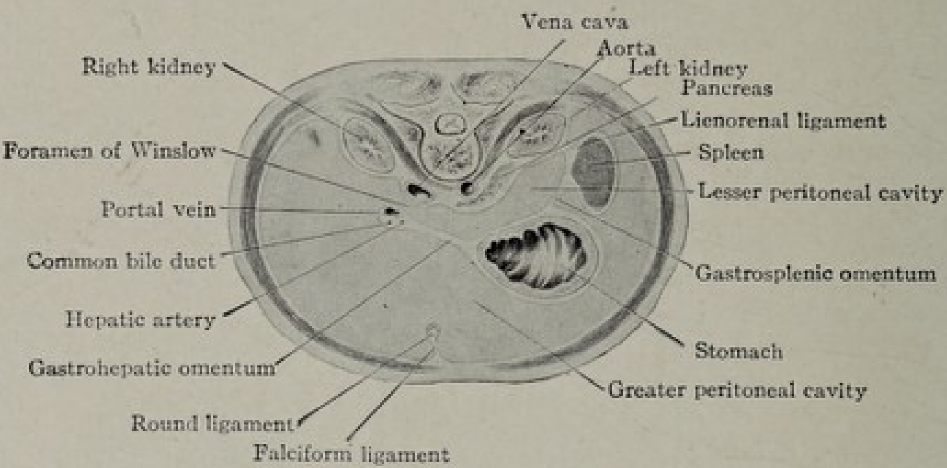


FIG. 440.—Transverse section made through the foramen of Winslow (epiploic foramen). (Viewed from above.)

ternal os to the bladder, forming the *uterovesical fold*. From the fundus of the bladder it passes up the abdominal wall to reach the umbilicus.

The peritoneum lining the lesser cavity can be followed upward from the anterior surface to the pancreas. It ascends on the posterior abdominal wall to the under surface of the liver, forming the under layer of the coronary and left lateral ligaments, and at the transverse fissure is reflected to the posterior surface of the stomach, forming in its course the posterior layer of the gastrohepatic omentum. From the greater curvature it passes downward and then upward to the colon, forming the posterior layer of the gastro-colic omentum, over the colon to form the second, and after turning upward the third layer of the great omentum. From the posterior edge of the transverse colon it passes to the anterior surface of the pancreas, having in its course formed the upper (cephalad) layer of the transverse mesocolon.

Viewing the Body in Transverse Section.—On examining a transverse section made below the foramen (epiploic) of Winslow, the peritoneum is seen coming from the parietes and passing over the ascending colon, leaving its posterior surface uncovered. Thence it passes over the vena cava and spine, to go to the mesentery and small intestines. Returning to the spine, it passes over the aorta, and out over the descending colon, usually leaving a portion of its posterior surface uncovered. Thence it returns to the anterior parietes.

In a section made passing through the foramen (epiploic) of Winslow (Fig.

440), the mode of formation of the lesser cavity of the peritoneum and the relation of the peritoneum to the stomach, spleen, and kidneys will be more readily understood. Beginning on the anterior abdominal wall, at the median line and proceeding to the right, the peritoneum is seen to enclose the round ligament of the liver, forming a mesentery for it named the falciform ligament. Continuing around, the peritoneum lines the inner surface of the anterior and lateral abdominal walls, covers the anterior surface of the right kidney, and, after forming the posterior wall of the foramen (epiploic) of Winslow, covers the vena cava, aorta, spine, and pancreas; it then passes over the left kidney to go to the spleen, forming the anterior layer of the lineorenal ligament. It is then reflected from the spleen to the posterior surface of the stomach, forming the posterior layer of the gastrosplenic omentum. From thence it passes forward on the stomach, past the pylorus to the upper surface of the first portion of the duodenum. Here it winds around the hepatic artery, portal vein, and common bile duct to reach the anterior surface of the stomach. This reflection forms the free anterior edge of the foramen (epiploic) of Winslow. From the fundus of the stomach it passes to the spleen, forming the anterior layer of the gastrosplenic omentum. It winds around the lateral or costal surface, and the medial or renal surface of the spleen, and thence passes to the left kidney, forming the posterior layer of the lienorenal ligament. After covering the lateral portion of the kidney, it is reflected to the abdominal wall which it follows to the median line.

The Transversalis Fascia.—Superficial to the peritoneum and between it and the structures which it covers is a layer of fibrous tissue which varies in thickness. The part which lines the muscles of the anterior abdomen is called the transversalis fascia. It is thickest and most marked in the lower portion of the abdomen. Posteriorly the fascia is continuous with the aponeurotic band forming the union of the superficial and deep layers of the lumbo-dorsal fascia, while anteriorly it combines with the anterior abdominal aponeurosis to form the posterior sheath of the rectus muscle about the linea semicircularis, while below this it is a separate layer. Above it unites with the fascia covering the diaphragm and below at the crest of the ilium at Poupart's (inguinal) ligament it is continuous with the iliac fascia. At the femoral ring it is continued downward under Poupart's (inguinal) ligament to form the anterior wall of the femoral sheath. The fascia is continued downward over the spermatic cord for which it forms a funnel-like investment known as the infundibuliform (internal spermatic) fascia.

Subperitoneal Fat.—In certain locations there is more or less fatty tissue between the transversalis fascia and the peritoneum, and sometimes it is impossible to differentiate them. They blend in the region of the kidneys, the mesenteries, inguinal regions, etc. In the femoral canal the transversalis fascia is continuous with the sheath of the vessels and the subperitoneal fat with the septum crurale. The protrusion of this subperitoneal fat in the median line usually above the umbilicus forms the epigastric alluded to on page 419.

THE ABDOMINAL VISCERA

The abdominal contents should first be studied as to their position and general relations, so that they can be readily found and identified, and then studied as to their intimate relations to the immediate surrounding structures.

By knowing the first, an operator is enabled to expose quickly the affected part, and by knowing the second he is enabled to carry out the desired procedures. While it is true that the presence of tumors or enlargement of the various organs or embryonic defects may distort and displace them and so render their exposure and recognition difficult, nevertheless a knowledge of the normal relations is necessary in order to solve the difficulties which arise in operating for or studying the various abdominal diseases and injuries.

It must be borne in mind that the extent and position of the various organs is not always the same, even though they are not diseased. It is easier to find a distended than a contracted stomach; in some people the liver though not diseased may be lower than in others, etc.

When the abdominal cavity is freely opened the general relation of the organs is visible as in Fig. 441. In the upper portion is seen the *liver*. Its edge usually is inclined upward toward the left, but sometimes it passes almost transversely across. In the male its lower edge should be about even with the lower edge of the thorax (tenth rib) but in females it may be a finger-breadth lower. Its anterior edge is marked by the *gall-bladder* and *round ligament*. The gall-bladder is liable to be a little to the lateral side of its normal position at the upper extremity of the right linea semilunaris. The round ligament reaches the liver not at the median line but 2.5 to 4 cm. to its right. The point at which the liver crosses the median line is approximately 4 cm. below the tip of the ensiform cartilage. The *stomach* is seen to the left of the liver, between it and the left costal cartilages. Frequently the stomach is seen to pass a little to the right of the median line, particularly if it is distended. A small portion only, 2.5 to 4 cm., is seen in the median line and its lower border slopes up and to the left to disappear under the edge of the ribs. Immediately below the stomach lies the transverse colon, concealed beneath omentum. The *omentum* hangs down from the lower edge of the stomach and spreads over almost the whole of the abdomen below. It is frequently encountered in operating for appendicitis even through a McBurney incision, and is often found in a hernia. The gall-bladder is almost the only organ below the liver and stomach which it is not liable to cover, and even this is covered following attacks of acute cholecystitis. Not infrequently the omentum is not found spread out, but from the movements of the intestines it may lie between their coils or be displaced largely to the left. The *transverse colon* passes upward and to the left; it crosses the median line just below the stomach and may reach the level of the umbilicus or even lower. Not infrequently, however, there may be a coil of small intestine between the level of the umbilicus and the transverse colon, or a coil may show itself between the stomach above and the transverse colon below.

The *cæcum* and the commencement of the *ascending colon* are almost always seen superficially in the right iliac fossa. The lower end of the cæcum may reach as far forward as the middle of the Poupart's (inguinal) ligament, but when the ascending colon reaches the upper edge of the iliac crest it sinks backward out of sight, to reappear again above at the commencement of the transverse colon just below the gall-bladder.

The *descending colon* and *sigmoid flexure* are usually seen lying close to the abdominal wall somewhere between the left iliac crest and approximately the middle of Poupart's (inguinal) ligament. The amount visible is variable,—sometimes a considerable length is seen, at others only a single knuckle. Their presence and location are more uncertain than are those of the cæcum and ascending colon on the right side. The *small intestines* fill the remainder of the visible space. They enter the pelvis, usually are found in hernial sacs, and cover both the ascending and descending colon in the flanks. The coils in the upper and left portions of the abdomen are more likely to be jejunum, those in the lower and right portions are more likely to be ileum. Either may be found in the pelvis.

THE STOMACH

The stomach at birth is rather tubular and has a capacity of about 25 c.c. The œsophagus enters it less obliquely which accounts for the readiness with which regurgitation occurs. The pyloric antrum is only poorly marked.

When the stomach is moderately distended it is a pear-shaped organ lying almost entirely to the left of the median line and occupying the epigastric and left hypochondriac regions. It has an average capacity of 1 to 2 litres (about 2½ pints). Its direction is an oblique one, being downward, forward, and to the right. The upper two-thirds are more longitudinal, the lower third more transverse, the two parts making an angle of 60 to 70 degrees. The part just adjoining the pylorus is slightly enlarged when the stomach is distended, and is called the *antrum*. The stomach is spoken of as having anterior and posterior walls, but they could just as truthfully be called superior and inferior, especially when the organ is distended. When it is relaxed it tends to hang in a more vertical position, but when it is distended it rotates on a transverse axis, the greater curvature coming forward, and the organ assumes a more horizontal plane. When the stomach is empty it may not

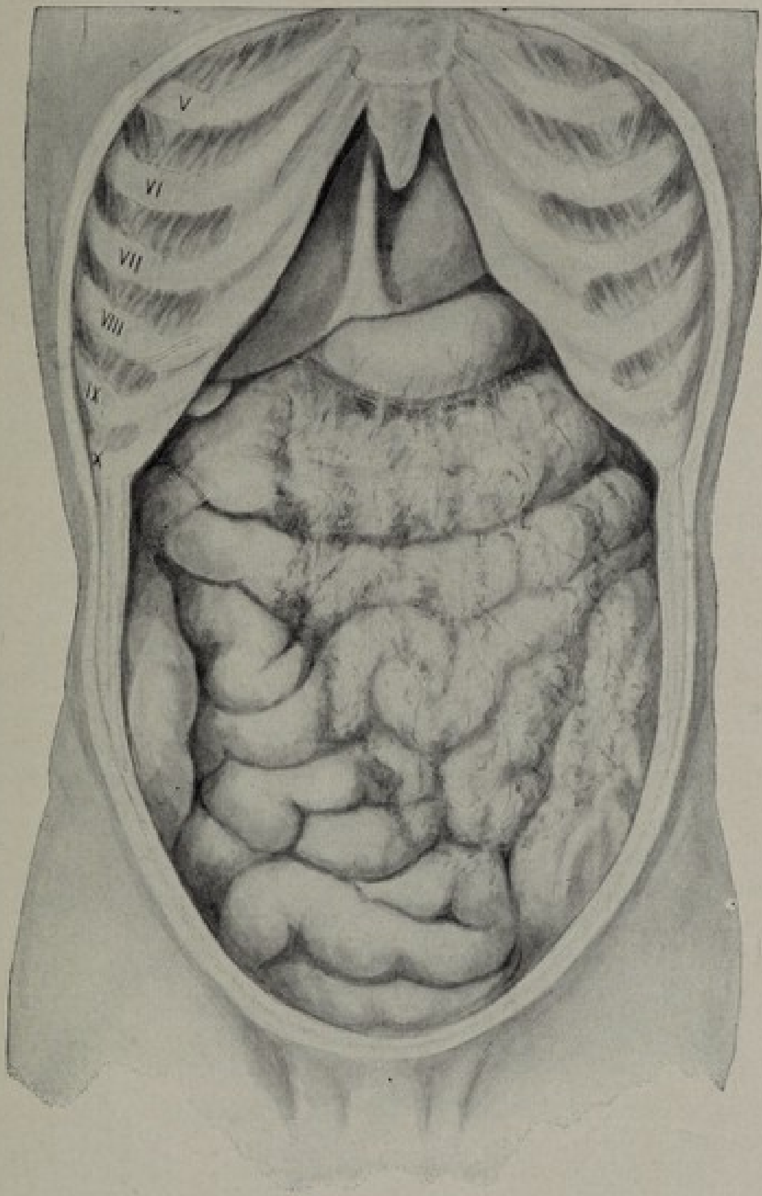


FIG. 441.—View of the abdominal organs *in situ*. Beneath the ensiform process is seen the liver with the round ligament to the right of the median line, below come the stomach, then the transverse colon, and lower down the small intestines, over which is spread the great omentum. In the right iliac region is seen the ascending colon and in the left the termination of the descending colon.

be relaxed but contracted. This contraction is liable to be very marked toward the middle of the organ, producing the *hour-glass stomach*. At other times the contraction proceeds a variable distance from the pylorus toward the cardiac extremity. In such cases instead of being pear-shaped the stomach becomes more or less tubular so as to resemble the remainder of the intestinal canal. It then differs but little in appearance from the duodenum, and the position of the pylorus is not readily recognized. This is a continuation of the fœtal type and is more commonly seen in the female. If, as may normally occur, the contraction extends well over toward the cardiac end, then liquids do not lodge in the stomach but pass almost immediately through it into the small intestine beyond. When this condition is found to exist, the stomach is to be recognized by its position, its attachments, and the thickness of its walls.

It hangs suspended by its cardiac extremity from the œsophagus. This is beneath the seventh left costal cartilage, about an inch from the edge of the sternum and 10 cm. from the surface; this brings it opposite the eleventh dorsal vertebra immediately in front of the aorta. The pylorus lies just under the edge of the liver, either in the median line when the stomach is empty or, as is more often the case, 2.5 cm. or more to the right of the median line—a little higher up than the gall-bladder or opposite the eighth right costal cartilage and on a level with the first lumbar vertebra. The pylorus is usually a little higher in women than in men. W. J. Mayo has pointed out the conjurie of veins running from the greater to the lesser curvature as marking the position of the pyloric sphincter regardless of the size or shape of the stomach. If the liver is contracted the pylorus and adjacent portion of the stomach may be in direct contact with the anterior abdominal wall. The lesser curvature is 7.5 to 12.5 cm. long and passes downward, forward, and in the right. The axis of the stomach is oblique. It slants downward and to the right and passes forward until the distal portion of the pylorus carries it backward and upward. The lesser curvature is vertical until the pyloric antrum is reached when it becomes nearly horizontal.

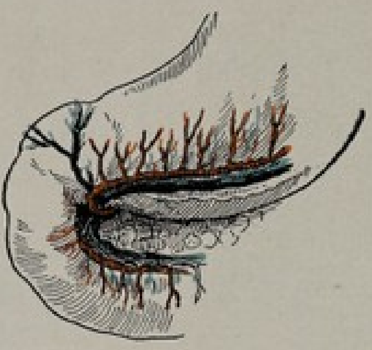


FIG. 442.—Congerie of veins marking the pyloric sphincter.

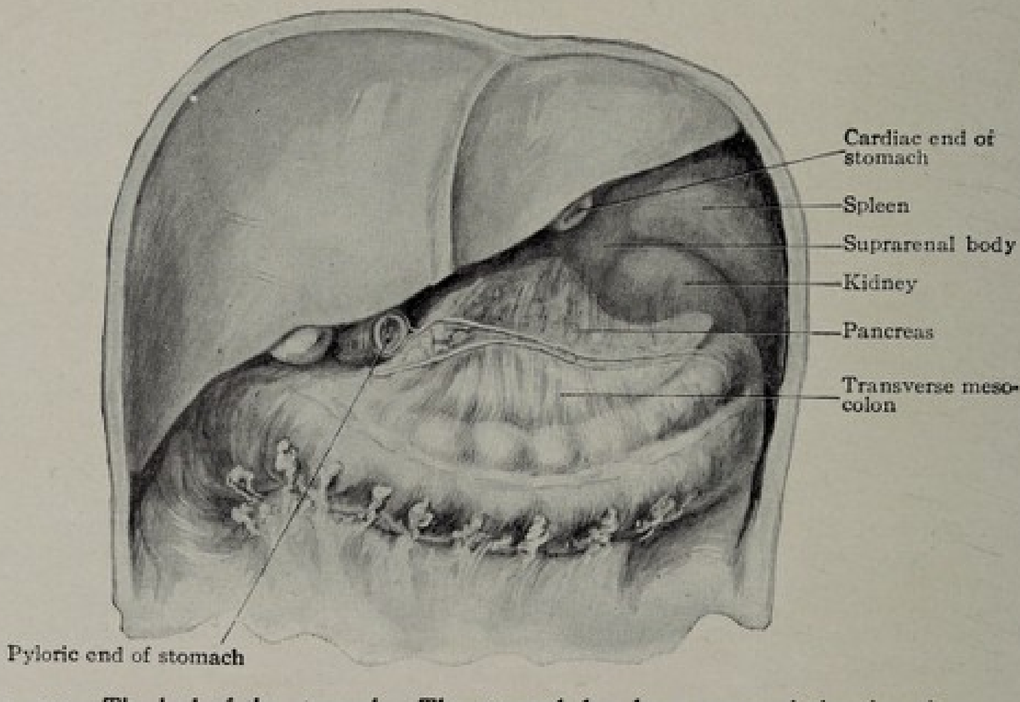


FIG. 443.—The bed of the stomach. The stomach has been removed showing the surrounding structures.

Relations.—The stomach rests on the transverse mesocolon, which covers the pancreas, solar plexus, aorta, thoracic duct, vena cava, and crura of the diaphragm posteriorly; further to the left are the left suprarenal body, kidney, and spleen (Fig. 443).

In front are the diaphragm, abdominal parietes, and liver. Above are the lesser or gastrohepatic omentum, liver, and diaphragm. Below is the gastrocolic omentum, transverse colon, and to the left of the body and fundus is the gastrosplenic omentum.

Percussion.—In physical diagnosis the size of the stomach is outlined by percussion, it being filled with air or gas to distend it. In the median line its resonance above will be limited by the edge of the liver; below, while usually 5 to 7.5 cm. (2 to 3 in.) above the umbilicus, it is not considered to be dilated, especially in old people, unless it reaches below the umbilicus. It leaves the left costal margin opposite the ninth or tenth costal cartilage. In the left mammary line stomach resonance may reach up to the fifth or sixth rib, while farther to the left it reaches the spleen about in the midaxillary line.

Traube's semilunar space is limited above by the edge of the left lung, indicated by the sixth interspace; laterally by the spleen, indicated by the mid-axillary line; and medially by the costal margin. Normally this area is resonant from the presence of the stomach beneath, but pleural effusion causes it to be dull on percussion.

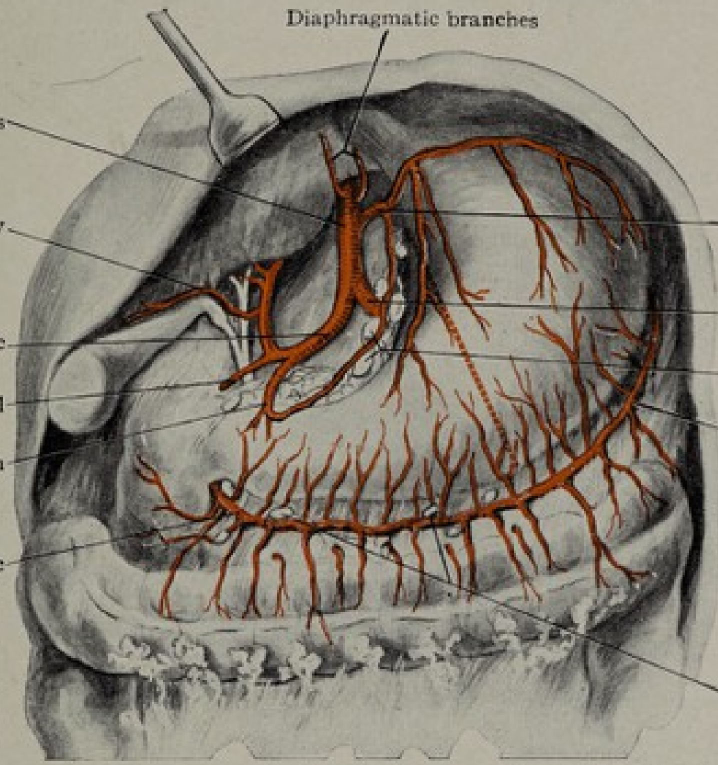


FIG. 444.—Blood supply and lymphatics of the stomach, and Hartmann-Mikulicz line.

Blood Supply.—The *cœliac axis* gives off the gastric (coronary), hepatic, and splenic arteries, all of which give branches to the stomach. The *gastric* (coronary) gives branches to the œsophagus which pass through the hiatus œsophagus and cardiac end of the stomach and then runs along the lesser curvature to unite with the pyloric branch of the hepatic. It lies between the layers of the gastrohepatic omentum and sends branches anteriorly and posteriorly over the surface of the stomach (Fig. 444).

The *hepatic artery* runs along the upper border of the pancreas to the first part of the duodenum. As it nears the pylorus gives off a pyloric branch which passes to the left along the lesser curvature, and a gastroduodenal branch, which divides into the superior pancreaticoduodenal to supply the duodenum and head of the pancreas, and the right gastro-epiploic artery which passes to the left along the greater curvature of the stomach.

The *splenic artery* which is the largest branch of the cœliac axis passes upwards and to the left along the upper border of the pancreas. Near the spleen it gives off the left gastro-epiploic artery which proceeds along the greater curvature of the stomach between the layers of the gastrosplenic ligament to unite with the right gastroepiploic, a branch of the gastroduodenal artery. It also gives off the *vasa brevia* which pass backward in the gastro-splenic omentum to the greater

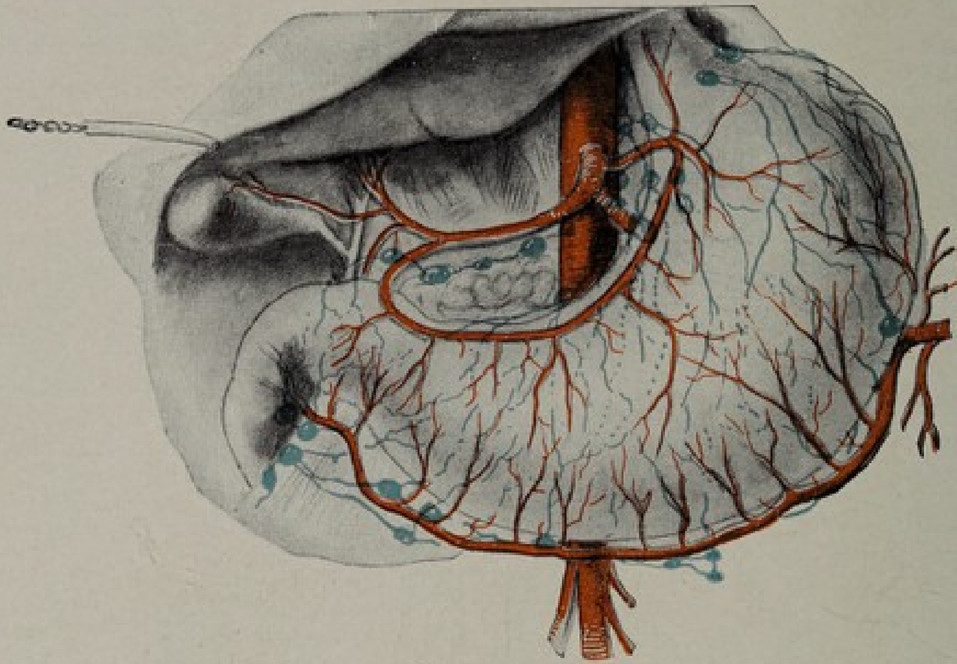


FIG. 445.

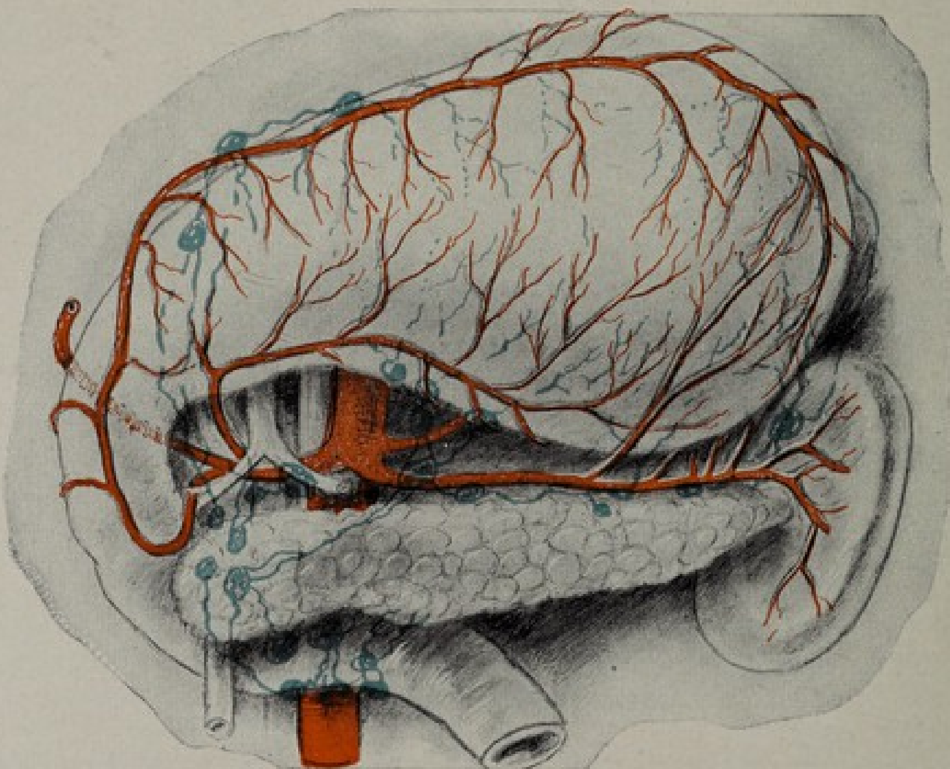


FIG. 446.

FIGS. 445 and 446.—Lymphatics of stomach. Fig. 445—Anterior. Fig. 446—Posterior. Modified from Balfour.

curvature. It is probably through these vessels and their accompanying veins that hæmatemesis occurs in certain splenic disorders.

Reeves has shown that although the cardiac end of the stomach has a rich arterial network which freely anastamose, the pyloric end is supplied by straight terminal vessels which do not anastomose. He presumes that embolism with resulting impaction may be a factor in the frequency of ulcer in the pyloric portion of the stomach. (Fig. 447.)

The more the stomach is distended the closer do the arteries of its greater and lesser curvatures lie to its walls. The fundus is supplied by the *vasa brevia,* small branches which leave the splenic artery in the gastrosplenic omentum.

The **veins** follow the course of the arteries. The right gastro-epiploic empties into the superior mesenteric and the left into the splenic; they then enter the portal vein. The pyloric and coronary vein empty into the portal vein direct. The latter receives branches from the œsophagus which become varicose in cirrhosis of the liver. At the pylorus the congerie of veins form an important landmark (Fig. 442).

Lymphatics.—The lymphatic nodes of the stomach are found principally around the regions of the pylorus—inferior gastric nodes, and the lesser curvature and cardiac extremity—superior gastric nodes. The inferior nodes drain the greater curvature toward the pylorus while the superior nodes drain the lesser curvature and cardiac end. The fundus is drained by radicles which empty into the nodes which accompany the splenic artery. While some nodes may be found along the greater curvature toward the pyloric end, Cunéo and Poirier state that it is rare to find nodes in the middle portion of the greater curvature and quite exceptional to meet with them in the region of the fundus. The relation of the lymphatics of the stomach are given in Figs. 444, 445 and 446.

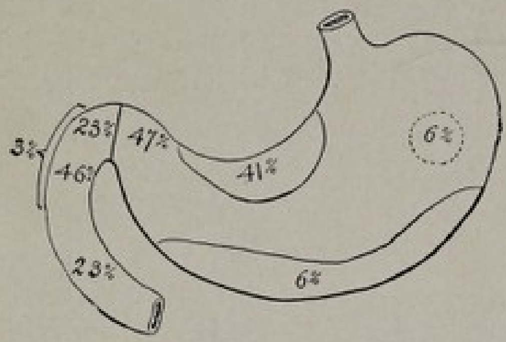


Fig. 447.—Frequency of ulcer. Stomach and duodenum. (Deaver.)

AFFECTIONS OF THE STOMACH

In disease the stomach may be contracted or dilated, and is often the seat of ulcer, polypoid growths, and carcinoma.

The stomach may be variously shaped in normal individuals. In some it may be of the steer-horn type, in others the pylorus may lie considerably higher than the pyloric antrum thus resembling a water-trap, while in the majority of individuals the size may vary considerably.

Contracted stomach occurs either as a normal or pathological condition; it has already been alluded to on page 455. The contraction of the middle, producing the hour-glass shape, results from cicatrices and adhesions due to gastric ulcer. In cases of œsophageal stricture or carcinoma the contraction may be marked. It then embraces mainly the right third of the organ and the affected portion resembles the adjoining duodenum. Abstention from food in the course of an illness may also cause contraction which one should be prepared to encounter in case of operation. A normal contracted condition of the right end of the stomach, often of a more or less hour-glass shape, is frequently encountered in autopsies when death has been caused by disease of other organs (Fig. 448).

Dilation results from functional diseases as well as obstructive affections, such as ulcer of carcinoma, involving the pylorus. It may occur as the result of an acute or chronic lesion. Distention causes the pylorus to pass from the midline 2.5 to 7.5 cm. (1 to 3 in.) to the right. The organ becomes more horizontal and descends so that its lower border sinks below the umbilicus—its extreme normal level. Sometimes the greater curvature alone is lowered, while in others the gastrohepatic omentum is stretched and the pylorus as well as the greater curvature descends. This is called *gastroptosis.* The amount of distention is recognized by percussion, as pointed out on page 457, or by administering bismuth and examining by the x-ray. Acute gastric dilatation has been accounted for by numerous theories among which are, the formation of duodenal kink, the stretching of the superior mesenteric vessels over the third portion of the duodenum and an autonomic imbalance between the vagus and splanchnic sympathetics.

Ulcer occurs most frequently along the lesser curvature and at the pylorus. The percentages given in Fig. 447 are taken from Deaver. The ulceration may open an artery, producing hemorrhage, or there may be adhesions to neighboring organs, resulting in the formation of abscess, or direct communication with the greater or lesser peritoneal cavity may be produced. Healing of ulcers near the pylorus may cause stenosis resulting in distention. Hemorrhage may occur from the vessels of the stomach walls or the vessels along the lesser curvature, the splenic or hepatic arteries or even the portal vein. One reason why the arteries along the curvatures are not more frequently affected is because they often lie a short distance away from and not in immediate contact with the stomach walls. Adhesions to surrounding organs are least liable to form when the perforation is on the anterior wall. If the perforation occur into the free cavity a general peritonitis quickly ensues. A perforation on the posterior wall involves the lesser cavity of the peritoneum, and the infection must travel first through the foramen of

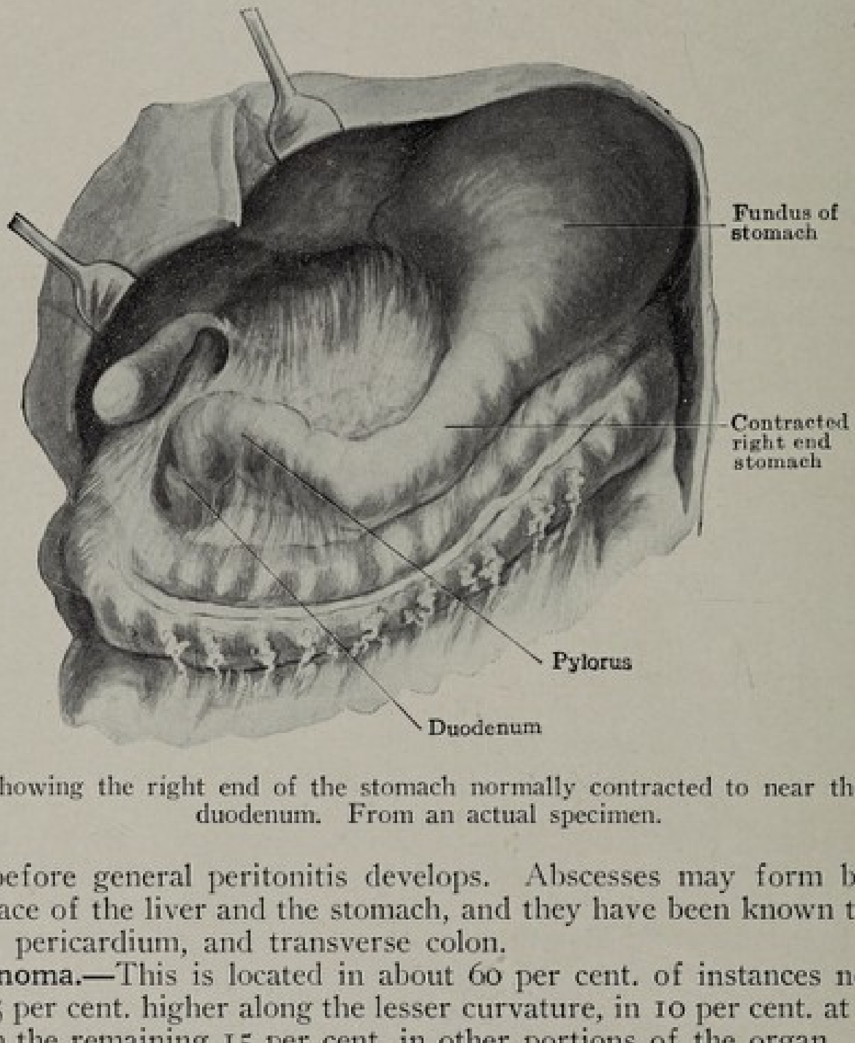


FIG. 448.—Showing the right end of the stomach normally contracted to near the size of the duodenum. From an actual specimen.

Winslow before general peritonitis develops. Abscesses may form between the under surface of the liver and the stomach, and they have been known to penetrate the pleura, pericardium, and transverse colon.

Carcinoma.—This is located in about 60 per cent. of instances near the pylorus, in 15 per cent. higher along the lesser curvature, in 10 per cent. at the cardiac end, and in the remaining 15 per cent. in other portions of the organ. Cunéo has shown that extension occurs in the lymphatic nodes along the lesser curvature, in those of the greater curvature along the right third of the stomach adjacent to the pylorus, and in the nodes around the pylorus and head of the pancreas. (Figs. 444, 445, 446.) It has been noticed that there is no tendency to extension to the region of the duodenum. It will thus be seen that a line (Hartmann-Mikulicz) drawn from the junction of the right and middle thirds of the greater curvature to the cardiac extremity would have nearly all the nodes to the right. It is this portion which is removed in pylorectomy and partial gastrectomy; owing to the extension of the disease up the lymphatics of the œsophagus, enlarged nodes may sometimes be present in the left supraclavicular fossa or even in the left axilla.

The tumor is often felt in or near the median line, a variable distance above the umbilicus; it may drag the pylorus lower down than normal. If the stomach is distended the tumor may be carried 5 to 7.5 cm. to the right of the median line. If, as is not uncommon, the disease infiltrates the walls of the stomach, the tumor can be felt passing to the left side, disappearing under the costal margin.

Adhesions and ulceration are common. They are so marked that peritonitis from acute perforation is moderately rare. The ulceration may open into adjacent organs, as the colon. The colon may be adherent to the stomach and the large omentum contracted into a roll. The adhesions and pressure from the growth may interfere with the biliary ducts, so that jaundice ensues. Interference with the portal vein and vena cava may result in ascites. Thrombosis of the veins sometimes occurs. In this disease, as in gastric ulcer, adhesions to the lesion are least liable to form, when the growth involves chiefly the anterior wall, and here perforation is most likely.

Syphilis of the stomach may closely simulate carcinoma. It is more apt to occur in younger individuals and a positive complement fixation test is usually obtained, although the latter may be present with a true carcinoma.

OPERATIONS ON THE STOMACH

The following are some of the operations which are performed on the stomach: *gastrotomy*, or the opening of the stomach to remove foreign bodies or to explore its interior; *gastrostomy*, or the making of a gastric fistula to introduce food, *pyloroplasty*, or the widening of a constricted pylorus; *pylorectomy*, for the removal of cancerous or strictured pylorus; *gastrectomy*, or the removal of a part or the whole of the stomach; and *gastro-enterostomy*, or the establishing of a fistula between the stomach and the small intestine.

Incisions.—The incision for gastrostomy is 4 cm. long, over the outer third of the left rectus muscle, beginning 2 cm. below the edge of the ribs. The fibers of the rectus are parted by blunt dissection from above downward, as this is less apt to tear the lateral branches of the superior epigastric artery than if made in the opposite direction. The incisions for pyloroplasty and partial or complete gastrectomy are made in or near the median line and reach from the tip of the ensiform cartilage to the umbilicus. That for pyloroplasty is placed usually to the right of the median line, all others to the left. In incising to the right of the median line the incision should not be carried down to the umbilicus or the round ligament will be divided. The incisions are placed to one side of the median line in order to open the sheath of the rectus and pass through or to retract the muscular fibers, thus allowing of a more secure closure of the wound and diminishing the liability to hernia. In incising the posterior layer of the sheath of the rectus and peritoneum one should avoid wounding the edge of the liver, which crosses the median line midway between the xiphosternal articulation and umbilicus, being higher or lower according to its size. The stomach is recognized as lying immediately below and in contact with the under surface of the left lobe of the liver. If in doubt, follow the under surface of the liver to the transverse fissure, thence over the lesser or gastrohepatic omentum to the lesser curvature of the stomach. The omentum may present in the wound instead of the stomach. It is to be pushed downward and the stomach sought for under the liver. The transverse colon should not be mistaken for the stomach. It lies under the omentum and can be identified by its longitudinal bands. In operating on the pylorus it may be found lying in the median line or 5 cm. or even 7.5 cm. to the right. It is marked by the congerie of veins (Fig. 442). The normal pylorus will readily admit the index finger. The incision skin advised by Finney for pyloroplasty is 15 to 20 cm. long through the right rectus muscle.

Partial gastrectomy is the operation usually done for carcinoma. Pylorectomy is too incomplete and total gastrectomy is too often impossible. In performing a partial gastrectomy, an incision just to the right or left of, or in, the median line is made from the ensiform process to the umbilicus. The gastrohepatic omentum is then doubly ligated from the pyloric end toward the cardiac end, well beyond the limits of the tumor. The ligatures are to be placed close to the liver and sufficiently far away from the lesser curvature to allow of the removal of the lymphatic nodes lying along it. The gastric (coronary) artery is ligated below the cardiac opening, where it reaches the lesser curvature (See Fig. 444, page 457). The pyloric branch of the hepatic is ligated as it reaches the stomach. The gastroduodenal artery is ligated behind the pylorus and the left and right gastro-epiploic on the greater curvature are then ligated doubly: the gastrocolic omentum being divided between the double ligatures. Care must be taken not to ligate the middle colic artery in the transverse mesocolon or gangrene of the colon will result. The duodenum is then doubly clamped and divided, and also the stomach, in what has been called the Hartmann-Mikulicz line (Fig. 444), which will remove most of the lesser curvature and at least a third of the greater curvature. The duodenum is then carefuly closed and the stump peritonealized. The continuity of the gastrointestinal tract is restored by one of the many procedures now used, all of which are based on either the Billroth I or Billroth II principle. The closure of the stomach and the addition of a posterior gastro-enterostomy is known as the Billroth II operation. The Polya operation also belongs to this type. In fact any procedure which utilizes the jejunum of the anastomosis to the stomach is based on the Billroth II principle.

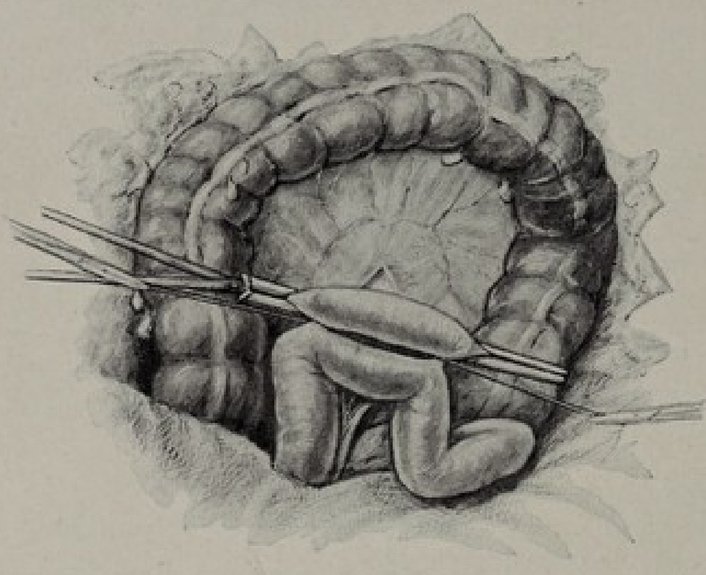


Fig. 449.—Gastro-jejunostomy. Relation of opening and anastomosis to the colon and transverse mesocolon.

In the Billroth I operation, or in its modifications the stomach and duodenum are anastomosed.

In the Polya procedure a very wide anastomosis either by the anterior or posterior method is performed, the jejunum being anastomosed to the entire open end of the stomach.

The Finney pyloroplasty is a valuable contribution to gastric surgery and in selected cases is a substitute for gastro-enterostomy. It consists of anastomosing the duodenum and stomach. If it is difficult to lay the duodenum along side of the stomach without tension the lateral reflection of the peritoneum from the second portion of the duodenum should be incised so as to mobilize it.

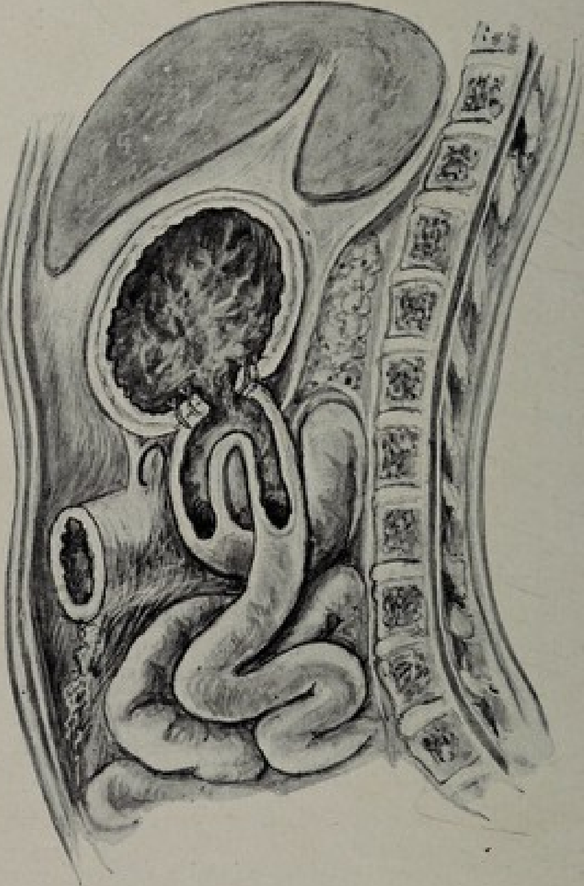


Fig. 450.—Gastro-jejunostomy. Correct position of loop and anatomical relations.

The Rammstedt operation is utilized in congenital pyloric obstruction. The hypertrophic musculature is divided through in a longitudinal direction. The incision is carried down to but not into the submucosa, which shows as a glistening membrane and points up through the opening.

In performing a *gastro-enterostomy* (Figs. 449 and 450) the upper portion of the jejunum is brought up and anastomosed with the anterior or posterior wall of the stomach. If the omentum is not seen at once on opening the peritoneum it will, perhaps, be found lying rolled up along the lower border of the stomach. It is to be brought out of the wound and turned upward. On its lower surface is seen the colon running transversely from right to left. Follow the transverse mesocolon down to the spine and the commencement of the jejunum will immediately be felt and can be seen coming through the mesocolon, with the ligament of Treitz running from its upper border to the parietal peritoneum. After this is located the next

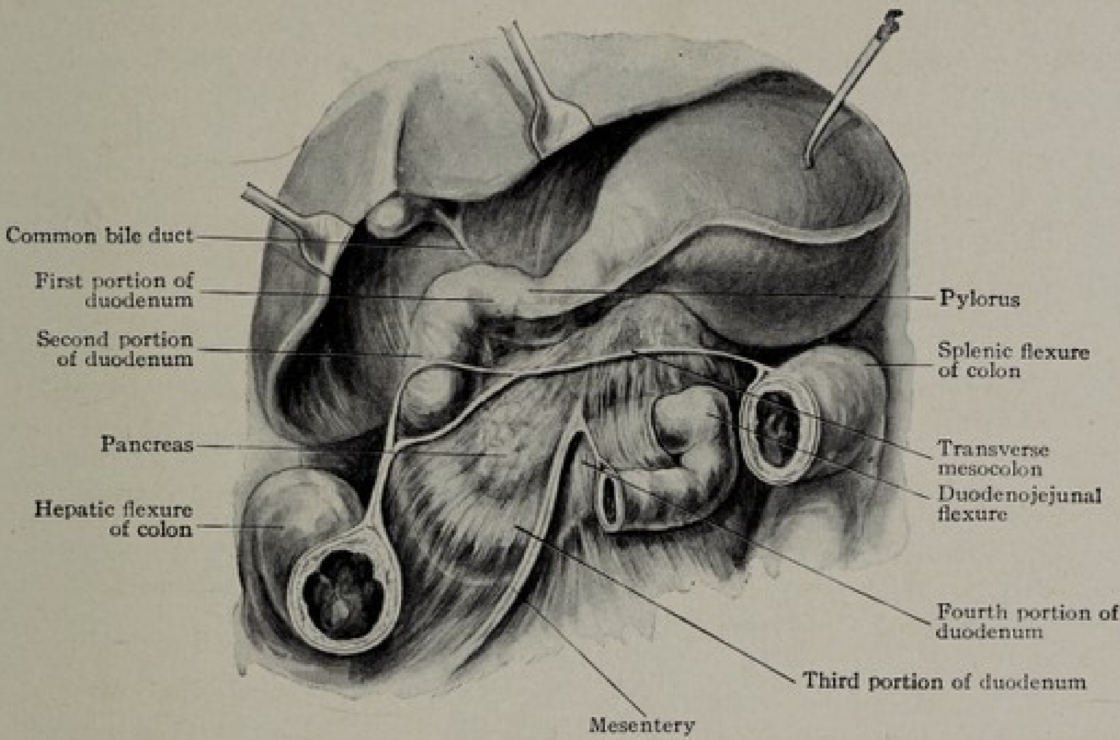


FIG. 451.—The duodenum, showing its course and relation to the surrounding organs.

step is to expose the posterior wall of the stomach by making an opening in the avascular area of the transverse mesocolon. This space is located under the arch formed by the middle colic artery and its left branch. It is important to prevent injury to this vessel, destruction of which would cause gangrene of a portion of the transverse colon. The highest possible loop of the jejunum is anastomosed to the pyloric end of the stomach so that when reposition occurs the distal end of the gut will have been anastomosed to the greater curvature and the proximal end toward the lesser curvature. Anterior gastro-enterostomy is rarely practised now but consists in bringing a long jejunal loop in front of the transverse colon and anastomosing it to the anterior gastric wall.

THE SMALL INTESTINE

The small intestine begins at the pylorus and ends at the ileocæcal valve. It has an average length of 6.75 metres (22 ft. 6 in.) in the male, independent of the age, weight, and height of the individual and in the female nearly 15 cm. (6 inches) longer (Treves). Jonnesco gives its length as 7.5 metres (24 ft. 7 in.) and Sappey as 8 metres (26 ft. 3 in.). The duodenum is about 25 to 30 cm. (10 to 12 in.) long, and two-fifths of the remainder, or about 8½ ft., is jejunum, and three-fifths, or about 12½ ft., is ileum.

THE DUODENUM

The duodenum is the thickest, widest, and most fixed portion of the small intestine. It has no mesentery and is attached at least in the larger part of its length to the posterior abdominal wall. Its diameter is from 3.75 cm. to 5 cm. and its muscular and mucous coats are thicker than those of the jejunum or ileum. It also possesses in its upper half the *glands of Brunner* (*glandulæ duodenales*) in the submucous coat. It is thus seen that in its structure it resembles more the stomach than the intestine and, like the stomach, is especially prone to ulcer, being even more prone to it than the latter. While carcinoma frequently originates at the pylorus and extends to and involves other parts of the stomach, it does not tend to involve the duodenum except in the juxtapyloric growths or in those instances in which the carcinoma involves the ampulla of Vater. This is probably due to the lymph stream from the pylorus running toward the stomach and away from the duodenum. The duodenum is also of interest in consequence of its intimate relation to the biliary passages as well as to the pancreas and its ducts. Inflammation of the gall-bladder frequently gives rise to adhesions between the duodenum and gall-bladder. The second portion of the duodenum is sometimes opened in order to extract a biliary calculus impacted in the ampulla of Vater at the mouth of the common bile-duct. The upper portion of the duodenum in Finney's operation for

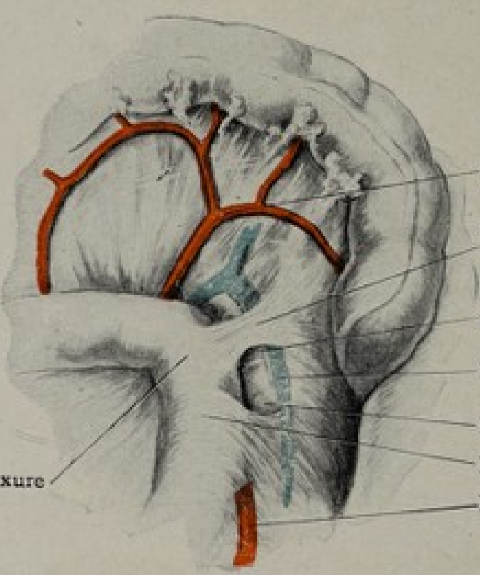


Fig. 452.—The duodenojejunal flexure and duodenal fossa; the jejunum drawn to the right.

pyloroplasty is opened down from the strictured pylorus and sutured to a corresponding opening in the stomach, thus making a large communication between the duodenum and the stomach and eliminating the stricture. To expose the retroduodenal portion of the common bile duct it is necessary to divide the lateral reflection of the peritoneum covering the second portion of the duodenum. The duct is then exposed, frequently being covered by a small amount of pancreatic tissue.

In shape the duodenum resembles a horseshoe enclosing the head of the pancreas. It begins on the right side of the body of the first lumbar vertebra and ends on the left side of the body of the second lumbar vertebra. At its commencement it is suspended from the liver by the duodenohepatic ligament, which is the free edge of the gastrohepatic omentum in which run the hepatic artery, portal vein, and common bile-duct.

The duodenum is composed of four portions. The *first portion* (superior) begins at the pylorus and ends at the neck of the gall-bladder. It is about 5 cm. long, and runs backward along the body of the first lumbar vetrebra. The *second portion* (descending) is about 10 cm. long, and runs down the right side of the bodies of the lumbar vertebræ to the lower border of the third. The *third portion* (variously called ascending, transverse, or inferior) runs diagonally upward across the body of the third lumbar vertebra to its left side and then the *fourth portion* ascends to the left side of the second, where it takes a sharp turn and is continued as the jejunum beyond the ligament of Treitz (Figs. 451 and 452).

Relations.—First portion: Above and in front are the quadrate lobe of the liver and the gall-bladder; below is the pancreas; and behind, from left to right, lie the gastroduodenal artery, the portal vein, the common bile duct, and the vena cava.

Second portion: In front is the liver, the neck of the gall-bladder, and the transverse colon. Behind are the renal vessels, ureter, right kidney, and psoas muscle. To its medial side lie the pancreas and vena cava. The common bile-duct runs on the medial side between the duodenum and the pancreas; at the middle of this portion of the duodenum the bile-duct joins with the pancreatic duct to empty into the duodenum through the ampulla of Vater, about 10 cm. from the pylorus.

Third portion: In front are the superior mesenteric artery and root of the mesentery; behind lie the vena cava, aorta, and left psoas muscle. Sudden pull of the root of the mesentery and the superior mesenteric vessels across the third portion of the duodenum is given as a cause of post-operative gastric dilatation and a partial obstruction is known as arterio-mesenteric ileus. This condition has been carefully described by Codman. In order to be sure of this etiology the first, second and proximal part of the third portion of the duodenum must be dilated. Above, it lies in contact with the pancreas. The termination of the duodenum is usually on the left of the aorta, but Dwight in fifty-four cases found it twenty-six times on the right of the aorta until just before its terminal flexure. It was wholly on the right side six times, in front of the aorta eleven times, and had crossed the aorta eleven times.

The entire duodenum may be dilated as occurs in chronic duodenal obstruction from kinking at the ligament of Treitz which marks the duodenal-jejunal flexure. Duodeno-jejunostomy has been practised for this condition.

Peritoneal Covering.—First part: The pyloric half is almost completely covered by peritoneum, but the distal half only on its anterior surface. Second part: No peritoneum on its inner and posterior surfaces, and only on its outer and anterior where not covered by the transverse colon. Third and fourth parts: The anterior and left sides are covered by peritoneum except where crossed by the root of the mesentery and superior mesenteric vessels.

JEJUNUM AND ILEUM

The jejunum is about 8½ ft. long and the ileum about 12½ ft. They are bound to the spinal column by the mesentery, which extends from the left side of the body of the second lumbar vertebra to the right sacro-iliac joint.

Duodenojejunal Flexure and Fossæ.—The point of ending of the duodenum and beginning of the jejunum is marked by a sharp bend called the *duodenojejunal flexure*. The beginning of the jejunum passes downward, forward, and usually toward the left. If the transverse colon is thrown upward and the jejunum is pulled sharply to the right, a folded edge of peritoneum containing some muscular fibres is seen passing from the flexure to the parietal peritoneum. This is called the *suspensory ligament* or *muscle of Treitz*. The fossa which is behind it is the *superior duodenojejunal fossa of Treitz* while that below is the *inferior duodenal fossa*. Below the fossa runs the inferior mesenteric artery and near the left edge of the ligament runs the inferior mesenteric vein. If the fossa is abnormally large, the intestines may enter it and produce a retroperitoneal hernia. In dividing the ligament of Treitz, there is danger of dividing the inferior mesenteric vein (Fig. 452). Jejunostomy is performed for temporary relief in intestinal obstruction of the mechanical or paralytic type or in cases where intensive feeding is to be given and the oral or gastric route cannot be used. The exposure of Ravdin through an incision in the projected anterior axillary line just in front of the eleventh rib suffices to immediately locate the high jejunum without a large left rectus exploratory incision.

The small intestine decreases in size and thickness from its upper to its lower end. The diameter of the jejunum is about 4 cm. while that of the ileum is about 3 cm.

The walls of the jejunum are thicker, redder, and more vascular than those of the ileum and the valvulæ conniventes are better developed. The ileum is thinner, narrower, paler and particularly when diseased, the large Peyer's patches can be seen.

The **intestinal coils,** while not constant in position, are most apt to be as follows: The commencement of the jejunum is in the upper left portion of the abdomen. The ileum is more in the right lower quadrant of the abdomen. According to Treves, the intestine from six to eleven feet from its commencement has the longest mesentery and is apt to be found in the pelvis. The lower end of the ileum is also usually found in the pelvis, and rises over its brim to join the cæcum.

There is no certainty, however, of finding a definite piece of the small intestine under any special point on the surface, because the varying distention and movements of the gut cause frequent changes of position.

Meckel's Diverticulum.—In the embryo of the vitello-intestinal duct passes from the umbilicus to the lower end of the small intestine. Normally this disappears, but sometimes a portion of it remains and there is found, one to three feet proximal to the ileocæcal valve, a finger-like projection from the side of the ileum, 5 to 7.5 cm. long. This is called *Meckel's diverticulum,* and may become the site of disease. It is present in about 2 per cent. of individuals. From its extremity a fibrous band may run to the umbilicus. This has been in rare instances the source of strangulation, causing intestinal obstruction (Fig. 453).

Fig. 453.—Meckel's diverticulum.

Diverticula of the Small Intestine.—Diverticula may occur in the duodenum, jejunum or ileum. In man duodenal diverticula have been found in from 3 to 11 per cent. of necropsies. Inflammation of a duodenal diverticulum may involve the papilla of Vater and cause jaundice by obstructing the outlet of the duct. Unless they give definite symptoms these lesions do not require treatment.

Peyer's patches (noduli lymphatici aggregati) are most numerous in the lower portion of the ileum. They become ulcerated in typhoid cases and are frequently the site of perforations. These patches are from 1 to 2.5 cm. wide and 2.5 to 7.5 cm. long. When affected in typhoid fever they can readily be seen through the intestinal walls. By holding the intestine up against the light both Peyer's patches and the valvulæ conniventes can readily be seen.

The perforations in typhoid fever occur usually within three feet of the ileocæcal valve, though occasionally they may occur, as we have seen, in the appendix, or higher up in the small intestine, or even in the large intestine.

OPERATIONS

The small intestines are frequently resected and anastomosed with themselves or other portions of the gastro-intestinal canal. Gastro-enterostomy has been alluded to previously.

On opening the abdomen, if it is desired to find the upper end of the small intestine, the omentum is lifted upward, drawing with it on its under surface the transverse colon. The hand is passed backward on the undersurface of the transverse mesocolon until the spine is reached; on its left side will be felt the duodeno-jejunal flexure. On drawing the jejunum to the right, the ligament of Treitz will be seen. A loop 40 cm. (16 in.) down may be taken and brought up in front of the omentum and used for an anterior gastro-enterostomy, or the intestine immediately below the flexure may be used for a posterior gastro-enterostomy. If one desires to find the lower end of the small intestine, then a search is made for the cæcum in the right iliac region. It is recognized by its longitudinal bands and is followed down to the ileocæcal junction. If the case is one of typhoid fever, a rapid examination is then made from the ileocæcal valve upward for the perforation. It is desirable at times to determine which is the proximal and which the distal end of an intestinal loop. The best way to do so is to follow the loop down to the mesenteric attachment, as advised by Monks; if the mesentery proceeds up and to the left you have the proximal end; if, however, it is passing down to the right you have the distal end.

The intestine receives its nourishment from the mesentery and will become gangrenous when detached over too long a distance, hence it is necessary to avoid injury or detachment of the mesentery or its vessels. When extensive detachment has occurred the non-viable portion of intestine should be resected.

THE MESENTERY

The mesentery usually extends from the left side of the body of the second lumbar vertebra to the right sacro-iliac joint although this line of attachment is subject to some variation. It is from 15 to 20 cm. long at its root and spreads out like a fan, to be attached to the small intestine. It is comparatively thick, especially toward its root, and contains the superior mesenteric artery and vein, nerves, and lymphatics. The mesenteric lymphatic nodes are numerous, from 130 to 150 (Quain) in number. They are frequently involved in carcinoma, sarcoma and tuberculosis, and may form masses which may be mistaken either for independent tumors or outgrowths from other organs. They are sometimes the site of simple inflammation which may go on to abscess formation. They become calcareous and and by the Röntgen rays may cast shadows which have been mistaken for calculi of the urinary tract.

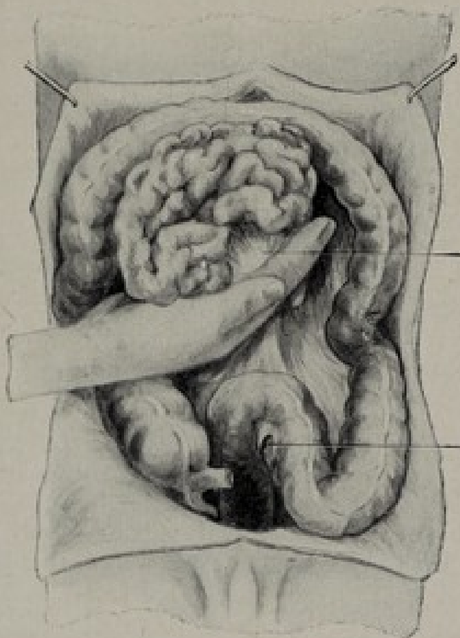


FIG. 454.—The mesentery is seen running downward toward the right sacro-iliac joint; the index finger is below it and the other three fingers above. The small intestines have been raised on the hand and turned upward thus exposing the pelvis and entire left lower half of the abdomen for examination.

The mesentery has its vessels sometimes ruptured by violence or blocked by emboli or thrombi. This is likely to cause gangrene of that portion of the intestine to which they are distributed. In abdominal operations the greatest care is to be taken not to injure these vessels, and in hemorrhage the least possible amount of ligation is to be done. Obstructions of a mesenteric branch may necessitate the resection of that part of the small intestine which it supplies.

It is particularly important to bear in mind the direction of the mesenteric attachment on account of its influence in directing the course of the blood in cases of hemorrhage. The small intestines are attached at the free end of the mesentery like the leaves of a book to its back. Bleeding originating from the right and upper quadrants of the abdomen will pass *over* the intestines and tend to gravitate toward the right iliac fossa. Bleeding originating from the left and lower quadrants tends to pass under the intestines toward the left iliac fossa. In searching the abdomen through a median incision for the source of a concealed hemorrhage, the intestines are first pushed down and to the left, and the right side of the abdominal wall lifted with retractors. This will expose to view the upper surface of the small intestines, the ascending and transverse colon, the right kidney, liver, stomach, and head of the pancreas. Should additional search be necessary the small intestines are raised and turned upward and to the right (Fig. 454), being brought out of the wound if necessary. This will expose the under side of the small intestines and mesentery, the sigmoid flexure, descending colon, left kidney, spleen, and tail of the pancreas, with the left end of the stomach and left lobe of the liver above.

The mesentery attains its greatest length, according to Treves, from a point 6 feet from the duodenal jejunal flexure, a point 11 feet from the same site, where it measures 25 cm. (10 in.). In hernia, length of the mesentery permits the small bowel easily to enter the hernial sac. Rarely openings are present in the mesentery which may allow the entrance and strangulation of a coil of the intestine.

THE LARGE INTESTINE

The large intestine comprises (1) the *cæcum* and *appendix*, (2) *ascending colon*, (3) *transverse colon*, (4) *descending colon*, (5) *sigmoid colon*, composed of the iliac colon and pelvic colon, and (6) the *rectum* and *anal canal*.

The length of the large intestine exclusive of the rectum and anal canal is 135 cm. (4 ft. 6 in.) in the female, and 140 cm. (4 ft. 8 in.) in the male. If the anterior abdominal wall is removed the cæcum and part of the ascending colon are visible, but in the upper part of the lumbar region the colon disappears, being overlaid by the small intestine. Having turned at the hepatic flexure, it again comes into view below the lower edge of the liver and passes superficially across the abdomen to disappear under the left costal margin to form the *splenic flexure*. It is not visible again until it reaches the region of the crest of the ilium, where it once more becomes superficial and follows Poupart's (inguinal) ligament down to near its lower end, where it turns backward and upward to form the sigmoid loop which descends along the sacrum. In operating it is necessary to be able to distinguish large from small intestine. In distention of the colon the flanks and the area just above the umbilicus becomes distended.

Size.—The large intestine at its commencement at the cæcum may have a diameter of 7.5 cm., but it decreases in size, and, especially if empty, the descending colon and sigmoid flexure may only be 2.5 cm. in diameter. A distended part of the small intestine will be larger than a contracted part of the colon. Inasmuch as operations are frequently done for obstructive conditions which greatly enlarge the involved parts, it is unreliable to depend on size as distinguishing the large intestine. There are three *longitudinal bands* (*tæniæ coli*) on the colon, from 6 to 12 mm. (¼ to ½ in.) wide, according to the amount of distention. One is anterior, another postero-lateral, and the third postero-medial. On the transverse colon they have the same relative position when the great omentum and colon are raised and turned upward. They all begin at the appendix and traverse the large intestine until the rectum is reached, where they blend together, forming a longitudinal layer which is weak at the sides and strong anteriorly and posteriorly.

Sacculation of the colon is produced by the longitudinal bands being one-sixth shorter than the rest of the tube. While sacculation tends to become less marked on distention, it is still a valuable means of identification. Dividing the longitudinal bands will cause the sacculation to disappear and the gut to lengthen. Diverticulitis of the large bowel is not a surgical curiosity. Sir Humphrey Rolleston first described it in 1905. In the large bowel it most frequently occurs in the sigmoid colon. When diverticula become inflamed obstruction may result and at operation the lesion may be mistaken for carcinoma. The inflammation may occur in one diverticulum or in a series of diverticula.

Appendices epiploicæ or the small tags of peritoneum containing fat, are found along the large intestine as far as the rectum. They are most numerous along the medial longitudinal band and the transverse colon, and are usually entirely absent in the cæcum and proximal ascending colon.

CÆCUM AND APPENDIX

The cæcum is the blind pouch of the large intestine which extends beyond the opening of the ileum. It is about 7.5 cm. broad and 6.25 cm. long. Its three longitudinal bands converge to the appendix and are continued over it. It lies in the right iliac fossa on the iliacus and psoas muscles, more on the latter, and reaches to its medial edge. It is in contact with the abdominal wall above the lateral half of Poupart's (inguinal) ligament. In fetal life the cæcum is cone-shaped and passes gradually and regularly into the appendix. It increases in size more rapidly on its lateral side, so that the appendix, which was before opposite the long axis of the gut, becomes placed to the medial side just below the ileocæcal valve.

Four varieties of cæcum are given by Treves: (1) the conical or fetal type, (2) a globular or quadrilateral type, in which the development of both sides is even, (3) the adult type, in which the lateral side is much larger than the medial, (4) an irregular type, in which there is an excess of development of the lateral side and an atrophy of the medial side resulting in placing the root of the appendix close to the lower and posterior portion of the ileocæcal junction.

Cunningham describes three varieties: (1) a fetal conical type, (2) an infantile type, in which the lateral side is somewhat larger than the medial and (3) an adult type, 93 or 94 per cent., in which the lateral side is much the larger, and the root of the appendix is on the medial wall just below the ileocæcal valve (in the adult about 2 cm.—¾ in.).

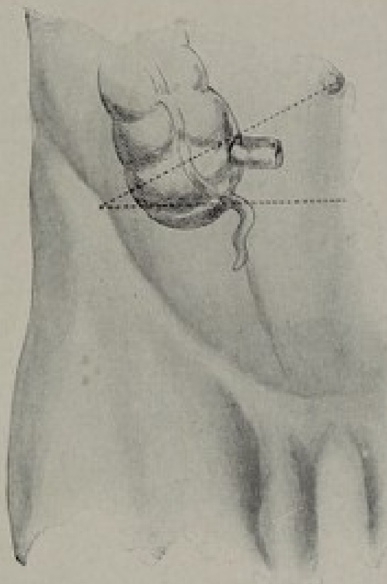


FIG. 455.—The relations of the appendix. The ileocæcal junction is seen to be about one inch below the middle of a line joining the anterior superior spine and umbilicus or where this line crosses the linea semilunaris. The base of the appendix is under the point of crossing of the linea semilunaris and the middle of a horizontal line running from the anterior superior spine to the mid-line of the body; it is one inch below the ileocæcal junction.

The **ileocæcal valve** marks the junction of the ileum and the large intestine. On the surface of the body it corresponds to a point 2.5 cm. below the middle of a line joining the anterior superior spine and the umbilicus and the same distance above the middle of a transverse line drawn from the anterior superior spine to the median line. This point is about on the linea semilunaris and directly above the point where the external iliac artery passes under Poupart's (inguinal) ligament. In about 50 per cent. of instances the ileocæcal valve permits barium introduced by enema to pass into the ileum.

Vermiform Appendix (processus vermiformis).—The appendix varies much, both in length and diameter. In health its average length may be given as from 8.75 cm. to 10 cm. and its diameter as 6 mm. (¼ in.). It is pale in color and soft in consistence, with its blood-vessels barely visible. In disease it becomes firm and red and the injected vessels are distinctly seen. It becomes much increased in diameter, frequently equaling in size a finger or thumb, and lengthens to 15 cm. or even more. It possesses a serous peritoneal coat, a longitudinal muscular, a circular muscular, a submucous and a mucous coat. The lumen of the appendix has been found to be partially occluded in at least one-fourth of all adults. This occlusion occurring toward its distal extremity is not regarded as pathological, but constrictions occurring elsewhere in the length of the tube are probably the result of previous disease.

The opening of the appendix in the cæcum is about 2.5 cm. below and a little behind the ileocæcal opening. The fold of mucous membrane guarding it has been named the *valve of Gerlach* but it is not generally regarded as a distinct valve.

The root of the appendix is only about 2 cm. below the lower edge of the ileum and is often even closer on account of the lower surface of the ileum being in contact with the cæcum at that point. It corresponds to a point on the surface of the body where the right semilunar line crosses a line joining the two anterior superior spines (Fig. 455).

The **meso-appendix (mesenteriolum)** comes off the lower surface of the mesentery. It is shorter than the appendix, hence the twisting and curling of the latter. It usually, but not always, extends to the tip and contains toward its left or free border the appendicular artery.

The **ileocolic artery**, from the superior mesenteric, as it approaches the ileocæcal junction divides into five branches: (1) the *colic*, distributed to the colon; (2) the *ileal*, to the upper surface of the ileum; (3) the *anterior ileocæcal branch*, to the front of the cæcum, passing through the ileocolic fold; (4) the *posterior ileocæcal artery*, to the posterior part of the cæcum; (5) the *appendicular artery*. The appendicular artery descends behind the ileum to enter the meso-appendix and, after sending one recurrent branch to the root of the appendix and another to the ileocæcal fold, passes along the left or free edge of the meso-appendix, and, if this is short, it may be continued on the surface of the appendix to its extremity (Fig. 455).

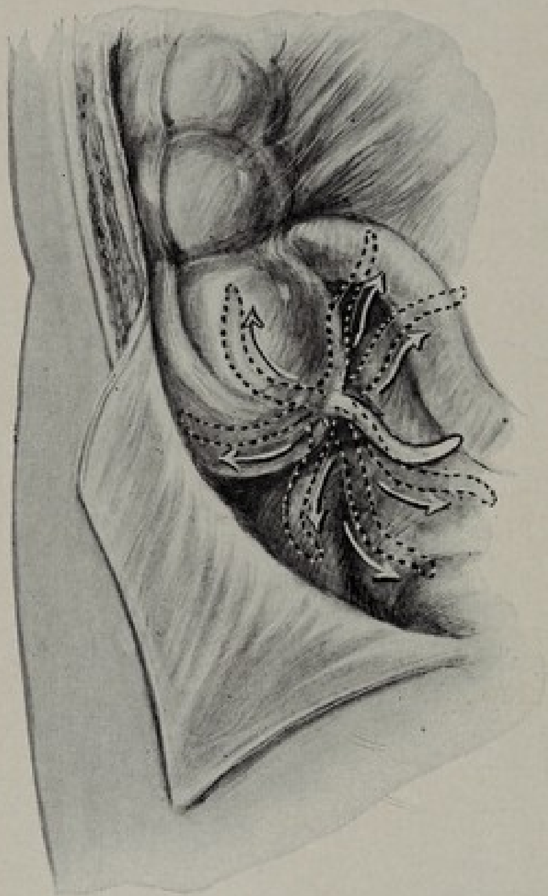


Fig. 456.—Normal position of appendix and variations which are dependent upon developmental conditions.

In removing the appendix this artery requires ligation and if the ligature is not placed close to the root the recurrent branches will not be included and may cause considerable bleeding.

The veins of the appendix and the cæcum end in the **ileocolic vein**, which joins the superior mesenteric veins and helps to form the portal vein. Hence infection is carried by the blood stream from the appendix and cæcum directly to the liver.

Position of the Appendix.—The position and direction of the appendix have been variously described and much discussed. This has risen from the fact that it is so curled, curved, and twisted on itself that it is impossible to say that it points in any definite direction, and that, being so mobile, it may be found in almost any position, swinging around with its point of attachment to the cæcum as the axis. We agree with Cunningham when he says that it runs generally in one of three directions: (1) over the brim into (or towards) the pelvis; (2) upward behind the cæcum; (3) upward and medialward toward the spleen. As he says, each of these has been considered the normal position by one or more observers. It is evident that, as the appendix comes off close to the ileum, this is its most fixed and constant point. In certain cases the cæcum retains its high fetal position and then the appendix will be higher than usual. If the appendix is long and straight, its tip may reach to or beyond the median line; it may lie in contact with the rectum, ovary, tube, or bladder; it may lie low down close to Poupart's (inguinal) ligament or curved upward behind the colon, reaching in front of the kidney and nearly or quite to the liver. When retrocæcal it lies on the quadratus lumborum; when lower it may lie on the iliacus or psoas muscle. If it goes over the brim of the pelvis it lies on the external iliac artery. The external iliac vein is below and to the medial side and is largely protected from injury in operating by the stronger and tougher artery.

Cæcal Folds and Fossæ.—There are three folds and three fossæ formed by the peritoneum in the neighborhood of the cæcum.

1. The *superior ileocæcal* (*ileocolic*) fold runs from the upper surface of the mesentery just above the ileum to the upper anterior surface of the cæcum. In it runs the *ileocæcal* (*anterior*) *artery*. Beneath it, with its opening toward the left, is the *superior ileocæcal fossa* (Fig. 457).

2. The *inferior ileocæcal fold* passes from the termination of the ileum to the front of the meso-appendix; it contains a small recurrent branch of the appendicular

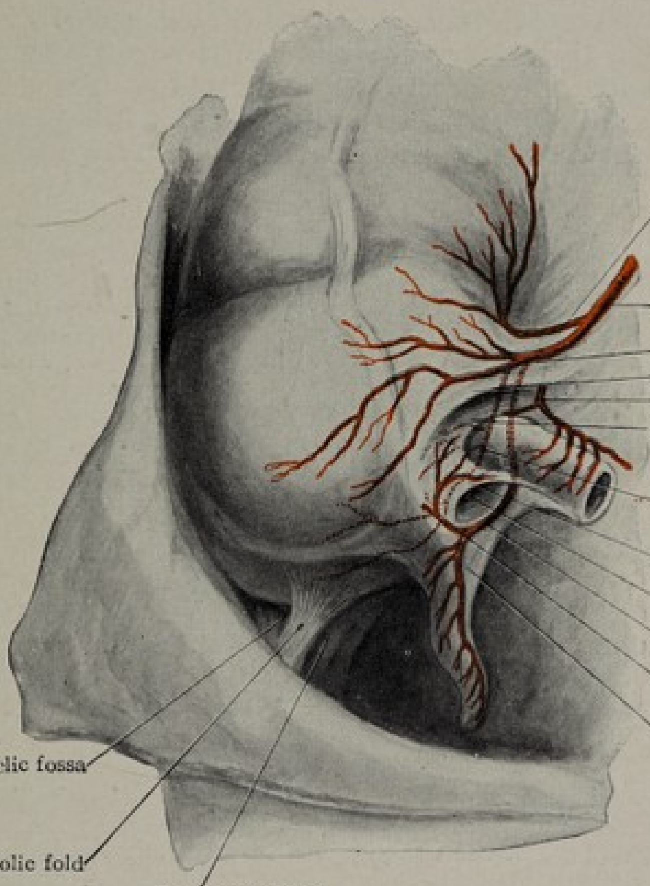


Fig. 457.—The appendix and ileocæcal region, showing the folds, fossæ, and arteries.

artery. Beneath it and between it and the meso-appendix is the *inferior ileocæcal fossa*, which may sometimes contain the appendix.

3. The *retrocolic fold* is not constant and may be multiple. It passes from the lower and outer surface of the cæcum to the peritoneum beneath. It binds down the end of the cæcum and not infrequently must be divided before the cæcum and appendix can be raised; the fossæ on each side of it are called the *retrocolic fossæ*.

Lymphatics of the Cæcum and Appendix.—The lymphatics of the cæcum and appendix drain into a group located in the mesentery of the ileocæcal angle, accompanying the ileocolic artery. According to Poirier and Cunéo there are three sets: an anterior cæcal, a posterior cæcal, and an appendicular.

The *anterior cæcal lymphatics* drain the anterior surface of the cæcum and, after traversing one or two small nodes, pass in the ileocæcal fold up to the main ileocæcal group.

The *posterior cæcal lymphatics* drain the posterior portion of the cæcum and, after traversing three to six small nodes, empty likewise into the ileocæcal group.

The *appendicular lymphatics* form four or five trunks which accompany the artery between the layers of the meso-appendix. They then pass across the posterior surface of the ileum to empty into the ileocæcal group.

Poirier and Cunéo state that the lymph-trunks from the appendix pass through one to three nodes placed in the retro-ileal portion of the meso-appendix, but Kelly and Hurdon state that in the majority of instances these trunks empty into one or two nodes some distance above the ileum in the ileocæcal angle, forming a part of the ileocæcal chain. These latter authors state that there are three sets of lymph-capillaries in the appendix: a superficial or subperitoneal set, another between the submucous and muscular layers, and a deep set in the mucosa around the glands of Lieberkuhn.

The three great lymph-streams, anterior cæcal, posterior cæcal, and appendicular, are quite distinct from each other and from the surrounding lymphatics of the pelvis and colon; when these latter are involved it is not by a lateral extension from these three streams but by direct infection from the regions which they themselves drain. From the ileocæcal nodes the lymphatics follow the arteries to the nodes at the root of the mesentery and empty into the receptaculum chyli. They

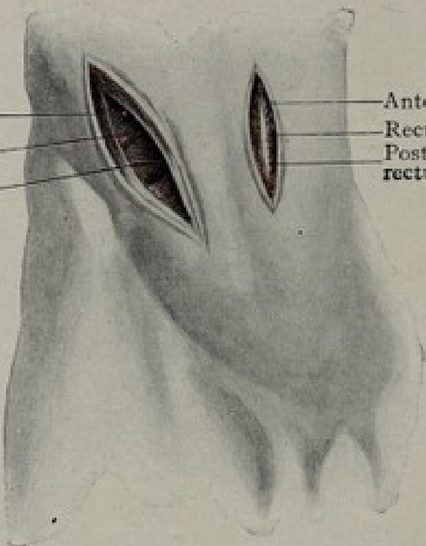


FIG. 458.—Incisions used for operations on the appendix. The longitudinal operation passes through and separates the fibres of the rectus muscle. The oblique operation (that of McBurney) separates the external oblique, internal oblique, and transversalis muscles in the direction of their fibres.

do not follow the veins to the liver, hence infection of the liver is not caused through the lymph-channels in appendicitis.

Appendicitis.—*Diagnosis.*—The most fixed part of the appendix is its root. This corresponds to a point on the linea semilunaris opposite to the anterior superior spine of the ilium. The painful tip of the appendix may be anywhere in a circle 10 cm. in radius around this point. It may be lying posterior and simulate ureteral calculus or other kidney trouble; it may be up toward the liver or gall-bladder; it may be toward the left, even beyond the midline; it may be in Douglas's cul-de-sac and be confounded with disease of the uterus, tubes, and bladder. It overlies the ureter and may be mistaken for calculus therein. An enlarged gall-bladder can have its painful apex at McBurney's point. Typhoid ulcers occur close to and, as we have observed, may involve the appendix. All these relations must be remembered. McBurney placed the most tender point 4 to 5 cm. from the anterior superior spine in a direction toward the umbilicus. We would place it near the root of the appendix at least 2.5 cm. (1 in.) lower down and a little farther in.

Operation.—An incision for appendicitis often used is a longitudinal one over the edge of the rectus muscle, either going directly through it or drawing it to one side (Fig. 458). In McBurney's operation the external oblique is split in the direction of its fibres and the internal oblique and transversalis are parted upward and medialward in the direction of their fibres, thus making a hole through which the appendix is removed. Davis preferred a transverse incision with its centre over the linea semilunaris opposite to or 2.5 cm. above the anterior superior spine. The sheath of the rectus is divided transversely and the muscle displaced toward the median line. The lateral portion of the incision runs slightly oblique to the fibres of the external oblique and almost exactly in the direction of the fibres of the internal oblique and transversalis (Fig. 459).

As soon as the peritoneum is opened the omentum may present itself. This is displaced to the left. Some coils of small intestine if present are to be pushed to the left also. The intestine then presenting will be the colon or cæcum, because it is fastened to the posterior wall and cannot be moved away. The longitudinal bands will also identify it. Another way is to pass the finger down the inside of the abdominal wall and the floor of the iliac fossa and bring up the cæcum. Always work from the outer toward the inner side, because (see Fig. 454) the ascending colon and cæcum almost always lie against the abdominal wall on the surface of the iliacus muscle above the outer half of Poupart's (inguinal) ligament.

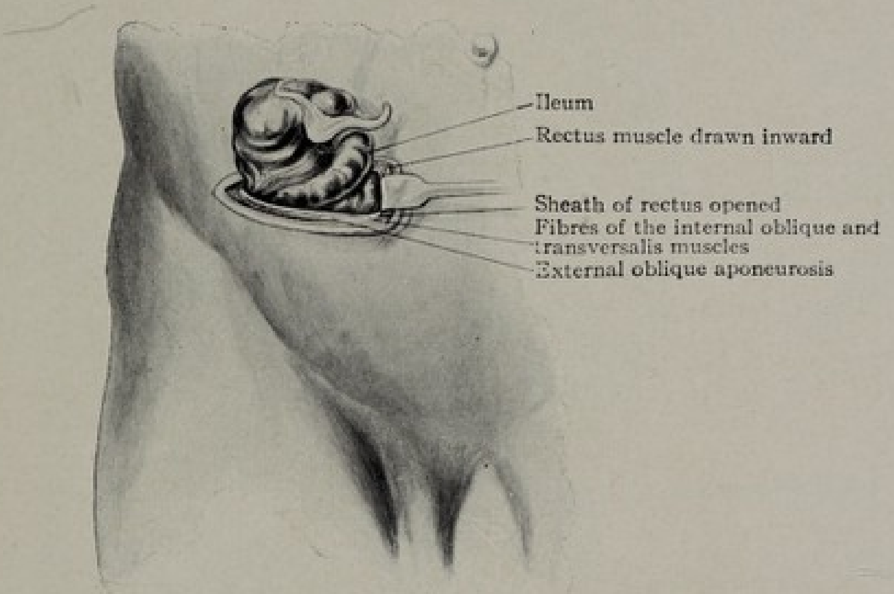


Fig. 459.—Davis' incision for appendicitis. The cæcum has been lifted out of the wound, bringing with it the appendix.

The cæcum is to be drawn up and turned toward the head. The longitudinal bands, all of which lead to the appendix, are to be followed down over the cæcum until the appendix is reached. If the bands are not visible, identify the ileocæcal junction and about 2 cm. or less below and behind it will be the root of the appendix; its tip may be anywhere. It can be removed from its root out to its tip. A ligature is to be placed around the meso-appendix because the appendicular artery, especially its recurrent branch, may bleed quite freely. The root of the appendix may sometimes be at, instead of below, the ileocæcal junction. The small intestine and cæcum almost always overlie the appendix.

The present author prefers the McBurney incision in all cases of acute appendicitis. The incision gives adequate and direct exposure and does not expose large areas of small bowel. If necessary the internal oblique and transversalis can be incised across their fibers and a lesion in the pelvis properly exposed and treated. In chronic appendicitis where exploration is required the right rectus or paramedian incision will give more satisfactory exposure.

THE COLON

The **ascending colon** lies in contact with the anterior abdominal wall from its lower end to above the iliac crest; here it dips down to lie on the kidneys and form the hepatic flexure above (Fig. 460). At this point some of the coils of the small intestine may lie in front of the hepatic flexure, between the beginning of the transverse colon above and the ending of the ascending colon below. The ascending colon lies on the quadratus lumborum muscle and kidney behind and has the psoas to its medial side. It has no mesentery or peritoneum on its posterior surface in 64 per cent. of the cases (Treves) and in tumors of the kidney it may be pushed forward and across their anterior surface. This is a point to be remembered in diagnosis.

The **transverse colon** passes diagonally up and to the left across the abdomen. It starts at the hepatic flexure on the under surface of the liver to the outer side of the gall-bladder. It runs parallel with the lower edge of the liver and stomach

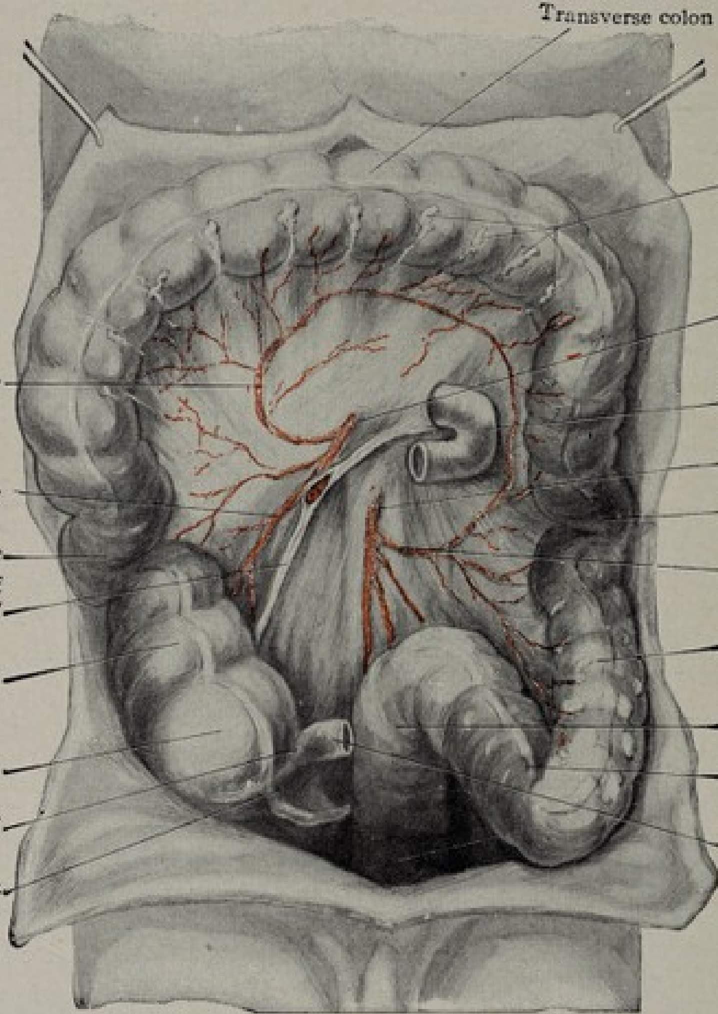


Fig. 460.

and its lower border may reach nearly or quite to the level of the umbilicus. The great omentum passes over the transverse colon, so that to see the latter it is necessary to raise the omentum and look on its under surface. The omentum as it passes from the colon to the stomach forms the gastrocolic omentum and the two organs may be either close together or some distance apart. The transverse colon instead of running upward and to the left may form a large curve downward, reaching almost to the pelvis. In cases of dilatation and descent (*ptosis*) of the stomach the transverse colon descends with it. The transverse mesocolon passes backward and one layer goes up and covers the pancreas while the other goes down to the mesentery. Its importance in gastro-enterostomy has been pointed out. Tumors and cysts of the pancreas may push forward above it, or below it, or it may cross directly over the surface of the growth.

The **descending colon** at its commencement at the splenic flexure is much higher and more deeply situated than is the hepatic flexure. It follows the stomach upward and backward and lies against the spleen. From here it descends and is entirely covered by small intestine, the sigmoid flexure coming to the front in the left iliac fossa. The descending colon is much smaller in size than the ascending colon, and like it in the majority (two-thirds) of cases has no mesentery. In doing a colostomy through the loin, the external border of the quadratus lumborum muscle is the guide to the descending colon. It lies 1.25 cm. behind the middle of the crest of the ilium.

Sigmoid Flexure.—The sigmoid colon is composed of two parts: one in the iliac fossa, called the iliac colon, and the other in the pelvis, called the pelvic colon, or *omega loop of Treves.*

The *iliac colon* is about 12.5 to 15 cm. long, and runs from the crest of the ilium to the inner edge of the iliopsoas muscle. It has no mesentery in 90 per cent. of the cases (Jonnesco), and usually comes into contact with the abdominal wall to the inner side of the anterior superior spine sometimes as far down as the middle of Poupart's inguinal ligament. In doing an inguinal colostomy this is the portion of the colon it is desired to find. It is then followed down until a part is reached which has sufficient mesentery to allow of its being drawn out of the wound.

The *pelvic colon* is about 40 to 42.5 cm. long and runs from the edge of the psoas muscle to the level of the third sacral vertebra. It makes a large horseshoe-shaped loop, from which it was named by Treves the *omega loop*, and has a mesentery from 3 to 8 cm. (1¼ to 3½ in.) long. The length of the loop as well as its mesentery and its position all vary considerably. Its terminal portion usually runs longitudinally down to end in the rectum, but its intervening portion may pass over the bladder to the right side, or high above the symphysis, or even extend well up in the abdominal cavity. On the under or left side of the loop between its branches is the *intersigmoid fossa* (see Fig. 454, page 467); sometimes it forms a constricted pouch in which a knuckle of intestine has been known to become strangulated.

THE LIVER

The liver is wedge-shaped and has three surfaces. These are superior, inferior, and posterior. The posterior forms the base of the wedge and its anterior edge is the apex. The liver is divided into five lobes by five primary fissures and has five ligaments (Fig. 461).

The **lobes of the liver** are: (1) left, (2) right, (3) quadrate, (4) Spigelian, (5) caudate. The *left lobe* is one-sixth the size of the right. It comprises that part to the left of the falciform ligament above and the umbilical and ductus venosus fissures below. The *right lobe* comprises that part to the right of the falciform ligament above and the fissures of the gall-bladder and vena cava below. The *quadrate lobe* is the anterior, small, square-shaped lobe between the fissure of the gall-bladder on the right and the umbilical fissure on the left. It extends from the anterior edge back to the portal fissure. The *Spigelian lobe* is best seen posteriorly, extending from the vena cava on the right to the fissure of the ductus venosus on the left. The *caudate lobe* or process is the name given to the liver tissue running from the lower end of the Spigelian lobe to the right lobe. It is frequently considered as a portion of the Spigelian lobe. It passes behind the portal fissure and between it and the vena cava. *Riedel's lobe* is the name given to an abnormal, tongue-like projection of liver tissue from its anterior edge, which may extend downward either over the gall-bladder or external to it. Mayo Robson has seen it extend to the cæcal region, and an inflamed gall-bladder being directly beneath caused pain to be experienced at McBurney's point. The condition is then likely to be mistaken for appendicitis.

The **fissures of the liver** are best understood by examining its under surface, where they can be seen arranged in the form of the letter H. They are as follows: (1) The *umbilical fissure*, running from the umbilical notch on the anterior edge to the left end of the portal (transverse) fissure; it contains the round ligament. (2) The *fissure of the ductus venosus*, running upward from the left end of the portal fissure between the left and Spigelian lobes; it contains the remains of the fetal ductus venosus. This fissure and the umbilical fissure form the great longitudinal fissure. (3) The *fissure of the gall-bladder*, separating the quadrate from the right lobe and ending at the right extremity of the portal fissure; in it lies the gall-bladder. (4) The *fissure of the vena cava*, between the Spigelian and right lobes, lodging the vena cava. (5) The *portal fissure*,—this forms the transverse bar of the H.

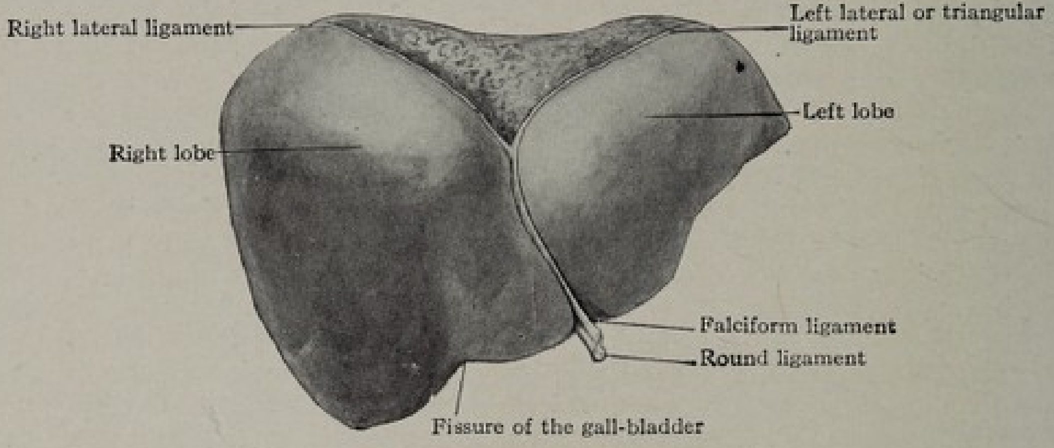


FIG. 461.—View of the anterior and upper surfaces of the liver.

Its left end receives the umbilical and ductus venosus fissures and its right end the fissures of the gall-bladder and vena cava. It contains the *portal vein, hepatic artery, hepatic duct, nerves,* and *lymphatics*; attached to its sides is the lesser or gastro-hepatic omentum. The portal fissure is also called the *transverse fissure*, and the name *longitudinal fissure* is sometimes applied to the combined umbilical and ductus venosus fissures. (In the recent anatomical nomenclature these fissures are called fossæ.) (Fig. 462.)

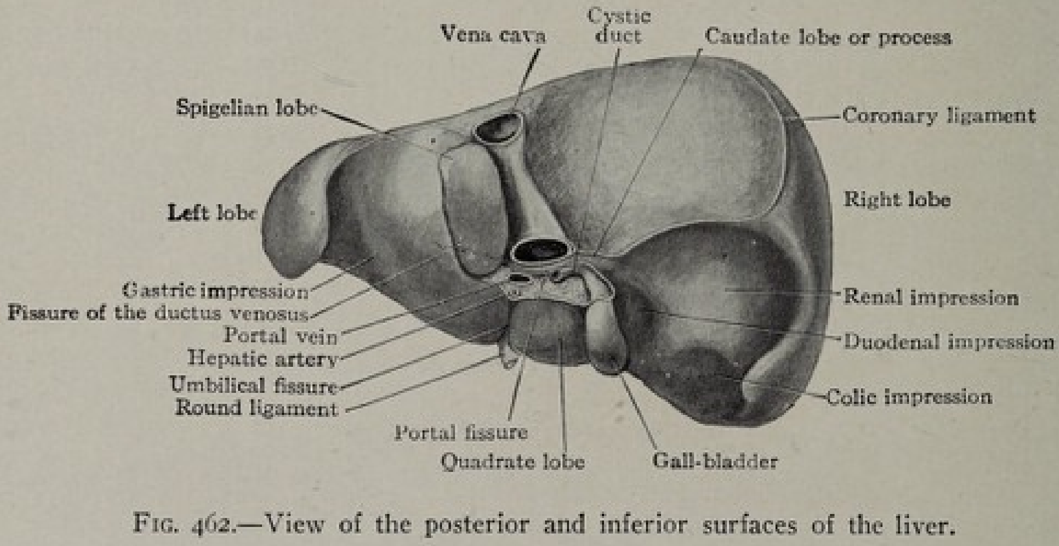


FIG. 462.—View of the posterior and inferior surfaces of the liver.

The **ligaments of the liver** are five in number: (1) the coronary, (2) the triangular, (3) the falciform, (4) the round, and (5) the ligament of the ductus venosus. The *coronary ligament* surrounds the posterior surface which is not covered by peritoneum. It is 4 to 6 cm. (1½ to 2½ in.) wide and extends from the vena cava 7.5 to 10 cm. (3 to 4 in.) to the right, terminating in a pointed end which has been called the right lateral ligament. The *triangular* or *left lateral ligament* extends as far to the left of the falciform ligament as the coronary does to the right. It is attached to the diaphragm in front of the œsophagus, while the coronary is attached to the back of the diaphragm. The *falciform ligament* starts near the umbilicus, passes to the umbilical notch of the liver 2.5 to 4 cm. (1 to 1½ in.) to the right of the median line and thence over the top of the liver to near its posterior edge, where it blends in front of the vena cava on the right side with the coronary ligament and on the left with the triangular ligament. The *round ligament* is the round cord in the free edge of the falciform ligament which runs from the umbilicus to the umbilical notch and thence to the portal fissure to join the left branch of the portal vein. It is the remains of the fetal umbilical vein. The *ligament of the ductus venosus* runs from the left branch of the portal vein to the vena cava in the fissure of the ductus venosus. The ductus venosus, like the umbilical vein, becomes obliterated at birth.

Position of the Liver.—The liver rises to the fourth costal interspace on the right side, to or slightly above the xiphosternal junction in the midline, and the lower border of the fifth rib on the left side, to its extremity, just beyond the apex of the heart, at the lower border of the sixth rib. Its lower border passes from this point to the eighth left cartilage, crosses the middle line about midway between the

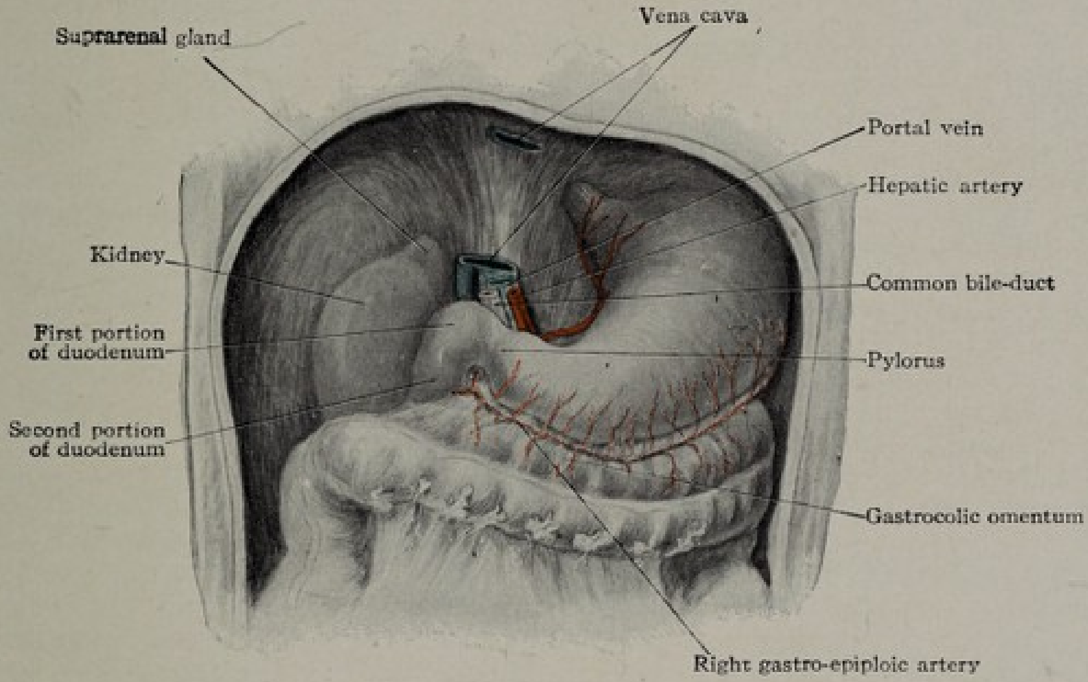


FIG. 463.—The bed of the liver. The liver has been removed to show the surrounding structures.

xiphoid articulation and umbilicus to the ninth right costal cartilage, and thence follows the edge of the ribs posteriorly, being about 2.5 cm. (1 in.) lower in women. The upper limits of its percussion dulness are the upper border of the sixth rib in the right mammillary line, the eighth in the axillary, and the tenth in the scapular.

Relations of the Liver.—The superior surface lies in contact with the diaphragm, except the portion extending about 7.5 cm. (3 in.) below the xiphosternal junction in the median line and sometimes the small projecting edge beyond the ribs, which lies in contact with the abdominal wall. The *posterior surface* lies over the tenth and eleventh thoracic vertebræ, the crura of the diaphragm, the œsophagus, aorta, vena cava, and right suprarenal gland. The *inferior surface* to the left rests on the cardiac end and upper surface of the stomach and gastrohepatic omentum. Beneath the quadrate lobe is the pylorus and beginning of the duodenum. Beneath the caudate lobe is the *foramen of Winslow* (foramen epiploicum) of which it forms the upper boundary. Farther to the right are the depressions for the hepatic flexure of the colon and the right kidney and suprarenal gland (Fig. 463).

The *size* of the liver varies, being small in atrophic diseases and much enlarged in others; therefore, alterations in the area of dulness are frequent. It moves with respiration and sometimes hangs lower than normal.

Wounds and Injuries of the Liver.—The liver may be ruptured in falling or by being struck by some body from without. The rupture may involve its anterior edge or superior surface. In all examinations it should not be forgotten that the right and left sides are separated completely by the falciform ligament. On account of the walls of the vessels being imbedded in the liver tissue they do not readily collapse and hemorrhage is often fatal. Rupture of the posterior nonperitoneal surface is not so dangerous as elsewhere.

Abscess.—Hepatic abscess may be either single or multiple. Hepatic abscess is as a rule the result of an infection in some part of the intestinal tract whose venous blood finally drains into the portal circulation. The most frequent cause of subdiaphragmatic abscess is suppurative appendicitis or a perforated peptic ulcer. Pus on the upper surface of the liver, between it and the diaphragm, is called *subdiaphragmatic abscess*. The pus unless drained surgically may discharge outward between the ribs, or upward into the pleural cavity, lung, or pericardial sac. In incising for subdiaphragmatic abscess the tenth rib in the axillary line can be resected without opening the pleura, but if the eighth or ninth is chosen the pleural sac may be opened. For this reason the costo-phrenic space should be obliterated by packing for several days before the incision through the diaphragm into the abscess cavity is made. If the abscess points at the inferior surface it may break into the stomach, duodenum, or colon. It may be reached by an incision through the abdominal walls to the right of the median line. The position of the falciform ligament, about 4 cm. to the right of the median line, should be remembered, and if the left lobe of the liver is to be treated the incision should be made to the left of the ligament.

Multiple abscesses are started in the liver by conveyance of infection through the portal vein, as occurs in appendicitis, or by direct extension up the common duct from the intestine, or from an inflamed gall-bladder or bile-ducts through the hepatic duct and its ramifications.

Portal Obstruction.—The veins of the portal system have no valves. The portal vein is formed by the union of the splenic and superior mesenteric veins and the gastric, pyloric, and cystic veins. The splenic receives the blood from the spleen, the stomach, and pancreas, the descending colon, sigmoid flexure, and rectum. The superior hemorrhoidal vein drains the rectum and empties into the inferior mesenteric, which passes into the splenic and finally into the portal vein. The superior mesenteric vein drains the remainder of the large and small intestine.

In cirrhosis, carcinoma, and occasionally gall-stones, the flow of blood through the portal vein is interfered with. If portal obstruction either from a lesion of the liver, of the vein itself, or from a lesion outside of the vein is produced, the distended and varicose veins of the stomach sometimes rupture, causing hæmatemesis; and dilatation of the hemorrhoidal veins produces hemorrhoids.

Especially when there also is pressure on the vena cava the superficial and deep veins of the abdominal wall become enlarged (see page 430). The main anastomoses are: (1) between the gastric (coronary) vein of the stomach and the œsophageal veins which empty into the vena azygos major; (2) between the epigastrics (superficial and deep) below and the terminal branch of the internal mammary above; (3) between the epigastric veins and portal vein through the para-umbilical vein (caput medusæ, page 430); (4) through the thoracico-epigastrica between the axillary and epigastric (see Fig. 417); (5) between the superior hemorrhoidal and the middle hemorrhoidal, emptying into the internal pudic.

GALL-BLADDER AND BILIARY PASSAGES

The **gall-bladder** lies in the fissure of the gall-bladder, with its fundus just about level with the edge of the liver and its body pointing inward, upward, and backward; its neck, which is S-shaped, is near the right end of the portal fissure. It is 7.5 cm. (3 in.) long and 2.5 to 3 cm. (1 to 1¼ in.) in diameter. It holds one to one and a half ounces. Below, it rests on the transverse colon and first part of the duodenum. It is attached to the liver by connective tissue and the peritoneum which covers both the liver and gall-bladder. According to Brewer one-third to one-fourth of its surface is uncovered by peritoneum. In 5 per cent. of cadavers it had a distinct mesentery. The tip (fundus) of the gall-bladder lies in contact with the abdominal wall at the tip of the ninth costal cartilage, where the right linea semilunaris strikes the costal margin, and just at the outer edge of the rectus muscle, which is about 7.5 cm. from the median line (Fig. 465).

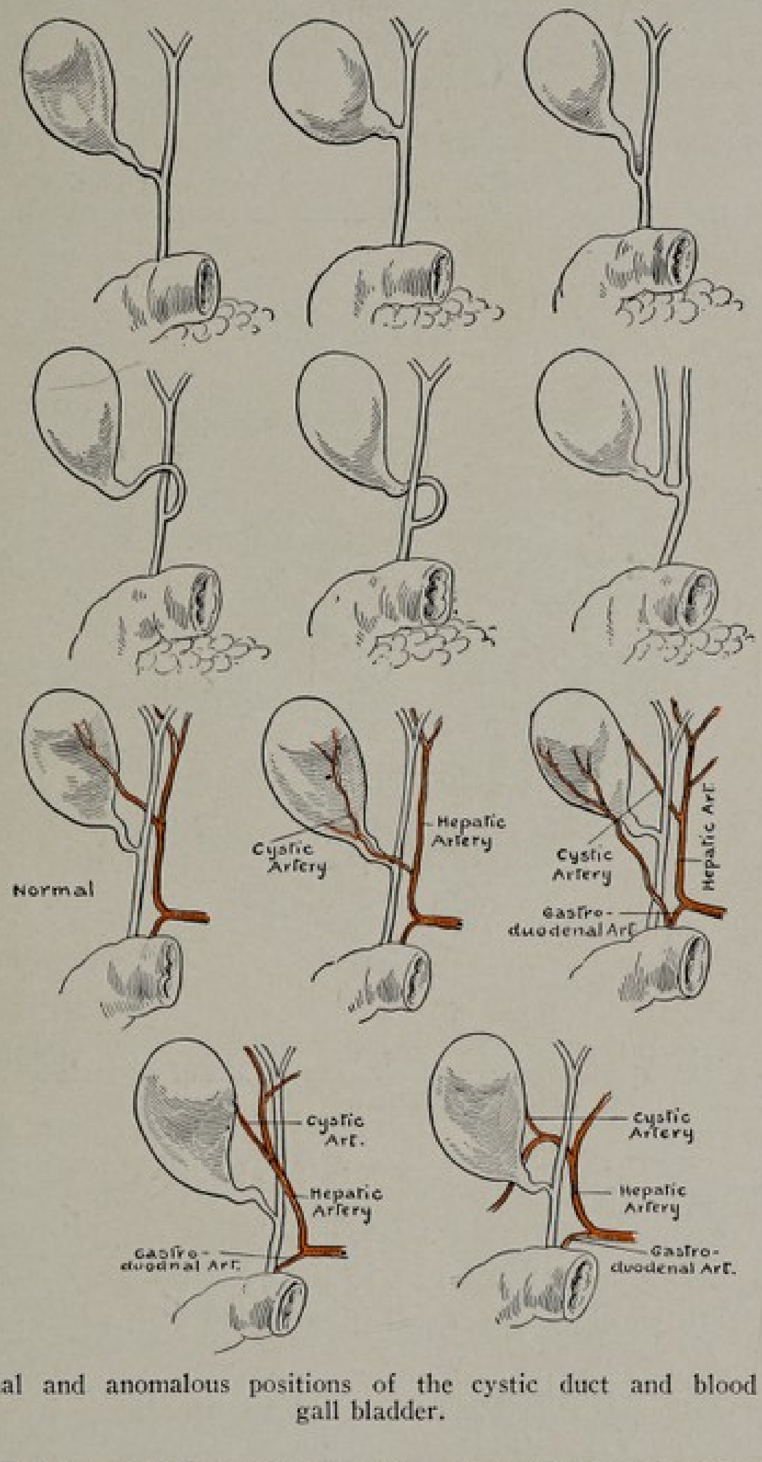


FIG. 464.—Normal and anomalous positions of the cystic duct and blood supply to the gall bladder.

Hepatic, Cystic, and Common Ducts.—A careful knowledge of the anatomy of this region is essential for good surgical results. Ductal variations are frequent and cholecystectomy should not be considered until the ductal arrangement has been visualized. The *hepatic duct* is formed by the union of the right and left branches in the portal fissure. These branches unite and in forming the hepatic duct describe a T. The left branch runs in front of the left division of the portal vein, while the right one usually crosses it. It is about 2.5 cm. long and 6 mm. (¼ in.) wide. The *cystic duct* is smaller in diameter than the hepatic and 3 to 4 cm. long and joins it as it emerges from the portal fissure. Both the neck of the gall-bladder and the cystic duct contain constrictions of the mucous membrane (valvula spiralis Heisteri) which obstruct the passage of a probe or stone. They are especially well marked in early life but later the spiral ridge atrophies and is broken up at many places, leaving detached folds with a semilunar outline. Hence gall-stones are frequently found impacted or lodged in the neck of the gall-bladder or somewhere in the course of the duct. The cystic artery lies above the duct. The *common duct* is formed by the union of the hepatic and cystic ducts at the edge of the portal fissure, and empties into the duodenum about the middle of its second portion on its inner wall. It is 7.5 cm. (3 in.) long and 6 mm. (¼ in.) or more in width. It passes almost directly downward, inclining a little to the right, between the folds of the lesser omentum, in front of the foramen of Winslow (foramen epiploicum) behind the first portion of the duodenum, and then between the pancreas and the inner wall

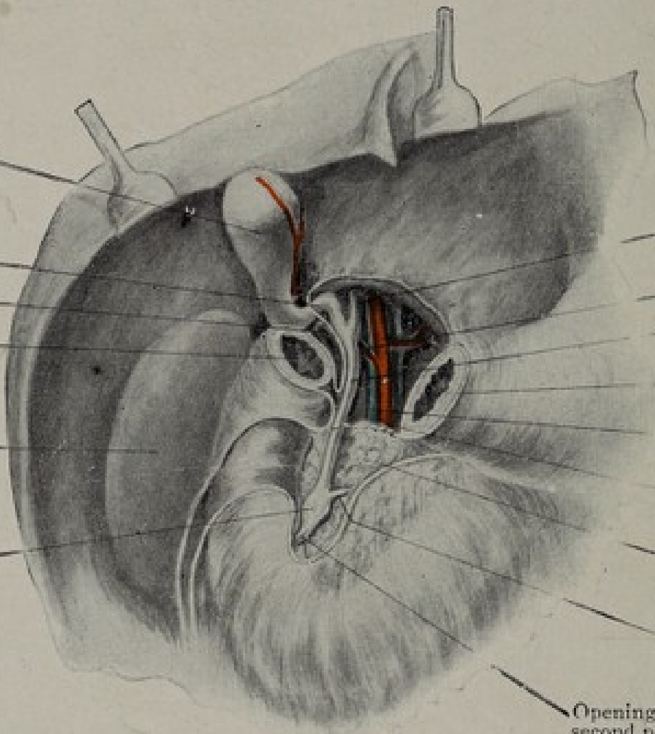


FIG. 465.—The biliary passages. The edge of the liver has been raised, exposing its under surface; the first portion of the duodenum and anterior surface of the pancreas has been removed exposing the common bile-duct and blood-vessels.

of the second portion of the duodenum. It is, at this part, in two-thirds of the cases, completely surrounded by pancreatic tissue. As it passes through the duodenum, which it pierces obliquely, it expands into the *ampulla of Vater* and receives the *pancreatic duct*, or *duct of Wirsung*. Above, it lies directly on the portal vein, with the hepatic artery to its left. About half of the duct, 3 to 4 cm., is above the duodenum and half behind it. The retroduodenal portion of the common duct can be exposed by incising the peritoneum on the superior and outer surface of the second portion of the duodenum and turning that structure downward and toward the midline.

Anomalies of the extra-hepatic ductal and arterial system are frequent. The cystic duct may run parallel with the common duct and enter it at a very acute angle, the right hepatic duct may empty into the cystic duct; the gastroduodenal artery may be found anterior to the common duct or the cystic artery may cross in front of the common hepatic duct. These and other anomalies are illustrated in figures (see previous page).

The **hepatic artery** passes along the upper edge of the pancreas, to which it gives branches; it then gives off the pyloric to the lesser curvature of the stomach, the gastroduodenal (see page 459), and finally right and left terminal branches. The left supplies the left lobe of the liver, the right crosses usually behind but sometimes in front of the bile-ducts and terminates in the right lobe, after first giving off the *cystic artery*. This runs usually behind, but sometimes in front of the hepatic duct, and then between it and the cystic duct, and has superficial branches which ramify on the surface of the gall-bladder and deep branches which run up the grooves between the gall-bladder and liver. It is these branches which bleed when the gall-bladder is removed. One of the deep arteries may be larger than the other or lacking. Some very fine branches come directly from the liver. These are numerous arterial anomalies in this area some of which are illustrated in figure 464, (page 479). Ligation of the main trunk of the hepatic artery may lead to the death of the patient.

Lymphatic nodes are found in the portal fissure and accompanying both the common and cystic ducts. They are especially involved in carcinoma. The importance of the close connection of the lymphatics of the gall-bladder and those of the pancreas and liver must not be underestimated. Francke showed that the lymphatics of the gall-bladder coursed immediately beneath the posterior surface of the upper portion of the head of the pancreas. Deaver has shown this connection to be a frequent cause of peripancreatic lymphangitis and lymphangitis. Graham more recently has called attention to the intimate connection of the gall-bladder lymphatics with those of the adjoining liver parenchyma.

The **kidney** (Morrison's) **pouch** is a name given to the space in front of the right kidney. The foramen of Winslow (foramen epiploicum) opens into it from the left and the abdominal wall is to its right. The liver is above and the duodenum and transverse colon below. Liquids from the lesser peritoneal cavity and bile-passages flow into this hollow, which can be drained by a tube inserted through a "stab-wound" made through the abdominal wall just to the outside of the right kidney.

Gall-Stones.—These and carcinoma are the main surgical affections of the biliary passages. The latter may be primary in the gall-bladder or in the extra-hepatic ductal system or it may be secondary to pyloric cancer in which case the ducts are obstructed by enlargement of the lymph-nodes in the gastro-hepatic omentum. Gall-stones are most frequent in the gall-bladder, next in the common duct, and lastly in the hepatic ducts. Obstructive symptoms are not often observed from gall-stones in the hepatic duct alone. Obstruction of the common duct causes jaundice. Simple gall-bladder disease does not result in icterus so that practically, jaundice is only seen in obstruction of the common duct. Gall-stones usually form in the gall-bladder and, as the cystic duct is smaller than the common duct, if a stone gets out of the former it is frequently passed into the intestine (Fig. 466). On account of the contracted opening of the common duct into the duodenum, stones are liable to be retained in the ampulla of Vater. This causes a damming back of the bile, and the common duct increases in size. Very large gall-stones may cause ulceration into the duodenum or colon or may press on the portal vein and vena cava, and produce ascites. In operating for gall-stones, Mayo Robson incised through the middle of the right rectus muscle and prolonged the upper part along the edge of the ribs to the lateral side of the ensiform cartilage. Where more room was desired Bevan added a transverse cut outward from its lower end. Kocher made a curved incision 4 cm. below the edge of the ribs. The subcostal incision has many advantages especially so since only one intercostal nerve is divided. In order to make the liver project a hard roll is placed beneath the back. To bring the gall-ducts to the surface the liver is dragged down and its edge turned up over the upper extremity of the wound. The gall-bladder can be drawn out and this straightens the curves in the cystic duct. By placing one or two fingers in the foramen of Winslow (foramen epiploicum) the thumb can palpate the cystic and the common duct until it disappears behind the duodenum. Gall-stones in the second (retroduodenal) portion of the duct or in the ampulla of Vater can often be felt through the walls of the duodenum. If it is desired to gain access to this portion of the duct, the peritoneum on the outer side of the second portion of the duodenum, binding it to the posterior abdominal wall, must be divided. The duodenum is then turned to the left and the common duct followed down if necessary through the pancreas to the ampulla of Vater. Stones impacted in the ampulla of Vater can be removed by incising the front of the second portion of the duodenum and then cutting down on the stone through the papilla. In some cases it may be impossible to pass a probe down the cystic duct owing to its being caught by the valve-like folds of the mucous membrane. In removing the gall-bladder, bleeding will be less if the cystic artery be first clamped. If this is not possible, then the bleeding will occur from the branches on one or both sides of the gall-bladder. The peritoneum is to be cut through, not torn. Bleeding from the liver

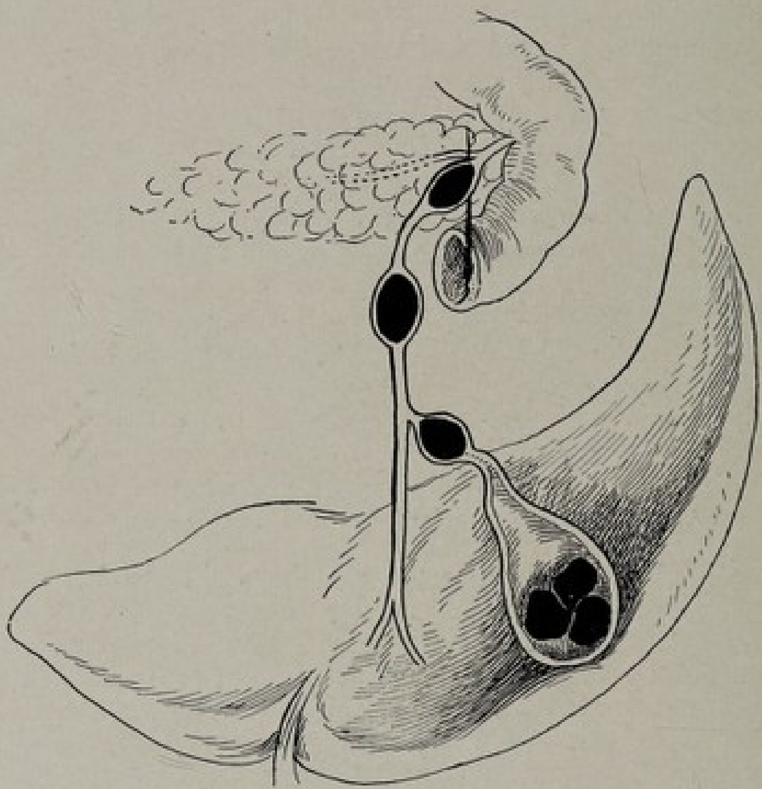


Fig. 466.—Common position for impaction of gall bladder stones in biliary tract.

substance is slight and readily stopped by pressure. In incising the common duct for calculi the relation of the portal vein behind and the hepatic artery to the left should be remembered. These can be avoided by cutting down on the calculus.

THE PANCREAS

The pancreas is composed of two portions joined at right angles to each other. Together they measure about 20 cm. (8 in.). It is divided into a head, neck, body, and tail. The neck is about 2 cm. broad, while the head and body are each about 3 cm. The head is about 5 to 6.25 cm. long and lies parallel to the vertebral column on its right side. It is enclosed in the loop of the duodenum. The body is about 12.5 cm. long and runs transversely from the first portion of the duodenum across to the spleen. The flexure joining the head and body constitutes the neck. It is 2.5 cm. long. The tail is simply the extremity of the body; this is omitted in some descriptions. The body crosses the first lumbar vertebra, while the head lies on the right side of the second and third (Fig. 467).

Pancreatic Ducts.—The pancreas has two ducts, a main one called the *pancreatic duct*, or *duct of Wirsung*, and an accessory one called the *duct of Santorini*. The duct of Wirsung runs nearly the whole length of the gland, and, bending somewhat downward at the neck and joining the common bile-duct at the ampulla of Vater, pierces the duodenum obliquely and empties in a common orifice on its mucous surface. It is 3 to 4 mm. (1/8 to 1/6 in.) in diameter at its termination. The accessory duct of Santorini comes mainly from the lower portion of the head of the pancreas and empties separately in the duodenum 2 cm. above and a little anterior to the biliary papilla. It communicates with the duct of Wirsung in the substance of the pancreas.

Relations.—Posteriorly, the head lies on the vena cava while the body crosses the aorta, renal vessels, suprarenal gland, and left kidney. Anteriorly, it is covered with peritoneum and on it lies the stomach; inferiorly, is the attachment of the transverse mesocolon, beneath which comes the duodenojejunal flexure. Immediately to the right of this flexure and between it and the head of the pancreas issue the superior mesenteric vessels. At the extreme left is the splenic flexure of the colon.

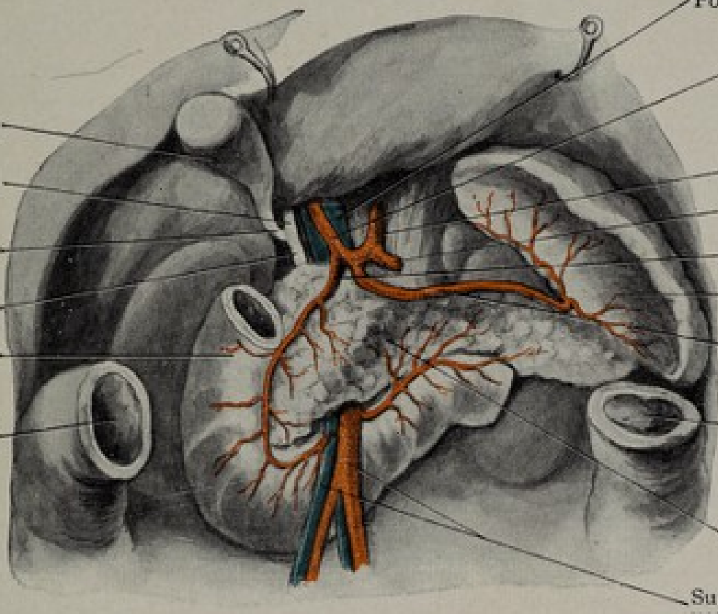


FIG. 467.—The pancreas and spleen.

Pancreatic Cyst and Abscesses.—The pancreas is the subject of inflammation which may cause necrosis and abscess; it also is affected with cysts and new growths. Calculus may also be present.

Suppuration may produce a sub-diaphragmatic abscess or perforate the diaphragm and form an empyema. In cases of abscess protruding anteriorly, instead of opening through the peritoneum in front, the pus may be evacuated through a posterior incision made in the right or left costovertebral angle. If the pus has been evacuated through an anterior incision the finger may be introduced into the abscess cavity and used as a guide for a posterior incision.

The body of the pancreas can be approached from below the transverse mesocolon or through gastrocolic omentum.

Cancer of the pancreas usually affects the head of the gland. This accounts for the frequency with which obstruction of the common bile duct occurs with this lesion. The resulting jaundice is said to be painless as distinguished from the painful jaundice of common duct stone, but this is not always true.

Pancreatic growths tend to project forward in one of three general directions—viz.: (1) between the liver above and the stomach below; (2) between the stomach above and the transverse colon below; (3) below the transverse colon. The second is the most frequent. When the enlargement comes forward opposite the attachment of the transverse mesocolon it may grow between the layers of the mesocolon and push the transverse colon in front of it instead of going below or above it.

After the cyst has been evacuated it may be stitched to the edges of the incision anteriorly and a counter opening made posteriorly on the left side beneath the twelfth rib.

THE SPLEEN

The spleen lies high up in the left posterior corner of the abdomen in contact with the diaphragm. It follows the direction of the tenth rib, being covered by the ninth, tenth, and eleventh ribs and extending from a point 4.5 to 5 cm. lateral to the median line posteriorly to the midaxillary line anteriorly. Its upper end is opposite the tenth dorsal vertebra, or ninth spine (see Fig. 471).

Relations.—It has four surfaces: a posterior one, which lies in contact with the diaphragm; an anterior one toward the stomach; an inferior small one, resting on the splenic flexure of the colon; and an internal one, in contact with the left kidney at its upper anterior portion. The hilum is on its anterior or gastric surface and posterior to it is a depression in which is lodged the tail of the pancreas.

Ligaments.—The spleen develops from the mesoderm between the layers of the dorsal mesogastrium. After rotation of the stomach and development of the spleen the distal part of the dorsal mesogastrium becomes the *gastrosplenic ligament* or omentum. Posteriorly, the mesogastrium fuses with the parietal peritoneum forming the *lienorenal ligament,* extending above as the *lienophrenic ligament,* and below as the *colicolienal ligament.* A fifth ligament, the *phrenocolic* (*costocolic*) runs from the diaphragm opposite the tenth and eleventh ribs to the splenic flexure of the colon. The upper surface of the colon is concave, forming a fossa (splenic fossa) in which the spleen rests and which, of course, aids in supporting it.

Blood Supply.—The splenic artery, the largest branch of the celiac axis, passes along the upper border of the pancreas and across the front of the left kidney to the spleen. Near the hilum a superior branch supplies the upper pole and terminal branches supply the lower pole. The vasa brevia to the stomach arise from the terminal branches. The left gastro-epiploic may arise from the inferior terminal branch but usually from the main vessel 3 or 4 cm. from the hilum. Many veins emerge, unite and empty into the superior mesenteric behind the superior edge of the pancreas.

Splenic Enlargement.—The spleen is enlarged in many diseases, such as malaria, leukæmia, typhoid fever, splenic anæmia, and others. This enlargement is to be detected by palpation and percussion. The normal spleen lies under the ribs, therefore it can be palpated only when it enlarges and projects beyond the costal margin or when its pedicle (ligaments) becomes stretched and allows it to wander down. Normal percussion dulness extends anteriorly to the midaxillary line; posteriorly it merges into the kidney dulness and cannot be limited. From above down the dulness would be from the ninth to the eleventh rib in the posterior axillary line.

Wounds of the Spleen.—The upper portion of the spleen rises as high as the tenth dorsal vertebra or ninth spine; as the lung posteriorly descends at least one vertebra lower and the pleura still another lower, it follows that a penetrating wound entering the ninth costal interspace in the line of the angle of the scapula would wound first the pleura, then the lung, then the diaphragm, then the spleen, and finally the stomach. If it entered one interspace below—the tenth—it would open the pleural cavity but would probably escape the edge of the lung.

Splenectomy.—Indicated in extensive rupture, abscess, tumors and cysts and in certain of the splenomegalies, notably Banti's disease, hæmolytic jaundice, syphilis, malaria, etc. The operator must recall the position of the ligaments, fundus of the stomach and tail of the pancreas and be aware of the possibility of dense adhesions to the diaphragm and the presence of abnormal vessels, particularly large thin-walled veins. A high left rectus incision is usually employed. If possible the organ should be delivered and its pedicle ligated and divided. If adhesions render this procedure impossible or difficult the pedicle may be ligated *in situ* and the organ delivered as the adhesions are freed. The greater curvature of the stomach must always be identified and freed before clamping the pedicle. The tail

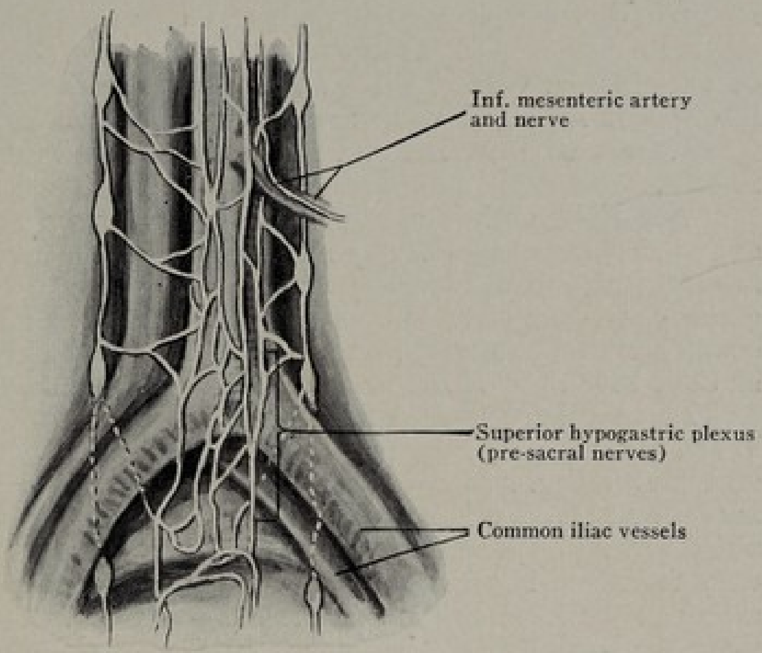


FIG. 468.—Lower lumbar and sacral sympathetic ganglia and trunks.

of the pancreas may remain in contact with the spleen when this is drawn forward and may need separation by dissection.

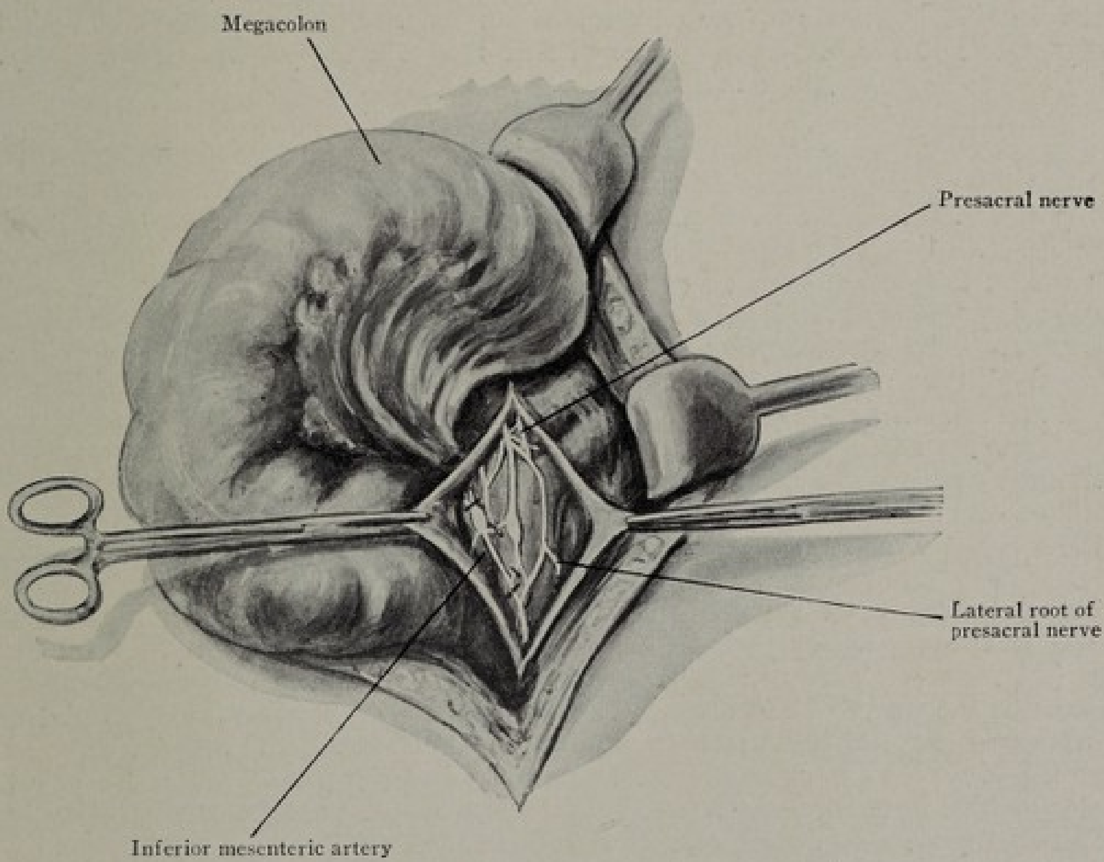


FIG. 469.—Exposure of presacral nerve and plexus.

Abdominal Sympathetic System.—Resection of the abdominal sympathetic ganglia for various vascular lesions of the extremities and for megalocolon recently has gained considerable favor. The pelvic sympathetics are sectioned for intractable dysmenorrhea and for the pain of malignant disease of the uterus. In vascular disease of the lower extremities, when vaso-constriction is an important factor, lumbar sympathetic ganglionectomy is of real value. In those instances where chronic constipation is accompanied by a dilated colon or in which it is the result of true Hirschsprung's disease operations on the abdominal sympathetic offer a measure of relief. Rankin and Learmonth have described the operation for the latter lesion while Adson and his associates have described the operation for the former.

The right or left sympathetic chains can be excised through an abdominal exposure more easily than by the posterior approach. When it is desired solely to interrupt the sympathetic supply to the large bowel especially on the left side the entire ganglionic chain should not be excised, the Rankin and Learmonth technic being preferred. Lumbar ganglionectomy for peripheral vascular disease should be done only after it has been established that sympathetic overstimulation exists.

In exposing the structures on the left side the sigmoid colon is mobilized. When the presacral nerve is to be resected for dilatation of the colon this is not necessary (Figs. 468 and 469). The promontory of the sacrum is identified and in many instances it is possible to see strands of the presacral nerve over the aorta and below its bifurcation just beneath the peritoneum. The latter is incised vertically from the level of the promontory to the origin of the inferior mesenteric artery at the level of the third lumbar vertebra. The nerve is divided below at the right border of the left common iliac vein. It is then raised and its attachments separated from the third and fourth lumbar ganglia. As the dissection is continued the lateral portions of the nerve which arise from the first and second lumbar ganglia are exposed and divided. By following the middle root of the presacral nerve upward the two principal roots of the inferior mesenteric plexus are exposed and resected. If the middle root of the presacral nerve cannot be used as a guide the main trunks of the inferior mesenteric plexus will be found at the positions of five and seven o'clock with reference to the position of the artery.

THE UROGENITAL ORGANS

The *metanephros,* or permanent kidney, is derived from two distinct sources. The secretory portion, that is Bowman's capsule, the proximal convoluted tubule, the loop of Henle and the distal convoluted tubule, is derived from the caudal end of the *Wolffian body* (*urogenital ridge*), whereas the collecting tubules and the pelvis are an outgrowth of the upper end of the ureter, which is derived from a bud springing from the *Wolffian duct* (*mesonephric duct*) near its lower extremity (Fig. 470). The entire kidney and ureter are therefore of mesodermal origin. The renal primordia are brought together by the upward, outward growth of the ureteral radical. This union effected, the nephrogenic element separates from the Wolffian body and forms a cap over the developing pelviotubular tissue at the cephalic end of the ureteral stalk and is carried cephalad by it through about three segments to its final resting place in the renal fossa. The kidney then rotates so that the hilum is directed inward instead of forward. Developmental faults account for pelvic kidneys, horseshoe kidneys, solitary kidneys, etc.

The development of the lower urinary tract is closely connected with that of the hind gut. At an early period there is a dilatation of this organ to form the *cloaca* (Fig. 470). This receives the excretory ducts of the *pronephroi,* which later become the ducts of the *mesonephroi* and finally of the *metanephroi.* They are mentioned above as the mesonephric ducts or Wolffian ducts. After giving off a ventral bud which grows somewhat cephalad to become the *allantois,* the cloaca becomes divided by a transverse "wedge" of tissue which grows caudad through it till it reaches the *cloacal membrane*, an area where the entoderm of the cloaca is in contact with the ectoderm of the surface of the embryo. Thus divided, the cloaca becomes the dorsally placed rectum and the ventrally located *urogenital sinus.* The point at which the wedge of tissue described above unites with the cloacal membrane is the primitive perineum. The division takes place in such a manner that the Wolffian ducts open on the dorsal wall of the urogenital sinus. A little later the terminal portions of these ducts flare out so as to bring the ureteral orifices directly into the urogenital sinus. Still later, as a result of further unequal growth, the orifices of the ureters and Wolffian ducts become separated and the form of the sinus is materially changed, so that a vesical and a urethral portion can be recognized. In the male the latter portion contains the openings of the Wolffian (ejaculatory) ducts and gives rise to the *phallic urethral bud*, which carries the anterior portion of the cloacal membrane (*urethral meatus*) to the end of the genital tubercle. Embryologically therefore, the mucosa of the vesical trigone and of the floor of the proximal urethra—including that of the verumontanum in the male and of the whole canal in the female—is mesodermal, while that of the remainder of the bladder and urethra is entodermal. The *prostate*, derived from urethral buds, is probably entirely entodermal.

The *genital glands* are formed on the ventromedian surfaces of the Wolffian bodies (urogenital ridges) as elongated structures extending caudad from the diaphragm. By a process of atrophy at their cephalic ends and caudad growth

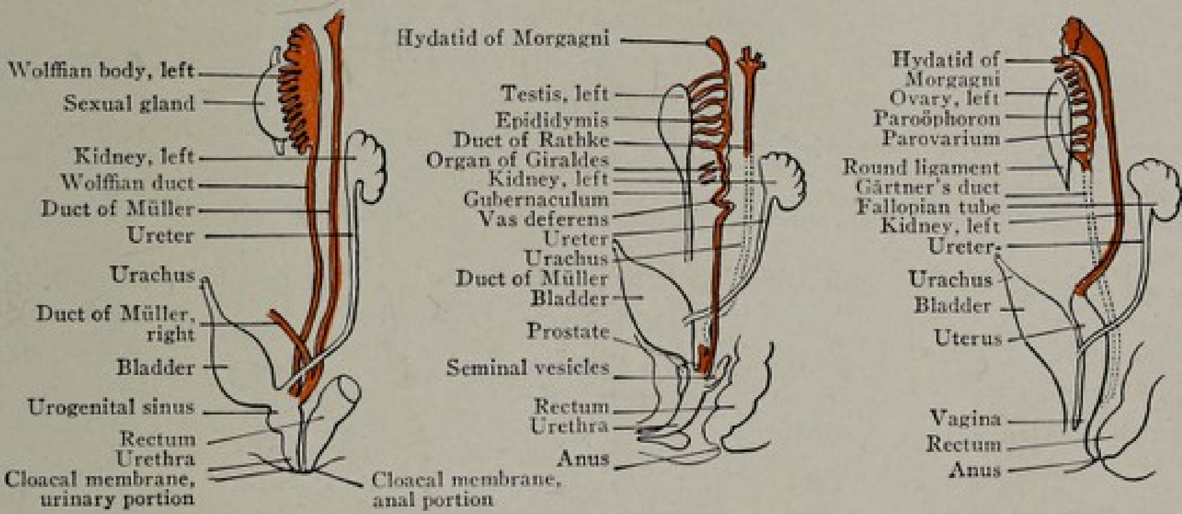


FIG. 470.—The development of the genital organs.

their position is gradually shifted till they are at the brim of the pelvis. Later there is a true migration, the ovary rotating into a transverse position and moving caudad to the Fallopian tube, and the testicle descending through the inguinal canal into the scrotum. While the sex glands are still undifferentiated masses of cells the *ducts of Müller* are formed in the urogenital ridges. After differentiation, in female embryoes these ducts continue to develop, becoming the Fallopian tubes, uterus and upper part of the vagina, while the Wolffian ducts disappear almost completely. In the male, however, the Wolffian ducts survive, becoming the *epididymes, vasa deferentia, seminal vesicles* and *ejaculatory ducts*, while the Müllerian ducts atrophy except for a few vestigial organs.

THE KIDNEYS

The kidneys when normal are about 12 cm. (4½ in.) long, 6 cm. (2½ in.) broad and 3 cm. (1¼ in.) thick. The right is the thicker and the left a little the longer.

They lie in the lumbar regions under the lower portion of the thoracic wall. Their upper ends are nearer the midline than the lower and the inner edges point forward and inward, thus one surface is antero-external and the other postero-internal.

Relations to the Surface.—The kidneys are not fixed organs, but normally move upward and downward with respiration. Consequently the locations given below are only approximate. Viewed posteriorly the right kidney has its upper edge opposite the eleventh dorsal spine and the lower edge of the eleventh rib. Its lower edge is opposite the upper edges of the third lumbar spine and vertebral body and about 4 cm. (1½ in.) above the highest point of the crest of the ilium, which is opposite the fourth spine (Fig. 471). The left kidney is usually 1.25 cm. (½ in.) higher, but being a little longer than the right, its lower limit may not be quite that much higher. The kidneys are slightly lower in women and children than in men. The hilum is at the level of the interval between the first and second lumbar spines (H. J. Stiles). Viewed anteriorly, the lower edge of the right kidney is 2.5 cm. (1 in.) above a transverse line through the umbilicus; the left is a little higher. The upper edges are approximately opposite the tip of the ensiform cartilage. The upper poles approach within 3 cm. (1¼ in.) of the median line.

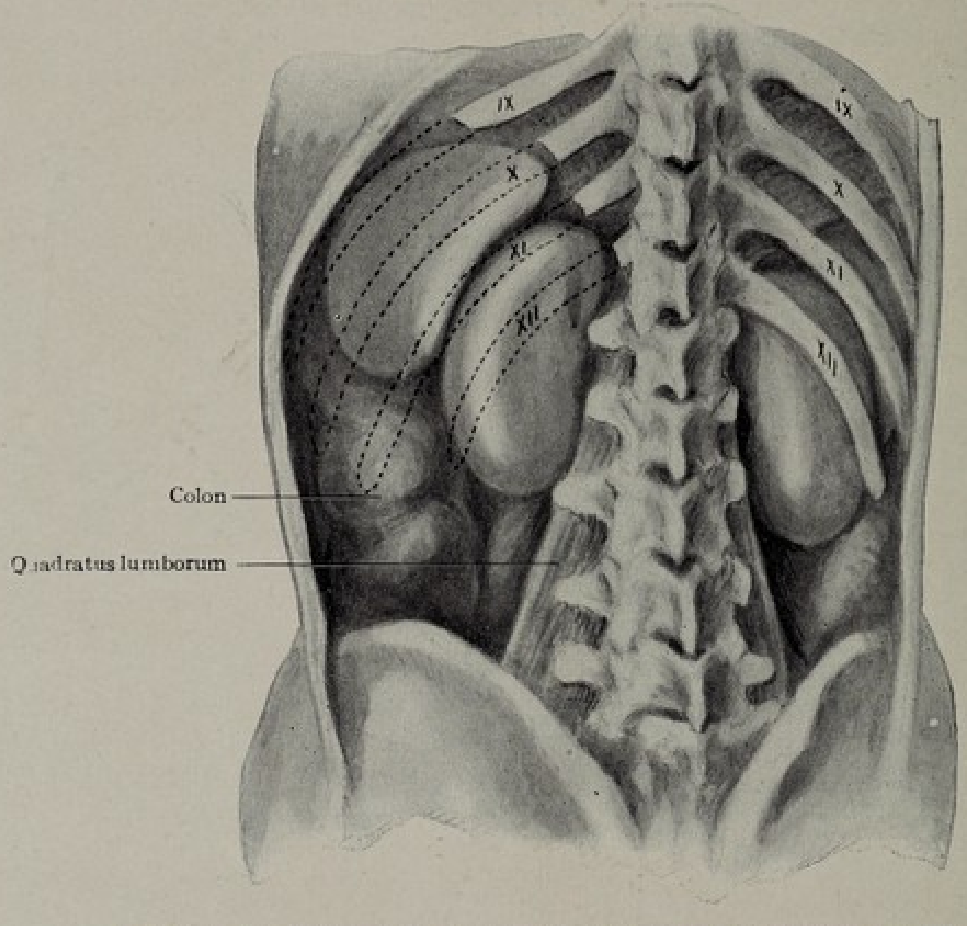


FIG. 471.—Posterior view, showing the relations of the spleen and kidneys.

About two-thirds of the kidney lies to the inner and one-third to the outer side of a line drawn longitudinally through the middle of Poupart's ligament. The hilum is 4 to 5 cm. (1½ to 2 in.) out from the middle of a line joining the upper extremities of the two semilunar lines.

Deep Relations.—The *posterior surface,* upper portion, is against the diaphragm; its lower portion, from within out, rests on the psoas, quadratus lumborum, and transversalis muscles. Between the kidney and the quadratus lumborum run the last thoracic, the iliohypogastric, and the ilioinguinal nerves, covered by the transversalis fascia. As this fascia leaves the body of the first lumbar vertebra it arches over the psoas muscle, forming the internal arcuate ligament. It then becomes attached to the transverse process of the first lumbar vertebra. Thence it proceeds out over the quadratus lumborum to be attached to the outer portion of the twelfth rib, forming the external arcuate ligament. It then blends with the fascia giving origin to the internal oblique and transversalis muscles. Between the fibres of the diaphragm which arise from the external arcuate ligament over the quadratus lumborum muscle—and the fibres arising from the twelfth rib, is a triangular space with its base downward. It is called the *hiatus* and if marked allows the pleura and the kidney to come in contact without any muscular fibres intervening. This favors the passage of pus from the region of the kidney into the pleural cavity.

The *anterior surface* relations differ on the two sides. The *right kidney* is in contact with the suprarenal gland above, then with a large area of the liver; below

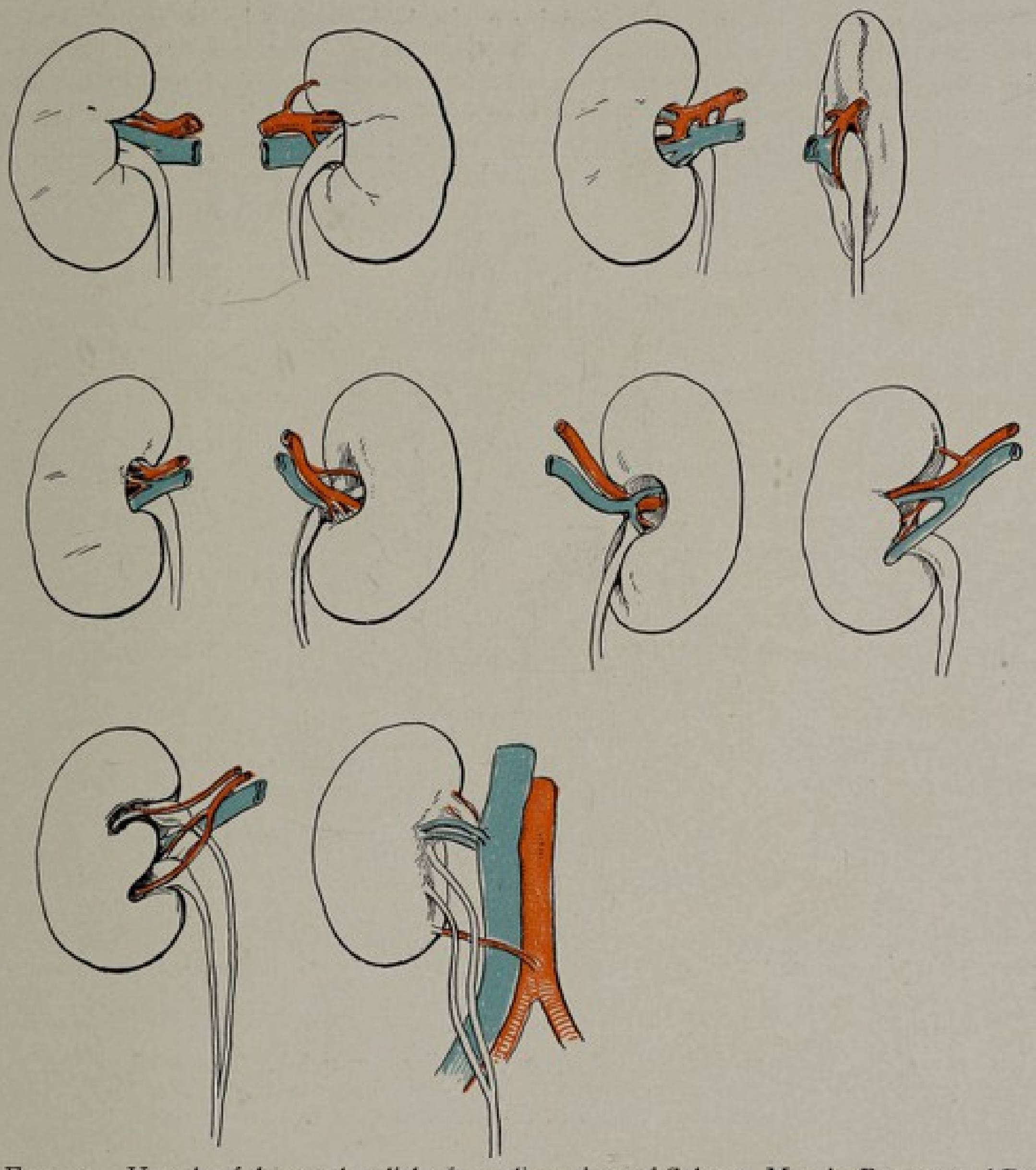


FIG. 472.—Vessels of the renal pedicle, from dissections of Sobotta, Morris, Bonney and Davis, illustrating variations in arrangement. The first two figures, rear view, show the pelves uncovered by vessels (usual finding).

to the inner side is the descending or second part of the duodenum, and to the outer side the hepatic flexure of the colon. On the *left side* above and within is the left suprarenal gland. Beneath it is a small area for the stomach, and still lower a larger one for the left end of the pancreas. On the outer portion of the anterior surface is an area for the spleen and below one for the splenic flexure of the colon and jejunum.

The **hilum** is the name given to the notch in the inner edge of the kidney. It contains the *pelvis* and the renal vessels and nerves. The *sinus* is the cavity of the kidney. The edges of the pelvis are attached to the borders, or rim, of the hilum.

Renal Pedicle.—The constituents of this structure—arteries, veins, nerves and ureter—have no uniform arrangement. The nerves are spread over the vessels as a network, rather more anteriorly than posteriorly. The larger structures are usually stated to be placed from before backward in the order "vein, artery, ureter," and from above downward "artery, vein, ureter," but the arrangement varies, so that in operating on the pelvis it is not safe to assume there are no vascular elements behind it. Bonney found the anteroposterior arrangement described in but 34 of 40 cadavers with single arteries; he makes no statement as to the superoinferior order.

Typically each kidney is supplied by a single branch of the aorta, the renal artery, its origin being at the level of the first lumbar vertebra. The right renal artery passes behind the vena cava to reach the kidney. Exceptionally the arteries are multiple, springing from the aorta at any point below the diaphragm, or from branches of the aorta, and entering the kidney at the hilum or elsewhere (Fig. 472).

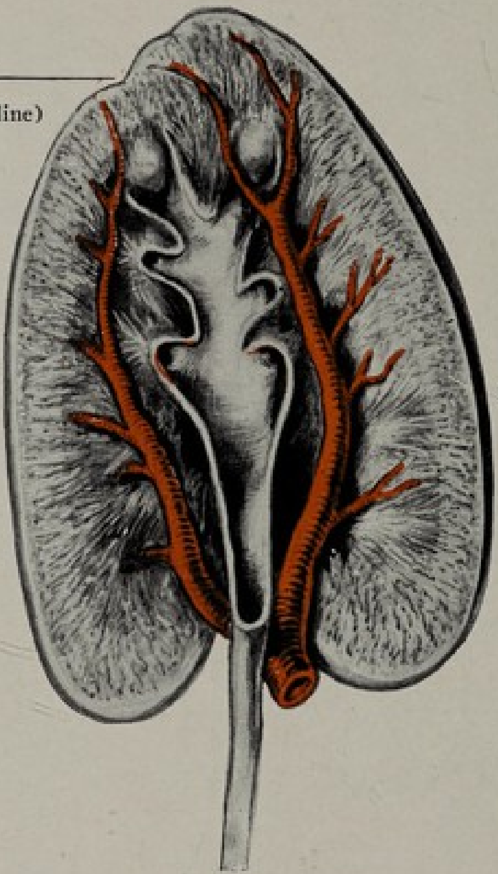


FIG. 473.—Transverse section of the kidney (semidiagrammatic). The renal artery is seen dividing into anterior and posterior branches. Incisions into the organ are to be made as indicated on the posterior surface just back of the prominent edge.

Bonney found multiple arteries in 19 of 59 bodies examined. On entering the kidney the arteries divide into anterior and posterior groups. The anterior group is somewhat the larger, so that in doing a nephrotomy the incision should be made in *Brödel's white line*, about a centimeter back of the convexity (Fig. 473). Whether renal arteries be single or multiple they are always terminal vessels; consequently in freeing a kidney one should guard against the inadvertent or unnecessary severance of polar arteries, both to avert hemorrhage and to avoid infarction.

Renal **Capsules.**—There are two capsules of the kidney—one fibrous and one fatty. The *fibrous capsule* covers the outside of the kidney, passes into the hilum and lines the sinus. It can be stripped from the kidney, but when the organ is diseased it brings small portions of the kidney substance with it. The *fatty capsule* surrounds the kidney, being more abundant around its edges than on its anterior and posterior surfaces. The kidney lies comparatively loose in this fatty capsule, slipping upward and downward. The fatty capsule is continuous below with the subperitoneal fat.

Perirenal Fascia of Gerota.—Covering the fatty capsule is the perirenal fascia, composed of two layers—anterior and posterior. It is developed from the subperitoneal areolar tissue. The anterior layers of the two sides are continuous with each other over the vertebral column. Each proceeds outward over the vessels, ureter, and kidney in its fatty capsule to blend at the outer and upper borders with the posterior layer; below, it fades away in the subperitoneal tissue of the iliac fossa. The posterior layer passes inward behind the kidney from its outer and upper borders, to be attached to the sides of the vertebral column. Above, these layers are attached to the diaphragm; below, they are continuous with the subperitoneal tissue of the iliac fossa. There is also perirenal fat outside the perirenal fascia, between it and the parietal muscles.

Displacements of the Kidneys.—It has already been noted that the kidneys are not fixed organs, but move upward and downward in their capsules with respiration. Kelly gives the normal excursion as 1.5 to 5 cm. in women and about half this amount in men. The fascias, blood vessels and intraabdominal pressure on which the kidneys must depend for the maintenance of their position are by no means powerful forces, so it is not strange that for various reasons—childbearing, accidents, structural peculiarities, etc.—abnormal mobility of one or both kidneys is of frequent occurrence. Abnormal mobility, with consequent descensus, constitutes the condition known as *movable kidney* or *nephroptosis*. Extreme degrees of movability constitute the condition popularly termed floating kidney; as there is no agreement as to when a movable kidney becomes a "floating" organ, use of the latter term should be discouraged. From an anatomicosurgical standpoint extreme degrees of movability are of interest because such organs become pedunculated, the pedicles consisting of double layers of peritoneum inclosing the renal vessels and nerves and the ureters. Consequently in operating on such kidneys, in order to avoid opening the peritoneal cavity, one must completely free the peritoneum from the posterolateral parietes before dissecting inward and forward between the peritoneal lamellæ to reach the kidney.

Congenital misplacements and abnormalities are occasionally encountered, among them being nonascent or pelvic kidney, fused or horseshoe kidney, transabdominal dystopia or ectopy, nonrotation and various degrees of nondevelopment, including absence. Formerly preoperative diagnoses of these conditions were rare; today urography (by intravenous injection) and pyelography (by retrograde injection) are available, so failure to apprehend the existent condition in advance of operation is seldom excusable. The posterior or mesial projection of the calyces from the pelvis in a pyelogram, as contrasted with normal lateral projection, is significant of renal nonrotation and consequently of a developmental anomalous condition. Ectopic kidneys commonly have several short arteries, often entering on the anterior surface; they are consequently difficult to mobilize. Special care must be used to avoid hemorrhage.

Tumors.—As the kidney enlarges it does so in a forward and downward direction. As it comes forward it may go to the outer side of the colon, to its inner side, or carry the colon directly in front of it. On the right side it usually pushes the ascending colon inward while on the left side the descending colon in most cases passes to the front and a little to the *outer* side. Renal tumors may be mistaken for tumors of the liver, gall-bladder, spleen, ovaries, and retroperitoneal glands.

Infections.—The kidney is frequently the seat of inflammatory conditions. The tissues affected may be the parenchyma, the pelvis, or the perinephric fascia; or all may be affected. The condition commonly called "pyelitis" is a *pyelonephritis* in the great majority of cases. *Pyonephrosis* is a term used to denote an empyema of the pelvis and calyces, the ureter being obstructed. Multiple abscesses in the kidney are often termed "surgical kidney," and may be associated with pyonephrosis. In a perinephric abscess the pus is extrarenal, involving the adipose capsule and perirenal fascia; it commonly points in the loin. As the perirenal fascia is open below and to the inner side the pus may descend to the iliac fossa or follow inside the sheath of the psoas muscle beneath Poupart's ligament. It may work its way up along the psoas under the ligamentum arcuatum and empty through the lung, or perforate the diaphragm at the hiatus and so reach the lung (page 487). We have seen it work along the under surface of the liver and point anteriorly at the costal margin. It may also rupture into the duodenum or colon, into the pericardial or peritoneal cavities, into the ureter, bladder or urethra, into the vagina, or passing through the sacrosciatic foramen may point in the buttock, or burrowing beside the femoral vessels may point on the anterior surface of the thigh.

The Suprarenal Glands.—The right gland is on the upper anterior surface of the kidney, while the left is more on the upper inner surface above the hilum. The gland rests on the adipose capsule and is not attached to the kidney, so that when the fatty capsule is stripped off in removal of the kidney the suprarenal gland is left behind. They lie opposite the eleventh and twelfth dorsal vertebræ

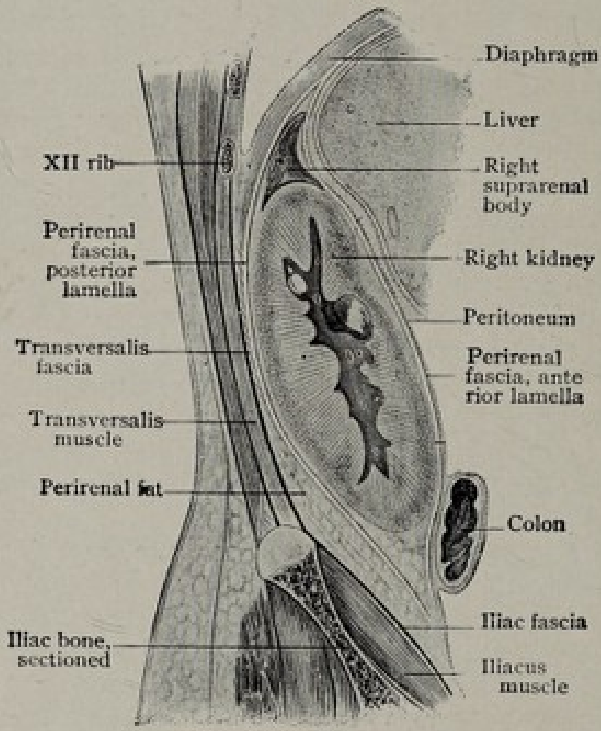


Fig. 474.—Diagrammatic longitudinal section, showing relations of supporting tissue to right kidney. (Gerota.)

and are 5 to 6 cm. (2 to 2½ in.) apart. A needle thrust into the eleventh interspace close to the spine would penetrate the suprarenal. The right one lies behind the foramen of Winslow. The arterial supply of the suprarenals is from three sources, the phrenic and renal arteries of the corresponding sides and the aorta. On the right side the veins usually empty into the vena cava, sometimes into the phrenic and renal; on the left side they are tributaries of the renal. Surgical access may be had through a transverse incision starting below the twelfth rib at the margin of the erector spinæ muscle and extending nearly to the rectus. The twelfth rib should be resected.

Renal Pelvis and Ureter.—Functionally as well as developmentally these are one, being designed for the conveyance of the urine from the renal papillæ to the bladder. From end to end, and the major and minor calyces are to be included in the "pelvis," the tract is a mucosa-lined muscular tube along which the urine is made to flow by peristaltic waves, aided to some extent by gravity. This has become increasingly clear during the last few years through study of urograms (intravenous injection). Even the minor calyces have recurrent systoles and diastoles.

Pelvis and calyces conform to no fixed normal in arrangement and contour.

We may say that to be considered normal they must be of such a character as to evidence the ability to empty themselves. If examination shows that this is not being done, pathology is present and the cause is to be sought. The arrangement may be various. Usually there are two or three major calyces opening from the pelvis, and each of these in turn drains one or more minor calyces; but number, form and arrangement vary (Fig. 475). Also there is marked variation in the

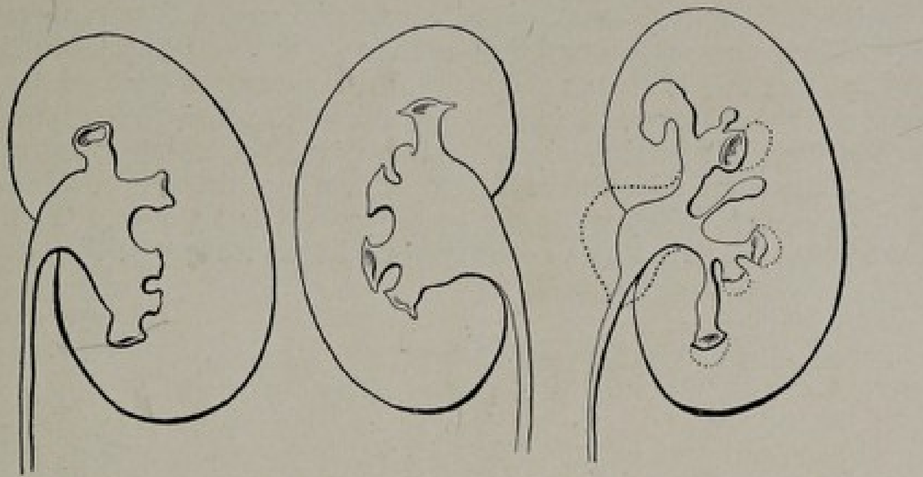


FIG. 475.—Relation of renal pelvis to parenchyma. The dotted line in illustration at the right shows the manner in which an "intrarenal" pelvis may become "extrarenal" when the ureter is obstructed.

position of the pelvis in reference to the kidney—whether it is an "extrarenal" or "intrarenal" pelvis, a matter of much importance to the surgeon planning to remove a pelvic calculus, as in the former case a pyelotomy would probably be easy, in the latter difficult or impossible. Preoperative knowledge must depend on an accurate interpretation of X-ray films. The posterior surface of the pelvis is usually freer of bloodvessels than the anterior, and is therefore the point of election for pyelolithotomy.

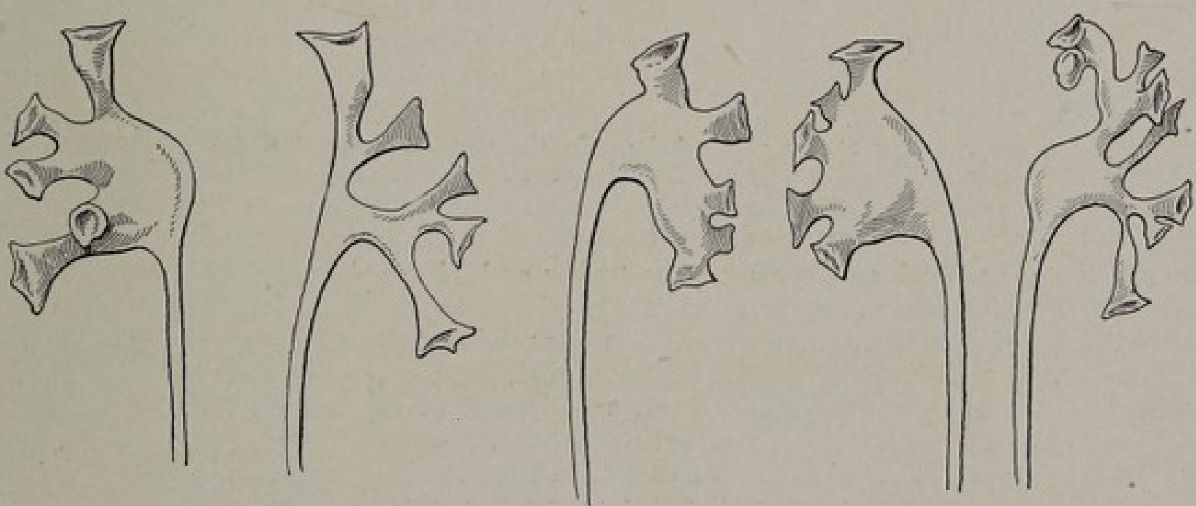


FIG. 476.—Types of renal pelves and calyces. All are "normal".

The *ureter*, usually from 25 to 30 cm. in length, and 3 to 6 mm. in diameter, runs from the kidney to the bladder in a somewhat undulant course. It is commonly described as consisting of a series of spindles, with one narrowing a short distance below the renal pelvis, a second at the point where it crosses the brim of the pelvis, at the bifurcation of the common iliac, about 15 cm. from the bladder, and a third in its terminal 5 cm., with its smallest lumen at the vesical orifice; but with the exception of the terminal constriction these findings are not constant. More-over, the ureteral walls are highly distensible, so that measurements vary widely in accordance with the energy with which the gauge is applied.

As the ureter descends from the kidney it parallels the spine, usually sweeping outward slightly as it approaches the brim of the pelvis to cross the sacroiliac joint. In the male it is crossed by the vas deferens and its vessels. In the female the uterine artery crosses it in the broad ligament 3 or 4 cm. above its lower extremity.

Throughout the greater part of its course the ureter lies in close proximity to the peritoneum, and may even be adherent to this membrane. But it is a mistake to assume that this is always the case, or that when the peritoneum is stripped up that the ureter will always be found adherent to its posterior surface. This frequently is the case, but particularly when there is periureteral inflammation, as in cases of impacted stone which have developed a ureteritis, and in tuberculosis, the ureter may be found tightly adherent to the posterior parietes. The X-ray has demonstrated that the ureter is so loosely placed that it may be displaced laterally

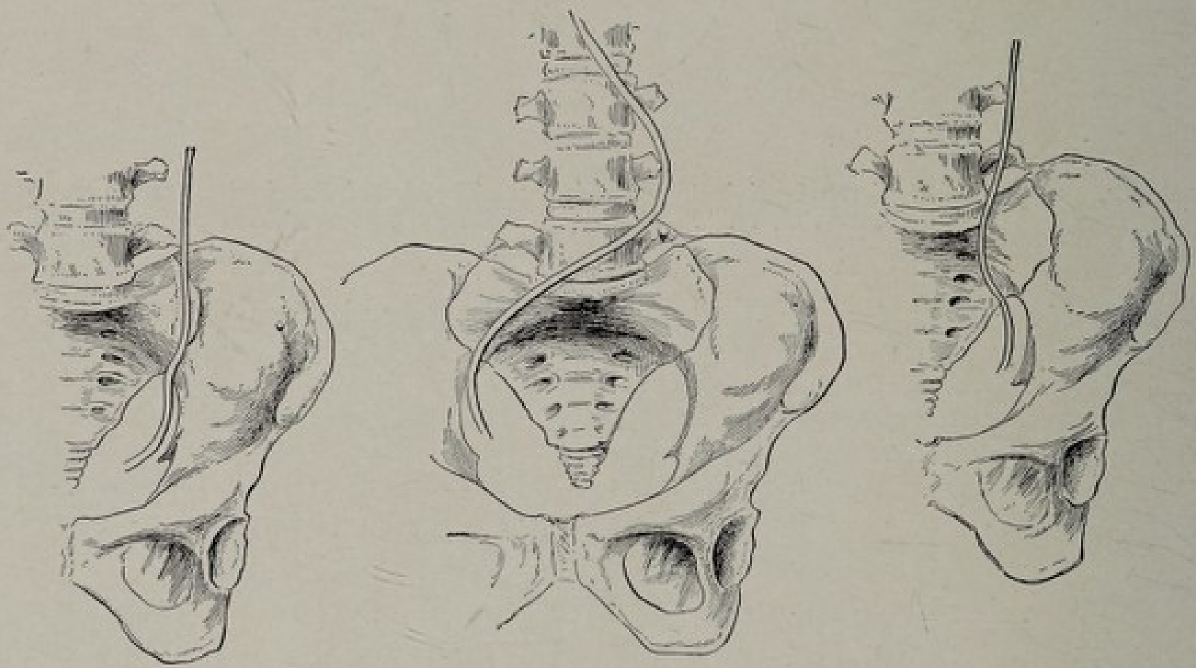


Fig. 477.—The ureter at the pelvic brim. In the central illustration the duct had been displaced by a huge hydronephrosis; it returned to the right side of the vertebral column after drainage with a ureteral catheter.

by a catheter as much as 5 cm.; a large tumor or hydronephrosis may carry it well across the midline of the body (Fig. 477).

The blood supply of the ureter comes in part from the renal vessels by way of the pelvis, in part by way of the bladder, and in part from small vessels which enter it at various points along its course. Division of the last set and the accompanying nerves does not interfere with nutrition.

OPERATIONS ON THE KIDNEY AND URETER

The abdominal musculature is so arranged that for satisfactory exposure of the kidney or upper part of the ureter the section of muscular fibre is necessary. (The intermuscular and intramuscular incisions, save in exceptional instances, give inadequate exposure and will therefore not be described.) Fortunately, the healing of the muscles divided in these incisions is rapid and strong, so that if care be used to avoid nerve injury a weakened abdominal wall is not to be feared. In addition to the avoidance of injury to *important nerves* (twelfth thoracic, iliohypogastric and ilioinguinal) in incising the parietes for the exposure of the kidney one must guard the *pleura* which extends below the inner half of the twelfth rib. The lower two thirds of the ureter may be operated upon without the division of muscle fibres or injury to motor nerves. Figs. 220, 233, 412 to 416, and 434 to 438 are illustrative of the parts involved in these incisions.

The most generally useful incision for renal operations starts over the *eleventh intercostal space* at the outer margin of the erector spinae muscle and passes downward and outward in a slightly curved course till it is 1 inch above the highest point on the crest of the ilium, when it turns forward and inward to parallel this bone. While the incision usually stops 5 to 10 cm. (2 to 4 inches) from the anterior superior spine of the ilium, in exceptional instances it may be carried even past this point.

Deepening the incision, at the upper end one encounters the *latissimus dorsi*, and beneath it at the extreme upper limit of the wound a few fibres of the *serratus positicus inferior*. Farther down the external oblique, internal oblique and transversalis muscles come into view in successive layers; all must be divided. When cutting the deeper muscles care must be exercised to avoid injuring the twelfth thoracic, iliohypogastric or ilioinguinal nerve, all of which may lie in the course of the incision. In the upper part of the wound a well defined anterior layer of the lumbar fascia may be identified, or the operator may come down on the *transversalis fascia* without having recognized a lumbar aponeurosis. Having buttonholed and torn the transversalis fascia (well back so as to avoid the peritoneum) the pararenal fat appears in the wound. Under this fat lies the kidney surrounded by its fatty capsule and the fascia of Gerota. At this point the operator should determine whether he has sufficient room for his operative procedure, or whether additional space is desirable. If the latter be the case, especially if the kidney be firmly adherent high under the ribs, the needed room should be sought by dividing the *external arcuate ligament*, using the utmost care not to damage the diaphragm or pleura. The twelfth rib is thus mobilized. In the depths of the wound the structures likely to be injured are the peritoneum, the colon, the duodenum and the great vessels.

For ureteral exposure the incision must be made in accordance with the portion of the canal sought. For the upper ureter the incision is similar to that for the kidney. For the extreme lower portion (the lower 4 cm. [1½ in.]) a midline suprapubic incision, with paravesical dissection and displacement of the bladder inward, is best. To reach intermediate portions of the ureter muscle splitting "gridiron" incisions, placed at appropriate levels, may be used.

When operating on women through the muscle-splitting incision it is important to keep above the broad ligament. The ureter is crossed by the uterine artery close to the bladder.

Ureterointestinal Anastomosis.—Of the various operations proposed for implanting the ureter into the bowel those of Coffey have received the most favorable consideration. The basic principle is the same in his three operations—the insertion of the ureter into the bowel in such a manner that for a short distance it lies *between* the *muscularis* and the *mucosa*, so that the intraintestinal pressure will close the lumen of the ureter and protect it and the kidney from contamination.

THE PELVIS

The pelvis is composed of the two *innominate bones*, the *sacrum*, and the *coccyx*. It is constructed with a view to connecting the lower extremities with the trunk, to support the weight of the trunk and to promote locomotion, to act as a receptacle and protector of the pelvic viscera and to fulfil the function of parturition.

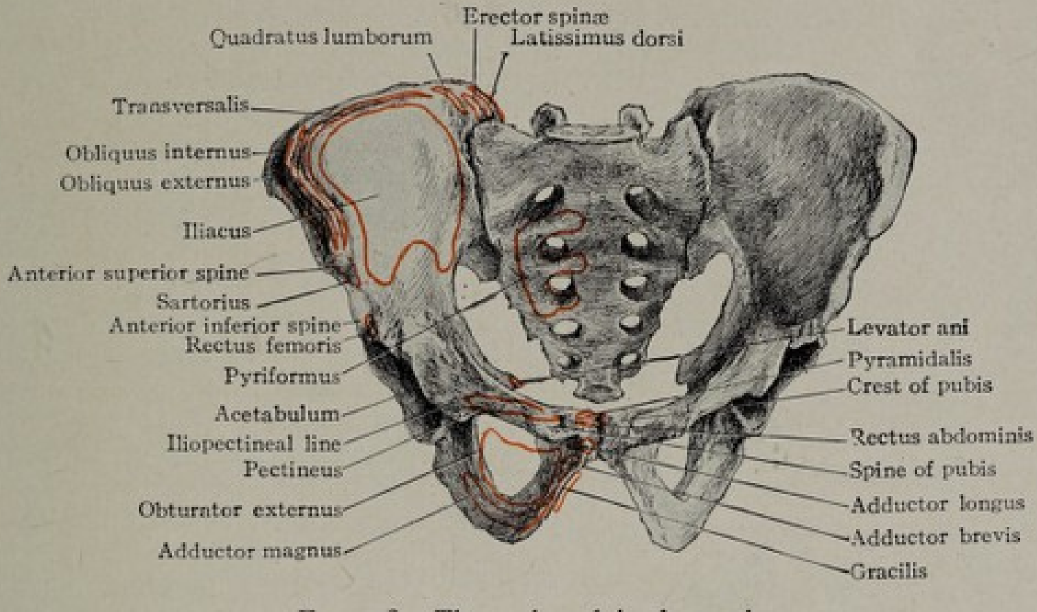


FIG. 478.—The male pelvis, front view.

In infancy locomotion and parturition are in abeyance, hence the pelvis is undeveloped, the bladder and uterus are almost entirely in the abdomen, and the rectum is almost straight. As the child begins to use its lower limbs for locomotion the pelvis increases progressively with the growth of the lower extremities, and with

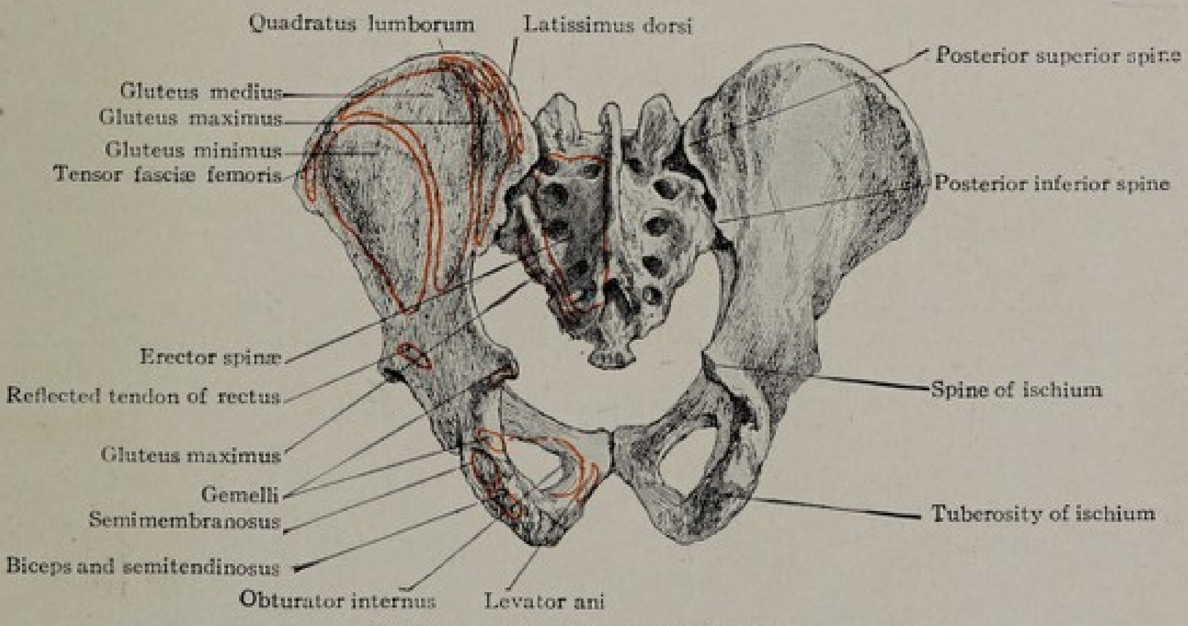
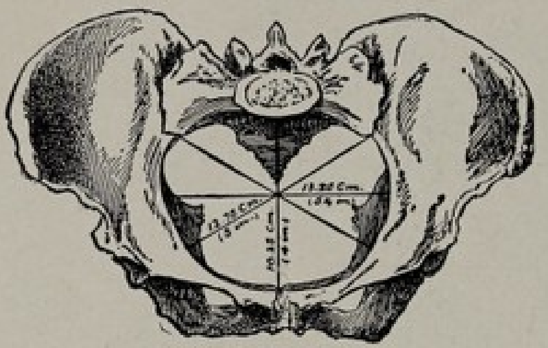


FIG. 479.—The male pelvis, back view.

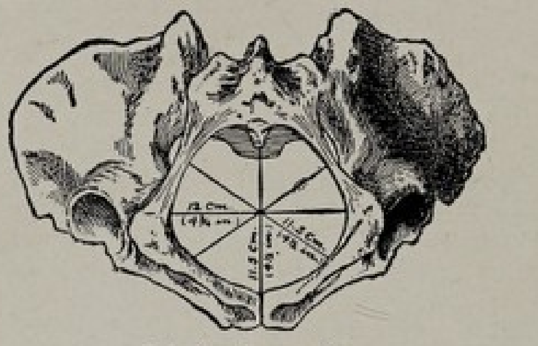
the advent of puberty its development is completed. The structure of the pelvis in relation to the function of locomotion will be considered later in connection with the pelvic girdle and lower extremity; here we will consider it in relation to the pelvic viscera and their functions.

That part of the pelvis above the iliopectineal line has been called the *false pelvis*, while that below is the *true pelvis*. The *inlet* of the pelvis is formed anteriorly by the crest and spine of the pubes, the iliopectineal lines on the sides, and the base of the sacrum with its promontory posteriorly. The *outlet* is formed by the pubic arch anteriorly with the symphysis in the middle, the rami of the pubes and ischia on the sides, and the great sacrosciatic ligaments and coccyx posteriorly. The viscera above the inlet are abdominal, those below are pelvic. When the body is vertical the inlet forms an angle of 60 degrees with the horizon, and the promontory of the sacrum is 9 to 10 cm. (3½ to 4 in.) above the upper edge of the symphysis.

The **male pelvis** is fashioned preëminently for locomotion: it is both heavier and rougher; the false pelvis is broad and shallow while the true pelvis is deep and narrow and its capacity is less. The inlet is heart-shaped, the tuberosities closer together, and the pubic arch narrower. The obturator foramen is oval (see Figs. 478 and 479).



Superior view, inlet.



Inferior view, outlet.

FIG. 480.—The female pelvis, superior and inferior views, with the diameters of the inlet and outlet.

The Female Pelvis.—In addition to the functions common to the two sexes the female has that of child-bearing. To fulfil this the female pelvis is different from that of the male. It is smoother, its bony prominences not being so marked (see Fig. 480). The extreme width of the pelvis does not differ much in the two sexes, some authorities giving them as of equal size and some stating that the female is slightly narrower. Its cavity is larger and shallower. The symphysis pubis is narrower and the sacrum is shorter and less curved. The acetabula are set wider apart as are also the tuberosities. This causes the thyroid foramen to be triangular in the female while it has a long diameter parallel with the long axis of the body in the male. It also causes the subpubic angle to be greater in the female, forming an angle of about 90 degrees as against 65 degrees to 70 degrees in the male. The inlet of the female pelvis is more oval and not so heart-shaped. The cavity is largest at a level between the second and third sacral vertebræ posteriorly and the middle of the symphysis anteriorly. It is smallest between the sacrococcygeal articulation behind and the lower third of the symphysis in front, and the spines of the ischia on the sides. There are three diameters of the pelvis used in obstetrics.

Dwight, in "Piersol's Anatomy," gives them as follows:

	MALE.			FEMALE.		
	Inlet. cm. (in.)	Cavity. cm. (in.)	Outlet. cm. (in.)	Inlet. cm. (in.)	Cavity. cm. (in.)	Outlet. cm. (in.)
Anteroposterior .	10.25(4)	11.5(4½)	8.25(3¼)	10.25(4)	12.75(5)	11.5(4½)
Transverse	12.75(5)	12.0(4¾)	9.00(3½)	13.25(5¼)	12.75(5)	12.0(4¾)
Oblique	12.00(4¾)	11.5(4½)	10.25(4)	12.75(5)	13.25(5¼)	11.5(4½)

Sacro-iliac Articulation.—The sacrum is wider in front than behind and larger above than below. This causes it to be wedged between the two ilia where it is firmly held by the sacro-iliac ligaments, the irregularity of the joint surfaces and the thinness of the cartilaginous layer. A small amount of movement is possible in most cases: it takes place around a transverse axis about opposite to the second sacral foramina. If relaxation of the ligaments occurs through pregnancy, osteo-arthritis or the stress of strains due to occupation, etc., symptoms of looseness and discomfort appear which demand relief. Flexion produces pain. Treatment consists in fixing the joints by firm belts around the pelvis or applying a low plaster of Paris jacket or spinal corset or brace which both compresses the pelvis and fixes the lumbar spine and prevents movements in both antero-posterior and lateral directions.

The cavity of the pelvis is narrowed somewhat by the soft parts on its sides. The blood-vessels, nerves, and obturator muscles are placed laterally and so usually escape injury. In pregnancy the venous flow is most often interfered with. The first evidence of this is the dusky hue of the vagina; hemorrhoids and varicosities of the veins of the external genitals and lower extremities are common. The rectum and bladder being placed more anteroposteriorly, interference with their functions is frequent. The peculiarities of the female pelvis are evident from birth and are not solely acquired with age.

Pelvic Walls.—On looking laterally at the inside of the pelvis, the iliopectineal line is seen separating the abdominal from the pelvic portion. On the iliac or abdominal portion lie the iliacus and psoas muscles. Below the iliopectineal line

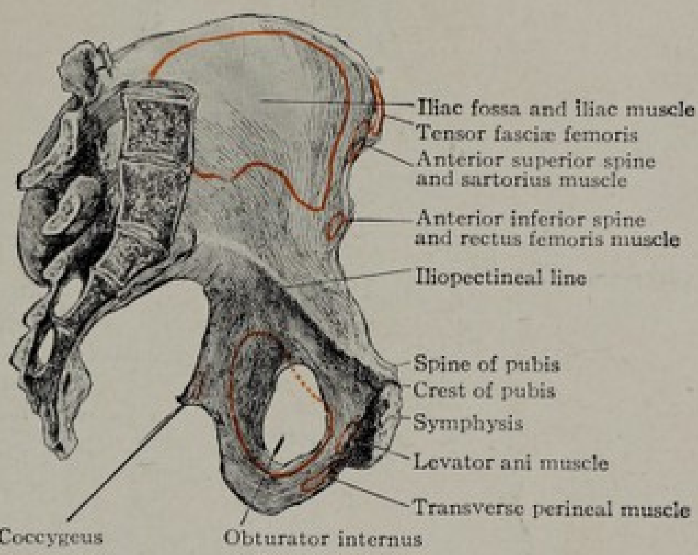


Fig. 481.—View of the pelvis from the inside.

anteriorly is the body of the pubis with the symphysis in the median line. The descending ramus of the pubis passes down to be continuous with the ramus of the ischium to the tuberosity. A short distance above the tuberosity is the spine of the ischium. Posteriorly are the five vertebræ of the sacrum and the four of the coccyx. Passing upward from the tuberosity of the ischium to the sacrum is the *great sacrosciatic ligament* (*ligamentum sacrotuberosum*); passing backward from the spine of the ischium to the sacrum and coccyx is the *lesser sacrosciatic ligament* (*ligamentum sacrospinosum*). The large opening above the lesser sacrosciatic ligament is the *great sacrosciatic foramen*. Through it pass the pyriformis muscle, with the gluteal vessels and superior gluteal nerve above, and, below, the sciatic vessels and nerves, the internal pudic vessels and nerve, the inferior gluteal nerve, and the nerves to the obturator internus and quadratus femoris. The smaller opening below the lesser sacrosciatic ligament is the *lesser sacrosciatic foramen*, through which pass the tendon of the obturator internus, the nerve to it, and the internal pudic vessels and nerve. In front of these two foramina is a third, the *obturator*. It is closed by a membrane except at its upper inner portion, which gives exit to the obturator vessels and nerve. Attached to the inner surface of this membrane is the origin of the obturator internus muscle and to its outer surface the obturator externus (Fig. 481).

Pelvic Floor.—The pelvic outlet is closed by two muscles, the levator ani and coccygeus. These on each side constitute the pelvic floor. The coccygeus is a comparatively small muscle passing from the spine of the ischium to the coccyx. The *levator ani* is the main muscle which supports and retains the pelvic and abdominal viscera in their normal positions. It arises from the "white line"—which is a thickening of the pelvic fascia extending from the posterior surface of the pubes in front to the spine of the ischium behind—and descends to be attached to the coccyx posteriorly, then around the lower portion of the rectum just above the external sphincter and, farther front, surrounds the vagina of the female or the prostate gland in the male. The part surrounding the prostate has been called the *levator prostatæ*. The anterior edge of the levator ani muscle reaches to the central tendon of the perineum (Fig. 482).

Pelvic Herniæ.—Hernial protrusions of the pelvic contents may occur through the upper portion of the obturator membrane, following the vessels and nerve. This

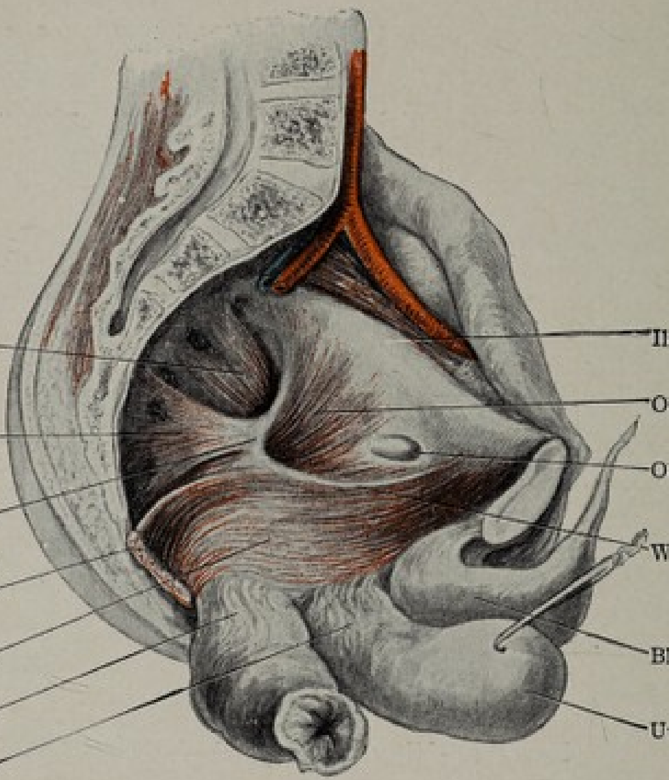


Fig. 482.—Levator ani muscle and interior of pelvis; the bladder, uterus and vagina, and rectum have been loosened and turned down.

is called an *obturator hernia*. The sac is usually to the medial or inner side of the vessels and nerve. It makes its appearance in Scarpa's triangle and is covered by the pectineus muscle. Death has frequently occurred in these cases from strangulation. *Sciatic hernia* is the name given to those forms in which the intestine escapes through the great sciatic notch, passing just above or just below the pyriformis muscle. *Perineal herniæ* are those which work their way downward in other places. Thus the sac may push down between the rectum and bladder and bulge in the perineum. It may pass between the coccygeus and levator ani muscles or between the fibres of the latter and bulge into the ischiorectal fossa or forward into the labium of the female.

Prolapse.—The rectum and vagina as they pierce the pelvic floor may prolapse or protrude through the anus or vulva. Prolapse of the *rectum* is a common affection and if marked may drag down the peritoneum so that some coils of small intestine may be around the prolapsed part. In childbirth the pelvic outlet is frequently torn and the *vagina* prolapses and may drag the uterus down with it, or, the support being lost, the uterus descends and drags the vagina with it and everts it. The vaginal outlet, if much relaxed, allows the rectum to bulge downward and forward, forming a *rectocele*, or the bladder may bulge downward and backward, forming a *cystocele* (see Fig. 482).

The Pelvic Fasciæ.—As the iliac fascia passes over the brim of the pelvis it covers the internal obturator muscle on the walls of the pelvis, hence it is called the *obturator fascia*. From the upper posterior surface of the arch of the pubes anteriorly to the spine of the ischium posteriorly this obturator fascia is thickened, forming the *"white line"* to give origin to the levator ani muscle. At the white line the obturator fascia gives off a visceral layer—the rectovesical fascia—which covers the inner or upper surface of the levator ani, then a second layer, the *anal fascia*, covering the under or outer surface of the levator ani muscle, while the obturator fascia itself is continued down on the obturator internus muscle to form the outer wall of the ischiorectal space. The *rectovesical fascia* passes downward and inward over the levator ani muscle to cover the pyriformis and coccygeus muscles behind, then the rectum, vagina, and bladder in front. In the male it covers the prostate gland, forming its sheath, and at its anterior portion forms the deep or posterior layer of the triangular ligament of the perineum. This pelvic fascia acts as a barrier between the abdominal and pelvic cavities above and the

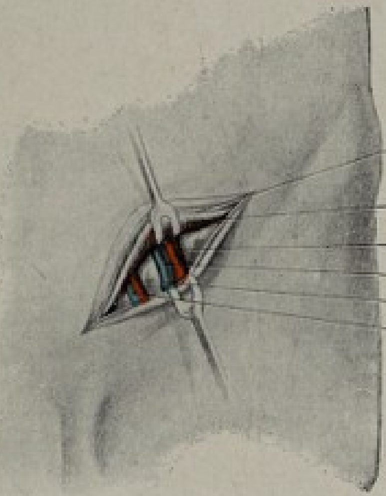


FIG. 483.—Ligation of the external iliac artery.

perineal region below. Pus originating above it tends to form an abscess which rises toward the abdominal cavity, and pus originating below it tends to work toward the surface in the perineum.

Iliac Vessels.—The *iliac arteries* commence at the bifurcation of the aorta on the left side of the disk between the third and fourth lumbar vertebræ. This is 2 cm. (3/4 in.) below and to the left of the umbilicus and on a level with a line joining the highest points of the iliac crests. They run in a line drawn from this point to midway between the anterior superior spine of the ilium and the symphysis pubis. This is to the inner side of the middle of Poupart's ligament. They are about 15 cm. (6 in.) in length, the upper third, 5 cm. (2 in.), being the common iliac and the lower two-thirds, 10 cm. (4 in.), being the external iliac arteries. The internal iliac comes off opposite the sacro-iliac joint on or a little above a line joining the anterior superior spines. The right common iliac artery is a little the longer because it comes from the left side of the vertebral column, and the left common iliac vein is the longer because it goes to the right side. The *left iliac veins* lie to the inner side of the left iliac arteries in their entire course. The *right iliac vein* starts at the inner side of the right external iliac artery and then passes behind it to reach the vena cava on the right side of the vertebral column. The ureters cross the iliac arteries at their bifurcation, and in the female are accompanied by the ovarian arteries and veins. The genitocrural nerve passes downward on the external iliac artery and goes with it beneath Poupart's ligament. Lymphatic nodes accompany the iliac vessels and drain the lower extremity, the abdomen below the umbilicus and the pelvic viscera.

Ligation of the Iliac Arteries.—The iliac arteries can be reached for ligation through an incision 2 cm. above and parallel to Poupart's ligament, reaching

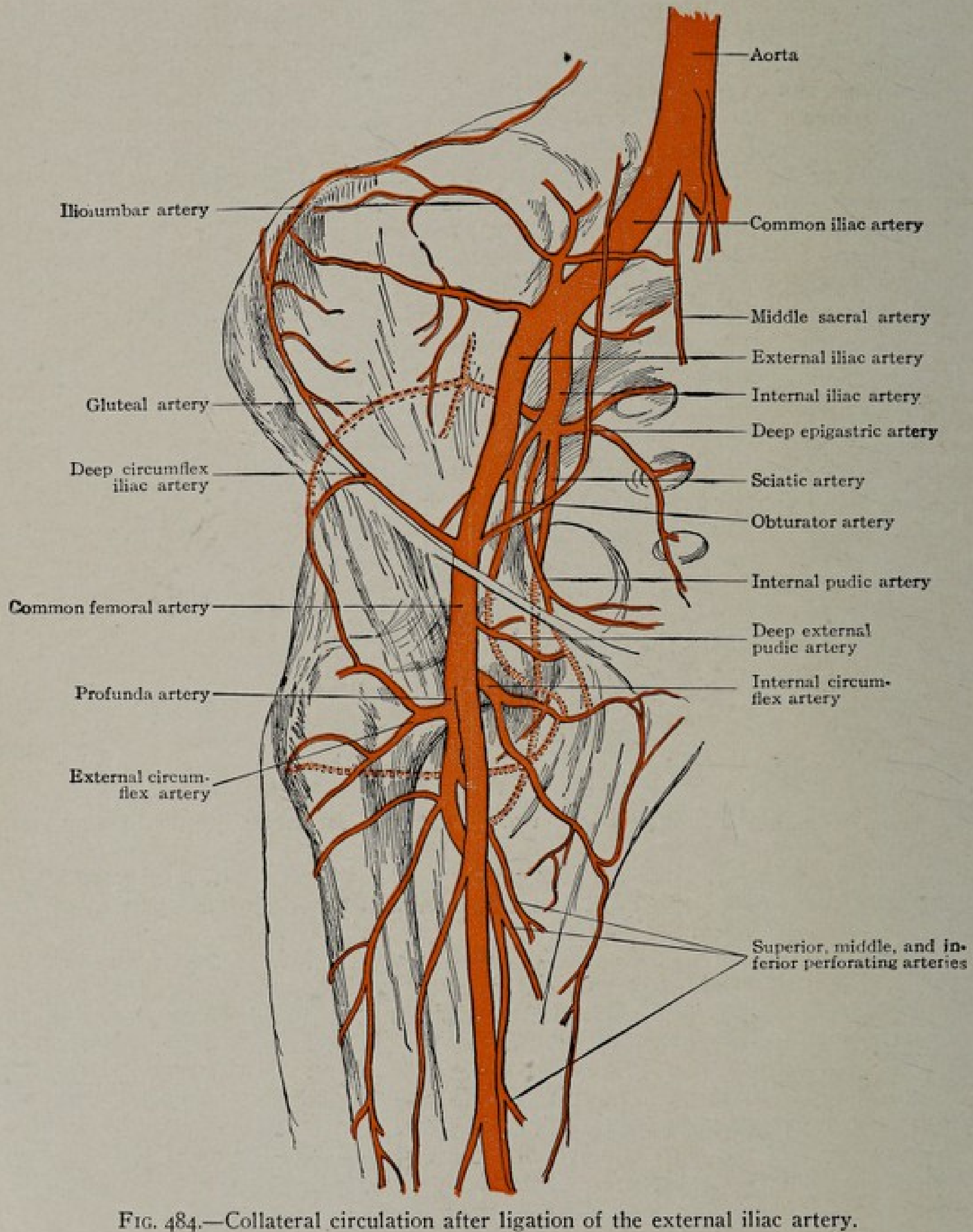


Fig. 484.—Collateral circulation after ligation of the external iliac artery.

from the inner side of the external iliac artery to above the anterior superior spine if necessary. If the external iliac only is to be ligated this can be done through a comparatively small incision, but if it is desired to reach the internal or common iliac then the incision must be quite large. When the peritoneum is reached it is lifted up from the iliac fascia beneath and the external iliac artery followed up as far as desired. When the peritoneum is raised the ureter is usually lifted with it; it will be encountered crossing the point of bifurcation of the common iliac into the external and internal iliacs. The relation of the veins to the iliac artery on the two sides is to be borne in mind when passing the needle (Fig. 483).

Collateral Circulation (Fig. 484).—When the external iliac artery is ligated the following anastomoses occur:

Iliolumbar	with deep circumflex iliac
Gluteal	with external circumflex
Obturator	with internal circumflex
Sciatic	with superior perforating
Internal pudic	with deep external pudic
Internal mammary, intercostals, and lumbars	with deep epigastric

Ligation of the iliac arteries by a transperitoneal instead of subperitoneal route has been advocated by Dennis (1886). This lessens the danger of wounding the deep circumflex iliac and deep epigastric arteries, the vas deferens, the ureter, puncturing the veins and loosening up the subperitoneal tissue. Treves has used a median incision from the umbilicus to the pubes.

THE PELVIC VISCERA

RECTUM AND ANAL CANAL

The **rectum** extends from the level of the third sacral vertebra to where it pierces the levator ani muscle, 3.7 cm. (1½ in.) in front of the tip of the coccyx,

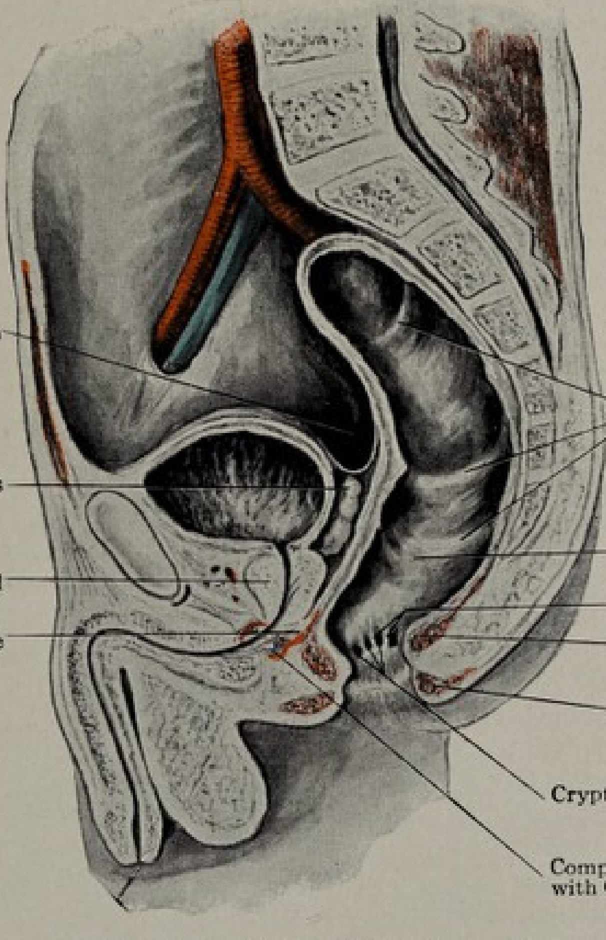


Fig. 485.—Rectum and anal canal.

but at a lower level, and opposite the lower and anterior part of the prostate. It is 8.75 cm. (3½ in.) long and passes into the anal canal; this latter is 2.5 to 4 cm. (1 to 1½ in.) long, and extends to the skin border (Fig. 485).

When collapsed the rectum appears as a nearly straight tube following the curve of the sacrum, but when distended it becomes distinctly sacculated. It possesses an external longitudinal and internal circular layer of muscular fibres. The longitudinal fibres are continuous with those on the colon but instead of being composed of three bands are fused together into two bands, anterior and posterior. On the sides the longitudinal fibres are not so abundant. The circular fibres are continuous on the anal canal as the internal sphincter. For the distance of 4 cm. (1½ in.) between the tip of the coccyx and its termination, the rectum lies on the two levator ani muscles, which join in the median line. The lower portion of the rectum is larger than the upper and is called the *ampulla*.

The anterior surface of the rectum at the ampulla lies against the posterior surface of the prostate but is not intimately adherent to it. At the apex of the prostate the anterior rectal wall makes a more or less sharp turn backward. At this part the rectum and the prostate are embraced by the fibres of the levator ani muscle, which practically blend with the compressor urethræ muscle and surround the membranous urethra. The muscular fibres passing from the longitudinal layer of the rectum to the membranous urethra have been called by Proust the *recto-urethralis muscle*; they keep the lower extremity of the ampulla of the rectum in close approximation to the apex of the prostate. This is the part of the rectum which has been frequently wounded in the operations of perineal lithotomy and prostatectomy. In the latter operation division of this band allows the rectum to be pushed back and exposes the apex of the prostate.

The sacculation of the rectum is produced by three creases or crescentic folds, called the *rectal valves* or *valves of Houston* (*Dublin Hospital Reports*, 1830). Of these the middle is the largest. It springs from the right anterior quadrant about 5 to 6 cm. (2 to 2¼ in.) above the margin of the anal canal. The superior and inferior valves spring from the left posterior quadrant a short distance above and below the middle valve. At the juncture of the rectum and sigmoid flexure there is another fold on the anterior wall which tends to obstruct the view in making examinations. These valves are composed of connective tissue and circular muscular fibres covered with mucous membrane.

Peritoneal Relations.—The posterior portion of the rectum has no peritoneal covering, the mesosigmoid ceasing opposite the third sacral vertebra, about 12.50 cm. (5 in.) from the anus. From this point the peritoneum slopes downward and forward, covering the sides and anterior surface of the rectum 5 cm. (2 in.) lower. The peritoneum is here reflected forward over the bladder in the male forming the rectovesical pouch and over the vagina and uterus in the female forming the pouch of Douglas. It is within 7.5 to 8.5 cm. (3 to 3½ in.) of the anus. This leaves 2.5 cm. (1 in.) or more above the prostate which is not covered by peritoneum. It was through this space that the bladder was formerly tapped with a trocar to relieve it when distended. The peritoneum on the sides is less firmly attached to the rectum and pelvic colon than it is on its anterior surface.

Rectal Examination.—The finger can palpate the anal canal and rectum for a distance of 10 cm. (4 in.) from the surface. Anteriorly as soon as the finger passes the sphincters the apex of the prostate can be felt; also the membranous urethra, particularly if it contains a bougie or sound. The prostate can be outlined and its size determined. If the prostate is not enlarged the base of the bladder above can be palpated and the tip of the finger will reach the rectovesical pouch. From the upper or posterior edge of the prostate and extending from near the midline upward and outward are the seminal vesicles, sometimes the seat of tuberculous disease. Just to the outer side of the upper end of the seminal vesicles are the lower ends of the ureters. Should a ureteral calculus become impacted at this point it might possibly be felt through the rectum. Posteriorly the coccyx and the hollow of the sacrum can be felt. The segments of the coccyx frequently are luxated or fractured and it is the seat of pain—coccygodynia—for which excision is done. These injuries cause either an ankylosis or a deformity of the coccyx which can often readily be detected by a finger internally and the thumb externally. Laterally the finger can explore the region of the spine of the ischium, the sacrosciatic foramina, and the tuberosities. If a patient is placed in the knee-chest position and a speculum is introduced the rectum immediately distends with air and its interior is visible as far as the promontory of the sacrum. By means of extra long tubes even the sigmoid loop can sometimes be seen. The valves of Houston are readily seen through the speculum.

In introducing tubes and bougies for examination or therapeutic purposes the greatest care is necessary, as death has not infrequently resulted from perforation into the peritoneal cavity.

The Anal Canal.—This extends from the rectum to the anus or its opening on the skin, a distance of 2.5 to 4 cm. (1 to 1½ in.). It begins at the level of the levator ani muscles and has the apex of the prostate directly in front of it and the tip of the coccyx behind and a little above. With the body vertical the anal canal has its axis inclining upward and forward toward the bladder; as soon as the sphincter ani is passed the axis of the rectum changes to upward and backward toward the hollow of the sacrum. In introducing a speculum it should always be inclined first anteriorly and then posteriorly. Opposite the level of the levator ani the circular muscular fibres increase to form the *internal sphincter.* This extends down the anal canal for a distance of approximately 2.5 cm. (1 in.) and ends above the skin margin or, as it has been called, the "white line of Hilton." The *external sphincter* surrounds the lower part of the canal and stretches in a spindle shape from the tip of the coccyx to the central point or tendon of the perineum. Anteriorly it blends with the fibres of the levator ani and the other muscles of the perineum. It is a thick, powerful, voluntary muscle and extends outward from the white line of Hilton or mucocutaneous junction.

Mucous Membrane.—The upper half of the mucous membrane of the anal canal has six or eight longitudinal ridges or folds called the *columns of Morgagni or Glisson.* Between the lower ends of these columns are small hollows called the *crypts of Morgagni,* and the free edges of the mucous membrane guarding the crypts are the *anal valves.*

Blood-Vessels

Arteries.—The rectum and anal canal are supplied by the superior, middle, and inferior hemorrhoidal, and middle sacral arteries (Fig. 486).

The *superior hemorrhoidal artery* is the terminal branch of the inferior mesenteric. It descends in the pelvic mesocolon until it reaches the rectum, when it divides into two lateral branches. These descend on its surface to about its middle, when they subdivide into six or eight branches which pierce the muscular coat and descend in the submucosa, one beneath each column of Morgagni. At the lower end of the rectum and anal canal they anastomose with the terminal branches of the middle and inferior hemorrhoidal arteries.

The *middle hemorrhoidal arteries,* one on each side, come from the anterior branch of the internal iliac. They descend on the lower part of the rectum and supply the posterior portion of the bladder and vagina, or prostate and seminal vesicles, the lower anterior half of the rectum and upper part of the anal canal, and anastomose with the superior hemorrhoidal branches above and the inferior hemorrhoidal below.

The *inferior hemorrhoidal arteries,* two or three on each side, are given off from the internal pudic while in Alcock's canal, at the outer posterior portion of the ischiorectal fossa; they pass inward and downward to supply the outer surface of the levator ani and internal and external sphincters and lower portion of the rectum and anal canal. They anastomose with the middle and superior hemorrhoidals. They are distributed more to the posterior portion of the lower part of the rectum and anal canal while the middle is distributed more to its anterior portion.

The *middle sacral artery* passes down in the median line from the bifurcation of the aorta to the tip of the coccyx, where it ends in Luschka's gland. It gives a few branches to the rectum at its upper part but they are supposed not to go deeper than the muscular coat. It anastomoses with the superior hemorrhoidal.

Veins.—The veins of the rectum and anal canal accompany the corresponding superior, middle, and inferior hemorrhoidal arteries. They form two plexuses, an internal submucous plexus and an external plexus on the surface of the rectum. The internal plexus in the submucous coat begins at the anus in fine venous capillaries which pass upward, mainly in the columns of Morgagni, where they form small dilatations or pools and unite into larger branches which pierce the muscular walls about the middle of the rectum to empty into the main superior hemorrhoidal veins and thence into the inferior mesenteric.

The inferior hemorrhoidal veins receive branches from the anus and outer surface of the sphincters and levator ani muscles and pass thence to the internal pudic veins.

The middle hemorrhoidal vein drains the blood from the external hemorrhoidal plexus on the outer surface of the lower half of the rectum and empties into the internal iliac. It anastomoses with the superior hemorrhoidal above, at about the

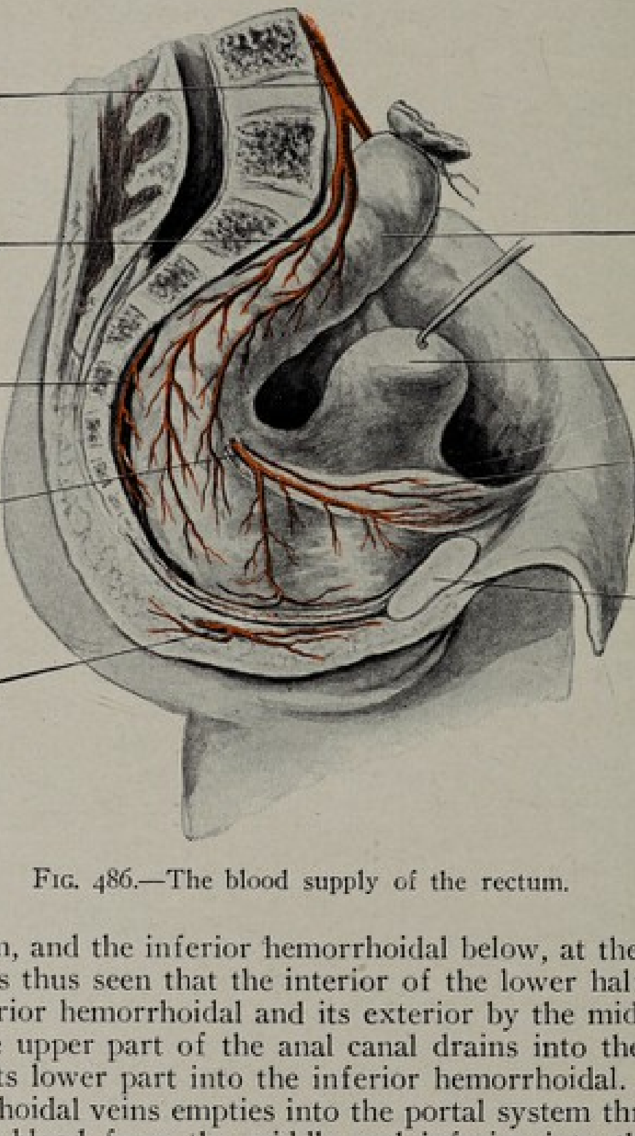


FIG. 486.—The blood supply of the rectum.

middle of the rectum, and the inferior hemorrhoidal below, at the upper portion of the anal canal. It is thus seen that the interior of the lower half of the rectum is drained by the superior hemorrhoidal and its exterior by the middle hemorrhoidal. The blood from the upper part of the anal canal drains into the superior hemorrhoidal, that from its lower part into the inferior hemorrhoidal. The blood from the superior hemorrhoidal veins empties into the portal system through the inferior mesenteric, and the blood from the middle and inferior into the general venous system through the internal pudic, internal iliac, and inferior cava. These veins are usually regarded as being without valves, though the opposite view is held by some.

Lymphatics.—According to Poirier and Cunéo there is a superior group accompanying the superior hemorrhoidal vessels and draining the mucous membrane of the anal canal and rectum and terminating in the nodes of the pelvic mesocolon after traversing the pararectal lymph-nodes; also a middle group partly communicating with the above through the pararectal lymph-nodes while the remainder accompany the middle and inferior hemorrhoidal vessels and drain the lower part of the anal canal above the white line. A third group comes from the skin of the margin of the anus and drains into the inguinal nodes. The pararectal (anorectal of Gerota) nodes may become enlarged in cases of nonmalignant ulcer and can be felt in the region of the ampulla by the finger introduced through the anus, thus leading to a mistaken diagnosis of carcinoma (Fig. 487).

Nerves.—The anus is supplied by the inferior hemorrhoidal branch of the internal pudic nerve, which, as shown by Hilton, crosses the ischiorectal space on the outer surface of the levator ani muscle and passes between the internal and external sphincters to emerge between them at the white line, from whence it sends filaments up on the mucous membrane and down on the skin. This explains the great sensi-

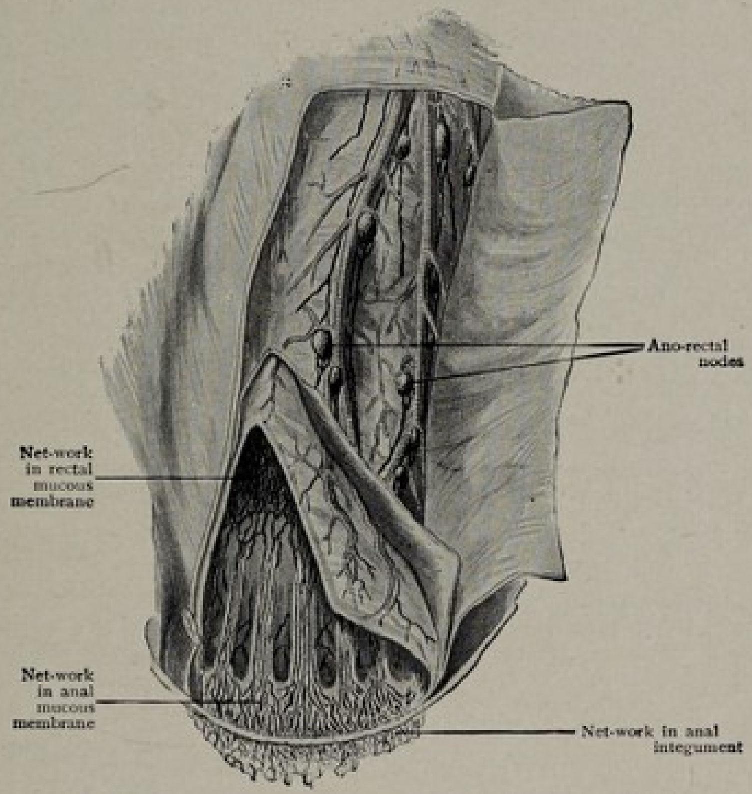


FIG. 487.—Lymphatics of rectum. (Gerota.)

tiveness of the region. It also supplies the external sphincter, hence the association of spasm with pain.

AFFECTIONS OF THE RECTUM AND ANUS

Examination.—If the buttocks are drawn aside the mucous membrane of the anus is everted and a considerable portion of the anal canal becomes visible. The lower part of the columns and crypts of Morgagni and the anal valves are seen. If the patient strains or bears down, the mucous membrane of the anal canal is brought into view in almost its entire length. One is thus enabled to see dilated veins or hemorrhoids, ulcers, fissures, foreign growths, both benign and malignant, and the openings of fistulæ. By means of a speculum the entire anal canal can be seen. It should be introduced pointing obliquely anteriorly, and if it is desired to view the interior of the rectum above after it has passed the internal sphincter it is to be directed obliquely upward and backward. In digital examination the first resistance encountered is that of the external sphincter; as its edge is passed a sulcus can often be felt, immediately following which the internal sphincter is passed and the finger enters the rectum. The sulcus is about opposite the crypts of Morgagni and is formed by the interval between the contraction of the external sphincter below and the internal sphincter blended with the insertion of the levator ani above. It is just above Hilton's white line.

Imperforate Anus.—In an early stage of the development of the embryo the cloaca is the common termination of the genito-urinary system and the intestinal canal. Later the cloaca becomes divided by a septum into the urogenital sinus in front and the rectum behind. A depression in the skin called the anal pit appears opposite the rectum and the membrane between disappears in the fourth month. This membrane is produced by the growing together of the ectoderm and entoderm, the mesoderm being pushed aside. The failure of this membrane to perforate forms imperforate anus. The method of development explains the various malformations of these parts. The anal pit may be absent; the membrane may not perforate; the rectum may end in a blind pouch some distance up from the anus; or it may discharge through a sinus into the bladder or vagina.

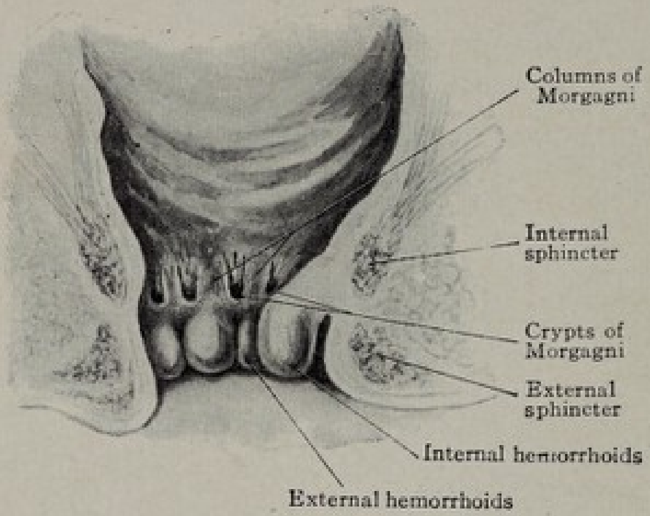


Fig. 488.—Hemorrhoids.

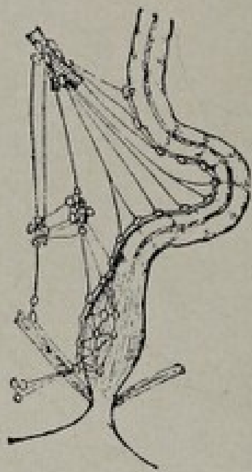


Fig. 489.—Schematic representation of the extramural lymphatic system of the rectum and pelvic colon.

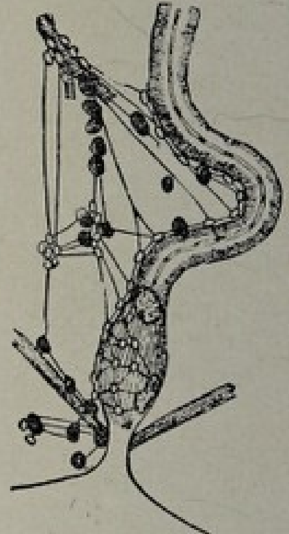


Fig. 490.—Map showing the various positions in which metastatic deposits and postoperative recurrent growths have been found to occur. The ischiorectal fat, the levators ani, and the pelvic mesocolon (particularly the parietal border) are exceedingly vulnerable tissues.

Hemorrhoids.—Hemorrhoids or piles are varicosities or dilatations of the veins of the anus of anal canal. The middle hemorrhoidal veins are not enlarged because they do not drain the mucous membrane, they are not inside but outside the rectum. When the inferior hemorrhoidal veins are dilated they form external hemorrhoids and are situated at the margin of the anus below the white line and external sphincter, and they cannot be replaced in the rectum. When the superior hemorrhoidal veins are dilated they form internal piles (Fig. 488). The dilatation involves the superior hemorrhoidal veins from the beginning of the mucous membrane at the white line up the entire length of the anal canal and sometimes a short distance up the rectum. There is a natural tendency for external piles to be covered almost wholly by skin and for internal piles to be covered solely by mucous membrane. Inflamed internal piles can be pushed back in the rectum. If an internal pile is continued down over the white line or an external pile is continued up over the white line then they are called intero-external piles. Hemorrhoids consist almost wholly of dilated venous sinuses. The existence of arterial hemorrhoids is now denied although small arterial branches are sometimes encountered in the ordinary venous pile. The strawberry pile is composed of venous capillaries instead of the larger venous canals usually present. They bleed more freely than does the ordinary venous pile. When external hemorrhoids are operated on they are usually thrombosed. They are then incised and the clots turned out; at other times when not inflamed they are excised and the edges stitched with catgut or the wound packed. Internal piles are either ligated or treated with the clamp and cautery. In applying the ligature the base of the pile is loosened below near the white line and detached for some distance above and then ligated. This is facilitated by the loose attachment of the mucous membrane. Bleeding is not marked because the blood-vessels enter the pile from above. In Whitehead's operation, or excision of the pile-bearing area, the mucous membrane is readily separated by blunt dissection from the parts beneath owing to the laxity of the submucous tissue; it is then excised and the cut edge sewn to the skin at the anus.

Fistula.—Fistula in ano may start as an ischiorectal abscess which perforates internally into the rectum or anal canal and externally through the skin. It may also start as an ulcer of the mucous membrane of the rectum or crypts of Morgagni and then produce an ischiorectal abscess which finally opens on the skin. The most common site of the internal opening is just above the anus and below the insertion of the levator ani. This is in the groove between the external and internal sphincters. Sometimes, however, the fistula pierces the levator ani and opens into the ampulla of the rectum. As the external opening is usually to the outer side of the external sphincter this latter is divided in operating, as is also a part or all of the internal sphincter if the opening is high up. Incontinence of fæces is usually avoided if the sphincter is only divided at one place and at right angles to its fibres, not obliquely.

Anal fissures occur usually on the posterior wall of the anus associated with a hemorrhoid. Its location, involving the white line, explains its great pain.

Carcinoma.—Cancer of the rectum spreads in three ways: (*a*) By direct extension through the walls of the bowel, into the perirectal fatty tissue, and thence to the *fascia propria* at which time there begins fixation to the sacrum, prostate, bladder, uterus or vagina. (*b*) Through the venous return, the liver may become involved. (*c*) By means of the lymphatics. Miles describes the lymphatic spread quite clearly. (Figs. 489 and 490.)

"*The Zone of Downward Spread.*—The tissues contained in this lymph area are: the perianal skin, the ischiorectal fat, and the external sphincter muscle. Anatomically there is free intercommunication, through the ano-rectal glands, between the lymphatic plexuses of the wall of the rectum and those contained in the structures mentioned above; and consequently it is easy to understand how a cancer cell, detached from the main growth, may be carried by the lymph stream to a distant point in this area. It is also obvious that even an exhaustive microscopical examination, involving the cutting of a large number of sections, might fail to detect such isolated cancer cells. There is, however, abundant clinical evidence that the tissues in this area are very vulnerable to metastatic deposit and to post-operative recurrent growth.

"*The Zone of Lateral Spread.*—This lymph area embraces the following structures: the levatores and muscles, the retrorectal lymph-glands, the internal iliac glands, the base of the bladder and the vesiculæ seminales, and in the female, the posterior wall of the vagina, the cervix uteri, and the base of the broad ligament with Poirier's gland. Of these, the most important are the retro-rectal glands and the levatores ani muscles, as they are very frequently the seat of metastatic deposit in quite early cases.

"*The Zone of Upward Spread.*—This lymphatic area is the most important of the three, from the point of view of the spread of cancer from the rectum. The structures contained therein are: the pelvic peritoneum, especially that on either side of the parietal attachment of the pelvic mesocolon; the pelvic mesocolon in its entirety, the paracolic lymph-glands, and the group of glands situated at the bifurcation of the left common iliac artery.

"The most important avenues of invasion are the ischeorectal fat, the levatores ani muscles, the retro-rectal glands and the pelvic mesocolon."

Excision of the Rectum.—The operations performed for the removal of the rectum are numerous and mostly very complicated. They may be divided into (1) the perineal; (2) the trans-sacral; (3) the combined abdomino-perineal.

In the perineal operation the incision is made from near the base of the scrotum to the coccyx, surrounding the anus. If the incision is made near the white line the external sphincter is saved and turned to each side with the skin flap. The external sphincter is split anteriorly as far as the central point of the perineum and posteriorly to the coccyx. The rectum being drawn forward the levator ani muscle is cut through on its sides and posterior surface about 4 cm. (1½ in.) above the anus, the coccyx, if necessary, being excised. The rectum is then drawn back, the finger slipped beneath the anterior portion of the levator ani, which is farther from the surface than the posterior, and it is divided. These fibres practically constitute the recto-urethralis muscle of Proust. This is near the apex of the prostate; from here up to the peritoneal reflection or rectovesical pouch the rectum is loosely attached but at that point it is necessary to divide the rectal fascia (a part of the rectovesical fascia, p. 501) on the sides, where it passes as two strong fibrous lateral pelvi-rectal

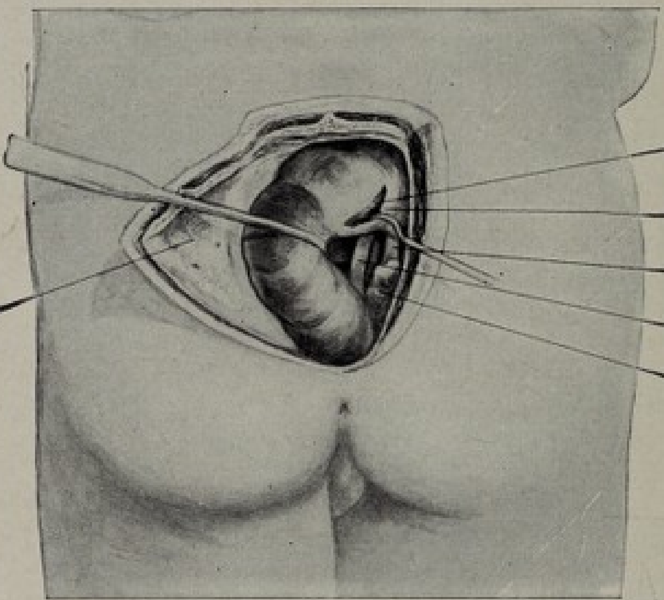


FIG. 491.—Excision of the rectum. The sacrum has been divided and turned aside. The rectum is drawn to the left, exposing the ureter and vas deferens and seminal vesicle, and the peritoneal cavity has been opened above.

bands below the level of the ureters to the fourth sacral foramina, after which the rectum can be drawn still further down. If it is desired to go still higher the peritoneum may be pushed up off the rectum or it may be opened and the mesorectum detached close to the sacrum so as not to injure its vessels. The detached rectum is then brought down, cut off, and its divided end sutured to the skin.

The trans-sacral exposure is usually termed the Kraske operation. A median incision is made in the median line from the middle of the sacrum to and sometimes around the anus. The gluteus maximus is detached and the coccyx excised. Close to the sacrum the lower part of the sacro-sciatic ligament is cut through. The sacrum is then chiselled across at the level of the fifth sacral vertebra. The usual line of section through the third sacral vertebra is liable to produce injury to important nerves, cause loss of bladder control, and predispose to sacral hernia. The lateral and middle sacral arteries may have to be ligated. The rectum and surrounding fat are then worked off from the hollow of the sacrum posteriorly and from the urethra, bladder, etc., anteriorly up to the peritoneal reflection. The peritoneum is then opened and clipped close to the rectum and the meso-rectum detached close to the sacrum. This mobilizes the pelvic colon. The rectum is then removed. Several procedures are used to complete the operation. The proximal stump may be sutured to the fascia and skin at the upper angle of the wound, forming a posterior anus.

A portion of the anal mucosa may be left and the proximal stump sutured to it, preferably by the tube method. The proximal stump may be closed and the peritoneum sutured close, the fecal current passing through an abdominal anus (colostomy).

The combined abdominal and perineal removal of the rectum is to be preferred if a radical procedure is attempted. The operation is based on the method of Quenu, although now the procedure of Miles or Jones is usually followed. The abdomen is opened and the bowl divided at a point between the anastomotic loops of the first and second sigmoidal branches of the inferior mesenteric artery. The ends are invaginated and the proximal subsequently used for the colostomy. The peritoneum is then incised on either side of the pelvic mesocolon and the entire "bloc" of fat, lymph-nodes, and lymphatic-bearing tissue worked off the ligamentous structures in front of the sacrum down to the level of the sacro-coccygeal articulation which is recognized by the firm attachment of the fascia propria recti to the end of the sacrum. The inferior mesenteric artery is ligated immediately below the origin of the first sigmoid branch. Watch for the ureters during the entire operation. The anterior wall is separated from the bladder, seminal vesicles or from the vagina. Separate the rectum from its lateral attachments and divide the ligaments. If properly separated the rectum may now be pushed down into the cavity of the pelvis and the incised edges of the peritoneum brought together if possible or patched by a flap dissected up from the bladder or broad ligaments. The operation is completed by a procedure similar to the perineal exposure and the rectum removed from below.

Anal Triangle and Ischiorectal Region.—The anal triangle is made by the superficial transverse perineal muscles forming its base and the tip of the coccyx its apex. It contains the anal canal with the ischiorectal fossæ on each side.

The **ischiorectal fossa** is wedge-shaped, its base, extending between the tuberosity of the ischium and the anus, is about 2.5 cm. (1 in.) in breadth, and its apex extends up 5 to 7.5 cm. (2 to 3 in.), to the junction of the levator ani and internal obturator muscles. Its inner wall is formed by the levator ani and coccygeus muscles and its outer wall by the obturator internus muscle. Its deepest extreme posterior portion constitutes the *posterior recess*. This communicates superficially, beneath the coccygeal attachment of the external sphincter, with the fossa of the opposite side (see Fig. 482).

The *anterior recess* (pubic, Waldeyer) runs forward between the prostate gland internally and the ischiopubic ramus externally; the deep and superficial transverse perinei muscles and the deep layer of the triangular ligament are superficial to it.

The *internal pudic vessels and pudic nerve* lie on the internal obturator muscle and ramus of the ischium in a fibrous canal formed by the obturator fascia. It is called *Alcock's canal* and is 4 cm. (1½ in.) above the tuberosity.

The *inferior hemorrhoidal vessels and nerves* enter the ischiorectal fossa at its posterior and outer side and run on the surface of the levator ani muscle toward the anus. The *superficial perineal* vessels and nerves enter the fossa anteriorly and immediately pierce the posterior edge of the superficial perineal (Colles's) fascia to supply the structures between it and the superficial layer of the triangular ligament.

Practical Application.—The principal affection of the ischiorectal fossa is abscess. This is probably started by violence and infected from the rectum. It commonly tends to point through the skin or open into the rectum. On account of its tendency to burrow it is to be opened early. This is done by making an incision of ample size through the skin and then opening the abscess by blunt dissection in order to empty all pockets. Bleeding is usually slight because the vessels lie deep and escape being wounded. Should the abscess not break externally it may do so internally. If superficial it pierces the anal canal between the external and internal sphincters and makes an opening at about the white line. If it is very deep it may open into the ampulla of the rectum above the internal sphincter (see page 485). It is more common for pus to burrow down into the ischiorectal space through the levator ani than it is for it to burrow up from the ischiorectal fossa (Tuttle). Therefore in extensive ischiorectal abscesses communicating with the interior of the pelvis one should look for the origin of the trouble above. An abscess on one side is liable to be followed by one on the other and pus quite commonly crosses the median line posterior to the anus.

THE BLADDER

(Male)

While regarded as a fixed organ, the bladder is mobile save at its base where it is attached to the prostate and surrounding parts. Its dome ascends and descends

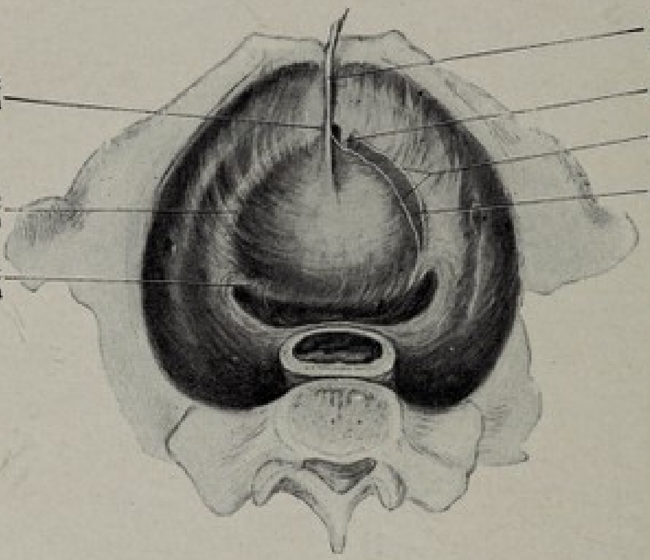


FIG. 492.—View of the interior of the male pelvis, showing the bladder attachments.

each time it is filled and emptied, its shape altering materially. Particularly when distended, its position is influenced by the push or pull of neighboring organs. Bladder capacity, a matter of frequent inquiry by our patients, in normal individuals varies from about eight ounces to over a quart; in diseased conditions the range is from a few c.c. to several quarts.

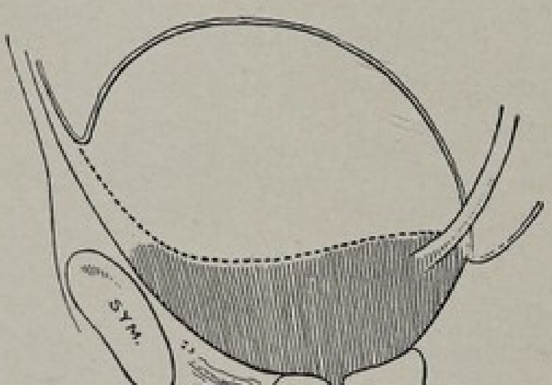


FIG. 493.—The bladder in its empty and distended state. When distended the peritoneal reflection on the anterior abdominal wall is seen to be raised. The posterior or rectovesical reflection remains nearly or quite unchanged.

Certain terms are used in speaking of various parts of the bladder. The triangular area on its floor having at its angles the orifices of the ureters and the urethra is universally known as the *trigone*. With less reason the region of the attachment of the urachus has been called the *apex*, and also the *summit, vault, dome* and *fundus*; the last term is also used, more properly, for the trigone and area adjacent to it posteriorly. Anterior, lateral and posterior walls are self explanatory. With the exception of the trigone none of the areas mentioned have definite boundaries.

Position.—The empty bladder lies in the pelvis in the midline of the body, immediately behind the pubis. As it fills with urine the upper part becomes an abdominal organ (Fig. 493). Below, intimately connected by the musculature of the trigone, is the prostate; behind this the bladder rests on the seminal vesicles and rectum, and laterally on the levator ani muscles and the internal obturators. The upper portion of the bladder is covered with peritoneum, and is in contact with the intestines.

Attachments.—The bladder and prostate are intimately connected by mucous membrane, fibrous tissue and muscle. In addition to this the lower part of the bladder is held in place by a reflection of the rectovesical or pelvic fascia. This fascia invests the whole organ, but is of considerable density only in the lower portion, especially in front where two bands, one on each side of the symphysis, bind it and the prostate to the pubis (*puboprostatic* or *anterior true ligaments of the bladder*) and laterally where it is reflected from the levator ani muscles (*lateral true ligaments*). The urachus, a vestigial structure running from the upper part of the bladder to the umbilicus, sometimes called the *superior true ligament*, does little to maintain position; it must be divided when the bladder is mobilized for such operations as resection and diverticulectomy. The so-called *"false ligaments"* (lateral and superior) are merely peritoneal reflections in the regions indicated.

Shape.—The bladder contour varies with the amount of contained urine. When empty the upper half descends on the lower segment till the upper surface is flat or slightly concave, sloping somewhat downward and backward from the posterior margin of the pubic symphysis. As it fills it becomes first globular and then sausage shaped, the long diameter extending upward and forward, in the axis of the pelvis.

Relation to Peritoneum.—When empty the peritoneum passes across the top of the bladder; there is then no protrusion into the abdominal cavity. But as the bladder fills its dome pushes upward, and front, back and sides become peritonealized in varying degree. From a surgical standpoint the peritoneal relations of the back and front are of importance.

Posteriorly the rectovesical pouch is approximately 8.75 cm. (3½ in.) from the anus, but it may be as little as 7.5 cm. (3 in.), or as much as 10 cm. (4 in.). The attachment of the rectovesical pouch to the rectum is so firm that whether the bladder be distended or collapsed its distance from the prostate, 2.5 to 4 cm. (1 to 1½ in.) is but little altered. Waldeyer gives 1.5 to 2 cm. (⅗ to ⅘ in.) as the greatest possible variation.

Anteriorly the displacement upward of the peritoneal fold is commonly greater, sometimes as much as 2.5 cm. (2 in.), so that this amount of nonperitonealized bladder wall *may* be above the pubic crest. But even when the bladder is greatly distended, as to the level of the umbilicus, there may be *no* raising of the peritoneum. Therefore *one is not warranted* in assuming that because the bladder is distended an instrument can be thrust into it immediately above the pubis with entire safety. Cystostomy is a safer procedure than suprapubic aspiration.

Interior of the Bladder.—The walls of the collapsed bladder are slightly irregular, from the inability of the mucosa to contract to the same extent as the underlying muscles, but when distended the walls are smooth, except when trabeculation has resulted from pathological causes, e.g. obstruction. In contrast to the remainder of the bladder the trigone, having a mucosa which is tightly adherent to the subjacent tissues, is little affected by varying degrees of distension. Though described as being more vascular and smoother than the remainder of the bladder, the differences are not sufficient to be recognizable save with the cystoscope. At operation it can only be defined by identifying the orifices of the urethra and ureters. The first can easily be found with the finger; the latter must be searched for in their probable locations, about 32 mm. (1¼ in.) apart and approximately the same distance from the urethral orifice; but measurements vary enormously in different individuals, and symmetrical arrangement cannot be counted on. When viewed cystoscopically it is usually possible to make out the *interureteric bar* of Mercier.

Bladder Musculature.—The muscle tissue in the walls of the bladder is described as consisting of two layers, an outer longitudinal and an inner circular. They are almost indistinguishable save near the vesical orifice; both layers have the same function, to empty the bladder. According to Wesson both layers contribute fibres which pass around the urethra in an oblique manner, forming what is known clinically as the *internal sphincter*. Wesson further describes what he terms the *trigonal muscle*, derived from the longitudinal muscle fibres of the ureters. These fibres pass across the trigone, some to the opposite ureter, some to the urethra and down it to the verumontanum. These latter by their pull open the urethral orifice and permit urine to escape. "The *external sphincter* is made up of striated fibres which have their origin in the lateral wall of the prostate near the vesical orifice. These fibres do not make a complete circle of the urethra but end in a raphé of connective tissue behind the membranous urethra" (Wesson).

Nervous Control of the Bladder and its Sphincters.—Three distinct sets of nerves are involved in the storage and expulsion of urine,—sympathetic, parasympathetic and spinal. While a vast amount of work has been done, our knowledge is still incomplete, but the following facts seem to be well established:—

Sympathetic fibres, derived from the first four lumbar segments, and probably also from the three lower thoracic, pass through the superior hypogastric plexus (presacral nerve) lying on the aorta at its bifurcation, the left common iliac and neighboring structures between the iliacs down to the promontory of the sacrum (Wetherell), the inferior hypogastric nerves and the hypogastric ganglia. They consist of afferent fibres, probably carrying sensations of over-distension and pain, and efferent fibres which are inhibitory to the detrusor bladder muscles, and motor to the internal sphincter.

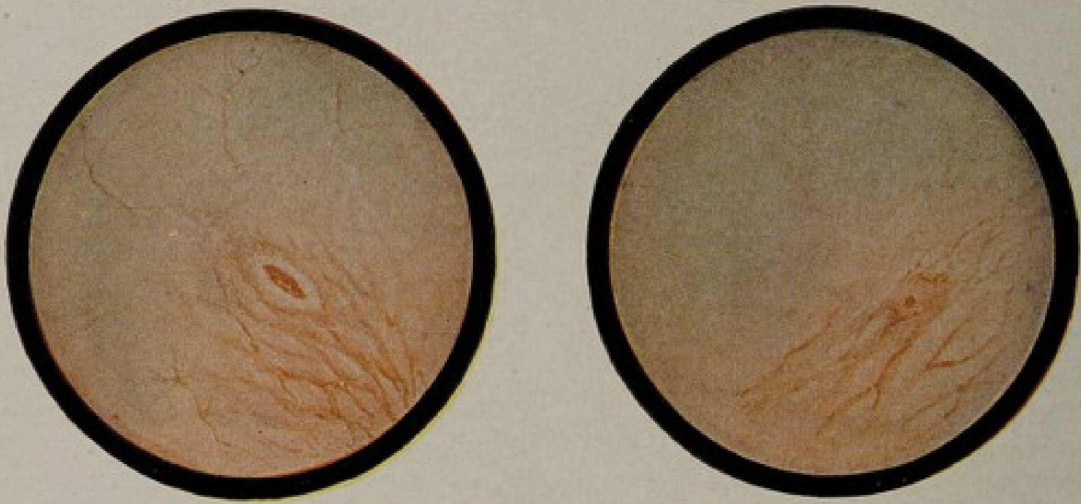


FIG. 494.—The picture on the left demonstrates a normal mucous membrane and ureteral orifice. On the right the ureteral orifice will be observed to be small, round, atrophic, and functionless.

Parasympathetic fibres from the 2nd, 3rd, and 4th sacral segments are also distributed through the hypogastric ganglia, reaching these structures through the pelvic nerves (nervi erigentes). Their afferent fibres are believed by Rose to transmit the sensation of bladder tone. The efferent fibres are antagonistic to the sympathetics, i.e. they are motor to the detrusor and inhibitory to the internal sphincter.

The pudic nerves supply sensory fibres to the posterior urethra, and motor fibres to the striated muscle of the external sphincter.

To the surgeon the chief interest in this recital of the nervous supply of the bladder lies in the fact that there is a concentration of the sympathetic fibres in the "presacral nerve," and that in certain cases its resection relieves pain or permits the parasympathetic supply to function better (retention of neurogenic origin).

Operative Considerations.—Suprapubic puncture, for the relief of retention, passing a needle through the prevesical tissues in a backward and slightly downward direction immediately above the pubis, has been performed thousands of times without complications; in a small percentage of cases extravasation of urine has occurred, sometimes resulting in the death of the patient. Attention has already been called to the fact that the peritoneum may remain as low as the crest of the pubis when the bladder is distended. In hospital work cystostomy is therefore to be preferred to suprapubic puncture, this operation being reserved for emergencies in the patient's home.

Most operations on the bladder are performed through a midline suprapubic incision. The length of the incision varies with the work to be done, maximal length—to or even above the umbilicus—being required for diverticulectomy, and partial or complete removal of the bladder. The Trendelenburg position should be used in all operations except simple cystosomy.

After the recti have been separated for the full length of the incision the bladder is exposed by nicking the fascia overlying the fat in the lower part of the wound, enabling one by sponge dissection to strip up the peritoneum from its surface. The procedure is made easier by preliminary filling of the bladder. When the attachment of the urachus is reached sharp dissection is required, and the greatest care is needed to avoid the peritoneum. After this point has been passed further mobilization of the viscus is accomplished without difficulty. In removing bladder, vesicles and prostate for carcinoma the guidance of a finger in the rectum is helpful during the deeper dissection.

THE PROSTATE

The normal prostate gland is of the shape of a large chestnut. It is 3 to 4 cm. (1¼ to 1½ in.) wide, 2.5 to 3 cm. (1 to 1¼ in.) long, and 3 cm. (1¼ in.) thick. An indistinct furrow on its posterior surface separates it into two lateral lobes. There is no median lobe, as the prostatic tissue, except in those rare cases in which no such tissue exists, is continued uninterrupted across the median line in the form of a commissure. For clinical purposes we may consider the prostate as having an apex, a vesical surface or base, and a rectal or posterior surface.

The vesical surface is pierced a little anterior to its centre by the urethral opening, which passes through the gland to the apex. A fissure in the base near its posterior border receives the ducts of the seminal vesicles and the vasa, close to the midline. These unite within the substance of the prostate to form the ejaculatory ducts, which pass downward and forward to open into the urethra at the verumontanum, usually on the lips of the utricle.

The portion of the prostate below and behind these ducts is the posterior lobe, an embryological and clinical entity. It is the usual starting point for prostatic carcinoma; benign hypertrophy of the posterior lobe is a curiosity. The portions of the prostate to the sides of the urethra are known as the lateral lobes, though there is no encapsulation to give them definite boundaries, their tissue blending with that of neighboring parts of the organ. In the normal prostate there is no "middle" lobe and no anterior lobe; pathologically these may be found arising from the posterior or anterior commissural regions, behind or in front of the urethra at the vesical orifice (see Hypertrophy). The structure of the prostate is that of a compound tubular gland, each tubule of which is surrounded by a stroma of fibrous tissue and involuntary muscle.

Sheath and Capsule.—The *capsule* of the prostate is a condensation of the fibromuscular stroma referred to above. The *sheath* is a portion of the rectovesical fascia. It surrounds the organ and binds it to the pubis in front (puboprostatic ligaments), to the bladder above and to the deep layer of the triangular ligament below. Within its meshes in front of the prostate and at the sides is the prostatic venous plexus. Posteriorly the prostate is separated from the rectum by a *double layer* of fascia (that of Dénonvillier's). The *anterior* layer of this fascia covers the prostate, and extending upward binds the seminal vesicles to the bladder; the *posterior* layer is adherent to the rectum.

Relations.—The apex rests on the posterior layer of the triangular ligament 1 to 2 cm. (½ to ¾ in.) behind and a little below the subpubic angle. This is about 3 cm. (1¼ in.) above the level of the white line of Hilton; as the rectum is drawn forward by the *rectourethralis muscle* the prostate is felt by the palpating finger as soon as it passes the anal sphincter. If the patient relaxes his muscles it is possible in most cases to palpate not only the prostate but the seminal vesicles, ampullæ of the vasa and the lower portion of the posterior wall of the bladder; unless diseased the latter structures cannot be differentiated.

Just above the apex of the prostate the levatores ani muscles swing in to support it laterally.

Nerves.—Little is known of the nerves of the prostate which is of surgical importance. However, Young has pointed out that a plexus in the *preprostatic fascia* controls the external sphincter, so that it is essential that this fascia be spared in doing a panprostatectomy for carcinoma, in order to preserve urinary control.

Hypertrophy and Bar Formation.—The studies of Randall and others seem to show that prostatic hypertrophy may start in any part of the organ, including the periurethral mucosal glands and the subcervical glands of Albarran, located beneath the mucosa of the floor of the urethra just outside the vesical orifice. Microscopically the bulk of the tissue is usually adenomatous, but occasionally muscle and fibrous tissue play a considerable part. Grossly the picture varies according to the starting point and the direction of growth. When posterior commissural tissue or

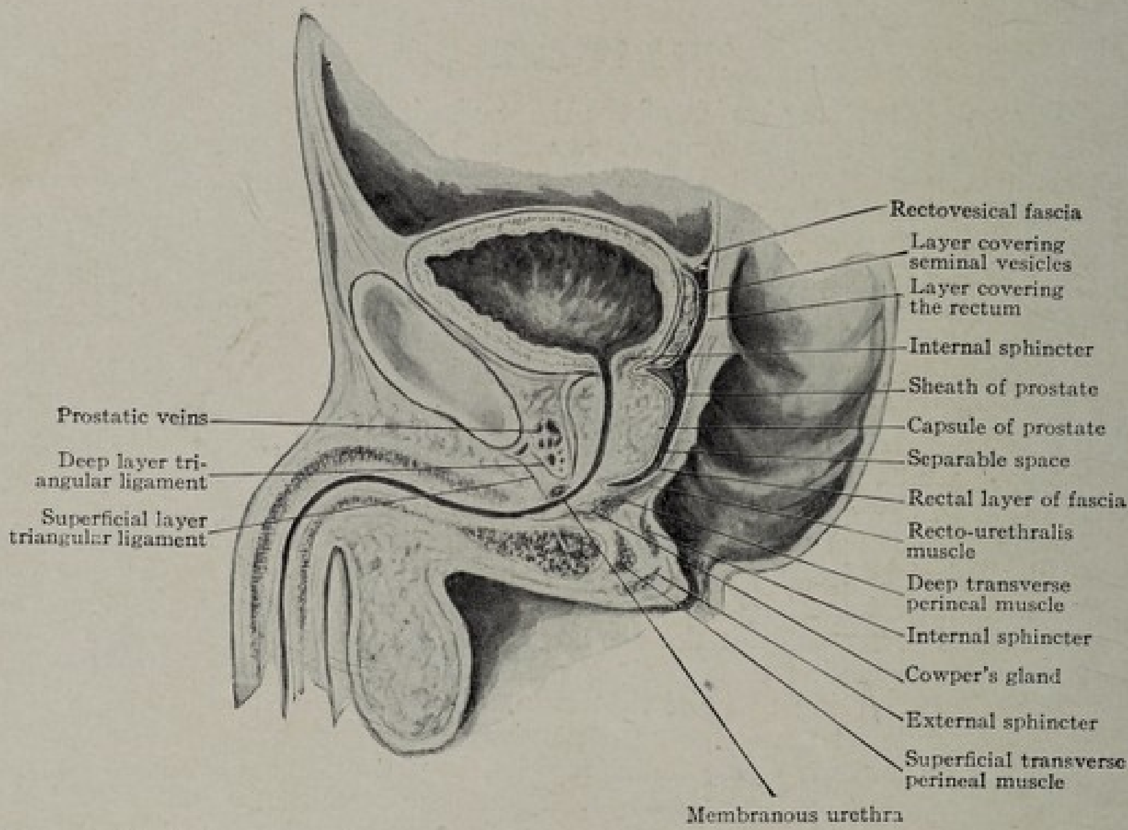


FIG. 495.—Sagittal section of male pelvis. (The layers of Dénonvillier's fascia have been artificially separated.)

Albarran's glands are the points of origin a *"median lobe"* is produced—sometimes a mere *"glandular bar"* as we used to call the condition, sometimes a sessile or pedunculated growth extending far up into the bladder. When *"lateral lobes"* are formed, whether from periurethral mucosal glands or prostatic tissue, we are more apt to find the bladder pushed up into the abdomen, its sphincter remaining intact—but here also we may find the prostate herniating into the bladder, with destruction of the internal sphincter.

Bar formation is an entirely different process. It is a fibrosis, the result of infection. Bars are obstructive, but there their resemblance to hypertrophy ends. Briefly stated, bars are sharp edged, small, fibrous bodies, never palpable by rectal examination, which tend to reduce the size of the vesical orifice; hypertrophies are rounded, of considerable size, usually recognizable by rectal examination, and tending to enlarge the size of the vesical orifice. Hypertrophies are encapsulated in the sense that by their growth they compress the normal prostatic tissue, so that a "line of cleavage" exists about them.

Treatment of Prostatic Obstruction.—Suprapubic prostatectomy, perineal prostatectomy and cystoscopic resection are the operative procedures now in use, the pathological condition and the experience of the operator determining the choice.

In the first the prostate is approached transvesically. At present the most favored method of starting the enucleation is that of Squier, wherein a finger is introduced into the urethra through the vesical orifice, when by making pressure between two of the prostatic lobes, usually ventrally between the lateral lobes, the mucosa is ruptured and the finger readily finds the line of cleavage between the hypertrophied and the normal tissue. Guided by the sense of touch the cleavage plane is followed till the growth is entirely free. Occasionally scissors must be used to divide dense tissue to avoid trauma to normal structures.

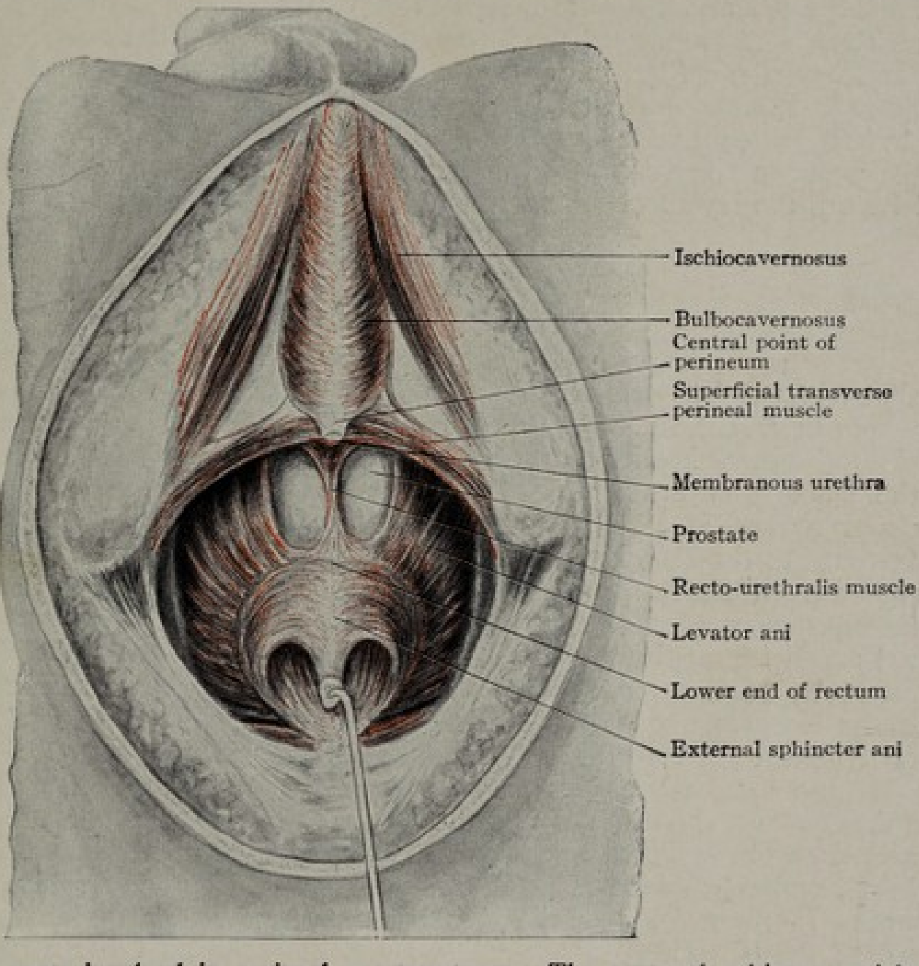


FIG. 496.—The parts involved in perineal prostatectomy. The external sphincter ani has been freed at the central point of the perineum and with the lower portion of the rectum has been drawn back, thus putting the recto-urethralis muscle on the stretch and exposing the prostate to each side.

Perineal prostatectomy is a technically more difficult procedure, requiring an exact knowledge of the perineal tissues. The technique of Young or one of its modifications is almost universally employed. Access is had through an inverted "V" incision, which divides the skin and superficial fascia. The space on each side of the central tendon, behind the superficial transverse perineal muscles, is then opened by blunt dissection. The structures in the midline, the central tendon and the rectourethralis muscle, are thereafter carefully cut from the bulb, bringing one down on the two layers of Dénonvillier's fascia behind and attached to the membranous urethra. The posterior of these must be cut and pushed back with the rectum to expose the prostate. The posterior surface of the prostate is deeply incised to gain access to the hypertrophied tissue; an inverted "V" incision which passes directly into the urethra is commonly employed. Instruments specially designed for the operation are essential.

Cystoscopic resection is specially applicable to bars and small commissural hypertrophies, but is used by many urologists for the relief of retention from larger growths. It consists in the cutting away of tissue, under cystoscopic guidance, by means of a loop electrode, carrying a high frequency cutting current. Since the introduction of this method the various "punch" instruments have been discarded, in large measure.

Abscess.—Collections of pus in the prostate, from whatever cause, when of sufficient size to be recognized by rectal palpation should be drained through a perineal incision. Formal exposure of the prostate, as in prostatectomy, is unnecessary. Since the rectum is drawn forward by the rectourethralis muscle, it is safer to make the incision to one side than in the midline. The incision is similar to that formerly used in perineal lithotomy, but shorter—it starts 2 cm. (¾ in.) in front of the anus, on the side corresponding to the most prominent part of the prostate, and passes outward and backward toward the tuberosity of the ischium for about 3 cm. (1¼ in.). Guided by a finger in the rectum a hemostat is passed through the space at the side of the central tendon and pushed through the prostatic capsule into the abscess. If there is a second abscess in the opposite side of the prostate the forceps may be partially withdrawn, carried through the space between the layers of Dénonvillier's fascia and the second abscess opened.

THE SEMINAL VESICLES

The seminal vesicles are about 5 cm. (2 in.) long and lie on the bladder above the prostate. They diverge on each side toward the ureters, which they overlap and which intervene between the vesicles and bladder wall. The vasa deferentia run along the inner border of the vesicles and join the ducts from the vesicles to form the ejaculatory ducts on entering the posterior portion of the prostate. Their upper portion is covered by the peritoneum of the rectovesical pouch. They are fastened to the bladder by the rectovesical fascia, and are in close relation with the prostatic plexus and vesical veins. They are within reach of the finger introduced through the anus and may be massaged and their contents expressed. They are not readily recognized by touch, unless thickened by disease. The seminal vesicles are really nothing more than blind diverticula from the vasa deferentia and partake of its diseases. The epididymis, vas deferens, seminal vesicles, and prostate are all frequently involved in tuberculosis of the genito-urinary tract.

The seminal vesicles may be operated upon for pyogenic infection, acute (abscess) or chronic (to remove focus of infection), for tuberculosis, and for neoplasm (in connection with neoplasm of neighboring organs). Approach may be blind, under guidance of a finger in the rectum, or, preferably, by careful dissection. In the latter case the incision is as in Young's perineal prostatectomy (p. 516); the dissection is carried beyond the prostate, the rectum and peritoneum being pushed from the anterior layer of Dénonvillier's fascia as it lies over the vesicles. This fascia must be incised for their exposure. When doing seminal vesiculectomy particular care must be used in ligating the tissues about their upper poles.

THE VAS DEFERENS

Starting at the tail of the epididymis, the vas deferens passes upward at the back of the testicle and spermatic cord to pass through the inguinal canal. When it leaves the internal abdominal ring it winds around the outer side of the deep epigastric artery and dips down over the brim of the pelvis 4 or 5 cm. (1½ to 2 in.) posterior to the pubic spine. It then runs downward and backward on the side of the pelvis, under the peritoneum, crossing superficially the obliterated hypogastric artery, the obturator vessels and nerve, the vesical arteries, from the inferior of which it receives the artery of the vas, and finally the ureter. In its scrotal course it is easily identified by its "whip cord" character. The surrounding tissues being soft, the vas is very movable, so that difficulty is sometimes experienced in immobilizing it for such operations as vasosection and vasopuncture. We have found it most satisfactory for the operator to do the holding himself, placing his thumb *behind* and the index and middle fingers in front and at the sides. The incision should be 1 cm. (½ in.) long, at right angles to the course of the vas; as soon as the skin is divided a sharp double tenaculum can be made to encircle the duct through the overlying tissues.

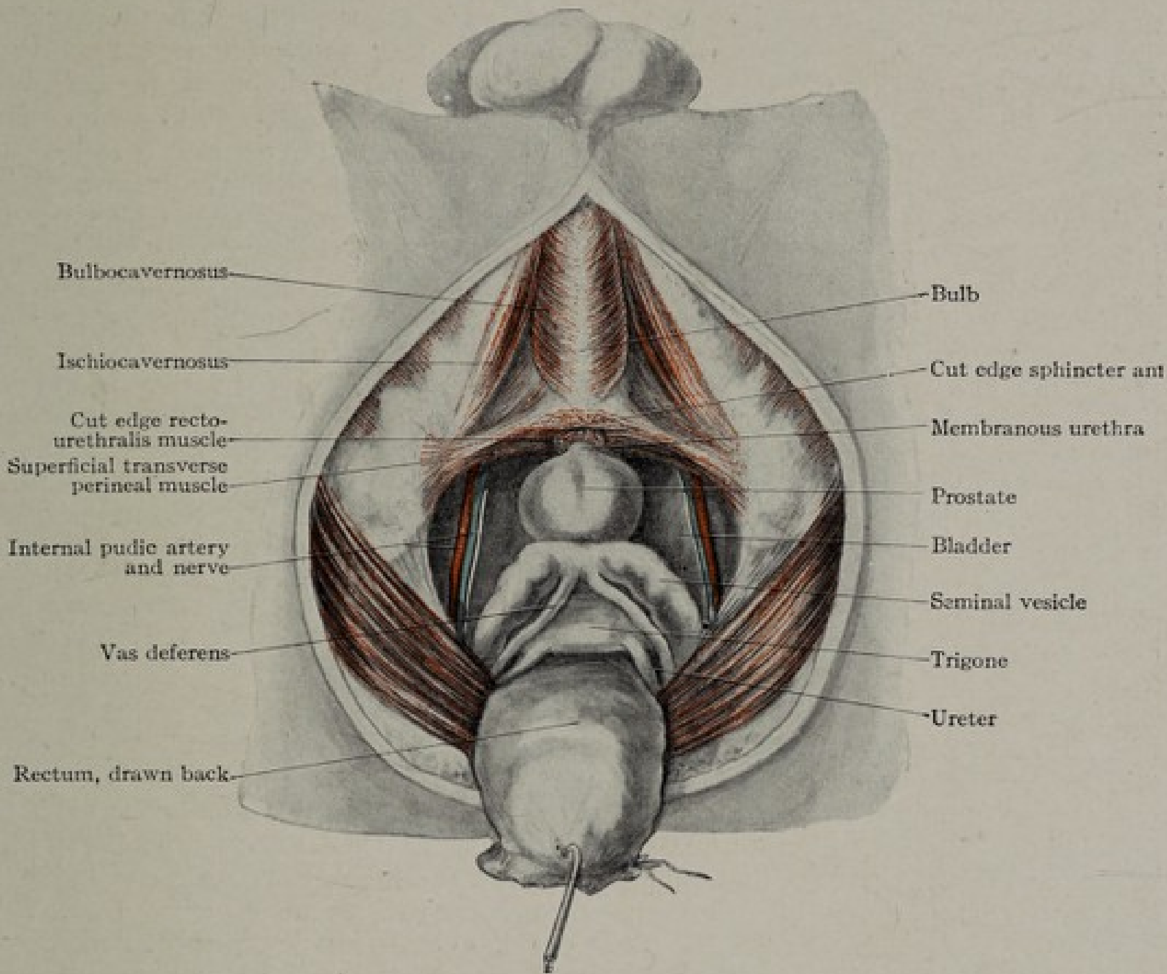


FIG. 497.—The prostate gland and seminal vesicles exposed by dividing the external sphincter and recto-urethralis muscle and pulling the rectum forcibly back.

The ampulla of the vas is sometimes incised for chronic infection in connection with operations on the seminal vesicles (through the same perineal incision), or the vas may be removed *in toto* for tuberculosis through incisions in the perineum and groin, as a part of epididymovasoseminovesiculectomy.

THE FEMALE GENERATIVE ORGANS

The female pelvic organs are so often the subject of operative procedures that an exact knowledge of the relations of the uterus, vagina, ovaries, Fallopian tubes, round and broad ligaments, and ureters is of great importance.

THE UTERUS

The normal unimpregnated uterus is approximately 7.5 cm. (3 in.) long, 5 cm. (2 in.) broad, and 2.5 cm. (1 in.) thick. It consists of a fundus, body, and neck. Its fundus is that part above a line joining the two openings of the Fallopian tubes at the cornua. The neck of the uterus or cervix embraces 2.5 cm. (1 in.) of its lower portion. Between the neck and fundus is the body. The cavity of the uterus is small, its anterior and posterior walls being almost in contact, while laterally it extends toward the Fallopian tube openings. The opening through the cervix is the cervical canal; it opens into the vagina by the external os and into the uterus by the internal os; it is round in shape. The external os in the nullipara is round but in those who have borne children it is a transverse slit. The cervical canal is narrowed at both the internal os and the external os while it is larger between; hence in passing instruments into the uterus they traverse with difficulty the external os and the internal os but pass readily between the two and into the uterine cavity beyond.

The cervix enters the upper end of the vagina in its anterior wall and presents downward and backward (Fig. 498). Its posterior lip is longer than the anterior. The part of the cervix which protrudes into the vaginal vault is known as the portio vaginalis; the portion which lies above the vaginal attachment is called the portio supravaginalis. The cervix forms an obtuse angle with the uterus. The entire uterus swings backward and forward on an imaginary axis which passes from side to side at the level of the internal os. Thus, whatever moves the fundus backward throws the cervix forward and vice versa.

Position.—The uterus is most firmly fixed to the vagina and its upper portion is the most movable. Lying between the bladder anteriorly and intestines and rectum posteriorly its position varies with the condition of those organs. Normally it inclines anteriorly (anteversion). It lies in contact with the bladder, no intestines intervening. With an empty bladder it may point almost horizontally just above the top of the symphysis pubis, the external os being almost at the same level. As the bladder distends and the rectum becomes empty the fundus rises more and more until the axis of the uterus may coincide with that of the vagina, or even pass beyond; and then it is said to be retroverted. The uterus is normally almost straight or slightly bent forward. In some individuals it is more or less sharply bent at the region of the internal os either forward or backward. It is then said to be anteflexed or retroflexed. When retroflexed the fundus can frequently be felt as a round hard mass behind the upper posterior portion of the vagina.

Attachments.—In addition to being attached to the vagina the uterus has certain folds or ligaments which pass from it to the surrounding parts. Anteriorly the peritoneum is reflected from the uterus at the level of the internal os to the bladder, forming the *uterovesical fold*. Posteriorly the peritoneum descends from the uterus over the posterior surface of the upper portion of the vagina for 1 or 2 cm. (½ in.) and thence onto the rectum constituting the *rectovaginal* or *recto-uterine fold*. The deep pouch so formed is called *Douglas's pouch*. On each side are three ligaments: the *broad ligament* is the largest and most important. The two broad ligaments and uterus form a diaphragm which extends from one side of the pelvis directly across to the other, thus dividing it into anterior and posterior compartments. On the side of the uterus the broad ligament extends from the round ligament and Fallopian tube above down to below the level of the internal os. The anterior layer blends with the uterovesical fold at the level of the internal os, while the posterior goes to the bottom of the pouch of Douglas. It passes outward to be attached to the sides of the pelvis from the external iliac vein above down to the floor of the pelvis. Between the two peritoneal layers of the broad ligament from above downward are the Fallopian tube, the ovarian vessels, the adult remains of the Wolffian system, the round ligament, the uterine vessels and the ureter. At its pelvic attachment the broad ligament widens out, having the round ligament as its anterior edge and the *infundibulopelvic* or suspensory ligament of the ovary as its posterior edge. This latter runs not to the uterus but to the fimbriated extremity of the Fallopian tube and ovary and contains the ovarian vessels. A little posterior is the *utero-sacral ligament* (recto-uterine); it extends posteriorly and laterally from the uterus near the level of the internal os and contains muscular and fibrous tissue, the muscular tissue goes to the rectal wall while the fibrous goes to be attached to the second and third sacral vertebræ. This ligament on each side forms the outer border of Douglas's pouch.

Contained in the broad ligament between the Fallopian tube and ovary can be seen the remains of the parovarian or organ of Rosenmüller (page 487) and Gärtner's duct. A little farther in are the remains of the paroöphoron not clearly visible to the unaided eye.

The *round ligament* leaves the cornu of the uterus just below and anterior to the Fallopian tube, and passes outward, forward, and slightly upward to reach the internal inguinal ring and canal through which it passes to end in the subcutaneous

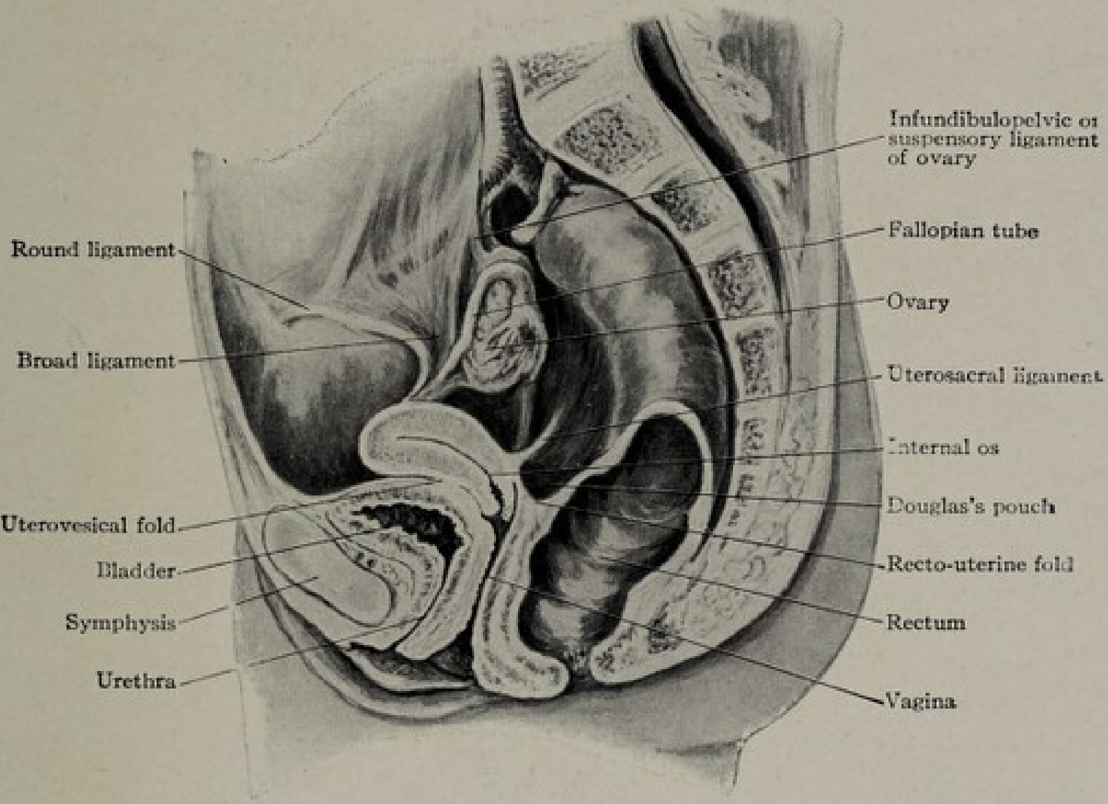


FIG. 498.—Lateral view of the interior of the female pelvis.

tissue and skin of the labium majus. Owing to the ovary and Fallopian tube falling backward the round ligament is seen as a distinct cord passing to the sides of the pelvis. It receives branches from the deep epigastric artery and from the utero ovarian anastomosis.

THE OVARY

The ovary is about 4 cm. (1½ in.) long, 2 cm. (⅘ in.) wide, and 1 cm. (⅖ in.) thick. It is connected with the posterior surface of the broad ligament by a very short mesentery, the mesovarium. It is through this that the ovarian vessels pass. It has two ligaments, one, the suspensory or infundibulopelvic ligament, is a fold of peritoneum going up to the side of the pelvis above and contains the ovarian vessels; the other, the *utero-ovarian ligament*, going in the broad ligament to enter the uterus just below and behind the Fallopian tube. The ovary lies longitudinally or obliquely against the outer wall of the pelvis with the ureter just behind and below its posterior edge. From its upper end proceeds the suspensory or infundibulopelvic ligament and from its lower end the utero-ovarian ligament. The normal Graafian follicles and corpus luteum should not be mistaken for pathological cysts. The Fallopian tube surrounds the upper end of the ovary and its fimbriated extremity clings to its surface (Fig. 499).

Fallopian Tubes.—The Fallopian tube is about 11 cm. (4½ in.) long and runs in the broad ligament along its top or free edge from the uterus to the ovary.

Its inner portion between the proximal end of the ovary and uterus is straight and smaller in diameter than the rest and is called the *isthmus*. Its lumen is about 3 mm. (1/8 in.). The part beyond, or *ampulla*, curves around the ovary from above downward and is larger than the isthmus and has a lumen of about 8 mm. (1/3 in.).

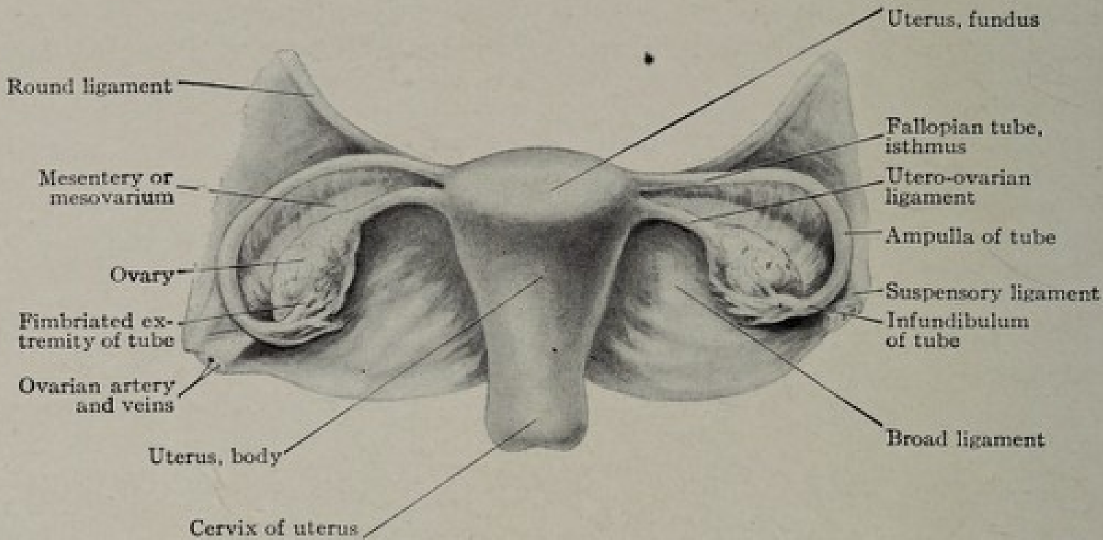


FIG. 499.—The uterus, ovaries, and tubes.

The size of the abdominal opening of the Fallopian tube is about 2 mm. or 1/12 in. The part of the broad ligament between the tube and mesovarium is called the *mesosalpinx*.

THE VAGINA

The vagina is about 7.5 cm. (3 in.) long; its posterior wall is longer than the anterior, being 8.75 cm. (3½ in.) long. It will thus be seen that if the uterus is slightly depressed, as it often is, the cervix is within easy reach of the examining finger, if, however, it is drawn up, as by an abdominal growth, it may be reached only with difficulty. The hollow formed by the anterior wall of the vagina blending with the anterior lip of the cervix is called the *anterior fornix*. The depression behind the posterior lip is the *posterior fornix*, behind which is *Douglas's pouch*. At the vulvar outlet the lumen of the vagina is anteroposterior in direction, it then changes to lateral and at the cervix becomes round. Its walls are in contact. In nulliparæ the tube is more uniform in size, but in multiparæ it is small at each end but large in the middle. It is much more dilatable and larger in the latter, hence operations in nulliparæ are comparatively rarely done through the vagina. Anteriorly the vagina in its upper portion is in relation with the bladder. In its lower portion (about one-third) it is in intimate relation with the urethra except at the upper portion of the latter. Posteriorly its upper 1 or 2 cm. (¼ to ¾ in.) is in front of the peritoneum and Douglas's pouch, below this lies the rectum, and between it and the surface is the perineal body. Laterally the ureters are close to the vagina and about half way up they empty into the bladder. In its lower portion the vagina is joined by the insertion of the levator ani muscle. The connection of the vagina to the bladder in front and rectum behind is loose, so that in performing operations it is readily separated from these organs.

The Ureter in the Female.—The pelvic portion of the ureter in the female is about 10 cm. (4 in.) long. It crosses the pelvic brim at a level with the first piece of the sacrum and passes over either the common iliac artery at its bifurcation or the external iliac at its commencement. It then follows the wall of the pelvis downward just posterior to the ovary and, near the floor of the pelvis, bends forward to pass through the base of the broad ligament, traversing the loose connective tissue (parametrium) and being about 1.5 to 2 cm. (½ to ¾ in.) outside of the cervix. At that point it is crossed by the uterine artery. It then inclines somewhat inward and forward along the sides and anterior wall of the vagina to enter the bladder. Its opening in the bladder is about 2.5 cm. (1 in.) below the level of the external os, which is almost as far down as the middle of the anterior vaginal wall. The ureters run in the bladder wall obliquely for about 2 cm. (¾ in.) and their openings are from 2.5 cm. to 5 cm. (1 to 2 in.) apart according to the amount of vesical distention (Fig. 493).

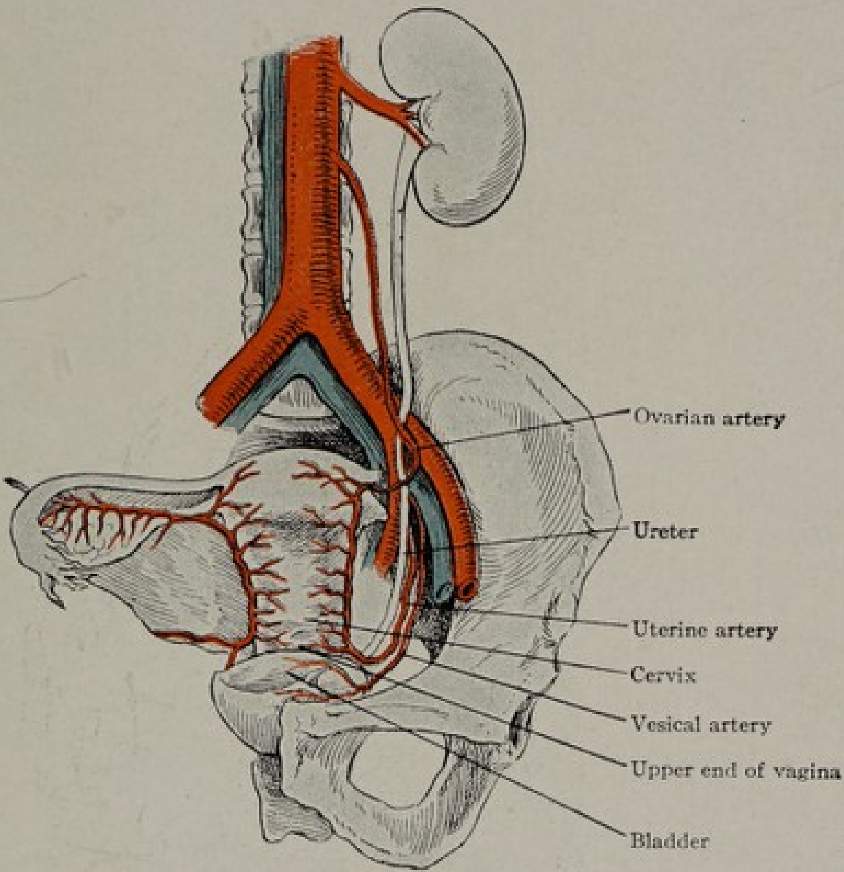


Fig. 500.—The ureter, ovarian artery, and uterine artery; showing their relation to the pelvic organs.

Blood-Vessels.—The main blood-vessels of the pelvic genital organs are the uterine and ovarian arteries, described by some authors as the single utero-ovarian artery.

The **uterine artery** comes from the internal iliac and passes almost horizontally in the base of the broad ligament toward the lower portion of the cervix. A small branch (Sampson's artery) is given off near the mid-point of the broad ligament which courses directly upward to the ovary. As it approaches the cervix it gives off a cervicovaginal branch passing to the upper part of the vagina. At this point it has just crossed in front of the ureter and is about level with the external os. It then inclines upward, reaching the side of the uterus at its junction with the vagina. It passes up the side of the uterus, in nulliparæ a short distance away from its side, but in multiparæ close to it, until it reaches the cornu above. It here is continuous with the ovarian artery.

The **ovarian artery** comes down from the aorta as does the spermatic artery in the male. It crosses the brim of the pelvis in front of the ureter, enters the infundibulopelvic or suspensory ligament of the ovary and runs horizontally towards the uterus in the broad ligament between the Fallopian tube and the ovary. It gives branches to the ovary and tube and as it reaches the cornu of the uterus it crosses in front of the round ligament and joins the uterine artery. At this point a branch is given off to the round ligament. As the uterine and ovarian arteries are continuous with each other either one may be the larger and they vary considerably in size.

A branch of the deep epigastric artery accompanies the round ligament inward and anastomoses with the uterine and ovarian arteries. It may be enlarged in disease of the ovaries and tubes.

Lymphatics (According to Poirier and Cunéo).—The *cervix* has three sets of lymphatics. The first passes outward and upward along the side of the pelvis anterior to the ureter to empty into the nodes along the external iliac artery. The second set passes backward behind the ureter to empty into a node on the anterior division of the internal iliac artery. The third set passes from the posterior surface of the cervix almost directly backward in the uterosacral ligaments to empty, some into the lateral sacral nodes high up in the hollow of the sacrum and some into the nodes of the promontory (Fig. 501).

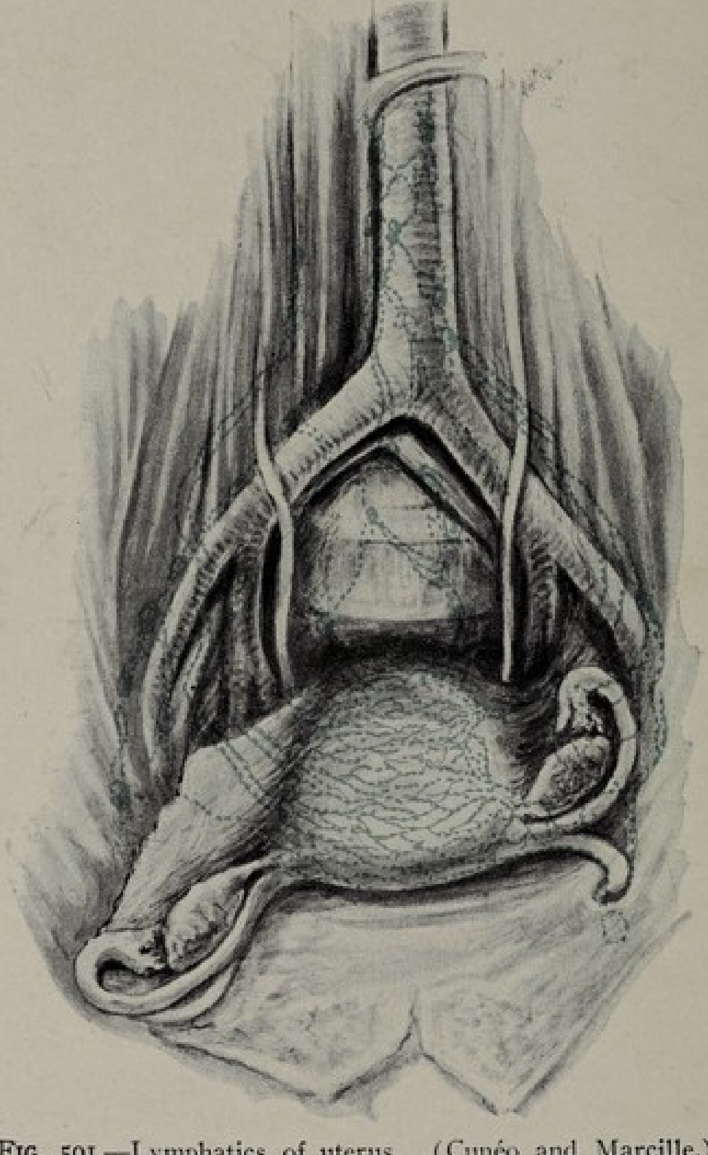


FIG. 501.—Lymphatics of uterus. (Cunéo and Marcille.)

The lymphatics of the *body of the uterus* communicate with those of the cervix below and at the cornu pass out as four or five trunks along the broad ligament between the ovary and Fallopian tube, being joined by branches from the ovary. They pass through the infundibulopelvic (suspensory) ligament and follow the ovarian vessels to empty into the aortic nodes below the kidney. A few lymphatic vessels pass from the uterus in the round ligament to the inguinal region and drain into the deep inguinal glands. The *ovarian* lymphatics form four to six trunks which ascend with the ovarian vessels to end in the lower aortic nodes. Opposite the fifth lumbar vertebra they communicate with the trunks from the body of the uterus.

Nerve Supply.—The ovary receives its chief nerve supply from the ovarian plexus of the sympathetic system. This plexus is made up of branches from the intermesenteric and renal plexuses and it follows the ovarian artery to its termination. In the infundibulopelvic ligament the plexus divides into branches which supply the ovary, the Fallopian tube, and adjacent areas of the broad ligament.

The nerve fibers in the walls of the uterus and vagina are derived directly from the hypogastric ganglia which lie between the layers of the broad ligament near its base. These ganglia are made up of sympathetic fibers from the hypogastric plexus and of para-sympathetic fibers, nervi erigentes, from the first to fourth sacral roots. Afferent fibers pass from the ganglion to the second and third sacral sympathetic ganglia.

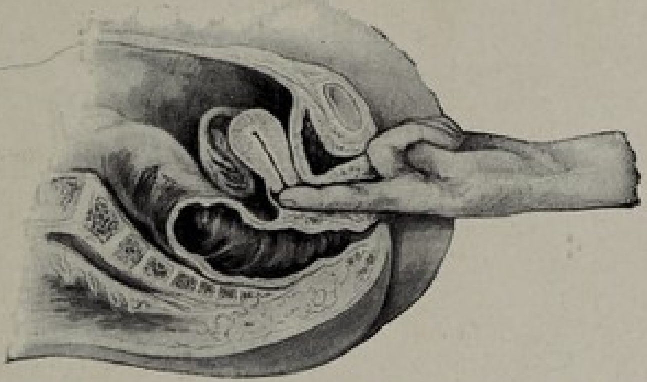


Fig. 502.—Digital vaginal examination. Ovary slightly prolapsed but as yet has not descended entirely into Douglas's pouch.

The hypogastric plexus is divided into two portions: that lying above the level of the first sacral segment is the superior hypogastric plexus while the portion below this point is the inferior hypogastric plexus. The superior plexus, or presacral nerve, is composed of the right and left inferior mesenteric nerves from the inter-mesenteric plexus and fibers from the first to the fifth lumbar sympathetic ganglia. In some individuals the component fibers of the plexus unite to form a single nerve trunk while in others there is a plexiform arrangement. The plexus is situated just anterior to the bifurcation of the aorta from which it is separated by a thin layer of fascia. Anteriorly it is covered by loose connective tissue and the posterior parietal peritoneum. A few fibers course along the common iliac vessels but the body of the plexus continues downward over the promontory of the sacrum and divides into the right and left inferior hypogastric nerves (inferior hypogastric plexus). These nerves diverge from their point of origin and each accompanies the corresponding internal iliac artery, giving off fibers which accompany the branches of the artery. Other branches are given to the rectum and to the ureter after which each nerve terminates in the formation of the hypogastric ganglion. From this ganglion fibers pass to the uterus, vagina, and bladder.

The hypogastric plexus exerts a vaso-constrictor action and the para-sympathetic fibers produce vaso-dilatation of the vessels of the genital organs. The sympathetic (hypogastric) nerves inhibit secretion and the parasympathetics stimulate secretory activity. Since the functions of menstruation and parturition are not disturbed by section of all of the extrinsic nerves of the uterus, it seems clear that these nerves convey no essential motor impulses. The fact that severe pelvic pain can be relieved by section of the superior hypogastric plexus indicates the sensory function of these fibers.

Pelvic Examination.—Examination of the external genitalia consists first in inspection for congenital malformations and evidences of disease. Particular attention should be given to Skene's tubules and Bartholin's glands as these structures so frequently harbor gonococcal infection. An attempt should be made to express pus from the urethra by digital pressure on the anterior vaginal wall. Secretion should be expressed from each Bartholin's gland with the forefinger in the vagina making counter pressure against the thumb on the labium majus. If the gland is enlarged, it can easily be felt between the thumb and forefinger. Inspection and palpation of the vaginal orifice will reveal its virginal, marital or parous condition. If parous, the degree of injury to the pelvic floor is to be noted; bulging of the anterior and posterior vaginal walls, as the patient increases her intra-abdominal pressure, indicates the presence of cystocele and rectocele. The cervix is felt as a rounded firm prominence in the vaginal vault. If the uterus lies in normal anteflexion the cervix is directed posteriorly toward the hollow of the sacrum; if the uterus is displaced posteriorly, the cervix points toward the symphysis. The consistency, size, contour and range of mobility of the cervix should be noted.

Bimanual examination consists in palpating the pelvic organs through the vagina with the index and forefingers of one hand, while the other hand makes counter pressure on the lower abdominal wall. The position, size, consistency, contour, mobility and degree of tenderness of the uterus should be noted. It is essential that the bladder and rectum be empty as these structures when filled produce considerable displacement of the pelvic organs. If the fundus lies in anteflexion it can be distinctly palpated between the vaginal and abdominal hands. When abnormally anteflexed the fundus can be felt by the vaginal fingers alone. If retroflexed, the fundus cannot be felt with the abdominal hand but can often be palpated by running the vaginal fingers along the posterior vaginal fornix. It can be identified as the fundus of the uterus by tracing its direct continuity with the cervix. Normally the uterus has a definite range of mobility without the production of pain on motion. Reduction of mobility suggests inflammatory or malignant infiltration of the parametrium or the adnexæ.

The ovary can be palpated with the vaginal fingers in the lateral vaginal vault while the abdominal hand makes counterpressure just above and parallel to the corresponding Poupart's ligament. The non-adherent ovary slips freely between the palpating hands and is normally slightly tender to touch. The ovaries not infrequently prolapse into the cul-de-sac of Douglas where they can be felt posterior to the cervix. Normal Fallopian tubes are rarely palpable but when enlarged they can be felt as distinct masses lateral to the uterus or prolapsed into Douglas' pouch. The lower end of the ureter, when thickened by disease or distended by a calculus, can be palpated as it crosses above the antero-lateral vaginal vault.

Bimanual examination should always be followed by visualization of the vagina and cervix through a speculum; otherwise erosions and eversions of the cervix, as well as polypi and early carcinoma, may easily escape detection.

OPERATIONS ON THE FEMALE PELVIC ORGANS

The more frequent operations are the removal of the uterus,—hysterectomy,—removal of the ovary,—oöphorectomy,—removal of the Fallopian tubes,—salpingectomy. These operations are usually done through an abdominal incision near the median line between the umbilicus and the symphysis pubis. Not infrequently they are done through the vagina. Both inspection and palpation of the pelvic organs are greatly facilitated by elevating the pelvis so that the intestines gravitate toward the diaphragm—Trendelenburg's position (Fig. 503). The first structure encountered after opening the peritoneal cavity is the great omentum which often extends as low as the symphysis. As it hangs from the transverse colon it is to be displaced upward and not toward the sides. The next structures exposed are either the small or large intestines. The transverse colon normally should not come below the umbilicus but it may reach to the level of the symphysis and it likewise should be displaced upward. Sometimes the sigmoid colon may make its appearance from the left and more rarely the cæcum from the right.

Both of these structures are bound to the posterior abdominal walls and may often be covered in front by coils of small intestine. Quite frequently however, the cæcum on the right and iliac colon on the left come in contact with the anterior abdominal wall in the iliac fossæ in the neighborhood of the anterior iliac spines and may extend part way down Poupart's ligament. The sigmoid colon, if distended, may bulge anteriorly, but more usually it lies posteriorly covered by the small intestines. If it or the cæcum are encountered they are to be pushed upward and to the side. The small intestines are to be displaced upwards. The bladder lies in the mid-line anteriorly and directly behind it is the uterus. If the uterus is drawn to one side the broad ligament of the opposite side is made tense and the round ligament is seen running to the internal ring anteriorly and, more posteriorly, is the Fallopian tube. On the posterior surface of the broad ligament below the outer end of the Fallopian tube lies the ovary. Farther posteriorly, in the hollow of the sacrum, is the rectum, with Douglas's pouch between it and the uterus. If

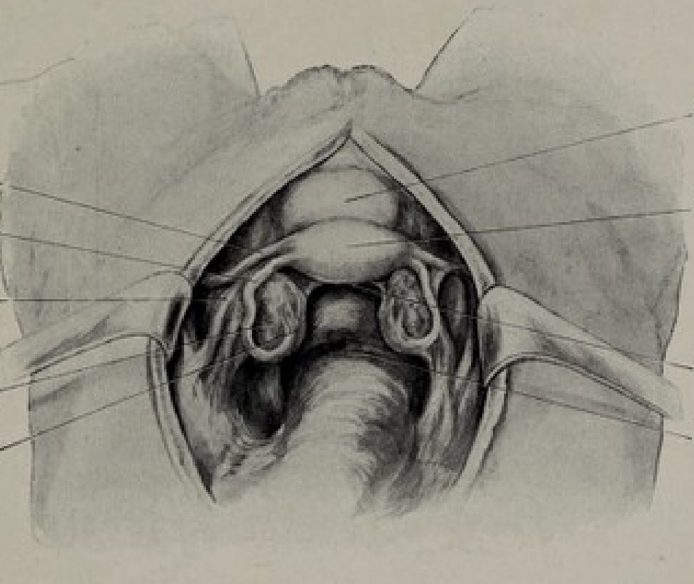


Fig. 503.—View of the interior of the female pelvis in the Trendelenburg position.

it is desired to recognize the structures by touch instead of sight, the anterior abdominal wall is followed down over the bladder and the fundus of the uterus is recognized as a hard rounded mass. This can be grasped between the thumb and fingers and followed laterally past the cornu to the broad ligament. If the tubes and ovaries are enlarged they may be found lying posterior to the uterus in Douglas's pouch instead of laterally.

HYSTERECTOMY

Removal of the uterus is most often performed through a median lower abdominal incision. The vaginal route was more frequently employed before the advent of aseptic technique but is now reserved by most surgeons for cases of complete procidentia. If the entire uterus, including the cervix, is removed the operation is known as a total or pan-hysterectomy; if only the fundus and body of the uterus are removed, a supravaginal hysterectomy.

Supravaginal hysterectomy, so called because the amputation is performed above the point of attachment of the vagina to the cervix, is performed through a median lower abdominal incision, preferably with the patient in the Trendelenburg posture. After packing the small intestine and the omentum upward, the fundus of the uterus is grasped with a tenaculum and is pulled upward and to the right. The left round ligament is clamped one-half inch distal to its origin and a ligature is placed one-quarter inch distal to the clamp. The round ligament and the subjacent half-inch of the broad ligament are cut between clamp and ligature. This cut opens the broad ligament and allows the anterior and posterior leaves of the ligament to separate. Closed scissors are passed underneath the anterior leaf of the broad ligament across the anterior surface of the uterus just above the level of the internal os. As the peritoneum is loosely attached to the lower segment of the uterus anteriorly, this step of the operation is practically bloodless. The anterior leaf of the broad ligament is incised across the anterior surface of the uterus. The right round ligament and anterior leaf of the right broad ligament are dealt with similarly. The bladder can now be easily separated by blunt dissection from the cervix and anterior vaginal wall. If the tubes and ovaries are to be removed along with the uterus, the broad ligaments are ligated lateral to the ovaries in their infundibulo-pelvic portions. The ovarian vessels lie near the free edge of the infundibulo-pelvic ligament and beneath them there is a clear avascular zone through which the ligature should be passed. If the tubes and ovaries are to be conserved, the broad ligaments, including the tubes, utero-ovarian ligaments, and utero-ovarian anastomoses, are ligated near the uterine cornua. A clamp is placed medial to the ligatures to control reflux bleeding and the broad ligament is severed between clamp and ligature. The uterine vessels are ligated on each side at the level of the internal os. These ligatures should pass horizontally to avoid inclusion of the ureter which lies about one-half inch below and lateral to the vessels at this point. The cervix is amputated by a wedge-shaped incision at the level of the internal os. The stump of the cervix is closed by interrupted sutures and the round ligaments are fixed into the lateral angles of the stump to avoid subsequent prolapse of the cervix. The raw surfaces are peritonealized chiefly by means of the flap of peritoneum which was reflected downward from the lower segment of the uterus anteriorly.

Total hysterectomy is performed by the same technique as that detailed above until the uterine vessels are to be ligated. These vessels are ligated one-half to one inch below the level of the internal os. The parametrium is incised for a short distance downward between the ligated vessels and the cervix, being careful to cut near the cervix. The parametrium, with its rich venous plexus, is clamped, cut and ligated bit by bit until the entire cervix and the upper one-half inch of the lateral vaginal wall are free from lateral attachments. The uterus is pulled upward and forward bringing the utero-sacral ligaments into view. A small transverse incision is made in the peritoneum of the posterior wall of the cervix just above the origin of the utero-sacral folds. The peritoneum is dissected from the cervix and upper half-inch of the posterior vaginal wall. The utero-sacral ligaments are ligated and cut from their attachment to the uterus. The bladder is separated by blunt dissection from the anterior vaginal wall. The entire uterus is removed by circumcision of the vagina just below its attachment to the cervix. The vaginal wound is oversewn, the round and utero-sacral ligaments are sutured to the stump of the vagina and the raw areas are peritonealized. Particular care must be taken to avoid injury to the ureter in performing total hysterectomy. If the bladder is separated for some distance from the anterior vaginal wall, the ureters are necessarily carried downward with the bladder and therefore further from danger. If the parametrium is clamped and ligated near the cervix and if mass ligatures are avoided there is little chance of injury. The possibility of serious hemorrhage from the extremely vascular parametrium must be borne in mind.

Vaginal Hysterectomy.—The uterus, if not much enlarged, can be removed through the vagina when, as is the case in multiparæ, it is lax and capacious.

The cervix is grasped and drawn down to the vulva and the mucous membrane incised in the anterior fornix and posteriorly close to the uterine tissue. The bladder is pushed up and separated from the cervix by dry dissection with occasional snipping of fibrous bands by scissors until the peritoneum at the level of the internal os is reached. The peritoneum, which from this point up is adherent to the uterus, is opened and divided to the broad ligaments on each side. Douglas's sac is next opened posterior to the cervix and close to it, and the opening enlarged with the finger to the broad ligaments. A clamp is now placed on each broad ligament low down to control the uterine arteries. By hooking the finger above the fundus it can be brought back and down and out, the ovaries usually coming with it. The remaining portion of the broad ligaments is then either clamped or tied to control the ovarian arteries. Some operators use clamps alone, others use ligatures. Vaginal branches which bleed are grasped with hæmostats and ligated. The ureters, which lie 1.5 to 2 cm. (½ to ¾ in.) away from the cervix, are pushed outward when the opening in Douglas's sac is enlarged, and will be avoided by not placing the clamps too far away from the cervix.

Salpingectomy.—Removal of one or both fallopian tubes is often necessary because of extensive damage resulting from pelvic inflammatory disease or tubal pregnancy. In some cases the enlarged tube may be adherent to the ovary, the posterior leaf of the broad ligament, the postero-lateral wall of the uterus, the sigmoid, the rectum and adjacent loops of small intestine. The adherent structures must be released by careful blunt or sharp dissection. After mobilizing the tube, it should be held by forceps so that its blood supply in the mesosalpinx is distinctly visible. Beginning at the outer end of the tube, the mesosalpinx is sutured—ligated in small segments and divided as near the tube as possible. Segmental ligation and preservation of as much of the mesosalpinx as possible are essential in preserving an adequate blood supply to the retained ovary. Especial attention should be given to the ligation of the rather large vessels which supply the cornual end of

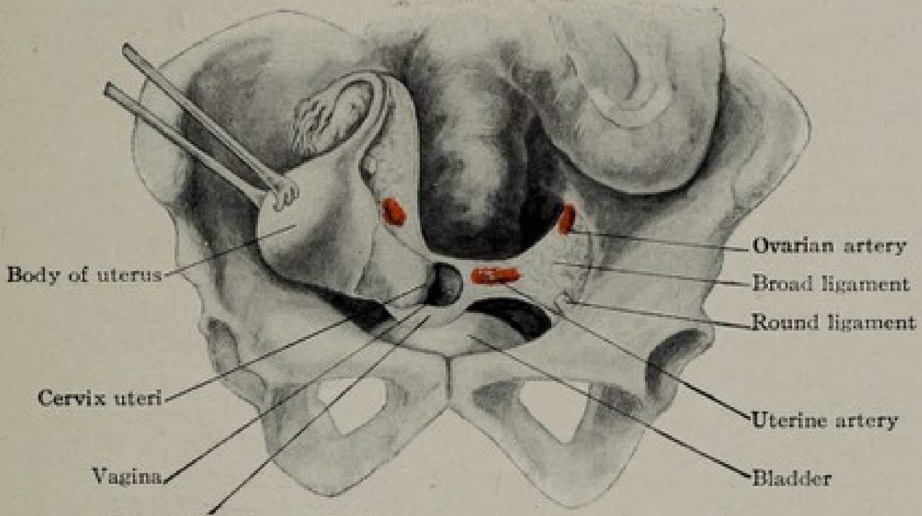


FIG. 504.—Removal of the entire uterus.

the tube. The intramural portion of the tube is excised along with a small wedge of the uterine cornu. The uterine wound is closed with several interrupted sutures, the cut edges of the mesosalpinx are oversewn, and the round ligament is attached to the fundus of the uterus in such a manner as to peritonealize the uterine incision.

Salpingo-oophorectomy.—The ovary may be removed alone but usually the corresponding fallopian tube is removed with it. The combined operation is simpler and the danger of injury to the pampiniform plexus is obviated. The infundibulopelvic ligament is doubly ligated, a clamp is placed distal to the ligature to control reflux bleeding and the ligament is severed between the clamp and ligature. The incision is carried across the broad ligament below the ovary to the side of the uterus. The uterine vessels are ligated near the cornu, the intramural portion of the Fallopian tube is removed and the uterine wound is closed by interrupted sutures. In cutting across the broad ligament, a small but often troublesome artery (Sampson's) may be severed as it courses upward from the uterine artery to supply the ovary. The raw surfaces are peritonealized by suture of the cut edges of the infundibulopelvic and broad ligaments and by suture of the round ligament over the cornual incision.

Tumors of the Broad Ligament (intraligamentary tumors).—Certain tumors originating either from the structures of the broad ligament or ovary, or side of the uterus, grow between the layers of the broad ligament. Parovarian cysts arising from the remains of the Wolffian body are of this character. These intraligamentary cysts are retroperitoneal, i.e., they lie between the layers of the broad ligament. The Fallopian tube is spread over and is adherent to their upper surface. As they grow downward they come in contact with the ureter, which may become adherent to the bottom or the lateral aspect of the growth. The liability of injury to the ureter is the greatest danger in these cases, and can only be escaped by searching for, recognizing, and avoiding it. These growths are exposed by splitting the peritoneum covering them after which they can be shelled out by blunt dissection. At times they are large and formidable and extremely difficult to remove.

Extra-Uterine Pregnancy.—The most dangerous factor in operating for extra-uterine pregnancy is hemorrhage. The tumor is usually tubal in position. The bleeding comes from the sac, therefore loosening and isolating it should be done with the greatest care to avoid rupturing it. If already ruptured the blood is to be rapidly sponged out, the uterus recognized and grasped with the hand, which is then slid outward until the ruptured tumor is felt and drawn up. The blood comes to the tumor from the ovarian artery and uterine artery. To control the former a clamp or ligature is placed on the infundibulo-pelvic ligament close to the pelvic wall. To control the latter a clamp is placed low down on the broad ligament close to the uterus. The active bleeding then ceases and salpingectomy or salpingo-oophorectomy is performed.

Laceration of the Cervix.—The cervix is made accessible for operation by grasping it with tenaculum forceps and drawing it down to the vulva. It is there held to one side, which renders the laceration easily accessible for excision and the introduction of sutures. Bleeding is controlled by the sutures.

SURGERY OF THE PELVIC SYMPATHETIC NERVES

Section of the superior hypogastric plexus (pre-sacral nerve) is occasionally performed for the relief of intractable dysmenorrhea or pain arising from extensive pelvic malignancy. The patient is placed in the Trendelenburg posture and a lower midline abdominal incision is made. The small intestines are displaced upward and the sigmoid is displaced upward and to the left. In thin individuals the nerve filaments can usually be seen beneath the parietal peritoneum covering the promontory of the sacrum. The peritoneum is incised in the midline just above the promontory, the nerve filaments are isolated, and a segment of each branch is excised. If the operation is being performed for the relief of pain in cases of malignant disease, the two lower lumbar sympathetic ganglia on each side should be resected in addition to the pre-sacral nerve. The right lumbar sympathetic chain lies in close proximity to the lateral border of the inferior vena cava and the left chain is usually located just beneath the left border of the aorta. The posterior parietal peritoneum is closed with a continuous suture and the abdominal incision is closed in layers.

THE FEMALE EXTERNAL GENITALS

The *mons veneris* is a cushion-like pad of fat located over the anterior surface of the pubic bones. It is covered by thick skin which is rich in large hair follicles, sweat glands, and sebaceous glands.

The *labia majora* extend posteriorly from the mons and are homologous to the respective halves of the scrotum in the male. The outer surface is similar in structure to the mons veneris; the inner surface is more delicate but also contains small hair follicles and sebaceous glands. The subcutaneous tissue is rich in fat. The labia majora meet anteriorly at the anterior commissure and posteriorly they join to form the posterior commissure.

The *labia minora* are delicate folds of hair-free skin which lie medial to the labia majora; together they form the lateral boundary of the vestibule. The labia minora divide anteriorly to encircle the clitoris, forming the prepuce above and the frenum on the lower surface. The labia minora diminish in size posteriorly where they blend with the labia majora. A short distance in front of the posterior commissure they are joined by a transverse fold called the fourchette.

The only portions of the *clitorus* which are visible when the labia are retracted are the glans and a part of the body. The latter is seen as a small vertical ridge in the skin covering the lower portion of the symphysis pubis. The body of the

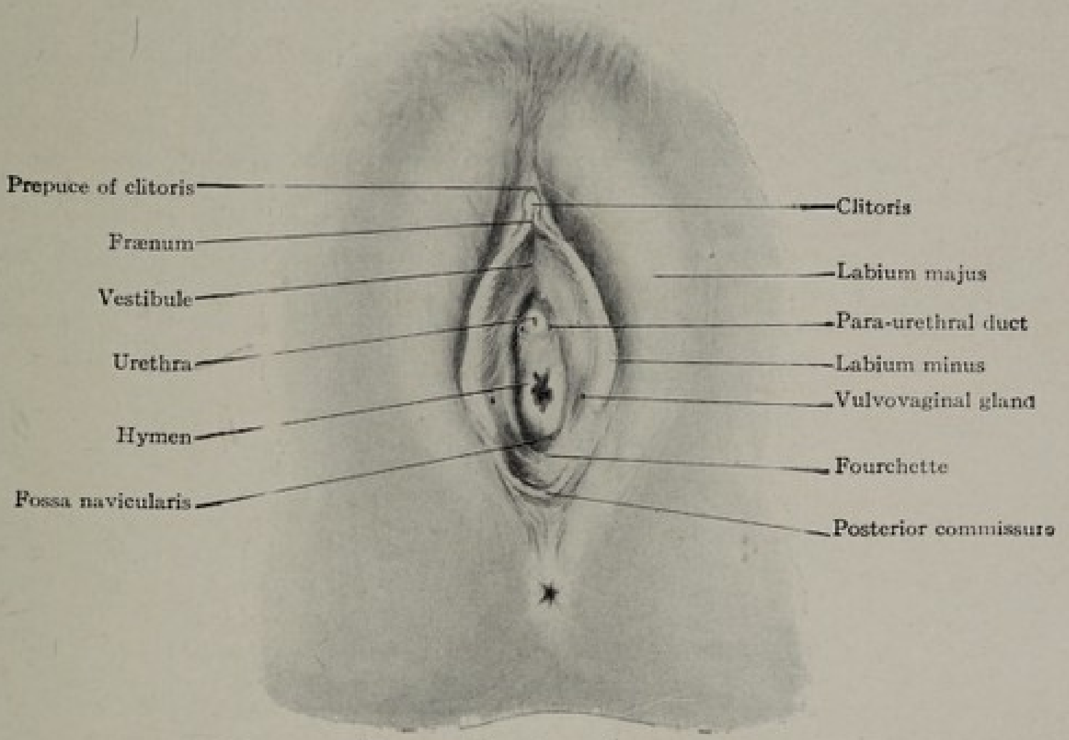


Fig. 505.—External female genitals (vulva).

clitoris is composed of the united anterior terminations of the corpora cavernosa and the vestibular bulbs. The corpora cavernosa diverge posteriorly as the crura and each attaches to the corresponding descending ramus of the pubis. The vestibular bulbs diverge from their point of union and extend posteriorly and laterally just under the skin of the vestibule. The component parts of the clitoris are composed of erectile tissue.

The *external urinary meatus* is located in the vestibule 2.5 cm. posterior to the glans clitoris. Just within each postero-lateral margin of the meatus is the opening of the para-urethral (Skene's) duct.

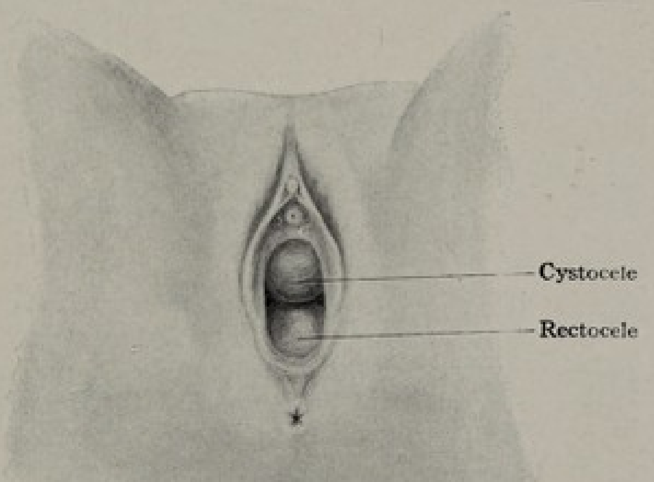


Fig. 506.—Hernia of the bladder (cystocele) and of the rectum (rectocele).

The vulvo-vaginal gland (of Bartholin) is situated in the lower half of the vestibule on each side. It is a compound racemose gland and is homologous to Cowper's gland in the male. Each duct empties into the vestibule in the sulcus between the labia minora and the vaginal orifice. The openings are just visible to the naked eye and are located near the junction of the lower and middle thirds of the margin of the vaginal orifice.

The *hymen* is a thin membrane of skin which is attached around the circumference of the vaginal orifice. The *carunculae hymenales* are the irregular remnants of the ruptured hymen. The fossa navicularis is the small depressed space between the hymen and the fourchette.

THE PELVIC DIAPHRAGM AND FEMALE PERINEUM

The perineum or pelvic outlet is the lozenge shaped space bounded anteriorly by the pubic bones; laterally, by the ischio-pubic rami, the ischial tuberosities, and the sacro-sciatic ligaments; and posteriorly, by the coccyx. It is subdivided by a transverse line just anterior to the ischial tuberosities into an anterior or urogenital triangle and a posterior or anal triangle.

The pelvic floor, in the broadest sense, includes all the structures between the pelvic peritoneum and the skin of the perineum. Its chief support is derived from two separate musculo-fascial diaphragms, the upper or levator diaphragm and the lower diaphragm or triangular ligament. The upper diaphragm is composed of the paired levator ani and the paired coccygeus muscles, together with

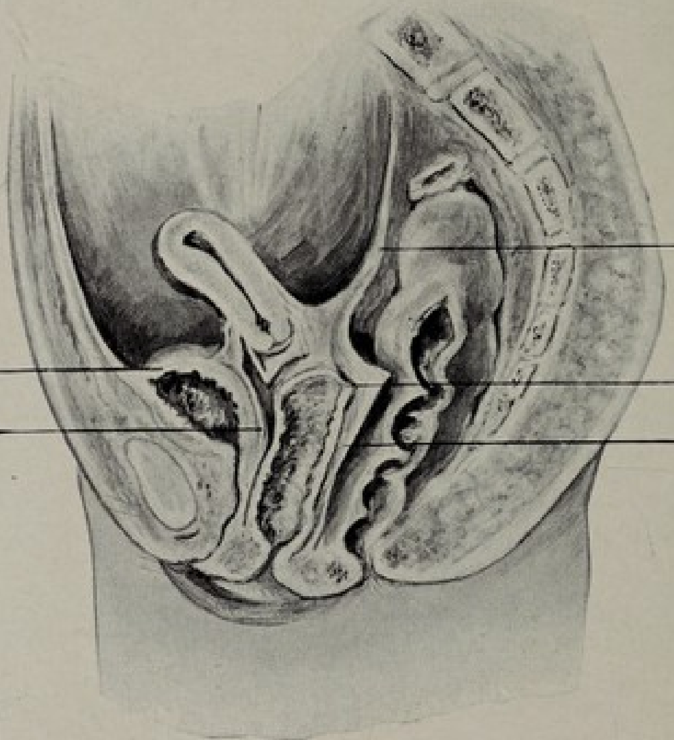


FIG. 507.—Pelvic fasciae.

the fasciae which cover both the superior and inferior surfaces of the muscles. The levator ani muscle is composed of two portions; the ileo-coccygeus arises from the pubic rami and the "white line" of the parietal pelvic fascia as far posteriorly as the ischial spine, and inserts into the coccyx and the ano-coccygeal raphe; the pubo-coccygeus is the stronger medial portion which arises from the posterior aspect of the body and the descending rami of the pubis and passes backward along the sides of the urethra, vagina and rectum to insert into the coccyx and sacrum. The most medial fibers decussate with their fellows from the opposite side in the space between the vagina and anus (central point of perineum) to form the external anal sphincter. The pubo-coccygeus lies in intimate contact with the lower third of the lateral vaginal wall and by its forward traction on the anal sphincter it serves as the chief constrictor of the vagina. The upper diaphragm is completed posteriorly by the coccygeus (ischio-coccygeus) which arises from the spine of the ischium and the lesser sacro-sciatic ligament and inserts into the lateral border of the coccyx and sacrum.

The levator ani muscles are covered on their superior surfaces by a strong fascia which is continuous at the "white line" with the parietal pelvic fascia overlying the obturator internus muscle. This superior layer of fascia completely closes the floor of the pelvis except for the openings of the urethra, vagina and rectum and to these structures it gives a sheathing investment of strong fibrous tissue. The lower surface of the levators is covered by a somewhat thinner layer of fascia which is also continuous with the parietal pelvic fascia at the "white line". The superior and inferior layers of the levator fascia unite (Farrar) at the lateral walls of the vagina; this fused structure passes from side to side posterior to the vagina and constitutes the chief support of the recto-vaginal septum. Goff, to the contrary, maintains that the easily dissected layer of tissue which lies between the vagina and rectum and between the vagina and the bladder is not fascia in the true histological sense, but is rather the muscular coat of the vagina. Regardless of their histologic nature, these layers of tissue constitute strong supportive structures which can be utilized in the repair of cystocele and rectocele.

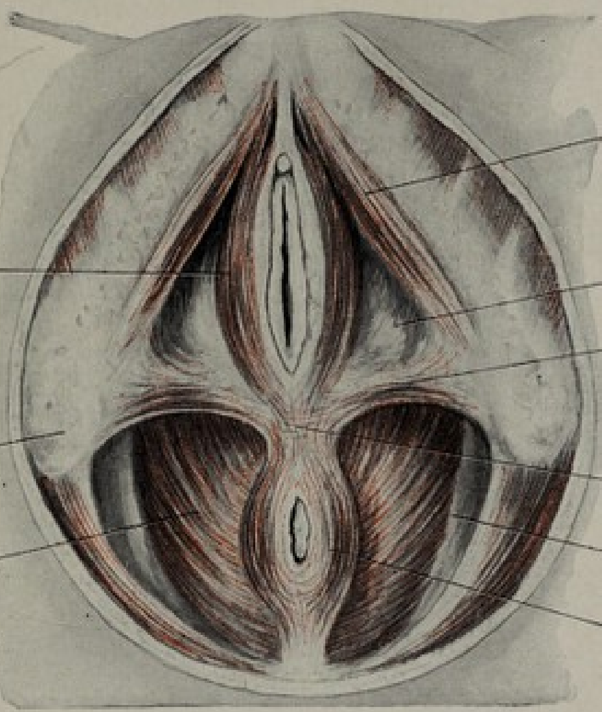


Fig. 508.—Female perineum.

The lower diaphragm or triangular ligament reinforces the levator diaphragm over the uro-genital triangle. It is composed of two slightly separated layers of strong aponeurotic fibers which are attached anteriorly to the body of the pubis and laterally to the ischio-pubic rami as far posteriorly as the ischial tuberosities. The two layers fuse posteriorly, forming a strong fascial band which extends across the perineum. The inferior fascia of the levator ani is adherent to the superior layer of the triangular ligament. The ligament is pierced by the urethra and the vagina; between its layers lie the constrictor urethræ and the transversus perinei profundus muscles in addition to the pudendal vessels and nerves.

The superficial fascia of the perineum is divided into two definite layers, a superficial fatty stratum and a deeper aponeurotic layer. The fatty layer is continuous posteriorly with the adipose tissue of the ischiorectal fossa; anteriorly it forms the labia majora and the mons veneris and is continuous with the fatty tissue of the anterior abdominal wall. The deep layer (Colles') is continuous anteriorly with the deep layer of the superficial fascia (Scarpa's) of the anterior abdominal wall. Laterally, it is firmly attached to the ischio-pubic rami and posteriorly it fuses with the base of the triangular ligament. Between this layer and the inferior surface of the triangular ligament is a shallow space known as the superficial perineal compartment. It is traversed by the urethra and vagina and contains the crura of the clitoris, the bulbs of the vestibule, the ischiocavernosus, the bulbo-cavernosus and the transversus perinei superficialis muscles, and the vulvo-vaginal (Bartholin's) glands.

SURGICAL CONSIDERATIONS OF EXTERNAL GENITALIA AND PELVIC FLOOR

The *mons veneris* and *labia majora* are well supplied with veins which, in pregnancy or in association with pelvic tumors, may become varicose; rupture of these varicosities may produce hematomata of considerable size.

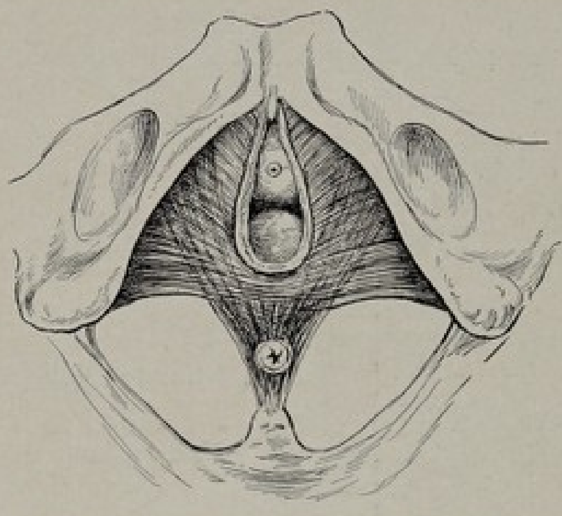


FIG. 509.—Schematic drawing of the pubococcygeus muscles and the urogenital trigone.

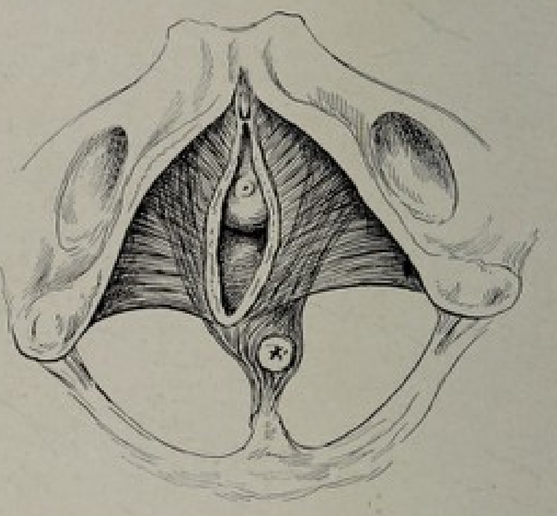


FIG. 510.—Laceration through the right vaginal sulcus. Note lateral retraction of the right pubococcygeus.

The *external urinary meatus* is sometimes the seat of a papillo-angiomatous growth called urethral caruncle; such growths are bright red in color, bleed easily on trauma and are extremely tender. This condition must be differentiated from the more frequent prolapse of the urethra mucosa, in which the color is that of the normal mucous membrane and tenderness is not nearly so marked. The treatment of both conditions is excision. The *para-urethral ducts* (Skene's) which empty into the floor of the meatus are frequently involved in cases of gonorrhea, and re-infection of the upper genital tract may occur repeatedly from these foci until they are destroyed by the actual cautery. Small cysts or abscesses may develop in the para-urethral glands and bulge into the anterior vaginal wall.

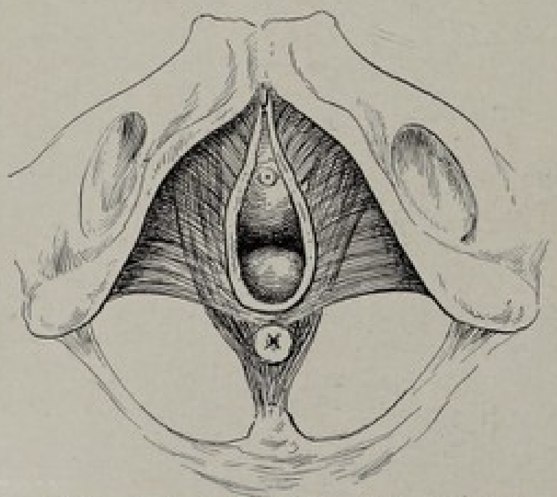


FIG. 511.—Laceration through both vaginal sulci. Note that both pubococcygeus muscles retract laterally. The anal canal is displaced posteriorly allowing the formation of a rectocele.

The *vulvo-vaginal glands* (Bartholin's) are frequently infected by the gonococcus, and the glands may harbor the organisms for months or years. In some cases the involved glands can be palpated as firm shot-sized nodules while in others cysts or abscesses of considerable size may be formed as result of stenosis of the duct. If the gland is palpable it should be removed; otherwise, reinfection of the genital tract may occur repeatedly from this focus. Removal of the vulvo-vaginal gland is often attended by considerable bleeding because of its close proximity to the erectile tissue of the bulb of the vestibule.

The hymen may remain completely imperforate, causing retention of menstrual blood; in such cases it must be excised. Dyspareunia may necessitate excision of tender *myrtiforme carunculæ*.

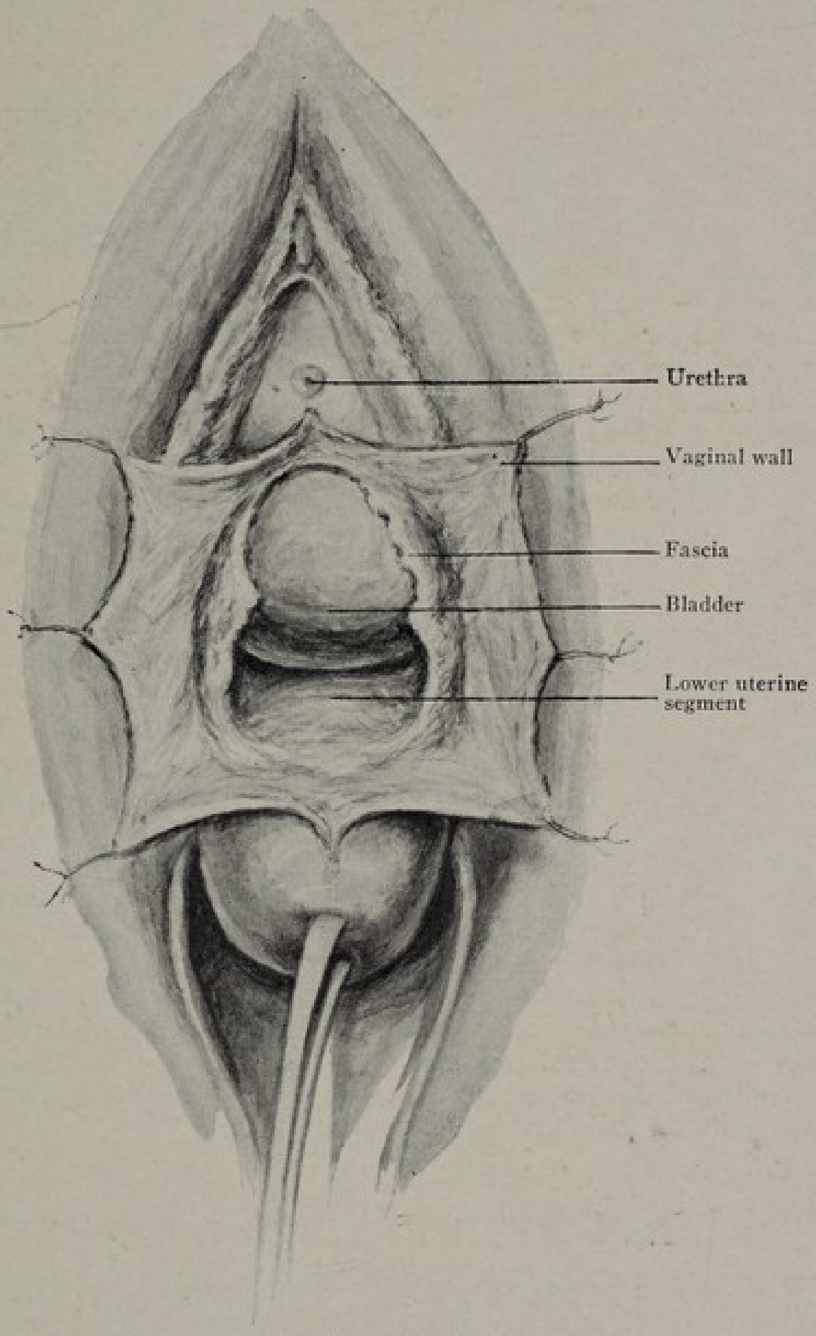


FIG. 512.—Anterior colporrhaphy.

The *perineum* is frequently lacerated in child-birth. If the rent involves only the skin or mucous membrane, it is known as a first degree tear; if the underlying muscle and fascia are involved, the tear is second degree; third degree or complete tears are those which include the anal sphincter, with or without involvement of the bowel wall.

Rectocele. Second and third degree tears necessarily involve the supporting fasciæ including the deep layer of the superficial fascia, the urogenital diaphragm (triangular ligament) and both layers of the levator fascia. In addition, the pubococcygeus (medial) portion of the levator ani is either torn or is separated from its fellow of the opposite side. This separation produces a rent or an attenuation of that portion of the levator fascia which lies anterior to the rectum. The loss of support thus produced in the perineum and recto-vaginal septum allows the vulva to gape and the anterior rectal wall to bulge into the vagina. This hernia is known as a rectocele.

The repair of a rectocele is based on the following principles: triangular denudation of the perineum and rectocele, reduction of the herniated anterior rectal wall, repair of the torn or attenuated levator fascia anterior to the rectal wall, re-uniting in the mid-line the severed and retracted pubococcygeus muscles, suture of the uro-genital diaphragm including the deep and superficial transversus perinei muscles and suture of the superficial fascia and skin.

In complete laceration of the perineum, it is necessary, in addition to the above principles, to repair the rent in the anterior rectal wall and to isolate and re-unite the retracted ends of the torn sphincter ani muscle. These ends are usually easily identified by a dimple of the skin which overlies the retracted muscle end.

Cystocele.—The chief supports of the bladder are: the cardinal ligaments attached to the anterior and lateral surfaces of the cervix, the attachment of the bladder to the cervix, and the pubo-cervical (utero-vesical) fascia extending from the cervix to the pubes.

Frequently following injury in child-birth, and occasionally because of congenital weakness, these supports are inadequate and allow the bladder to prolapse and bulge into the anterior vaginal wall. This condition is known as a cystocele. The repair of a cystocele is based on the following principles: denudation of the overstretched anterior vaginal wall, detachment of the bladder from the pubo-cervical fascia and from the cervix, elevation of the bladder and its fixation high on the anterior wall of the uterus, reuniting the torn and attenuated fascial supports underneath the bladder and closure of the vaginal incision.

The interposition of the uterus (Watkins-Wertheim operation) between the anterior vaginal wall and the bladder gives excellent results in selected cases of cystocele. As pregnancy and labor subsequent to this operation are not advisable, it is applicable chiefly to women who have passed beyond the menopause. Adequate utero-sacral ligaments are essential to its success as the cervix must be held well back toward the hollow of the sacrum. The uterus must be small enough to place into its new position and must be large enough to form an adequate support to the bladder. The principles of the operation are: exposure and elevation of the bladder as described for the ordinary repair of cystocele, transverse incision of the peritoneum of the utero-vesical cul-de-sac, drawing the uterine fundus forward through the peritoneal incision, firm attachment of the fundus to the anterior vaginal wall near the external urinary meatus, closure of the vaginal mucosa over the anterior wall of the uterus. On completion of the operation the uterus lies horizontally in the pelvis underneath the bladder.

THE MALE EXTERNAL GENITALS

PENIS.—The penis is composed of three erectile bodies, the *corpora cavernosa* and the *corpus spongiosum*; the last is traversed for the greater part of its length by the urethra, and is sometimes called the *corpus cavernosum of the urethra*. The proximal ends of the corpora cavernosa are attached to the inner surfaces of the rami of the pubes and ischia; their distal ends are covered by the *glans penis*, a part of the corpus spongiosum. This body lies in a groove below and between the corpora cavernosa, and consists of a posterior swelling, the bulb, a long slender body, and an anterior expansion, the glans. The urethra enters its upper surface near the posterior end of the bulb and traverses it to the apex of the glans.

Each of the erectile bodies has its own fascial covering, or tunica albuginea. Those of the corpora cavernosa are particularly dense and strong; they fuse in the midline with one another, forming an incomplete *septum pectiniforme*, permitting the intercommunication of the venous spaces of the right and left corpora. It is therefore impossible to dissect one corpus cavernosum from the other, though the corpus spongiosum can be separated from the overlying cavernous bodies without injury to either.

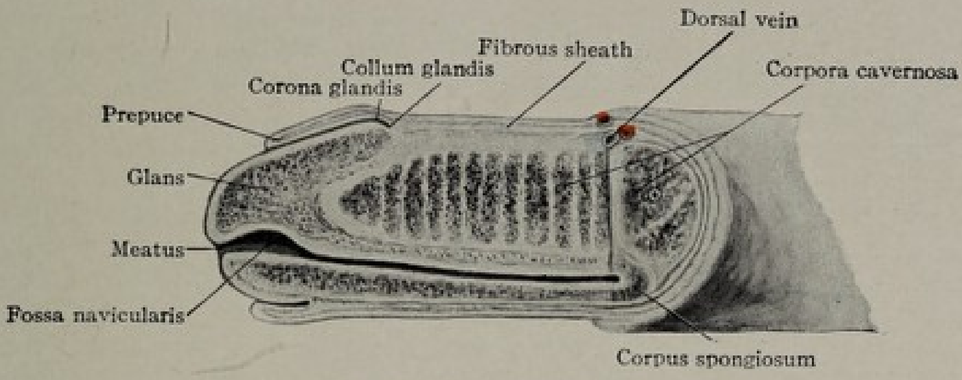


FIG. 513.—Structure of the penis.

Outside the tunicae albugineae are two additional layers of fascia, those of Buck and Colles, binding the penile bodies together. (Buck's fascia is described as sending a partition between the corpora cavernosa above and the corpus spongiosum below.) Over these is a layer of loose areolar tissue and the skin, with its dartos fibres. All of these structures are firmly attached to one another back of the swelling of the glans (*corona glandis*), in the region variously called the *coronary sulcus, collum glandis,* and *cervix penis.* The glans is covered by tightly adherent, moist integument and a double layer of skin, the *prepuce*; the attachment of this to the corona glandis usually extends ventrally to the urethral meatus, forming the frenum. The lining of the preputial sac, both preputial and glandular, histologically is skin, not mucous membrane, despite its moist character.

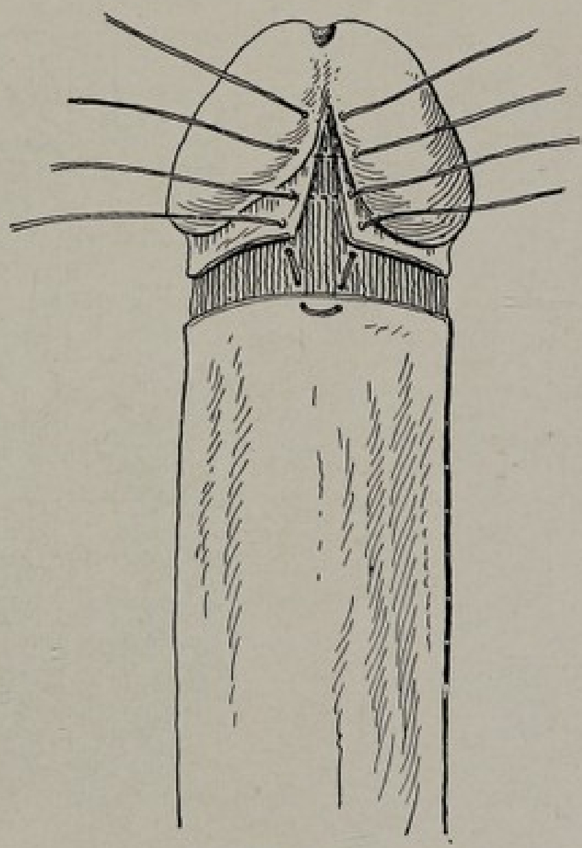


FIG. 514.—Circumcision.

If, in the performance of circumcision, the frenum is removed annoying bleeding is frequently encountered. This is more frequently a venous ooze than an arterial spurt, and is best controlled by deeply placed sutures. The method of suture shown in Fig. 514 not only controls such hemorrhage but by producing a long flat surface prevents a downward pull on the meatus during erection.

Blood Vessels and Nerves.—The chief vessels of the penis are the dorsal vein and the two dorsal arteries, all of which run beneath the fascia in the midline above the septum pectiniforme, and the central arteries of the corpora cavernosa. The other vessels are too irregular in their course to warrant description. In amputating the penis the above vessels should be secured before releasing the tourniquet, if one has been used.

The nerves of the penis may be considered as divided in two sets, superficial and deep, Buck's fascia separating the two groups. Considered thus, for such operations as circumcision it is necessary to inject in two regions, unless one is content to flood the operative field with the anesthetizing solution and operate in the presence of marked edema. The superficial nerves are blocked by three subcutaneous injections at the base of the penis. The deeper fibres are caught as they emerge back of the corona by a circle of wheals in this region, or blocked by injections into the venous spaces of the corpora cavernosa, the method being an application of Bier's intravenous anesthesia. This method gives anesthesia of the whole end of the penis, not of the prepuce alone.

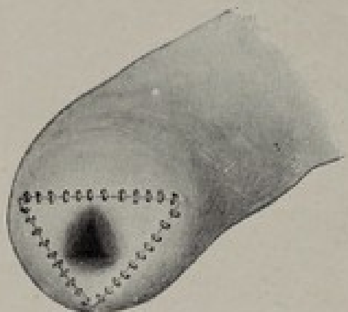


Fig. 515.—Amputation of the penis. Mucous membrane of urethra everted, cut in triangular form and sewed to the skin to avoid cicatricial contraction. (Dr. Davis' method.)

Scrotum, Testicles and Spermatic Cords.—The scrotum is the bag-like container of the testicles and spermatic cords. Its pigmented skin is either smooth or wrinkled, according to whether the muscular fibres of the underlying *dartos* to which it is closely attached, are relaxed or contracted. In the midline the dartos sends inward a sheet of fascia (*septum scroti*) to divide the scrotum into right and left compartments. Urologists describe Colles' fascia as lining the scrotum inside the dartos, while anatomists state that the dartos blends with Colles' fascia in the perineum and with Scarpa's fascia on the abdominal wall. The difference is largely one of names.

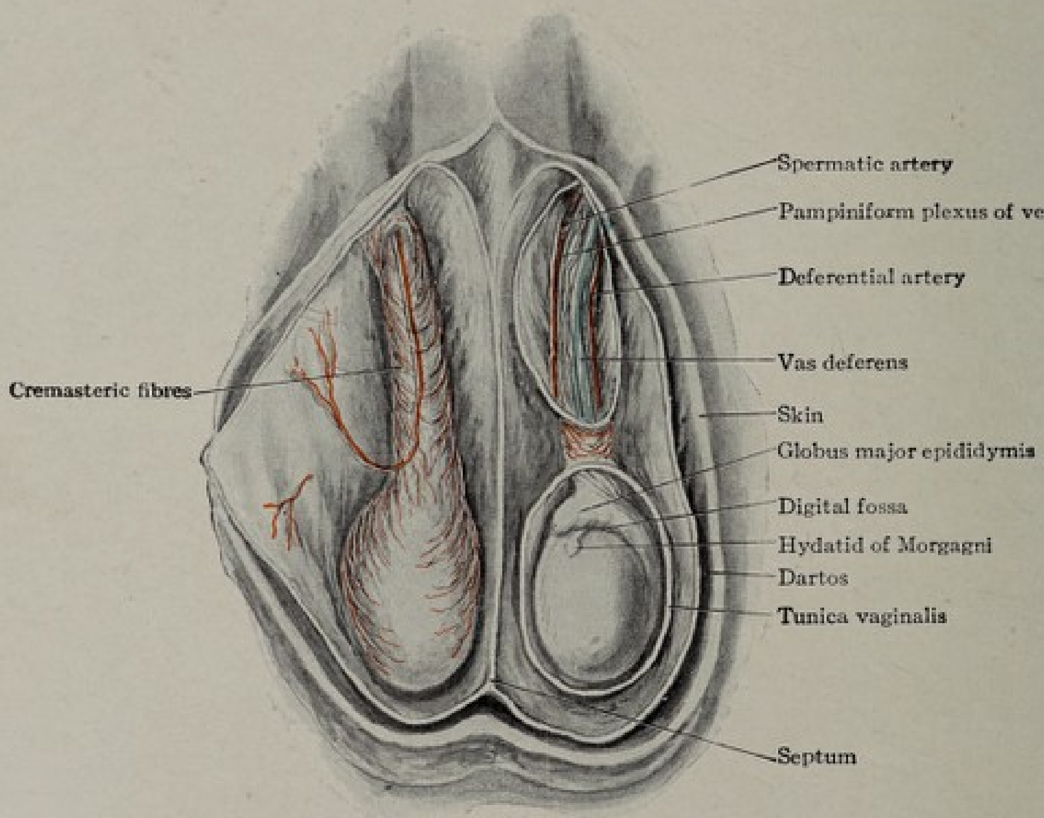


Fig. 516.—Scrotum and contents. The dartos has been separated from the skin; on the left side the three layers of spermatic fascia lying between the dartos and the tunica vaginalis are not shown.

The coverings of the testicles derived from the abdominal wall at the time of their descent will be described later. The blood supply is largely through the external pudics and superficial perineal arteries. The nerves are branches of the genitocrural and superficial perineal trunks.

Because of the close attachment of skin and dartos there is a strong tendency for the edges of an incision to become inverted, thus delaying healing, unless sutures are placed close to the margins of the wound. The tissues, loose and vascular, heal rapidly if proper attention be given to hemostasis, but if hemorrhage be not completely controlled a large hematoma with prolonged convalescence results. It is usually possible to clamp vessels before they are cut, materially lessening this hazard. "Urinary extravasations" (see p. 545) should be incised early to prevent extensive tissue destruction.

Testicles.—The development of the testicles has been described briefly on page 435. It is there stated that this organ moves from its place of formation within the abdomen to its final location in the scrotum. The means of whereby this migration is effected is not understood, but it is believed that the *gubernaculum testis* plays a part, probably as a guide rather than a tractor. The gubernaculum is a fibromuscular band of tissue running from the head of the epididymis to the bottom of the scrotum, as its chief caudal attachment. Fasciculi of the gubernaculum are described as attached to the perineal fascia, Poupart's ligament and Scarpa's triangle. The testicle may halt at some point along its normal path of descent, a condition known as undescended testicle or cryptorchism; it may also take an aberrant course, finding lodgment in such regions as the perineum, thigh, abdominal wall or true pelvis (*ectopia testis*).

In passing through the abdominal wall (inguinal canal) the testicle is preceded into the scrotum by a process of peritoneum and three layers of fascia derived from the wall of the abdomen. From without inward, therefore, the coverings of the testicle are:

The skin and dartos of the scrotum.

The external spermatic fascia, a thin layer derived from the inter-columnar fascia of the external ring.

The middle spermatic or cremaster fascia, consisting of fibrous bands and muscle bundles, derived from the lower margin of the internal oblique.

The internal spermatic fascia, derived from the transversalis fascia. This fascia becomes greatly thickened when a hydrocele develops; it should be removed as a part of the operation for the cure of this condition.

The tunica vaginalis, parietal and visceral layers, covers the testicle except at the back, where the epididymis is located.

The tunica albuginea, a strong white, fibrous membrane is the proper tunic of the testicle.

Normally the funicular peritoneal process becomes obliterated from the internal abdominal ring to a point just above the testicle but closure may be incomplete, permitting peritoneal fluid to pass down to the tunica vaginalis covering the testicle; this is called a *congenital hydrocele*. If the opening be large enough for intestine to enter, it forms a *congenital hernia* (see page 436). If the opening be closed above and fluid accumulates in the tunica vaginalis it forms an *infantile hydrocele*. If a portion of the vaginal process persist somewhere along the spermatic cord between the internal ring and top of the testis and form a cyst, it is called an *encysted hydrocele of the cord*. The vaginal process closes at its upper portion just before birth and in those cases which are patulous after birth (congenital hernia and hydrocele) there is a tendency to spontaneous closure, hence operative measures are usually deferred. The vaginal process also descends into the inguinal canal in the female; a hydrocele of it is called a *hydrocele of the canal of Nuck*.

Size, Position, etc.—The normal testicles are 4 cm. (1½ in.) long, 2.5 cm. (1 in.) wide, and 2 cm. (⅘ in.) thick. They are firm to the touch. If larger they are either hypertrophied or diseased. If hypertrophied their consistence is not materially altered, if diseased it is usually harder. If smaller they are usually atrophied and besides the lessening of size are also softer and flabby in consistency.

They lie attached at the inner posterior portion of the scrotum, their long axes pointing upward, slightly forward, and outward. In cases of hernia and hydrocele the testicle is usually to be felt at the inner posterior aspect of the swelling. In rare instances the testicle is placed anteriorly instead of posteriorly and is liable to be wounded in introducing a trocar into the tunica vaginalis to empty a hydrocele. To avoid this accident the position of the testicle should be determined not only by palpation but by examining with transmitted light. As the testicle is almost always low down the puncture should be made high and preferably on the outer side.

Epididymis.—This is sometimes considered as a part of the testicle, sometimes as a separate organ. It is attached to the back of the testis, but as it is longer than this gland it extends both above and below its poles. Structurally it is simply the convoluted duct of the testis, but because of its morphology and the diseases peculiar to it special description is warranted. It consists of a head or globus major, situated above and behind the testis, a body of smaller circumference than the head, placed behind the testis, slightly lateral to the median line, and a tail or globus minor, found behind and below the lower pole of the testis; the duct of the epididymis then becomes the vas deferens which ascends back of the testicle to become a part of the spermatic cord.

Three small appendages of the spermatic cord, epididymis and testis deserve mention because their torsion results in pain which simulates torsion of the testicle. These are paradidymis or organ of Giraldès, situated on the spermatic cord above the epididymis, the appendix of the epididymis on the globus major, and the hydatid of Morgagni on the testis near its upper pole. None of these bodies is constantly present.

Torsion of the testicle, characterized by severe pain, swelling and tenderness may occur either within the tunica vaginalis or outside this structure; the former is the more common.

When examining a diseased testicle one should ascertain, if possible, the tissues affected, feeling successively the cord, the epididymis and the testis, and trying to determine by means of palpation and transmitted light whether there is an effusion into the tunica vaginalis. It should be remembered that in the presence of an acutely inflamed epididymis the area of testicular tissue palpable is relatively small and soft; it may suggest an area of suppuration. Tuberculosis and acute inflammation, except that of mumps, commonly attack the epididymis, while neoplasm is more frequently seen in the testis. Syphilis may involve either organ, but the testicle is the more frequently affected.

The nerve supply as well as the blood supply of the testicle is through the spermatic cord; consequently anesthetization can be accomplished by injecting this structure as it emerges from the external ring. The blood-vessels enter and leave the testis on its posterior surface, about midway between the poles.

Spermatic Cord.—The left spermatic cord is longer than the right, hence the left testicle hangs lower. The cord is composed of the vas deferens with its artery, a branch of the superior vesical, and veins; the spermatic artery with its veins; the cremasteric artery; nerves; lymphatics and fascial coverings. The nerves are the genital branch of the genitocrural, and sympathetic fibres. The lymphatics drain into retroabdominal nodes as high up as the renal vessels.

There is a free anastomosis between the vessels of the cord, so that in exciting varicose veins of a varicocele one need only be sure that sufficient veins are left to care for the returning blood, but need not ascertain whether they are of the deferential or spermatic group. Nor is it necessary to spare the spermatic artery; the deferential artery alone is able to supply the testicle and epididymis. The artery of the vas is usually so closely associated with this structure that it is not likely to be ligated. The veins of the cord are known as the *pampiniform plexus*. At the internal ring the spermatic group is reduced to two, which later unite to form a single vessel which empties into the vena cava on the right side, and into the renal vein on the left. The left spermatic veins are said to be devoid of efficient valves, possibly the reason for the frequent occurrence of varicocele in the left cord.

The fascial coverings of the cord are derived from the abdominal wall, as in the case of the testicle; the intercolumnar, cremasteric, and infundibuliform layers correspond to the external, middle and internal spermatic fascias. In addition, next to the cord, is a very thin layer derived from the subperitoneal fascia. It is of importance only because it is occasionally the site of origin of lipomata.

THE URETHRA

The male urethra has an average length of 20 cm. (8 in.); as it is elastic this length may be materially increased by traction on the penis. In boys of 5 years the length is 8 to 10 cm.; at puberty it is 10 to 12 cm. In the normal adult the prostatic urethra measures 3 cm. (1¼ in.), and the membranous urethra, the portion between the deep and superficial layers of the triangular ligament, measures 1 cm. (⅖ in.). These two portions of the urethra together comprise the *posterior urethra*. In contradistinction, the portion of the canal distal to the superficial layer of the triangular ligament is called the *anterior urethra*. It is spoken of as containing *bulbous, perineal, scrotal, penile*, and *pendulous* portions; these overlap and are not sharply delimited.

The urethral lumen is not of uniform calibre. The meatus is the smallest and least distensible portion. In terms of the French or Charriére scale (being the diameter in thirds of a millimeter) the average meatus will admit a 25F. instrument; less than 20F. is pathological. Next to the meatus, the membranous urethra is the narrowest and least distensible portion; but here "distensible" is a relative term, so that an initial 28F. can usually be stretched to 32F. without great distress. The penile, bulbous and prostatic portions follow the membranous urethra in size and distensibility, the prostatic urethra's size being about 40F. Attempts have been made to estimate the urethral calibre from measurements of the flaccid penis, but the exceptions are too numerous for the rules proposed to be useful.

Relations.—The internal urethral meatus lies about 6.25 cm. (2½. in.) from the surface just behind the middle of the symphysis, if the body is in a vertical position. The membranous portion pierces the triangular ligament, 2.5 cm. (1 in.) or a little less below the subpubic ligament. The lowest portion is just in front of the triangular ligament. The urethra then rises slightly, 0.5 cm. (⅕ in.), and finally drops to the meatus. The subpubic curve of the urethra has a radius of about 4 cm. (1⅝ in.) and urethral instruments should be made with approximately this curvature. Due to the elasticity of the tissues this so-called "fixed curve" can be obliterated by the passage of a straight instrument. The membranous urethra can be palpated at the apex of the prostate by the finger in the rectum.

Structure.—The urethra is surrounded by a layer of erectile tissue (corpus spongiosum) covering a muscular layer which is continuous with that of the bladder. Beneath the muscular layer is the submucous, rich in blood-vessels, on which is laid the mucous layer. This latter is covered columnar epithelium except in the fossa navicularis, where it is of the flat pavement type.

The urethra contains small mucous glands opening on its surface—*glands of Littré*—and small pockets or recesses, called the *lacunæ of Morgagni*, into which some of the glands of Littré empty. The lacunæ are mostly in three rows on the roof of the penile portion; they open toward the meatus. A large one—lacuna magna—opens in the posterior portion of the roof of the fossa navicularis, a couple of centimetres behind the meatus. The glands of Cowper, placed between the layers of the triangular ligament, close to the mid line, open into the bulbous urethra, their ducts having pierced the superficial layer of the ligament. The racemose glands of the prostate open chiefly on the floor of the prostatic urethra, and the ejaculatory ducts open on the urethral crest (verumontanum), with the utricle (prostatic sinus) between them. The mucous walls of the urethra are normally in contact, making a vertical slit at the external meatus, a transverse one in the penile portion, one of horseshoe shape in the prostate at the level of the verumontanum, and again transverse just before the bladder is reached.

Urethral Muscles.—There are two sets of muscles in connection with the urethra; one set aids in expelling the urine and the other in retaining it. The expulsors are the longitudinal and circular fibres surrounding the urethra just outside the mucous membrane and the *accelerator urinæ* or *bulbocavernosus muscle.* The sphincters are the *compressor urethræ* or *external sphincter muscle,* about the membranous urethra, and the *internal sphincter* at the neck of the bladder, composed of fibres continued from the bladder. (See page 512.)

Practical Application.—The division of the urethra into anterior and posterior portions, according to whether distal or proximal to the superficial layer of the triangular ligament, is made on clinical as well as anatomical criteria. At this point, that is between the layers of the triangular ligament, the urethra (membranous portion) is surrounded by the strong compressor urethræ muscle, also known as external vesical sphincter and the "cut-off muscle". This muscle is so much stronger than the internal sphincter that, in relation to urethral discharge, it functions as a "water-shed", so that pus from the posterior urethra cannot pass forward to the meatus, but tends to make its way back into the bladder, while pus formed in the anterior urethra appears at the meatus, and is spoken of as "anterior discharge". This physiological condition forms the basis of the much used "two glass test", wherein clouding of the second specimen in an acute urethritis is interpreted as meaning involvement of the posterior urethra, since were the posterior urethra not involved the first portion of clear urine from the bladder would have washed the urethra clean (cloudy first glass), while the second specimen, flowing through a cleansed urethra, would be clear (clear second glass). It is also a matter of interest and clinical importance that the more serious complications of urethritis are associated with posterior involvement.

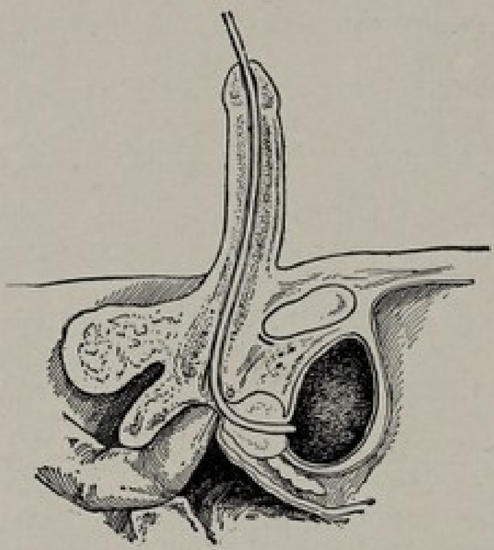


FIG. 517.—Method of passing the sound. The index finger in the rectum is guiding the sound through the membranous urethra.

In passing rigid urethral instruments one should try to visualize the part of the urethra being traversed. If one remembers that, the patient being on his back and the penis held toward the ceiling (Fig. 517), the urethra passes straight downward till the bulb is reached, and then curves cephalad till it is parallel with the table, and takes into consideration the shape of the instrument he is passing, little difficulty will be experienced. The roof of the urethra is smoother and less easily traumatized than the floor, and is therefore the safer guide. In difficult cases a finger in the rectum is of great assistance (Fig. 517).

In prostatic hypertrophy the urethra may be lengthened as much as 3 or 4 inches, the lengthening being, of course, in the prostatic portion. A metal catheter used in such a case should have a large curve (arc of circle of 6 cm. (2½ in.) radius).

THE MALE PERINEUM

The name perineum in its broad sense is applied to the structures of the outlet of the pelvis, superficial to the levator ani muscles. In its restricted anatomical sense it is applied to the subpubic triangle as far back as a line rejoining the anterior portions of the tuberosities. In its clinical sense it is the space between the anus and scrotum in the male and anus and vulva in the female.

Bony Landmarks.—On examining the pelvic outlet the symphysis pubis is seen anteriorly with the descending rami of the pubes and ascending rami of the ischia on the sides, leading to the tuberosities. Posteriorly is seen the coccyx, with the spines of the ischia on each side comparatively close to it. The greater sacrosciatic ligament runs from the sacrum to the tuberosity of the ischium, the lesser from the sacrum to the spine of the ischium. Taken together a diamond-shaped space is formed. In the female the pubic arch is wider, the tuberosities further apart, the spines of the ischia do not project so markedly inward, and the coccyx is more movable.

Perineal and Ischiorectal Regions.—A line drawn from the anterior portion of one tuberosity to that of the opposite side passes 1.25 cm. (½ in.) in front of the anus, and divides the outlet into the urogenital triangle or perineum in front, and the anal triangle or ischiorectal region behind.

Urogenital Triangle.—The urogenital triangle has the symphysis in front, the ischiopubic rami as far back as the anterior portion of the tuberosities on the sides, and a line joining the two behind. It is closed by a fibrous membrane called the triangular ligament.

The **central point of the perineum** is in the median line 2 cm. (¾ in.) in front of the anus; it marks the posterior edge of the triangular ligament in the median line, and is the point of junction of the anteroposterior and transverse muscles.

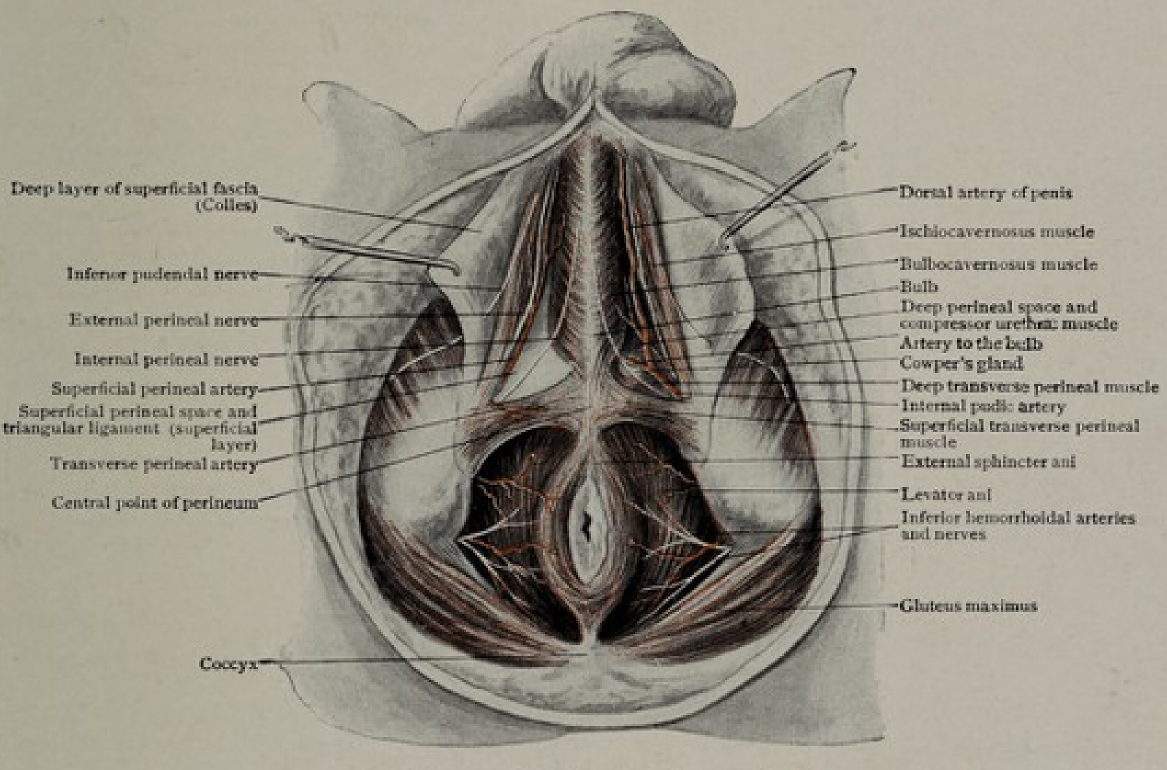


Fig. 518.—The male perineum. The superficial perineal space is shown on the left and the deep perineal space on the right.

Perineal Fascias.—There are four perineal fascias, viz.: (1) the superficial layer of the superficial fascia; (2) the deep layer of the superficial fascia, called also Colles's fascia; (3) the superficial layer of the deep fascia, or triangular ligament; and (4) the deep layer of the triangular ligament or pelvic fascia (Fig. 475).

The *superficial layer of the superficial fascia* is the subcutaneous fatty tissue, and is continuous with that of the surrounding parts and the dartos.

The *deep layer of the superficial fascia or Colles's fascia* is the fibrous under surface of the fatty superficial layer. Posteriorly it unites with the posterior edge of the triangular ligament; laterally it is attached to the ischiopubic rami; and anteriorly it is continuous with the under surface of the dartos of the scrotum, passes forward to form the suspensory ligament and extends down the penis as a thin layer outside Buck's fascia. It is continuous with Scarpa's fascia (deep layer of the superficial fascia) of the abdomen.

The *anterior layer of the triangular ligament* is a firm fibrous membrane stretching from one tuberosity to the other, and attached to the ischiopubic rami on the sides forward to the pubic arch. Between its anterior edge and the symphysis runs the dorsal vein of the penis; the dorsal arteries and nerves pierce it a little lower and to the sides; 2.5 cm. (1 in.) below the symphysis is the urethral opening with the openings for Cowper's ducts close behind it, and those for the vessels to the bulb close to it in front. The superficial perineal vessels and nerves pierce its posterior edge. The posterior edge of the triangular ligament blends with the posterior edge of the deep layer of the superficial fascia (Colles's).

The *deep layer of the triangular ligament* is a continuation downward of the pelvic fascia. It begins above on the inside of the pelvis, covering the obturator muscle as the obturator fascia; it then passes to the levator ani muscles as the recto-vesical fascia. The levator ani muscles do not meet in front of the rectum. The gap between them is filled in the median line posteriorly by the termination of the longitudinal fibres of the rectum (prerectalis muscles of Henle, recto-urethralis of Roux, Kalischer, Holl, Proust, and others—see page 503, Rectum),

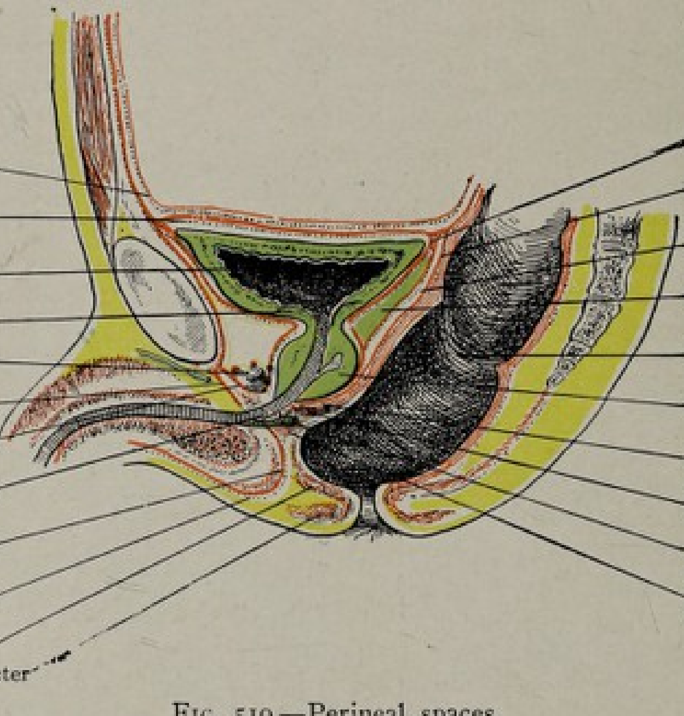


FIG. 519.—Perineal spaces.

at the sides by the deep transverse perinei and compressor urethræ muscles, and anteriorly by the continuation of the rectovesical fascia. From the deep transverse perinei muscles forward the rectovesical fascia is called the deep layer of the triangular ligament. (Fig. 519.)

Perineal Spaces.—There are two perineal spaces, one superficial space between the triangular ligament (superficial layer) and the deep layer of the superficial fascia (Colles's fascia), and the other, the deep perineal space, between the superficial layer of the triangular ligament and its deep layer.

Superficial Perineal Space.—The superficial space has on its sides the crura of the penis attached to the ischiopubic rami and covered by the ischiocavernosus (erector penis) muscles. In the median line anteriorly lies the urethra with its erectile tissue covered by the bulbocavernosus (accelerator urinæ) muscle. The posterior portion lying on the triangular ligament is called the *bulb*, and reaches back to the central point of the perineum. From the central point the superficial transverse perineal muscles pass outward and somewhat backward to the rami of the ischia, and the sphincter ani passes back to the coccyx. The *internal pudic artery* comes forward from the spine of the ischium through Alcock's canal on the outer wall of the ischiorectal fossa, 4 cm. ($1\frac{1}{2}$ in.) above the lower edge of the tuberosity; when it reaches the posterior edge of the triangular ligament it gives off the superficial perineal artery, which pierces it and enters the superficial perineal space, where it gives off the small transverse perineal artery, and then continues anteriorly to the base of the scrotum. The pudic nerve sends two branches forward in this space, the posterior or internal superficial perineal toward the middle, and the anterior or external along the outer side of the space accompanying the superficial perineal artery forward to the scrotum.

The Deep Perineal Space.—This lies between the anterior and posterior layers of the triangular ligament. It contains the compressor urethræ (external vesical sphincter) muscle surrounding the urethra. Embedded in this muscle are *Cowper's glands.* Their ducts, 2 cm. (⅘ in.) long, pierce the anterior layer of the triangular ligament to empty into the bulbous urethra. Immediately behind the compressor urethræ is the deep transverse perinei muscle passing across from one ischiopubic ramus through the central point of the perineum to the other. Running along the outer side of the space on each side is the continuation of the internal pudic artery. It gives off the artery to the bulb about 3 cm. (1¼ in.) in front of the anus, and then about 1.25 cm. (½ in.) below the subpubic ligament pierces the anterior layer of the triangular ligament and divides into the artery to the corpus cavernosum and artery to the dorsum of the penis; it is accompanied by the pudic nerve, which divides in like manner. Posteriorly this space is open, not being closed by any fascia except that lining the under or superficial surface of the levator ani muscle in the ischiorectal fossa. In the mid-line the continuation of the longitudinal fibres of the rectum called the prerectal or recto-urethralis muscle blend with the fibres of the deep transverse perineal muscle.

Practical Application.—The perineum is involved in extravasations of blood and urine in cases of rupture of the urethra; in operations on the deep urethra and bladder for the retention of urine from stricture; and in operations for vesical calculus, enlarged prostate, and disease of the seminal vesicles.

Extravasation of Urine and Blood.—Urinary extravasation results most often from stricture and occurs almost always in front of the anterior layer of the triangular ligament. The urine enters the superficial perineal space and is confined superficially by Colles's fascia and above by the triangular ligament. It is prevented from going back into the ischiorectal space by the union of Colles's fascia and the triangular ligament posterior to the superficial transverse perineal muscles; it is prevented from extending laterally by the attachment of Colles's fascia to the ischiopubic rami; hence it works its way forward, distends the scrotum, and extends up over the crest of the pubis between the spine of the pubis and the median line. Reaching the surface of the abdomen it is prevented from descending on the thigh by the attachment of the deep layer of the superficial fascia (Scarpa's fascia) just below Poupart's ligament, so it flows laterally and makes a collection in the flank of each side above the iliac crests. It may also infiltrate the penis as far forward as the glans. The septa in the median line of the abdomen, perineum, and scrotum hinder but do not prevent the passage of the urine from one side to the other. In treating it, numerous free incisions are made down to the deep fascia. (Keyes has called attention to the fact that so-called urinary extravasations contain no urine, but are virulent anærobic infections; he prefers to call the process "peri-urethral gangrene".)

Rupture of the Urethra.—This is produced by falling astride a hard object and jamming the urethra against the subpubic arch, or by fractures of the pelvis. The rupture almost always involves the urethra just in front of the triangular ligament and sometimes a part of the membranous urethra. The superficial perineal space becomes infiltrated with blood, and if urine is passed it follows the blood, collecting between Colles's fascia and the triangular ligament.

If the membranous urethra is ruptured the blood and especially the urine may escape into the deep perineal space between the layers of the triangular ligament. It may break or leak through the anterior layer and enter the superficial perineal space; it may work backward into the ischiorectal regions; it may work up and back between the prostate and rectum or breaking through the deep layer of the triangular ligament it may work up and anterior behind the symphysis pubis, in the prevesical space (of Retzius) (see Fig. 519). Ruptured urethra is treated by perineal section or by a retained catheter; cystostomy is usually indicated.

Perineal Operations.—Operations limited to the urogenital triangle are comparatively rare—external urethrotomy with or without a guide (an instrument passed through the stricture), urethrostomy, extirpation of the penis and drainage of extravasations comprise the list, and some of these involve other regions. Perineal lithotomy, either median or lateral, is not now done; when perineal extraction of a vesical calculus is indicated it is done as a prostatotomy, the approach being as in perineal prostatectomy. In external urethrotomy the cavernous tissue of the bulb of the corpus spongiosum is incised. Bleeding is best controlled by means of sutures.

Operations on the prostate and seminal vesicles are done through inverted V or U incisions in the anterior part of the anal triangle (see page 518). It is of the utmost importance to keep back of the transverse perineal muscles (Fig. 518). Injury to the rectum is to be avoided by careful division of the rectourethralis muscle close to the urethra (Fig. 519), and incision of the posterior layer of Dénonvillier's fascia (Fig. 495), so that the gut can be pushed back out of the way.

THE BACK AND SPINE

SURFACE ANATOMY

On examining the back of a person standing upright a *median furrow* is seen (Fig. 520). In the bottom of this the tips of the *spinous processes* can be felt. If the back is bent these processes can be distinctly seen; they should form a straight line. The second cervical spine can be felt by deep pressure in a relaxed neck. The sixth is usually the first one visible and the seventh cervical and first dorsal are very prominent, often the latter the more so. The furrow ends abruptly at the top of the sacrum. From this point down to near the top of the gluteal fold is a *triangular space* with its base above and apex downward. Its apex marks the third sacral spine, and just above this latter, opposite the second sacral spine, on each side can be felt the posterior superior iliac spines. The *erector spinæ* (sacrolumbalis) muscles form elevations on each side of the furrow, most marked in the lumbar region.

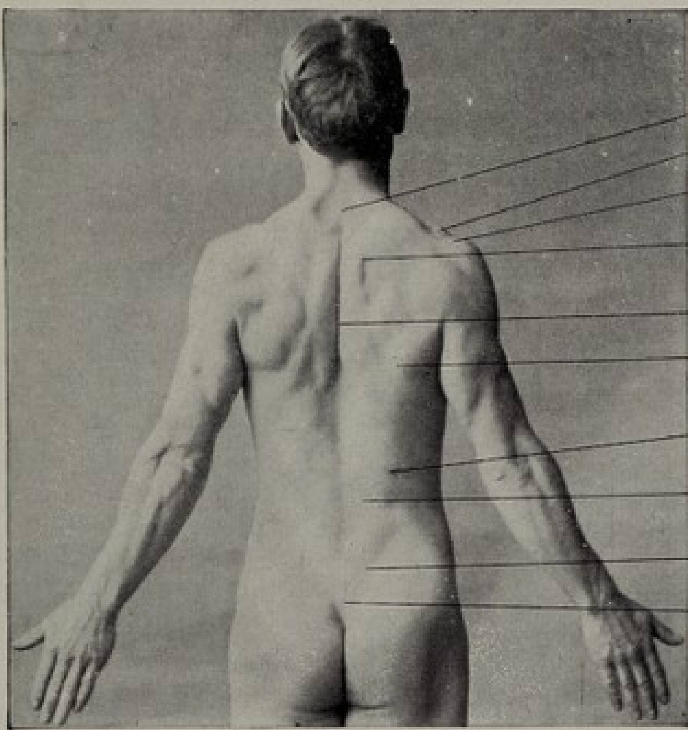


FIG. 520.—Surface anatomy of the back.

In muscular people the erector spinæ is seen to consist of two parts: an inner longissimus dorsi muscle, and an outer iliocostalis. Above, the projections of the *scapulæ* are visible. If the arms are by the sides the posterior border of the scapula is parallel to the median line. The root of the spine of the scapula in a muscular person makes a depression. It is opposite the third dorsal spine or the body of the fourth thoracic vertebra, and marks the upper end of the fissure of the lungs. The spine of the scapula is subcutaneous and can be traced out to the acromion process. The lower angle of the scapula is opposite the upper border of the eighth rib; the upper angle covers the second rib but its tip is level with the first.

In the lumbar region the erector spinæ muscle forms a clearly marked prominence. The twelfth rib usually projects beyond its outer edge, which is marked by a depression separating it from the abdominal muscles in front. It is through this depression that operations on the kidney are performed (see page 492). The distance between the twelfth rib and crest of the ilium is usually 6.25 cm. (2½ in.) but it may be more and is often less. Just above the middle of the crest of the ilium is Petit's triangle (page 448); and to the inner side of the lower third of the posterior edge of the scapula is another small triangle. Its upper side is formed by the trapezius, its lower by the latissimus dorsi, and its outer by the posterior edge of the scapula. As the lung is nearest the surface at this point it is often chosen for physical examination, puncture, etc.

THE VERTEBRAL COLUMN

Normally the spinal column is composed of seven cervical, twelve dorsal, five lumbar, five sacral, and four to five coccygeal vertebræ. The sacral vertebræ tend to fuse together, forming a single bone, the sacrum. This fusion is complete at the twenty-fifth year. The coccygeal vertebræ join later, fusion occurring in middle life. Sometimes in advanced age the coccyx and sacrum fuse together. The cervical vertebræ are almost always seven in number, but both the dorsal and lumbar vary much more frequently than is usually supposed. The occurrence of thirteen instead of twelve ribs on a side is not uncommon and I have seen skeletons with only eleven. A rudimentary cervical rib also occasionally occurs.

FIG. 521.—Lateral view of the adult spine, showing its curves. (Piersol.)

The tips of the spinous processes of the cervical vertebræ, the first two dorsal, and last four lumbar, pass almost horizontally backward and are therefore nearly opposite the bodies of the vertebræ to which they are attached. The tips of the spines from the third to the last dorsal inclusive, however, are opposite the bodies of the next vertebræ below them, being inclined downward, while the tip of the first lumbar is about opposite the intervertebral disk beneath.

Curves.—At the third month of intra-uterine life there is only one large curve, convex posteriorly. At birth there are two curves, each convex posteriorly, a dorsal and sacral, probably to accommodate the thoracic and pelvic viscera; after the erect position is assumed the cervical and lumbar curves become established. The cervical passes into the dorsal curve at the middle of the second thoracic vertebra and the dorsal into the lumbar at the middle of the last thoracic vertebra. (Fig. 521). *Laterally,* there is a slight curve in the dorsal region with its convexity to the right, probably due to the increased use of the right hand.

Movements.—Flexion and extension are free in the neck and lumbar region, rotation is slight in the cervical region, free in the upper portion of the dorsal, and gradually diminishes to be absent in the lumbar region.

DEFORMITIES OF THE SPINAL COLUMN

The weight of the head is borne on the condyles of the occiput, and a perpendicular let fall from the condyles passes through the points where the spinal curves pass one into the other and thence through the anterior edge of the promontory of the sacrum. Hence if one curve is altered by injury or disease it is of necessity accompanied by a corresponding change in the curve on the opposite side of the perpendicular line. The first is called the primary curve and the other the secondary one. In anteroposterior curvatures these curves are exaggerations of the normal curves but in lateral curvatures they are newly formed because there is, practically, no normal lateral curve in the spinal column. The spine may project abnormally backward, forming a *kyphosis*; forward, *lordosis*; and more or less laterally, *scoliosis*.

Kyphosis.—The vertebræ are supported one above another by two points of contact, a posterior one, formed by the articular processes, and an anterior one, formed by the bodies of the vertebræ separated by the intervertebral disks. Of these two supports, that afforded by the bodies and disks is the more important. The laminæ and pedicles with their attached articular processes are frequently fractured, but the shape of the vertebral column is but little altered; even after laminectomy the spine remains comparatively straight. When, however, the bodies of the vertebræ are destroyed, as occurs in tuberculous disease and crushing injuries, the anterior portion of the spine collapses and the parts bend, the spines projecting backward forming a hump (Fig. 522). Thus the angular character of the deformity is explained by the method of construction of the spine.

FIG. 522.—Kyphosis or angular anteroposterior curvature, usually due to caries of the bodies of the vertebræ.

FIG. 523.—Lordosis or hollow back, caused by congenital luxation of the hips.

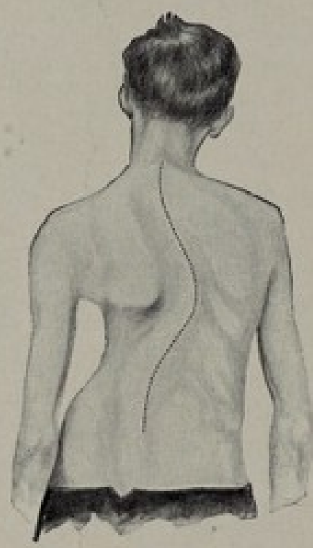


FIG. 524.—Scoliosis or lateral curvature of the spine.

Besides this *angular kyphosis* there is another form, due to general weakness. This is seen in rachitic children; owing to a weakness of all the tissues the normal curves become increased and, as in young children, the normal spine has one long general curve with its convexity posteriorly, we find this curve greatly increased, forming a *rachitic kyphosis*.

Lordosis.—When a child is born and for some time thereafter the spine possesses a slight dorsal and a pelvic curve. When it sits up and begins to hold its head erect and look around, the cervical curve develops. Still later when it begins to walk the lumbar curve develops. An increase in the lumbar curve, or lordosis, is caused by general weakness as just described for rachitic kyphosis, or it results from some disease or injury interfering with the lower extremities and thus disturbing the centre of gravity. This occurs in congenital luxation of the hips (Fig. 523), in which the heads of the femurs are set too far back, and also in rachitic deformities of the lower extremities, hip disease, etc. Likewise, if the abdominal viscera are unduly prominent, the thoracic region is carried further back to maintain the balance, and hence a hollow back is produced. Ankylosis of the hip in a flexed position causes lordosis when the limb is brought straight down as in walking. Therefore in cases of lordosis one should remember that it is a secondary condition dependent on diseased conditions of the viscera or extremities and is comparatively rarely an independent affection.

Scoliosis.—A normal spine is either absolutely straight or very slightly convex to the right in the dorsal region, probably due to the increased use of the right hand. While scoliosis is called lateral curvature of the spine, it is not a simple lateral bending, but is a complex distortion (Fig. 524). R. W. Lovett has shown that a flexible straight rod can be bent in one plane either anteroposteriorly or laterally, but that a curved rod cannot be bent laterally without twisting or rotating. Inasmuch as the human spine is curved convexly backward in the dorsal region and convexly forward in the lumbar region, lateral bending is accompanied by rotation of the vertebræ and their attached ribs. The bodies of the vertebræ are carried toward the side of the convexity of the curve and the ribs on that side project backward, producing a marked hump and often an elevation of the shoulder. As a primary curve forms, an attempt is made to restore equilibrium by bending the remaining portion of the spine in the opposite direction, hence the curves, if of long duration, are double or compound, and these secondary curves are called compensating curves. Marked lumbar curves are usually accompanied by prominence of the hip on the side of the convexity, but the pelvis usually remains level. Should the length of the limbs be unequal, allowing tilting of the pelvis, the prominence of the hip would be on the side of concavity. It is obvious that the weight of the body tends to aggravate these pathological curves. The treatment of scoliosis is directed to correcting these faulty curves by exercises and appliances intended to support and stretch the body on the contracted or depressed side and restore the tone and power to the relaxed muscles and tissues of the opposite side.

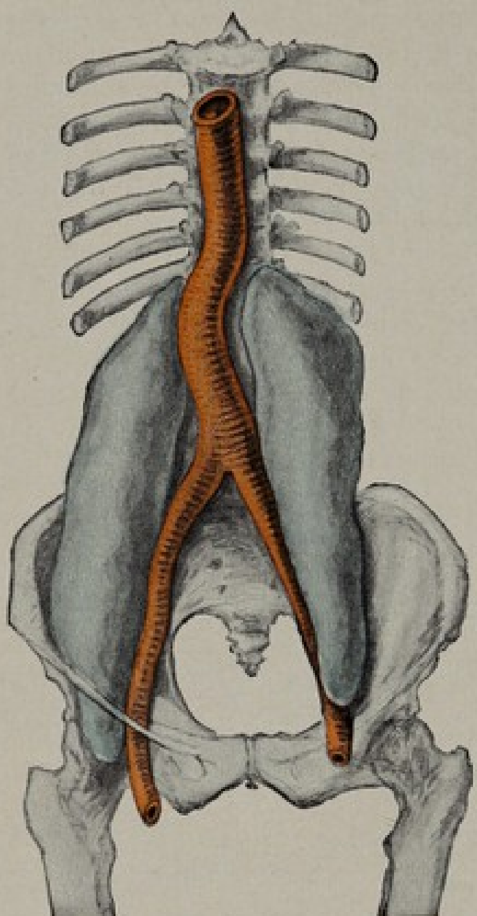


FIG. 525.—Psoas abscess originating from spinal caries of the dorsolumbar vertebræ and following the psoas muscle to the groin. (From a sketch by the author of a specimen in the Mütter Museum of the College of Physicians.)

Spina Bifida.—The spinal canal is formed by the laminæ of the vertebræ arching over and uniting posteriorly. This union begins in the dorsal region and progresses towards the head and sacral regions. Failure of union constitutes spina bifida. While the defect usually occurs in the vertebral arches, the malformation may be in the bodies of the vertebra (anterior spina bifida).

Spina bifida is most frequent in the lumbar and sacral regions, rarest in the thoracic part. A *myelo-meningocele* represents a developmental arrest at an early period, in which the vertebræ, spinal cord, membranes, and skin are involved. As the posterior wall of the neural tube has failed to close, the cyst communicates with the central canal of the cord. It is the most severe and the most common type. A *meningocele* is a hernia of the membranes through the defect in the bony arch. As the cord has attained complete evolution and the epidermis closed it is not so severe as the preceding. *Spina bifida occulta* is marked by a cleft arch and an adhesion of the cord to the skin, but no hernial protrusion. Hypertrichosis frequently covers the area of defect. A *syringomyelocele* presents a dilatation of the central canal causing a protrusion through the defect in arch and dura. Spina bifida is usually accompanied by hydrocephalus, or talipes, or various forms and degrees of paralysis. Treatment by operation consists in a repair of the hernial protrusion by means of muscle and fascia flaps after excision and closure of the sac. Operation should not be attempted in the presence of hydrocephalus, irreparable deformities, paralysis of the sphincters or complete paraplegia.

AFFECTIONS OF THE SPINAL COLUMN

Caries of the Spine.—While caries of any part of the vertebræ may occur from injury, it is almost always the result of tuberculous disease in the bodies; the pedicles, laminæ, and processes remain unaffected. As the bodies become destroyed the anterior portion of the spine collapses, and this causes a projection of the spines of the affected vertebræ posteriorly or kyphosis. This projection of one or more spinous processes is the surest indication of spinal caries or Pott's disease.

There is also rigidity of the affected region. This is recognized by the attitude assumed and by having the patient, if an adult, bend the back anteroposteriorly. Small children should be placed flat on a table, face down, and then gradually raised by the feet. If the spine is normal the child will readily bend in the lumbar and lumbodorsal regions. The movable regions, embracing the cervicodorsal and dorsolumbar vertebræ, are the sites most frequently affected. Distention of the abdomen and pain occur from involvement of the spinal nerves. The tenth dorsal nerve arrives anteriorly at the level of the umbilicus, the twelfth is midway between the umbilicus and symphysis and also sends an iliac cutaneous branch a couple of inches behind the anterior superior spine to the skin of the buttock, and below and in front of the great trochanter. The abdomen above the external inguinal ring is supplied by the hypogastric branch of the iliohypogastric from the first lumbar.

Psoas abscess is common. The psoas muscle arises from the lower border of the body of the twelfth dorsal and the bodies of all the lumbar vertebræ. The prevertebral fascia covering the bodies of the vertebræ is continued downward over the psoas muscle as its sheath. Therefore when pus forms in the bone it enters the sheath and follows it downward under Poupart's ligament, usually just outside, but sometimes, as it gets still lower down, to the inside of the femoral vessels (Fig. 525). At other times it works its way backward and points in the angle between the erector spinæ muscle and the twelfth rib, or along the edge of the erector spinæ lower down, or a little farther out above the top of the middle of the crest of the ilium at Petit's triangle (see page 448). It may also find an exit through the great sacrosciatic notch and point on the posterior aspect of the thigh. Pus originating in the cervical region produces retropharyngeal abscesses, which, if involving the second to the fifth cervical vertebræ, may either point in the pharynx or work outward to the posterior edge of the sternomastoid muscle (see page 177).

INJURIES OF THE SPINAL COLUMN

The vertebræ may be dislocated and fractured.

Dislocation is rarer than fracture; it is most common in the cervical region. The cervical vertebræ have their articular facets sloping downward and backward, hence dislocation occurs when the upper vertebræ are pushed in front of the lower. The cervical spine normally has but slight rotation, hence when luxated one articular surface is rotated or pushed over and in front of the one below, the opposite articular surface acting as the axis and the distance between the two articulations as the radius of the arc in which the luxated parts move. The elevation of the luxated articular process over the one below is favored by the bending of the spine above toward the opposite side. The head is rotated and inclined toward the uninjured side. Bilateral luxation is rare without associated fracture. It is produced by anterior flexion, and the head and neck are inclined forward while the lower vertebra of the dislocated joints inclines backward, producing a kyphotic condition.

Luxation affects most often the fourth, fifth, and sixth cervical vertebræ. The atlas may be dislocated forward or backward by rupture of the transverse ligament, fracture of the odontoid process, or by a slipping of the process under the ligament.

Luxation of the atlas laterally is very rare, owing to there being normally a total rotation of 60 degrees.

The upper three vertebræ can be palpated on their anterior surfaces by the finger introduced into the mouth.

Posteriorly the second, third, and fourth spines are too deeply placed between the muscles to be palpated.

To reduce the luxation an anæsthetic is given to relax the muscles, and cautious extension is made and the head gently rotated.

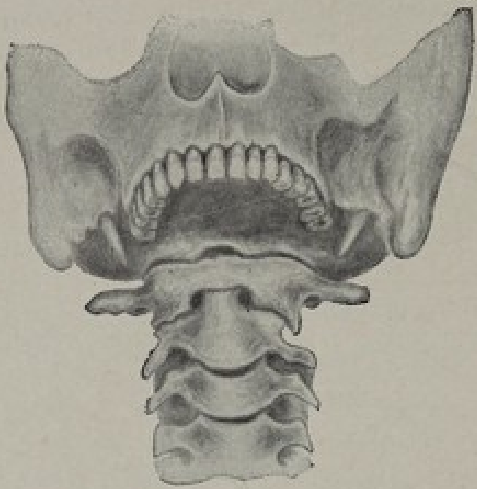


FIG. 526.—Anterior view, showing relation of transverse process of atlas to tip of mastoid process.

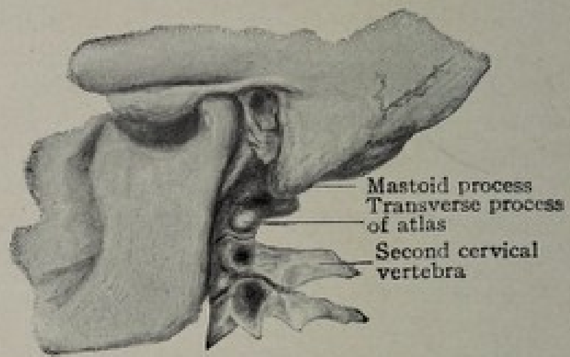


FIG. 527.—Lateral view, showing relation of transverse process of atlas to tip of mastoid process.

Fracture of the spine is frequently associated with luxation. It is most frequent low down in the cervical region and at the junction of the dorsal and lumbar vertebræ, these being the places where the more fixed dorsal portion passes into the more movable cervical and lumbar portions (Fig. 528). The vertebræ are supported at three points—the bodies and the two articular processes. The spinous and articular processes are rarely fractured alone; they may be broken, however, by direct violence. The laminæ on each side of the articular processes may be broken and the detached part with the spinous process may be pushed inward, injuring the cord. Fracture of the bodies is most frequent and is due to anterior flexion. The bodies and intervertebral disks are compressed, crushed, and torn. This is accompanied by either luxation or fracture of the articular processes, and occurs most often in the region of the lower dorsal vertebræ. Injury to the cord is common. The parts are not often fixed in a markedly displaced position, as is the case with luxations of the neck, hence attempts at reduction are rarely necessary and fixation is to be aimed for in treatment. The site of injury is determined not only by an examination of the spinous processes but also by the extent of interference with the functions of the cord (see page 554).

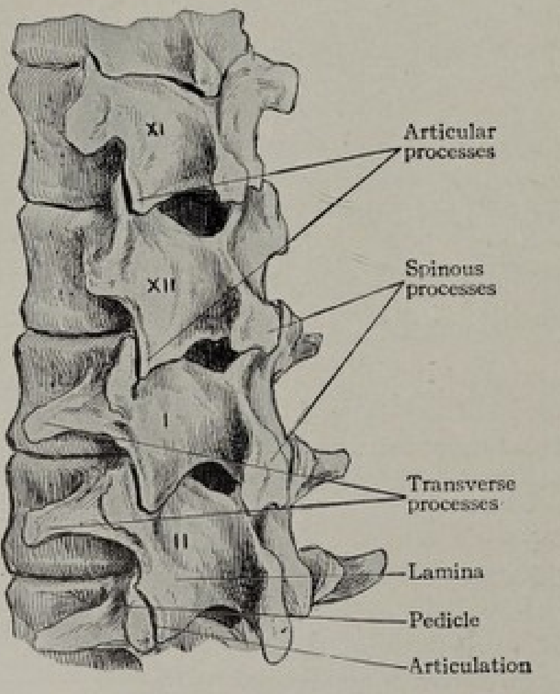


FIG. 528.—Showing the method of articulation of the eleventh and twelfth dorsal and the first and second lumbar vertebræ.

THE SPINAL CORD AND ITS MEMBRANES

The spinal cord lies within the vertebral canal, carefully protected by a bony framework. It is 45 cms. (18 inches) long in the male. In the fetus of three months the cord extends to the end of the spinal canal, at birth it has risen to the third lumbar vertebra and in the adult it is opposite the lower border of the first. It will thus be seen that the point of exit of the spinal nerves from the cord is always some distance higher up than their exit from the intervertebral foramina. The cord is enlarged in the cervical and lumbar regions, the cervical enlargement ending opposite the second dorsal, and the lumbar enlargement beginning opposite

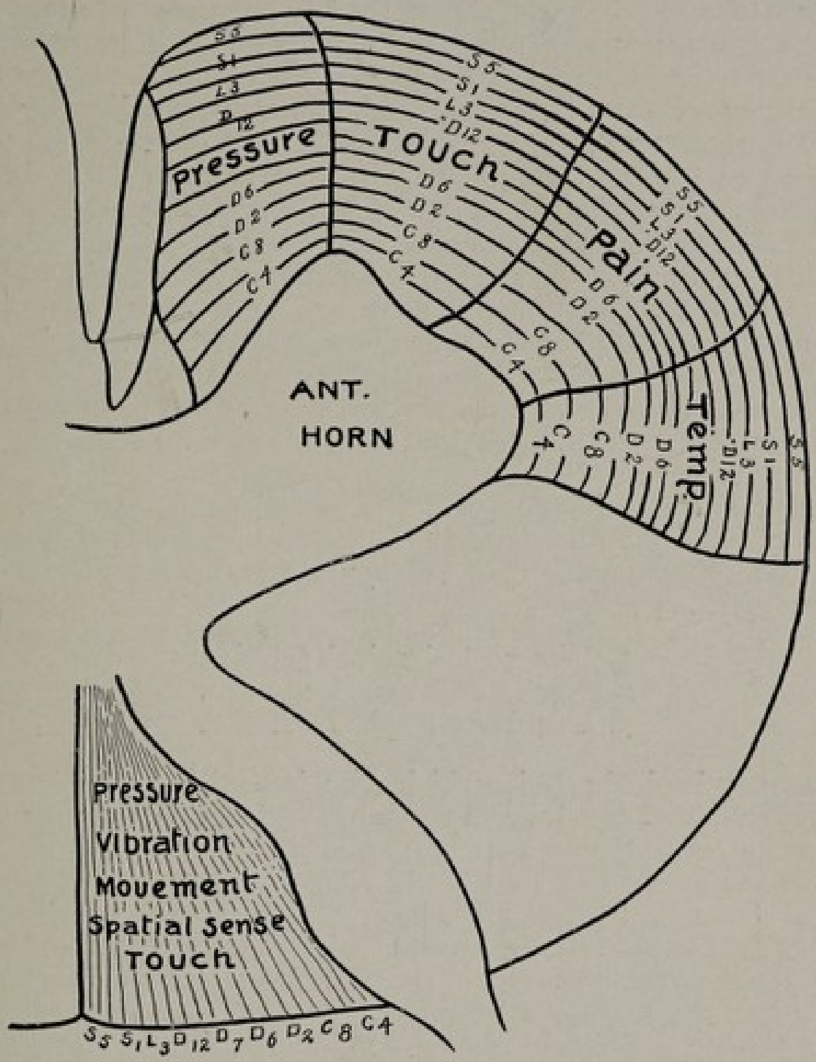


FIG. 529.

the tenth dorsal vertebra. These enlargements correspond with the origin of the nerves to the upper and lower extremities.

Spinal Segments.—The spinal cord is divided into segments. These are thirty-one in number; eight are cervical; twelve thoracic; five lumbar; five sacral and one coccygeal. Each segment embraces that portion of the cord which gives exit to one pair of anterior roots and receives one pair of posterior roots. These segments correspond with the segmental arrangement of the bodily musculature and sensory areas. Each posterior root is associated with a definite cutaneous sensory area, as seen in the diagram (Fig. 529), and it is this association which makes for accurate topical diagnosis in spinal cord diseases. There is a definite skin area associated with each spinal segment, the extent of this area being well demarcated in each instance, and differing from the distribution of the peripheral nerve. It is through the reflex arcs of the spinal cord that reflexes are mediated, there being definite "centers" or segmental levels concerned in the production of reflexes. The levels of the more important reflexes are shown in the accompanying chart.

Reflex	Segment
Biceps	C 5-6
Triceps	C 6-7-8-
Patellar	L 2-3-4-
Achilles	L 5 and S 1
Abdominal	T 10-12
Cremasteric	L 1-2

Spinal Roots.—The inequality in the rate of growth between the vertebral column and the enclosed spinal cord affects the relations between the nerves and the intervertebral foramina through which they leave. In the upper levels of the cord the nerves leave at about the same level as the corresponding vertebra. Below the third cervical, the nerves leave the spinal canal at an increasingly oblique course, until in the case of the last lumbar and sacral nerves, the latter descend almost vertically to leave the spinal canal and there is a discrepancy of from five to nine vertebrae from the segment of origin of the nerve.

Each spinal root is formed by the union of the anterior and posterior roots of each segment. In the cervical region there are eight roots, one more than the number of vertebrae, due to the fact that the uppermost cervical nerve lies above the atlas, while the other cervical nerves emerge below the vertebral body. The spinal nerve roots are covered by the three coverings of the spinal cord in their intravertebral course. As each root passes out through its foramen, it is covered by dura and arachnoid.

On each posterior root is a ganglion, the posterior root ganglion.

Blood Supply.—The blood supply of the spinal cord is a matter of uncertainty. The blood supply as worked out by Tilney and Riley is as follows: the spinal cord is supplied by:

1. The ventral spinal arteries.
2. The dorsal spinal arteries.
3. The lateral spinal arteries.

There are two ventral spinal arteries which arise from the vertebral arteries. They descend into the vertebral canal where they fuse to form the anterior spinal artery. This artery terminates at the fifth cervical segment. Below this point it is formed by the lateral spinal arteries which unite to form the anterior spinal in the ventral sulcus. The dorsal spinal arteries are two in number descending on the dorsal part of the cord to the fifth cervical segment where they are replaced by the lateral spinals. The lateral spinal arteries arise from the vertebral and ascending cervicals in the neck, from the intercostals in the thorax, from the lumbar and sacral arteries in the lumbar and pelvic regions. Each artery divides into two branches on the side of the cord, the ventral branches and the dorsal branches. The former pass to the ventral surface of the cord, giving off an ascending and descending branch, the ascending branch of one segment uniting with the descending branch of another to form the anterior spinal artery from the fifth cervical segment to the conus terminalis. The dorsal spinal arteries are formed in the same way by the dorsal branches of the lateral spinal arteries. The main branches of the anterior spinals are the ventro-median vessels which supply the anterior horns. The posterior horns are supplied by the dorsal radicular arteries from the dorsal spinals. The white matter is supplied by the peripheral arteries.

TRANSVERSE SPINAL LESIONS

In endeavoring to localize transverse lesions of the cord, such as result from traumatism, tumors, etc., one must bear in mind that the spinal nerves originate from segments in the cord some distance above where they make their exit from the spinal foramina. Chipault (quoted by Starr) gives the following practical rule: "In the cervical region add one to the number of the vertebra, and this will give the segment opposite to it. In the upper dorsal region add two; from the sixth to the eleventh dorsal vertebra add three. The lower part of the eleventh dorsal spinous process and the space below it are opposite the lower three lumbar segments. The twelfth dorsal spinous process and the space below it are opposite the sacral segments." The spinal cord ends at the lower part of the first lumbar vertebra.

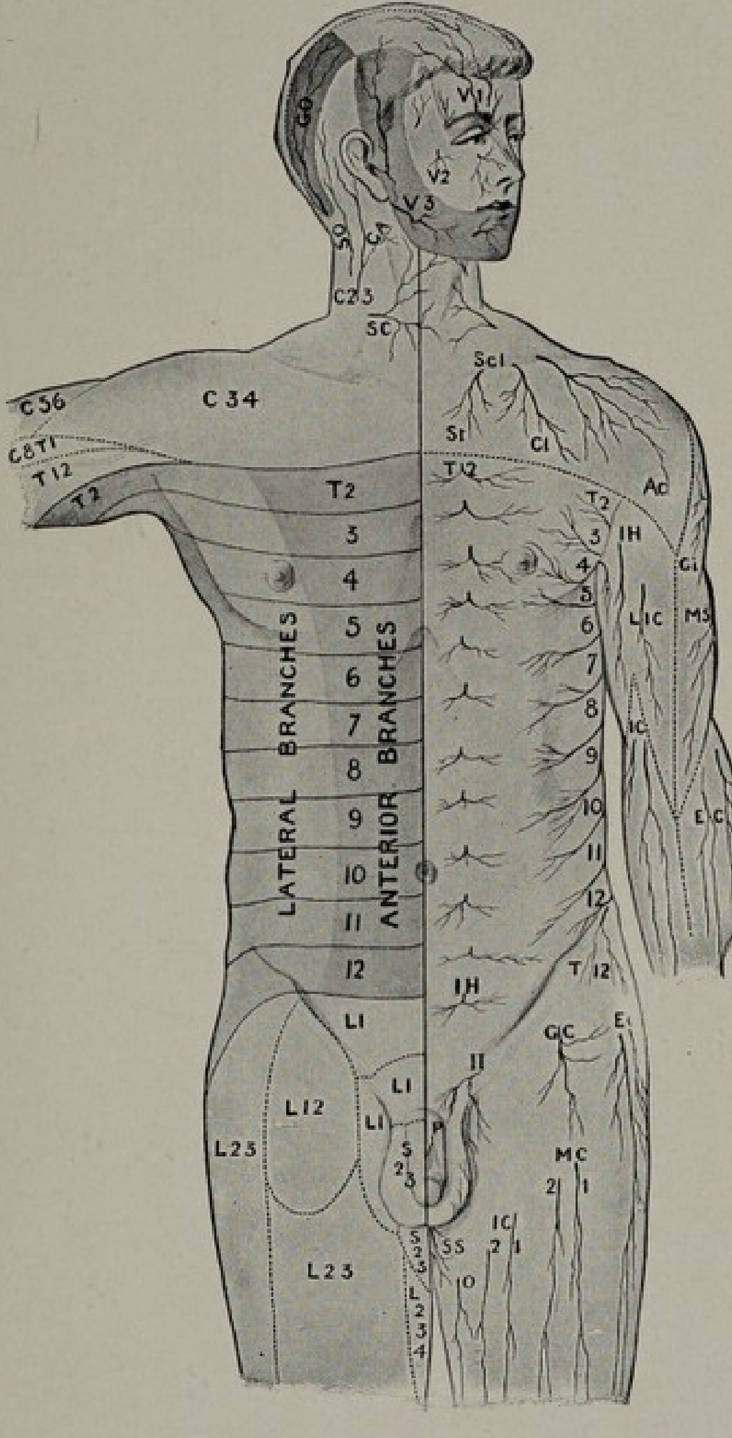


FIG. 530.—Diagram of distribution of cutaneous nerves, based on figures of Hasse and of Cunningham. On right side, areas supplied by indicated nerves are shown; on left side, points at which nerves pierce the deep fascia. V^1, V^2, V^3, divisions of fifth cranial nerve; *GA*, great auricular; *GO*, *SO*, greater and smaller occipital; *SC*, superficial cervical; *St*, *Cl*, *Ac*, sternal, clavicular, and acromial branches of supraclavicular (*Scl*); *Ci*, circumflex; *MS*, musculospiral; *IH*, intercostohumeral; *LIC*, *IC*, lesser internal and internal cutaneous; *EC*, external cutaneous; *IH*, iliohypogastric; *II*, ilio-inguinal; T^{12}, last thoracic; *GC*, genitocrural; *EC*, external cutaneous; *MC*, middle cutaneous; *IC*, internal cutaneous; *P*, pudic; *SS*, small sciatic; *O*, obturator; *C*, *T*, *L*, and *S*, cervical, thoracic, lumbar, and spinal nerves. (Piersol.)

The areas of cutaneous sensibility aid in determining the seat of the lesion. The nerves supplying these various areas are shown in Fig. 486.

Lesions above the fourth cervical nerve are very speedily fatal. The muscular paralyses, as guides to the sea of the lesion in the cervical region, are given by Thorburn as follows:

Supraspinatus and infraspinatus	Fourth cervical nerve.
Teres minor (?)	
Biceps / Brachialis anticus	Fifth cervical nerve.
Deltoid	
Supinator longus	
Supinator brevis (?)	
Subscapularis	Sixth cervical nerve.
Pronators	
Teres major	
Latissimus dorsi	
Pectoralis major	
Triceps / Serratus magnus	
Extensors of the wrist	Seventh cervical nerve.
Flexors of the wrist	Eighth cervical nerve.
Interossei	First dorsal nerve.
Other intrinsic muscles of the hand	

In fractures of the dorsal region Thorburn has shown that the lesion is usually two vertebræ higher than the nerve coming out from below the displaced vertebra. They cause paralysis of the abdominal muscles, legs, bladder, and rectum.

According to Starr, fractures in the region of the last two dorsal vertebræ cause anæsthesia up to Poupart's ligament, and if the patient recovers the thighs remain paralyzed. In fractures of the upper part of the lumbar region the paralysis may be limited to the legs below the knees but involves the bladder and rectum. Recovery leaves the patient with some power of getting about on crutches with the aid of apparatus to keep the ankles and knees firm, as the thighs are under voluntary control.

Lesions below the first lumbar, those of the cauda equina, give paralysis of the feet and peronei, loss of control of the bladder and rectum, and anæsthesia in the saddle-shaped area on the buttocks, about the anus, and on the posterior part of the genitals.

The diagnosis between lesions of the cauda equina and lower portion of the cord is not always possible. The prognosis of lesions of the cauda equina is, of course, much better than when the cord itself has been injured.

SPINAL MENINGES

The cord is covered by a continuation downward of the cerebral meninges. It has a dura mater, arachnoid, and pia mater.

Dura Mater.—The outer or endosteal layer of the cerebral dura mater ends posteriorly at the edge of the foramen magnum but anteriorly at the third cervical vertebra. The inner or meningeal layer continues downward as a tough fibrous tube from the foramen magnum to the second or third sacral vertebra, and thence is prolonged downward as a fibrous cord (coccygeal ligament) to be attached to the periosteum over the coccyx. The dura mater in the spine does not, as in the skull, act as a periosteum. The vertebræ have a separate periosteum in addition. Between the dura mater and the bodies of the vertebræ is a somewhat loose space filled with fat, fibrils of connective tissue, and a venous plexus. In injuries these vessels are ruptured and bleed and give rise to clots; the blood, however, does not get inside the membranes and the effusion rarely assumes a sufficient size to produce compression of the cord. These veins pierce the ligamentum subflavum and thus communicate with the dorsal spinal veins. The dura mater is almost never torn in injuries even though the cord may be crushed (Fig. 531).

Arachnoid.—The arachnoid of the spinal cord is a stouter membrane than the cerebral arachnoid. Above it is continuous with the cerebral arachnoid at the foramen magnum. Below it blends with the dura at about the level of the third sacral vertebra. Thus it is seen that while the cord itself ends at the lower border of the first lumbar vertebra the subarachnoid cavity is prolonged nearly or quite to the third sacral. As in the brain, the cavity between the arachnoid and the dura above is slight, the two membranes being practically in contact, so that there is almost no subdural space. Between the arachnoid and pia, however, there is a considerable cavity which is continuous with the same space beneath the cerebral arachnoid. It communicates with the fourth ventricle just above the calamus scriptorius by the foramen of Magendie in the median line, and at the sides by the foramina of Key and Retzius, and also by slits at the descending horns of the lateral ventricles. Hence it is that the ventricular fluid can be drained by a lumbar puncture.

Through this subarachnoid space pass the septum posticum behind and the ligamenta denticulata on each side from the pia to the dura mater. It is also traversed by the anterior and posterior roots of the spinal nerves, the former being in front and the latter behind the ligamentum denticulatum. The arachnoid contains neither vessels nor nerves (Fig. 532).

Pia Mater.—The spinal pia mater is thin and closely invests the cord. It carries the blood-vessels of the cord and sends prolongations posteriorly to the dura as the septum posticum, laterally as the two ligamenta denticulata, and also around the anterior and posterior roots of the spinal nerves. It terminates below in a two-pronged fork, at the level of the first lumbar vertebra. Elsberg calls attention to the fact that the first lumbar root rests upon the inner prong of this fork thus making it serve as a useful landmark for the identification of this root and by counting from this one can identify each posterior root.

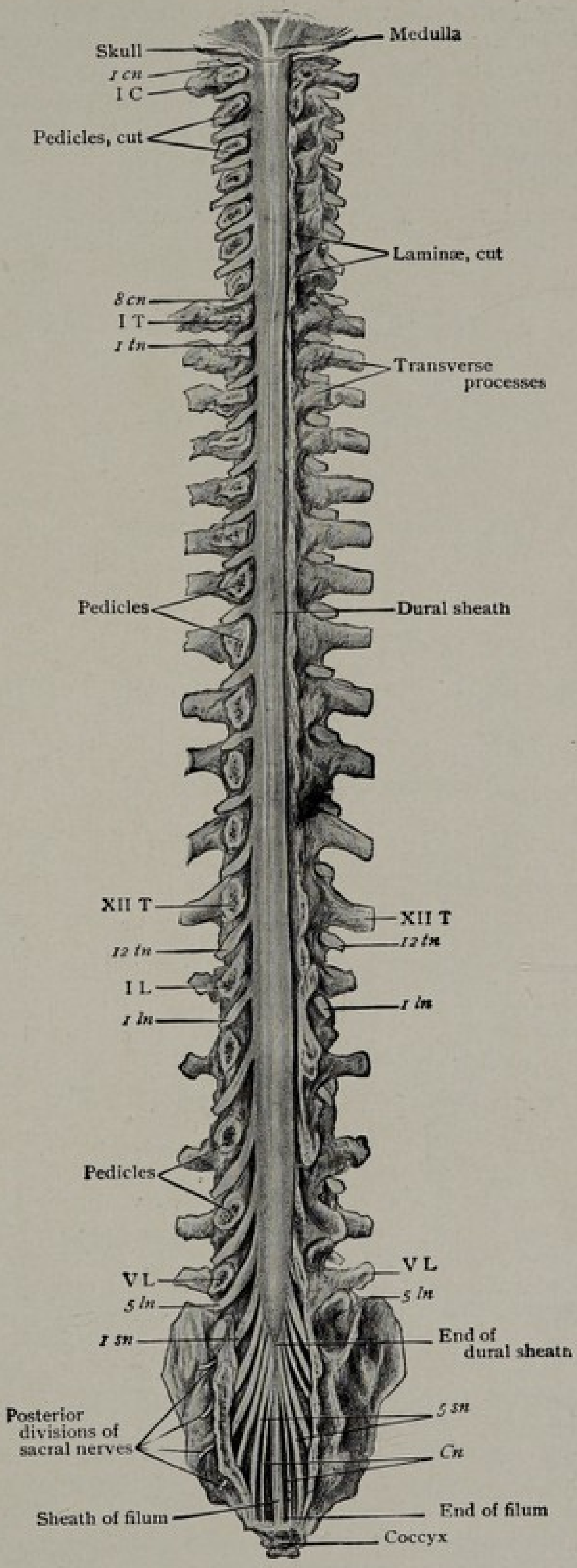


Fig. 531.—Spinal cord enclosed in unopened dural sheath lying within vertebral canal; neural arches completely removed on right side, partially on left, to expose dorsal aspect of dura; first and last nerves of cervical, thoracic, lumbar, and sacral groups are indicated by Italic figures; corresponding vertebræ by Roman numerals. (Piersol.)

Spinal Vessels.—Three arteries supply the spinal cord, an *anterior spinal* in the median line of the anterior surface and two *posterior spinal* just in front of the posterior spinal roots (Fig. 533). The veins are more numerous. They consist of three sets or plexuses, one on the cord in the meshes of the pia mater, another in the spinal canal between the dura mater and the bone, and the third on and around the outside of the vertebræ. The veins on the cord in the anterior and posterior median fissures communicate above with the veins of the medulla. The lateral veins empty through the radicular veins which accompany the spinal nerve roots. The veins in the spinal canal form anterior and posterior plexuses between the dura and bone and communicate with the extraspinal plexuses around the laminæ and spinous processes posteriorly (dorsi-spinal veins) and the plexus around the bodies anteriorly.

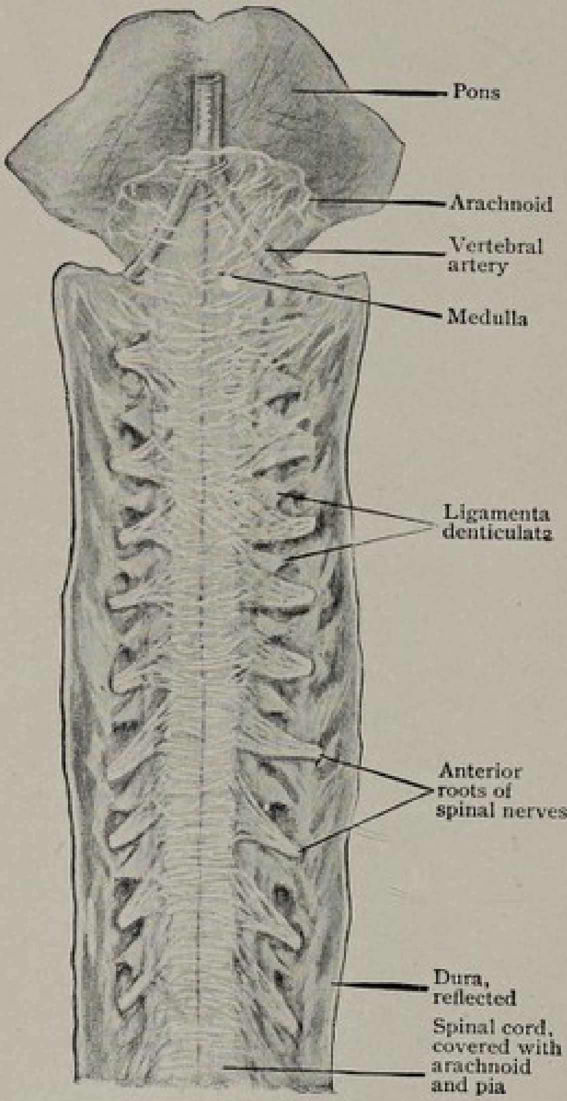


FIG. 532.—Upper part of spinal cord within dural sheath, which has been opened and turned aside; ligamenta denticulata and nerve-roots are shown as they pass outward to dura. (Piersol.)

Spinal Hemorrhage.—Spinal hemorrhages, though sometimes caused by disease, are usually the result of injury. They frequently accompany fractures and dislocations. They may be either extradural, intradural, or in the cord—hæmatomyelia. They exist either coincident with the original injury or appear within a few hours.

Spinal hemorrhages are rarely large and those in the substance of the cord are the more common. They are usually venous. *Extradural hemorrhage* comes from the plexuses between the dura and bone and the clot may extend through the intervertebral foramina. It is usually of small extent and practically does not produce paralysis from pressure on the cord, hence operation for its relief is useless. *Intradural hemorrhage* comes from the vessels of the pia and may invade not only the subarachnoid but also the subdural space. It may remain localized at the site of injury or the blood may sink and fill a considerable portion of the spinal canal. Owing to the looseness of the cord in its dural sheath the hemorrhage spreads and does not usually give rise to pressure symptoms, hence operation is rarely advisable. Large hemorrhage sometimes comes down from cerebral apoplexy or injuries. *Hæmatomyelia.*—Hemorrhage into the substance of the cord may be caused by hypertension or accompany the contusion due to dislocation or fracture. The paralysis which follows serious injuries of the spine is usually due to hemorrhage into the gray or white matter of the cord. The gray matter being the softer is the more frequently affected, the blood penetrating it for quite a distance. Hemorrhage into the gray matter destroys it and produces an incurable paralysis. When into the white matter restoration of function through absorption may occur in from four to six weeks. In either case operation usually is of no service. The location of the hemorrhage will be revealed by the interference with the functions of the cord. The hemorrhage can occur in the form of a column of blood infiltrating the gray matter of several segments in one or both directions from a starting-point. The longer extension is usually toward the brain. It is usually limited to one side of the cord. Generally in small and sometimes in

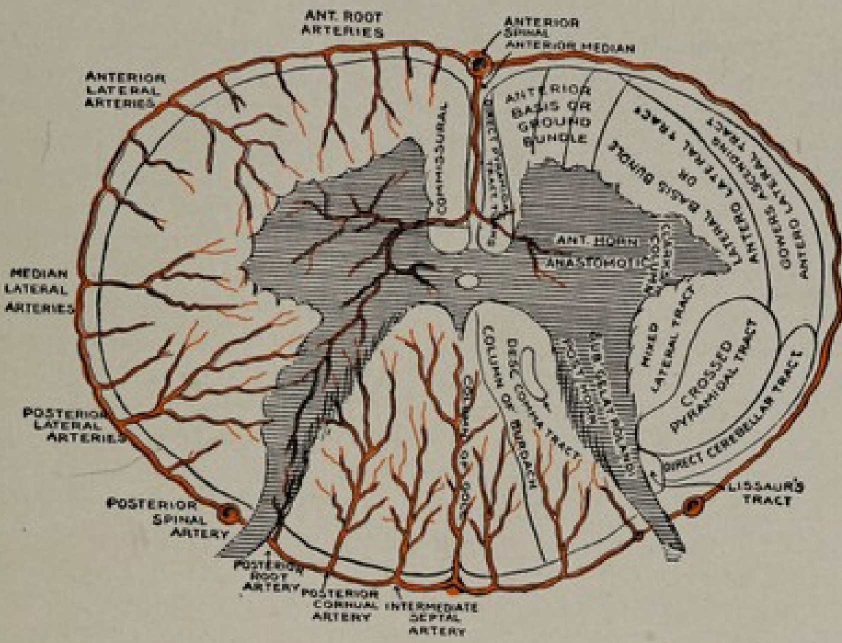


FIG. 533.—Diagram of the spinal cord in the lower cervical region, with its blood-vessels.

large hemorrhages the effect is mainly mechanical, but especially large hemorrhages may be surrounded by areas of softening.

FUNCTIONS OF THE SPINAL CORD

The spinal cord is a reflex organ. There is no localization within it equivalent to the localization within the brain. Such localization as exists is due to the presence of ascending or descending tracts which lie within its substance and which are concerned with the conduction of specific types of stimuli. There is further within the cord segmental localization of a motor, sensory and reflex nature, due to mediation of reflexes through particular segments of the cord, and the intimate relation of the spinal roots to sensory and motor segmentation within the body.

GRAY MATTER

Anterior Horns.—In the anterior horns lie the large multipolar motor cells which give rise to the anterior roots and which are motor in function. Their size varies in different levels of the cord, being greatest in the cervical and lumbar regions. There is a loss of these cells in anterior poliomyelitis, which is responsible for the paralysis and atrophy of the muscles in this disease. The syndrome caused by disease of the anterior horn cells is: loss of power, wasting of muscles, fibrillary twitchings and loss of the reflex due to interruption of the reflex arc.

Posterior Horns.—In the posterior horns lie ganglion cells which give origin to the fibers of pain and temperature. In the ventro-median portion of the posterior horns lie the columns of Clarke which give rise to the spino-cerebellar fibers. Entering the posterior horns are the posterior roots, some fibers of which terminate around cells in the posterior horns. Involvement of the posterior roots by inflammation causes pain in the root distribution and impairment or loss of the reflex arc. Involvement of the posterior root or its ganglion is found in herpes zoster, tabes dorsalis, meningomyelitis and in some tumors.

Lateral Horns.—In the thoracic portion of the spinal cord especially and also in the lumbar portion to a lesser degree are lateral grey columns which lie at the junction of the dorsal and ventral horns. From the cells in this region run the efferent fibers of the vegetative nervous system.

WHITE MATTER

Dorsal Columns.—In the dorsal portion of the spinal cord run two columns of long white fibers. The laterally placed column is the Fasciculus Cuneatus (Column of Burdock), and the mesially placed column is the Fasciculus Gracilis (Column of Gall). The Fasciculus Cuneatus carries fibers from the trunk and arms and the Gracilis from the lower extremities. The fibers in the Fasciculus Gracilis run from the lumbar to the sixth dorsal region, where the Fasciculus Cuneatus begins. These columns are sensory in function carrying deep sensation particularly vibration and position senses. Some fibers of touch are carried also. The columns are degenerated especially in tabes dorsalis. They are also degenerated in postero-lateral sclerosis. Fibers which run in the dorsal columns come from peripheral organs such as muscles, bones and joints, pass through the posterior roots to the dorsal columns, going to the Nuclei Gracilis and Cuneatus in the medulla. From here they decussate to reach the opposite thalamus by means of the internal arcuate fibers and the mesial fillet.

Lateral Columns.—In these columns run the fibers of the cortico-spinal or pyramidal tracts which take their origin in the pre-central gyri and pass to the anterior horn cells after decussation in the medulla. These columns are seen degenerated in hemiplegia, in primary lateral sclerosis, multiple sclerosis and postero-lateral sclerosis.

Antero-lateral Columns.—In these columns run the fibers of pain and temperature which have their origin in posterior horn cells and which decussate through the central grey matter of the cord around the central canal, reaching the antero-lateral columns. They lie at the periphery of the cord, covered by the ventral spino-cerebellar tracts. They run through the cord and the base of the brain to reach the thalamus. The fibers of pain and temperature run in separate columns. These fibers are affected often in postero-lateral sclerosis due to pernicious anemia or multiple sclerosis. According to Foerster electrical stimulation of these columns causes painful sensations in the segmental area stimulated. Lesions in these columns or their fibers in the central grey matter cause a disturbance or loss in pain and temperature on the opposite side of the body.

In the antero-lateral area run the spino-cerebellar fibers which lie at the periphery of the cord. These take their origin in the columns of Clarke. There are two columns, dorsal and ventral. Both enter the cerebellum through the inferior cerebellar peduncle (Corpus Restiforme), the fibers terminating in the vermis. The dorsal tract of Flechsig is called the direct tract because it proceeds directly to the cerebellum through the restiform body. The ventral tract of Gower is the indirect tract because it retraces its steps to come back to the restiform body and the cerebellum. Lesions in these areas, as in postero-lateral sclerosis, cause cerebellar symptoms such as asynergia and disturbances in co-ordination.

Other Tracts.—In the spinal cord run the rubro-spinal tracts which lie under the lateral cortico-spinal tracts. They take their origin in the red nucleus in the mid-brain, decussate immediately and pass down the lateral columns. Their function is not clear.

The vestibulo-spinal tracts take their origin in the vestibular area of the medulla, especially from Deiter's nucleus, and pass to the anterior horn cells. They probably have some part in the regulation of muscle tone. Experimental lesions of the vestibular area cause decreased tonus and reflexes on the opposite side.

LESIONS OF THE CORD

The *lesions affecting principally the gray matter of the cord* are anterior poliomyelitis, syringomyelia, progressive muscular atrophy, and arthritic muscular atrophy.

Anterior Poliomyelitis.—In anterior poliomyelitis or infantile paralysis the lesion is mainly in the anterior horn and is evidenced by a paralysis of the muscles involved, atrophy, and the abolishing of the reflexes. The deformities seen are secondary results of the paralysis.

Syringomyelia is an acquired enlargement of the central canal or the formation of new canals in the gray matter. It produces motor, sensory, and trophic disturbances which vary according to the part of the cord attacked.

Progressive Muscular Atrophy (Duchenne's Disease).—The atrophy begins most often in the hands and extends to other parts of the body. There occurs an atrophy of the gray substance of the anterior horns which may extend to the brain; even the white substance of the direct and crossed pyramidal tracts may also show degeneration. There is a type in which there is a lack of demonstrable cord lesions. Among its various forms are those called pseudomuscular hypertrophy, progressive muscular dystrophies (Erb), and primitive progressive myopathies (Charcot).

Arthritic Muscular Atrophy.—Disease of the joints often results in marked disturbance of the gray matter of the cord, which in turn is followed by muscular atrophy.

Lesions Affecting Principally the White Matter of the Cord.—The principal lesions affecting the white matter are lateral sclerosis, locomotor ataxia, combined posterolateral sclerosis, Friedreich's ataxia, and hereditary spastic paraplegia.

Lateral sclerosis, or spastic paraplegia, is almost unknown as a primary affection. It is a sclerosis of the pyramidal tracts. It occurs as a secondary degeneration, the result of cerebral disease, producing the spastic paraplegia of infants—Little's disease—and also follows transverse lesions of the spine from tumors, caries, fractures, etc.

Locomotor ataxia, or tabes dorsalis, when advanced, may affect the entire portion of the cord between the posterior horns and the commissure, from the filum terminale to the medulla. It begins in Clarke's column (a group of cells in the posterior horn of the cord extending from the seventh cervical to the second lumbar nerves) and may involve the direct cerebellar tracts and Gowers's ascending anterolateral tracts and also the posterior nerve roots. It produces both motor and sensory disturbances as well as trophic changes.

Combined Posterolateral Sclerosis (Ataxic Paraplegia of Gowers).—This produces symptoms combining spastic paraplegia and locomotor ataxia. The following structures are affected: columns of Burdach, Goll, crossed pyramidal tract, direct pyramidal tract, and not always the ascending tract of Gowers.

Friedreich's ataxia (family or hereditary ataxia) is a progressive paralysis often appearing through many generations. There is a sclerosis of the columns of Goll and Burdach, crossed pyramidal tract, Gowers's tract, direct cerebellar tract, Lissauer's tract, and often atrophy of the cells of Clarke's column.

Hereditary Spastic Paraplegia.—This is a degeneration of the pyramidal tracts, columns of Goll and Burdach, and direct cerebellar tract. The disease has been traced through many generations.

OPERATIONS OF THE SPINE

Spinal Puncture.—Spinal puncture may be performed either for diagnostic purposes, for relief of accumulations of subarachnoid fluid, or for the purpose of producing spinal anæsthesia.

The lumbar region is usually selected and the puncture made in the median line or to one side and either above or below the spine of the fourth lumbar vertebra. A line passing from the highest point of the crest of one ilium to that of the opposite side passes through the lower part of the spine of the fourth lumbar vertebra. The puncture should always be made below the upper border of the second lumbar vertebra, because the spinal cord extends down to that point. The lumbar spines are nearly or quite horizontal and do not incline downward as do those of the cervical and dorsal regions. Lumbar puncture should be performed with the patient lying on his side.

Technic for Laminectomy.—Two points are to be borne in mind in performing a laminectomy. The first is the position of the patient. The head of the patient is placed at a level slightly below that of the operative field. This is done to prevent excessive loss of spinal fluid. Secondly, complete hemostasis during each stage of the procedure, which necessitates accurate knowledge of the anatomy of the spine.

The initial incision is made directly over the spinous processes. The skin and subcutaneous tissues are then separated down to the intervertebral fascia. In high cervical incisions care should be exercised in keeping to the median raphe, otherwise troublesome bleeding will be encountered. The incision is made long enough to include one spine above and one below the processes to be removed.

The intervertebral fascia is separated from the spines. The muscles are then stripped from the spinous processes and lamina by means of a broad chisel. Gauze tampons, previously wrung out in hot saline, are temporarily packed between the muscle and bone to check muscle bleeding. Vessels in the muscle may have to be ligated.

Self-retaining retractors are introduced. The ligamentæ interspinalis are then divided between the spines and each spinous process is removed separately with bone cutting pliers. The laminæ are removed piecemeal on each side with appropriate rongeurs as far as the articular process if necessary. Bleeding from bone is checked by the use of wax. The dura and epidural fat are then exposed. Any bleeding from vessels within the epidural fat is controlled by pressure or muscle stamps.

The dura is opened by a median incision. If care is exercised the two layers of the dura may be divided without cutting the arachnoid, thus enabling inspection of the cord in its proper relationships without escape of spinal fluid.

The dura is closed by a continuous silk suture. The muscles are approximated by interrupted sutures in such a manner so as to leave the least amount of "dead space." The intervertebral fascia, subcutaneous tissue and skin are brought into apposition by tier sutures. Closure is effected without drainage.

Technic for Cordotomy.—Cordotomy has been proven by Frazier and others to be a practical method for the relief of intractable pain. By section of the spino-thalamic tract only pain and temperature will be lost to within one or two segments at the level of incision on the contralateral side of the body. For relief of pain in the pelvis and lower extremities, Grant recommends section at the fourth thoracic segment. Pain in the upper extremities is controlled by section at the fifth cervical segment. Unilateral cordotomy has been performed as high as the third thoracic segment (Stookey).

Only three laminæ need be removed and the cord exposed according to the technic for laminectomy. The cord is rotated so as to expose the antero-lateral surface and fixed by grasping the denticulate ligament. A cataract knife or Frazier's cordotomy knife is used to sever the spinothalamic tracts. The incision is made 2.5 millimeters anterior to the line of emergence of the posterior roots, to a depth of 2.5 millimeters and forward 2.5 millimeters. Grant recommends cutting all the superficial fibers from the exact insertion of the denticulate ligament to the point just below the corresponding anterior root. Great care must be taken to place the incision accurately or the motor pathways may be interrupted and paralysis of the lower extremities result. Following the incision, there is a moderate ooze without serious consequence.

The dura is sutured by a continuous silk suture and the wound closed according to the technic for laminectomy.

The needle used should be from 6.25 cm. (2½ in.) to 10 cm. (4 in.) long, according to the age and size of the patient. It should be introduced in the median line and pushed upward. In its entrance it pierces the muscles, then the ligamentum subflavum, which passes from one lamina to the other, and finally the dura mater and arachnoid. Failure is liable to occur either from the patient straightening the spine when the puncture is made or from failure to enter the spinal membranes owing to pushing the dura in front of the cannula. A needle enters more readily and surely than does a small trocar with its cannula. The shoulder formed by the cannula, particularly if not well made, is apt to push the tough dura ahead of it instead of puncturing.

Lumbar puncture is performed for purposes of diagnosis and treatment in cases of inflammation, tumor and other conditions. In cases in which a pressure reading is desired as in suspected tumor cases, it is very important to have the patient recumbent.

Technic for Rhizotomy.—In certain cases of intractable neuralgia of the extremities, intercostal neuralgia, gastric crises, etc., division of a number of the posterior roots gives relief. Such roots as are represented in the zone of hyperæsthesia, usually four or five in number, are selected. It is important to remember the rule given by Chipault (p. 554) regarding the relation of the point of exit to the point of origin in determining the site of laminectomy. Frazier prefers ligation of the root with silk instead of section to avoid the bleeding that attends cutting the small artery which accompanies each root. As regeneration of the posterior root does not occur this is physiologically equivalent to section.

Resection of the posterior roots has also been performed for the relief of severe forms of spasticity especially in congenital spastic paraplegia and diplegia (Little's disease). The operation is based on the idea of reducing the stream of afferent impulses and should be so planned as to cut two of the three roots from which a given group of muscles derives its sensory supply.

THE LOWER EXTREMITY

GENERAL CONSIDERATIONS

The lower extremity is designed to bear the weight of the body and serve as a means of locomotion.

It is composed of a pelvic girdle, thigh, leg, and foot.

The pelvic girdle serves as the medium of connection of the lower extremity to the trunk in the same manner as does the shoulder-girdle for the upper extremity.

We saw that prehension, characterized by mobility, was the distinguishing feature of the upper extremity and that the shoulder-girdle was composed of two bones, was loosely joined to the trunk, and held the upper extremity out away from it.

The lower extremity on the contrary has two functions, it must bear the weight of the body and must move this weight around from place to place; hence strength is essential and a less amount of mobility suffices. To meet these changed conditions the lower extremity differs in its construction from the upper in the following respects:

1. The pelvic girdle is composed of one bone—the innominate—instead of two. It may be said by some that the innominate bone consists of three separate bones—the pubis, ischium and ilium, each of which forms a part of the pelvic girdle, but these fuse so completely that the lines of union are not visible in the adult.
2. It also forms a part of a complete bony ring instead of being incomplete posteriorly.
3. It is more firmly joined to the trunk.
4. The hip-joint is placed closer to and in more intimate relation with the trunk than is the shoulder.
5. The bones of the lower extremity are heavier and stronger than those of the upper.
6. The joints are larger and stronger, but their movements are not so extensive.
7. The muscles are coarser and their functions are not so highly specialized.

THE BONY PELVIS

The pelvis is composed of the pelvic girdle on each side (innominate bones), and the sacrum and coccyx posteriorly. It serves two purposes. It supports and protects the abdominal and pelvic viscera, and serves as the connection between the trunk and the lower limb. It is divided into two parts—the false pelvis, above the iliopectineal line, and the true pelvis, below the iliopectineal line.

The false pelvis serves to support the abdominal viscera, as its name indicates, like a basin. In man it is large and flaring because his normal position is upright, but in the lower animals, as the quadrupeds, whose normal position is horizontal, it is smaller and less prominent.

The true pelvis contains and protects the pelvic organs and also serves as the connecting link between the trunk above and the extremity below; hence, as it has a double function, it has of necessity a composite structure. In order to contain and protect the pelvic viscera it is made hollow, and in order to support the weight of the body on the legs it is made strong. The pelvic contents are not exposed to injury to the same extent as is the brain; therefore, instead of having a complete covering of bone, like the skull, the bony pelvis is merely a framework comprised solely of those parts essential to strength.

The pelvis supports the trunk in two postures, the standing and sitting. In the former the weight is transmitted through the acetabula, and in the latter to the tuberosities of the ischia.

MECHANISM OF THE PELVIS

As was pointed out by Henry Morris, the bony pelvis is composed of arches. The two main arches are the femorosacral and the ischiosacral. These are strengthened by subsidiary arches which join the extremities of the main arches so as to strengthen and fix them. These counter-arches are essential in that a portion of any weight to be carried by the main arch is conveyed to the centre of the counter-arch and are borne in what is termed the line of the arch. The ties of both arches are united in front of the symphysis, which like the sacrum is common to both arches.

Femorosacral Arch (Fig. 534).—This arch extends from the acetabula on the sides to the sacrum in the middle, which is its keystone. The weight of the body is transmitted downward through the spine to the sacrum, and then through the two sides of the femorosacral arch to the heads of the femurs. For an arch to be effective its two extremities must be firmly anchored, so that they do not separate when pressure is made on it. In artificial arches, as used in bridges, this separation is guarded against by a rod running from one extremity to the other, forming a cord of the arc. In the pelvis this mechanism is impossible, because this "tie-rod" would

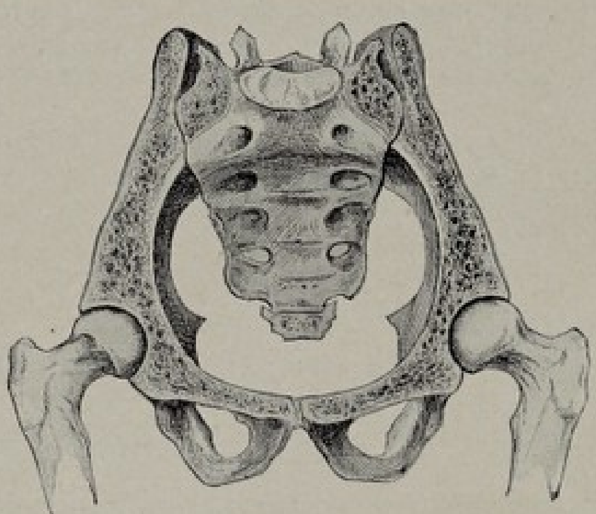


Fig. 534.—The femorosacral arch. The main arch passes upward from one hip-joint to the other through the sacrum: the subsidiary arch passes downward from one hip-joint to the other through the pubes.

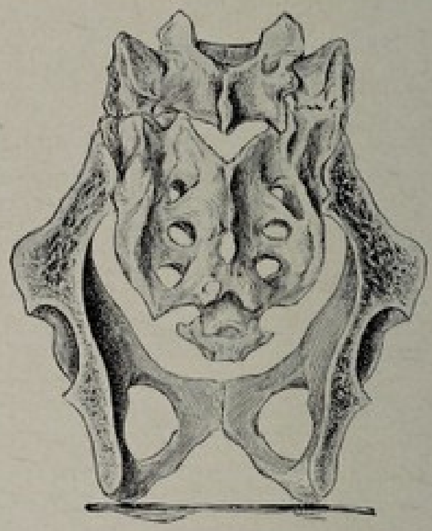


Fig. 535.—The ischiosacral arch. The main arch passes upward from one tuberosity of the ischium through the sacrum down to the opposite tuberosity; the subsidiary arch passes forward from one tuberosity of the ischium through the pubes and back to the opposite tuberosity.

infringe on the cavity of the pelvis, and it is to obviate this that a counter-arch is introduced. This secondary arch is formed by the horizontal rami and bodies of the pubic bones, and passes anteriorly from one acetabulum to the other on the opposite side. It is much weaker than the primary arch.

Ischio-sacral Arch (Fig. 535).—In sitting, the pelvis, viewed laterally, is in much the same position as in standing, being in both almost vertical and beneath the spinal column. The thighs, however, are horizontal and the bulk of the weight is supported by the tuber ischii. From the keystone or sacrum the weight is transmitted through the ilium and body of the ischium to the tuberosities on each side. This primary arch is strengthened by the secondary arch formed on each side by the ramus of the ischium and the descending ramus and body of the pubis. Notice that this likewise is weaker than the primary arch.

FRACTURES OF THE PELVIS

It is important to know the mechanism of the pelvis in order to understand pelvic fractures. Once this mechanism is comprehended it is easy to explain why a fall upon the feet, or a crush in either the lateral or anterior posterior direction, although dissimilar in their force, may produce closely similar injuries.

The flaring wings or alæ of the ilium are not infrequently fractured by direct violence. The line of fracture is usually transverse (Fig. 536). The displacement is slight on account of the muscular attachments of the iliacus muscle inside and the glutei muscles outside. The anterior third of the crest of the ilium is subcutaneous and prominent, hence by manipulating it crepitus can usually be elicited and the diagnosis made. Recumbency and the support afforded by adhesive plaster is all the treatment necessary.

The more serious fractures, however, are those of the true pelvis. A fall upon the feet usually causes the head of the femur to fracture the acetabulum, and even force the former through the latter, or to fracture the pubes. The pelvic cavity is somewhat heart-shaped; the sacrum projects anteriorly and is so strong that it is rarely fractured. At or just outside of the sacro-iliac joints is, however, one weak point; between the acetabulum and the pubes, through the rami of the pubes and ischium and thyroid foramen, is another; and at the symphysis is a third.

The most frequent fracture passes through the pelvic ring twice, anteriorly through the rami of the pubis and ischium and thyroid foramen and posteriorly through or just external to the sacro-iliac joint. This double fracture occurs because the protection afforded by the "tie" or counter arch having been withdrawn, the force is expended on the main arches which tend to spread. Either the anterior sacro-sciatic ligaments give away with resulting disjunction of the joint or a fracture of the ilium into the sacro-sciatic notch occurs. When there exists a double vertical fracture, one anteriorly and one posteriorly, the fragment may be displaced upward. This may give rise to the diagnosis of a fracture of the femoral neck. However, if measurements are taken it will be found that there is no change in the relation of the greater trochanter to anterior superior iliac spine on the affected side. Whenever a fracture of the pelvis is suspected, search for this fracture. Examine the rami of the pubes. Pressure made along Poupart's ligament just external to the spine of the pubes will usually reveal a tender spot and may elicit crepitus. A posterior fracture should be suspected if there is pain in the distribution of the superior gluteal, the lumbo-sacral, the upper sacral or the obturator nerves. The gravity of the pelvic injury depends upon the presence of visceral complications, just as the gravity of a cranial injury depends upon the cerebral damage. A digital examination through the rectum or vagina may likewise indicate the site of the fracture. The bladder is frequently wounded, the rectum almost never and the urethra rarely.

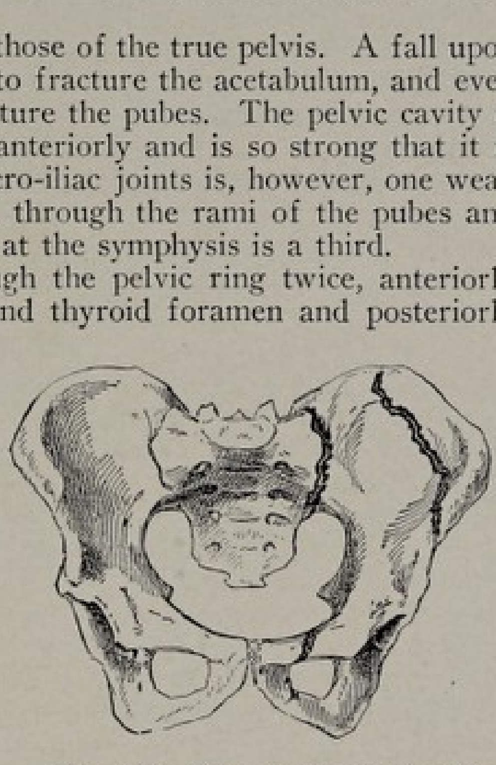


FIG. 536.—Diagram illustrating fracture of the pelvis; one fracture is seen passing through the ilium; the other passes through the sacro-iliac articulation posteriorly and the thyroid foramen anteriorly.

The symphysis, while comparatively a weak part is rarely the site of injury. In childbirth the attachment of the pubes to each other becomes relaxed and a slight physiological separation occurs.

ATTACHMENT OF THE LOWER EXTREMITIES TO THE TRUNK

The human body usually occupies one of three positions: standing, sitting, or lying. The functions of the lower extremity are to afford support to the body and accomplish locomotion, therefore any disturbance of the normal relation of the extremities to the trunk interferes with the carrying out of those functions and proper support is not given and locomotion is imperfect. In such cases the positions assumed in standing, sitting, and lying are abnormal, often to an extent sufficient to constitute serious deformities, and locomotion, as in walking or running, is seriously impaired or rendered impossible.

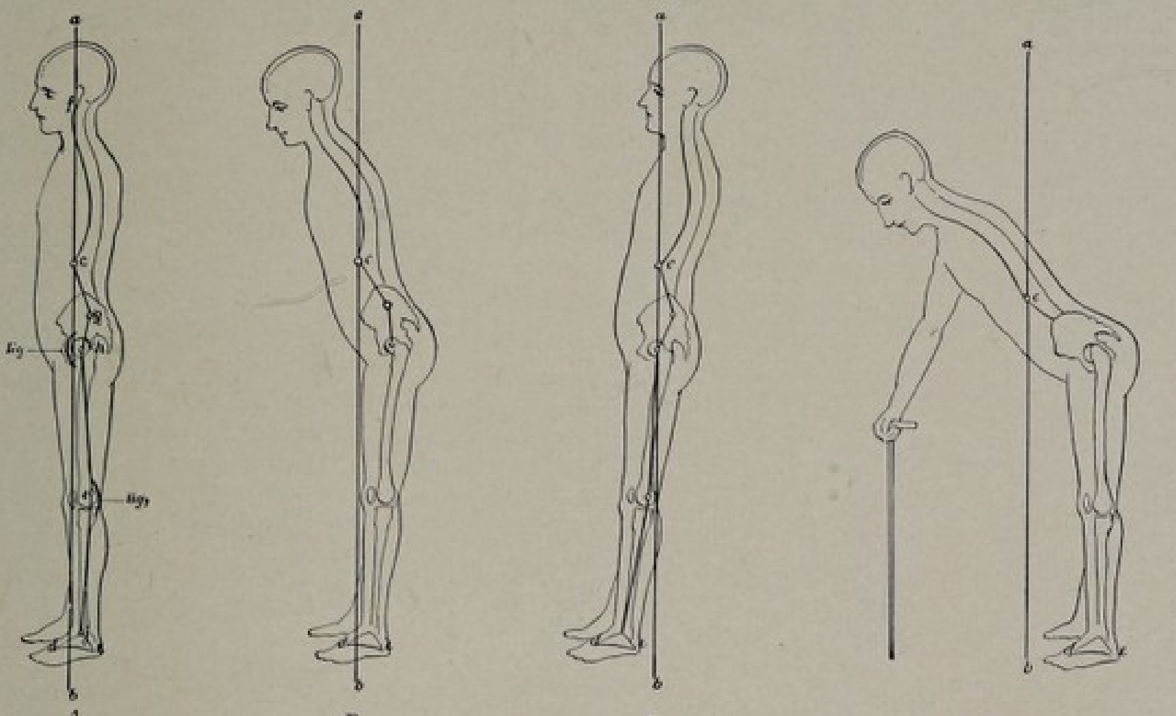
The connection of the lower extremities with the trunk is through the means of the pelvic girdle and spinal column; therefore the pelvis and vertebræ above exert a marked influence on the extremities below and must be taken into consideration. The normal upright position of man is obtained by maintaining a proper balance. This balance can be disturbed either anteroposteriorly or laterally. The lower limbs are placed laterally, one on each side; this gives greater stability in that direction, so that when a person falls it is usually in a forward or backward direction rather than toward the side.

Anteroposterior Equilibrium.—In the upright position the highest joint is that between the occiput and atlas and the lowest that of the ankle; to enable the body to be in a state of rest, in the upright position, with the use of the least amount of muscular exertion these joints are placed almost vertically one above the other. For the same reason if any part of the skeleton lies in front of a line joining the condyle of the occiput with the astragalo-scaphoid joint it is counterbalanced by a projection toward the opposite side. Thus the anterior curve of the cervical region is followed by the posterior curve of the dorsal; the anterior of the lumbar, by the posterior of the sacral. The hip-joint has its centre of motion slightly behind the centre of gravity as has also the knee. A vertical line through the center of gravity must fall within its base of support. This latter is formed by the arch of the foot; its two ends are the tuberosity of the calcaneum posteriorly and the head of the first metatarsal bones anteriorly. The body is in the position of greatest stability when the centre of gravity is midway between those two points, which is when it passes through the astragalo-scaphoid joint. As the line of gravity passes from the centre of the arch toward the ends, equilibrium becomes more unstable until, when it passes beyond them, it is lost and the body begins to fall. In maintaining a normal erect posture hyperextension of the hip-joint is prevented by the anterior or iliofemoral ligament; hyperextension of the knee is prevented by the lateral, posterior, and crucial ligaments (Fig. 537, *A*). The main muscular efforts required are those of the muscles of the back of the neck to hold the head level, owing to the head being heavier anterior to the condyles, and the muscles of the back of the leg to prevent the dorsal flexion at the ankle, due to the centre of gravity falling in front of the ankle-joint. When a person falls asleep in the erect posture the head drops forward and when a soldier is shot his calf muscles give way and he falls forward on his face.

Deformities of the spine affecting its curves have already been alluded to (page 548). When the spine is the part affected it is usually the case that the secondary curve fully compensates for the increased primary one, hence there is no necessity for any change in the position of the joints below, and we find people with marked deformities of the spine who are normal from the waist down and who stand and walk perfectly well. Occasionally a case presents itself in which the secondary curve has not entirely compensated the primary one and then the body is bent at the hips until the centre of gravity is brought over the base of support (Fig. 537, *B*). If the deformity throws the centre of gravity too far back, by bending the hips it will be brought forward, but if for any reason, such as ankylosis, flexion is impossible, then it cannot be corrected at the hip-joint, and therefore in such cases equilibrium is unstable and the body falls (Fig. 537, *C*). If from deformity the centre of gravity is thrown so far forward as to fall beyond the base of support then a cane or crutches is required (Fig. 537, *D*).

When the hip-joint is involved it is never affected by hyperextension (the iliofemoral ligament prevents that), but always by flexion. This throws the centre of gravity forward; to bring it back a secondary curve is produced in the lumbar region, and we have a condition of lordosis established; if this is insufficient then the knees may be partly flexed, and if both are insufficient then artificial support or crutches must be used. This is the reason why flexion is sought to be avoided in the treatment of coxalgia, and why osteotomy is done when the hip is ankylosed in a flexed position. Practically speaking there is no efficient compensation occurring at the sacro-iliac joints, the pelvis moving with the lumbar vertebræ.

Lateral Equilibrium.—In the upright position the centre of gravity falls midway between the ankles of the two feet. The fact of there being two points of support adds to the stability, which increases as the feet are separated. Hence it is that falls in an anteroposterior direction are more common than sideways. In standing the weight is transmitted from the spine through the femorosacral arches (page 566) to the hip-joint, thence downward through the femur and leg-bones to the astragalus. Here we have to deal with straight lines and angles rather than curves. The spine is normally straight; the line from the spine to the hip-joint is practically straight (no bending being possible), and from the hips to the feet



A. B. C. D.

FIG. 537.—Anteroposterior equilibrium.

FIG. *A*.—The body in the erect position; the centre of gravity *c* is about in the upper lumbar region; *d-e* is the base of support. The vertical line *a-b* through the centre of gravity *c* passes through the occipito-atloid joint above, in front of the sacro-iliac joint *g*, the hip-joint *h*, the knee-joint *i* and the ankle-joint *j* and falls between the points of support *d-e*, passing through the astragalo-scaphoid joint. Hyperextension of the hip and knee is prevented by ligaments.

FIG. *B*.—When the trunk is inclined forward by bending at the hip-joint, the increased projection of the head and upper portion of the trunk in front of the centre of gravity is counterbalanced by the increased projection of the hips and lower portion of the trunk posteriorly. The vertical line through the centre of gravity still cuts the base of support *d-e* and the body remains in a state of equilibrium.

FIG. *C*.—When the body inclines backward, hyperextension at the hip is prevented by ligaments; therefore, when the vertical line *a-b* through the centre of gravity *c* falls beyond the base of support *d-e*, the body is in unstable equilibrium and it falls.

FIG. *D*.—If the body, as occurs in some diseases and injuries, is inclined so far forward as to bring the vertical line *a-b* through the centre of gravity *c*, in front of the base of support *d-e*, then it is in a state of unstable equilibrium and additional support is used, in the form of a cane, to prevent falling forward.

is likewise straight, and the centre of gravity falls midway between the ankles (see Fig. 538, *A*).

The two innominate bones and the sacrum form practically one solid bone, therefore the two hip-joints always maintain the same relative position to each other. When the leg is completely extended there is no lateral movement at the knee-joints. There is a marked more or less lateral movement in the subastragaloid joint which allows the leg to be inclined to one side without moving the foot. From these facts it is evident that lateral equilibrium can be disturbed by a deviation of the spine above the sacrum to one side (Fig. 538, *B*), and also by anything that affects the length of either leg (Fig. 538, *C*). The femorosacral arch is rarely affected, the most usual affection being sacro-iliac disease, or fracture, or relaxation of the sacro-iliac joint, especially in pregnancy.

The lateral equilibrium is maintained almost solely by muscular force except when a position of rest is assumed. The hip-joint is capable of both abduction and adduction, and in the erect position the ligaments on both the upper and lower surfaces of the joint are lax and do not contribute any support. When, however, a position of rest is desired the hips are moved laterally so that the centre of gravity falls on one leg, which is kept extended, the opposite hip then descends until further adduction is stopped by the ligaments on the top of the hip of the other side (Fig.

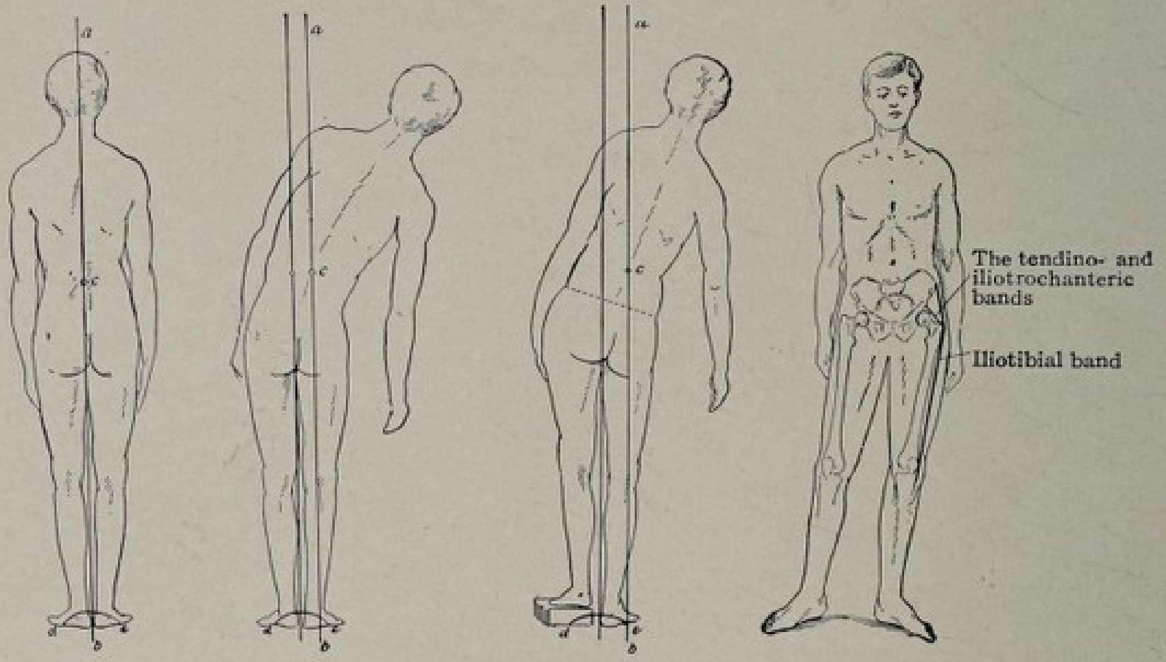


FIG. 538.—Lateral equilibrium.

Fig. *A*.—The body being erect, a vertical line *a-b* through the centre of gravity *c* falls midway between the ankles or base of support *d-e* and the body is in stable equilibrium.

Fig. *B*.—The trunk being inclined to the right, the centre of gravity *c* is shifted to the right and a vertical line *a-b* through it falls still within the line of support *d-e* and the upright position can still be maintained.

Fig. *C*.—If the relative length of the two legs is altered, as by placing a block beneath one of them, the pelvis and upper portion of the body incline to the opposite side, until a vertical line *a-b* through the centre of gravity *c* falls beyond the extremity of the base of support *d-e* and the body is in a position of unstable equilibrium.

Fig. *D*.—The body in a position of rest. The weight is borne mainly on the left leg; the right side of the pelvis falls until the iliotrochanteric and iliotibial bands are tense, when the position can be maintained without muscular effort.

538, *D*). These ligaments are the outer limb of the iliofemoral (Y) ligament and the reinforcing tendinotrochanteric band, an offshoot from the rectus tendon, the iliotrochanteric band, and by the iliotibial band from the crest of the ilium to the outer tuberosity of the tibia.

Balance.—For the movements of the body to be properly performed a definite normal relation of the parts to one another must be maintained, whether the body is in a state of motion or at rest. During movement the position of the bones is controlled by the muscles; when at rest, the muscles relax and the position of the bones is controlled by the ligaments. The weight of the body acts as a constant force pressing downward. For this constant pressure not to do harm it is nicely balanced on the bones and ligaments aided by the muscles. If any one of these three is disturbed the balance is altered and disability and ultimate deformity results. A distortion of a bone, as a badly united fracture, throws the weight and muscular action too much to one side and first the action of the part is impaired and then, if use is persisted in, deformity increases. When a person who is standing becomes tired he assumes a position of rest, that is, the muscles relax, the joints are extended and the weight is borne on the ligaments. If, now, as in adolescents, these ligaments are weak, they give way. If in the foot, flat-foot results; if in the knees, then knock-knee; if in the back, scoliosis of lateral curvature. If it is the bones which are the primary cause of the lack of proper balance, the surgeon by osteotomy, excisions, etc., will restore them to their proper direction. If it is the muscles, as in infantile and other paralyses, transplantations, or the taking of a tendon from

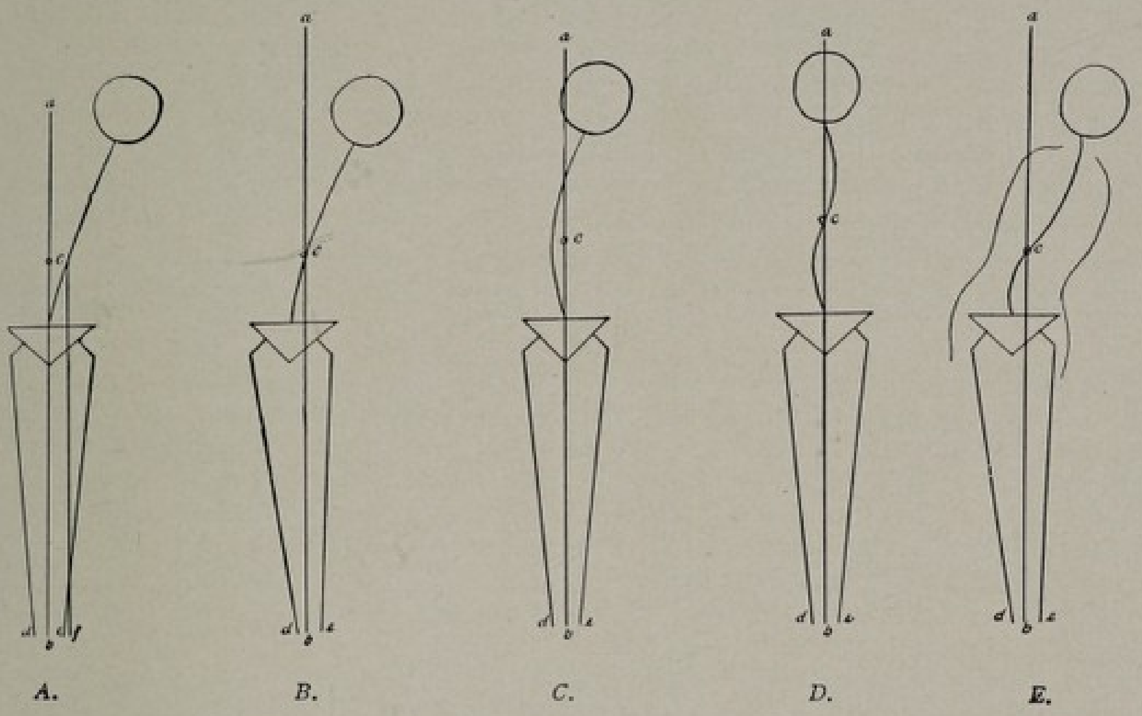


Fig. 539.—Deviation of the spine above the sacrum.

Fig. *A*.—If the trunk is inclined to one side, a vertical line *a-b* through the centre of gravity is shifted to *c-f*, and therefore falls outside of the base of support *d-e* and unstable equilibrium results.

Fig. *B*.—The inclining of the trunk to the right has been compensated by shifting the pelvis to the left, and the vertical *a-b* through the centre of gravity *c* falls within the base of support *d-e* and stable equilibrium has again been restored.

Fig. *C*.—If the deviation of the lower part of the trunk to the left is counterbalanced by a deviation of the upper part to the right then the vertical *a-b* through the centre of gravity *c* falls within the base of support *d-e* and the body remains in stable equilibrium.

Fig. *D*.—If a complete curve in the lumbar region is compensated by a complete curve in the dorsal and cervical regions above, then the centre of gravity *c* is not shifted and a vertical line through it still falls within the base of support *d-e*, and the body remains in stable equilibrium.

Fig. *E*.—If the curves are irregular, shifting more of the weight of the upper part of the body to the right, the pelvis is shifted to the left until the centre of gravity *c* is again brought within the base of support *d-e* and stable equilibrium is again restored.

the strong side and placing it on the weak side, will be resorted to. If it is mainly the ligaments, these will be aided in their function by the use of apparatus, while by means of exercises the muscles are aided in regaining their normal power. The conservative surgery of the extremities has as its underlying principle the restoration of equilibrium to a part whose balance has been disturbed.

DEVIATIONS OF THE SPINE ABOVE THE SACRUM

When, as in lateral curvature or scoliosis, there is a pathological curve developed, the centre of gravity is shifted from the midline to one side and it falls nearer the foot of the side toward which the trunk is inclined (see Fig. 539, *A*). This makes the equilibrium unstable so that to restore stability the hips are inclined to the opposite side and the centre of gravity is brought once more midway between the ankles (Fig. 539, *B*). This condition is produced when there is a single incomplete curve or deviation to one side; if, however, the curve is complete and again reaches the median line, as is often the case in scoliosis, then the centre of gravity is not disturbed and there is no lateral shifting of the pelvis (see Fig. 539, *C*). If the primary curve is accompanied by a secondary curve, both being complete and crossing the median line, then also there is no shifting of the pelvis (Fig. 539, *D*). If, however, the curves are so irregular as to shift more of the weight to one side than the other, then the pelvis shifts (Fig. 539, *E*). This causes the hip on the side opposite to the inclination to appear higher than the other, but it is not really so and the pelvis still remains level. It is therefore evident that it is unnecessary and unwise to attempt to correct the deformity by raising the apparently low hip by a high shoe. All these conditions occur in the lateral curvatures or scolioses of childhood and adolescence as well as the deviations which occur from empyema, sciatica, Pott's disease, and other affections. A knowledge of the principles involved is essential to comprehending their production and to directing the exercises and applying the apparatus used in their correction.

DISTORTIONS ACCOMPANYING AFFECTIONS OF THE LOWER EXTREMITIES

The hip-joint is capable of flexion, extension, adduction, abduction, and rotation. From the hip to the foot is a straight line; it can be shortened by disease or injury of the bones of the thigh or leg, and in rare cases it can be lengthened by disease at the epiphyses producing a more rapid growth than normal. It is almost unknown for hyperextension of the hip to exist, because if the femur is intact the iliofemoral ligament prevents it. If the head is gone then the upper end of the femur luxates upward and backward. Rotation likewise produces little effect on the position of the greater trochanter. Deformities due to flexion, abduction, adduction, and shortening are common.

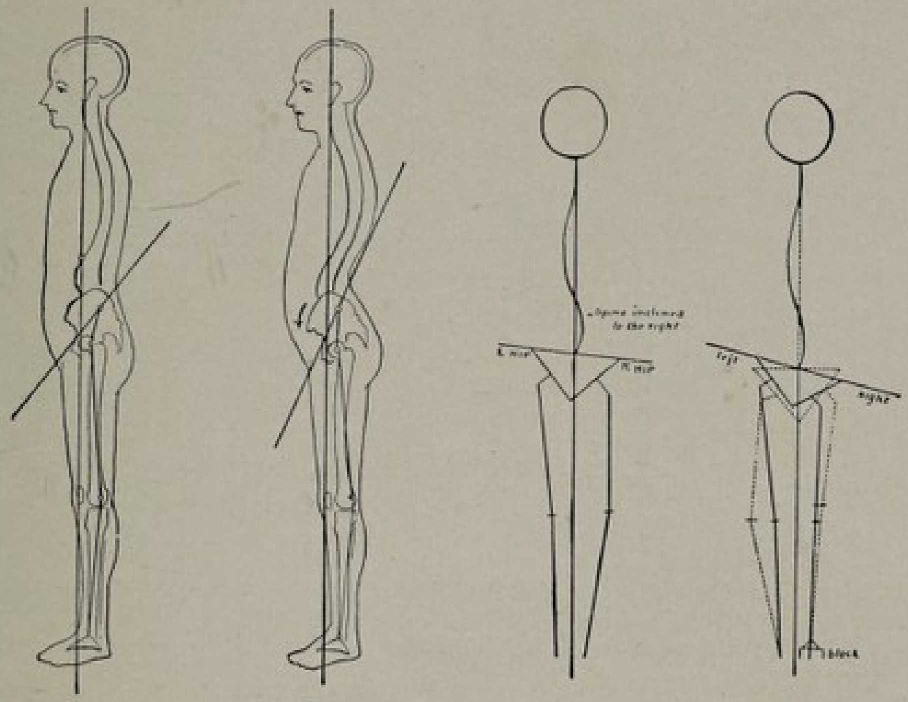
Increased Flexion.—Fig. 540, *A* shows the normal position; Fig. 540, *B* shows hyperflexion at the hip. The increased forward bend of the pelvis necessitates an increase in the lumbar curve in order to maintain the anteroposterior equilibrium. Thus lordosis is produced with the accompanying hollowing of the back and projection of the buttock. This is common in coxalgia and congenital luxations of the hip.

Hyperadduction and Hyperabduction.—If there is hyperadduction, as when one hip is ankylosed in a position of adduction, as shown in the left limb (Fig. 540, *C*), the pelvis is carried up toward the left; to restore the balance the spine is inclined to the right. If, however, the right limb is hyperabducted or fixed in a position of abduction, then in assuming the upright posture the right hip descends and the spine is inclined toward the side of the affected limb, as seen in the right hip of Fig. 540, *C*. In treating these conditions the spine can be brought straight by raising the *ab*ducted limb, but doing so will increase their inequality still more and shift the pelvis too far to the left. For this reason raising the shoe is not advisable, but an osteotomy and removal of the adduction or abduction is the proper treatment.

Effects of Shortening or Lengthening of a Lower Extremity.—The shortening of one limb produces the same effect as the lengthening of the opposite one: in other words it is the inequality of the limbs that counts. In Fig. 540, *D* the right extremity is the shorter; this causes the pelvis to tilt to the right, carrying the lower part of the spine with it and producing a right convex curve which is most marked in the lumbar region. To restore the equilibrium the parts above are carried to the left. Thus a lateral curvature is produced, which, contrary to those which originate in the spine, is accompanied by tilting of the pelvis. In these cases the deformity may be great. If the spinal curvature extends high the shoulders may be uneven, the hips are uneven in height and one projects farther out than the other, the legs may be visibly unequal in length, and there is marked limping of gait. The remedy is obvious. The short limb is to be made equal to the long one by raising the shoe or by other means.

MEASUREMENT OF THE LOWER LIMBS

The ability to determine accurately the length of the lower extremities is essential to diagnosis and important in treatment. It is a difficult thing to do and requires knowledge, care, and practice. It may be accepted as a fact that the limbs are normally equal in length. It is true that in rare cases there may be a slight inequality, but an amount of inequality readily detected by measurement will usually produce an unevenness in the gait, a slight limp.



A. *B.* *C.* *D.*

Fig. 540.—Distortions accompanying affections of the lower extremity.

Fig. *A.*—Normal erect position, showing the normal inclination of the pelvis and normal relation of the back and buttocks.

Fig. *B.*—The pelvis has been tilted forward and downward, being flexed on the thighs; this results in an increased hollowing of the back and an increased protrusion of the buttocks.

Fig. *C.*—The left thigh is adducted and the right abducted. If the left hip is ankylosed in a position of adduction, as shown, then the pelvis is tilted down on the right, inclining the spine immediately above in the same direction. This moves the centre of gravity to the right, but is compensated by a shifting of the pelvis to the left, thus bringing the vertical through the centre of gravity within the base of support. If the right hip is ankylosed in abduction, the same condition results. In order to compensate for the uneven lengths of the limbs produced by tilting the pelvis, the knee of the apparently lengthened limb is bent.

Fig. *D.*—The solid outline shows the position assumed when the right leg is shorter than the left. By placing a block under the short right leg the pelvis is raised to a horizontal line and the curves of the spine are straightened, as shown by the dotted outline.

To measure accurately, bony landmarks are preferable to the soft parts, such as the umbilicus; these bony points must be carefully identified, they must be in their normal position, and the tape-measure must be accurately applied.

Measurements are usually taken either from the umbilicus or anterior superior spines to the internal malleoli. The latter is the more accurate and shows the actual shortening, while the former shows the apparent shortening. To identify the tip of the internal malleolus is usually easy enough, but the anterior superior spine is not so evident. The anterior portion of the crest of the ilium should be followed forward until its anterior superior spine can be distinctly felt. In applying the tape it is better not to rest it on the superficial surface of the spine nearest the skin but rather on its inferior surface nearest the feet. It should be placed below the spine and then pushed firmly upward and backward against its lower surface. The superficial surface of the anterior superior spine is often so rounded or flat as to make it an uncertain point to measure from. To put the parts in their normal position it is necessary to see that a line joining the two anterior superior spines is at a right angle with the long axis of the body, otherwise the tilting of the pelvis will vitiate the results. Fig. 541, *A*, front view, shows the normal relation; *g* is the umbilicus; *g-h*, the median line; *a*, left anterior spine; *b*, right anterior spine; *c*, left trochanter; *d*, right trochanter; *e*, left internal malleolus; *f*, right internal

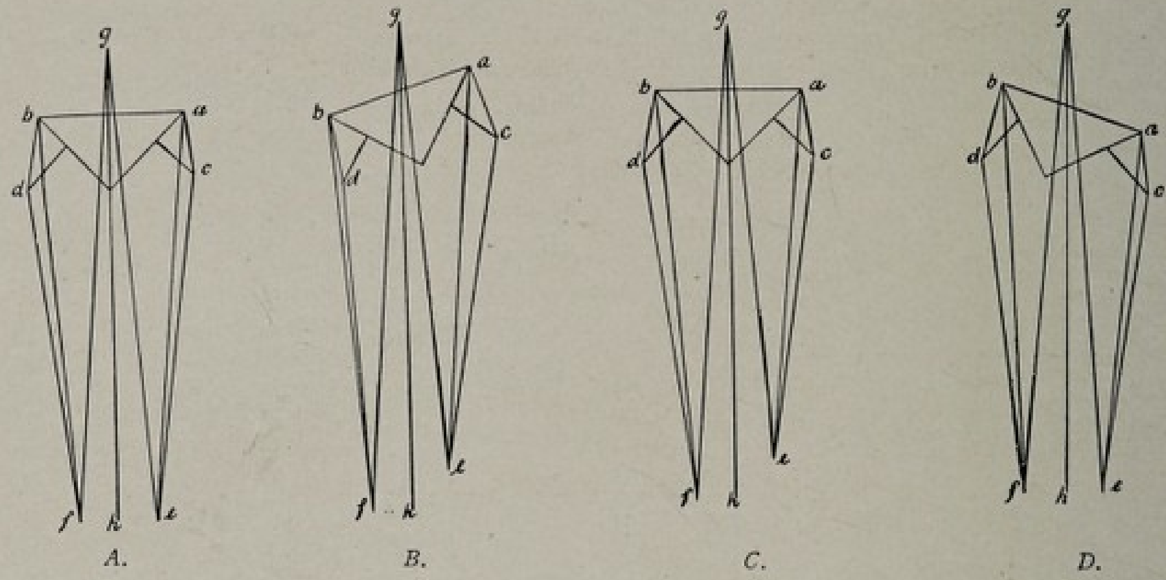


FIG. 541.—Measurements of the lower limbs, viewed from the front. *a*, left anterior superior spine; *b*, right anterior superior spine; *c*, left trochanter; *d*, right trochanter; *e*, left internal malleolus; *f*, right internal malleolus; *g*, umbilicus; *h*, lower end of median line.

Fig. *A*.—The line of the pelvis *a-b* is in its correct position at a right angle to the long axis of the body *g-h*: *a-e* equals *b-f*, and *g-e* equals *g-f* and *a-c* equals *b-d*.

Fig. *B*.—The limbs in this figure are of equal length but the pelvis is tilted. The pelvis *a-b* is tilted up on the left and down on the right. Apparent shortening of the left leg is seen by comparing *g-e* with *g-f*. Actual measurements shows *a-e* to be a trifle longer than *b-f* and *a-c* longer than *b-d*.

Fig. *C*.—One leg shorter than the other, but the pelvis is in the correct position. The actual shortening found by comparing *a-e* with *b-f* corresponds with the apparent shortening found by comparing *g-e* with *g-f*.

Fig. *D*.—Legs unequal, pelvis tilted down on the side of the short leg. The apparent lengths *g-e* and *g-f*, taken from the umbilicus *g*, show the legs apparently equal, but the distance *b-f* is longer than *a-e* and the absolute or actual amount of shortening is only to be found by levelling the pelvis as in Fig. *C*, when the apparent and actual amount of shortening will be found to agree.

malleolus. The line *a-b* is to be at right angles to *g-h*. Then *a-e* = *b-f* and *g-e* = *g-f*.

Fig. 541, *B* shows the effect of tilting of the pelvis, the legs being of equal length. *a-b* instead of being at right angles to *g-h* is inclined upward on the left side and down on the right. Apparent shortening is seen by comparing *g-f* with *g-e*. Actual measurement shows *a-e* to be a trifle longer than *b-f*. This is accounted for by the tilting causing *b-d* to approach each other while *a-c* have separated.

If one hip is ankylosed its femur should be moved laterally until the line joining the two anterior superior spines is at right angles to the median line of the body; the opposite limb is then to be abducted to a similar degree and the measurements of the two limbs can then be compared.

When the legs are unequal and the pelvis is in a correct position, the apparent and actual measurements agree (Fig. 541, *C*).

When the legs are unequal the pelvis is tilted down on the side of the short leg (Fig. 541, *D*). Apparent length taken from the umbilicus shows the legs equal, but the distance *b-f* will be found to be longer than *a-e*. This will not give accurately the actual amount of shortening because of the tilting of the pelvis. It can only be determined by levelling the pelvis so as to make the distances *a-c* and *b-d* equal.

The length of the extremity below the neck of the femur can be determined by feeling for the tip of the greater trochanter on its upper posterior border and measuring to the external malleolus and comparing with the opposite side.

WALKING

As locomotion is one of the main functions of the lower extremity, derangements of this function are to be explained by a knowledge of the normal action of its mechanism. The means by which support is accomplished have already been explained in the maintenance of equilibrium. Locomotion embraces walking, running, jumping, etc. Of these walking is the fundamental movement, and the others are only amplifications and modifications of it. In slow normal walking on a level surface the thigh moves on the pelvis, the leg on the thigh, the foot on the leg, and the toes on the rest of the foot. These movements are almost solely in an anteroposterior direction, there being almost no lateral or rotary movements; these begin only when the actions become violent and irregular, such as are necessary in running, overcoming obstacles, etc. It is for this reason that a person may have no limp when walking slowly, but a very perceptible one when walking rapidly. There is

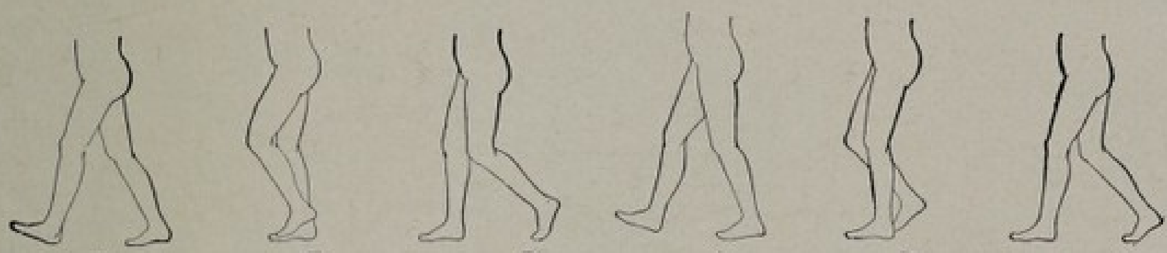


FIG. 542.—Walking. Tracings from photographs by Muybridge.

always a small amount of lateral motion present which varies with the individual and the sex.

As slow walking necessitates mainly anteroposterior motion, it can be explained by viewing the body laterally.

In ordinary walking the body inclines forward 5 degrees, in fast walking 10 degrees, and in running about 22 degrees (Weber). In walking (Fig. 542, *A*) the body is inclined forward and at the same time one leg begins to advance (the right). This causes flexion of the left ankle and flexion of the right hip (Fig. 542, *B* and *C*). As the right foot touches the ground it extends and the right knee flexes to avoid the shock of impact (Fig. 542, *D*), the left knee begins to flex and flexes more than the right in order for the left foot to swing clear of the ground while being advanced; if this was not done it would be necessary to raise the limb by tilting the pelvis up on that side. The left continues to advance flexed while the right gradually extends (Fig. 542, *E*), and finally when the right is fully extended the left is likewise fully extended (Fig. 542, *F*) and strikes the ground with the foot about at a right angle to the leg.

The object of flexion of all three joints is, first, to avoid shock in impact, and, secondly, to raise the free foot and allow it to swing forward clear of the ground. The object of extension is to push the body forward.

Part Played by the Various Joints.—The *hip*-joint flexes to an extent proportionate to the length of the step (Fig. 542, *A*). If this joint is put out of use by being ankylosed, first, the shock of impact is more severe, no flexion being possible; second, the limb cah only be brought forward by bending the pelvis on the opposite hip, and, to a certain extent, the trunk above backward; third, to aid still more to advance the foot forward the pelvis will be rotated laterally on the opposite hip. This causes a swaying of the trunk backward and forward and a side swing or waddle of the pelvis. Fourth, the forward propulsive force is weakened by the loss of the hip extensors. The *knee*, like the hip, lessens the shock of impact by flexing. It raises the foot clear of the ground as it is swung forward, and it aids propulsion by extension. If ankylosed, shock is increased, onward propulsive force is lost, and it is necessary to tilt the pelvis upward in order to raise the foot from the ground and allow it to swing forward. This abducts one or both legs and causes marked waddling. The *ankle* also reduces shock and gives propulsion; if ankylosed, shock is increased and propulsion weakened. This is the least necessary of the three joints and to substitute it artificial appliances are useful, so that in quiet walking limp may be almost lacking, but violent and complicated movements are to a large extent impossible. The toes, especially the big toe, aid in propelling the body forward.

REGION OF THE HIP

The hip is that portion of the body joining the lower extremity to the trunk. It differs in construction from the shoulder, because it is designed for strength as well as mobility; hence it is that the bones are heavier, stronger, with their processes more marked, and that the muscles also are bigger and more powerful. It is often the seat of injury and disease, the bones being fractured, the joint luxated, and frequently affected with tuberculosis and other diseases.

BONES OF THE HIP

The bones of the hip are the innominate bone and femur. The innominate bone has its shape determined by its relation to the trunk, being adapted to support and protect the viscera, while the femur has its shape determined by its relation to the extremity, being in the nature of a pole to support it.

The **innominate bone** (Figs. 543 and 544) is composed of the *ilium, ischium,* and *pubis.* These are united in the acetabulum by the Y-shaped cartilage and become ossified about the sixteenth year. The ilium has a crest which serves for the attachment of the transverse abdominal muscles. At its anterior extremity is the anterior superior spine, and at its posterior extremity the posterior superior

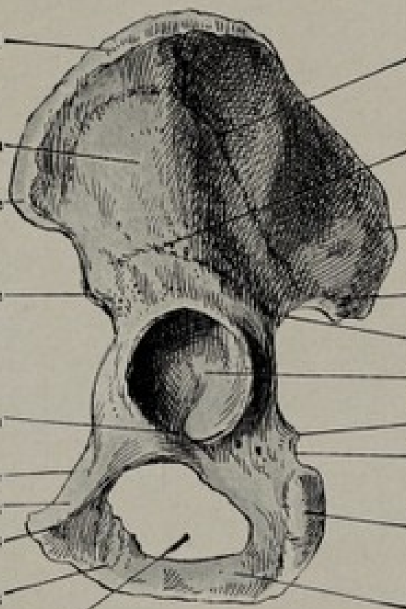


FIG. 543.—The innominate bone, viewed from the outside.

spine. Its large flat portion, called the *ala*, gives origin from both its inner and outer sides to muscles running to the thigh below. The glutei muscles are attached to its outer surface and the iliacus to its inner. Immediately below the anterior superior spine is the anterior inferior spine; to it is attached the rectus femoris tendon. The ischium is below and behind the acetabulum; its tuberosity gives attachment to the hamstring muscles—biceps (outer), semitendinosus, and semimembranosus (inner). Along the inner surface of the ramus of the ischium, in a fibrous canal (Alcock's), run the internal pudic vessels and nerve on their way to the perineum. They lie 4 cm. (1½ in.) from the surface. The pubis lies below and anterior to the acetabulum. Its upper inner edge forms the iliopectineal line, which is continued back to form the brim of the true pelvis. The superior or horizontal ramus goes to the ilium, while its inferior or descending ramus goes to the ischium. The upper surface of the superior ramus gives origin to the pectineus muscle; it is over this muscle that femoral hernia descends. The symphysis pubis is the junction of the two pubic bones in the median line. The crest is the upper anterior edge and gives attachment to the rectus and pyramidal muscles (for muscular attachments see Figs. 438 and 439, page 438). The outer extremity of the crest is the spine of the pubis. To it is attached the inner extremity of Poupart's ligament. The obturator foramen, if the body is in an upright position, is just be-

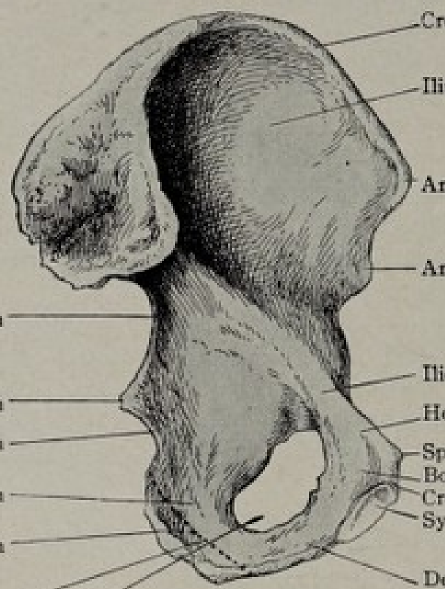


FIG. 544.—The innominate bone, viewed from the inside.

low and a little anterior to the acetabulum; it is closed by a membrane which is incomplete above to give passage to the obturator vessels and nerve. The outer surface of the membrane gives origin to the obturator externus muscle and the inner surface to the obturator internus. This latter passes out of the pelvis through the lesser sacrosciatic notch just below the spine of the ischium. Through the greater sacrosciatic notch, above the spine, come the pyriformis muscle and great sciatic

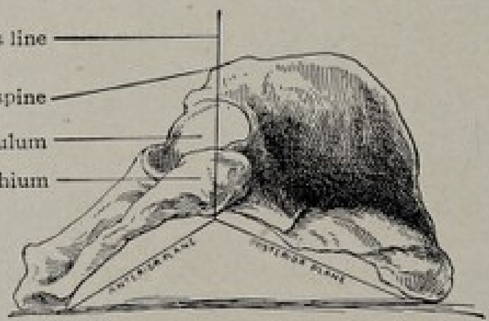


FIG. 545.—Innominate bone, resting on its inner side, to show the wedge-shaped formation of its outer surface. The apex of the wedge is Nélaton's line, running from the anterior superior spine to the tuberosity of the ischium; the anterior plane inclines downward and forward toward the pubis and the posterior plane inclines downward and backward on the ilium.

nerve. The acetabulum is located at the junction of the ilium, ischium, and pubis, and lies a little to the outer side of the middle of Poupart's ligament, with the femoral artery passing nearer its inner than its outer edge. The obturator foramen is below and a little anterior to the acetabulum when the body is upright and more anterior when it is horizontal. The bottom of the acetabulum has a large fossa, to the upper portion of which is attached the ligamentum teres, while the lower portion contains a pad of fat. This fossa opens by a large notch, called the *cotyloid notch*, on the side toward the obturator foramen; therefore the bony socket is incomplete at this point.

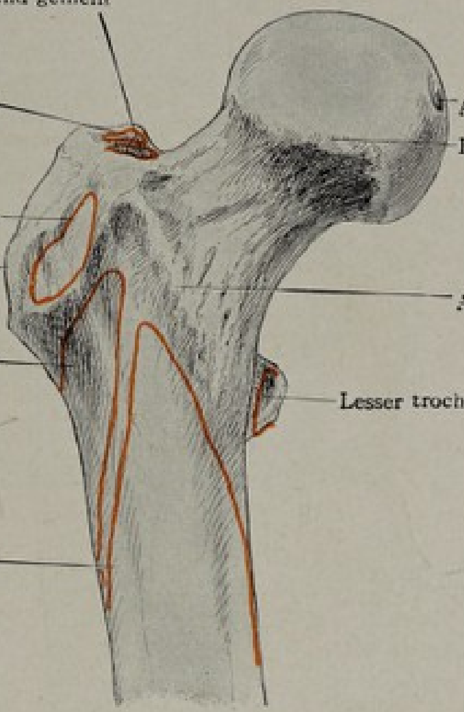


Fig. 546.—Anterior view of the upper end of the femur with muscular attachments.

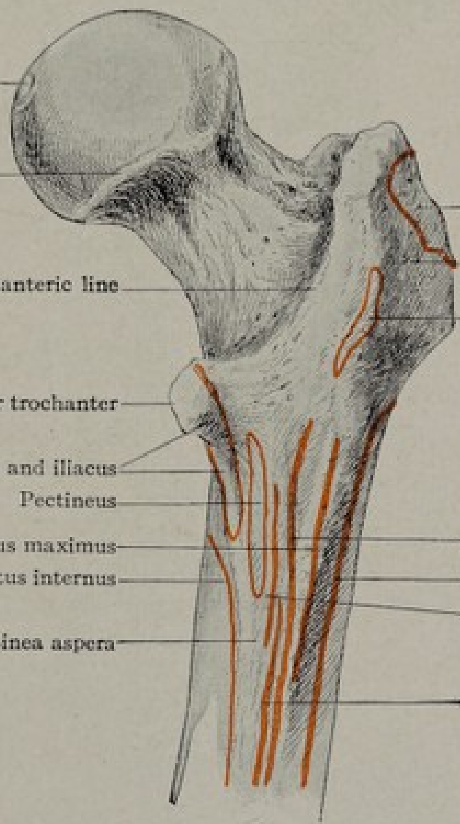


Fig. 547.—Posterior view of the upper end of the femur with muscular attachments.

Allis has pointed out that a line passing from the anterior superior spine to the tuberosity, called the *Roser-Nélaton line*, forms the apex of a wedge, the ilium sloping down on one side while the ischium and pubes pass down the other. It divides the innominate bone into two parts, an anterior plane and a posterior plane (Fig. 545).

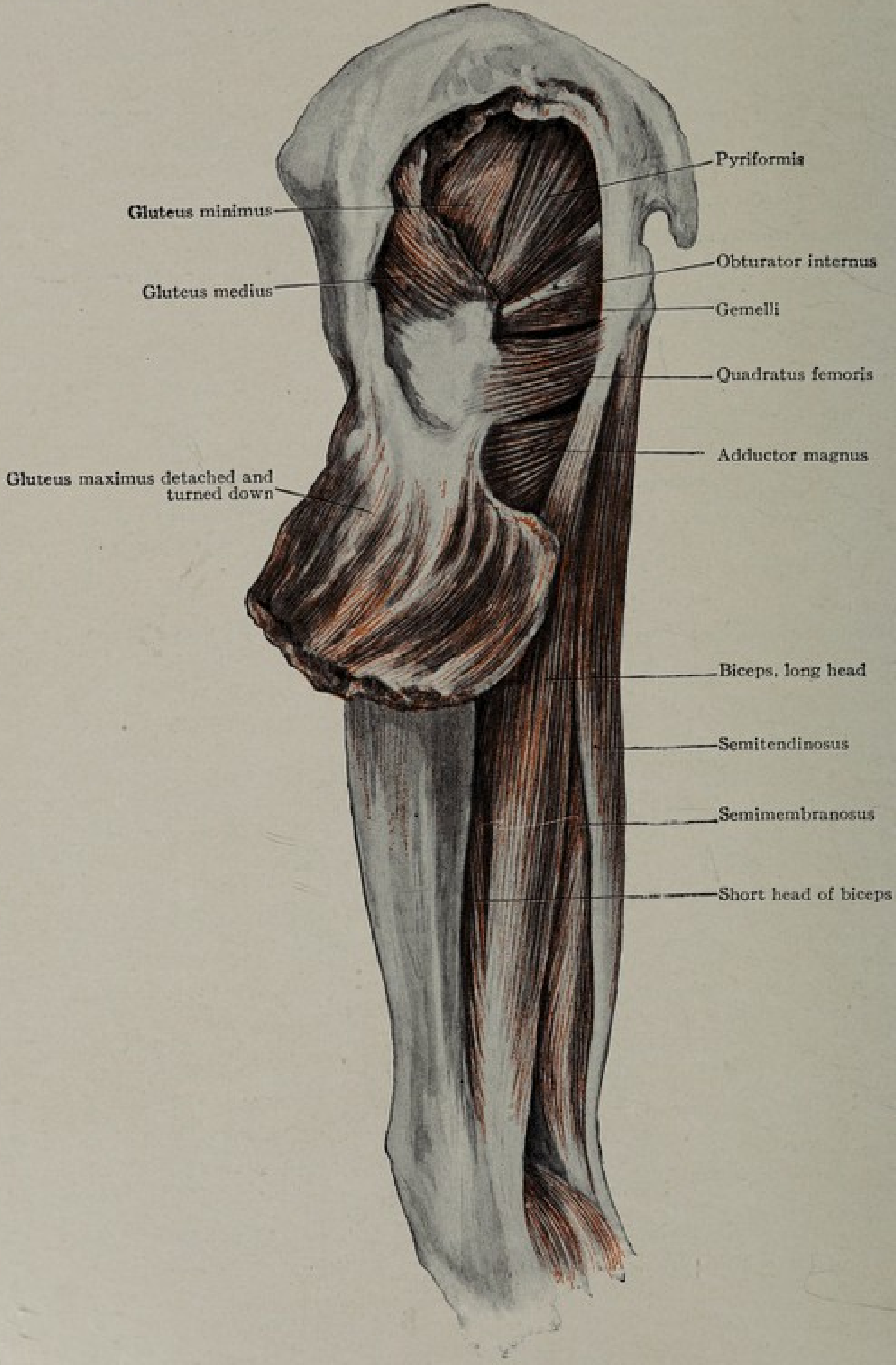


Fig. 548.—Muscles of the region of the hip.

The **femur** has its neck coming off from the shaft at an upward angle of about 127 degrees (125 degrees to 130 degrees). The head and neck do not lie in the same transverse plane as the line joining the two condyles, but are inclined slightly forward (about 12 degrees). Therefore the neck passes upward, inward, and a little forward. As the result of deformities or disease, the inclination of the neck to the shaft may be reduced, being 90 degrees or less. This condition is known as *coxa vara*. It may be increased, constituting *coxa valga*. The articular surface of the head forms slightly more than a hemisphere and has a pit below and posterior to its centre for the attachment of the ligamentum teres. At the outer upper extremity of the neck where it joins the shaft is the greater trochanter. Its tip or most prominent point is toward its posterior surface and is just about opposite the centre of the hip-joint. Downward and inward from the greater trochanter, on the inner and posterior surface of the shaft, is the lesser trochanter. Between the trochanters anteriorly and posteriorly run the intertrochanteric lines. The great trochanter and the part immediately below and posterior gives attachment to the three glutei muscles, the short rotators (Fig. 547), the pyriformis, the obturators, internus with its two gemelli and externus, and the quadratus femoris. The lesser trochanter gives attachment anteriorly to the psoas and the iliacus and immediately below to the pectineus.

The anterior intertrochanteric line marks the lower attachment of the capsule; the posterior has inserted into it the quadratus femoris muscle.

MUSCLES OF THE HIP

The muscles of the hip are numerous and their action is often intricate: many muscles are usually used to produce a single movement. Some muscles not only cross the hip-joint but another joint as well. Thus the psoas crosses the hip-joint and pelvis to reach the spine. The hamstring muscles, the rectus femoris, gracilis, and sartorius cross both the hip-joint and knee-joint, as does practically the tensor fasciæ femoris through its prolongation, the iliotibial band. The movements of the hip are flexion, extension, adduction, abduction, and rotation. Circumduction is a combination of the first four movements.

Flexion is mainly the result of the action of the sartorius, iliacus, psoas, rectus femoris, and pectineus.

Extension is mainly due to the gluteus maximus, medius, and minimus, biceps, semitendinosus, and semimembranosus.

Adduction is accomplished by the pectineus, adductor longus, brevis, and magnus, and to a less extent by the gracilis, quadratus femoris, and lower part of the gluteus maximus.

Abduction in the extended position is due to the tensor fasciæ femoris, sartorius, gluteus medius, and gluteus minimus. When flexed the short rotators also aid.

Internal rotation is produced mainly by the tensor fasciæ femoris and the anterior portion of the gluteus medius and minimus; three muscles only. The iliopsoas acts as a weak internal rotator if the femur is in a position of extreme external rotation.

External rotation is mainly due to the short external rotators—pyriformis, gemelli, obturators, quadratus femoris, the adductors, and the posterior portion of the three gluteals. To a slight extent the sartorius, iliopsoas, pectineus, and biceps may also aid at times.

SURFACE ANATOMY

The *crest of the ilium* running upward and outward as it curves backward in an S-shaped line, can be palpated in its entire length. In very thin people it causes an elevation of the surface, but usually it is marked by a depression. Its anterior third is subcutaneous and is more easily seen and felt than the posterior two thirds. A line joining the highest point of the crests passes through the fourth lumbar spine. To the left of the middle of this line the aorta divides into the two common iliacs. A line joining the anterior superior spines in front passes below the promontory of the sacrum. The *anterior superior spine* can be readily felt. It lies downward and outward from the umbilicus: as has been said, measurements are best taken by pressing the tape against its lower surface rather than its subcutaneous one.

The *posterior superior spine* is not as prominent as the anterior. It is marked by a dimple, is best recognized by following the crest of the ilium to its posterior extremity. It is opposite the middle of the sacro-iliac joint and the second sacral spine. The body of the second sacral vertebra is the limit to which the spinal meninges extend and therefore the lowest level at which cerebro-spinal fluid can be obtained.

The *posterior inferior spine* is 4 to 5 cm. (1½ to 2 in.) directly below the posterior superior spine. The *spine of the ischium,* which marks the position of the pudic and sciatic arteries, is 8 to 10 cm. (3 to 4 in.) below the posterior superior spine and the *tuberosity of the ischium* is 12 to 15 cm. (5 to 6 in.). Running forward from the posterior inferior spine for a distance of 4 to 5 cm. (1½ to 2 in.) is the *great sciatic notch*; through it pass the pyriformis muscle, gluteal artery and nerves (superior and inferior), sciatic nerves (great and small), sciatic artery, internal pudic artery, pudic nerve and nerve to the obturator internus muscle. A line joining the posterior superior spine and the tip of the great trochanter may be named the *posterior iliotrochanteric line* (iliotrochanteric line of Farabeuf). It marks roughly the posterior edge of the gluteus medius muscle and goes through the upper edge of the gluteus maximus. The gluteal artery and superior gluteal nerves cross this line at the junction of the upper and middle thirds, this being about opposite the posterior inferior spine. A line joining the tuberosity of the ischium and tip of the greater trochanter may be called the *ischio-trochanter line*: it is crossed at the junction of its inner and middle thirds by the sciatic nerve.

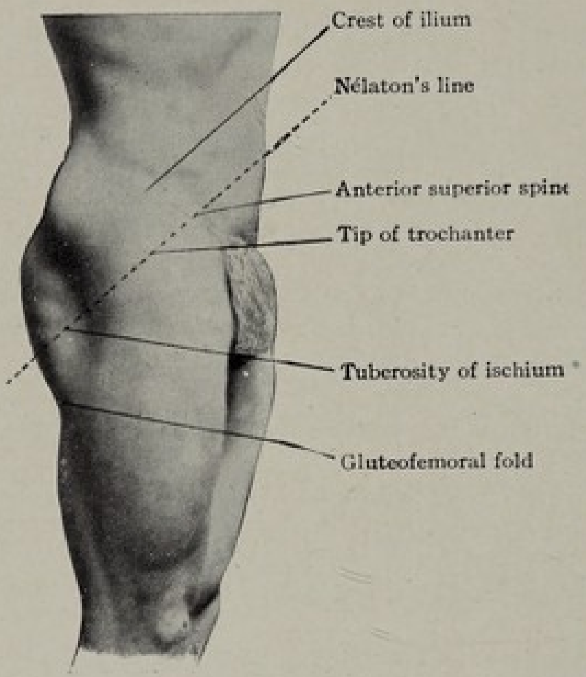


FIG. 549.—Surface anatomy of the region of the hip.

The *greater trochanter* is marked by an eminence in thin people and a depression in the plump and fat. Its anterior upper edge is crossed by the tendon of the gluteus medius and cannot be readily outlined. Its upper posterior extremity or tip is readily distinguished and is the spot used for measurements. This point is called the *tip of the greater trochanter* and must be searched for posteriorly. It is opposite the centre of the head of the femur and is on a level with the spine of the pubis.

The *Roser-Nélaton* line is one drawn from the anterior superior spine to the tuberosity of the ischium. It passes through the tip of the greater trochanter. It is of importance in fractures and dislocations (Fig. 550).

Bryant's triangle is to be drawn while the patient is lying on his back. One side is a perpendicular let fall from the anterior superior spine to the table, the other side is one joining the anterior superior spine and the tip of the greater trochanter, the base is a line running horizontally from the tip of the greater trochanter to the perpendicular line (Fig. 507). If the tip of the trochanter becomes elevated, as in fractures of the neck of the femur, it shortens the base of the triangle on the affected side as compared with the base of the triangle on the sound side.

The *anterior iliotrochanteric line* may be designated as a line joining the anterior superior spine and the tip of the greater trochanter. In normal individuals it slopes downward and backward, forming an *iliotrochanteric angle* (*b a c,* Fig. 550) of about 30 degrees. In cases of fracture or luxation this angle becomes reduced as the shortening increases until the tip reaches the level of the anterior superior spine. A rough estimate of this angle by sight and palpation usually enables one to decide immediately as to the presence of shortening from fracture or luxation without the trouble of erecting Bryant's triangle. The anterior iliotrochanteric line forms the anterior side of Bryant's triangle and the anterior half of the Roser-Nélaton line.

The *gluteal cleft* separates the buttocks. In its lower portion can be felt the coccyx. The *gluteal* (*gluteofemoral*) *fold* is formed mainly by the subcutaneous fatty tissues and passes horizontally outward from the lower part of the gluteal cleft. A shortening of the leg on either side causes the corresponding fold to incline downward. It is marked in extension and gradually lessens on flexion and disappears when 90 degrees is reached. It is crossed obliquely downward and outward at about its middle by the lower edge of the gluteus maximus. Its disappearance in coxalgia is caused by the flexion incident to that affection.

Ligation of the Gluteal, Sciatic, and Internal Pudic Arteries.—To ligate the gluteal artery incise the skin and part the fibres of the gluteus maximus in the upper two-thirds of a line joining the posterior superior spine and the top of the great trochanter (Fig. 551). The artery leaves the pelvis at a point at the junction of the upper and middle thirds of the latter line. Pull the lower edge of the gluteus medius up and the artery and superior gluteal nerve will be seen coming out between it and the pyriformis. To ligate the sciatic and internal pudic arteries an incision parallel to the one just described but about 7.5 cm. (3 in.) lower is made through the gluteus maximus, and just below the edge of the pyriformis from without inward will be found the great sciatic nerve, lesser sciatic nerve, sciatic artery, and the internal pudic nerve and internal pudic artery crossing the spine of the ischium. The point of emergence from the pelvis of these structures is the junction of the lower and middle thirds of a line from the posterior superior spine to the ischial tuberosity.

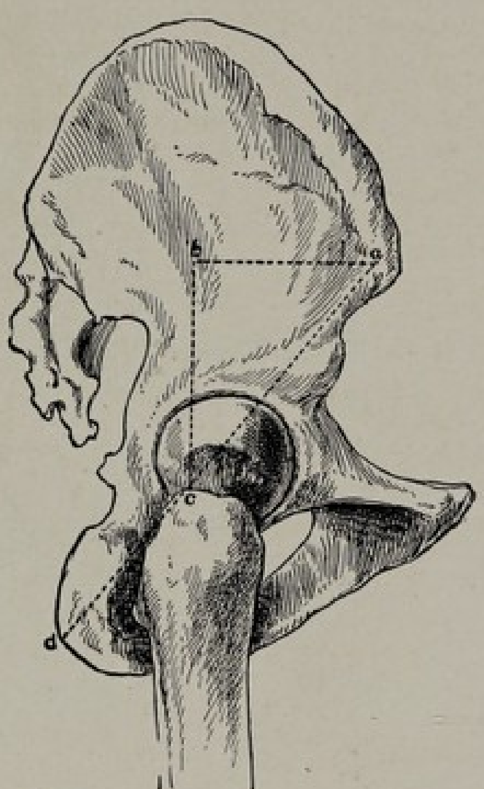


Fig. 550.—View of the outer surface of the bones of the hip showing Roser-Nélaton line (*a-d*), Bryant's triangle (*a b c*), iliotrochanteric line, (*a c*) and the iliotrochanteric angle (*b a c*).

Bursæ.—Covering the tuberosity of the ischium is a bursa which sometimes suppurates and forms a sinus. It can readily be excised. These sinuses are often bilateral.

THE HIP-JOINT

The hip-joint, like the shoulder, is a ball-and-socket joint, and, like it, moves in all directions. The main function of the shoulder is mobility, but the functions of the hip are mobility and support. To give the necessary support and security, the band-like ligaments uniting the bones are strong and the extent of the movements is restricted. Macalister points out that while the shoulder has 118 degrees of motion around a sagittal axis, abduction and adduction, the hip has only 90 degrees; around a coronal axis, flexion and extension, the shoulder has 170 degrees and the hip only 140 degrees. In the vertical axis the shoulder rotates 90 degrees, while the hip rotates only 45 degrees. In the upright position the centre of gravity falls in front of the axis of rotation of the hip-joint.

The head of the femur is 5 cm. (2 in.) in diameter and forms 5/7 of a sphere.

Below and behind its centre is the depression for the attachment of theligamentum teres. The acetabulum is much deeper than the glenoid cavity of the shoulder-joint and its depth is increased by the cotyloid ligament around its edge. This makes the joint air-tight and holds the femur in place by suction, hence it is called by Allis ("An inquiry into the difficulties encountered in the reduction of dislocations of the hip," Philadelphia, 1896) the sucker ligament. The acetabulum is incomplete at its lower anterior edge, forming the cotyloid notch. The cotyloid ligament bridges over this notch, and its deeper part loses its cartilaginous cells, becomes fibrous, and is called the transverse ligament.

Beneath the transverse ligament pass vessels, nerves, fatty tissue, and the extremity of the ligamentum teres, which is attached to the ischium just outside.

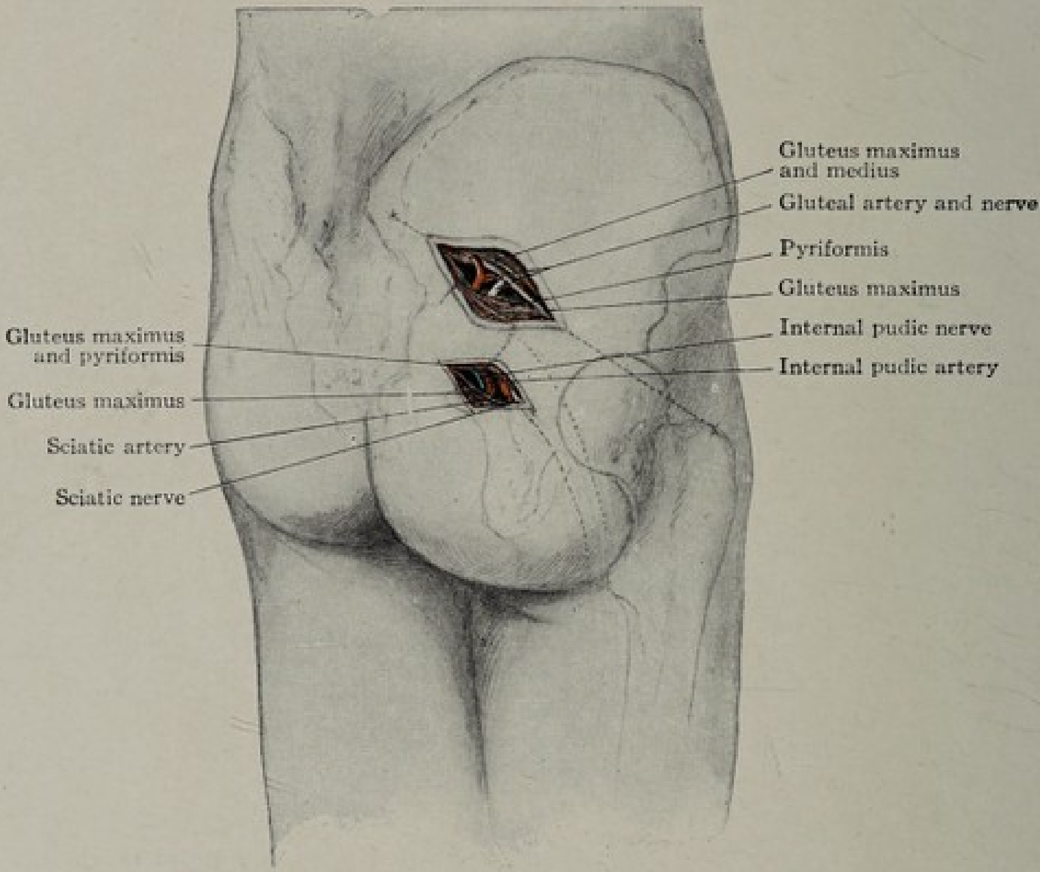


Fig. 551.—Ligation of the gluteal, internal pudic, and sciatic arteries.

Running up in the floor of the acetabulum from the cotyloid notch is a depression in which is lodged the ligamentum teres and a pad of fat called the *Haversian gland*. The ligamentum teres is composed of synovial and connective tissue. It is not strong and ruptures at about 14 kilos; the small artery it contains affords nourishment for itself alone, only a very small amount of blood going to the head of the femur. Bland Sutton regards it as a vestigial structure and a regression of the pectineus muscle. It is too weak to add much to the strength of the joint, and the view of Allis that its function is to distribute the synovial fluid and act as a lubricating agent is probably correct. The great pressure to which the articulating surfaces of the hip-joint are subjected requires special lubrication and this is furnished by the ligamentum teres and Haversian gland.

Like other joints, the hip has a capsular ligament which is strengthened by bands or ligaments. These ligaments are the iliofemoral, pubofemoral, and ischiofemoral.

Iliofemoral Ligament (Bertins' ligament or Y ligament of Bigelow).—This is the strongest ligament in the body. The single stem of the Y ligament is attached to the upper edge of the rim of the acetabulum just below the anterior inferior spine.

Its two branches are attached below to the anterior intertrochanteric line. Its upper edge is reinforced by a band from the ilium to the trochanter, the *iliotrochanteric band,* and one from the reflected tendon of the rectus, the *tendinotrochanteric band* (Henry Morris) (Fig. 552).

The pubofemoral ligament, also called the pectineofemoral ligament, runs outward into the capsule from the horizontal ramus of the pubes. It is quite weak.

Ischiofemoral Ligament.—Allis describes this ligament as follows: "It arises from the ischial portion of the rim of the socket and sends its fibres to the capsule to be blended with them. As its fibres extend upward they separate like two fingers or terminal processes, the one extending forward to the base of the oblique (posterior) line, the other running backward to the digital fossa (Fig. 553)."

It will be observed that this makes it a posterior Y ligament with a distinct bony attachment for its two arms (like the external lateral ligament of the elbow—see

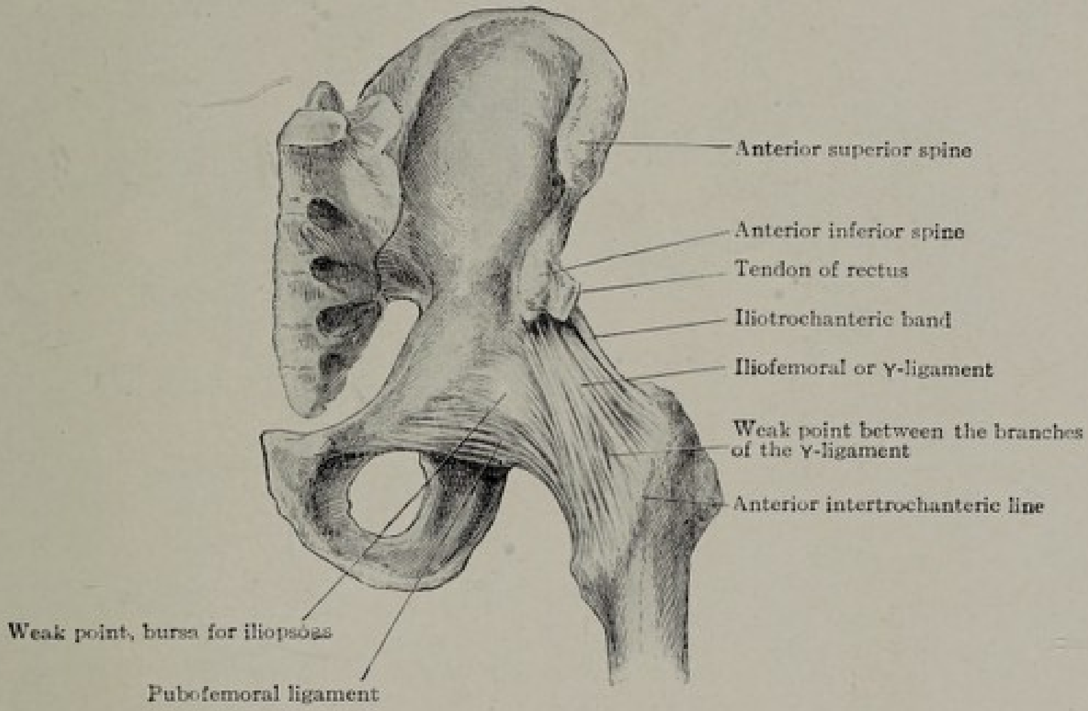


FIG. 552.—Anterior view of the ligaments of the hip-joint.

page 321). The web of the two arms is half way down the posterior surface of the neck of the femur.

Capsular Ligament.—The capsule of the joint is composed of a thin sac strengthened by the band-like ligaments just described. Wherever there is no reinforcing band the capsule is weak. The posterior and lower portion is weaker than the anterior and upper portion. There is a weak spot between the arms of the iliofemoral ligament anteriorly, a branch of the circumflex artery usually entering here. Between the pubofemoral and inner edge of the iliofemoral ligament is another weak point. A bursa here separates the iliopsoas from the joint and often communicates with the joint. A third weak spot is on the lower posterior part of the neck between the two branches of the ischiofemoral ligament (Fig. 554). Injections into the joint protrude very markedly at this point. The weakest part of the joint is the lower anterior, below the pubofemoral ligament and opposite the cotyloid notch; the strongest part is the upper anterior part.

DISLOCATIONS OF THE HIP

Classification.—Dislocations of the hip are either anterior or posterior. If the innominate bone is held horizontally it will be seen that the Roser-Nélaton line from the tuberosity to the anterior superior spine passes through the acetabulum. It forms the apex of a wedge the two sides of which pass down, one anteriorly and the other posteriorly (Fig. 555). Therefore when the head of the femur leaves its socket it passes down either anteriorly or posteriorly and we have either an anterior or a posterior luxation.

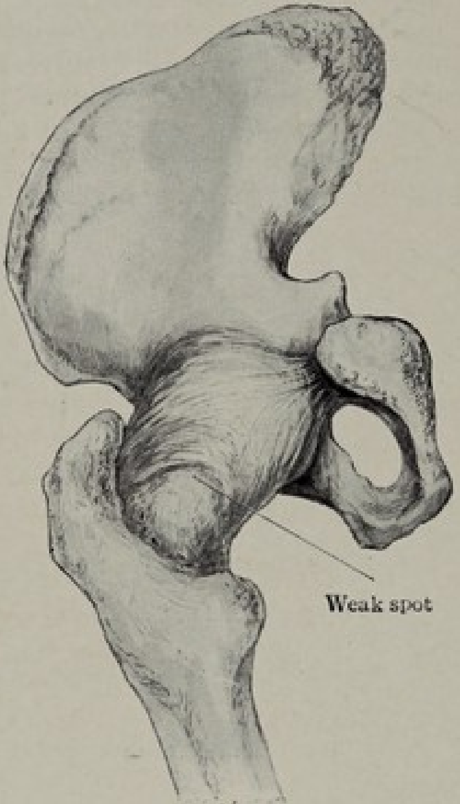


Fig. 553.—The ischiofemoral or posterior Y-ligament. The stem of the Y is attached at the base of the tuberosity of the ischium and one branch is seen going toward the greater trochanter and the other toward the lesser, leaving a weak spot between them half-way down the neck of the bone.

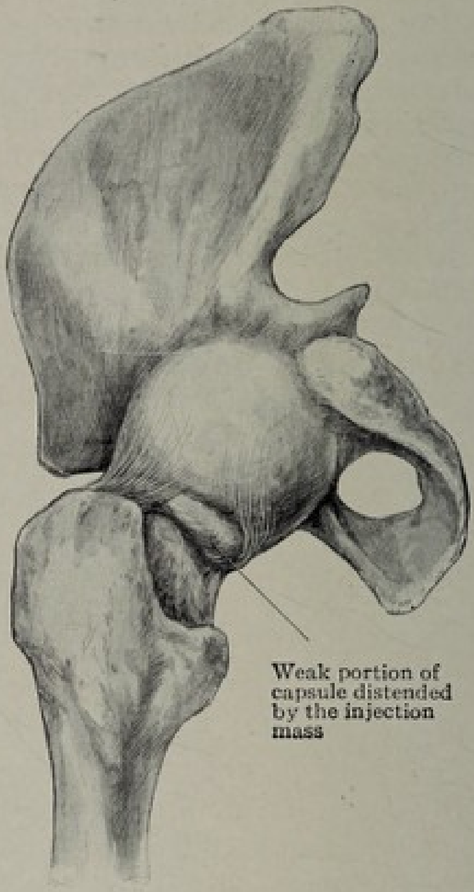


Fig. 554.—Hip-joint distended with wax; the capsule ends posteriorly half-way down the neck and is seen distended by the injection material protruding between the two arms of the ischiofemoral ligament.

The attachment of the iliofemoral ligament immediately above the acetabulum and of the ischiofemoral directly below also tend to prevent the head's emerging at

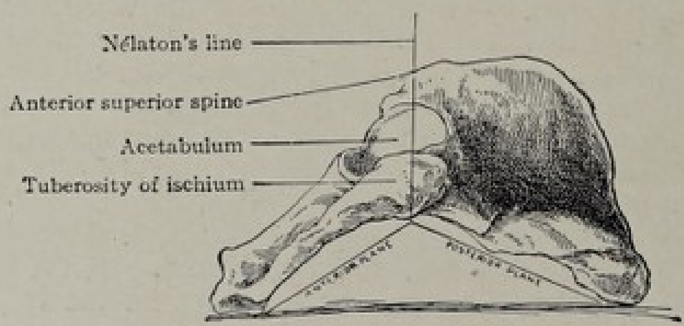


Fig. 555.—Innominate bone, resting on its inner side, to show the wedge-shaped formation of its outer surface. The apex of the wedge is Nélaton's line, running from the anterior superior spine to the tuberosity of the ischium; the anterior plane inclines downward and forward toward the pubis and the posterior plane inclines downward and backward on the ilium.

these places and favor its going anteriorly or posteriorly. Anterior luxations may be either low or high. The primary luxation is a low one into the thyroid foramen.

If then the thigh is rotated outward the head rises, and it becomes a pubic luxation. Posterior luxations may also be either high or low. The primary luxation is a low one either on the spine of the ischium or in the sciatic notch, and by rotation of the thigh inward it becomes a high one on the dorsum of theilium (Fig. 556). In certain very rare cases in which there has been an excessive amount of twisting the rotation is extreme and a form of dislocation called inverted is produced; it will be explained later.

Mechanism of the Production of Luxations.—The following should be borne in mind:

1. The neck of the femur makes with the shaft an angle of approximately 128 degrees.

2. In speaking of inward and outward rotation is meant inward and outward rotation of the *shaft* of the femur. Thus if the head (and neck) is pointing inward and we rotate the shaft inward, the head rotates outward posteriorly. If, however, we rotate the shaft inward while the head is pointing outward then the head moves inward anteriorly. Thus it is seen that in rotating the shaft inward the head is moved inward or outward according to its original position.

3. That while actually the axis of the head and neck does not coincide with a line drawn transversely through the condyles, but inclines forward at an angle of 10 or 12 degrees, nevertheless for practical purposes we may consider that it does so coincide and normally points directly inward.

4. The position of the greater trochanter can be recognized by its being directly above the external condyle, and the position of the head by its being directly above the internal condyle.

5. The muscles may be disregarded in the production of luxations, and the action of only the bones and ligaments considered.

6. A luxation results from the capsule being made tense or even ruptured by a leverage action of the bones, and the head then being thrust out on the anterior or posterior plane.

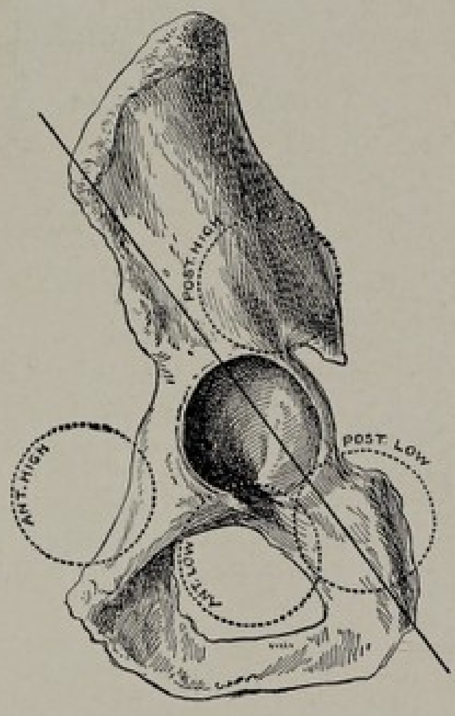


FIG. 556.—Diagram illustrating the position of the head in high and low dislocations on the anterior and posterior planes.

7. The primary luxation is a low anterior or posterior one. This may be changed by subsequent rotation of the thigh.

8. Luxations may occur either when the thigh is in abduction or adduction.

Luxation by Abduction.—If the thigh is forcibly abducted the adductor muscles rupture and, the abduction increasing, the head is raised out of the socket by the lever action of the femur as its neck strikes the rim of the acetabulum and its greater trochanter the ilium above. The head and neck are the short arm of the lever, the rim of the acetabulum or ilium is the fulcrum, and the shaft and distal extremity of the femur are the long arm. The head rises from the socket, ruptures a part at least of the capsular ligament, and then a thrusting force is added which pushes the head forward, producing a thyroid luxation (Fig. 557).

If while the limb is hyperabducted the shaft of the femur is rotated out and the limb brought straight down, parallel with that of the opposite side, then likewise the head may pass forward into the thyroid or pubic position. If while the head is on the anterior plane the thigh is flexed and the shaft rotated inward, then the head follows around the outer edge of the acetabulum and passes from a thyroid to a dorsal position, forming a posterior luxation.

Luxation by Adduction.—If the thigh is flexed and adducted the angle of the neck and shaft prevents any bony fulcrum from forming. If now the shaft is strongly rotated inward the iliofemoral or Y ligament becomes tense. It is wound around the neck of the bone and acts as a ligamentous fulcrum. The shaft revolves on its long axis, and as it turns inward the head turns outward and presses against the lower posterior part of the capsule, which ruptures, and a dorsal luxation is pro-

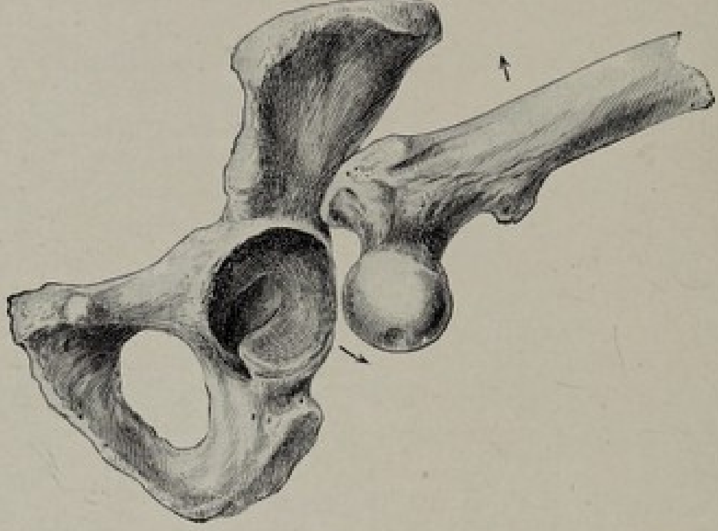


Fig. 557.—Luxation of the hip by indirect or leverage action. The shaft of the femur, from the greater trochanter out, is the long arm of the lever, the head and neck form the short arm and the upper edge of the acetabulum and ilium immediately above is the fulcrum. When the femur is abducted the head is lifted out of its socket rupturing the capsular ligament.

duced. A backward thrust in the long axis of the femur also favors the production of the luxation (Fig. 558).

By outward rotation of the shaft the head can be conducted around the edge of the acetabulum until it lies in the thyroid foramen on the anterior plane, thus changing a primary dorsal into a secondary thyroid luxation.

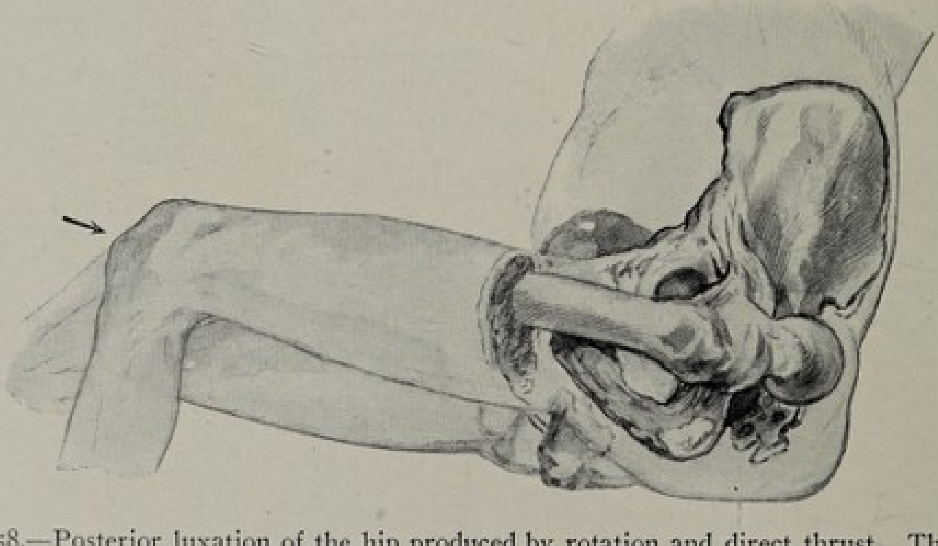


Fig. 558.—Posterior luxation of the hip produced by rotation and direct thrust. The femur is seen to be flexed on the pelvis, adducted and rotated inward; a thrust in the direction of the arrow then sends the head out of the acetabulum onto the posterior plane.

The Rent in the Capsule.—The capsule ruptures at its lower anterior or posterior portion according to whether it is primarily an anterior or a posterior luxation. If, however, the limb is rotated while the head is out of its socket, as in the production of a secondary position, then the capsule is torn still further, but the Y ligament is practically never torn either when the original luxation occurs or the secondary.

The rent in the capsule through which the head emerges has been proven both by Robert Morris and Dr. Allis to be always equal in size to the head of the femur and never a slit. Therefore is every case there exists a rent in the capsule large enough to allow of returning the head, provided it is not closed or obstructed by a rotation or malposition of the limb, or by some foreign substance such as torn muscle or infolding of the capsule.

Injuries to the Muscles.—When the thigh is abducted the adductor muscles are made tense, and if it is hyperabducted they are torn; these overstretched muscles, some of which may be ruptured, are the three abductors, the pectineus, and the gracilis. If the luxation is an anterior one the obturator externus will be torn because it arises from the outer surface of the thyroid membrane. If a posterior one the internal obturator may be injured. Allis has pointed out that when the head passes from one plane to another it may tear the obturator externus, quadratus femoris, and upper fibres of the adductor magnus. The tearing of these muscles usually exerts but little influence on the reduction of the luxation.

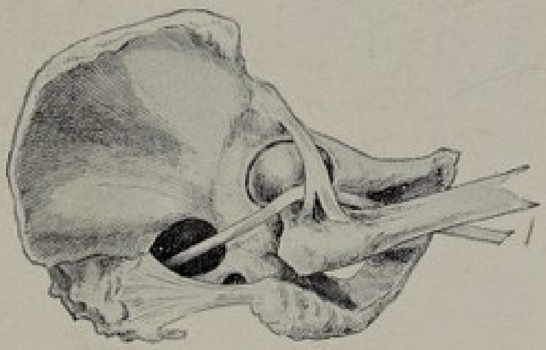


Fig. 559.—Showing the sciatic nerve caught around the neck of the femur. (After an illustration by Dr. Allis in his prize essay on the hip.)

Injuries to the Nerves.—Rarely the anterior crural nerve may be injured by being stretched over the head of the femur. The sciatic nerve has been injured, and Allis has shown how, when a dorsal luxation is rotated into a thyroid luxation, the sciatic nerve is likely to be caught around the neck of the femur (Fig. 559). This is favored by making a large circle while circumducting the knee, and also by extending the leg on the thigh, thus making the nerve tense and causing it to lie

Fig. 560.—Posterior or dorsal luxation of the left hip (from an original sketch by the author). The shortening is seen by comparing the position of the knees, the thigh is adducted and rotated inward.

closer to the socket. To detect this accident Allis advises that while an assistant pushes upward on the knee in the direction of the long axis of the femur, the surgeon by flexing and extending the knee will find the nerve alternately made tense and relaxed in the popliteal space. He has also shown that as long as the nerve is caught around the neck of the femur pain in the sciatic distribution persists and the knee cannot be brought down flat against the surface upon which the patient is lying.

Signs of Luxation.—When luxated *posteriorly* the foot is inverted whether it is a low or high dorsal. The thigh is adducted, bringing the knee of the affected side in front of the sound one. The thigh is usually slightly flexed. There is shortening, and the higher the position of the head the greater the shortening and the farther up the trochanter is above the Roser-Nélaton line. Shortening is best seen with the thighs flexed to a right angle (Fig. 560).

When luxated *anteriorly* the foot is everted or almost straight. If it is a low thyroid there will be little or no eversion; if it is a pubic luxation eversion will be more marked. The thigh is abducted; this is more marked in the thyroid and less in the pubic. The thigh is flexed in the thyroid but may be straight in the pubic. There is no shortening but there may be a slight lengthening difficult to demonstrate (Fig. 561).

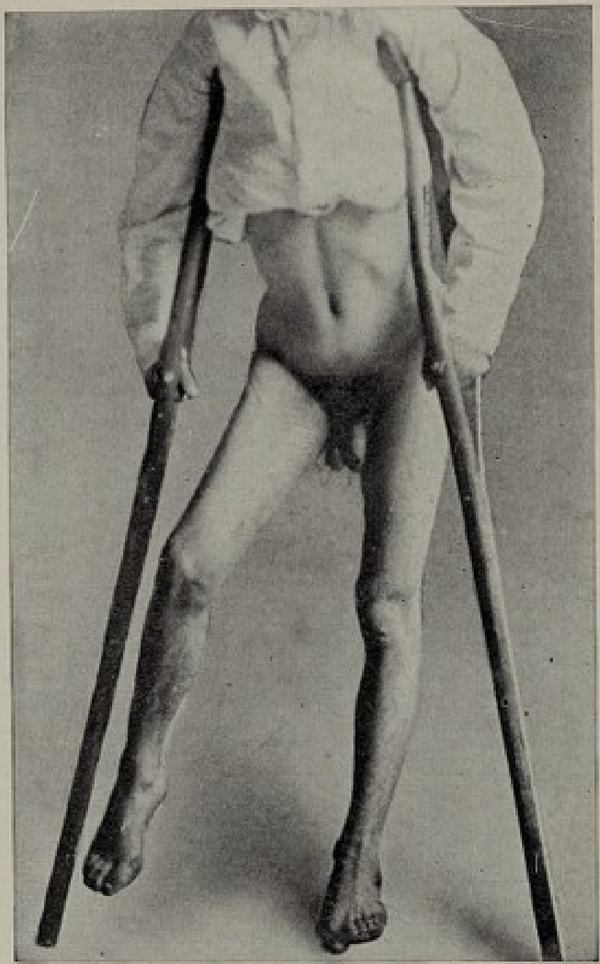


Fig. 561.—Thyroid luxation on the anterior plane. The thigh is flexed and abducted; the toes pointing forward. (From a photograph by Dr. Chas. F. Nassau.)

Reduction.—As in the shoulder there are two methods of reducing a dislocated hip, the direct and the indirect. The direct consists in placing the head in as favorable a position as possible and then directly pushing or pulling it towards the socket.

The indirect consists in using the thigh as a lever and rotating the head into place. These methods may be used in combination.

Direct Method for Dorsal Luxations.—Patient flat on the floor on his back. Flex the knee on the thigh, and the thigh on the abdomen; this brings the head down from a high position to a low one below the acetabulum. Adduct the thigh slightly; this relaxes the Y ligament and prevents the head catching on the rim of the acetabulum.

Grasp the ankle with one hand, then place the other hand or arm beneath the bent knee and lift upward and inward thus raising the head over the rim of the acetabulum into the socket. If the head does not enter, rotate the thigh gently, first out and then in, lifting at the same time. This rotation is to open the rent in the capsule to its widest extent. Too much rotation narrows the rent and obstructs the entrance of the head. An assistant may at the same time endeavor with his hands to push the head up towards the socket.

Another way of using the direct method (Stimson) is to place the patient face downward on a table with the thigh flexed at a right angle hanging over its end. The leg is then flexed at the knee and pressure made directly downward, gently moving or rotating the head from side to side. This is safe and efficient.

Direct Method for Anterior Luxations.—In pubic luxations first slightly abduct the thigh and rotate the shaft of the femur inward so as to transform the pubic to a thyroid luxation. For thyroid luxations flex the knee to a right angle, and then flex the thigh on the abdomen to a right angle or even more and slightly abduct (Allis). Then with one hand grasp the ankle and with the other hand or arm in the flexure of the knee lift up and slightly out, thus guiding the head toward the socket, rotating a little if necessary (Fig. 562).

The Indirect or Lever Method for Dorsal Luxations.—Flex the leg on the thigh and the thigh on the abdomen in a position of adduction. Then sweep the knee in a small circle with external rotation, when the knee reaches the point of starting bring the limb down straight. Allis cautions against describing too large

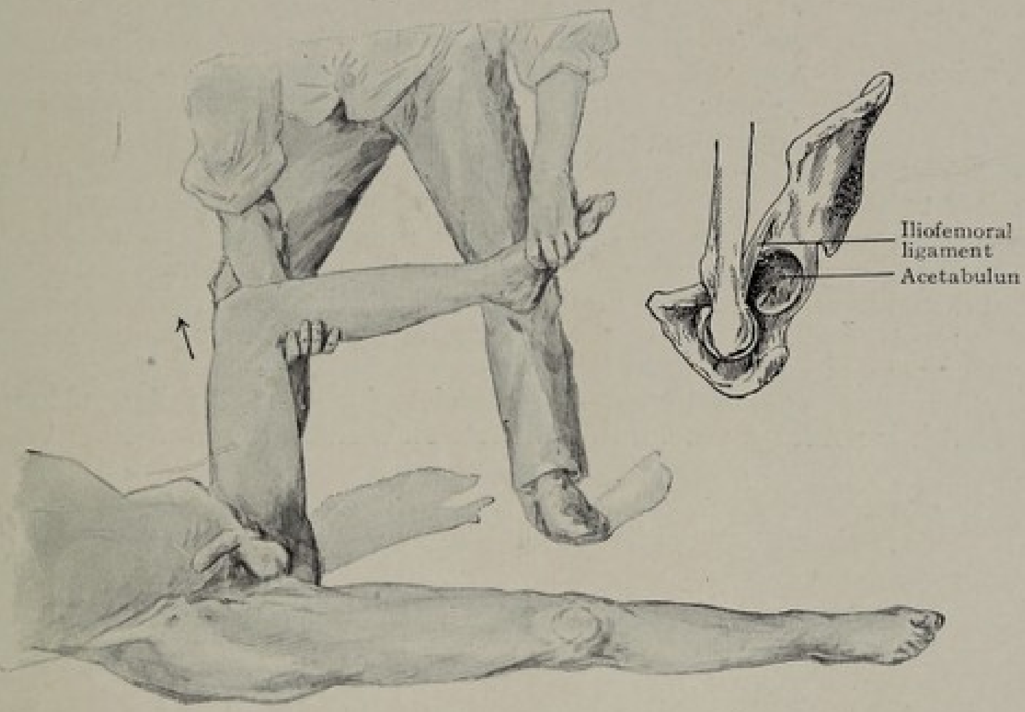


Fig. 562.—Reduction of an anterior (thyroid) luxation by the direct method. The pelvis is to be held firmly to the floor. The thigh is to be flexed, abducted (Allis), and the head lifted upward and outward as shown in the small cut.

a circle with the knee on account of the liability of catching up the sciatic nerve. While rotating the thigh a lifting force may be added, as in the direct method. This method is practically circumduction (Fig. 563).

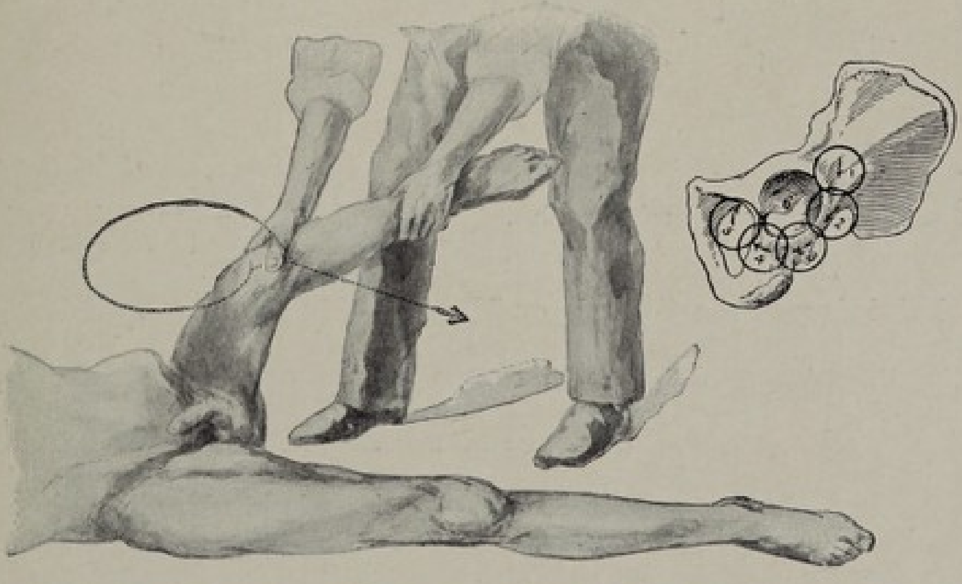


Fig. 563.—Reduction of a posterior (high) dorsal luxation by the indirect (lever) method of circumduction. The thigh is flexed and adducted; the knee describes the circle shown by the dotted line while the head pursues the course shown in the smaller cut to the right.

The Indirect or Lever Method for Thyroid Luxations.—Slightly flex the thigh, about to half a right angle, and rotate outward. Slightly abduct or adduct if necessary to relax the capsule before rotating outward.

Reversed Luxations.—In certain few cases, either from the peculiar character and direction of the primary injury or from an ordinary anterior or posterior luxation becoming subsequently more widely displaced, there result what are known as reversed luxations. They are of two kinds, reversed thyroid and reversed dorsal.

Reversed Thyroid.—In a thyroid luxation the toes point forward; if now the leg is forcibly twisted until the toes point directly backward a reversed thyroid is produced (Fig. 564). In reducing it the head must be first rotated back to its original thyroid position and then reduced by the usual methods.

Reversed Dorsal.—In a dorsal luxation the foot is inverted; if now the leg is forcibly twisted outward until the foot is everted, a reversed (or everted) dorsal luxation is produced (Fig. 565). To reduce it the leg must be rotated inward until the head resumes its original position posteriorly and then it may be reduced by the usual dorsal methods. In the production of both these reversed luxations the ligaments are torn still more and the iliofemoral ligament may even be partially detached from its insertion in the femur.

The Ligamentum Teres.—In complete luxations the ligamentum teres is torn but it is not large enough to constitute an obstacle to reduction.

Fig. 564.—Reversed thyroid luxation. (After Allis.)

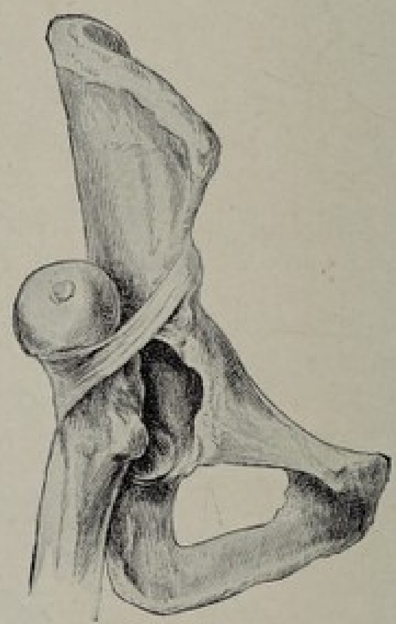


Fig. 565.—Reversed dorsal luxation. (After Allis.)

Infolding of the Capsule or Muscle.—Should the capsule be torn from its attachment to the femur, it may prevent reduction by filling the socket and preventing the entrance of the head. Fragments of muscle may act likewise. To clear the socket Allis advises first, rotation to tighten the Y ligament and pressing the head firmly in; second, to rock the head backward and forward and so clear the obstructing material out.

To Release the Sciatic Nerve.—If the sciatic nerve is caught around the neck of the femur and cannot be otherwise released, Allis advises extending the leg and cutting down on the nerve at the upper part of the popliteal space. It is then grasped and pulled taut, this releases it from the neck and the thigh can then be flexed and the head replaced: of course, if prferred, an incision can be made directly down on the nerve at the hip.

To Reduce a Dislocation Complicated by Fracture.—To accomplish this Allis advises first a trial of the usual direct method of traction and pressure on the head and, if this fails, then while the head is held as near to the socket as possible by an assistant the thigh is brought down and traction is made downward.

Congenital Luxations of the Hip.—In congenital luxations the acetabulum may be shallow, the head deformed, and the neck somewhat twisted on its shaft. These luxations are usually posterior.

Signs.—There is *no* eversion, no flexion on lying down in young cases, but lordosis is seen on standing (Fig. 566) and in old cases, also on lying down. The main point for diagnosis is shortening. The limb is shorter, measured from the anterior superior spine, and the anterior iliotrochanteric angle (page 580) is diminished or lost; the tip of the trochanter is above the Roser-Nélaton line, and the base of Bryant's triangle is lessened or even obliterated on the affected side. By careful palpation it can be recognized that the head is absent from its normal position beneath the femoral artery. Frequently the top of the trochanter is on a level with the anterior superior spine. The use of the X-ray is necessary to ascertain accurately the position of the head and as to whether or not the bones possess their normal shape.

Fig. 566.—Child with congenital luxation of hips, showing characteristic lordosis.

Reduction.—As the head is usually more or less fixed in its abnormal position, force has to be used to replace it. Paci of Pisa was the first to reduce them systematically by a modification of the circumduction method. He flexed the thigh on the abdomen, then firmly abducted, rotating outward, using the edge of a table as a fulcrum.

Lorenz used König's padded, wedge-shaped block under the trochanter as a fulcrum to pry the head forward.

Davis combined the direct and indirect methods by placing the child face down on a table with the affected hip on a sand pillow and the leg and thigh hanging over the side. The operator or an assistant then raises (flexes) the knee, bringing it toward the patient's axilla, while the operator presses with his hands and body-weight down on the trochanter. By gradually raising the knee and *keeping it close to the body* and pushing the head forward it eventually slips from the posterior to the anterior plane and into place (Fig. 567). When the head has been brought onto the anterior plane it is usually impossible to extend the knee, on account of tension of the hamstring muscles, as pointed out by Lorenz. After being reduced the thigh cannot be brought down at once to its normal position, as by so doing the head jumps out of its socket; so it is put up in plaster of Paris in an abducted position for some time and brought down gradually.

Fig. 567.—Author's method of reducing congenital luxation of the hip.

Old Dislocations of the Hip.—In these cases the problem is similar to that presented in the congenital lesion. The acetabular socket quickly becomes filled with organized fibrous tissue and it is sometimes necessary to reform the acetabulum after the method of Murphy. The operation is an exceedingly difficult one as anyone who has performed it can attest to.

Hip-Disease (Coxitis or Coxalgia).—Disease of the hip in its early stage is characterized by pain, limitation of motion, and limping. The pain is either a local one in the hip itself or a referred one. The hip is supplied by branches of the anterior crural, sciatic, and obturator nerves, and as these also supply the region of the knee, disease of the hip causes pains to be felt around the knee, most often on its inner side.

In an early stage the limitation of motion is due to muscular contraction and it disappears under anæsthesia. The limb is held in a position of flexion, abduction, and slight external rotation. The joint is more or less rigid. The loss of motion is only complete in extreme cases. In mild cases the limitation is only present as a reduction in the normal extent of movements, the joint may move freely and without constraint over a limited arc. The abnormal changes produced are to be recognized by careful inspection, measurements, and comparison with the opposite healthy limb.

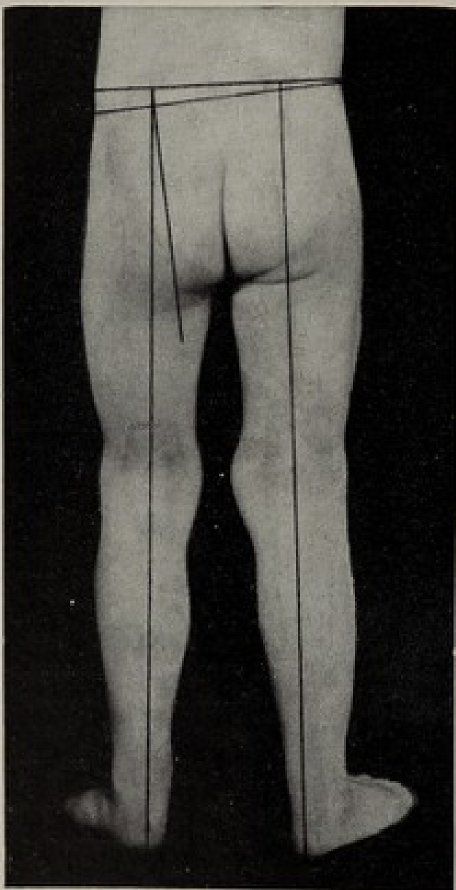


FIG. 568.—Early stage of coxalgia, showing the affected left limb abducted, thus lowering the pelvis on that side; slightly flexed, thus obliterating the gluteofemoral fold, and slightly everted.

Attitude.—Owing to the pain in the affected limb the weight of the body is borne mainly on the healthy limb. Viewing the patient anteriorly in an early case of the disease the external rotation is readily seen in the eversion of the foot. If the foot itself is normal, rotation takes place at the hip-joint and not at the knee or ankle; therefore a foot that is abnormally turned out indicates that there is something in the hip to cause it to turn out. The affected limb is seen to be held in a position of abduction, out away from the healthy one. The flexion is evidenced by the affected limb being placed a little in advance of the other and by the bending at the groin. If the feet are placed together there may also be flexion of the knee (Fig. 568).

Tilting of the pelvis may or may not be apparent, but it exists and can be demonstrated by a careful examination. Viewed posteriorly, besides the position of the limb as seen from in front, there is in addition a change in the gluteal folds and buttock. The gluteal fold on the affected side is lowered in position and shorter than on the healthy side and the buttock is flattened. The flattening of the buttock is caused by the flexion of the hip. This flexion likewise tends to obliterate the gluteal fold. The difference in height of the gluteal folds is caused by the tilting down of the pelvis on the affected side. An inequality in the lower limbs, whether due to shortening or to malposition, such as flexion, will be visible at once by an inequality of the gluteal folds, one being higher than the other. Flexion deformity is recognized when the patient is standing by the bending at the hip-joint and by the lordosis or hollowing of the back. When the patient is recumbent on a flat surface and both legs are brought straight down so that both knees are in contact with the table, then if flexion is present it causes the lumbar vertebræ to arch and the back to rise from the table. If now the thigh of the affected side is elevated until the back again touches the table the degree of elevation necessary to accomplish this will be the measure of flexion.

Measurements.—The child being flat on its back the pelvis is to be made level by seeing that a line joining the two anterior spines is at right angles to the median line. If abduction is present the limb points away from the median line. It cannot be brought straight down parallel with the sound leg without tilting the pelvis. If measured from the umbilicus to the internal malleolus the affected leg measures more than the sound one. This is called apparent lengthening. If when both limbs are placed in the same degree of abduction and are measured from the anterior spine to the internal malleolus they measure the same, there is no real shortening.

In *advanced disease* adduction is more common than abduction. This produces an apparent shortening, as shown by measurement from the umbilicus to the internal malleolus; if the sound limb is placed in the same degree of adduction as the affected one, the distances from the anterior spines will show no actual shortening unless there is a loss of bone or displacement at the hip-joint. The pelvis, instead of being tilted down on the diseased side, is tilted up. Flexion is usually more marked and the foot is usually inverted instead of everted.

Hip-Abscess.—Tuberculosis of the hip probably begins in the neighborhood of the epiphyseal line of the femur and involves the joint secondarily. The epiphysis of the head begins above near the edge of the articular cartilage and runs obliquely across upward and inward. It is thus entirely within the capsule and when pus forms it first perforates the articular cartilage and enters the joint and then perforates the capsule to point externally. There are three favorite places of exit, viz.: (1) on the posterior surface of the neck between the branches of the ischiofemoral ligament; (2) on the lower anterior surface beneath the iliopsoas tendon, between the pubofemoral and iliofemoral ligaments, through the bursa found here which may communicate with the joint; and (3) at the cotyloid notch.

The head and neck of the femur and also the acetabulum become carious. Pus may find an exit at other places besides those mentioned. It may perforate the acetabulum and show above Poupart's ligament at its outer side, or may break through the upper posterior portion of the capsule. Not often does it break through between the branches of the iliofemoral ligament. When it does break through anteriorly it points in Scarpa's triangle, commonly to the inside of the vessels; when it breaks through posteriorly it descends beneath the fascia lata and points on the posterior or outer portion of the thigh.

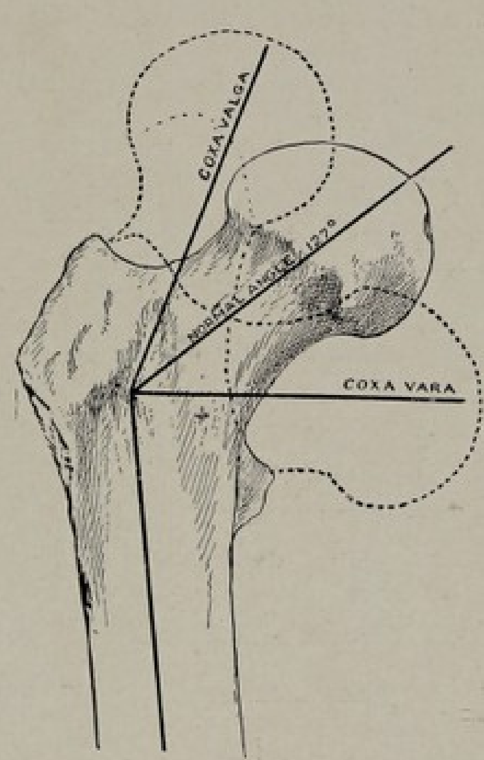


FIG. 569.—Normal angle of the head and neck to the shaft of the femur with the alteration in position in coxa valga and coxa vara shown by dotted lines.

Coxa Vara.—The normal angle which the head and neck make with the femoral shaft may vary, according to Humphry, from 110 to 140 degrees. Sometimes as a result of injury or disease the neck makes a more acute angle than normal, coming off at an angle of 90 degrees or less. This is called coxa vara (Fig. 569). In some cases it is due to a bending of the neck caused by softening of the bone, as in rachitic affections, or to fracture. The limb is shortened, the trochanter raised above the Roser-Nélaton line, and abduction and flexion are restricted. To rectify it Whitman's operation of wedge-shaped resection is done. A wedge of bone with a base of 2 cm. (3/4 in.), apex inward, is removed at a point opposite the lesser trochanter. The femur is then placed in abduction and the bone allowed to heal. When the limb is brought down the angle of the head and neck will be much increased and the deformity and disability will have been removed.

Coxa Valga.—The term coxa valga has been applied to the opposite condition, when the neck is nearly parallel with the shaft; it is rarer and of less importance than is coxa vara. Orthopædists regard 135 degrees as the normal limit of the angle between the neck and shaft of the femur, but Humphry placed it at 140 degrees.

Snapping Hip.—This condition is associated either with an abnormality of the fascia lata which causes it to catch back of the great trochanter or to an abnormal state of development of the tendon developed on the deep surface of the gluteus maximus, which constitutes the insertion of this muscle to the gluteal ridge of the femur. The exact cause must be determined and attended to. If it is due to a fascial band this can be separated and sutured to the trochanter so as to prevent it forming again, while if it is due to the deep tendon of the gluteus maximus this should be stitched down to the whole length of the trochanter.

OPERATIONS ON THE HIP-JOINT

The operations on the hip are usually done either for hip-disease or congenital or old luxations. Traumatic or pathological luxations or intracapsular fractures are also operated on. The joint may be approached either anteriorly or laterally.

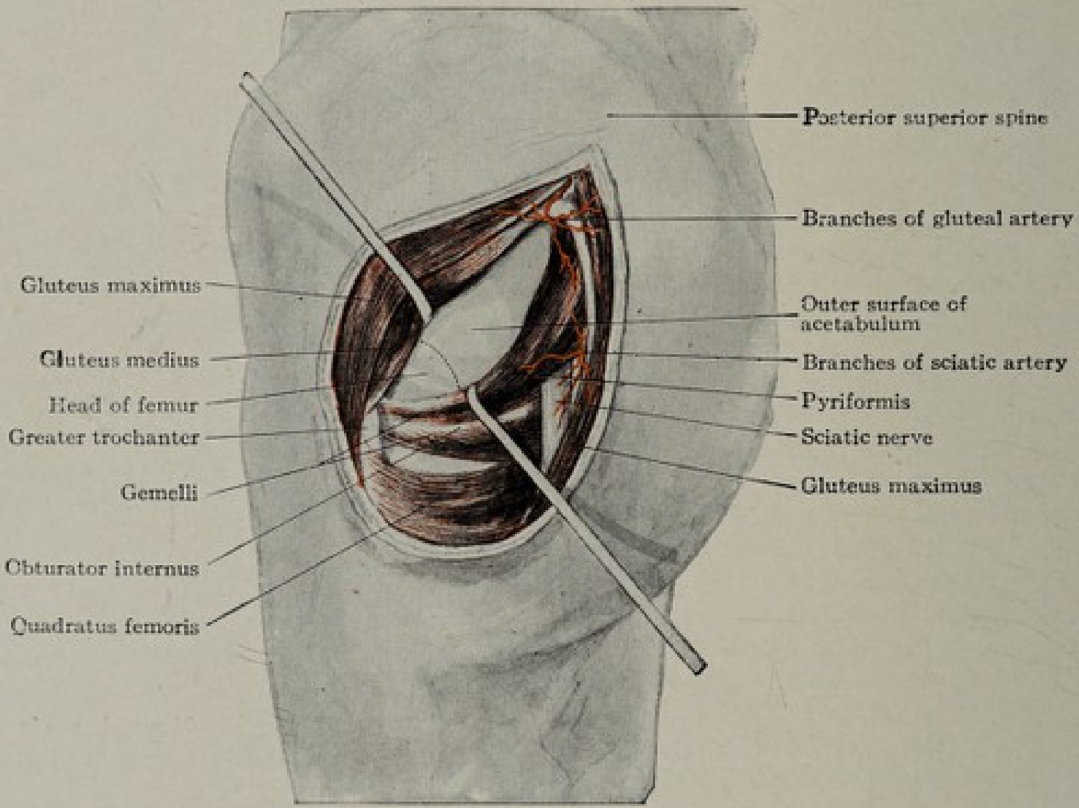


Fig. 570.—The lateral mode of approach in operating on the hip-joint; large incision made to show relation of the parts involved.

Lateral operations are the more mutilating, while anterior ones are often sufficient and less serious.

Lateral Operations.—In approaching the joint from the side the incision of Langenbeck is preferred. It begins well up on the buttocks on a line with the posterior superior spine and is continued down over the great trochanter in the axis of the thigh. If made with the limb flexed the line of incision will be straight. The muscular fibres and tendon of the gluteus maximus are cut in the line of the incision. This exposes the posterior edge of the gluteus medius, which is to be pulled forward, and the pyriformis, which is to be drawn backward or loosened from its insertion into the trochanter. The capsule can then be incised and the joint examined. Further exposure may be obtained by loosening the gluteus medius and gluteus minimus from their insertion in the top of the trochanter and pushing them forward. The ligamentum teres is often destroyed by the disease. Removal of the head of the femur enables the acetabulum to be examined and carious bone curetted away if necessary. The incision through the gluteus maximus muscle will be almost parallel to its fibres and near its anterior edge. Care is to be taken not to go too high up between the pyriformis and gluteus medius because the main trunks of the gluteal artery and superior gluteal nerve make their exit there from the great sacrosciatic notch. The principal bleeding will come from branches of the gluteal artery descending from that point. This operation is practically limited to cases of extensive caries in which it is desired to do a radical operation (Fig. 570).

Boeckmann, of St. Louis, made a large horseshoe-shaped flap over the greater trochanter. Its base was upward and it consisted of skin and superficial fascia. This flap was raised and a chain-saw passed underneath the muscles inserting into the top of the greater trochanter, and the latter was then sawed off and turned up as a flap. This exposed the upper surface of the head and neck of the femur. The operation was done for intracapsular fracture, the fragments being pinned together with ivory pegs and the trochanter brought down and again fastened in place with ivory pegs. The skin-flap was also brought down and sutured. While good exposure can be obtained by this method, it is almost too severe and has not been generally adopted.

Lorenz, in congenital luxations, incised from the anterior superior spine down

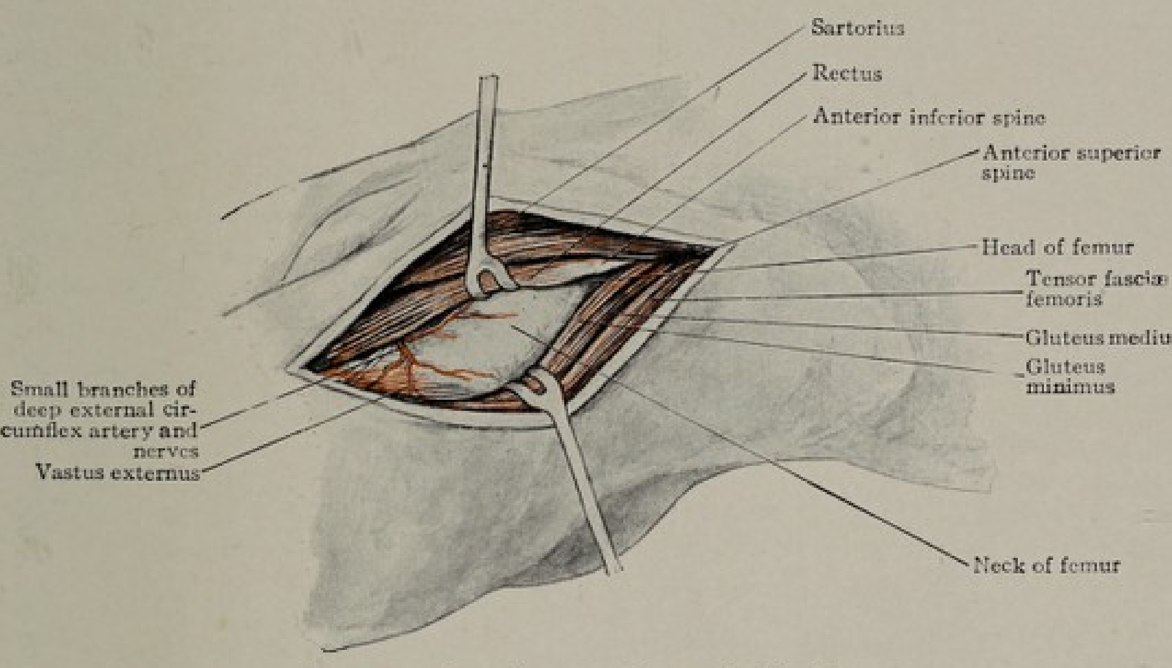


Fig. 571.—Anterior operation on the hip-joint.

and out toward the trochanter. The tensor fasciæ femoris is pushed forward and the glutei muscles backward. Hoffa modified this operation by making his incision along the anterior edge of the greater trochanter. As the hip-joint is nearer the anterior than the lateral surface of the body we believe it to be better to approach it from the front rather than from the side.

Anterior Operations.—Lücke made an incision from just below the anterior superior spine running downward and inward along the inner margin of the sartorius. The sartorius and rectus muscles were displaced outward and the iliopsoas inward.

Hüter, Parker, and Barker made the incision directly downward from the anterior superior spine and pulled the sartorius and rectus inward and the tensor fasciæ femoris and gluteus medius and minimus outward (Fig. 571).

The method of Hüter, Parker, and Barker, is not difficult. The only vessel encountered is a branch of the external circumflex. One should not go too low, or some muscular branches of nerves going to the vastus externus will be wounded. No muscles are divided. The writer has used this method with satisfaction in cases of hip disease and intracapsular fracture.

If additional room is desired the fascia lata may be divided laterally and the tensor fasciæ femoris and gluteus medius muscles may be detached from the spine of the ilium and back along the crest, as done by Codivilla. They are to be again sewed back into place before closing the wound.

Inferior Operations.—Ludlof, in congenital luxations, abducted the thigh to a right angle and made his incision along the tendon of the adductor longus. This muscle was then drawn downward and the pectineus upward and the joint exposed. The writer prefers to make an incision along the inner side of the femoral vein. The vessels are then to be drawn upward and outward and the pectineus downward and inward and the capsule is at once evident.

THE THIGH

STRUCTURE

The thigh is composed of the femur imbedded in three main sets of muscles, and is supplied and traversed by the femoral vessels and sciatic and anterior crural nerves.

The femur serves as a support and keeps the knee out away from the trunk.

The muscles move the thigh on the trunk, or *vice versa,* and the leg on the thigh.

The blood-vessels and nerves not only supply the structures of the thigh itself, but also serve as channels for the transmission of blood and nervous impulses to and from the parts beyond, hence their large size.

The Fascia Lata.—The deep fascia of the thigh is a strong layer which completely invests the muscles of the thigh and covers the gluteal region. It is attached above to the sacrum and coccyx, the crest of the ilium, Poupart's ligament, the body of the pubis, the inferior rami of the pubis and ischium, the ischial tuberosity and the great sacro-sciatic ligament. Inferiorly it is attached to the borders of the patella, and becomes continuous with the fascia of the leg. It varies greatly in its density. From the great trochanter downward along the outer surface of the thigh it is greatly thickened and is known as the ilio-tibial band. This portion is frequently used for fascial grafts, especially the lower two-thirds since the upper third receives the insertion of the tensor fascia lata muscle and part of the gluteus maximus. Over the saphenous opening the layer is thin and is known as the cribriform fascia.

MUSCLES OF THE THIGH

There are three main sets of thigh muscles, viz.: extensors, flexors, and adductors. We will limit our consideration to the long muscles.

Extensor Muscles.—The extensor muscles consist of the *quadriceps extensor,* composed of the *rectus femoris, vastus internus, vastus externus* and *crureus* (*vastus intermedius*), and we might add also the *sartorius.* The quadriceps of the thigh is homologous with the triceps, extensor of the arm, the fourth head of the latter muscle being the anconeus. The sartorius normally has no homologue in the upper extremity, but is sometimes represented by a slip from the latissimus dorsi to the triceps (dorsi-epitrochlearis—Macalister). The rectus arises by an interior or straight head from the anterior inferior spine of the ilium and a posterior or reflected head from the upper surface of the rim of the acetabulum. The tendon formed by the union of these two heads passes downward directly over the head of the femur and, in operating on the joint from in front, it must be deflected to one side. The belly of the muscle is separate and not attached to the other muscles (Fig. 572).

The vastus externus (vastus lateralis) forms the muscular mass on the outer surface of the thigh. A bursa separates it from the gluteus maximus above. Superficially it is readily separated from the crureus (vastus intermedius) but blends with it close to the bone. The line separating the two muscles is directly upward from the outer edge of the patella. The vastus internus (vastus medialis) arises from the inner edge of the linea aspera as high up as the lesser trochanter. Its outer edge blends with the crureus. The quadriceps extensor is innervated by the anterior crural (femoral) nerve.

The sartorius in the middle third of the thigh lies directly over Hunter's canal. It inserts into the tibia below and internal to its tubercle, hence it spans both the hip-joint and knee-joint. It flexes the thigh on the pelvis and the leg on the thigh. It also rotates the thigh outward and the leg inward especially when the latter is flexed. It is innervated by the anterior crural (femoral) nerve.

The **flexor muscles,** also called the **hamstring muscles,** comprise the *biceps femoris,* the *semitendinosus,* and the *semimembranosus.* The short head of the biceps arises from the outer lip of the linea aspera. Above, the long head is blended with the semitendinosus and arises from the great sacrosciatic ligament and the lower inner part of the tuberosity of the ischium. The semimembranosus arises from the tuberosity just above and external to the biceps and semitendinosus. The biceps, arising by its long head from the tuberosity, lies first to the inner side of the sciatic nerve, and then, as it crosses obliquely to reach the outer side of the knee, covers the nerve and finally lies to its outer side. The upper portion of the semimembranosus lies beneath both the long head of the biceps and the semitendinosus, and only comes to the surface between them from the middle of the thigh down. The tendons of the semimembranosus and semitendinosus form the inner hamstring tendons and the biceps the outer hamstring tendon (Fig. 573). The long head of the biceps femoris, the semitendinosus and the semimembranosus are innervated by the internal popliteal division of the great sciatic nerve, while the short head received its innervation by way of the external popliteal division of the nerve.

Fig. 572.—The quadriceps extensor muscle of the thigh.

The **adductor muscles** are the *adductor brevis, adductor longus, adductor magnus* and *gracilis*; for clinical purposes the *pectineus* may also be included, although it is morphologically simply a detached portion of the iliacus. The *quadratus femoris* and *obturator externus* belong morphologically to the adductor group, but from a clinical standpoint they are associated more with the external rotators of the hip than the adductors of the thigh. The adductor muscles separate the flexor and extensor groups on the inner side of the thigh. The adductor longus arises by a strong tendon from the body of the pubis just below its spine and inserts into approximately the middle third of the femur in the linea aspera (Fig. 574). When the thigh is abducted the tense edge of its tendon is evident, and if followed upwards it leads to the spine of the pubis. It lies on the same plane as the pectineus, which is immediately above; sometimes, especially in the female, an interval exists between the two through which the adductor brevis may be visible. Near its insertion it forms part of the floor of Scarpa's triangle and the upper part of the floor of Hunter's canal.

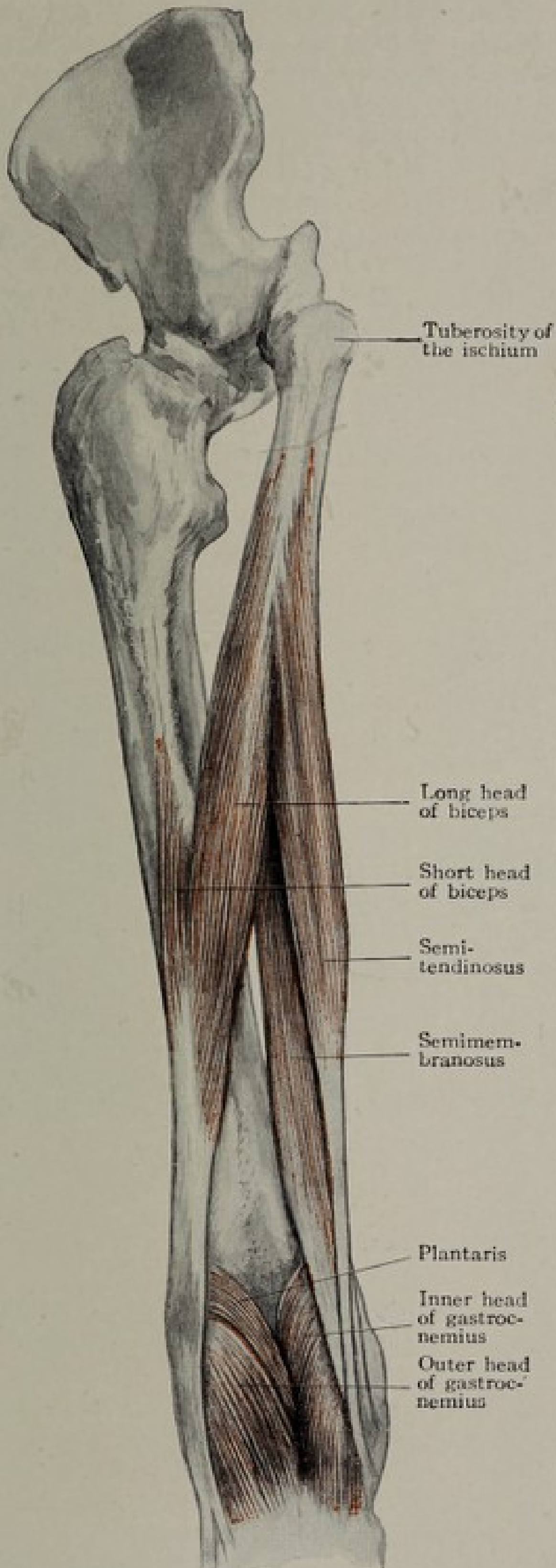


Fig. 573.—The flexor muscles of the thigh.

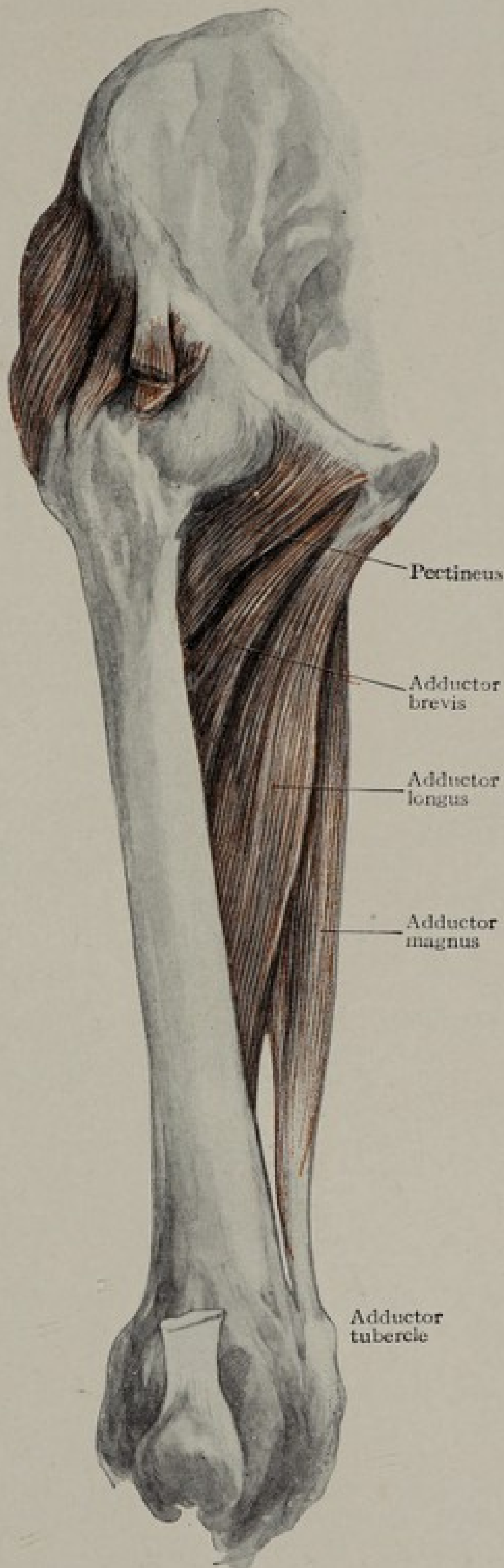


Fig. 574.—Adductor muscles of the thigh.

The adductor brevis arises from the descending ramus of the pubis just below the origin of the adductor longus and inserts into the femur from the lesser trochanter to the linea aspera. It lies directly behind the upper portion of the adductor longus and in front of the adductor magnus.

The adductor magnus arises from the ramus of the ischium, from the adductor brevis in front to the hamstring tendons on the tuberosity behind. It is inserted into nearly the whole length of the linea aspera, and by a distinct tendinous band into the adductor tubercle at the upper edge of the internal condyle. Its upper portion is sometimes called the adductor minimus. It is pierced near the bone by the perforating branches of the profunda femoris artery and near its lower portion by the femoral artery and vein. It forms part of the floor of Hunter's canal. Its homologue in the upper extremity is the coracobrachialis muscle.

The gracilis arises from the pubis just to the side of the adductor brevis and passes straight down the thigh to insert into the tibia, beneath the sartorious and above the semitendinosus. It is sometimes represented in the upper extremity by a slip from the lower border of the pectoralis major called the *chondro-epitrochlearis.*

The pectineus arises from the iliopectineal line to insert just behind and below the lesser trochanter. It lies on the same level as the adductor longus and just above it.

The gracilis, adductor longus, and adductor brevis are innervated by the anterior branch of the obturator nerve, while the adductor magnus receives its principal supply through the posterior division of the obturator nerve, although frequently some of its posterior fibres are innervated by the sciatic nerve.

SURFACE ANATOMY

If the thigh is flexed and rotated outward the sartorius is seen crossing it obliquely, and Scarpa's (femoral) triangle is evident as a depression downward

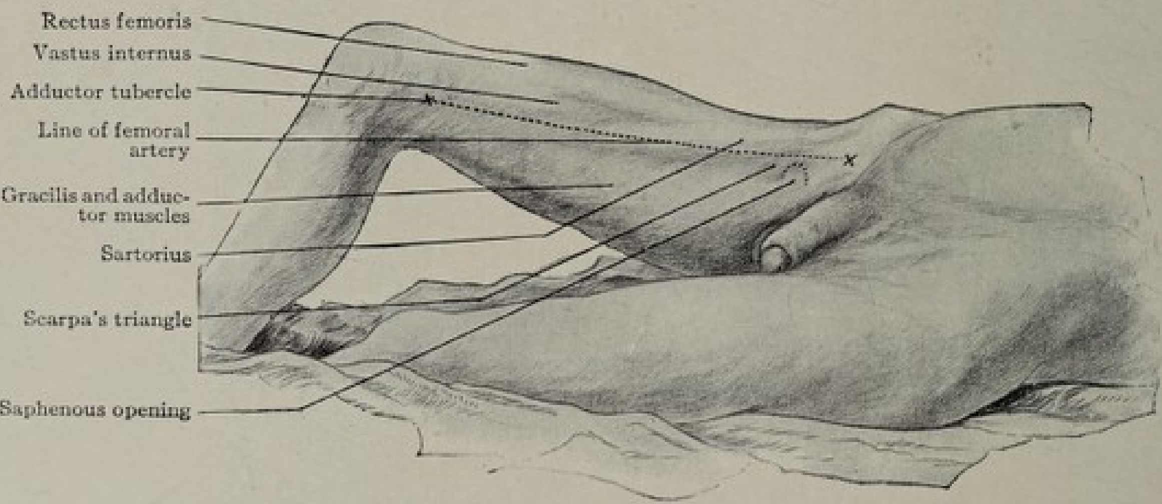


Fig. 575.—Surface anatomy of the thigh.

from Poupart's ligament. The muscular mass of the upper inner portion of the thigh is composed of the gracilis and adductor muscles. Immediately above the patella is the flat tendon of the rectus, and above and to the inner side of the patella is a rounded mass formed by the vastus internus (Fig. 575). Running upward and inward from the outer edge of the patella to the middle of the thigh is a groove which separates the rectus and vastus externus. On the outer side a flat groove is formed by the iliotibial band of the fascia lata. At its posterior border is the external intermuscular septum between the vastus externus and biceps.

Scarpa's (Femoral) Triangle.—This occupies approximately the upper third of the thigh. Its base is formed by Poupart's ligament, its outer side by the sartorius muscle, and its inner side by the adductor longus. Its floor is formed by the iliacus, psoas, pectineus, sometimes a portion of the adductor brevis, and the adductor longus muscles. It contains the femoral artery and vein, the anterior crural nerve, the long saphenous vein, and numerous lymphatics (Fig. 576). At its upper and inner part is the saphenous opening, at which femoral herniæ make their appearance. Psoas abscesses follow the tendon of the psoas muscle down and make their appearance in Scarpa's triangle, sometimes to one side and sometimes

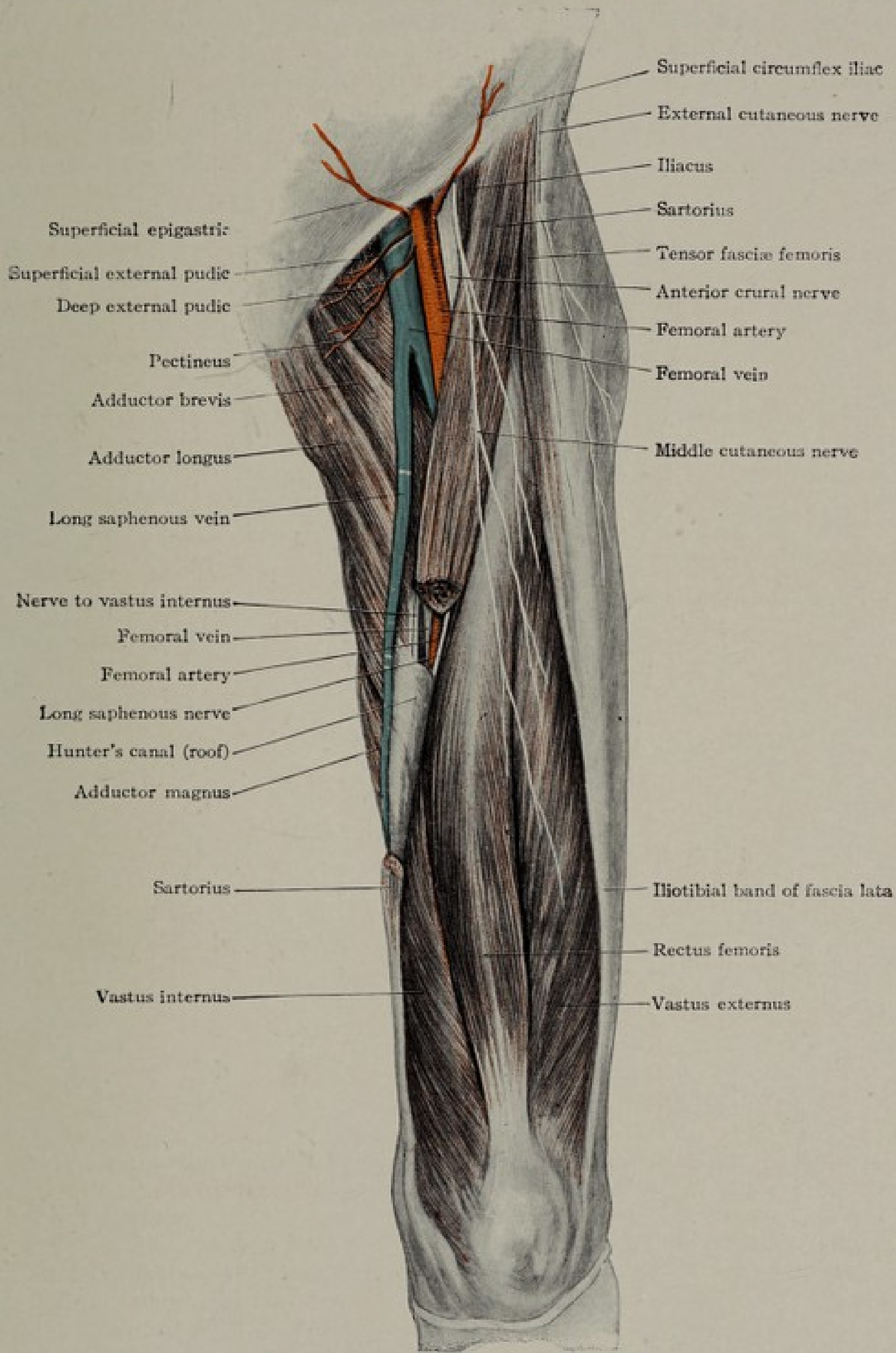


FIG. 576.—Anterior view of the structures of the thigh, Scarpa's triangle and Hunter's canal.

to the other of the artery. Pus from hip-joint disease likewise comes to the front at the upper part of the triangle on one side or the other of the femoral artery. The apex of Scarpa's triangle is a favorite site for ligation of the femoral artery.

Femoral Artery.—This artery is a continuation of the external iliac. Its course is downward, slightly inward and backward. Its line is from a point midway between the anterior superior spine and the symphysis pubis (this brings it to the inner side of the middle of Poupart's (inguinal) ligament) to the adductor tubercle at the inner upper part of the internal condyle, when the thigh is flexed upon the pelvis and rotated outward. Just below Poupart's ligament it gives off four small branches; the superficial external circumflex, superficial epigastric, and superficial and deep external pudic. About 4 cm. (1½ in.) down it gives off the profunda femoris, which is almost as large as the parent trunk. On reaching the edge of the sartorius it passes beneath it to enter Hunter's (adductor) canal, and at

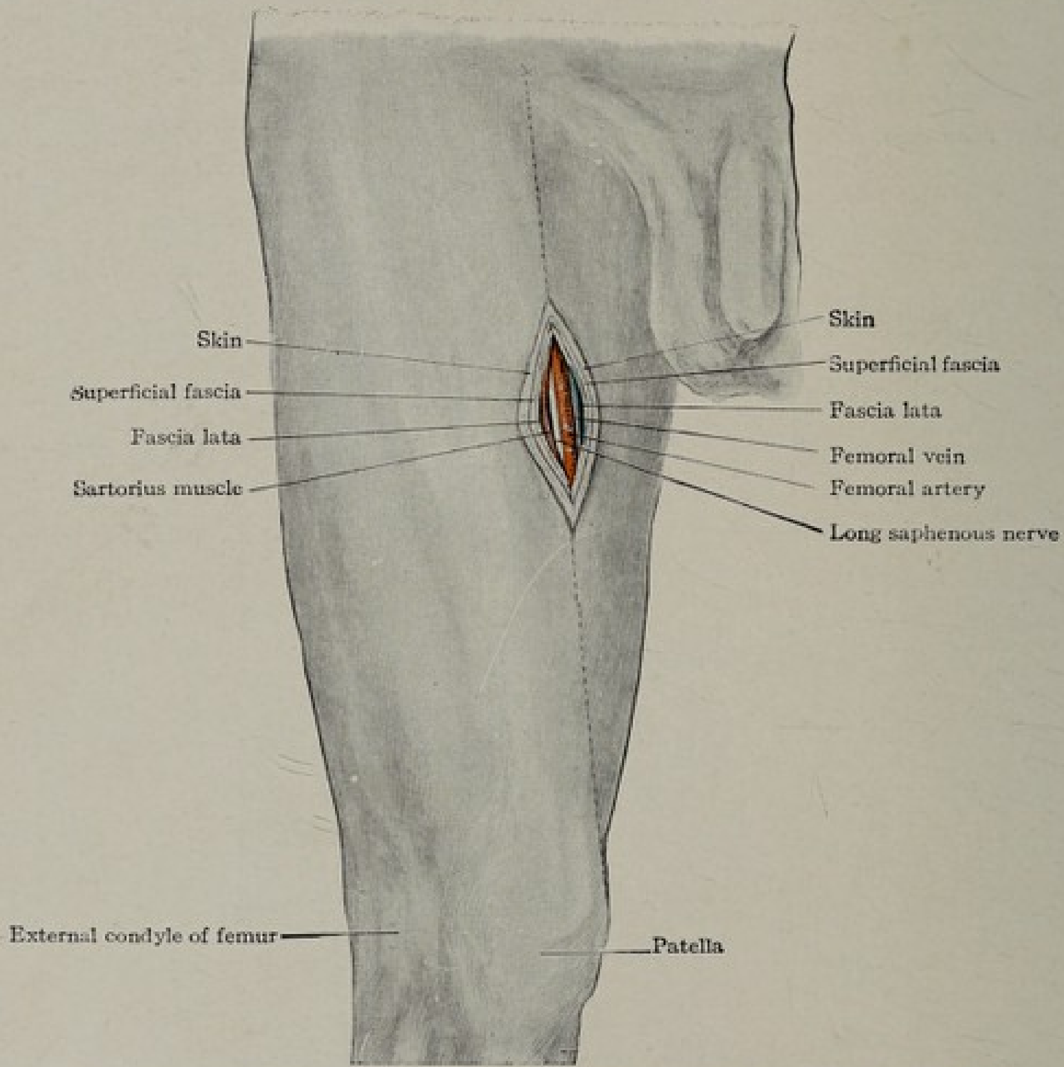


FIG. 577.—Ligation of the femoral artery at the apex of Scarpa's triangle.

the junction of the middle and lower third of the thigh it pierces the adductor magnus to become the popliteal. At Poupart's (inguinal) ligament the femoral vein lies to the inner side of the artery, but at the apex of the triangle it lies behind it. In its uppermost part the artery is enclosed with the vein in the femoral sheath.

Ligation of the Femoral Artery.—In ligating the femoral artery an incision is made in the line given above, and the artery sought for beneath the fascia lata. Ligatures are not placed high up, on account of the proximity of the deep femoral; lower down at the apex of the triangle is the preferred point. The crural branch of the genitocrural nerve lies on the artery for a short distance below Poupart's ligament; it is small in size. Just to the outer side of the artery, and sometimes touching it, is the anterior crural nerve, and running down its outer side are the internal cutaneous and internal saphenous branches. The femoral vein, which above was internal to the artery, at the apex of the triangle lies posterior to it (Fig. 577).

The **profunda femoris (deep femoral) artery** comes off at 4 cm. (1½ in.) below Poupart's ligament. Its branches are the external (lateral) and internal (medial) circumflex, and four perforating. The last perforating is terminal. The *external circumflex* passes outward over the iliacus and under the sartorius and rectus and divides into three branches; the ascending branch follows the anterior

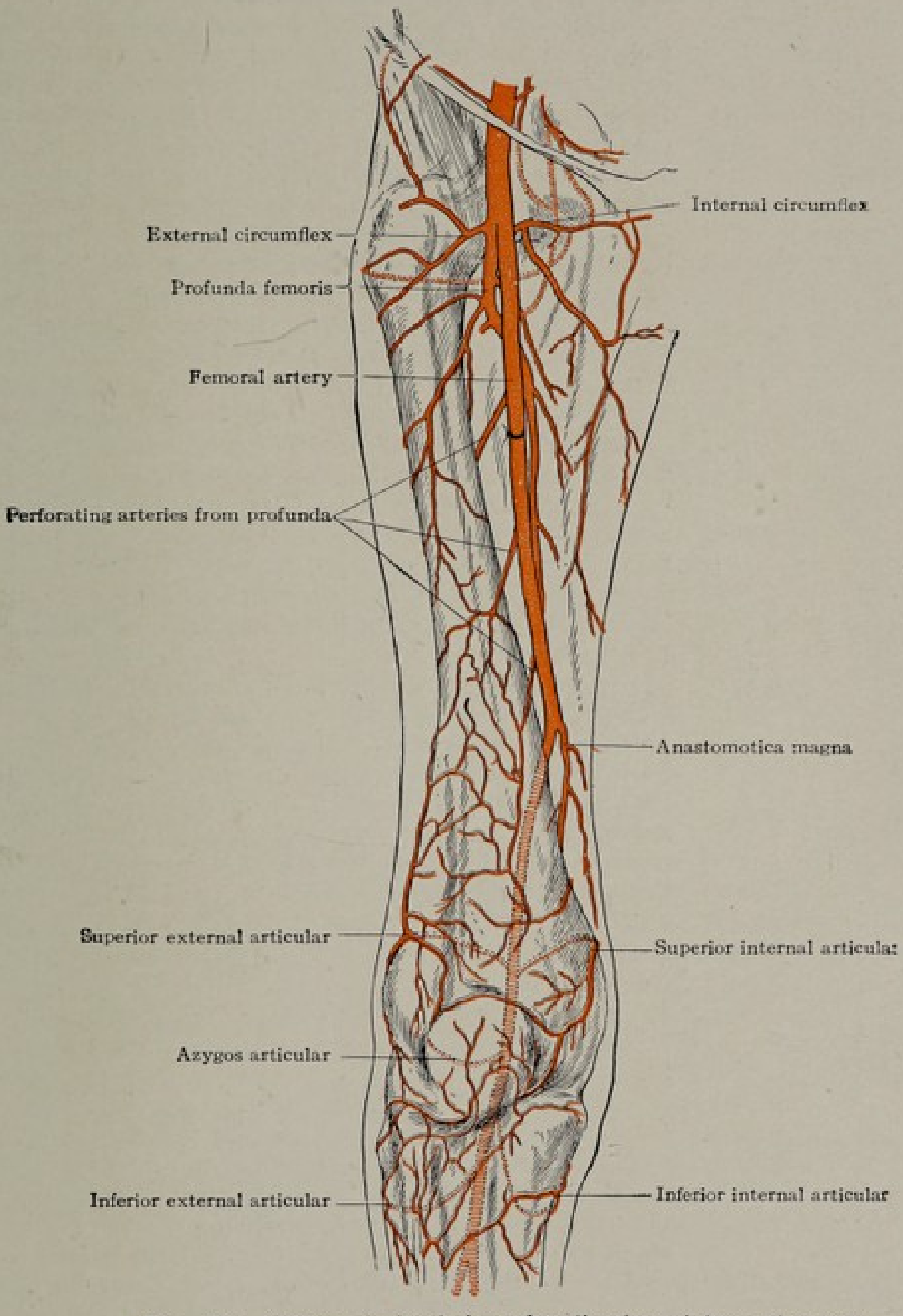


Fig. 578.—Collateral circulation after ligation of femoral artery.

intertrochanteric line and gives off a branch which enters the joint between the limbs of the iliofemoral or **Y**-ligament and a branch which anastomoses with the deep circumflex iliac and gluteal arteries. The transverse branch goes outward to the upper part of the vastus externus; and the descending branch supplies the muscle lower down. The transverse branch sends a branch to enter the crucial anastomosis; and the descending branch a branch to enter the circumpatellar anastomosis. The ascending and transverse branches lie beneath the incision, which is made in operating on the hip-joint anteriorly, and may be cut during the operation. The *internal circumflex* winds inwardly between the psoas and pectineus, then between the adductor brevis and obturator externus, and then between the adductor magnus and quadratus femoris to anastomose with the external circumflex, sciatic, and superior perforating (crucial anastomosis).

The four *perforating arteries* wind around close to the bone from within outward and terminate in the hamstring and vastus externus muscles. They perforate the adductor muscles and send large anastomotic branches to one another near the linea aspera. In operations on the femur, when the soft parts are detached from the posterior portion of the bone, the bleeding from these perforating branches is liable to be very free and on account of their depth difficult to control. It is this which renders operations like those for ununited and compound fractures dangerous.

Fig. 579.—Superficial lymphatic vessels of lower limb; semidiagrammatic. (Based on figures of Sappey.)

Hunter's (Adductor) Canal.—Hunter's canal occupies approximately the middle third of the thigh. It has an outer wall formed by the vastus internus muscle; a floor formed above by the adductor longus, and below by the adductor magnus; and a roof formed by a layer of fascia running from the adductor longus and magnus below to the vastus internus on the outer side. The canal runs from the apex of Scarpa's triangle to the opening in the adductor magnus muscle. The sartorius muscle lies on the roof of the canal (Fig. 576).

The Femoral (Superficial Femoral) Artery in Hunter's (Adductor) Canal.—The femoral artery in Hunter's canal has the vein, to which it is closely bound by fibrous tissue, first posterior and then slightly to its outer side. The internal or long saphenous nerve crosses the artery in front from its outer to its inner side. At the beginning of the canal the nerve to the vastus internus runs alongside of the long saphenous nerve, but it soon leaves it to enter the muscle. The long saphenous nerve leaves the artery as the latter perforates the adductor magnus and passes downward under the sartorius muscle to be distributed to the leg lower down, and to the inner side of the ankle.

Ligation of the Femoral Artery in Hunter's Canal.—In ligating the artery the incision is made over the sartorius muscle, which is to be pulled to the outer side; this exposes the roof of the canal, which is then opened. There is no need of including the long saphenous nerve in the ligature. Just before the femoral artery pierces the adductor magnus it gives off the anastomotica magna, whose superficial branch follows the long saphenous nerve, while its deep branch supplies the vastus internus muscle. This latter branch may be the source of troublesome hemorrhage in supracondylar osteotomy. Ligation in Hunter's canal should not be done as a matter of choice because of the danger of injuring the vein when attempting to separate it from the artery.

Collateral Circulation.—After ligation of the femoral artery below its profunda branch the external circumflex artery anastomoses with the muscular branches of the femoral, anastomotica magna, and superior articular arteries. The perforating arteries anastomose with the muscular branches below the ligature and with the superior articular arteries (Fig. 578).

Long or Internal Saphenous Vein.—The long saphenous vein begins in the venous arch on the dorsum of the foot and passes upward just in front of the internal malleolus, then along the inner posterior edge of the tibia, accompanied by the long saphenous nerve, then along the posterior border of the internal condyle and up in almost a straight line to the saphenous opening, 4 cm. (1½ in.) below and to the outer side of the spine of the pubis, where it empties into the femoral vein. It is this vein which is involved in varicose veins of the leg, and is frequently operated on. The blood from the inner and outer portions of the thigh collects into two veins which empty into the long saphenous before the saphenous opening is reached, or else join the vein at the saphenous opening, or else open separately into the femoral vein. There are then sometimes two or three veins at the saphenous opening coming below, instead of one. This is important to bear in mind when operating here, otherwise one of the side veins may be ligated or excised under the impression that it is the main trunk. Every opportunity should be utilized to impress on one's mind the exact course pursued by the vein, as otherwise it may not be readily found if not rendered conspicuous by distention or disease. The course of the internal saphenous varies in different subjects often taking a course to the outer side of the knee and then returning to the inner side of the leg. In the treatment of varicose veins of the leg by the injection into the varicosed veins of sclerosing agents it is important that the internal saphenous if varicosed be properly sclerosed to secure the best result. If this cannot be done or cannalization of the sclerosed vein should occur ligation of the internal saphenous near the saphenous opening should be practised.

Lymphatics of the Groin.—The lymphatic nodes of the groin are frequently the seat of infection necessitating operative measures. They are superficial and deep. For clinical purposes there is no better division of the superficial nodes than into an oblique set along Poupart's ligament and a longitudinal set along the blood-vessels (Fig. 579).

While as a general rule it may be stated that the nodes drain the region they are nearest to, this is frequently not the case. Therefore it is not always possible to infer the source of the infection from the location of the infected lymph node. The nodes of the groin drain the lower anterior half of the abdomen, the genitalia, lower limb, and the anal, gluteal, and lumbar regions.

They vary from 10 to 20 in number, and their efferent vessels either pass through the femoral canal to the nodes inside of the abdomen, especially around the iliac vessels, or may terminate in the deep lymphatic nodes of the femoral canal.

The deep lymphatics consist of one to three nodes in the femoral canal internal to the femoral vessels. They are not constant, and one which is sometimes found at the upper end of the femoral canal is known as the gland or node of Cloquet. They receive the deep lymphatics of the thigh, as well as sometimes a communication from the superficial lymphatics. They rarely become the seat of infection, but if inflamed may be mistaken for strangulated femoral hernia. Inflammation of the deep nodes may also simulate coxalgia. Filariasis of the femoral lymphatics may cause extreme swelling of the lower extremity. The nodes of the groin communicate with the external and common iliac nodes.

Excision of Inguinal Nodes.—The inguinal nodes frequently become inflamed and swollen (bubo) from infection transmitted from the parts which they drain or in the infections now termed granuloma inguinalis. For these they are frequently excised. The superficial nodes are located on the fascia lata around the saphenous opening, and at that point are intimately associated with and surround the veins. On this account it is easy to wound the veins, and the hemorrhage may be so free and so hard to control as to endanger the life of the patient. We know of two such fatal cases. This accident is to be avoided by freeing the edge of the mass below the saphenous opening and isolating the long saphenous vein, which is then followed up and exposed at its entrance into the femoral vein. The diseased mass is then to be dissected loose from each side, away from the vein, and removed. The femoral vein itself at this point is superficial, and if the saphenous opening is cleaned out it will of necessity be exposed.

The other veins emptying into the femoral at the saphenous opening above the long saphenous—the superficial circumflex iliac, epigastric, and external pudic—are usually small and so easily secured as to cause no trouble.

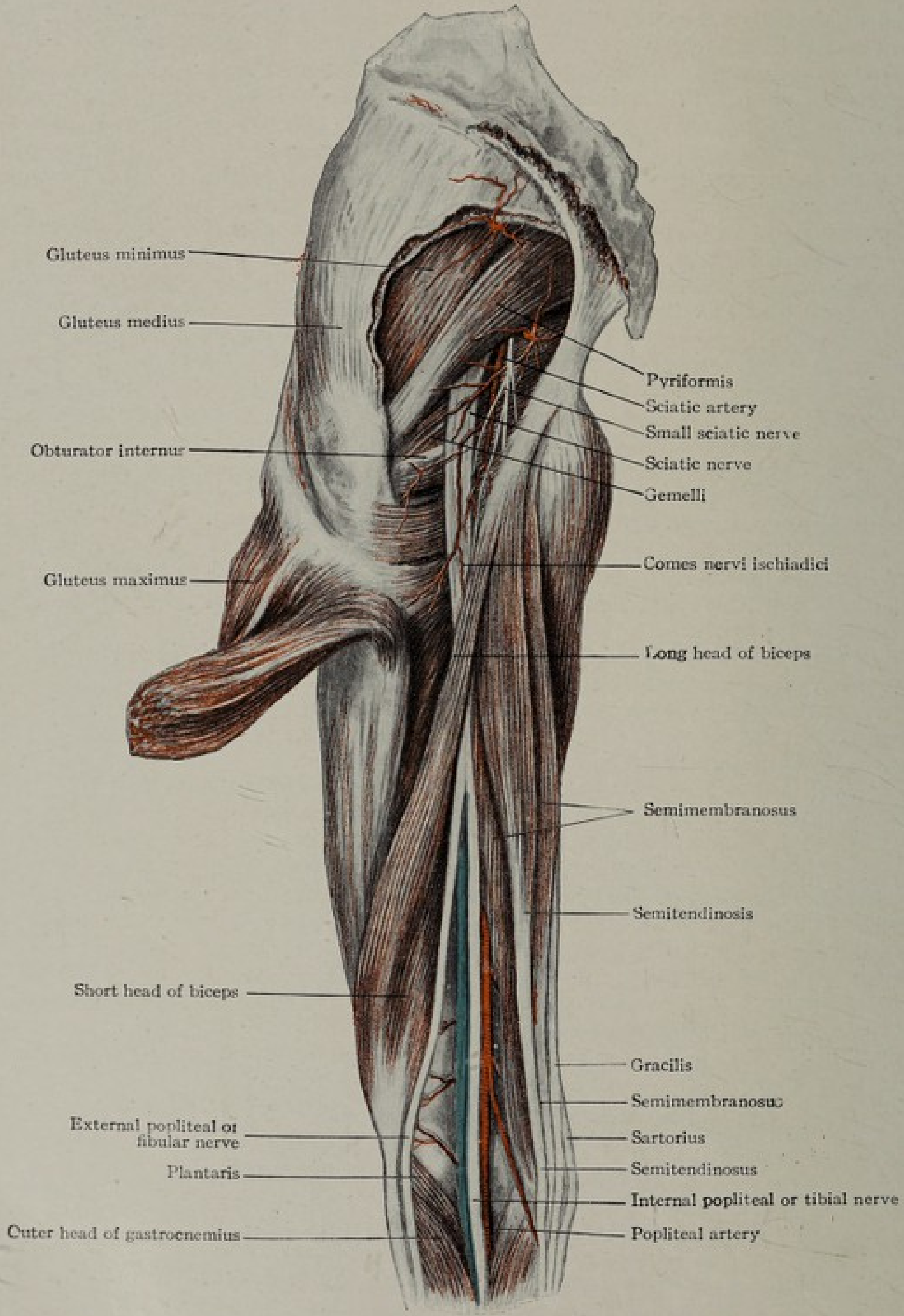


Fig. 580.—Sciatic nerve and structures of the posterior portion of the thigh.

Sciatic Nerve.—The sciatic nerve in its descent crosses a line joining the tuberosity of the ischium and greater trochanter at the junction of its inner and middle thirds. It then descends toward the middle of the popliteal space. It divides into the internal and external popliteal nerves at about the middle of the thigh (Fig. 580). Rarely it divides lower down, but more frequently higher up. When this occurs the internal popliteal (tibial) and external popliteal (perineal) are separated by the lower fibres of the pyriformis muscle. It is said that it will bear a weight of 183 lbs. but Symington has pointed out that it will tear out from its spinal attachment before this limit is reached. In exposing it the incision should be made high up at the gluteal fold, to the outer side of the tuberosity of the ischium. At this point it lies to the outer side of the biceps and on the adductor magnus; a little lower down it disappears beneath the biceps, and, if the incision is made here, the muscle must be displaced and it may only be found with difficulty. At the upper end of the popliteal space it again becomes visible, and can be found between the biceps on the outer side and the semimembranosus on the inner side.

Sciatica may be caused by injury to the sacral plexus in the pelvis, as by labor, or by injury to the nerves as they issue from the spine, as in fractures, luxations, bony outgrowths or tumors. The pain affects the back of the thigh and outer side of the leg.

FRACTURES OF THE FEMUR

The femur is usually fractured through the neck, greater trochanter, upper third of the shaft, middle of the shaft, or just above the condyles.

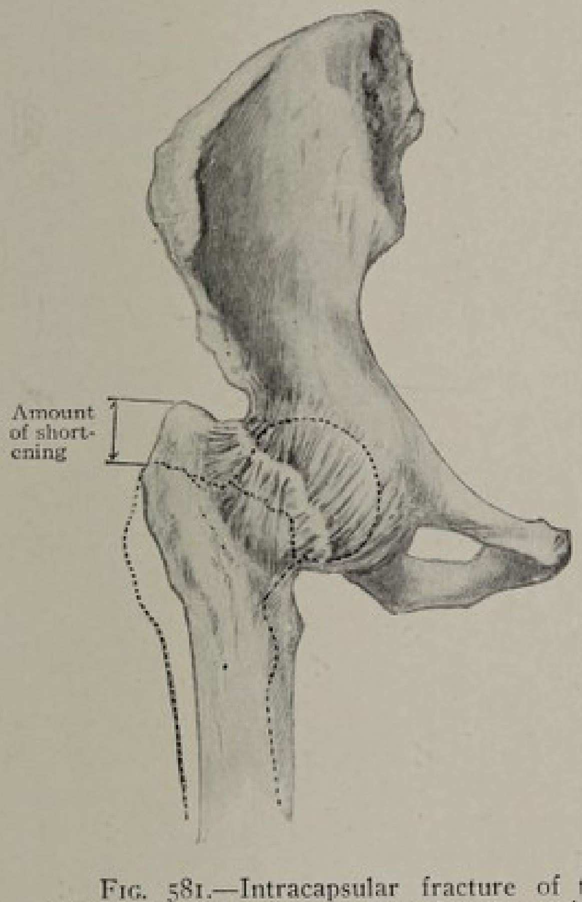


Fig. 581.—Intracapsular fracture of the neck of the femur showing the shortening. The dotted line represents the outline of the normal bone.

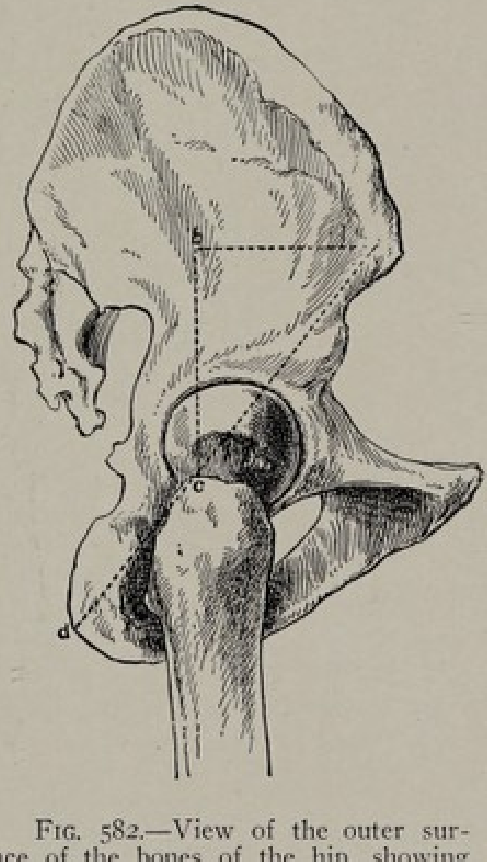


Fig. 582.—View of the outer surface of the bones of the hip, showing Roser-Nélaton line (*a d*); Bryant's triangle (*a b c*—*b c* being its base); the iliotrochanteric line (*a c*) and iliotrochanteric angle (*bac*).

Fractures of the Neck of the Femur.—These are often difficult of diagnosis and unsatisfactory in treatment.

The signs peculiar to this fracture are due to the displacement of the fragments. Some shortening occurs in all fractures of the femur (Fig. 581). Comparative measurements to ascertain this will be of no value if the pelvis is tilted (see page 594). If by measurement the limb is shorter than the opposite one,

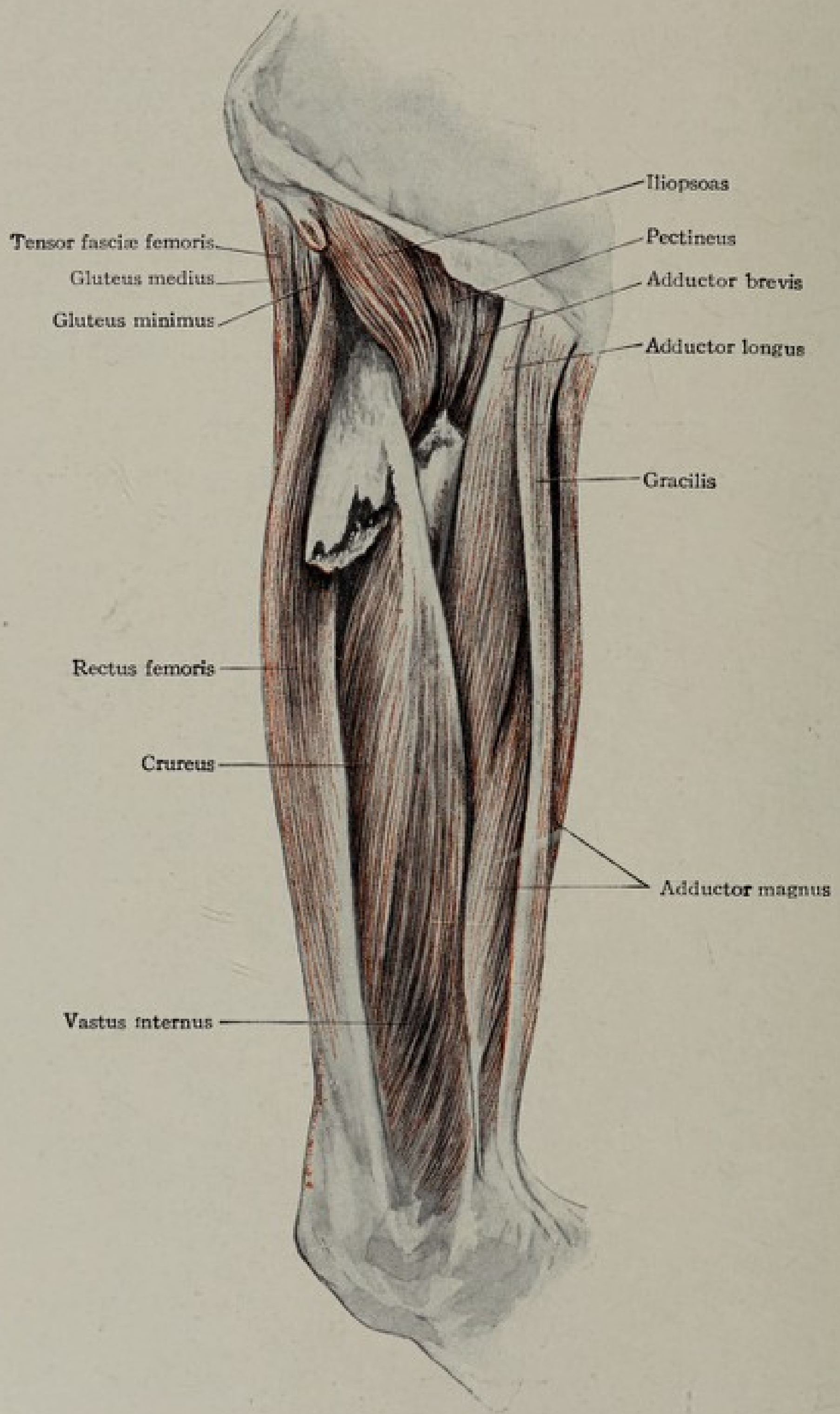


FIG. 583.—Fracture of the femur at the juncture of the upper and middle thirds. Upper fragment drawn forward and outward.

then if the distance from the tip of the greater trochanter to the external malleolus is the same on both sides, the injury must be higher up, or in the neck.

The iliotrochanteric angle instead of being thirty degrees will be diminished or lost. The tip of the greater trochanter will be above the Roser-Nélaton line. The base of Bryant's triangle will be shorter on the injured side (Fig. 582). If the extended limb is rotated the arc described by the greater trochanter will be smaller on the injured side because the shaft rotates on its axis instead of rotating in the acetabulum. The trochanter of the injured side is usually not so prominent as on the sound side. The iliotibial band is relaxed.

Shortening is well demonstrated by flexing the thighs with the patient on his back: the knee of the sound side will be found to be higher than that of the injured one.

In all fractures of the thigh the foot is placed by gravity in eversion. The rise of the greater trochanter, being nearer to the crest of the ilium, produces a slight fulness in the outer portion of Scarpa's triangle which is absent on the healthy side.

Line of Fracture.—The neck is fractured in one of two places, near the head, or near the trochanter. The former is intracapsular entirely, the latter partly intracapsular and partly extracapsular. As the capsule anteriorly descends as low as the intertrochanteric line and posteriorly only half way down the neck, the high fractures are entirely intracapsular and the low fractures intracapsular in front and extracapsular behind. This causes a marked difference in healing; complete intracapsular fractures do not unite firmly, but the fractures close to the trochanters not infrequently unite firmly with resulting good function.

Impaction.—Impaction of the other fragment by the neck of the bone is not rare, and firm union may occur. If the fracture is close to the head, the neck is impacted into and penetrates the head, but if the fracture is close to the trochanters, the neck penetrates the trochanters, frequently splitting them.

Mode of Injury.—In old people the bone is weakened by atrophy and the neck is often fractured by indirect violence, as by twisting, etc. Then the fracture is a high one; if, however, the fracture is by direct violence, as by falling and striking the hip, then the fracture is apt to be close to the trochanters and the prognosis better. Hence the importance of ascertaining the history of the injury. Fracture also occurs in young adults and children, usually from direct injury.

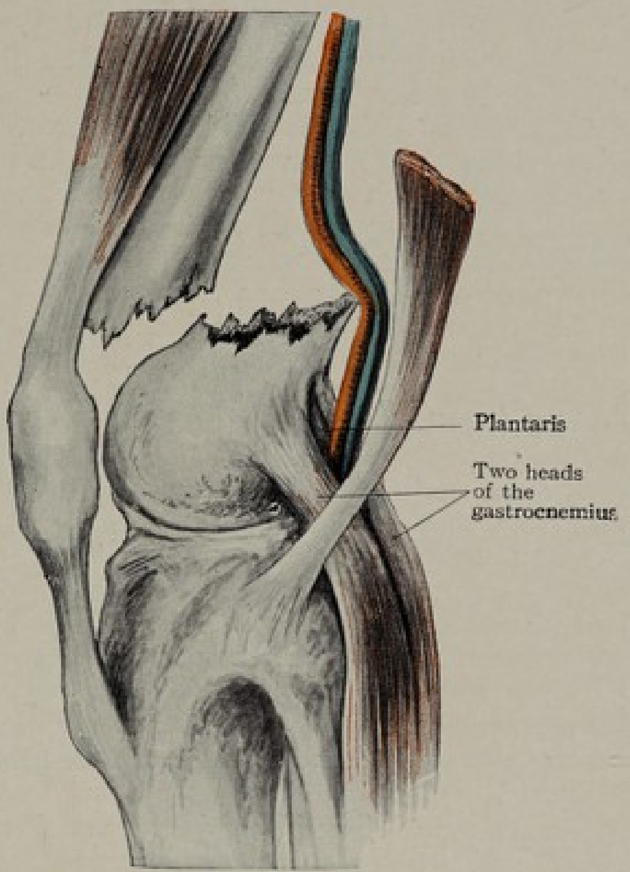


FIG. 584.—Supracondylar fracture of the femur. The lower fragment is seen to be drawn back into the popliteal space by the gastrocnemius and plantaris. The vessels are stretched over the sharp edge of the lower fragment.

Treatment.—Fractures of the neck close to the head are treated in full abduction, extension and internal rotation. A plaster spica is applied extending from the lower thorax to the toes, with a short spica to the opposite thigh. This is the Whitman method. Open reduction is occasionally resorted to and a bone peg or nail used to immobilize the fragments. In the intertrochanteric or fracture at the base of the neck the abduction need not be so full. An abduction plaster spica or traction in a Thomas splint may be used. Some surgeons prefer the Maxwell-Ruth method.

Fracture through the Trochanters.—This is almost always the result of a direct injury or blow on the hip. Impaction is almost the rule, the upper fragment being driven into the lower. Shortening and other symptoms are usually not so marked as in the other fractures and almost any method of treatment is followed by good results.

Fractures of the Shaft.—These may be in the upper, middle, or lower third. They all have a common displacement. The upper fragment is displaced forward and outward and the lower fragment backward and usually inward. The foot is usually everted.

Fractures of the Upper Third.—The displacement of the upper fragment forward and outward is usually marked. It is caused by the iliacus, psoas, and pectineus pulling it forward and rotating it out and the gluteus minimus and medius abducting it. The lower fragment is pulled in by the adductors and posteriorly by the gastrocnemius and plantaris (Fig. 583).

Fracture of the Middle Third.—The displacement is the same as in the upper third but to a less extent.

Treatment.—In the child (not more than six years old) the Bryant method of overhead traction is unusually efficient. If complete reduction can be obtained under anæsthesia a plaster spica will suffice. In the adult many prefer the use of a Thomas splint supplanted by skeletal traction from the femoral condyles. The hip is flexed as is the knee to release muscle pull on the fragments. Abduction is often necessary in fractures from the trochanters to the middle of the thigh.

R. Hamilton Russell has described a new method of extension useful in fractures of the shaft of the femur. His method employs traction of the thigh and partly flexed leg, the two forces of traction being so adjusted as to give the maximum full in the line of the femur which he believes cannot be obtained by a single force acting in a straight line. This method of treatment has found favor with some surgeons but it is not applicable to all cases particularly the fractures near the trochanters and the supracondylar fractures.

Fractures of the Lower Third—Supracondylar.—This is a particularly dangerous fracture because the lower fragment is drawn backward by the gastrocnemius and plantaris, and the popliteal vessels and internal popliteal nerve may either be wounded primarily or stretched over its sharp upper edge (Fig. 584). The artery lying deepest is the most liable to injury, then the vein, and finally the nerve. Gangrene necessitating amputation has occurred. Of course in attempting to replace the fragments the knee should be flexed to relax the gastrocnemius and plantaris.

Treatment.—The hip and knee are flexed. The Thomas splint is applied and skeletal traction is obtained from the femoral condyles. If reduction is not obtained in from seven to ten days in the shaft fractures, I prefer not to delay longer and resort to open operation.

AMPUTATION

Amputation at the Hip-Joint.—In amputating at the hip-joint, hemorrhage is especially to be guarded against. This comes from two sources, the femoral artery anteriorly and the branches of the internal iliac posteriorly. The most reliable way of controlling bleeding is probably by the use of the elastic tourniquet held in place by *Wyeth's pins.* These are two steel pins 5 mm. (3/16 in.) in diameter and 25 cm. (10 in.) long. One is entered 6 mm. (¼ in.) below the anterior superior spine and slightly to its inner side and traverses the tissues on the outer side of the hip for about 7.5 cm. (3 in.) from the point of entrance; the other is entered through the skin and tendon of the adductor longus 1.25 cm. (½ in.) below the perineum and made to emerge 2.5 cm. (1 in.) below the tuber ischii. The elastic tube is to be wound around the hip above the pins, which prevent its slipping down (Fig. 585). The amputation is then performed as desired. Compression of the aorta or common iliac by instrumental means is obsolete. Sometimes the common iliac is compressed laterally by the finger introduced through an incision in the abdominal walls, but with careful technique this is not necessary. The method of ligating the external iliac artery above Poupart's ligament has proved quite useful.

Another method consists in making lateral flaps with the femoral artery in the angle of the incision—all vessels are then clamped as they are divided.

In some operations the head of the femur is disarticulated before the flaps are made. In this case the first part of the operation is like a resection of the hip by the Langenbeck straight incision.

The bleeding of the posterior flap comes from branches of the gluteal, sciatic, obturator, and internal pudic arteries, derived from the internal iliac.

Amputation of the Thigh.—In amputation of the thigh by the flap method care must be taken to avoid splitting the femoral artery. Its position in the various portions of the thigh should be borne in mind. Anteroposterior flaps are to be preferred to lateral ones, and a short anterior flap is to be avoided because the scar is drawn posteriorly (Fig. 585). The muscles of the posterior part of the thigh, the

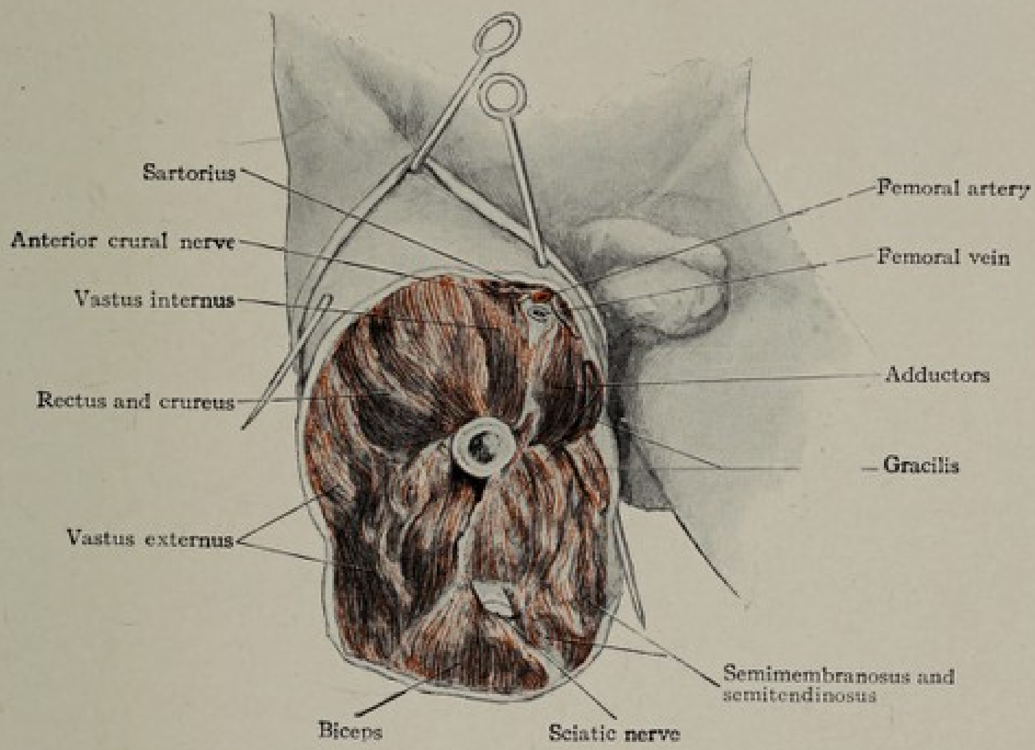


Fig. 585.—Amputation just above the middle of the thigh, showing insertion of Wyeth's pins.

hamstrings, are not attached to the bone, with the exception of the short head of the biceps, they therefore retract when cut and later pull the scar behind the bone. The crureus and vastus externus and internus anteriorly are attached to the bone, and hence cannot draw back either at the time of the operation or afterwards. The position of the femoral artery will depend on the point at which the amputation is made. It does not lie close to the bone until the popliteal space is reached. Bleeding from the perforating arteries along the linea aspera should, however, be looked for and the sciatic nerve should be isolated and cut short.

REGION OF THE KNEE

SURFACE ANATOMY

The bony landmarks are the patella, the two condyles of the femur, the tibia, and the fibula (Fig. 586).

The patella is pointed below where the tendo patellæ is attached, is slightly convex on its upper border, and its lateral edges are prominent, especially the outer. It usually has little tissue over it. With the limb extended and quadriceps relaxed the patella can be moved laterally. There is a hollow above the patella. When the muscle contracts this hollow is filled up by the rectus, and the muscular swells on each side produced by the vastus internus and externus are visible. When the quadriceps muscle is contracted the tense tendo patellæ becomes evident, when relaxed the soft fatty pad beneath the tendon can be felt.

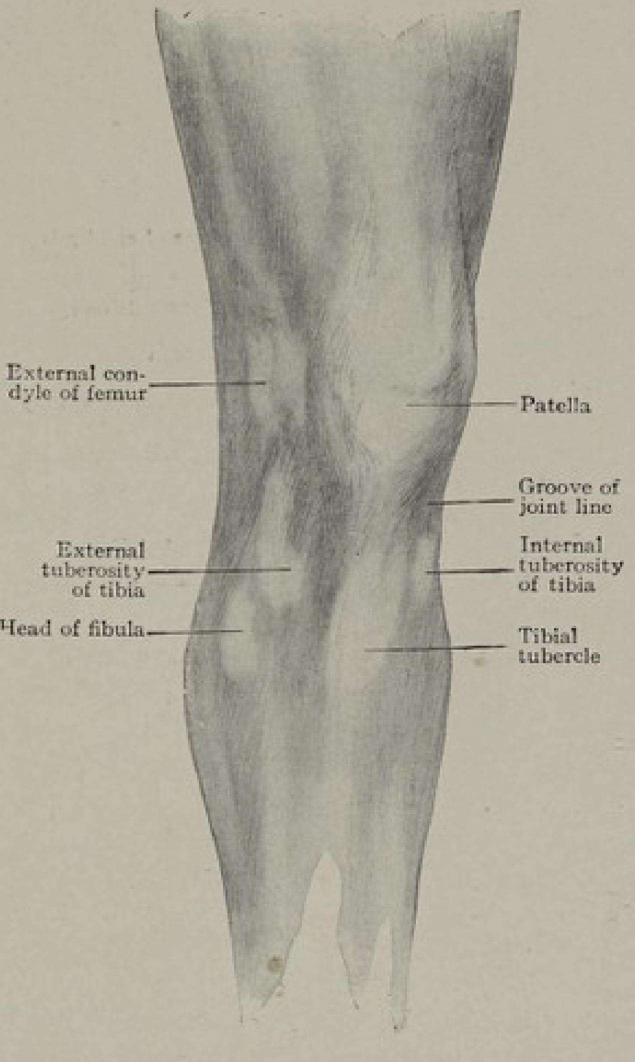


Fig. 586.—Surface anatomy of the knee.

About midway between the patella and tubercle of the tibia on each side can be felt a groove which indicates the line of the joint and the location of the semilunar cartilages. On the other side posteriorly opposite the level of the tibial tubercle can be felt the head of the fibula. Running upward from it is the tendon of the biceps. In front of the biceps can be seen and felt the iliotibial band of the fascia lata. It is difficult to distinguish the joint-line on the sides, therefore it is better to locate it by recognizing the sulci anteriorly on each side of the tendo patellæ; flexing the knee makes these depressions more distinct. The joint on the outer side is about 2 cm. (¾ in.) above the head of the fibula.

Posteriorly, with the leg extended, the condyles of the femur can readily be outlined; the inner is the more prominent. The upper edge of their articular surfaces can be felt on firm pressure at the sides, and the inner leads to the adductor tubercle, into which the adductor magnus tendon is inserted—this tendon can likewise frequently be felt. The tubercle of the tibia can best be seen and felt when the tendo patellæ is relaxed. It is about 4 cm. (1½ in.) below the patella. Just above and to its outer side, about 4 cm. (1½ in.) distant, is the external tuberosity of the tibia; into it is inserted the lower end of the iliotibial band. To the outer side at a little lower level can be seen and felt the head of the fibula. On the inner side is the flat rounded internal tuberosity of the tibia. Posteriorly is seen the fulness of the popliteal space; on its outer side the tendon of the biceps is readily felt and running with it is (the ham) external popliteal or common peroneal nerve; on the inner side the most prominent tendon is the semitendinosus with the semimembranosus beneath and the gracilis to the inner side while the tendon of the insertion of the sartorius lies in front of this covering the insertions of the gracilis and semitendinosus.

THE KNEE-JOINT

As the functions of the lower extremity are support and mobility, it is evident that in order to obtain mobility without unduly weakening the limb the ligamentous connection of the bones must be exceptionally strong. The knee is placed half way down the extremity, hence it has the bulk of the body above to support; also, the bones on each side of the joint are the longest in the body, hence their lever action is exceptionally great, which likewise necessitates that the joint be firmly braced by ligaments.

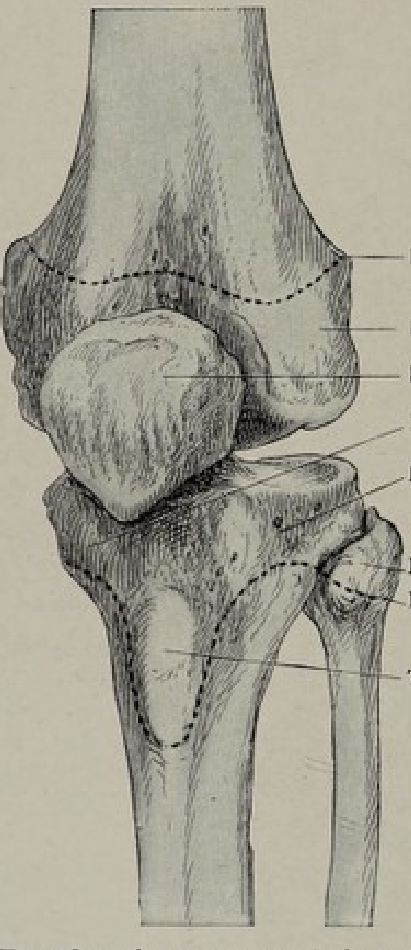


FIG. 587.—Antero-external view of the bones of the knee.

The Movements of the Knee.—The knee is primarily a hinge-joint; its main movements are extension and flexion. It can be extended to a straight line (180 degrees) and flexed until the thigh and upper portion of the leg come in contact, at about 45 degrees or even less. The movement is a combined gliding and rolling one. According to Morris, as extreme extension ends the leg rotates a little outward through a longitudinal axis, passing through the middle of the outer condyle of the femur, and as flexion begins it rotates inward. These rotary movements are, however, slight, and may practically be ignored. When flexion has proceeded to 150 or 155 degrees, the joint becomes comparatively loose, and this increases as the joint is flexed, until a rotation of 36 degrees (Morris) is allowed. This is of decided practical importance because injuries and treatment are intimately associated with the presence of rotatory movements. No rotation is possible when the knee is fully extended, the bones being then immovable.

Bones of the Knee-Joint.—The knee-joint is between the femur, the tibia, and the patella; the fibula does not enter into it (Fig. 587). The patella is only a sesamoid bone developed in the quadriceps tendon, and is not essential. In some of the lower animals it has a synovial membrane separate from the knee-joint proper.

The joint between the femur and tibia is built up of two separate lateral parts; the condyle and tuberosity of each side forming practically a separate joint and having a crucial ligament as one of its lateral ligaments. The object of thus combining two joints side by side to form one joint is to add to its strength and lateral stability. The condyles of the femur have their articular surfaces prolonged up on its anterior surface, not to aid in flexion and extension, but simply to facilitate the action of the patella. The outer condyle is the higher, to prevent external luxation of the patella. The articular surfaces of the condyles are not perfect arcs of a circle. If they were the motion would be solely a gliding one and the lateral ligaments and crucial ligaments would be equally tense in all positions, which is not the case, for, particularly in flexion, they become slightly relaxed. The upper surface of the tibia is slightly hollow and its spine projects upward between the condyles, thus adding to the lateral stability of the joint.

The patella is divided by a longitudinal ridge into two articular facets, the outer for the external condyle being the larger; the ridge lies in the intercondylar space. The inner part of the patella is thicker than the outer because the inner condyle is lower. The patella is a sesamoid bone which is developed more toward the deep surface of the tendon of the quadriceps. The tendon goes over the surface of the patella and is practically continued longitudinally through the superficial portion of the bone. If the dried specimen is hammered the bone can be pulverized and removed, leaving the tendon of the quadriceps continuous with the tendo patellæ. For this reason, when the patella fractures, the torn fibrous fringes are never on the articular surface but always on its superficial surface. The patella has its sharp apex below and fractures frequently tear it off, the small size of the fragment making repair difficult.

Ligaments of the Knee-Joint.—To provide for the support required to be given by the lower extremity, the ligaments and tendons binding the bones of the knee together are both numerous and strong. The bond of union is so strong that dislocations from traumatic causes are comparatively rare, and it is only when the ligaments have been weakened by disease that subluxations take place.

The knee possesses the usual *capsular ligament* but so hidden by strengthening bands and tendinous expansions that but little of it is seen. Anteriorly the capsule is strengthened by the tendon of the quadriceps, the patella, and the tendo patellæ (Fig. 588). Viewing these structures as a whole we see that their lower end is firmly attached at the tibial tubercle, but above their attachments are far removed from the joint. They are so strong and thick that pus from within does not tend to go through but goes around them. Their upper attachment is muscular, so they do not act to restrain movements except when the muscle is contracted; hence flexion is limited by contact of the soft parts posteriorly rather than by tension of the ligaments anteriorly. In complete extension the bulk of the patella rises above the articular surface, and connecting its upper edge with the anterior surface of the femur is only the thin capsular ligament, hence effusions into the joint bulge upward at this point. Extending about 5cm. (2 in.) above the patella is the subfemoral (supra-patellar) bursa; this in 8 out of 10 cases communicates with the

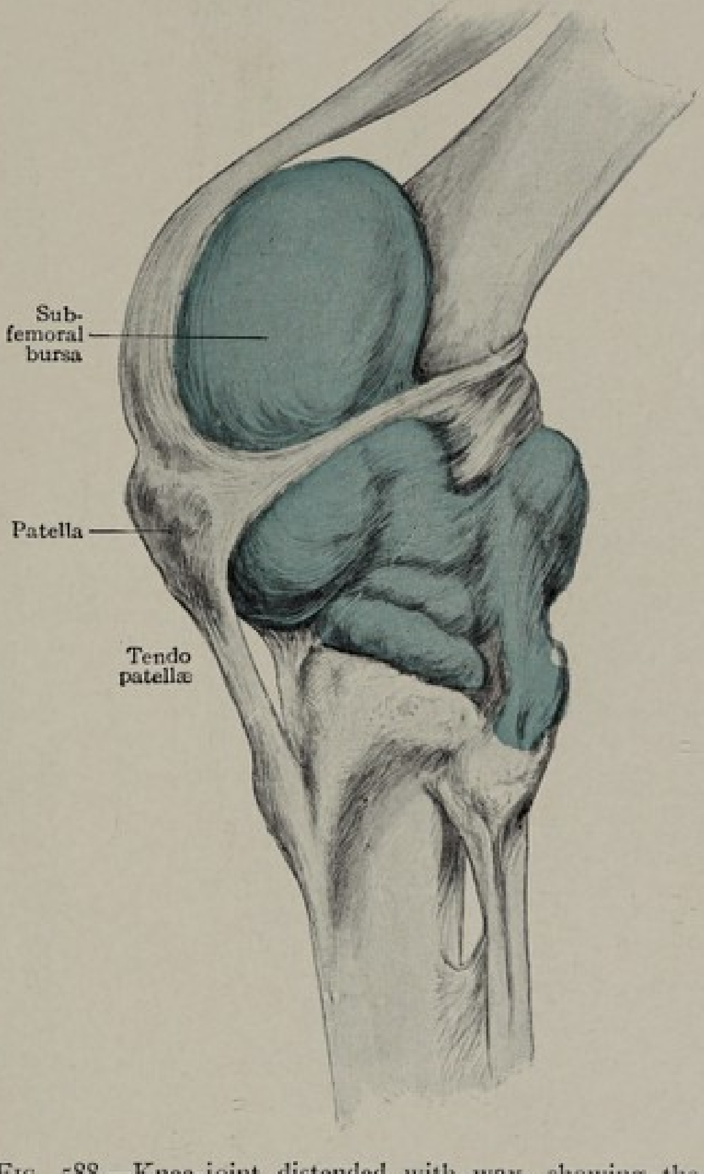


FIG. 588.—Knee-joint distended with wax, showing the extent of its cavity and capsular ligament.

joint, and effusions readily distend it. The patella normally lies in contact with the femur but when there is effusion in the joint it is pushed or raised up and is called a *floating patella.* Pressure on it causes it to strike on the femur beneath, which is readily felt and enables one to diagnose effusions within the joint. Posteriorly the capsule is thick, being strengthened by an expansion, called the posterior

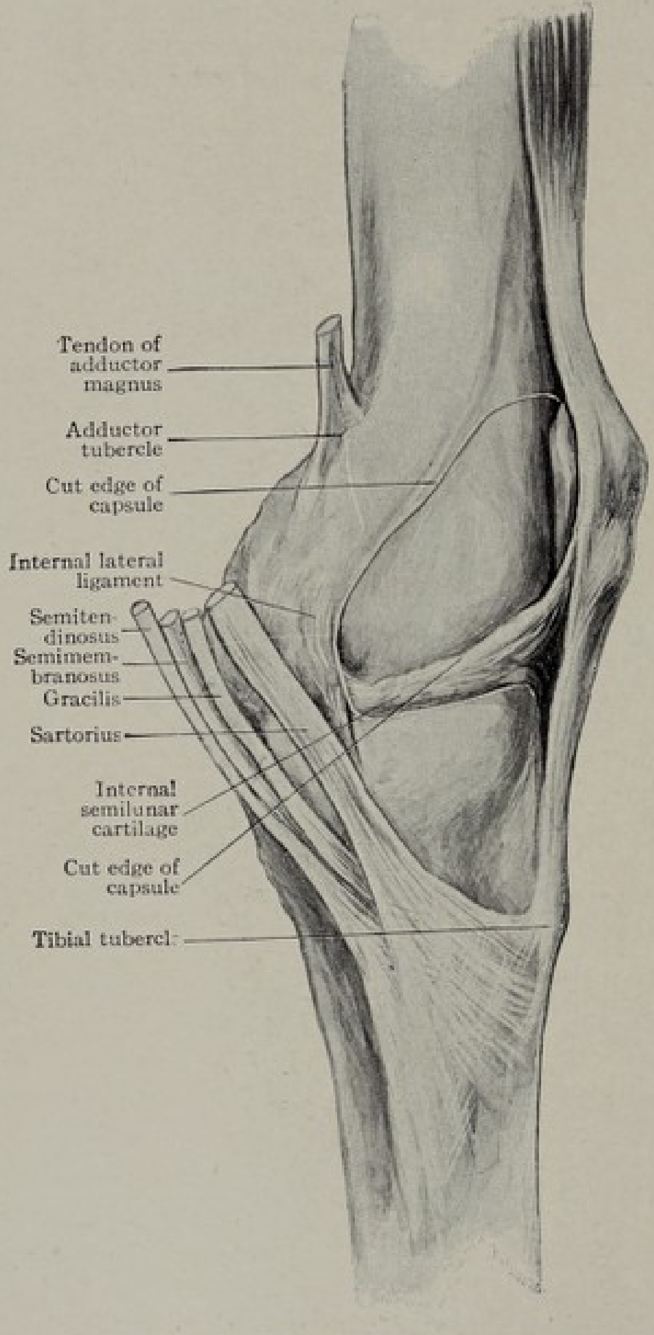


FIG. 589.—View of the inner side of the knee-joint; the capsule has been cut away from the edge of the patella to the internal lateral ligament, exposing the interior of the joint.

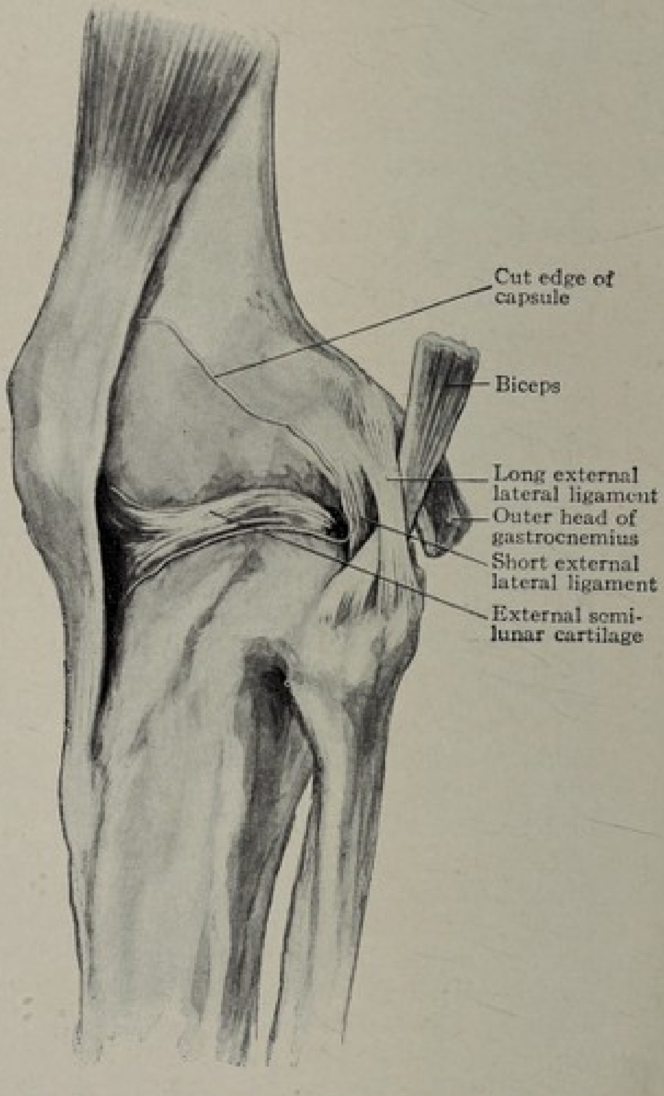


FIG. 590.—View of the outer side of the knee-joint. The capsule has been cut away from the edge of the patella to the external lateral ligament.

(oblique) ligament or ligamentum Winslowii, which goes upward and outward from the tendon of the semimembranosus muscle at the upper edge of the tibia. It is pierced by the branches of the azygos articular artery. The capsular ligament is weak below at the margin of the tibia and here pus may find an exit. It is less liable to come out above, but the bursa under the inner head of the gastrocnemius frequently communicates with the joint and is usually the origin of the ganglion so often seen in the popliteal region. When the joint becomes subluxated by disease the tibia is drawn backward and this posterior capsular ligament may shorten and prevent reposition forward. So strong is it that forcible attempts are liable to cause fracture.

Internally the capsular ligament is strengthened by the lateral expansion from the side of the patella and from the fascia lata over the vastus internus; these go to the inner tuberosity of the tibia and strengthen the lower part of the joint, but toward the upper edge of the internal condyle the capsule is again thin and effusions puff it out at that point.

Internal Lateral Ligament.—A band of the capsule to which the name internal lateral ligament has been applied runs from beneath the adductor tubercle to the tibia below the internal tuberosity; it is strengthened by fibres from the tendon of the semimembranosus and has the internal articular vessels and nerves passing between it and the tibia. It will be noted that it lies toward the posterior portion of the joint, hence it limits extension (Fig. 589).

Externally the capsule has likewise the fibrous expansion of the quadriceps from the side of the patella and the fascia lata. This latter is the strong iliotibial band and goes downward to insert into the outer tuberosity of the tibia (Fig. 590).

External Lateral Ligaments.—There are likewise two band-like ligaments on the outer side, the long and short external lateral ligaments. The long external lateral ligament arises from a tubercle just below and in front of the outer head of the gastrocnemius muscle. It is about 5 cm. (2 in.) long and is attached below to the fibula, anterior to its styloid process. It is embraced on each side by the split tendon of the biceps. Beneath it pass the popliteus tendon in its sheath and the inferior external articular vessels and nerve. Note that this is likewise at the posterior portion of the joint and therefore it too limits extension.

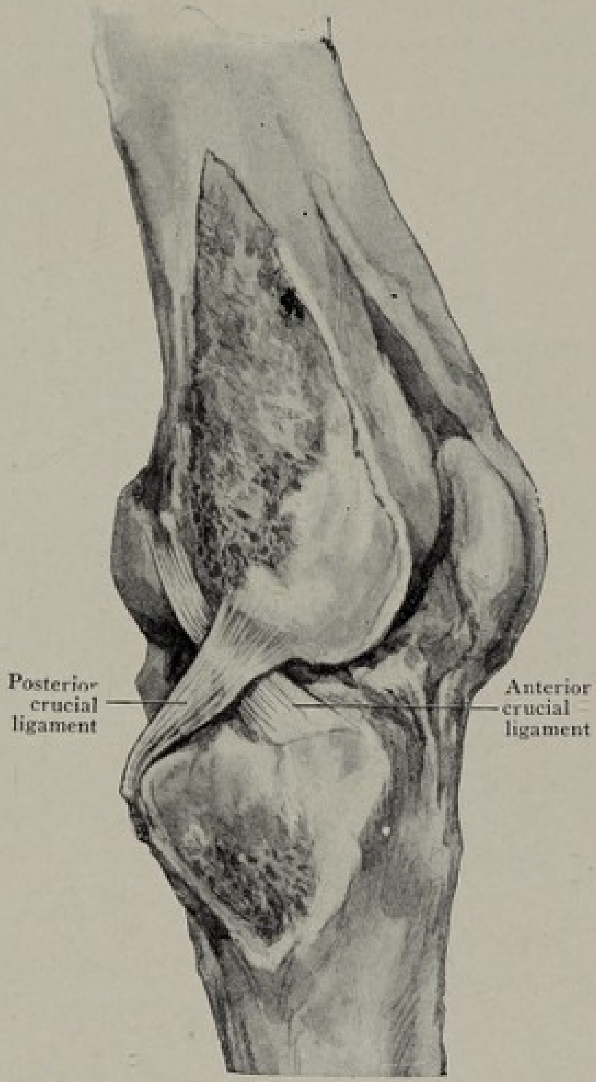


Fig. 591.—The crucial ligaments exposed by sawing off the inner surfaces of the femur and tibia.

The short or posterior of the two external lateral ligaments is often not to be recognized as a distinct structure, it passes from the styloid process of the fibula over the popliteus tendon to blend with the posterior capsular ligament on the external condyle. The lateral ligaments check extension and outward rotation of the tibia.

Crucial Ligaments.—These pass from the tibia, the anterior being attached in front of and the posterior behind the spine, upward to the intercondylar notch of the femur. The anterior or external passes upward, outward, and backward. The posterior or internal passes upward, inward, and forward. An easy method of remembering the origin and insertion of the crucial ligaments is to cross the knees. The anterior leg represents the direction of the anterior ligament, that is from within outward while the posterior knee represents the posterior ligament. They are never very lax in any position of the joint, but the anterior is most tense in extension and the posterior in flexion. The anterior tends to prevent displacement of the tibia forward and the posterior ligament displacement of the tibia backward. The posterior crucial ligament blends with the posterior capsule and in resecting the knee care should be taken in dividing this ligament that the popliteal artery is not wounded. A ligamentous band runs from the posterior crucial ligament to the external semilunar cartilage; it is called the *ligament of Wrisberg.* The knee-joint in some of the lower animals is composed of two separate joints, one for each condyle, and the crucial ligaments of man are simply the remains of lateral ligaments when separate joints exist. They check inward rotation.

Semilunar Cartilages, Coronary and Transverse Ligaments.—The semilunar cartilages are used to deepen the joint in the same manner as the cotyloid of the hip and glenoid of the shoulder. It is their method of attachment that is important. The external is nearly circular, the internal is semi-elliptical. The ends are fibrous and are attached in front of and behind the spine of the tibia. The transverse ligament is a band passing across the front from one semilunar cartilage to the other (Fig. 592). As Macalister has pointed out, there is no true coronary ligament. It is the part of the capsular ligament running from the semilunar cartilages to the tibia.

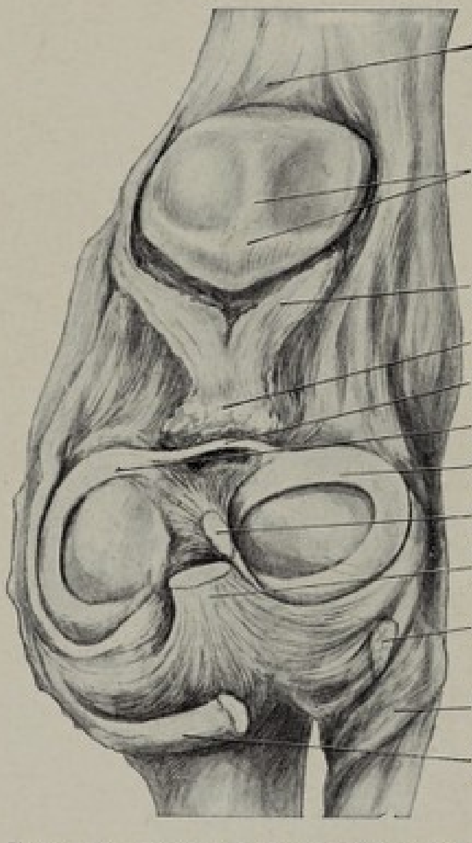


Fig. 592.—View of the interior of the knee-joint, looking forward.

The semilunar cartilages are attached by their outer edges to the capsular ligament. This attachment is less in extent in the case of the external, because its outer surface is obliquely grooved by the tendon of the popliteus muscle, but it has an additional attachment in the ligament of Wrisberg, as stated under the posterior crucial ligament. Humphry has pointed out that the semilunar cartilages in flexion and extension move with the tibia, but in pronation and supination (rotation) move with the femur.

Ligamenta Alaria and Mucosum.—Below the patella is a pad of fat extending under the upper portion of the tendo patellæ; a bursa is under the lower portion. Passing up from this pad to the intercondyloid notch and crucial ligaments is the ligamentum mucosum; below, it is continuous with the synovial fringes at each side of the lower edge of the patella which form the ligamenta alaria. We would suggest that it is possible that these ligaments perform for the knee-joint what Allis has suggested the ligamentum teres does for the hip, viz.: act as a swab to distribute the synovia over the articular surfaces.

Bursæ of the Knee.—There are a number of bursæ about the knee-joint, but they are not all of importance. *Anteriorly* there are the prepatellar, suprapatellar, and deep and superficial infrapatellar.

The *prepatellar* bursa lies in the subcutaneous tissue between the skin and patella. It is often enlarged, constituting "housemaid's knee" (Fig. 593). The bursa is almost always present, but often irregular in shape and character. Injuries frequently cause it to inflame. Sometimes the tendon of the quadriceps over the patella is ossified clear to the surface, which is often irregular and rough, and is felt immediately beneath the skin with apparently no subcutaneous tissue intervening. In these cases the bursa may be very irregular or loculated in shape, or there may be more than one. This is in accordance with the studies of Bize, who found (1) a bursa over the lower half of the patella in the superficial fascia, in eighty-eight per cent. of knees examined; (2) one beneath the aponeurotic layer which is continuous with the fascia lata in ninety-five per cent.; and (3) one beneath the fibrous layer of the quadriceps extensor tendon over the lower part of the bone in eighty per cent. of the cases. The sac of the bursa is usually very thin, but becomes thick and distinct as the result of irritation. Excision is usually the quickest way of curing housemaid's knee, but often the easier way of simple incision and drainage with a wick of gauze is sufficient.

The *suprapatellar* or subfemoral bursa extends from 5 to 7.5 cm. (2 to 3 in.) above the patella beneath the crureus muscle. It is liable to be injured by stabs or punctures, and thereby infect the joint with which it communicates in 8 out of 10 cases. It becomes distended in intra-articular effusions.

The *infrapatellar bursæ* are one between the skin and tibial tubercle and the other between the under surface of the ligamentum patellæ and the upper end of the tibia—they are unconnected with the joint and are not often diseased.

Posteriorly.—On the *outer side* of the joint there may be present (1) a bursa beneath the external head of the gastrocnemius which may communicate with the bursa between the popliteus tendon and external lateral ligament. (2) One between the biceps tendon and external lateral ligament, (3) another between the popliteus tendon and external lateral ligament, and (4) one beneath the popliteus, usually an extension of the synovial membrane of the joint. On the *inner side:* (1) the largest posteriorly beneath the internal head of the gastrocnemius, which usually communicates with the joint, especially in the adult, and sends a prolongation between the gastrocnemius and the semimembranosus. This is the most important posterior bursa. (2) There is one beneath the tendons of the sartorius, gracilis, and semitendinosus muscles. (3) One beneath the tendon of the semimembranosus, between it and the tibia; it rarely communicates with the knee-joint. (4) One between the tendons of the semimembranosus and the semitendinosus.

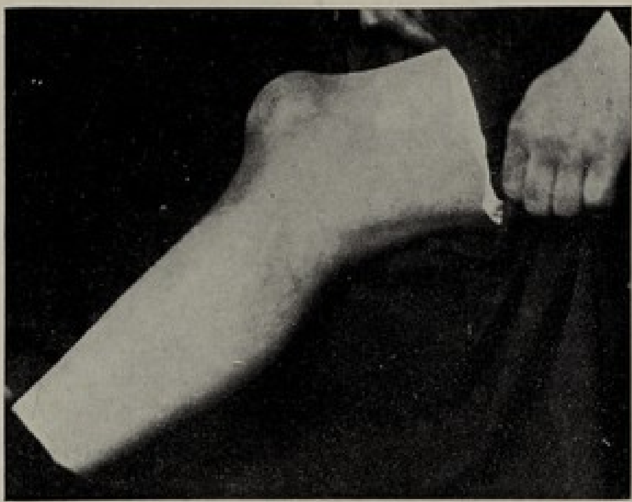


Fig. 593.—Housemaid's knee or enlargement of the prepatellar bursa.

Ganglion.—Sometimes a rounded tumor that is called a ganglion appears in the popliteal space. When the knee is flexed it is felt as a round, movable tumor which is hard and cystic. If the knee is extended it slides inward to the edge of the inner condyle and becomes hard and fixed. It usually originates from the bursa beneath the inner head of the gastrocnemius, is prolonged between it and the semimembranosus, and, when the knee is flexed, it either disappears entirely by its contents going into the joint or it can still be felt in the popliteal space. It may be a difficult matter to excise these cysts on account of their ramifications, and when this is impossible it is better to open them up, clean them out, and then sew the wound shut in order to avoid infecting the joint. Care should be taken not to mistake them for solid tumors popliteal aneurysm or enlarged lymph-nodes, all of which are less common than ganglion.

Fracture of the Patella.—The patella may be fractured in two ways, producing different lesions and requiring different treatment. Fracture is produced either by muscular contraction or by direct violence; the former is the more common.

Fracture by Indirect Violence.—As pointed out by Humphry, when the knee is fully flexed only the upper third or fourth of the articular surface of the patella is in contact with the condyles of the femur—the remaining two-thirds or three-fourths of the projecting portion of the bone resting on the pad of fat. When semi-flexed the greater part of its surface is in contact with the condyles, or at least the whole of its middle third. In full extension only the lower third or fourth or even less remains in contact.

When semi-flexed the patella is subjected to the greatest leverage strain; hence it is that fractures most often occur in this position and that the fracture occurs so frequently at the junction of the lower and middle portions. When the bone is fractured by indirect force (muscular) the line of fracture traverses its whole thickness and consequently the joint is always involved. Usually there are but two fragments. The extent of separation depends on the amount of laceration of the capsule on each side of the line of fracture (Fig. 594).

Fig. 594.—Fracture of patella, showing lateral tear of capsule.

On each side of the patella the fibrous expansion of the quadriceps tendon, fascia lata, and joint capsule, if intact, will prevent separation of the fragments. If it is ruptured widely it will permit a separation of about 2.5 cm. (1 in.). It is rare that the primary injury produces a wider separation, and those cases in which the fragments are wider apart are usually those in which the upper fragment has been subsequently pulled up by the contraction of the quadriceps. A fracture which when recent may have had only 1 cm. separation may subsequently show 7.5 to 10 cm. (3 to 4 in.). When the union is fibrous subsequent stretching may occur, also refracture increases the tendency to wide separation.

Fracture by direct violence is due to the direct impact of a blow or a crushing of the patella between the femur and some foreign body. In this case the capsule on the sides is but little torn and although there may be several fragments they do not become widely separated.

Macewen has pointed out that the torn fibrous portion of the quadriceps over the patella may hang down between the fragments and hinder union.

Treatment.—The method of treatment to be employed varies according to the character of the injury. When the fracture is from indirect force, means must be employed not only to hold the fragments together, but also to repair the rent in the capsule. Obviously the limb is to be kept in the extended position to relax the quadriceps. The rectus, on account of taking its origin from the pelvis, is also to be relaxed by elevating the limb. A common method of treatment is by open operation. First a flap is raised, exposing the fracture, then the fragments are approximated with wire or other sutures and the rent in the capsule closed with chromic catgut or silk.

In fractures by direct violence, when separation is not marked, the lateral fascial expansion remains untorn and no open operation is necessary; in others, when separation is more marked, and especially if the fracture is compound, a flap may be turned back and the patella surrounded with a strong suture of chromic gut or silk and the fragments thereby drawn together; the suture may also be introduced subcutaneously.

By open operation the blood and clots which usually fill the joint can be removed as well as any fibrous tissue from the tendon of the quadriceps which may lie between the fragments.

Dislocation of the Patella.—The articular surface of the patella is divided by a longitudinal ridge into an outer and inner part, which articulate with the corresponding condyles of the femur. The outer surface for the external condyle is much the larger. The outer condyle is also much higher than the inner and thus tends to prevent luxations. The lateral fibrous expansions on each side of the patella also help to hold it in place.

Favoring dislocation is the inclination inward of the knee and the oblique pull of the quadriceps. When a person is standing upright with the feet together the femurs diverge from the knee as they approach the hip, the knees forming an angle of 165 degrees with its apex in. When the quadriceps muscle contracts it tends to straighten this angle and so pull the patella out. If the ligaments are normal and the pull not too violent, luxation does not occur. When, however, from long disuse or disease the ligaments become relaxed, then a sudden and perhaps unusual contraction of the quadriceps will dislocate the patella. This also occurs if the outer condyle is abnormally flat or if the muscular contraction lifts the patella off or above the condyles, as occurs when the tendo patellæ is too long. In these, as in almost all other cases, the patella is dislocated outward (Fig. 595). Inward dislocation is almost unknown. Direct injury also produces dislocations, practically always outward. The most common form is for the articular surface of the patella to rest on the outer surface of the external condyle. Other forms, which are more rare, are for the inner edge of the patella to rest against the outer surface of the condyle; for the inner edge to be jammed into the upper portion of the intercondyloid notch with its outer edge sticking up; for the patella to be reversed with its articular surface forward and its anterior surface resting on the condyles.

Fig. 595.—Dislocation of patella outward.

For treating the affection in slight cases an elastic knee-cap may be of service, but a cure is probably best achieved by the operation of Goldthwait. In this the tendo patellæ is split longitudinally and its outer half detached from the tibial tubercle, passed under the remaining half, and sewed fast to the periosteum and expansion of the sartorius at the inner side of the anterior surface of the tibia. This shifts the pull of the quadriceps more inward and the shortening of the tendon holds the outer edges of the patella more firmly against the edge of the external condyle. Simple folding of the inner part of the capsule has been unsuccessful.

Albee advises a linear osteotomy of the external condyle with the insertion of a tibial bone graft into the defect after forcing the external condyle forward. Probably the best results are obtained by a combination of the Goldthwait and Albee operations particularly in those cases where the outer condyle is unusually flat.

Dislocation of the Knee.—The knee is rarely luxated and then only by such extreme trauma as sometimes to rupture the popliteal vessels and require amputation. It is frequently compound. The tibia may be luxated anteriorly (the most frequent), posteriorly, to either side, or it may be rotated on the femur.

These displacements are usually due to hyperextension and rotation. The laceration of the surrounding tissues is so extensive that replacement is usually easy by direct traction and manipulation. As a result of weakening of the ligaments by disease the hamstring tendons frequently pull the tibia backward, producing a subluxation often difficult to replace (Fig. 553).

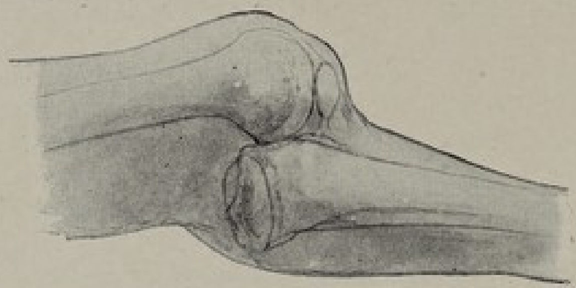


Fig. 596.—Subluxation of the knee from tuberculous disease, showing the relation of the bones. (From an original sketch by the author.)

Dislocation of the Semilunar Cartilages.—The semilunar cartilages (Fig. 549) do not become displaced in their entirety, but a portion of one of them is torn partly or completely loose and in moving about gets caught between the bones and produces the characteristic symptoms. The joint becomes useless at once and the patient may fall. The detachment of the cartilage, which is usually the internal one, is caused by either a direct blow on the part or by a twisting of the partly flexed limb. Use of the limb cannot be resumed until the caught cartilage is released. This is most readily achieved by extending the leg and then sharply flexing it. Sometimes the loosened cartilage instead of remaining attached at one end is free in the joint and may make its appearance alongside of the patella. Sometimes one end of the semilunar cartilage is attached to the crucial ligament while the other is attached to the capsular ligament, thus allowing the part between to stretch across the surface of the condyle and be compressed in walking. These floating cartilages form the "*gelenkmaus*" of the Germans. These two conditions were first described by Hey under the name of internal derangements of the knee-joint. Synovial disease, especially "villous arthritis," may also produce symptoms closely resembling those of detached cartilage.

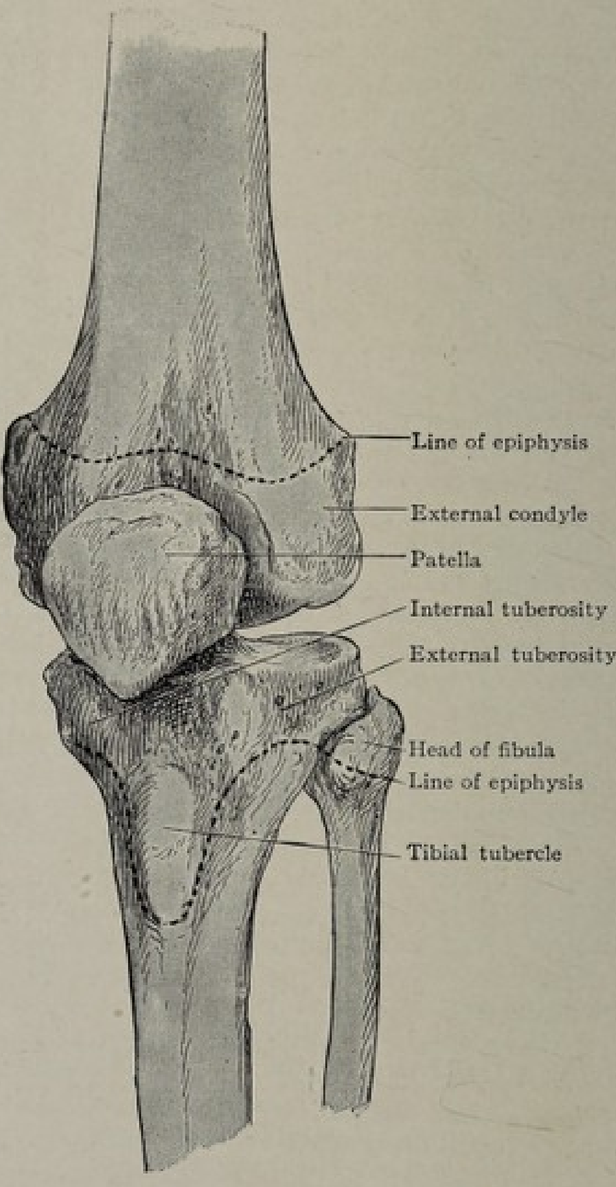


Fig. 597.—Antero-external view of the bones of the knee, showing the lines of the epiphyses.

Epiphyseal Separations.—The epiphyseal line marking the lower epiphysis of the femur starts at the adductor tubercle, at the upper edge of the internal condyle, and passes across transversely just above the edge of the articular surface. It joins with the shaft between the twentieth and the twenty-second year, sometimes as late as the twenty-fourth. The epiphysis of the tibia runs transversely across the tibia about 1.5 cm. (5/8 in.) below the articular surface and anteriorly passes down to embrace the tubercle (Fig. 597).

These epiphyseal separations are produced either by direct violence, by force applied laterally, or by twisting—a common way is for the leg to be twisted by being caught between the spokes of a revolving wheel. They never occur later than the age of twenty years and usually occur several years before that age has been reached.

Often the displacement is not serious and is corrected before the patient is seen by the surgeon. Occasionally, especially when the lower epiphysis of the femur is affected, displacement is marked, and the fractured surface of the fragment may be on the anterior surface of the shaft of the femur. Sometimes the injury is compound and the vessels so injured that amputation is required.

In spite of the fact that the greater part of the growth of the lower extremity occurs from the bones adjacent to the knee-joint epiphyseal separations almost never interfere with it. This is so true that epiphysiolysis or the deliberate separation of the lower epiphysis of the femur by bending the knee laterally over the hard edge of a table is the preferred operation with some surgeons for the correction of lateral deformities of the knee, especially knock-knee. The injury is usually treated as a simple fracture and heals without incident.

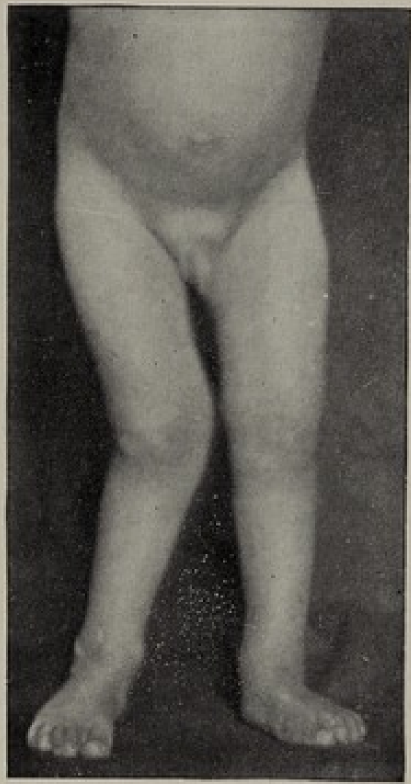


Fig. 598.—Knock-knee or genu valgum.

Resection of the Knee.—In making the skin incision care should be taken to carry it back sufficiently far to allow of division of the lateral ligaments; in so doing, however, one should not divide the long saphenous vein and nerve at the posterior edge of the internal condyle. It is essential to recognize the joint-line; it is just below the lower edge of the patella and thence extends laterally about a finger-breadth above the head of the fibula. It is customary to carry the incision from near the posterior edge of the femur on the inner side to the posterior edge on the outer side at the joint-line, passing over the middle of the tendo patellæ so as to allow this latter to be readily sutured later if desired.

Care is to be taken to avoid wounding the popliteal artery. This lies close to the posterior part of the capsule; hence the latter is not to be divided transversely but is to be separated by keeping the knife close to the bone. Finally, inasmuch as the bulk of the growth of the lower extremity occurs in the upper end of the tibia and lower end of the femur, it is essential to avoid removing the entire epiphyseal cartilages. For this reason formal resections have been abandoned in young children, and in adolescents as little tissue as possible is removed. The epiphyseal line in the femur runs transversely on a line with the adductor tubercle and passes close to the upper edge of the articular surface. The epiphyseal line in the tibia lies rather close to the articular surface, being 1.5 cm. (5/8 in.) below in adults and less in children; it slopes down in front to embrace the tibial tubercle (see Fig. 597). When the disease encroaches on the epiphyseal line, rather than remove it the affected parts are to be curetted away and the remainder left. In those cases where the knee is much contracted, either enough of the bone must be removed to allow of straightening or the hamstring tendons must be cut; if this latter is done the external popliteal nerve which runs on the inner posterior surface of the biceps tendon must not be wounded.

Tuberculous Disease of the Knee-Joint.—The disease begins usually in the epiphyses adjacent to the joint and involves the joint secondarily. The tibia is more frequently the seat than the femur. The swelling and hypertrophy of the synovial membrane and involvement of the adjacent soft parts obliterate the hollows on each side of the patella and cause a bulging below the patella. The knee looks round and swollen and the condition was formerly called white swelling from the surface being white in color. If liquid accumulates in the joint it becomes distended and flexed, assuming an angle of 120 degrees. The patella is raised from the condyles; it "floats" and if depressed by the finger can be felt striking on the femur beneath, thus demonstrating the presence of liquid in the joint. The swelling extends above the patella to an extent depending on whether or not the subfemoral bursa is involved and whether or not it communicates with the joint.

If pus forms it tends to find an exit beneath the lower edge of the posterior ligament or on either side of the patella at the upper end of the tibia. As the disease progresses the ligaments become weakened. The joint, being already flexed at approximately 120 degrees, is flexed still more by the hamstring muscles, and the head of the tibia in old cases becomes drawn backward in a position of subluxation (see Fig. 553, page 586). The pull of the biceps tendon while the leg is flexed rotates the leg outward and this position may persist: a condition of knock-knee is also sometimes marked.

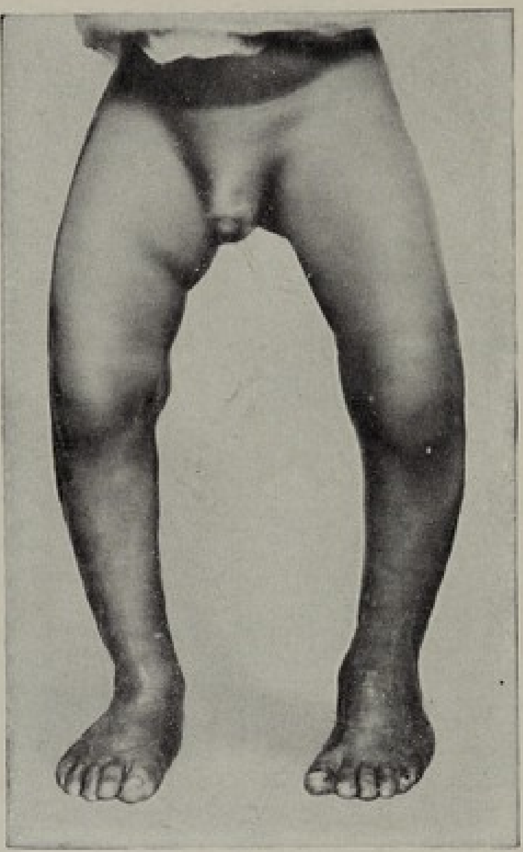


FIG. 599.—Bow-legs.

The disease is as a rule treated conservatively by apparatus, but in exceptional cases the lesser operation of erasion or the greater of resection of the joint must be done.

Knock-knee and Bow-legs.—These conditions most frequently result from rachitis or paralysis. Bowing inward of the knee is called knock-knee or genu valgum. Bowing outward is called bow-legs or in some instances, when the deformity is in the joint, as when the condyles are unequal in length, genu varum.

Knock-knee (Genu Valgum).—This condition has its point of bending most marked at the knee-joint. When caused by rickets the joint surfaces are often not much altered and the deformity is produced by a bending of the tibia or femur close to the joint; hence when an osteotomy is performed just above the condyles of the femur the joint is again brought level and resumes its functions normally (Fig. 598).

When deformities of the foot or the malpositions due to paralyses produce knock-knee, then often a certain amount of flexion and external rotation of the leg coexist with perhaps lengthening of the internal condyle. In these cases osteotomy of the femur must often be supplemented or substituted by suitable apparatus, operations on the foot, etc.

Bow-legs.—This is almost always caused by softening of the bones, as in rickets. The bending occurs in the bones of both the leg and thigh, and the location of the point of greatest bending is sometimes low down toward the ankles or close up to the knee-joint, or the whole diaphysis of the bones may be curved. They are often curved anteroposteriorly as well as laterally (Fig. 599).

When the point of greatest bending is close to the knee-joint it has been called genu varum, but the condyles remain of equal length and the epiphyseal line still remains parallel with the joint line.

As knock-knees and bow-legs so commonly occur in the activity growing period, from the second to the fifth year, apparatus is often of benefit, but frequently forcible straightening by means of an osteoclast or by the hand or epiphysiolysis (see page 625) or osteotomy is resorted to for their correction.

Osteotomy.—In osteotomy of the femur the bone is to be divided, as advised by Macewen, a finger-breadth, at least, above the adductor tubercle and 1.25 cm. (½ in.) in front of the adductor magnus tendon. In knock-knee many surgeons prefer dividing the bone from the outside of the limb instead of the inside as advised by Macewen. This incision avoids the epiphyseal line, which is opposite the adductor tubercle, and also the anastomotica magna and superior articular arteries. The popliteal vessels are also to be avoided by knowing their position and not directing the osteotome toward them. In performing osteotomy of the bones of the leg the tibia is to be divided by the aid of the chisel, and the fibula is to be broken by manual force. Wedge-shaped resections of bone are commonly not to be advised.

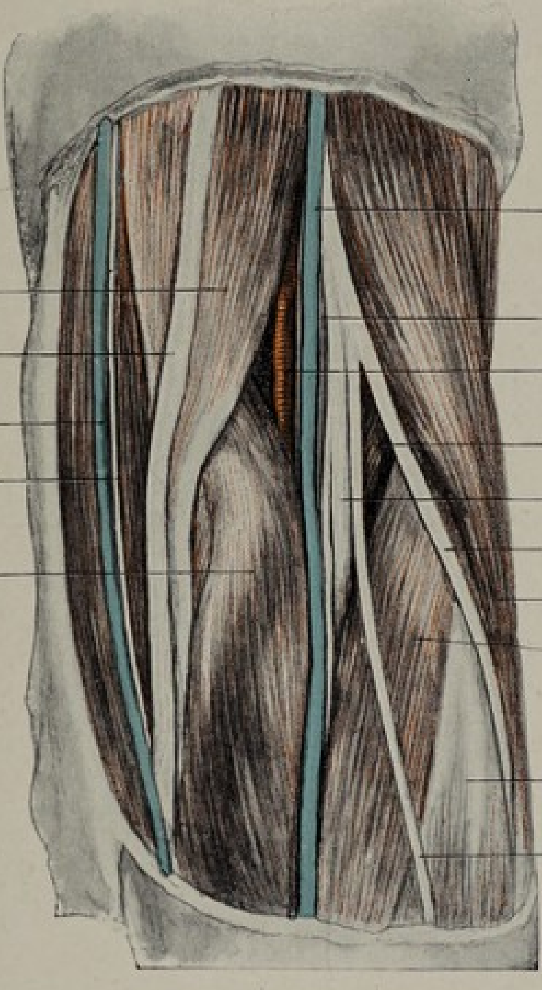


Fig. 600.—The popliteal space.

They are difficult to do, liable to complications, and, under the most favorable circumstances, are very long in healing and do not give any better results than simple osteotomy or osteoclasis.

Ligation of the Popliteal Artery.—In the *middle* of its course the popliteal artery lies deep between the condyles of the femur and on the posterior capsule and gives off the articular arteries. For these reasons ligation in this part of its course is not performed. To ligate it in the *upper part* of its course an incision is to be made along the outer edge of the semimembranosus muscle near the middle of the upper part of the popliteal space. The muscle being drawn inward the internal popliteal nerve is first seen and drawn outward, then the vein beneath is also drawn outward and the artery found beneath and a little to the inner side. Don't mistake the semitendinosus for the semimembranosus. The former is a round tendon, the latter is muscular. Another method consists in making the incision immediately behind the adductor magnus tendon. The semimembranosus and semitendinosus are then to be drawn backward and the artery located by its pulsation and the aneurism needle passed from within out. The nerve and vein, being more to the outer side, are not disturbed (Fig. 600).

To ligate the popliteal artery in its *lower third,* make an incision in the midline between the heads of the gastrocnemius muscle, avoiding the short saphenous vein and nerve. Open the deep fascia, draw the internal popliteal nerve to the inner side, the popliteal vein to the outer side, and pass the needle from without in. Flexing the knee will relax the gastrocnemius and enable the artery to be more readily exposed.

Amputation through the Knee-joint.—Disarticulation at the knee-joint is usually done either with a long anterior and short posterior or two lateral flaps. This amputation differs from others in the fact that a large rounded mass of bone—the condyles—with no muscles is to be covered by the flap. Therefore the flaps must be ample and if they are not a piece of the femur must be resected. The internal condyle is larger and projects more than the external. The cicatrix is drawn posteriorly by the hamstring muscles and the resultant stump is good for pressure bearing.

If possible the semilunar cartilages should be left on the femur, the incision for disarticulation being made between them and the tibia. The object of so doing is to prevent the retraction of the soft parts and the resultant protrusion of the bone. The extremities of the incision should be well back, so that the lateral ligaments can be readily divided, and should not extend higher than the edge of the tibia. If infection follows, pus may collect in the suprapatellar (subfemoral) bursa.

Stokes-Gritti Amputation.—In this operation (Fig. 601) a large anterior flap and a short posterior is used. The anterior flap is dissected up so as to include the patella. The soft parts are divided by a circular cut of the knife and the femur is divided just above the femoral condyles. The cartilaginous portion of the patella is removed with a saw and the remainder of the patella is fixed to the lower end of the femur.

THE LEG

The leg having to support the weight of the body has its bones strongly made. The tibia bears nearly all the weight because it articulates with the femur above and astragalus below and transmits the pressure directly from one to the other. The fibula is slight compared to the tibia and lies posterior to it and to the outer side.

The leg bones receive the insertion of the thigh muscles above and give attachment to the muscles which move the foot. The leg therefore is capable of being influenced by the movements of the foot below and the thigh above.

SURFACE ANATOMY

At the upper end of the leg can be felt the two tuberosities of the tibia. The lower edge of the tuberosities is on a line with the upper edge of the tubercle.

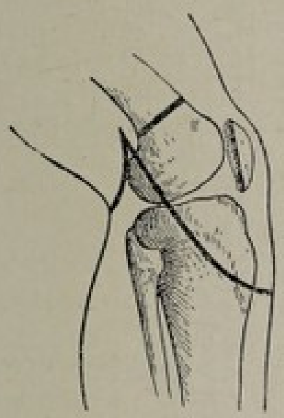


FIG. 601.—Stokes-Gritti amputation, showing incision in the soft parts and the lines of section in the femur and patella.

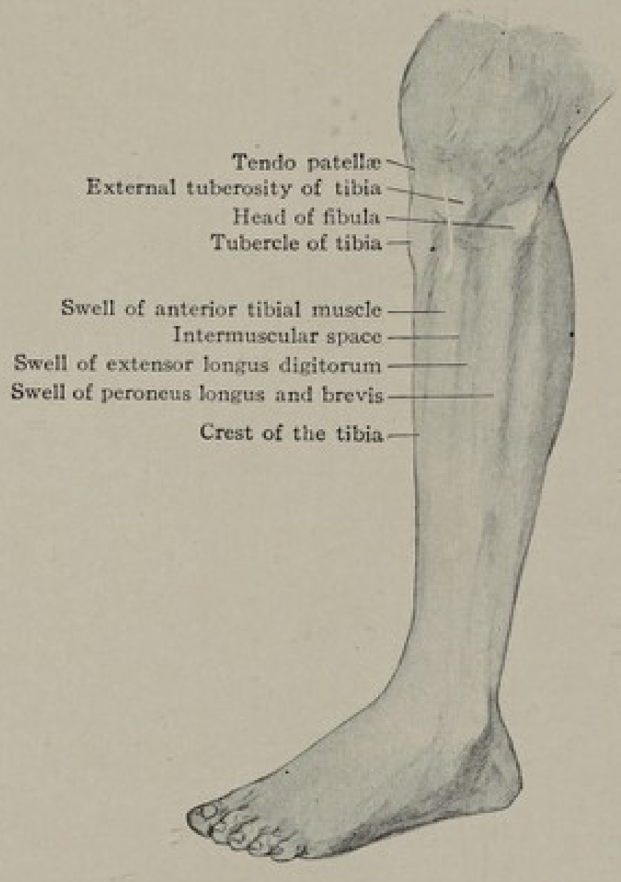


FIG. 602.—Surface anatomy of the leg.

The head of the fibula is almost level with (a little above) the tubercle of the tibia and is situated far posteriorly. Attached to the head of the fibula above is the biceps tendon accompanied by the external popliteal (fibular) nerve and the long external lateral ligament. The tendo patellæ is attached to the tibial tubercle. The tibia is triangular in shape, with a sharp edge—the crest or shin—forward, thus forming two surfaces, an internal and an external. The posterior surface is covered by muscles and is inaccessible. The internal surface is subcutaneous and leads down to the internal malleolus. The external surface has the extensor muscles between it and the fibula. The fibula a short distance below its head becomes covered by the

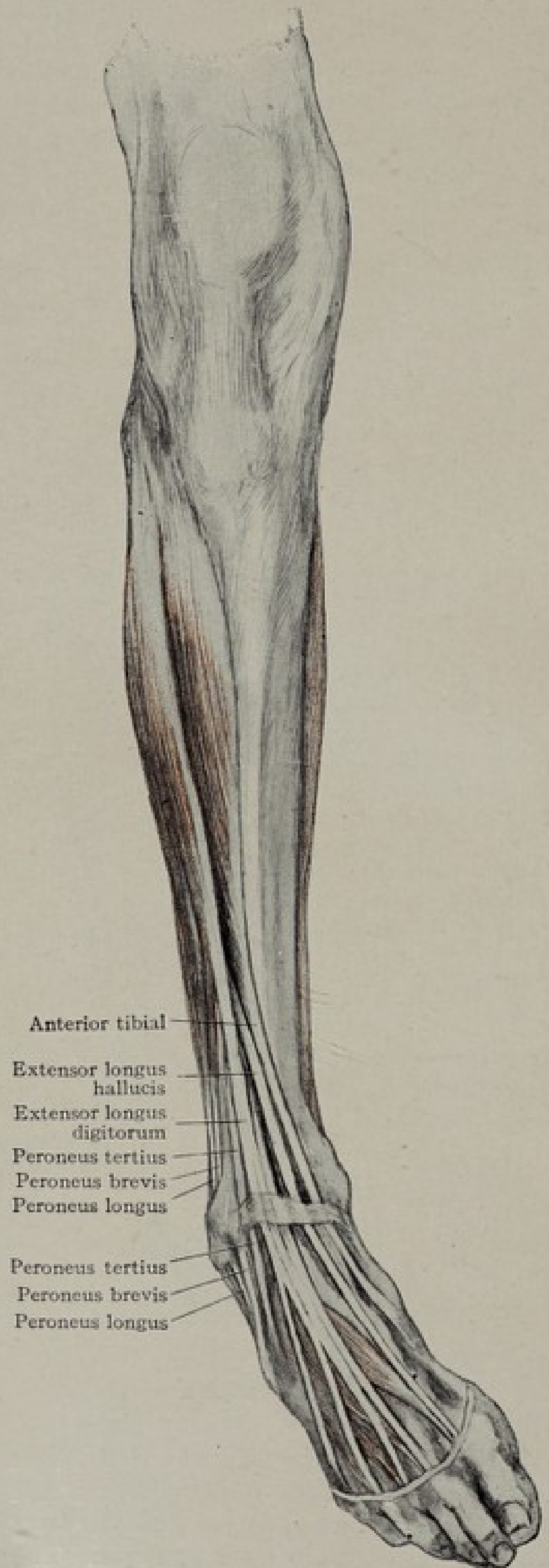


FIG. 603.—Extensor and abductor muscles of the leg.

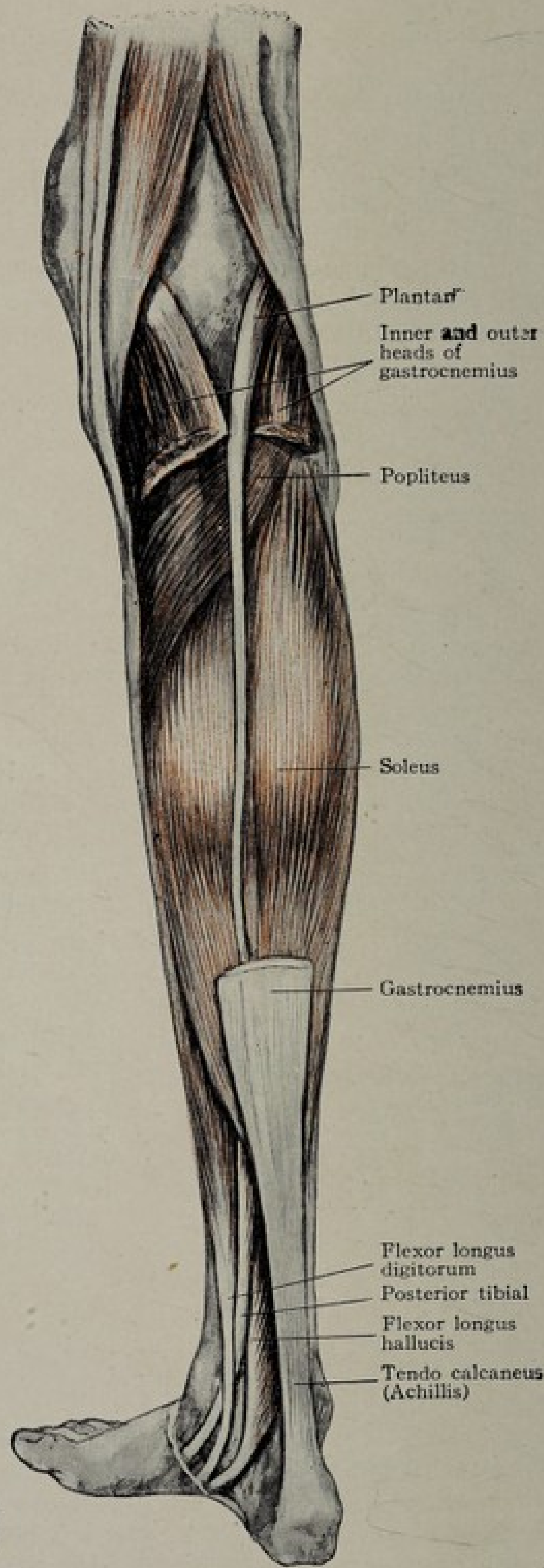


FIG. 604.—Flexors and muscles of the calf of the leg.

peronei muscles and only becomes subcutaneous in its lower anterior fourth. The upper portion of the leg is largely muscular, but at its lower portion it is mainly tendinous. By placing a finger over the muscles while the foot is moved one is enabled to determine whether or not they are paralyzed (Fig. 558).

MUSCLES OF THE LEG

The muscles of the leg are composed of four distinct groups of three each. They are *extensors, flexors, abductors,* and *muscles of the calf.*

The **extensor group** comprises the *tibialis anterior, extensor digitorum longus,* and *extensor hallucis longus.*

The **flexor group** comprises the *tibialis posterior, flexor digitorum longus,* and *flexor hallucis longus.*

The **abductor group** comprises the *peroneus longus, peroneus brevis,* and *peroneous tertius.*

The **calf muscles** comprise the *gastrocnemius, soleus,* and *plantaris.*

It will thus be seen that the extensor and flexor groups are composed of precisely similar muscles only on opposite sides of the leg. They tend to move the foot and toes forward and backward and balance each other. The abductors form a group around the fibula on the outer side of the leg and they abduct the foot. They tend to pronate it. The most active agents in adduction are the tibialis anterior and tibialis posterior. The muscles of the calf form a separate posterior group designed for use in walking and to compensate for the greater length of the foot anterior to the centre of motion at the ankle and its shortness posteriorly.

The extensor group lies between the tibia and fibula anterior to the interosseous membrane. The abductor group forms a mass over the fibula, and the flexor group lies between the tibia and fibula on the posterior surface of the interosseous membrane. The muscles of the calf constitute a superficial layer of muscles which end below in the tendo calcaneus (Achillis). The soleus, with the two heads of the gastrocnemius, is known as the triceps suræ muscle. It is absolutely essential to understand the grouping of these muscles of the leg because thereby its construction is rendered evident and their influence on distortions of the foot can be appreciated.

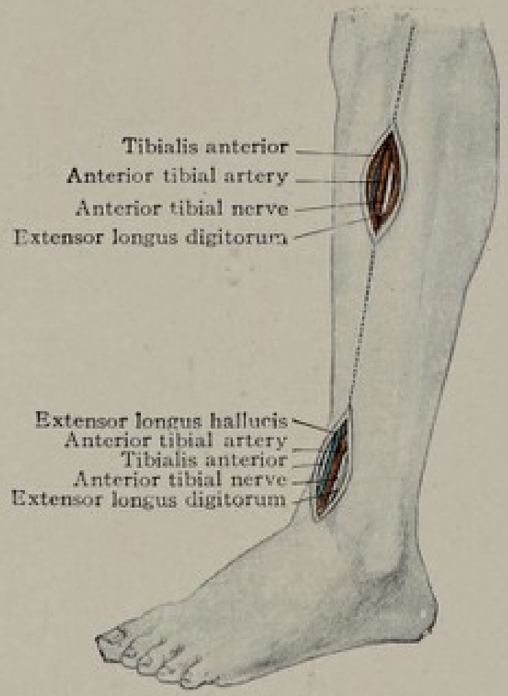


Fig. 605.—Ligation of the anterior tibial artery in its upper and lower thirds.

FASCIA OF THE LEG

The deep fascia of the leg is attached above to the tubercle of the tibia, the tuberosities of the tibia, and the head of the fibula. It is in reality a continuation of the fascia lata of the thigh. It gives off two septa from its under surface, one in front separating the abductor or peroneal group from the extensor group, and another posterior which separates the abductor group from the soleus posteriorly. This latter covers the deep flexors and separates them from the muscles of the calf and is continued across to be attached to the medial (internal) edges of the tibia. The deep fascia of the leg blends with the periosteum over the medial (internal) surface of the tibia and also with that of the lateral (external) surface of the fibula in its lower fourth. At the ankle the deep fascia is continued on through the annular ligaments.

The muscles of the leg take their origin partly from these fasciæ, and subsidiary septa pass between the muscles.

ARTERIES OF THE LEG

The leg has three main arteries, the *anterior tibial, posterior tibial,* and *peroneal.* The popliteal artery divided into the anterior and posterior tibial at the lower border of the popliteus muscle just below the lower edge of the tibial tubercle.

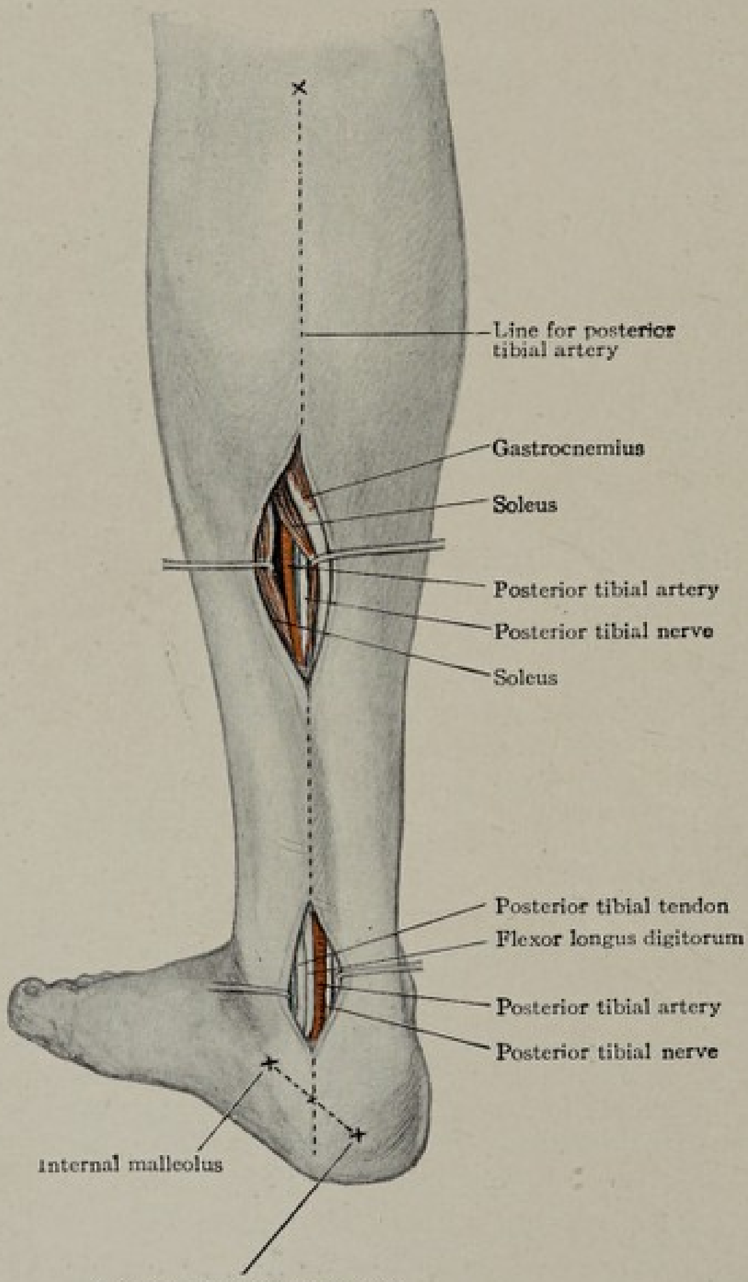


FIG. 606.—Ligation of the posterior tibial artery.

Two and a half cm. (1 in.), or a little more, below the edge of the popliteus muscle the peroneal artery is given off from the posterior tibial.

The Anterior Tibial Artery.—*Ligation.*—The line of the anterior tibial artery may be taken as from just internal to the head of the fibula to a point on the front of the ankle midway between the malleoli. The anterior tibial artery pierces the interosseous membrane, but the anterior tibial nerve winds around the head of the fibula and joins the artery 5 to 7 cm. (2 to 3 in.) or more lower than on its outer side. Injury to this vessel is a frequent cause of non-union after fracture of the lower end of the tibia.

In the Upper Third.—The artery lies between the tibialis anterior and the extensor longus digitorum muscles. This interspace is better recognized by touch than by sight, though a yellowish line of fat or the presence of some small vessels may indicate its position. The tendency is to make the incision too close to the tibia. This mistake will be avoided if the line of the artery has been marked and the incision made in it. After separating the muscles, the outer edge of the tibia can be felt and on the membrane close to it is the artery with venæ comites to each side and the nerve farther out. The needle is passed from without inward, and the veins may be included because they are so firmly bound to the artery and membrane as to be separated only with difficulty (Fig. 605).

In the Middle Third.—The incision having been made in the line of the artery, the septum between the tibialis anterior and extensor digitorum longus is usually visible as a depressed line. Flex the foot to relax the tendons, and on drawing the extensor digitorum outward the upper part of the extensor hallucis longus is seen, it also is drawn outward and the artery is found lying on the membrane with the nerve in front of it.

In the Lower Third.—Here, above the flexure of the ankle, the artery lies on the tibia between the tibialis anterior and the extensor hallucis longus. The nerve is to its outer or inner side or in front of the artery. Flexing the foot allows the tendons to be more readily separated, and movement of the foot and big toe will assist in identifying the muscles.

Posterior Tibial Artery.—*Ligation.*—The line of the posterior tibial artery is from the middle of the popliteal space to the middle of the line joining the internal malleolus and internal tuberosity of the calcaneus (os calcis); at this latter point it divides into the internal and external plantar arteries (Fig. 606).

In the Middle of the Leg.—The incision should be made 2 cm. (¾ in.) behind the edge of the tibia, avoiding the long saphenous vein. If the edge of the gastrocnemius comes into view draw it outward, incise the soleus muscle through its entire thickness, dividing the tendinous fibres in the body of the muscle. Separate the edges of the incision and seek for the artery on the obliquely running fibres of the flexor digitorum longus muscle. The nerve is to its outer side. The artery lies directly over the outer edge of the tibia, which can be felt with the finger. It is covered with a thin fascia. The ligature is passed from without inward.

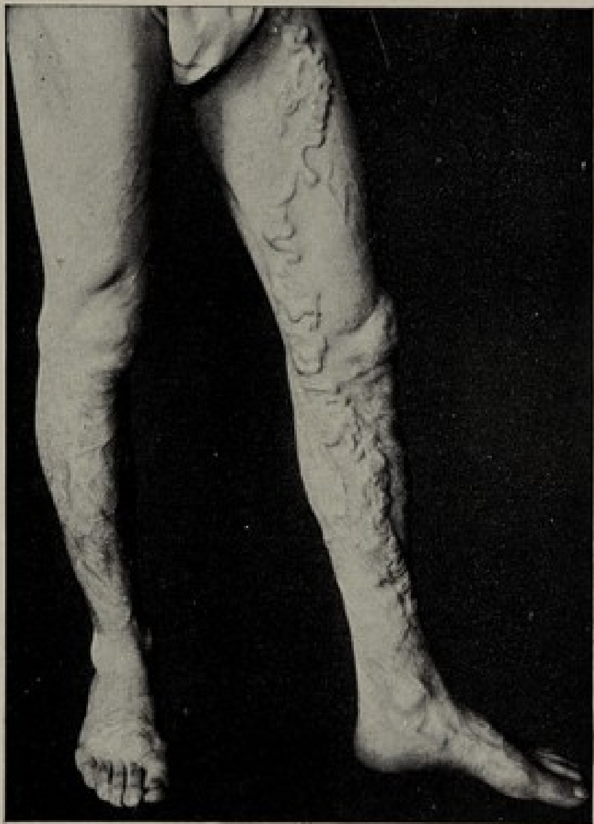


Fig. 607.—Varicose veins, affecting especially the internal or long saphenous vein.

Low Down in the Leg.—The incision may be made midway between the inner edge of the tibia and the edge of the tendo calcaneus (Achilles). The artery lies beneath the deep fascia on the flexor digitorum longus muscle with the nerve to the outer side. The muscle has fibres as low down as the malleolus and the artery is to the outer side of its tendon. If the artery is sought behind the ankle then it has the tendons of the tibialis posterior and flexor digitorum longus in front of it. Care should be taken that the main trunk is ligated and not one of its plantar branches in case of a high division. The relation of the structures posterior to the internal malleolus are tibialis posterior, flexor digitorum longus, vena comite, posterior tibial artery, vena comite, posterior tibial nerve, flexor hallucis longus.

Peroneal Artery.—The peroneal artery is given off from the posterior tibial 2.5 cm. (1 in.) below the lower edge of popliteus muscle. It follows the inner edge of the fibula beneath or in the fibres of origin of the flexor longus hallucis. If it is desired to ligate it, the incision is to be made over the inner edge of the fibula, the edge of the soleus is drawn inward, the fibres of the flexor longus hallucis divided, and the artery found at the junction of the inner edge of the fibula and interosseous membrane. At the lower extremity of the interosseous membrane the artery pierces it to be distributed to the outer anterior portion of the arsus and ankle.

VEINS OF THE LEG

The deep veins of the lower extremity accompany the arteries. The femoral and popliteal veins are single, but the arteries below have venæ comites. These deep veins all have valves and there are frequent communications with the superficial veins.

On the dorsum of the foot is a venous arch which unites with the inner dorsal digital vein to form the commencement of the internal or long saphenous vein. The outer extremity unites with the outer dorsal digital vein to form the commencement of the external or short saphenous vein.

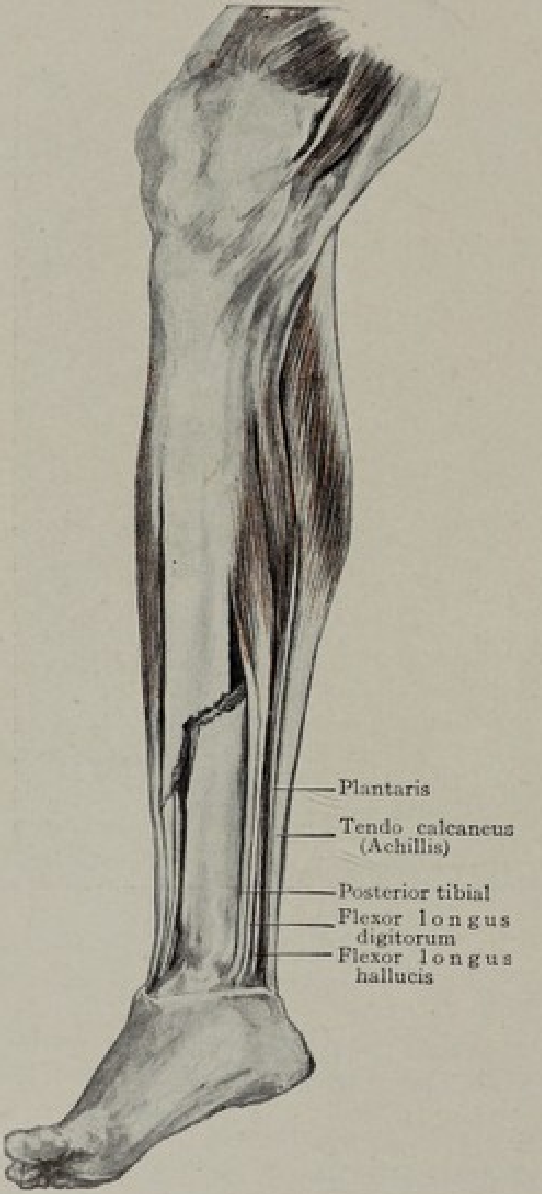


Fig. 608.—Fracture of the tibia with displacement of the upper fragment forward and lower fragment backward and upward.

The **internal** or **long saphenous vein** begins just in front of the internal malleolus, ascends on the inner surface of the tibia, passes along the posterior border of the internal condyle and thence up to the saphenous opening. In the leg it communicates with the deep anterior and posterior tibial and external saphenous veins and in the thigh with the femoral. At or near the saphenous opening it receives the external superficial femoral vein from the outer anterior surface of the thigh and the internal superficial femoral vein from the inner posterior portion of the thigh. Not infrequently one of these lateral branches may be almost as large as the internal saphenous itself and may be mistaken for it. From the knee down the internal saphenous vein is accompanied by the internal (long) saphenous nerve.

The **external** or **short saphenous vein** begins behind the external malleolus, ascends alongside the tendo calcaneus (Achilles), thence over the gastrocnemius to empty into the popliteal vein. Its branches anastomose with those of the internal saphenous on the inner side of the leg and it communicates through the deep fascia with the deep veins. It is accompanied by the external saphenous nerve.

Varicose Veins of the Leg.—A varicose condition of the veins of the leg is very common. In these cases the superficial veins, especially the internal saphenous and its branches, become lengthened, dilated and tortuous. Often the cause cannot be ascertained, but not infrequently pelvic tumors, and especially pregnancy, produce the condition by obstructing the blood-current. These may be contributing factors but the basis of the condition is to be found in an inherited weakness, of the vein wall, or to some irregularity in the arrangement of the valves. As exciting causes can be named any condition which leads to distention of the vein. The veins become distended and the valves, of which there are many, become insufficient. This destroys the valvular support of the blood column and the veins become tortuous and inflamed, the walls thicken and may become adherent to the skin. The walls in places give way, causing hemorrhages. They may become thin and sacculated and thrombi may form and suppurate. In the treatment of varicose veins, operative procedures have been reserved for those cases in which failure has resulted after the effort has been made to obliterate the varicose veins by the injection of sclerosing agents. In certain cases canalization of the thrombus formed by these agents will occur particularly if the internal saphenous is very large in the thigh. In these cases ligation of the internal saphenous vein near the saphenous opening may suffice; if not the internal saphenous is to be excised by stripping with a vein stripper and the tortuous veins of the leg excised to assure a permanent cure. Such procedures as the Schede and Trendelenburg operations are rarely performed at this time. The danger of embolism by the injection method is exceptionally rare as it has been shown that the circulation in a varicose vein is downward and an embolus would be obstructed by the small communicating veins before entering the deep group of veins. (Fig. 563.)

A varicose condition of the veins of the leg is a causative factor in chronic leg ulcer; hence, in order to cure it, the necessity of elevating the limb in its treatment, and the treatment of the veins as described above.

LYMPHATICS OF THE LEG

Sometimes there are one or two lymphatic nodes at the upper extremity of the anterior tibial artery but usually the first to be encountered are around the popliteal vessels,—below that point are only lymphatic radicles or vessels.

FRACTURES OF THE LEG

Fractures of the bones of the leg are most often due to direct violence, but sometimes to indirect. The tibia is rarely broken alone, but either it or the fibula may be fractured by a direct blow. On account of the tibia being subcutaneous these fractures are frequently compound. The shafts of the bones, being of compact tissue, are usually broken obliquely. When the fibula is broken above its lower fourth there is usually little displacement because the attached muscles hold it in place.

Fractures of the tibia whether accompanied or not by fracture of the fibula most often occur at the junction of the middle and the lower thirds. The line of fracture is downward, forward, and inward. The displacement of the lower fragment is backward, upward and slightly outward. It is produced mainly by the muscles of the calf pulling on the tendo calcaneus (Achillis). The upper fragment is pulled forward by the quadriceps femoris (Fig. 608).

The difficulty usually encountered in treatment is a persistent projecting forward of the upper fragment with a drawing up and turning outward of the lower fragment and foot. The displacing action of the tendo calcaneus (Achillis) is more powerful than that of the quadriceps. On this account the first attempt at correction should be to place the leg in the "Pott's position." This consists in flexing the knee to a right angle and placing the leg on its outer side. This relaxes the gastrocnemius and plantaris and is sufficient in some cases to allow of the displacement being remedied. If this fails extension may be tried with skeletal traction or tenotomy of the tendo calcaneus should be done and the fragments will at once come into good position.

Woolsey has pointed out that the weight of the foot tends to its outward displacement but another reason is that the insertion of the tendo calcaneus is not beneath the middle of the ankle-joint but more towards its outer side, so that when it contracts it carries the foot outward. The flexor and extensor muscles of the leg balance each other, but the peronei muscles on the outer side have no additional corresponding opponents on the inner side; hence another reason for displacement of the foot and lower fragment outward.

Fractures of the head of the fibula may injure or sever the peroneal nerve. Partial or complete paralysis of this nerve may also result from pressure, the nerve being caught within the callus during the healing of such a fracture.

AMPUTATION OF THE LEG

Amputation of the leg is best performed at the place of election, a hand's breadth below the knee-joint. This site is preferred because it gives a sufficient length to the stump below the knee and allows sufficient space below for the instrument maker to place the mechanism of the artificial leg which operates the foot. The sharp projecting edge of the crest of the tibia tends to produce ulceration of the tissues or skin in front of it, therefore it is to be cut off obliquely.

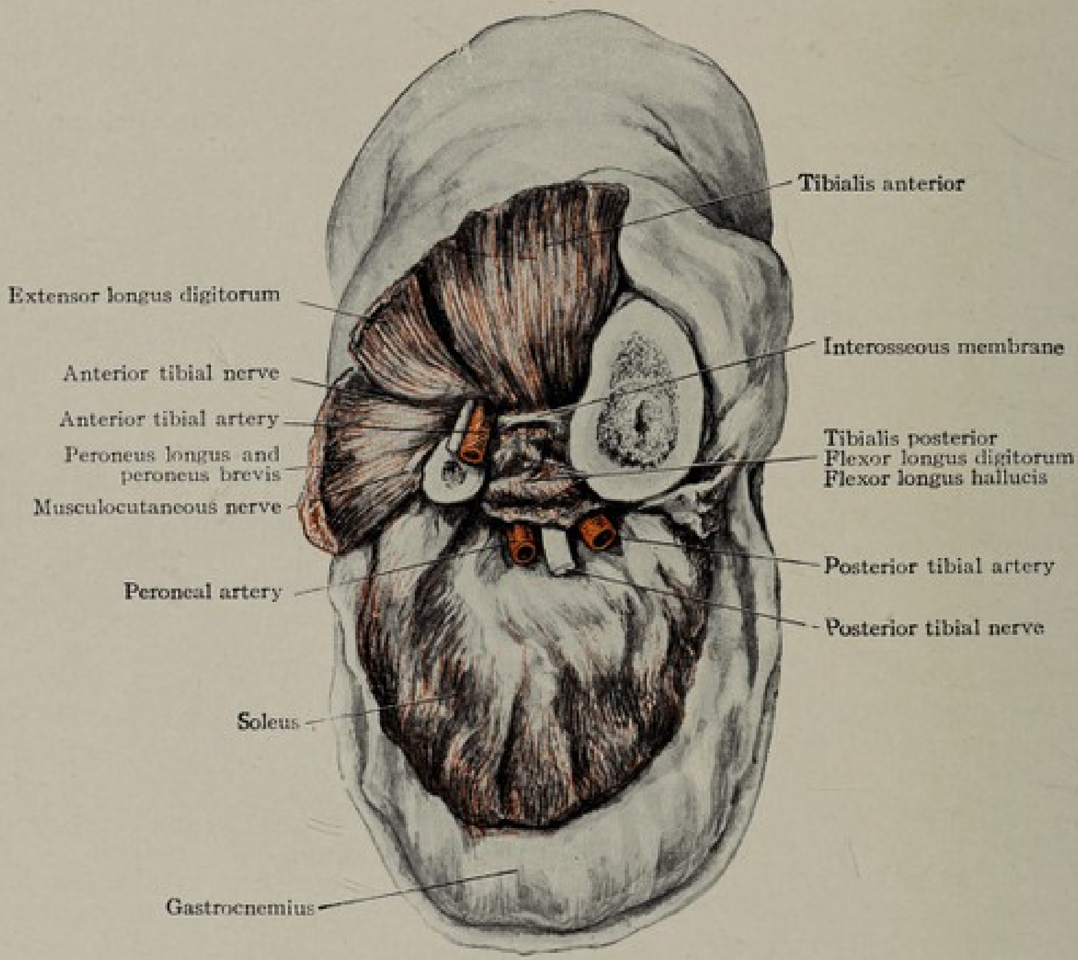


FIG. 609.—Amputation of the upper third of the leg.

The fibula, if divided at the same level as the tibia and especially if antero-posterior flaps are used, tends to project too prominently on the outer side, hence it is preferable to divide it at a higher level than the tibia.

The anterior tibial artery is to be sought for on the interosseous membrane close to the tibia with its nerve to the outer side.

The posterior tibial and peroneal are at the same level on the tibialis posterior muscle with the posterior tibial nerve lying superficial to the posterior tibial artery. (Fig. 609).

REGION OF THE ANKLE

The ankle-joint is composed of the tibia and fibula above and the astragalus below.

Surface Anatomy.—A knowledge of the contour of the ankle aids considerably in determining the character of its diseases and injuries. The malleoli form prominences with distinct hollows above and below them. The sharp anterior edge of the tibia if followed down leads to the tibialis anterior tendon. On the medial (inner) side the malleolus is large and flat. It is subcutaneous and can be readily

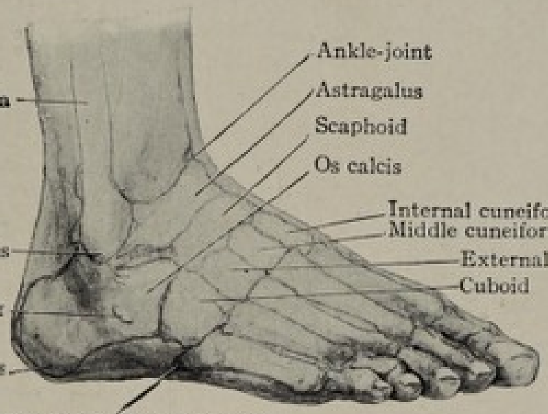


Fig. 610.—Surface anatomy of the outer side of the ankle.

palpated. At its interior edge is the commencement of the internal saphenous vein which runs up and slightly back to reach the posterior edge of the tibia 5 to 6 cm. (2 to 2½ in.) above the tip of the malleolus. About 4 cm. (1½ in.) below and in front of the internal malleolus is the prominent tubercle of the scaphoid.

The external malleolus is small and somewhat pointed, and is placed a finger-breadth below and behind the level of the internal malleolus. For a distance of

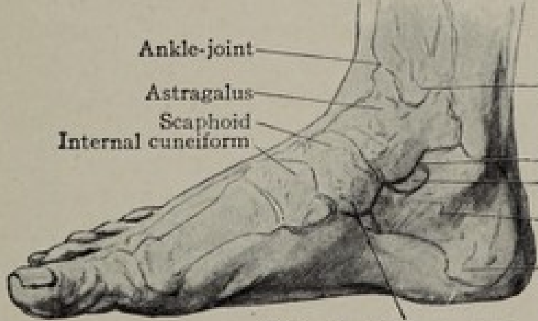


Fig. 611.—Surface anatomy of the inner side of the ankle.

about 7.5 cm. (3 in.) above its tip the fibula is subcutaneous and readily palpated. It is here that it is most often fractured. The transverse line of the joint is level with the upper limit of the swell of the internal malleolus—about 2.5 cm. (1 in.) above the tip of the external malleolus. The ankle is covered in front and behind by tendons, most of which, especially in thin people, can be felt and seen when they are put on the stretch. Anteriorly the innermost tendon is the tibialis anterior, next the extensor longus hallucis, and then the extensor longus digitorum. Sometimes close to the uter side of the extensor of the little (fifth) toe the contraction of the peroneus tertius tendon can be felt as it goes to be inserted into the fifth metatarsal bone near its base. Running directly downward along the posterior edge of the external malleolus and fibula are the peroneus longus and brevis tendons, the former being the more superficial. About 2.5 cm. (1 in.) below and a little in front of the external malleolus is the peroneal tubercle of the calcaneum; the peroneus brevis passes in front of it to be inserted into the prominent tuberosity of the fifth metatarsal bone. The long tendon passes behind the tubercle, winds around the cuboid, and crosses the sole to insert into the internal (first) cuneiform and base of the first metatarsal bone.

FIG. 612.—The upper articular surface of the astragalus, showing it to be slightly concave and one fourth wider in front than behind.

Posteriorly the tendo calcaneus (Achillis) is large and prominent—along the anterior edge of its lateral (external) side run the external (short) saphenous vein and nerve. Running upward from the posterior border of the internal malleolus the tibialis posterior tendon can sometimes be seen and felt. Posterior to it runs the flexor digitorum longus muscle, then the posterior tibial artery, accompanied by venæ comites, then the posterior tibial nerve, and lastly the flexor hallucis longus. The artery can be felt pulsating midway between the endo calcaneus and the internal malleolus. The anterior tibial artery can be felt pulsating to the lateral (outer) side of the extensor hallucis longus.

THE ANKLE-JOINT

Ligaments and Movements.—The ankle-joint is a pure hinge-joint and its motion is anteroposterior except in complete extension, when a small amount of lateral movement is possible. The range of movement is 80 degrees; 20 degrees flexion, and 60 degrees extension.

The tibia and fibula above articulate with the surface of the body of the astragalus below. The articular facet for the fibula is about twice as long from above downward as is that for the internal malleolus. The hollow below the internal malleolus is filled by the internal lateral (deltoid) ligament and the tendon of the tibialis posterior. The inferior tibiofibular joint is sometimes practically lacking, there being almost no continuation of the ankle-joint up between the tibia and fibula. The junction of these two bones is very strong, the ligaments being an anterior, posterior, interosseous, and a transverse inferior tibiofibular ligament which passes across the back of the ankle-joint reinforcing the posterior portion of the capsular ligament. The upper surface of the astragalus is one-fourth wider in front than behind, so that in extension it is not so firmly locked between the malleoli as in flexion (Fig. 612). Its upper surface is slightly concave. Flexion and extension take place on a transverse axis passing through the body of the astragalus at the tip of the external malleolus. This axis is not exactly transverse but is slightly oblique, so that on extension the foot is pointed slightly outward. The ankle has a capsular ligament which is very thin in front and behind the joint. Posteriorly it is reinforced above by the transverse inferior tibiofibular ligament. The flexor hallucis longus also supports it posteriorly. The internal (deltoid) and external lateral ligaments are strong, the internal being the stronger. The internal lateral or ligamentum deltoideum runs from the malleolus above to the scaphoid (navicular), astragalus (talus) and calcaneum below. It is crossed on its surface by the tendons of the tibialis posterior and flexor digitorum longus muscles (Fig. 613).

The external lateral ligament has three fasciculi: an anterior one to the astragalus; a middle one to the side of the calcaneum, and a posterior one to the posterior part of the astragalus (Fig. 614). In both extreme flexion and extension the edges of the tibia come in contact with the astragalus and hence limit further movement. The ligaments also aid in restricting motion.

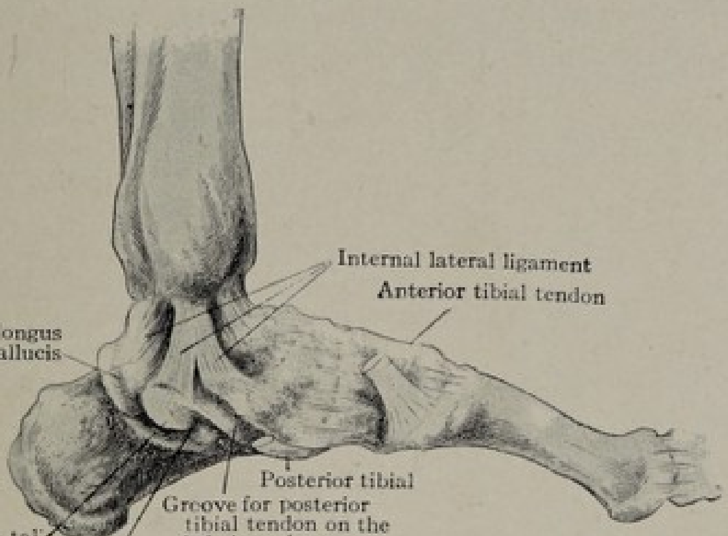


FIG. 613.—View of inner side of ankle-joint, showing the internal lateral ligament.

Distention of the Joint.—Fluid tends to find exit from the joint first anteriorly under the extensor tendons, next it tends to exude posteriorly and makes its appearance as a swelling on each side of the tendo calcaneus (Achillis). The ankle-joint is a comparatively tight one and in acute inflammations holds but little effusion. When injected it assumes the position of a right angle and flexion does not occur as

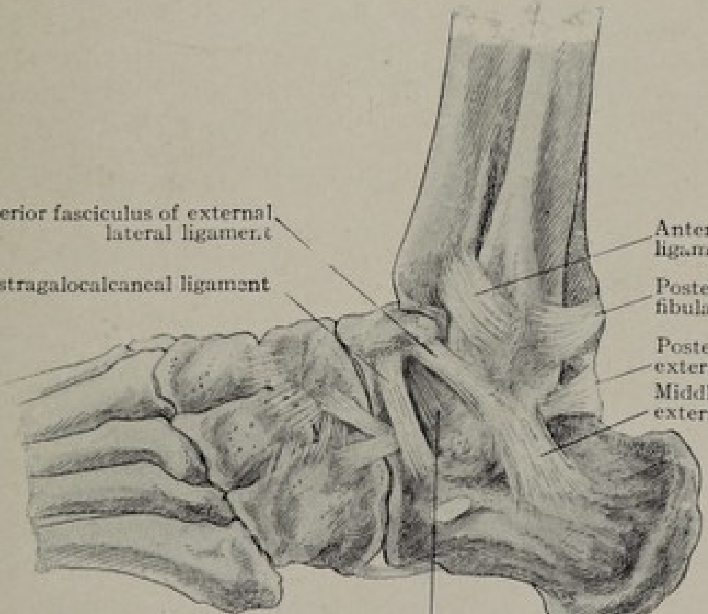


FIG. 614.—Ligaments of the outer side of the ankle.

in other joints (Fig. 615). The rounded appearance of the ankle in tuberculous and other affections is not due so much to effusion within the joint as to inflammatory and tuberculous exudate in the tissues around the joint.

Tuberculosis of the Ankle.—This most often affects the body of the astragalus. Sometimes the disease is located in the lower end of the tibia. In the former case other of the tarsal bones are also frequently involved. In the latter an extra-articular operation on the tibia above the internal malleolus may cure the disease, but the motion in the joint often remains impaired.

Excision of the Ankle.—Formal resections of the ankle are rarely performed. The joint is difficult to expose without extensive division of the tendons and other tissues. It is considered best to enlarge any existing sinuses and curette the diseased bone away.

If it is desired to excise the joint it can be done by König's incisions, one along the anterior edge of the internal malleolus and the other along the anterior edge of the external malleolus. Through these incisions all that is necessary can usually be done.

Fig. 615.—Ankle-joint distended with wax, showing that its capsule is weak anteriorly and posteriorly and strong laterally.

Sprain of the Ankle.—In what is usually called a sprain of the ankle the injury is not always confined to the ankle-joint and its ligaments. It has been shown that in many cases there is a tearing off of small fragments of bone, hence the name sprain-fracture. The ankle-joint has an anteroposterior motion, but the lateral motion of the foot takes place mainly in the subastragaloid joint with some additional movement allowed by the other tarsal joints. Inasmuch as sprains are usually the consequence of a lateral displacement, the resultant injury is frequently in the subastragaloid and sometimes in the adjacent tarsal joints. This condition can be suspected when the pain and swelling is located below and in front of the ankle rather than around the ankle itself. The sprain is more often the result of inversion than of eversion of the foot. In eversion the plantar ligaments are so strong that the foot moves as a whole and the force is transmitted directly to the ankle and leg bones, and most likely results in the production of a Pott's fracture of the fibula with or without a tearing off of the internal malleolus or rupture of the ligamentum deltoideum (internal lateral).

Treatment.—The principle of treatment in sprains is to prevent the ruptured ligaments and strained tissues being again irritated and kept from healing by subsequent movements of the injured parts. A small degree of movement is usually painless and unharmful, but a more extensive, and often accidental, movement causes the pain and disability to persist. The failure to apply an efficient dressing which properly limits motion until the primary effect of the injury has passed is the reason of these disabilities becoming chronic. Sometimes fixed dressings like plaster of Paris or silicate of soda are applied for two weeks. Fixation by adhesive plaster has been found very efficient in the minor sprains, but a more immobile dressing is more satisfactory in the more extensive lesions. Inasmuch as the injury is usually produced by inversion, the plaster is applied especially to prevent inversion and likewise to give general support. Gibney's method consisted in applying alternate narrow strips of adhesive plaster, one set beginning on the inner side of the foot and going well up on the outer side of the leg, and the other running parallel with the sole of the foot from the heel to the dorsum.

Another method consists in taking a long strip of plaster 7.5 cm. (3 in.) wide, and beginning high up the leg on the inner side, carrying it down under the sole and drawing it firmly up and fastening on the outer side of the leg almost to the knee. This is reinforced by encircling strips around the ankle and instep.

DISLOCATIONS OF THE ANKLE

The foot may be dislocated from the leg in nine different manners.

1. The foot as a whole may be carried outward. This is almost always associated with fracture of the fibula, and sometimes of the internal malleolus, constituting Pott's fracture (see pages 640 and 642).

2. The foot may be carried directly inward. This likewise is associated with fracture of the internal malleolus.

3. The foot may be rotated *out* on its own anteroposterior horizontal axis (parallel with the sole).

4. It may be rotated *in* on its anteroposterior horizontal axis. Both these may be accompanied by fractures.

5. The foot may be rotated inward on a vertical avis longitudinally through the leg.

6. It may be rotated outward on a vertical axis.

7. The foot may be luxated backward, the fibia coming forward on the astragalus (Fig. 616).

8. It may be luxated forward.

9. The astragalus may be pushed up between the bones of the leg.

Fig. 616.—Backward luxation of the foot at the ankle-joint.

In Numbers 1 and 2 inward and outward displacement the foot is not immediately beneath the leg, but is to one side of the leg. The outward luxation when accompanied with laceration of the inferior tibiofibular ligaments or tearing off of a small portion of the tibia and fracture of the internal malleolus and fibula constitutes Dupuytren's or Pott's fracture. In Numbers 3 and 4 the foot remains beneath the leg bones and is not displaced much laterally. Numbers 1 and 3 are usually grouped together as outward luxations, and 2 and 4 as inward luxations. Numbers 5 and 6 are very rare. The foot is rotated so that one side looks forward and the other backward.

Number 7 backward luxation is the most common, with the exception of Number 1. When associated with Pott's fracture, backward luxation is produced by hyperextension followed by a thrust and is often compound. The leg is bent backward until the anterior and lateral ligaments rupture, and then the thrust sends the tibia forward on the instep. The articular surface of the astragalus being wider in front opposes the luxation, and fracture of one or both malleoli may result.

Numbers 8 and 9 forward and upward luxations are extremely rare, the former on account of the difficulty in the application of the dislocating force,—the flexion and thrust,—and the latter on account of the extreme strength of the inferior tibiofibular ligaments.

Treatment.—In attempting reduction of these luxations the principal thing is to relax the tendo calcaneus (Achilles) by flexing the knee. If this is not sufficient, tenotomy should be practiced. Simple extension with slight rotation and manipulation will then accomplish reposition.

FRACTURES OF THE ANKLE

Fractures of the ankle are usually the result of a force applied laterally, though sometimes a turning of the foot on the vertical axis of the leg may assist. The force applied causes fracture by inversion or eversion of the foot.

Pott's Fracture or Fracture by Eversion.—This is named after Sir Percival Pott, Surgeon to St. Bartholomew's Hospital, London, who described the injury, and was himself a victim of it. The French call it Dupuytren's fracture. It is produced by forcing the foot outward, or by having the foot firmly fixed and then bending the limb outward, thus breaking it at the ankle. The fibula is broken 4 to 7.5 cm. (1½ to 3 in.) above its lower end and the ligamentum deltoideum (internal lateral) is either ruptured or the internal malleolus is torn off. Rarely the outer portion of the articular surface of the tibia may be torn off and displaced

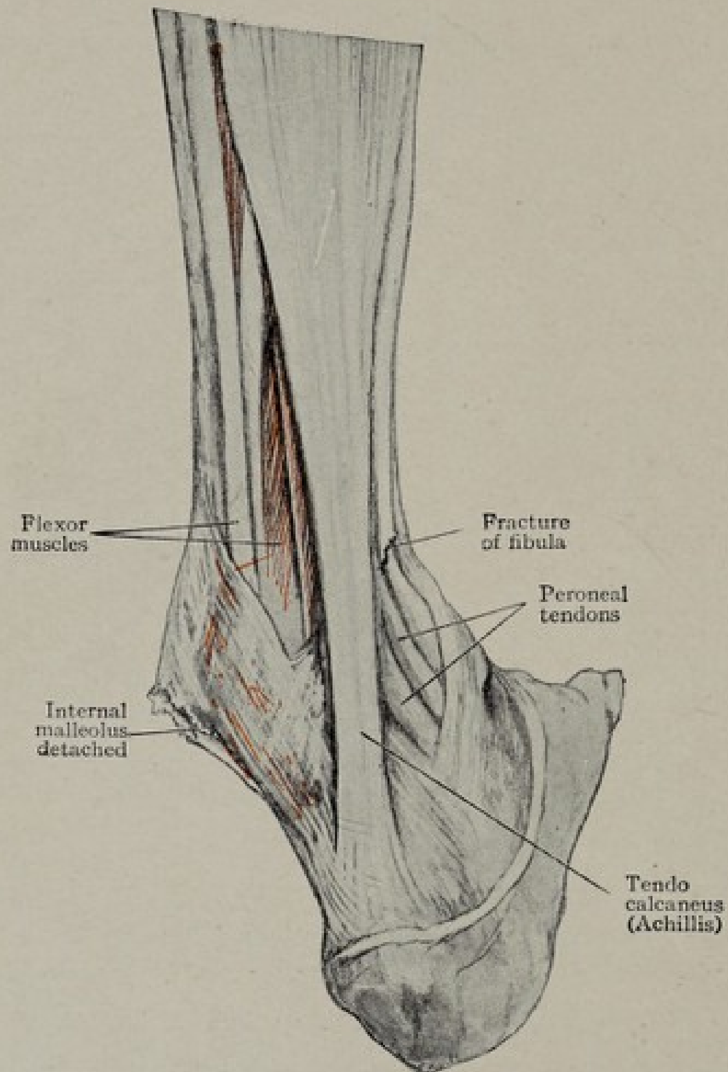


Fig. 617.—Pott's fracture of the fibula, showing eversion of the foot, point of fracture of the fibula, and tearing off of the point of the internal malleolus.

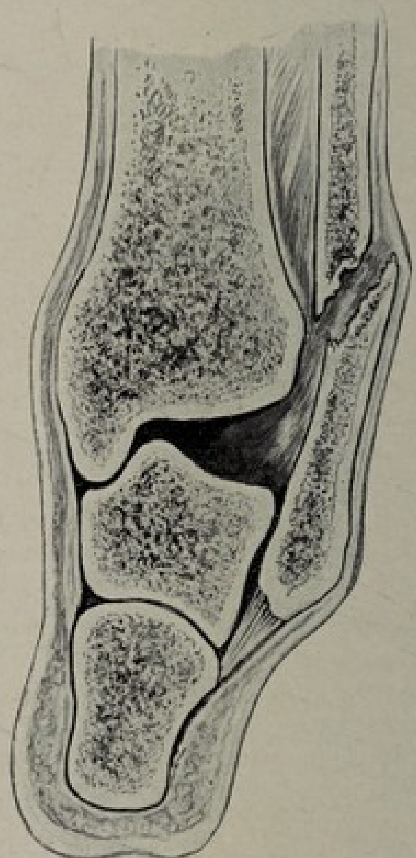


Fig. 618.—Illustrating fracture of the fibula by inversion of the foot.

outward with the lower fibular fragment. It is to be noted that in this fracture the foot, with the small fragments of tibia and fibula, is practically loosened from the bones of the leg, and the muscles of the calf being unopposed pull the foot backward and upward. Therefore the displacement of the foot is not only outward, but also backward and upward (Fig. 617).

Fracture by Inversion.—This is practically the opposite of the former and is not so frequent. The fibula is fractured by the traction of the external lateral ligaments which remain intact; it may break either above or below the strong inferior tibiofibular ligaments. The internal malleolus may also be torn off. The displacement is toward the inner side and upward and backward (Fig. 618).

Treatment.—In these fractures of the ankle replacement is often difficult and resultant deformities frequently cause considerable subsequent disability. For this reason especial efforts are to be made to reduce the displacement and maintain the fragments in proper position.

There are two main points of difficulty. The fractured ends of the fibula become displaced anteroposteriorly and also in the fracture by eversion (Pott's) become pushed inward toward the tibia. The deep fascia of the leg is attached to the fibula and its sharp broken ends may get so fastened or caught in this fascia as to require an open incision before they can be freed sufficiently to allow of their proper replacement. Another difficulty is in the reduction of both the lateral and posterior displacement. Here it is necessary first to relax the muscles of the calf by flexing the leg on the thigh, then by pulling and direct pressure the foot can often be replaced. If this fails tenotomy of the tendo calcaneus (Achilles) is to be done, which relaxes the parts still more by releasing the pull of the soleus, the

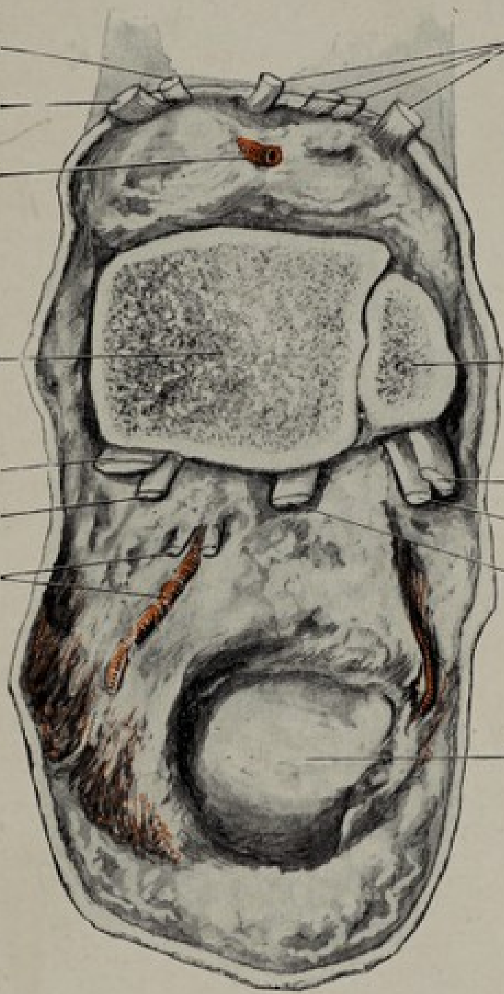


FIG. 619.—Syme's amputation of the ankle.

gastrocnemius and plantaris being already relaxed by flexion of the knee. This is sometimes necessary to prevent the persistent tendency of the foot to be drawn backward. After reduction not infrequently there is no further tendency to displacement, and the fracture box or any other simple means of retention is sufficient.

In other cases it is better to place the leg in the Pott's position, viz., lying on its outer side with the knee flexed. For similar injuries, Dupuytren advised placing the leg on a straight internal lateral splint on a pad which extended from near the knee down to the seat of fracture. The leg was fastened near the knee to the upper part of the splint, and the foot which projected beyond the pad was drawn by bandages toward the lower part of the splint. The essential feature in the treatment of fractures involving the ankle-joint is to secure and maintain the normal position and relationship of the astragalus to the articulating surface of the tibia.

If this is not obtained the mechanism of the foot is disturbed and unusual stress is placed upon the arches of the foot with a resultant breaking down of the arches.

AMPUTATIONS AT THE ANKLE

When amputation is performed at the ankle it is usually either by the method of Syme or that of Pirogoff.

Syme's Amputation.—"A transverse incision should be carried across the sole of the foot from the tip of the external malleolus or a little posterior to it (rather nearer the posterior than the anterior edge of the bone) to the opposite point on the inner side, which will be rather below the tip of the internal malleolus."

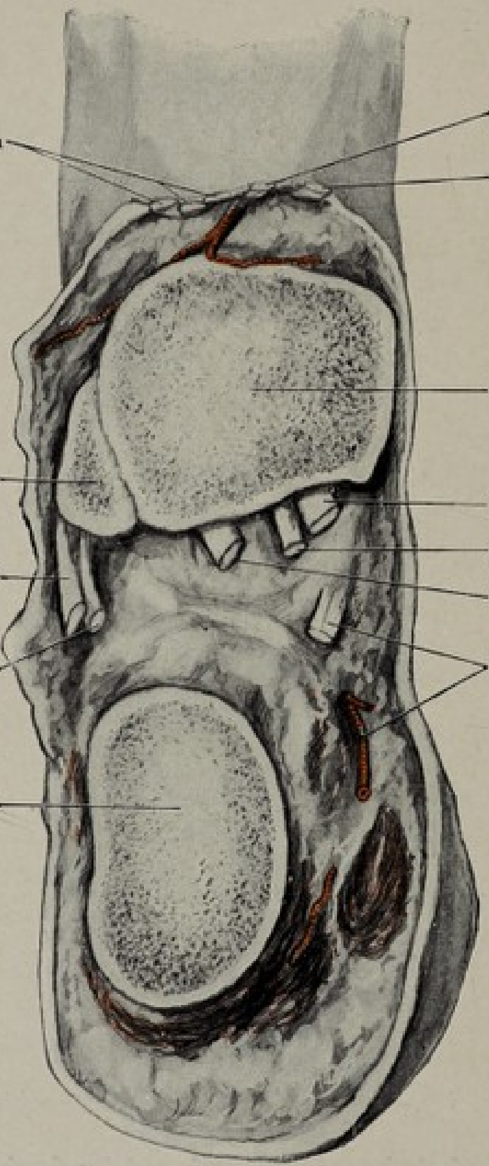


Fig. 620.—Pirogoff's amputation of the ankle.

The extremities of this incision are connected by another directly across the front of the ankle-joint. The anterior capsule is then divided and the lateral ligaments divided from within outward. The foot being bent down, the tendo calcaneus is cut close to the bone and the calcaneus dissected out. The malleoli are then to be cleared and sawn off with a thin slip of the articular surface of the tibia (Fig. 619).

Remarks: The incision across the sole must not go too far back on the inner side, as the internal calcanean branch of the external plantar artery will be divided and the integrity of the flap threatened. In clearing the calcaneus (os calcis) it is rather an advantage, especially in young people, to take off a thin slice of bone with the tendo calcaneus. In removing the slice from the tibia as little as possible (in growing patients) should be removed, to avoid injuring the epiphyseal cartilage. In dissecting back the flap of the heel, the point of the knife is to be kept close to the bone to avoid cutting the vessels in the flap itself.

Pirogoff's Amputation.—The sole incision is carried across from just in front of the external malleolus to just in front of the internal. The anterior incision is made across the front of the joint and the foot disarticulated by dividing the capsular and lateral ligaments. The foot is then bent down and the calcaneus sawn through the line of the sole incision. A slice is to be removed from the tibia and fibula and the sawn surface of the calcaneus brought up and sutured with chromic catgut (or other) sutures to the sawn surface of the tibia (Fig. 620).

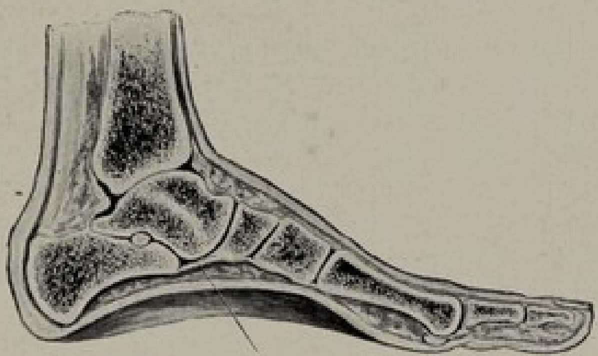
In bringing up the calcaneus to the tibia it may be found difficult to approximate them without undue tension on the tendo Achillis. To provide against this common difficulty it is customary to place the saw on the upper surface of the calcaneus well behind (a finger-breadth) the joint. Also to dissect back the heel-flap .50 to 1 cm. (¼ to ½ in.) so that more of the calcaneum can be removed. A larger slice is also taken from the tibia than in Syme's amputation. If the tension remains too great on the tendo calcaneus it is to be divided.

Since mechanical appliances have been so greatly improved better results are obtained for the patient when an amputation is done at the joint of election (middle third of leg). These amputations therefore of Pirogoff and Syme have fallen into disuse.

THE FOOT

The foot is intended for support and locomotion. The locomotion takes place in the upright position and, in moving, the weight is shifted from one foot to the other. Hence we see that if the foot is to fulfill its function of support it must have strength, because on it rests the weight of almost the whole of the body. If a person is at rest in a standing position the foot is subject to a continuous static pressure which, if any part of the foot is abnormal, whether from congenital or acquired qualities, will eventually result in distortion and impairment of function. If a person is moving about, the foot is subjected to a pressure which is dynamic (movable) in character, and is much greater in amount than is the static pressure of the body at rest.

The movements of the foot in locomotion are not always slow, sometimes they are exceedingly rapid. A person treads on an uneven or unstable surface and the foot must adapt itself instantly or injuries will result; failure to do so results in sprains, fractures, and luxations. In running rapidly the changes in position of the component parts of the foot are instantaneous, otherwise rapid running is impossible. In jumping especially the dynamic pressure plus the inertia causes an enormous strain on the foot. The mobility demanded of the foot is not so great, however, as that of the hand because the movements are neither so intricate nor so numerous. A consideration of these facts enables one to understand: first, the method of construction of the foot; second, its injuries, diseases and deformities; third, the means necessary to employ in preventing and curing them and in obviating to as great extent as possible their consequences.



Inferior calcaneo-scaphoid ligament.

FIG. 621.—Section of foot, showing the longitudinal arch.

The Construction of the Foot.—The foot is constructed with a view of possessing strength and mobility. Strength is obtained by the bones being short and solid, well compacted together in the form of a double arch, joined by strong ligaments, and supported by powerful muscles. The double arch forms the hollow of the sole of the foot. As pointed out by Ellis ("The Human Foot") when the two feet are placed together there is formed a "dome-shaped space" arching anteroposteriorly from the internal tuberosity of the calcaneum to the head of the first metatarsal bone, and laterally from the inner to the outer edge (Fig. 621). Mobility is obtained by the bones and joints being numerous and the muscles highly specialized.

Diseases and Injuries of the Foot.—Disease weakens the foot—sometimes, as in adolescents, the foot is weakened without any apparent disease. In other cases the bones and ligaments become affected, as in rickets, rheumatism, gout, and tuberculous disease. In still others the muscles become affected, either contracted, as in spastic diseases, or relaxed, as in infantile paralysis. When the bones and ligaments are involved they fail to bear the body weight, the arch is crushed and flat-foot and eversion results. Hence valgus is almost always a disease of weakness. If muscles become affected by spasm or paralysis all kinds of deformities are produced. There are many muscles controlling the foot and frequently only one or a few are paralyzed; this leaves the balancing muscles unopposed and they drag the part toward the healthy side. Anything that disturbs the equilibrium or balance of the various muscles results in distortions and deformities. Injuries impair the efficacy of the mechanism of the foot. A crush of the head of the first metacarpal bone destroys the anterior support of the arch and the resultant weakness is marked.

Traumatism produces flat-foot, also sprains, which, while not so deforming, are often disabling. Fractures and luxations occur and may impair the foot permanently.

Finally, many children have congenitally deformed feet which require treatment before they can fulfil their functions.

The Treatment of Affections of the Feet.—The foot is exceptionally accessible both for diagnosis and treatment. The bones and joints are accessible often to both sight and touch, and one should know where to look and feel for them. Exploratory operations in this portion of the body are out of place. An accurate knowledge of the structures of the foot is absolutely essential to intelligent treatment. The deformities are dependent on muscular action, and one should know the position of the tendons and the influence of the muscles. In amputating, a knowledge of the joints is essential. The problems presented are largely of a mechanical nature, to be solved by a thorough knowledge of the structures and the application of mechanical principles to living tissues. The surgeon unacquainted with anatomy of the foot should not attempt to treat its lesions.

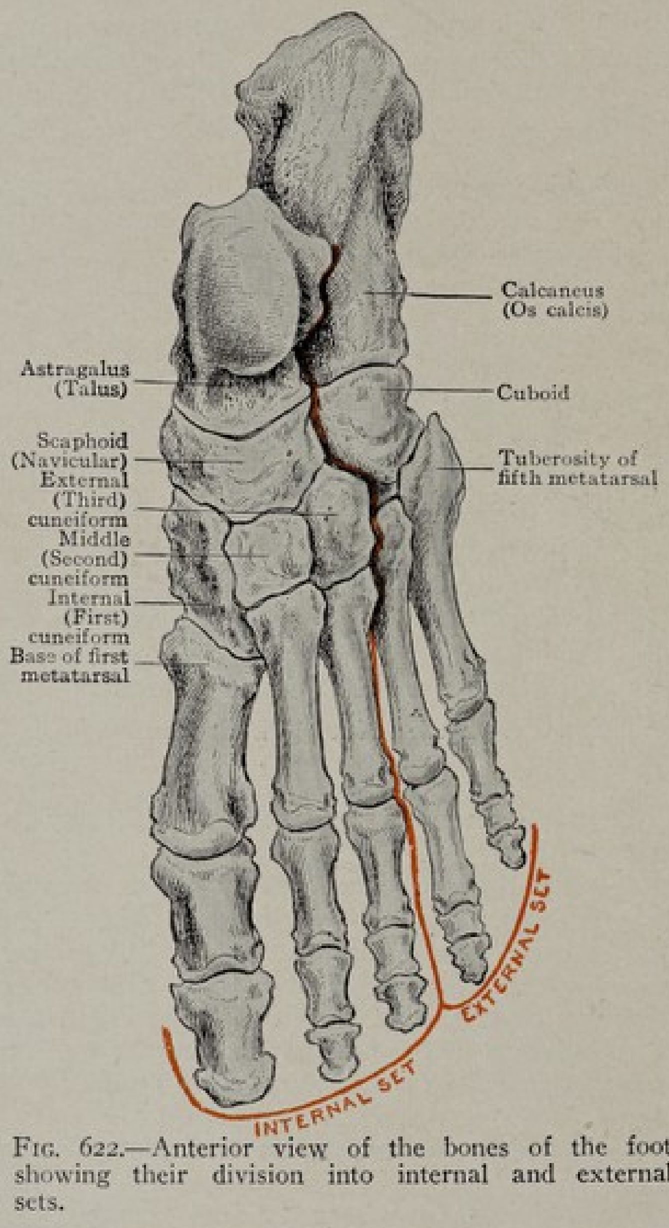


Fig. 622.—Anterior view of the bones of the foot showing their division into internal and external sets.

BONES OF THE FOOT

A knowledge of the bony structure of the foot is the key which unlocks its pathology. The bones of the foot are numerous, so as to give it mobility and to lessen shocks. If the bones become ankylosed the footing becomes insecure, balancing is difficult, the gait is altered, and great care is necessary in locomotion to avoid straining and injury.

The foot is triangular in shape, being broad across the toes and narrow at the heel. Its bones compose the *tarsus, metatarsus,* and *phalanges.* Of these the first two are essential, but the third is less so. Phalanges are more or less for prehensile uses, and as man, as we see him, encases his foot in shoes he makes but little use of the toes, hence they are the least important part of the foot. They are used somewhat in walking, and to a greater degree in balancing, climbing, running, etc. They add to the efficiency of the foot, but their loss does not impair it to a great extent. Intricate and delicate movements may be interfered with, but the more deliberate firmer movements, as in walking, may remain almost normal. The big toe has only two phalanges and this increases its strength at the cost of mobility. The remaining portion of the foot is composed of the metatarsus and tarsus—five bones of the former and seven of the latter.

The foot bones are divided longitudinally into two sets, and internal and external. The main weight of the body is transmitted through the *internal set*, which is in relation with the tibia. It consists of the *astragalus* (*talus*), *scaphoid* (*navicular*), the three *cuneiform*, and the inner three *metatarsal bones* with their corresponding phalanges (Fig. 622).

The *external* set is in relation with the fibula, and is composed of the *os calcis, cuboid*, and outer two *metatarsals* with their corresponding phalanges.

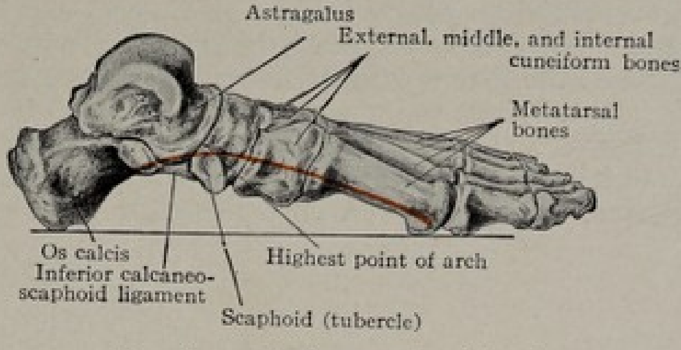


FIG. 623.—The inner arch of the foot.

As has been pointed out by Quénu and Kuss, (1909), while the main function of the internal portion of the foot is support, that of the external portion is balance. They suggest that from a functional standpoint the foot may be divided into an internal portion composed of all the tarsal bones and the first metatarsal bone with its phalanges, and an external portion consisting of the outer four metatarsal bones and phalanges. They show that in dislocation of the metatarsus the line of division passes between the first and second metatarsal bones; the first metatarsal is usually displaced inwardly, while the second, third, fourth, and fifth metatarsal bones are practically always displaced outwardly, there being a considerable separation between the metatarsal bone of the big toe and the second metatarsal bone adjacent.

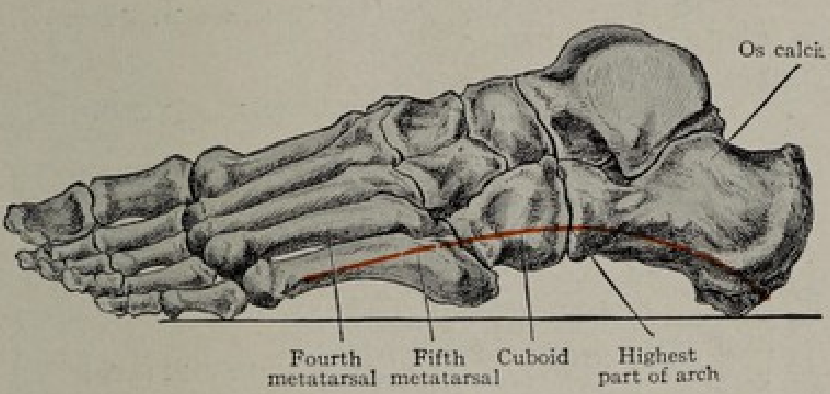


FIG. 624.—The outer arch of the foot.

When there is congenital absence of the tibia the foot bones related to it are also lacking, and when the fibula is lacking there are no bones of the external set. In man both sets contribute to support, but the tibial or inner set is the more important, the fibular or outer set being in a condition of regression.

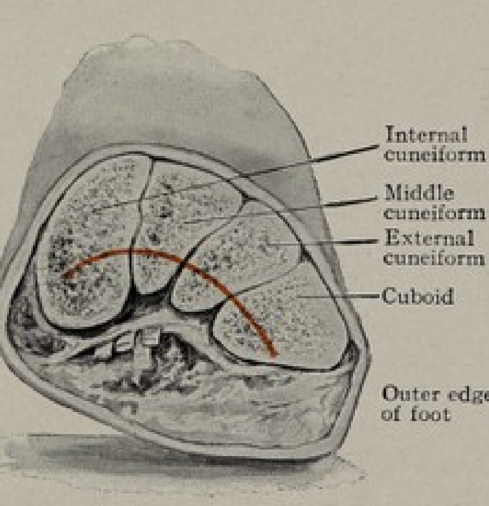


FIG. 625.—Transverse arch of foot.

As has been stated above, the foot is domeshaped, being arched anteroposteriorly and transversely. The anteroposterior arching has been divided into an inner and outer arch. The *inner arch* is composed of the calcaneus, astragalus, scaphoid, three cuneiform and inner three metatarsal bones. The highest point of this arch is the midtarsal joint between the astragalus and scaphoid (Fig. 623). The *outer arch* is composed of the calcaneus, cuboid, and outer two metatarsal bones. It is much lower than the inner arch. The highest point is between the cuboid and the calcaneus (os calcis) and when weight is borne on the foot this outer arch becomes obliterated and comes in contact with the ground.

The *transverse arch* has its outer end supported by the outer edge of the foot, which through the medium of the soft parts is in contact with the ground. Its inner end is supported by the inner edge of the foot which is some distance above the ground. Thus it is seen that the weight of the body is transmitted from the body of the astragalus in three directions, viz., backward to the tuberosities of the calcaneus, forward to the heads of the metatarsal bones, and laterally toward the base of the fifth metatarsal bone. The posterior pillar of the anteroposterior arch is short, thick, and composed of only two bones, the astragalus and os calcis. It is stiff and strong, but having only two parts is comparatively immovable. The anterior pillar of the arch is longer and has more bones and, while it is not so strong against static pressure as the posterior pillar is, on account of its elasticity and

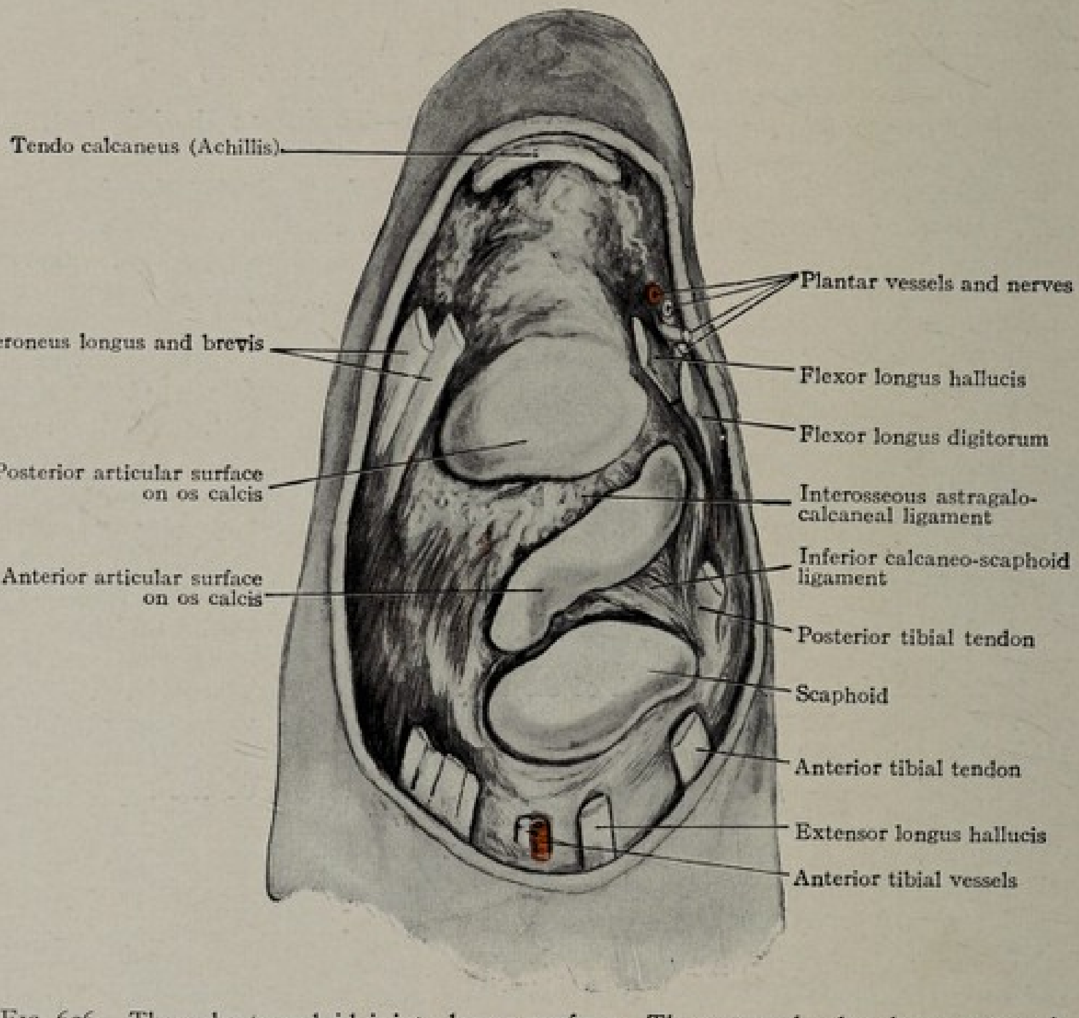


FIG. 626.—The subastragaloid joint; lower surface. The astragalus has been removed.

mobility, is far more effective against dynamic (active) pressure. Thus it is that when a person jumps from a height and alights on the sole of the foot the astragalus or calcaneus of the posterior pillar is fractured while the bones of the anterior pillar escape. The internal part of the foot is more liable to give than the external part because the external part is practically in contact with the ground while the internal part has as its support ligaments and muscles, and when these latter give way it is in the inner side of the foot which sinks. This is still more favored by the position of the tuberosities of the os calcis (calcaneus) with reference to the ankle-joint; they are not directly beneath it, but somewhat to its outer side.

THE JOINTS AND LIGAMENTS OF THE FOOT

The amount of movement that takes place between the bones of the foot is not as great as would be expected from their number. It is only in the subastragaloid joint that any considerable motion takes place, while a less amount occurs at the midtarsal joint. The contiguous tarsal bones are joined by numerous band-like, capsular, and interosseous ligaments which allow a limited amount of movement between them. In the aggregate these movements are considerable and make the foot as a whole quite flexible.

The Subastragaloid Joint (Articulatio talo-calcaneo-navicularis).—This is a horizontal joint formed by the astragalus (talus) above and the os calcis and scaphoid (navicular) below and in front. It runs obliquely forward and inward. The astragalus is not wedged in between the calcaneus and scaphoid like the keystone of an arch, but the foot moves freely beneath it. It has an inward motion of adduction around an anteroposterior or longitudinal axis with internal rotation around a vertical axis, and an outward motion of abduction with external rotation. The abduction and adduction movements cannot occur independently of rotation, they are combined. The astragalus is joined to the calcaneus below and scaphoid below and in front by short fibrous bands which help to form the capsule. The under surface of the subastragaloid joint is formed first by the surface of the

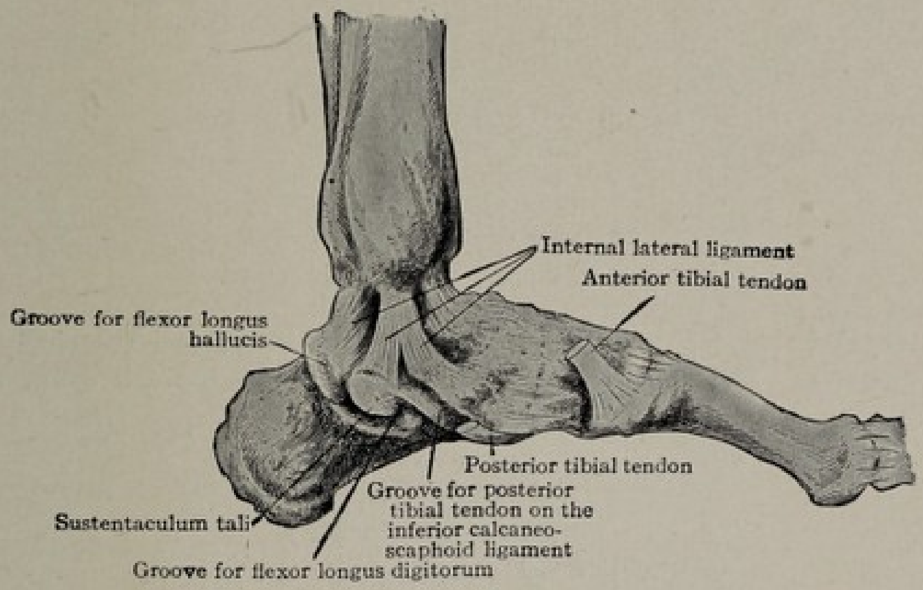


Fig. 627.—View of inner side of ankle-joint, showing the internal lateral ligament.

scaphoid, next by the inferior calcaneoscaphoid ligament, then by the upper surface of the sustentaculum tali, then by the interosseous ligament, and finally by the posterior surface of the calcaneus (os calcis). The inferior calcaneoscaphoid ligament is the most important one in maintaining the integrity of the arch (Fig. 626). In addition, in order to provide against the luxation, which is favored by the superincumbent body weight, the joint is strengthened by three ligaments, viz:

1. The *interosseous astragalo-calcaneal ligament*, which runs obliquely forward and outward between the calcaneus and astragalus and divides the subastragaloid joint into an anterior and posterior portion. It is very strong (Fig. 626).

2. The *internal lateral* (*deltoid*) *ligament* of the ankle, which sends fibres by its deep part from the tibia above to the side of the astragalus below and likewise to the scaphoid in front, and by its superficial part to the sustentaculum tali (Fig. 627).

3. The *external lateral ligament* of the ankle, the anterior and posterior fasciculi of which are both attached to the astragalus and the middle fasciculus of which goes to the calcaneus below (Fig. 628).

When the weight of the body is transmitted to the foot it tends to flatten the anteroposterior arch. If the arch descends it can only do so either by pushing the astragalus up—luxating it—or by the ligaments of the arch stretching or rupturing and allowing the two pillars of the arch to separate. In disease the ligaments elongate and by violence they may be ruptured, the arch in each case falls. If the ligaments supporting the astragalus remain intact then excessive lateral movement ruptures those on the side and a sprain of the subastragaloid joint is produced which is often called a strain of the ankle.

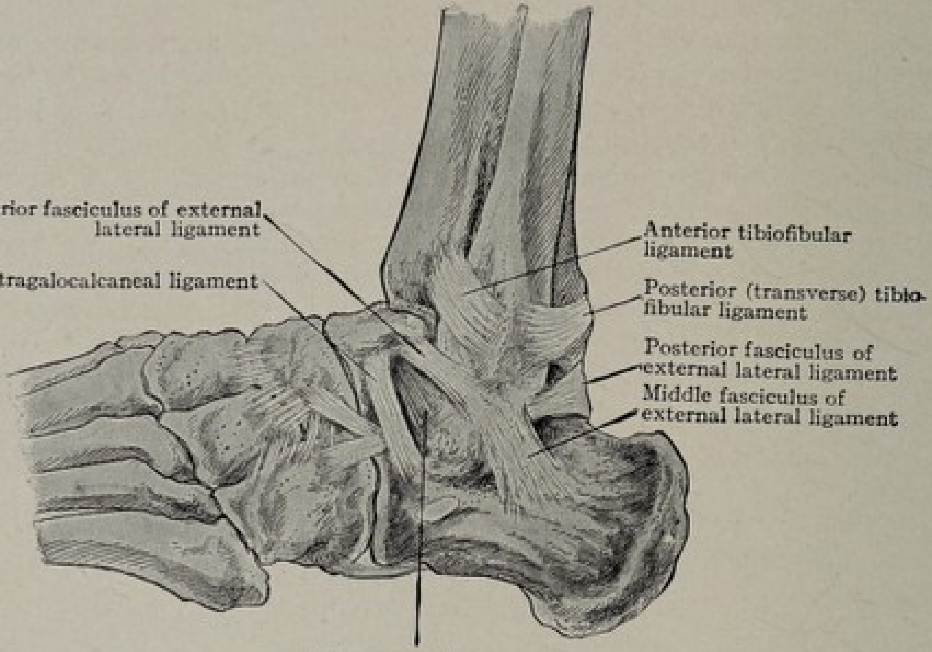


Fig. 628.—Ligaments of the outer side of the ankle.

The Midtarsal Joint (Chopart's Joint).—This is composed anteriorly of the scaphoid (navicular) and cuboid bones and posteriorly by the astragalus and

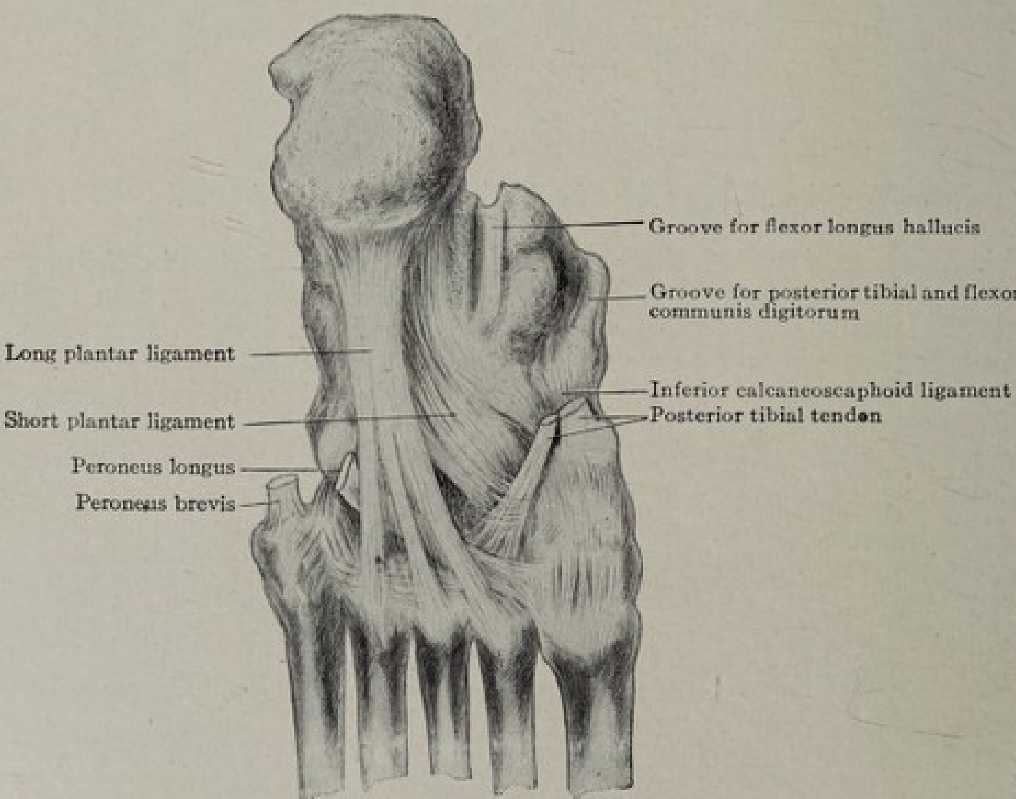


Fig. 629.—Ligaments and tendons of the sole of the foot.

calcaneus. The movements are not extensive and consist of flexion with inward rotation of the sole, and extension with outward rotation of the sole. The joint is separated into an inner and outer portion by an interosseous ligament where the cuboid, astragalus (talus), and os calcis meet.

The Ligamentous Support of the Arch of the Foot.—The bony construction of the arch or dome of the foot has already been explained (page 649). The various bones composing it are bound together not only by the short ligaments passing between contiguous bones, but the arch is strengthened by three special ligamen-

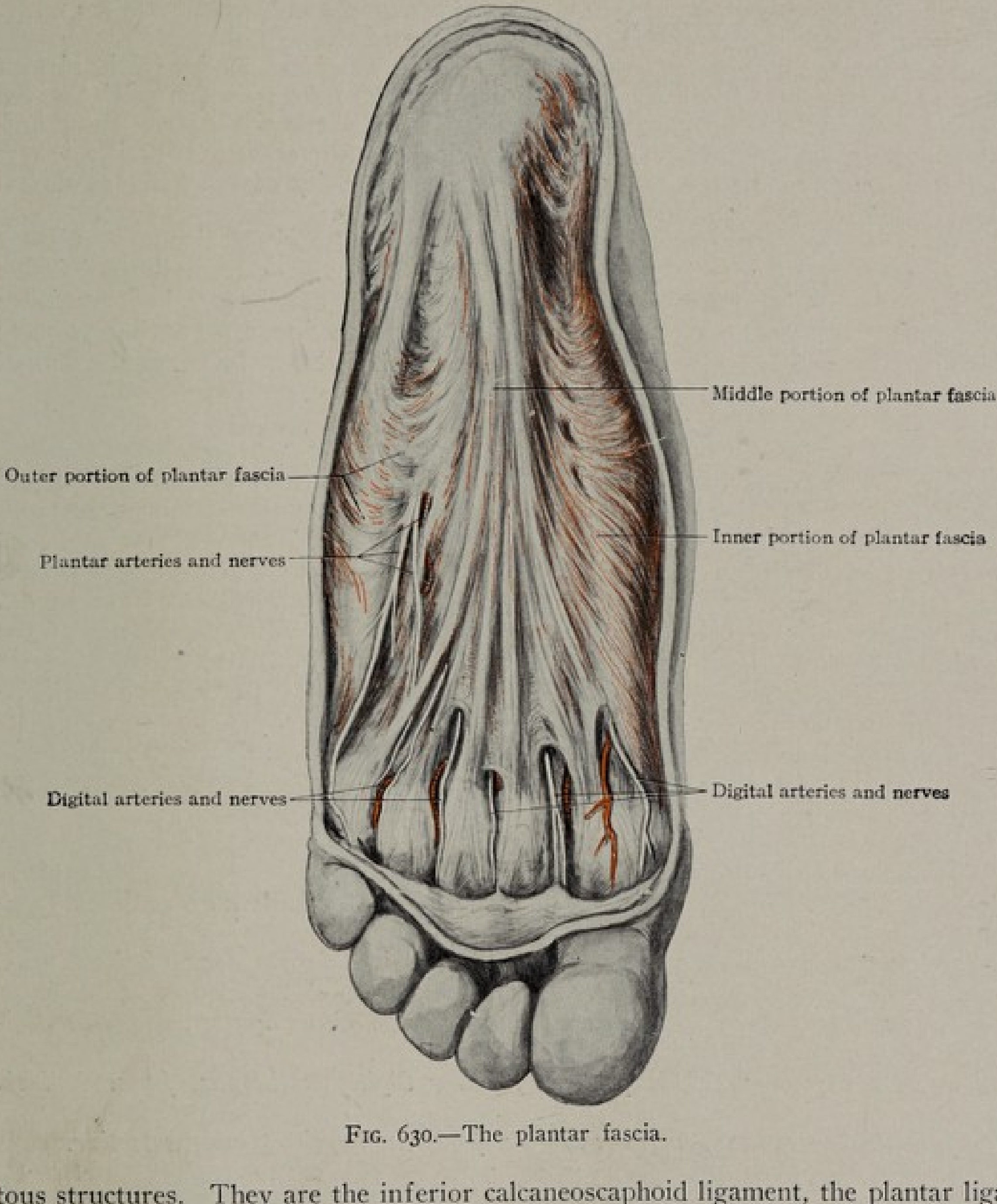


Fig. 630.—The plantar fascia.

tous structures. They are the inferior calcaneoscaphoid ligament, the plantar ligaments, long and short, and the plantar fascia.

The *inferior calcaneoscaphoid ligament* (*ligamentum calcaneonaviculare plantare*) runs from the lower inner portion of the scaphoid, posterior to its tubercle, to the sustentaculum tali. It is an extremely strong fibrocartilaginous band. Anteriorly and above it blends with the internal lateral ligament (deltoid) of the ankle. Together with the posterior surface of the scaphoid it forms a socket for the head of the astragalus. This ligament fills the long gap left in the inner arch of the foot between the scaphoid and calcaneus. Running under and supporting it is the tendon of the tibialis posterior (Fig. 629).

The *long plantar or long calcaneocuboid ligament* (*ligamentum plantare longum*) is attached to the under surface of the calcaneus (os calcis) in front of its tubercles and thence runs to the peroneal ridge on the cuboid bone and continues onward to the bases of the second, third, fourth, and fifth metatarsal bones. It makes a canal for the peroneus longus tendon, which runs beneath it.

The *short plantar or short calcaneocuboid ligament* (*ligamentum calcaneocuboideum plantare*) lies beneath the long ligament and is separated from it by a small amount of fatty tissue. It runs obliquely forward and inward from the under surface of the calcaneum to the posterior portion of the cuboid.

The Plantar Fascia (aponeurosis plantaris).—The middle portion of the plantar fascia runs anteriorly from the inner tubercle of the calcaneus (os calcis) to be attached to the sides of the metatarsophalangeal articulations and bases of the proximal phalanges. It is a thick, strong triangular band. The outer portion is a strong band running from the external tubercle to the tuberosity of the fifth metatarsal bone. The inner portion is thin and weak (Fig. 630).

These three ligamentous structures, the calcaneoscaphoid ligament, plantar ligaments, and plantar fascia are all large, strong, fibrous structures. They join the anterior and posterior pillars of the arches like the string of a bow and prevent them from separating. When a person is standing at rest these are the main ligaments which bear the weight of the body. The static weight is borne by the ligaments but the dynamic weight (movements) is borne by the muscles.

THE MUSCLES OF THE FOOT

The foot is acted upon by long muscles which come down from the leg and short muscles which arise in the foot itself. Of these the long muscles are the more important because they influence the position of the foot itself, whereas the short muscles act on the toes; as stated the movements of the toes are of secondary importance (page 648). The functions of the muscles are active or dynamic in character. They bear the weight of the body when in motion and direct the movements of the foot in locomotion. Their function and structure are to be studied together, as one explains the other, and a knowledge of them explains many deformities and indicates their treatment.

The *long muscles* have three distinct actions on the foot: (1) they support the arch of the foot; (2) they flex and extend the foot; (3) they abduct and adduct the foot—this latter being associated with a certain amount of rotation.

The action of the individual muscles is not a simple one. They act on two joints, the ankle and subastragaloid. If the former is stationary they abduct and adduct, if the latter is stationary they flex and extend, but if both move then a combined action of the muscles is necessary.

For our purposes we may divide the muscles into four groups of three each. They are (1) extensors, (2) flexors, (3) abductors, (4) muscles of the calf.

1. Extensor group: *tibialis anterior, extensor hallucis longus, extensor digitorum longus.*

2. Flexor group: *tibialis posterior, flexor digitorum longus, flexor hallucis longus.*

3. Abductor group: *peroneus longus, peroneus brevis, peroneus tertius.*

4. Muscles of the calf: *gastrocnemius, soleus, plantaris.*

The Action of the Muscles in Supporting the Tarsal Arch

Tibialis Anterior.—The tendon of the anterior tibial descends along the anterior edge of the internal malleolus and inserts into the lower inner surface of the internal cuneiform bone and base of the first metatarsal bone.

Tibialis Posterior.—Its tendon passes down close behind the posterior edge of the internal malleolus, crosses the internal lateral ligament of the ankle, passes under the inferior calcaneo-scaphoid (navicular) ligament and in front of the sustentaculum tali to insert into the tubercle of the (navicular) scaphoid. From the tubercle its tendon sends slips to all the tarsal bones except the (talus) astragalus and to the base of the second, third, fourth, and sometimes the fifth metatarsal bones.

Flexor Longus Digitorum.—Its tendon passes behind the internal malleolus immediately posterior to the tibialis posterior and then curves around the sustentaculum tali to enter the foot, passing forward to insert into the base of the terminal phalanges of the outer four toes.

Flexor Longus Hallucis.—This tendon descends across the middle of the posterior part of the ankle-joint and curves forward under the sustentaculum tali. It is the most posterior of the structures running behind the internal malleolus. It lies deeper than the tendon of the flexor digitorum longus, and as it crosses it gives to it a small slip. It then inserts into the base of the terminal phalanx of the big toe.

Peroneus Longus.—This tendon overlies the tendon of the peroneus brevis as it passes down immediately behind the external malleolus. It then winds around the outer surface of the calcaneus (os calcis) behind the peroneal tubercle to pass obliquely inward and forward across the sole of the foot, in a canal formed by the long plantar ligament and a groove in the cuboid bone, to insert into the base of the first metatarsal bone and internal (first) cuneiform.

Peroneus Brevis.—This tendon passes down behind the external malleolus beneath and a little anterior to the tendon of the peroneus longus. It passes in front of the peroneal tubercle and then goes forward to insert into the tuberosity of the fifth metatarsal bone.

Peroneus Tertius.—This tendon descends in front of the external malleolus and inserts into the upper surface of the fifth metatarsal bone near its base.

The other muscles of the leg do not support the tarsal arch. In considering the insertions of these tendons it will be seen that the tibialis anterior, peroneus tertius, and peroneus brevis are practically inserted into the convexity of the tarsal arch and tend to support it by pulling it upward. The flexor hallucis longus and flexor digitorum longus run longitudinally beneath the arch and so directly support it. The tibialis posterior and peroneus longus, one from the inner and the other from the outer side, meet and cross on the sole of the foot, thus forming a double sling immediately beneath the arch on which it rests when those muscles contract.

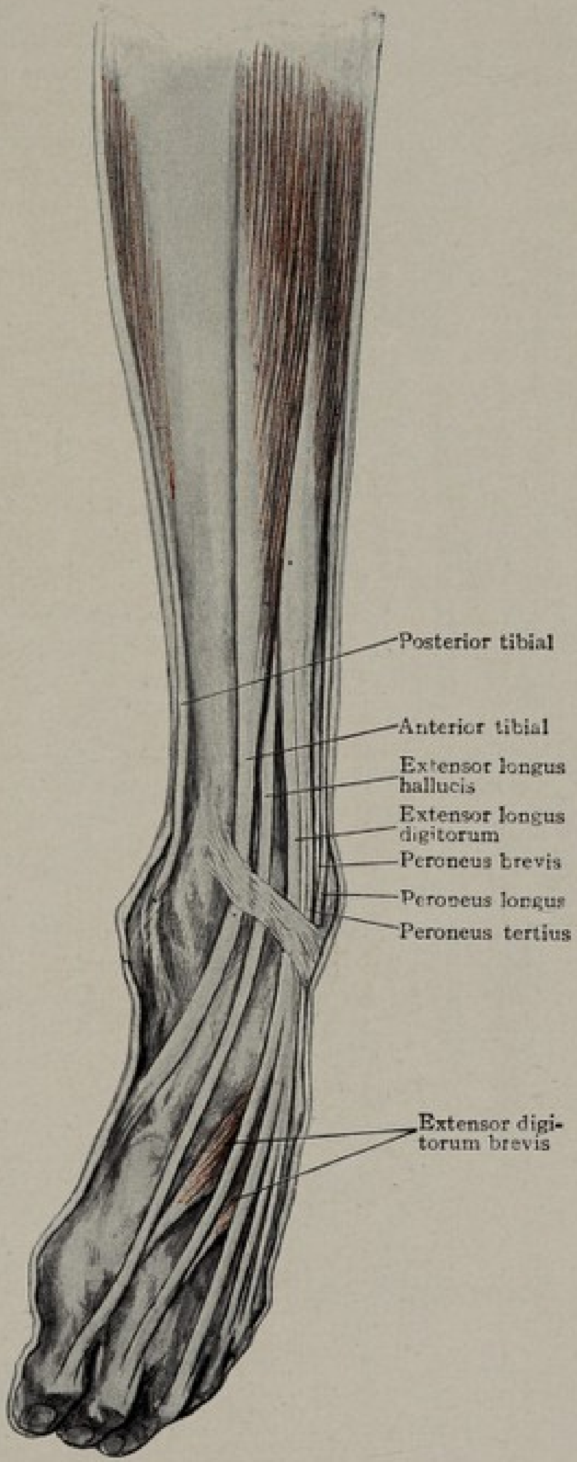


FIG. 631.—The foot in an adducted or supinated position.

If these muscles, on which the arch directly relies for its support when subjected to the strain of locomotion, are unable to meet the demands made upon them then the strain falls on the ligaments, and as these are intended for static and not dynamic purposes they weaken and give way and the arch descends. To cure such a condition over use must be avoided and the strength of the muscles is to be restored by exercise, massage, electricity, etc. The use of arch supports in the shoes to correct early cases of fallen arches ignores the fundamental principles upon which the support of the arch is dependent. For the most part these artificial supports act as splints relieving the muscles of their normal work resulting in increasing flaccidity of these muscles and a greater descent of the arch.

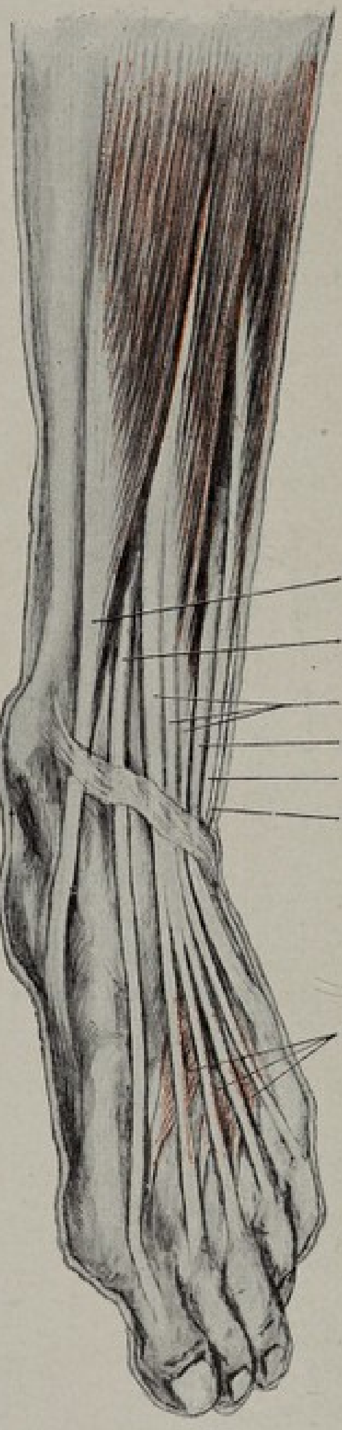


Fig. 632.—The foot in an abducted or pronated position.

The Action of the Muscles as Flexors and Extensors

The peroneus group of muscles exert so little influence on flexion and extension that in many cases they may be ignored. The peroneus tertius flexes the ankle, while the longus and brevis extend it. The common movements of the foot when great strength is not required are performed by the flexor and extensor groups of muscles; the muscles of the calf are not so much for adding to the kind of movements as to the amount. The powerful calf muscles have the function of aiding the body in maintaining the upright posture and especially in lifting and propelling it forward in locomotion. When most of the flexors and extensors are paralyzed the foot hangs loose from the leg, the so-called flail-foot. Weakness of the flexor group (tibialis posterior, flexor digitorum longus, and flexor hallucis longus) tends to favor a descent of the arch with consequent pronation or eversion. Weakness of the extensors causes toe-drop and inversion or supination.

Paralysis of the calf muscles deprives the posterior pillar of the arch of its support and the action of the flexors and extensors elevates the arch while the heel descends, so that a condition of hollow foot is produced.

Paralysis of the calf muscles is not rare, while that of the deep flexors is less common. The question of paralysis must be studied with reference to each individual case, because the affected muscles are not always completely paralyzed, neither are all the muscles of a group.

The Action of the Muscles as Abductors and Adductors

Lateral movements of the foot are comparatively weak when compared with those of flexion and extension. They are intended largely to maintain the balance or equilibrium and to adapt the position of the foot to uneven surfaces, etc. Three muscles act very dictinctly as abductors; they are the peroneus longus, brevis, and tertius. Two act as distinct adductors, viz.: the tibialis anterior and the tibialis posterior.

The muscles of the calf act more as abductors than adductors, because the insertion of the tendo calcaneus (Achillis) is not directly behind the ankle-joint but more to its outer side.

When the foot is deformed in the position of inversion, as in club-foot, the tibialis anterior and posterior are usually contracted, but when in the position of eversion, as in flat-foot, then spasm of the peronei or calf muscles is frequent.

Plantar flexion of the foot is a far more powerful movement than extension—flexion is associated with adduction or inversion and extension with abduction or eversion; hence it is that inversion is the position of strength and eversion of weakness. Feats of strength and agility cannot be performed by those who have markedly everted feet.

SURFACE ANATOMY OF THE FOOT

For the clinician and operator an exact knowledge of surface anatomy is absolutely essential. It can readily be acquired because the various bony points and tendons are usually evident both to touch and sight.

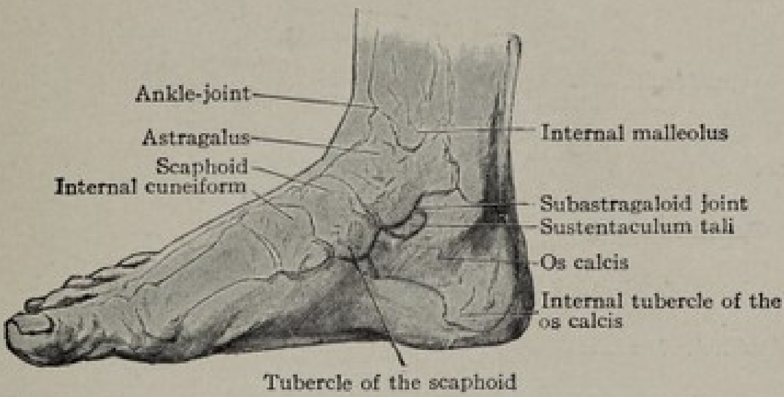


FIG. 633.—Surface anatomy of the inner side of the ankle.

Bony Landmarks.—There are five prominent bony points: they are the *internal* and *external malleoli*, the *tubercles of the calcaneous* (*os calcis*) and *navicular* (*scaphoid*) and the *tuberosity of the fifth metatarsal bone*.

The *internal malleolus* is large and flat and has a somewhat rounded lower edge. It is above and anterior to the external malleolus. Immediately in front of its anterior edge runs the commencement of the long saphenous vein. Around its lower posterior border runs the tendon of the tibialis posterior muscle on its way to the tubercle of the scaphoid.

The *external malleolus* is more prominent than the internal, smaller, and more pointed. The fibula above for its lower fourth is subcutaneous. The tip of the external malleolus is 2 cm. (¾ in.) below and behind the internal. Around its posterior and lower edge run the peroneus longus and brevis tendons.

The two *tubercles of the calcaneus* (*os calcis*) can be felt posteriorly and at the sides. The external surface can be followed forward, but the internal is buried beneath the soft tissues. Of the two tubercles on its under surface the internal can be felt on the sole of the foot by firm pressure.

The *tubercle of the scaphoid* (*navicular*) lies on the plantar rather than on the lateral aspect of the bone. It can be felt 4 cm. (1½ in.) below and in front of the internal malleolus. It is the landmark for the tarsal joints on the inner side of the foot. The tibialis posterior muscle runs from it to the posterior edge of the internal malleolus.

The *sustentaculum tali* can be found by feeling 2.5 cm. (1 in.) below the internal malleolus. It is not very distinct.

The *tuberosity of the fifth metatarsal bone* is the large bony prominence 6 cm. (2½ in.) below and in front of the external malleolus. It is the guide to the tarsal joints on the outside of the foot. The tendon of the peroneus brevis runs from it to the posterior edge of the external malleolus.

The *peroneal spine* (tubercle) can be felt indistinctly as a small bony prominence 2.5 cm. (1 in.) below and a little in front of the external malleolus. In front of it runs the peroneus brevis and behind it the peroneus longus.

The Tendons.—It is difficult to identify the position of the tendons, especially if one does not know where to look for them.

The *tendo calcaneus* (Achillis) is usually easily recognized, as it can be made tense, even in fat, chubby children, by dorsally flexing the foot.

The *flexor digitorum longus* and *flexor hallucis longus* lie too deeply behind the internal malleolus to be recognized; the latter is the more posterior.

The *tibialis posterior,* on strongly abducting the foot, can often be seen and felt along the posterior border of the internal malleolus and between the latter and the tubercle of the scaphoid, into which it inserts.

The *tibialis anterior* is the tendon nearest the anterior edge of the internal malleolus. It runs down to the first (internal) cuneiform bone about 2.5 cm. (1 in.) in front of the tubercle of the scaphoid.

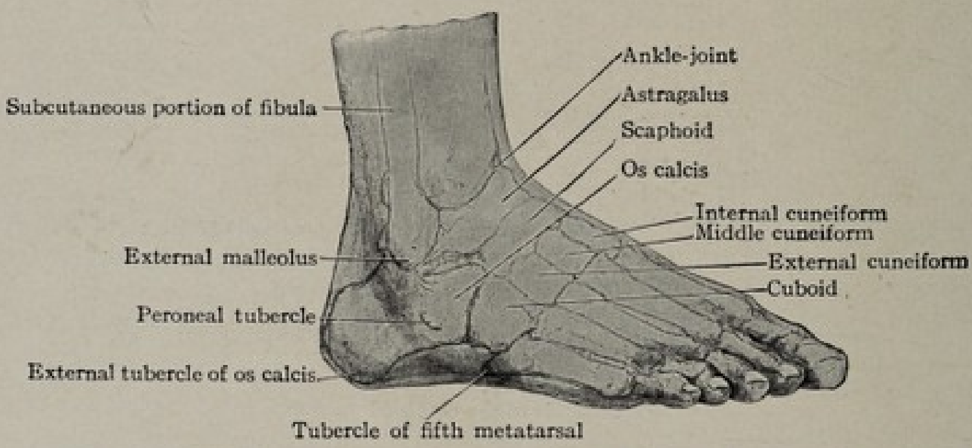


FIG. 634.—Surface anatomy of the outer side of the ankle.

The *extensor hallucis longus* lies just to the outside of the tibialis anterior and can often be made prominent by flexing the big toe.

The *extensor digitorum longus* tendons at the ankle lie close together just outside of the *extensor hallucis longus.* The *peroneus tertius* runs from them to the dorsum of the fifth metatarsal bone a little in front of its base.

The *peroneal tendons* can usually be made visible by sharply adducting the foot. The brevis is then seen running back to the peroneal spine 2.5 cm. (1 in.) below and a little in front of the external malleolus and from this point up to behind the malleolus; in thin people both the brevis and longus can be seen and followed up the lower part of the fibula.

The soft rounded prominence about 5 cm. (2 in.) in front of the external malleolus is the *extensor brevis digitorum muscle.*

The Joints.—The *ankle-joint* lies 1.25 (½ in.) above the tip of the internal malleolus.

The *midtarsal* (Chopart's) joint is best found on the inner side of the foot; here it passes immediately behind the tubercle of the scaphoid. On the outer side it is approximately at the middle of a line joining the external malleolus and tuberosity of the fifth metatarsal bone. At this point there is frequently a bony prominence formed by the anterior edge of the os calcis.

The *tarsometatarsal* (Lisfranc's) joint is best found on the outer side of the foot. It lies immediately behind the tuberosity of the fifth metatarsal bone, between it and the cuboid.

Its inner extremity can be found either by following up the first metatarsal bone from its head for about 5 cm. (2 in.) when a ridge of bone will be felt on its base, the joint being immediately behind it; or by identifying the tubercle of the scaphoid and allowing 2.5 cm. (1 in.) from its anterior edge for the internal cuneiform bone. Its exact location is to be recognized by pressing with the edge of the thumb at the suspected spot and moving the metatarsal bone with the opposite hand.

THE ARTERIES OF THE FOOT

The **dorsalis pedis artery** runs from the middle of the front of the ankle to the base of the first metatarsal interspace. The extensor hallucis longus tendon

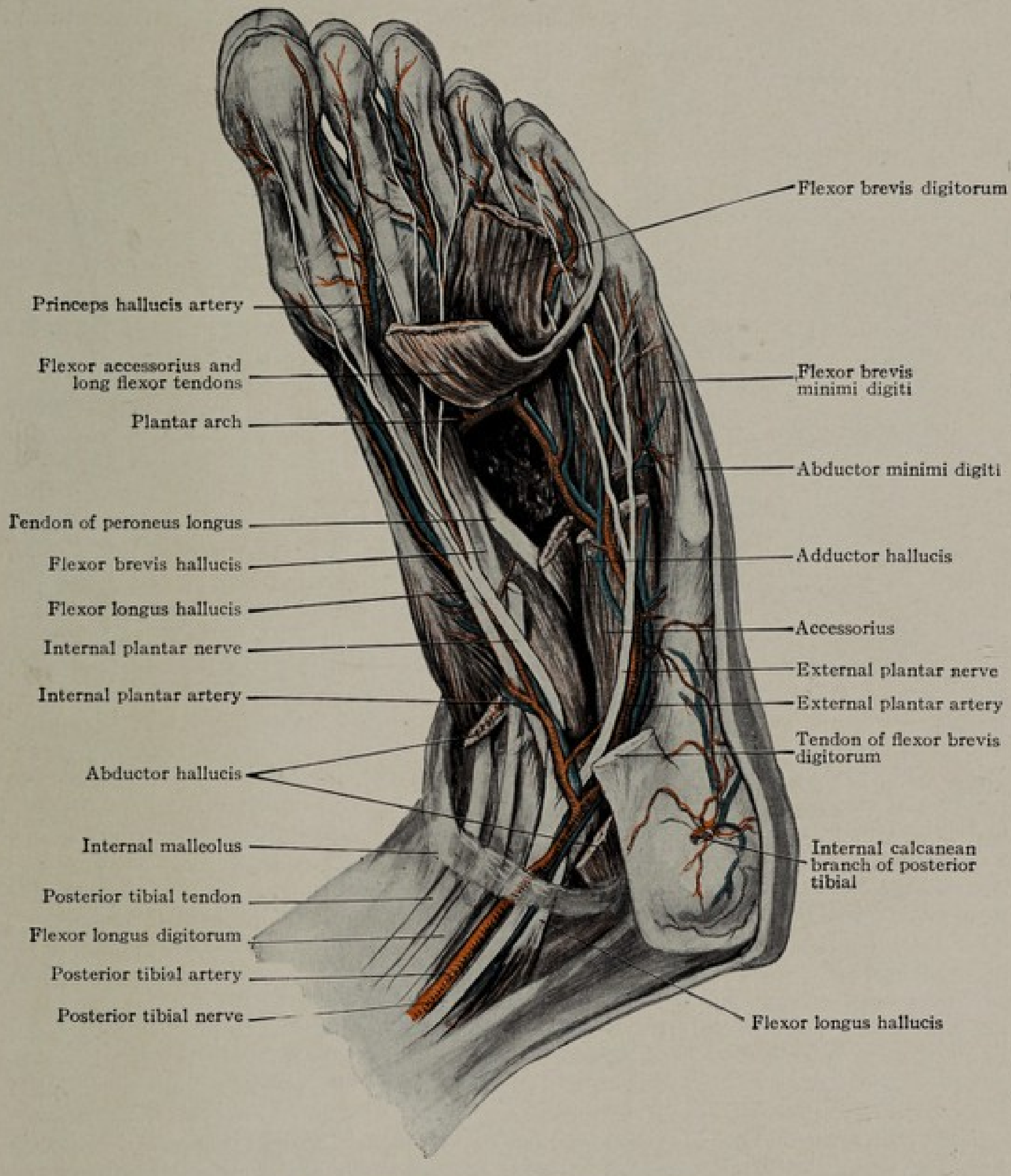


Fig. 635.—Plantar arteries and nerves.

is on the medial side and the extensor digitorum longus on the lateral. An incision made midway between these tendons exposes the muscular fibres of the extensor digitorum brevis; this is pulled to the outer side and the artery will be found lying on the bone beneath. The extensor digitorum brevis crosses it near its termination.

This artery is rarely the subject of ligation, but one frequently endeavors to feel its pulsation in order to determine whether the artery above is intact.

The Plantar Arteries.—The tibialis posterior divides into the internal and external plantar arteries at a point midway on a line joining the internal malleolus and internal tubercle of the calcaneus (os calcis). From this point the **internal plantar artery** runs forward along the medial side of the flexor hallucis longus in the groove between the abductor hallucis and flexor digitorum brevis. It is much the smaller of the two plantar arteries (Fig. 635).

The **external plantar artery** runs from the same point as the internal to the inner side of the base of the fifth metatarsal bone. To this point it lies beneath the flexor brevis digitorum and above the accessorius. It then dips deeper, lying on the interossei, and curves inward to end in the communicating artery which pierces the base of the first metatarsal space to anastomose with the dorsalis pedis.

It can be ligated by making an incision at the medial side of the base of the fifth metatarsal bone between the flexor digitorum brevis and the flexor brevis minimi digiti.

Formal ligation of the plantar arteries is not often required. If wounded the bleeding can be stopped by packing the wound, applying pressure, and elevating the foot as high as possible. Care is to be exercised in making incisions in the sole of the foot in the grooves to the inner and outer side of the flexor digitorum brevis for fear of wounding the plantar arteries. The external plantar is, however, not liable to be wounded if the incision is made back toward the tubercle of the os calcis.

The plantar arteries usually escape division in operating subcutaneously on the plantar fascia because the plantar fascia is above the flexor brevis while the arteries are below. It is so difficult to ligate bleeding arteries in the foot that it is usually better to pack the wound with an antiseptic gauze and elevate the limb.

AMPUTATIONS OF THE FOOT

The foot may be amputated through the midtarsal or tarsometatarsal joints. Ordinarily they give unsatisfactory stumps owing to the heel being pulled up by the tendo calcaneus (Achillis), and the shape of the inner part of the tarsal arch. This causes the patient to walk on the end of the stump, which soon becomes painful.

To perform these operations skilfully it is essential that one be familiar with the lines of the joints. Plantar flaps are used because the skin of the sole is tougher than that of the dorsum and the cicatrix is out of the line of pressure.

Mid-tarsal (Chopart's) Amputation.—This is made through the mid-tarsal joint. The guides to the joint are the tubercle of the scaphoid (navicular) on the inside and the ridge on the anterior end of the os calcis, midway between the external malleolus and the fifth metatarsal bone, on the outer side. A short dorsal and a long plantar flap are cut. The plantar flap is longer on its inner side to allow for the greater thickness of the foot on that side. It is easier to begin the disarticulation on the inside, going in just behind the tubercle of the scaphoid (navicular). This part of the joint is convex forward. On reaching the outer edge of the astragalus (talus) care should be taken not to slip posteriorly between the astragalus and os calcis, but to continue laterally. The extensor tendons are to be sutured to the end of the stump and frequently the tendo calcaneus (Achillis) is cut in an attempt to prevent subsequent elevation of the heel. (Fig. 636.)

Carelessness may result in opening the joint in front instead of behind the scaphoid (navicular).

Tarsometatarsal (Lisfranc's) Amputation.—The guide to this joint is the tuberosity of the fifth metatarsal bone on the outer side and the ridge on the base of the first metatarsal on the inner side. This latter is about 4 cm. (1½ in.) in front of the highest point of the tubercle of the scaphoid.

The joint is best entered from the outer side. The knife is to be passed first forward and then carried inward. Trouble is usually experienced when the base of the second metatarsal is to be disarticulated. It lies behind the others and some surgeons advise skipping it and opening the first metatarsal joint and then completing the disarticulation by opening the second last. The sawing off of the projecting first (internal) cuneiform bone as proposed by Hey is objected to on account of weakening the attachment of the tibialis anterior tendon. The same precaution is to be taken of making the plantar flap longer on its inner side, as was advised in Choparts' amputation, on account of the greater depth of the foot on this side. The line of the joint is best understood by reference to the position of the bones (Fig. 622). Tenotomy of the tendo calcaneus (Achillis) is not so often resorted to in this

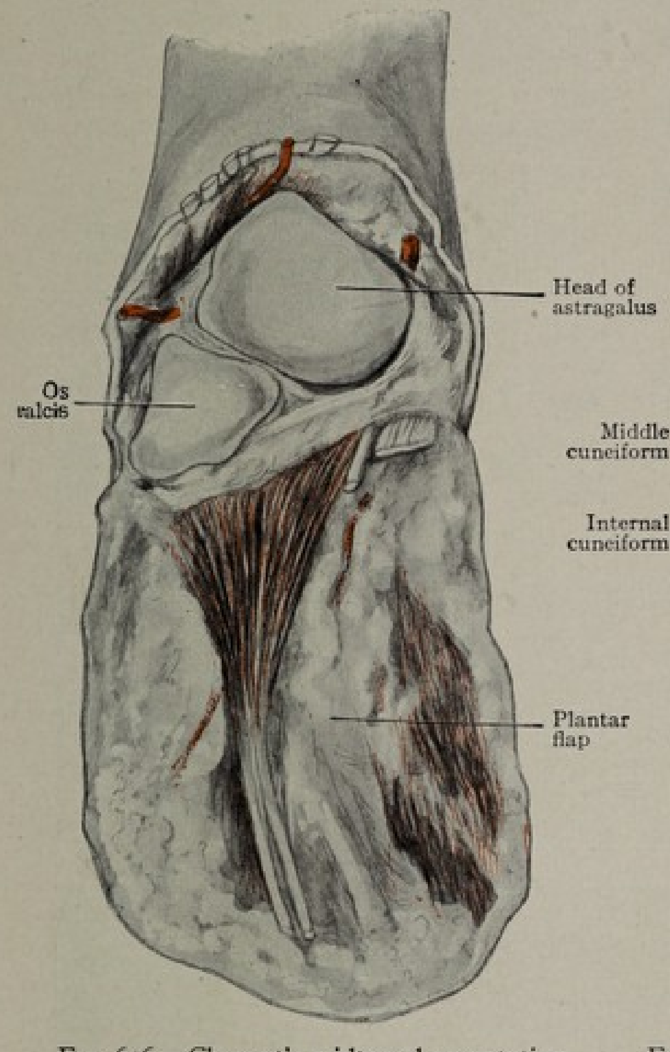


Fig. 636.—Chopart's midtarsal amputation of the foot.

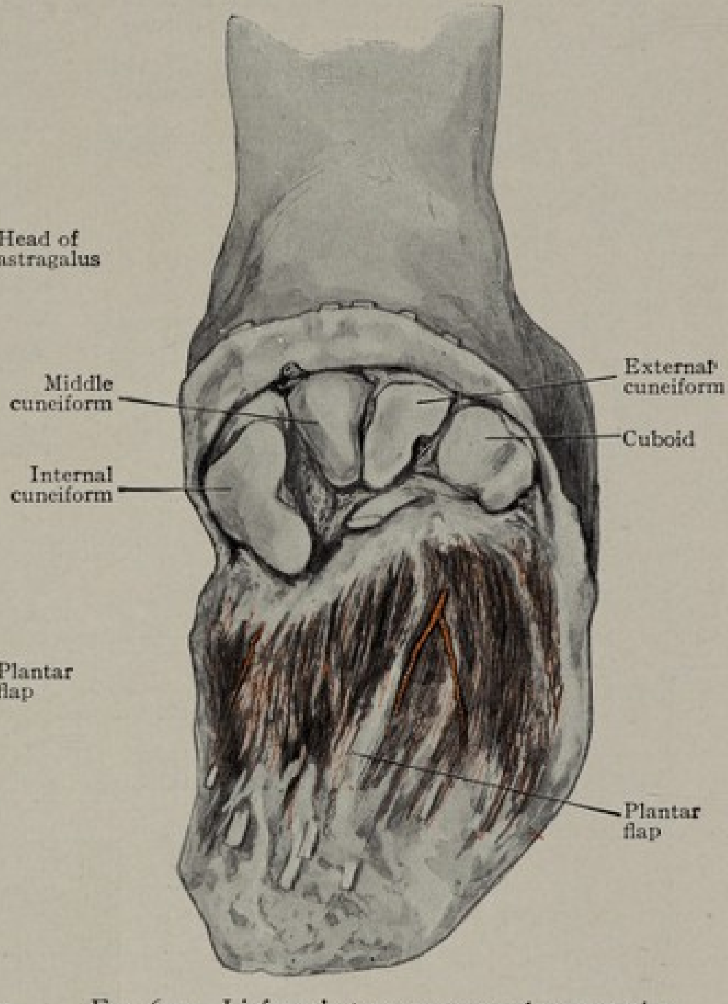


Fig. 637.—Lisfranc's tarsometatarsal amputation of the foot.

amputation as in that through the midtarsal joint (Fig. 637). These operations are very rarely done today.

PLANTAR ABSCESS

Abscesses of the sole of the foot are usually caused by infected punctured wounds, or by the extension of infection from wounds of the toes, etc.

The plantar fascia lies on the flexor brevis digitorum while the long flexor tendons lie beneath it. A punctured wound may perforate the plantar fascia and penetrate the flexor brevis which arises from its under surface, yet if this muscle is not entirely traversed by the wound the tendons of the long flexors beneath escape infection and the pus accumulates beneath the plantar fascia. In incising for these infections the surgeon must keep in mind the anatomy of the region, considerable disfunction resulting if the tendons are damaged.

Superficial Plantar Abscess.—In the superficial form of plantar abscess the pus tends to point in four directions: (1) it may come directly up through gaps between the fibres of the plantar fascia and make an hour-glass abscess, a small amount of pus being above the plantar fascia, between it and the skin, while a larger collection is beneath the fascia in the substance of the muscle; (2) it may burrow its way forward showing between the tendons in the direction of the webs of the toes; (3) it may appear in the groove on the outer side of the foot between the flexor brevis and abductor minimi digiti; (4) it may appear on the inner side of the foot between the abductor hallucis and flexor brevis (Fig. 638).

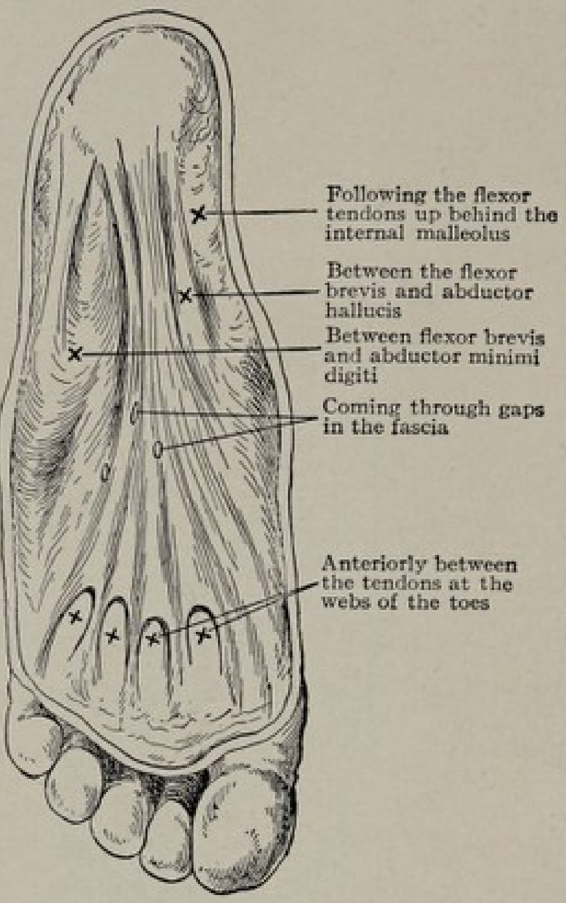


Fig. 638.—Diagram showing the points of exit of suppuration beneath the plantar fascia.

Deep Plantar Abscess.—In deep infection the pus accumulates around the deep flexor tendons and beneath the flexor brevis muscle. Its greatest tendency is to extend up the leg by following the flexor tendons behind the internal malleolus. It may also show itself in the grooves on either side of the flexor brevis, or between the tendons at the webs of the toes.

Incision of Plantar Abscess.—The safest way to open these abscesses is by the method of Hilton. The skin is first incised and the abscess opened by inserting a pointed hæmostatic forceps and opening its blades, or using some similar blunt instrument. This is done to avoid wounding the arteries. If necessary the whole thickness of the foot may be traversed by this means and a drainage-tube passed through from one side to the other.

Incisions should not be made over bony points where they would be subjected to pressure. Hence the heads of the metatarsal bones and the prominent outer edge of the foot are avoided. Incisions in the hollow of the foot and between the forward ends of the metatarsal bones are to be preferred. In opening a subcutaneous collection one should not be satisfied with simply incising the skin, but the fascia should be widely split to guard against a larger collection of pus beneath.

Fig. 639.—Talipes equinovarus.

Collections which present to the outer side of the flexor brevis are to be opened a little distance behind the base of the fifth metatarsal bone because the external plantar artery becomes somewhat superficial at its inner side.

FRACTURES OF THE FOOT

Special mention should be made of fractures of the calcaneus and talus. If the fracture line runs into the subastragalar joint which is common in fractures of the calcaneus, the injury to the joint surface causes pain in that joint. Allison and Wilson have strongly recommended that subastragalar arthrodesis be done in these recent fractures and claim excellent results with this method of treatment.

DEFORMITIES OF THE FOOT

The common deformities of the foot are those in which the parts affected are deformed or turned to an abnormal degree in the direction of their normal movements. Thus in *talipes varus* the foot is turned inward, hyperadducted; *talipes valgus* and flat-foot, turned out, hyperabducted; *talipes equinus* or hyperextended, *talipes calcaneus* or hyperflexed, and *talipes cavus* or increase of the arch of the foot.

These deformities may be either congenital or acquired, and it is not always easy to separate the two. A deformity may be thought by the parents to have existed from birth, when it may have been caused by an infantile paralysis occurring before the period of walking.

Foot deformities likewise possess two characteristics which are marked, they are those of paralysis or weakness and contraction or strength. They are usually associated but sometimes separate. There can be a paralysis without contraction, but inasmuch as the muscular system is built on the principle of balance it is obvious that if one muscle or set of muscles is paralyzed it is only a question of time until the opposing muscles become contracted. In a similar manner if contraction exists as the most prominent element and perhaps the primary one, it will usually be found that the opposing muscles and ligaments are stretched and weakened.

These conditions furnish the indications for treatment. Where weakness is the predominant feature then support is to be given and contraction of the relaxed tissue favored. Where strength and contraction is predominant then operations and forcible measures are necessary to overcome them. Also, when in a contracted case the contracted tissues have been overcome, there still remains the weakness of the opposing tissues to be remedied. It may be possible to bring the foot to a perfectly normal position, but until the previously weakened and overstretched tissues have regained their tone normal function will not be possible.

While the deformities may be simple they are usually compound; thus an equinus may be associated with a varus or valgus, and is then called an equinovarus or equinovalgus. Cavus or hollow-foot and calcaneous or lowering of the heel are often associated, so that it is difficult to draw a line separating them.

Talipes Varus.—Talipes varus in its most common form is congenital and is often associated with equinus or a drawing up of the heel. The prevailing deformity is one of adduction, with a certain amount of inward rotation (Fig. 639). The muscles favoring it are the tibialis anterior and tibialis posterior; therefore the tendons of these muscles are sometimes cut to prevent their drawing the foot upward and inward. Division of the plantar fascia is also often necessary. The main principles of treatment are to stretch the contracted tissues forcibly, either by manual or instrumental force, and then maintain the foot in its corrected position, often at first by plaster of Paris and later by apparatus, until the weakened opposing muscles have resumed their functions. This often takes so long that transplanting of tendons has been resorted to; thus the tendon of the tibialis anterior has been detached from its insertion on the inner side of the foot and transplanted to the outer side, so that the contracting force on the inner side of the foot is weakened, while the correcting force of the abducting muscles has been increased.

If equinus is present their tenotomy of the tendo calcaneus (Achillus) or forcible stretching of it allows the heel to descend.

Talipes Valgus.—In talipes valgus the foot is abducted or everted. It is sometimes associated with equinus and sometimes with calcaneus. It is more usually an acquired than a congenital deformity. It is a deformity that has weakness as its primary cause and most marked characteristic. This weakness is either a more or less general one affecting the ligaments and muscles, as shown by its occurring in adolescents, or else primarily a muscular one caused by spinal infantile paralysis (anterior poliomyelitis) (Fig. 640).

From what has been said of the normal movements of the joints (page 569 and *ante*) it is evident that a weakness of either the muscles or ligaments shows itself first by an eversion of the foot called the *pronated foot* which is followed by a descent of the tarsal arch or *flat-foot* and later by a more complete eversion or *pes valgus*. They are the three stages of the same process.

When a young person with apparently normal feet is subjected to excessive strain, as by long standing, etc., the muscles and ligaments are unable to bear the burden. The muscles give way first and the foot everts, mainly at the subastragaloid joint, thus is produced the pronated foot. The patient, unable to support the body weight sufficiently on the weakened muscles, relaxes them and allows the body weight to be borne on the ligaments. This excess of weight on the ligaments supporting the arch causes them to give way and the arch descends and flat-foot results. The process often stops here in the adolescent form or even if rheumatism is the weakening element (Fig. 641).

When paralysis—usually of the extensors and tibialis posterior—is the cause, then the ligaments not being so much affected may maintain the arch intact, but the whole foot is drawn outward by the peroneal and flexor muscles, aided also by the centre of gravity being shifted inward. The deformity is increased by walking and a true valgus results.

FIG. 640.—Paralytic talipes valgus.

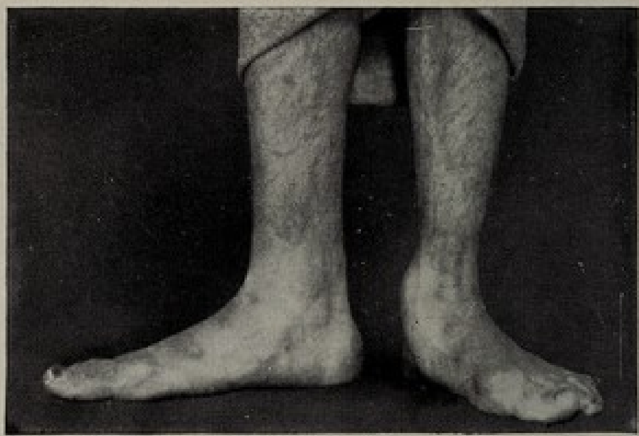


FIG. 641.—Flat-foot.

In the pronated foot and flat-foot of adolescents pain is often marked so that the relaxation of the inverting muscles is often accompanied by spasm of the everting muscles and the peronei muscles are frequently found markedly contracted. In paralytic valgus the eversion of the foot relaxes the peronei and they gradually shorten. It should be noted that the contraction of the peroneal muscles in one case is active, in the other passive.

Treatment.—In painful pronated and flat feet the contracted muscles can be relaxed by perfect rest in bed. Next the arch can be supported by pads or plates beneath the instep and the weakened muscles strengthened by massage, electricity, or appropriate exercises while the exciting cause of overwork is removed. In paralytic valgus, the foot may be brought straight by forcible stretching and held there by appropriate apparatus; or an artificial ankylosis (arthrodesis) of the subastragaloid and ankle-joints may be made to hold the foot in position; or the peroneal or other tendons, on the outer side of the foot, may be transplanted to the inner.

Talipes Equinus.—This sometimes exists as a pure form but it often accompanies varus and sometimes valgus. It is caused by a paralysis of the extensor muscles. The tendo calcaneus is contracted and the patient walks on the toes. By division or lengthening of the tendo calcaneus and forcible flexion of the foot the heel may be brought down but the foot will "flop" in a more or less flail-like condition from the leg. To remedy this either an apparatus is employed or sometimes the peroneal muscles or some of the flexor tendons are brought forward and the effort made to have them fulfil the function of the paralyzed extensors, which latter may also be shortened (Fig. 642). Where all the muscles are paralyzed and there is a flail-foot, a posterior bone block at the tibio-astragalar joint will support the foot.

Talipes Calcaneus and Talipes Cavus.—These result from paralysis of the muscles of the calf or of most of the flexor and extensor muscles (Figs. 643 and 644).

If the calf muscles are paralyzed the contraction of the tibialis anterior and tibialis posterior pull up the arch and the contraction of the flexor brevis digitorum pulls the pillar closer together, therefore the heel descends, the arch ascends, and the plantar ligaments contract. If the extensor muscles are also paralyzed the toes drop and the anterior deformity is increased.


Fig. 642.—Talipes equinus.

The *treatment* of this condition is as yet not entirely settled. The plantar fascia must be divided and the pillars of the arch separated and the arch depressed by forcible manual or instrumental means. To retain the foot in its corrected position the tendo calcaneus is sometimes shortened. Jones makes an arthrodesis (ankylosis) of the midtarsal and ankle-joints; Whitman excises the astragalus, pushes the foot back, and transplants the peroneal and posterior tibial tendons into the os calcis. Davis made a transverse section through the subastragaloid joint, pushes the foot back, and if necessary transplants the peroneal and posterior tibial tendons into the os calcis.

Hallux valgus is a subluxation of the big toe outward. There is usually a deformity of the bone, the joint surface of the head of the first metatarsal being inclined obliquely out. As the toe becomes displaced outward the extensor hallucis longus by its contraction tends to increase the deformity. On the side of the head


Fig. 643.—Talipes calcaneus.

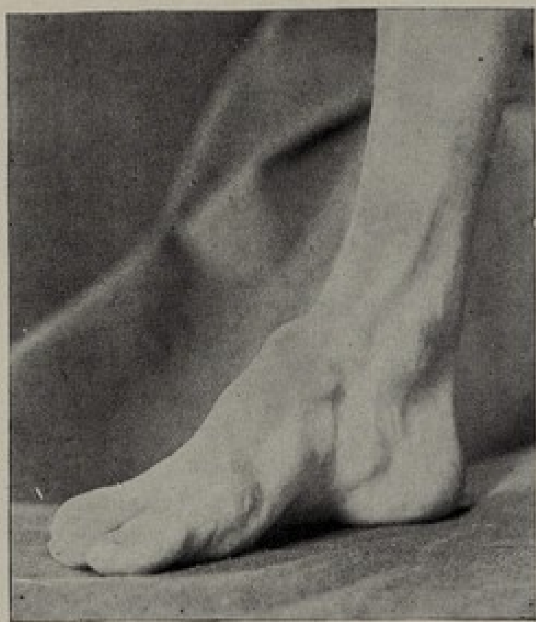


Fig. 644.—Talipes cavus.

of the protruding metatarsal bone a bursa develops and becomes painful, forming a *bunion*. This bursa sometimes suppurates (Fig. 645).

In some cases hallux valgus is due apparently to ill-shaped shoes, but in many cases, and these the worst, a rheumatoid condition is the main factor. In treatment the articular surface of the head of the first metatarsal bone is first resected or a wedge-shape resection of the metatarso-phalangeal joint is done. If desired a fascial flap can be interposed. This enables the toe to be brought straight. To keep it straight the tendon of the extensor hallucis is displaced inward and sewed in position with catgut, so that by its contraction it keeps the toe from again going outward.

FIG. 645.—Hallux valgus, showing the position of the bones.

Soresi has described an operation which has been particularly useful in those cases where the bursa overlying the joint has been inflamed or has suppurated and therefore unfavorable for interposition at the metatarso-phalangeal articulation as practiced in the Mayo operation. He separates the periosteum from the head of the metatarsal, resects subperiostially the metatarsal head, excises the bursa and redundant skin and closes the wound after straightening the toe.

THE TOES

The toes are shorter than the fingers and are not so often injured. When injured or diseased healing may be delayed by the constant motion to which they are subjected. For this reason rest should be enforced in obstinate cases by the application of bandages or splints.

Ingrown Nail.—This usually affects the big toe. It is caused commonly by the irritation and pressure of badly-shaped shoes. To cure it the side of the nail is sometimes removed. In so doing the nail should be removed well beyond the skin margin at the matrix otherwise it is reproduced in a distorted form. It requires several months for a new nail to grow out from the matrix. Packing cotton soaked in a solution of nitrate of silver, 10 grains to the ounce, beneath the edge of the nail destroys the infection, lessens the pressure, and usually relieves the acute trouble in a few days.

Hammer Toe.—This is a contraction of one of the toes, most often the second. The deformity is usually consecutive to the use of badly fitting shoes. Walsham, Shattock, and Anderson believe it to depend

FIG. 646.—Hammer-toe. (From author's sketch.)

on a contraction of the plantar fibres of the lateral ligaments and glenoid ligament on the under side of the joint. Others hold it to be a contraction of the tendons.

In treatment both conditions have to be considered. On pulling the toes the extensor tendon is put on the stretch, it should be divided, the remaining contractures are then either cut or broken by forcible stretching and the toe kept straight by bandaging until all tendency to contraction has been corrected. As a last resort resection of the joint is performed (Fig. 646).

Luxation of the Toes.—The big toe may become dislocated by direct violence, the lesion is often compound. The displacement is most often backward on the dorsum of the metatarsal bone. When the injury is not compound the same difficulty may be experienced in reducing it as occurs in dislocation of the thumb. The cause is the same. The head of the metatarsal bone becomes caught in the fibrous tissues of the capsule and between the two heads of the flexor hallucis brevis muscle. These each contain a sesamoid bone. The detachment of one of these heads from the base of the first phalanx may be necessary before replacement can be effected.

Dislocation of the other individual toes is not nearly so rare as it is thought to be. It results from jumping from a height and landing, perhaps on an uneven surface, with the toes. The proximal phalanx may be displaced upon the metatarsal bone and the resulting pain is often considered to be merely a sprain.

The head of the affected metatarsal bone can be felt projecting in the sole, the toe is shortened and the space between it and the adjacent one usually increased; but the diagnosis is difficult and is best established by means of a skiagraph. Reduction is difficult and even when accomplished is not apt to remain (Fig. 647). Resection may be required.

Fig. 647.—Dorsal luxation of the proximal phalanx of the second toe. Notice the shortening of the toe, its separation from the third toe, and the fulness over the head of the metatarsal bone. (From a sketch by the author.)

Metatarsalgia or Morton's Disease.—This is a painful affection of one of the metatarsophalangeal joints, usually the fourth. Its pathology is not settled, but treatment is based on the supposition that the heads of the metatarsal bones become pressed together, usually by tight shoes. Relief is often afforded by separating the toes with cotton; by winding adhesive plaster—several thicknesses—around the affected toe; by supporting the arch by pads or plates; by inserting a narrow longitudinal pad; or by resection or amputation.

Resection of the Metatarsophalangeal Joint.—In hallux valgus resection of the head of the metatarsal bone may give rise to a stiff joint. If the ankylosis is in a somewhat extended position, walking may not be impaired.

Excision of these joints may, and often does, give rise to a flail-like condition. The affected toe is deprived of its support and becomes displaced. Sometimes it gets beneath the adjoining toes and pain is caused by their superincumbent pressure. In other cases the toe is squeezed up above the level of the adjoining ones and is rubbed by the shoe above, causing painful corns. In either case the toe affected is a source of misery and not infrequently may require to be amputated. For these reasons excisions are seldom resorted to except in cases of hallux valgus. Here the wedge-shape resection of the metatarso-phalangeal joint with subsequent ankylosis gives good results.

Amputation of the Toes.—Amputation of the phalanges does not cause serious disability, but the loss of the head of the first metatarsal bone seriously weakens the foot, a fact not infrequently overlooked by the surgeon.

Amputation of the outer four toes at the metatarsophalangeal joint is a difficult operation because, unless one is well informed, it will be hard to strike the joint. It should be sought about 1 cm. (2/5 in.) behind the web on the dorsal aspect, and

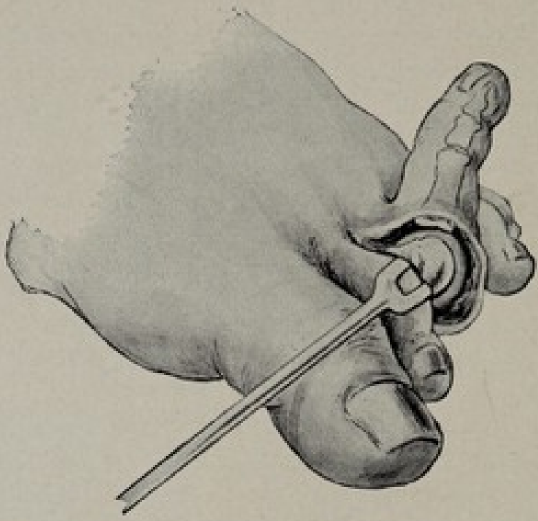


FIG. 648.—Amputation of a toe at the metatarsophalangeal joint, with lateral flaps, showing method of disarticulating.

if approached on the plantar aspect especial care is to be exercised not to go too far back and search for it on the neck of the metatarsal bone (Fig. 648). As in the hand so also in the foot when the proximal phalanx is bent the prominence (or knuckle) is formed by the head of the proximal (metatarsal) bone.

FROZEN SECTIONS

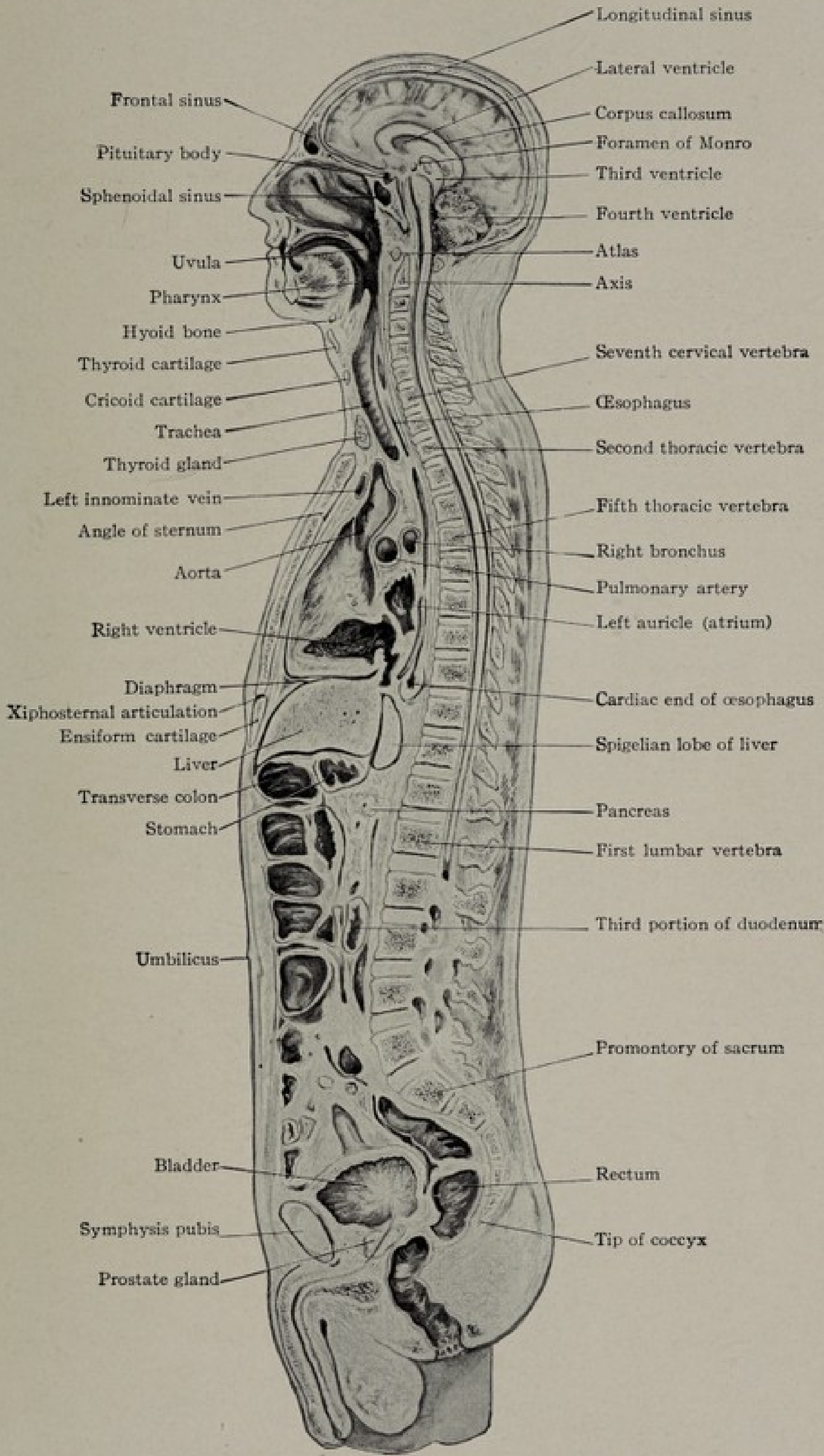


FIG. 649.—Median sagittal section.

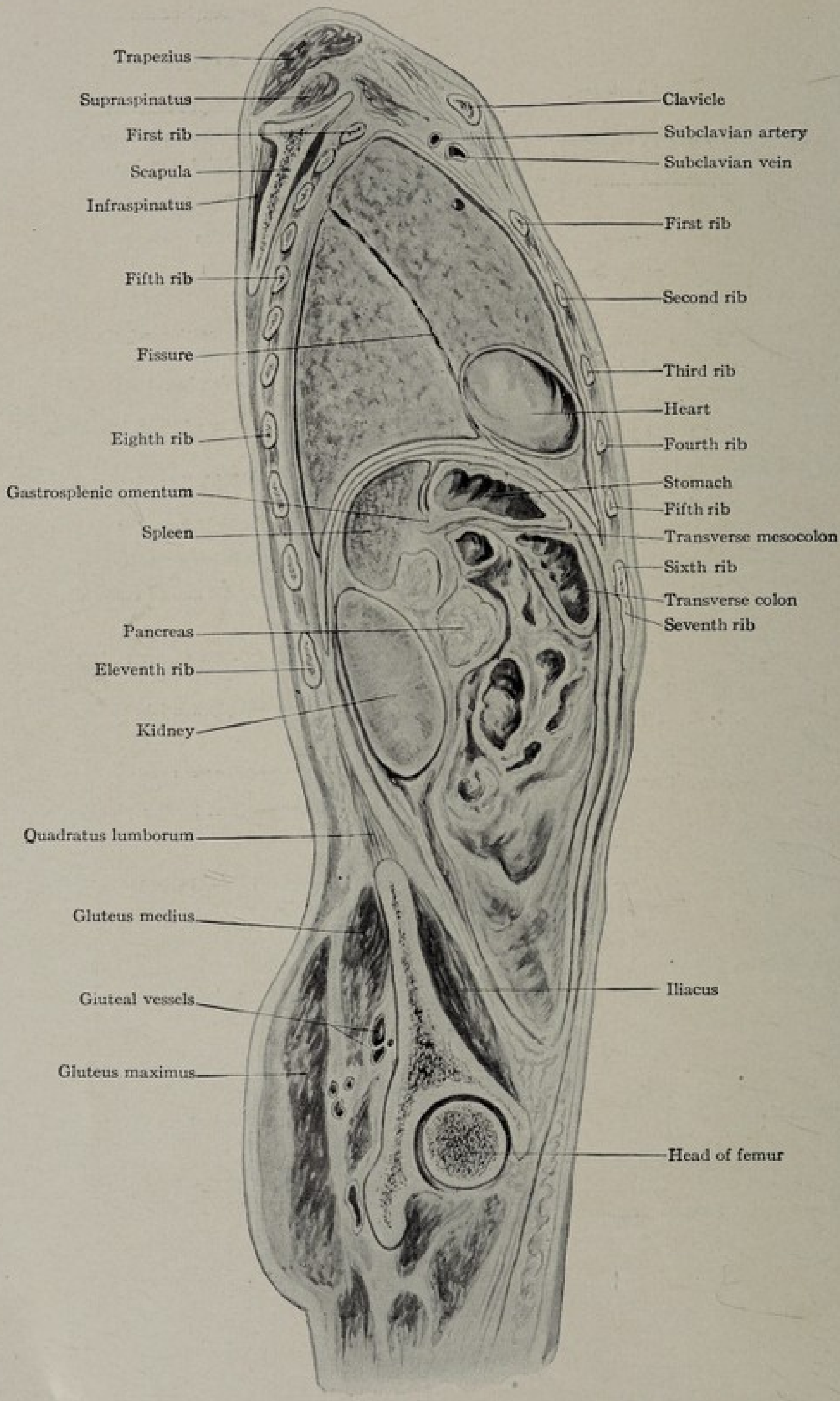


Fig. 650.—Sagittal section through about the middle of the left cavicle.

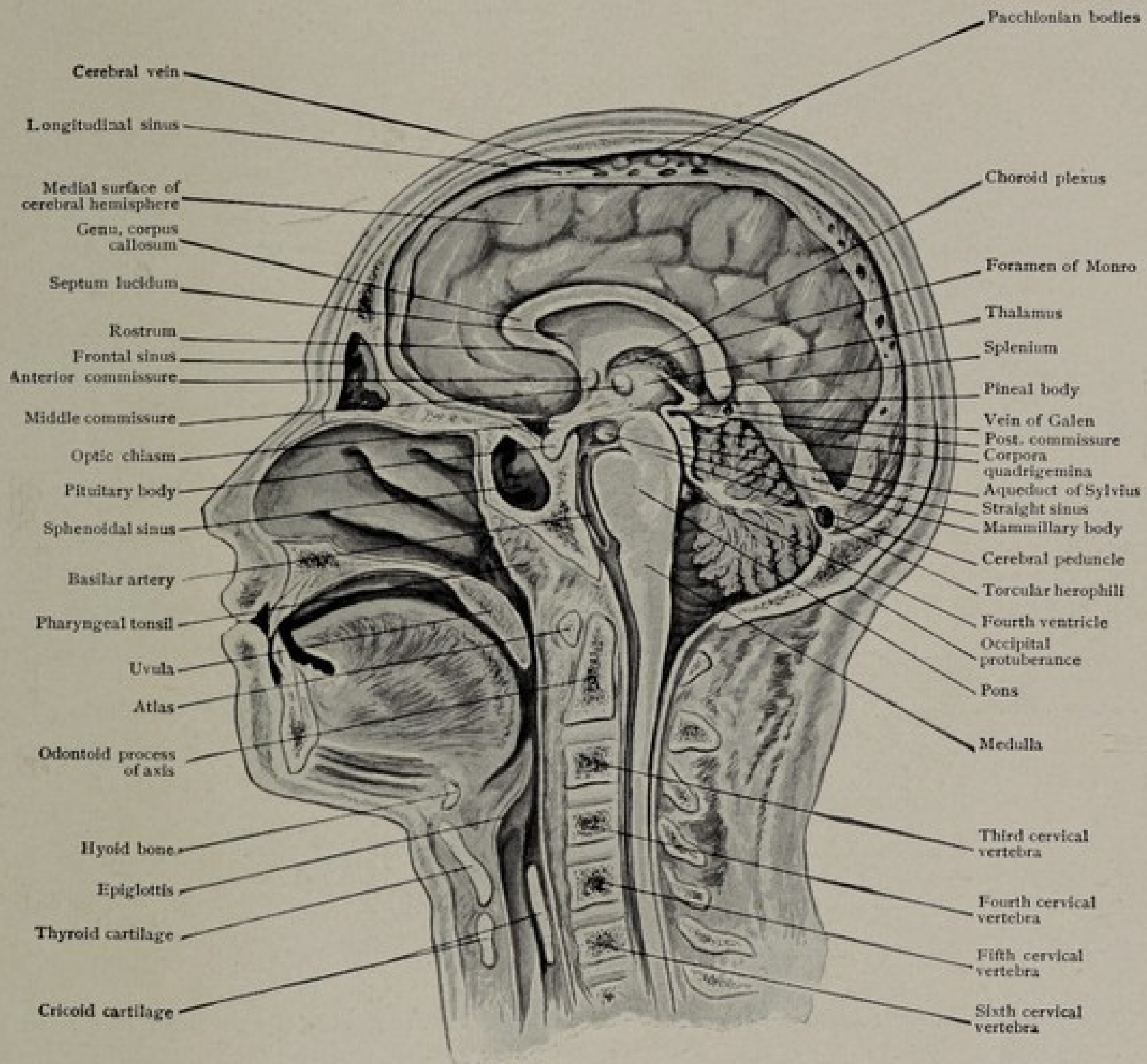


FIG. 651.—Median sagittal section of the head and neck.

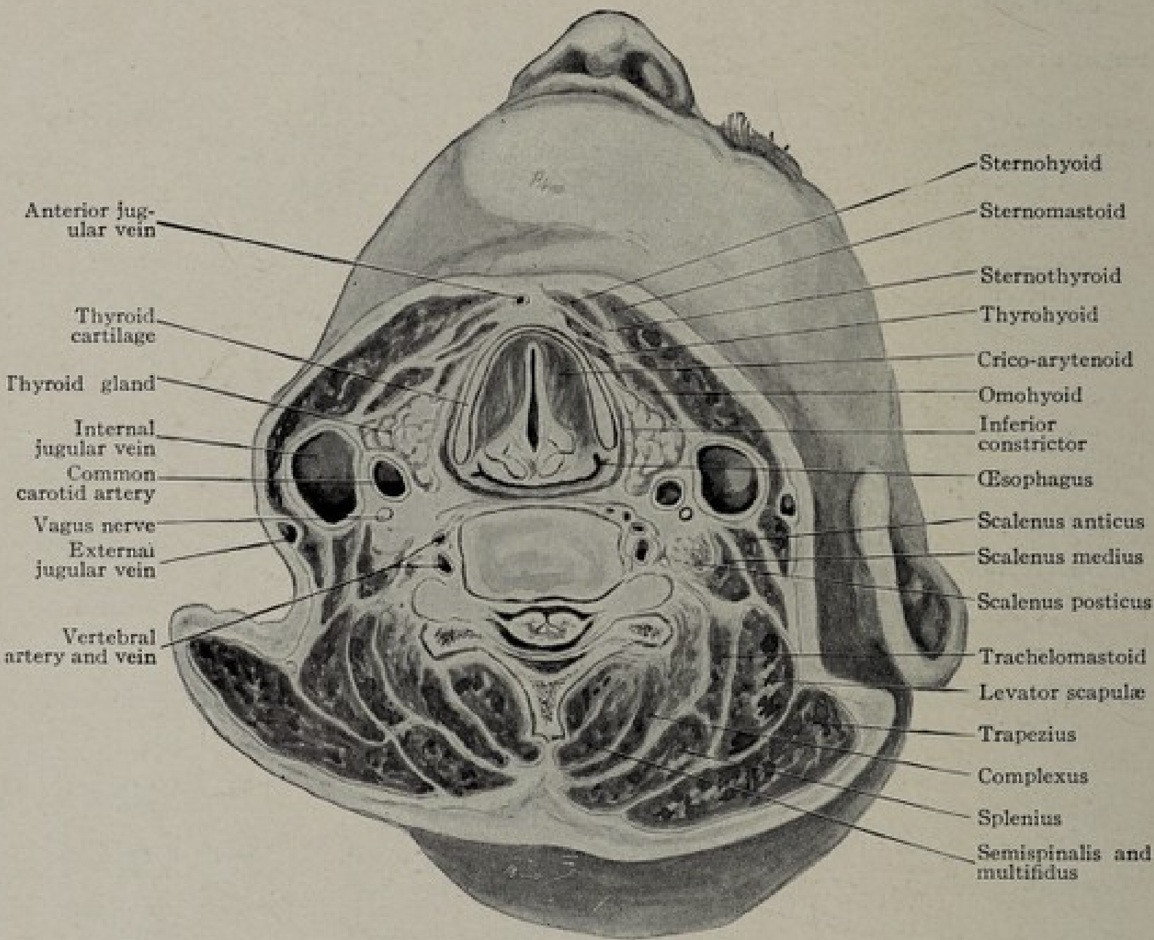


Fig. 652.—Transverse section through the intervertebral cartilage between the fifth and sixth cervical vertebræ.

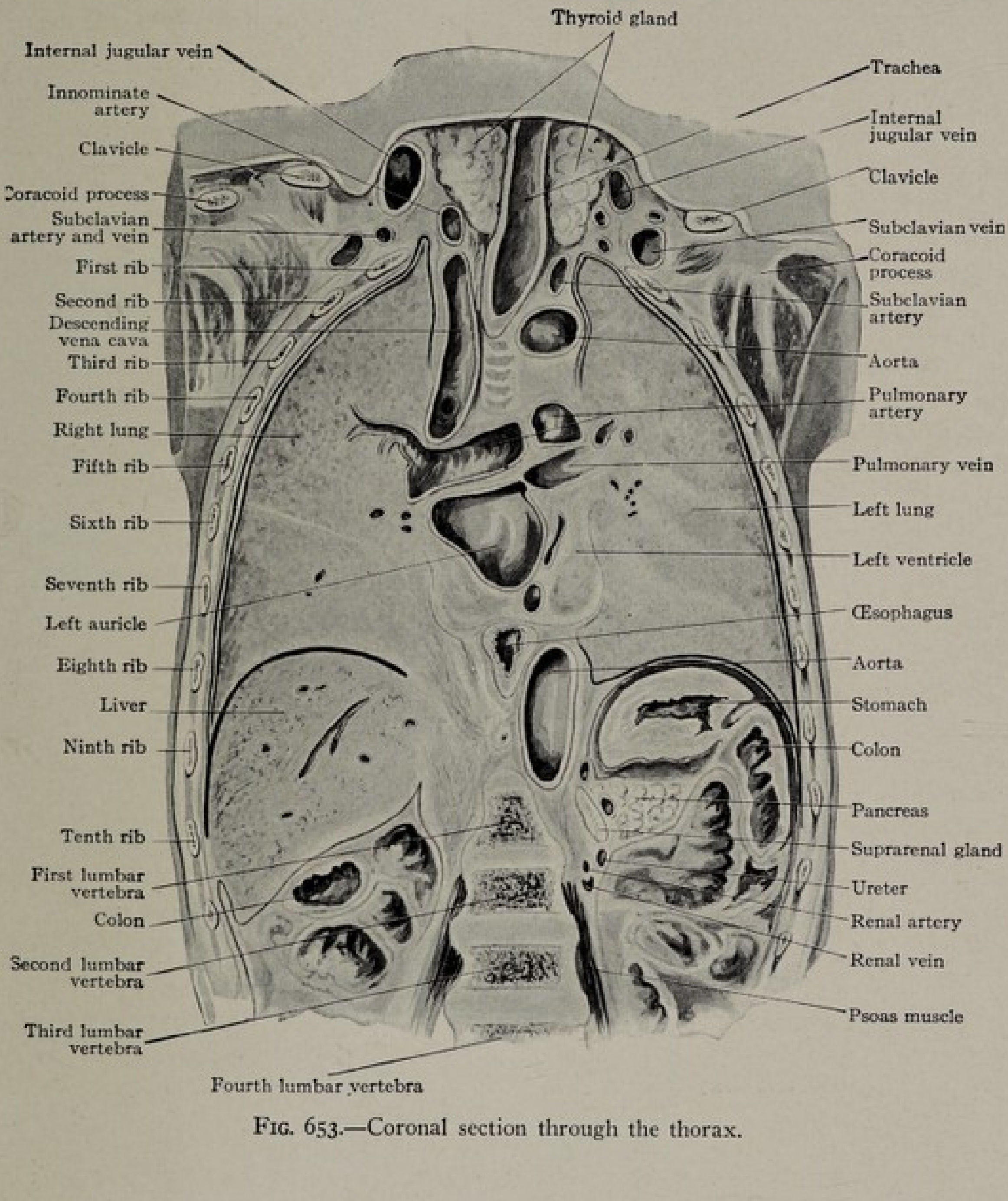


FIG. 653.—Coronal section through the thorax.

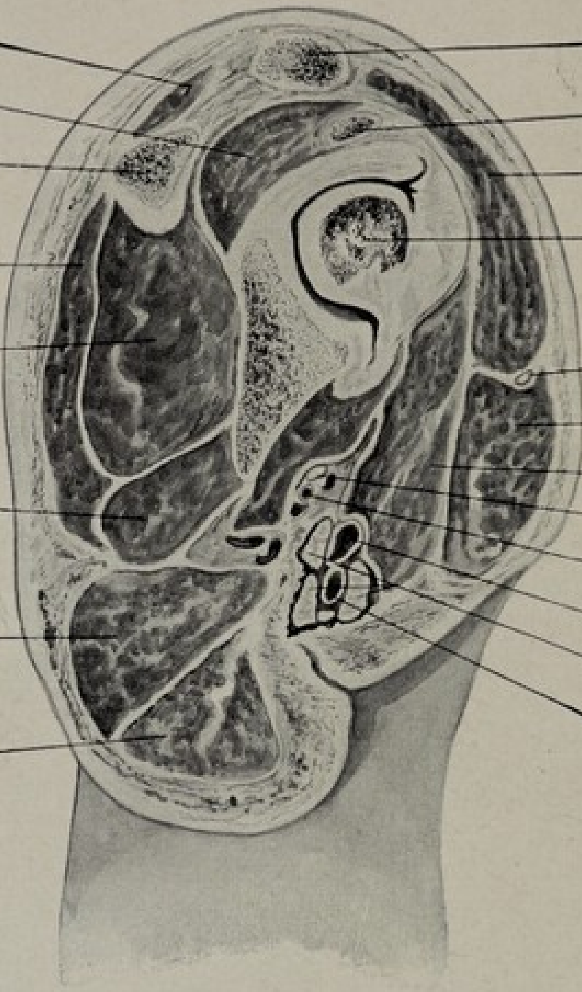


FIG. 654.—Sagittal section through the left shoulder.

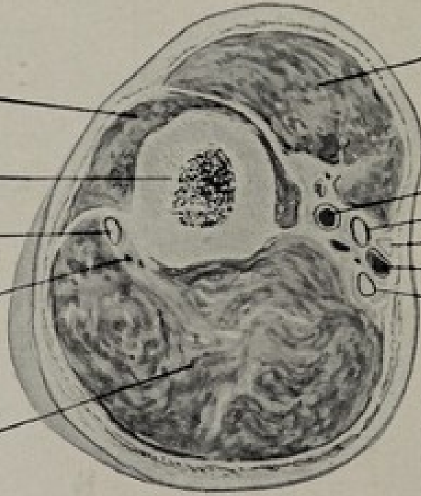


FIG. 655.—Transverse section through the middle of the arm.

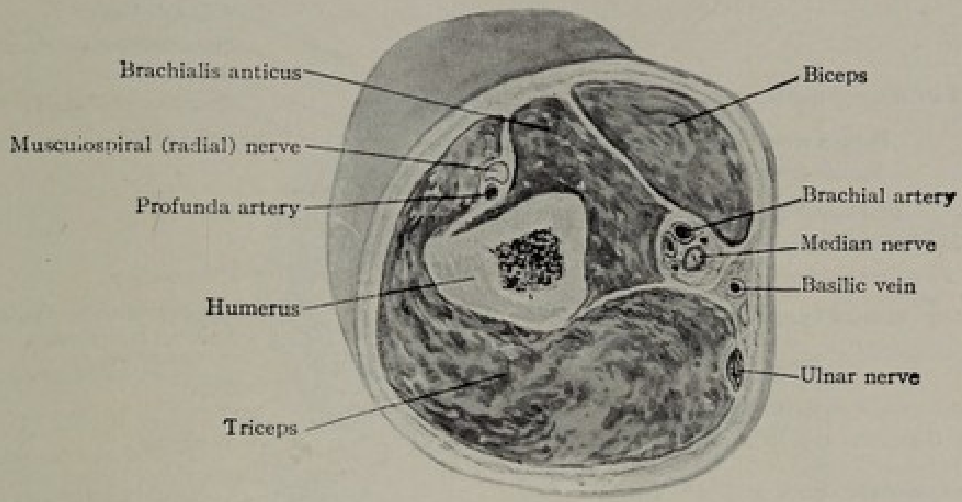


FIG. 656.—Transverse section through the lower third of the arm.

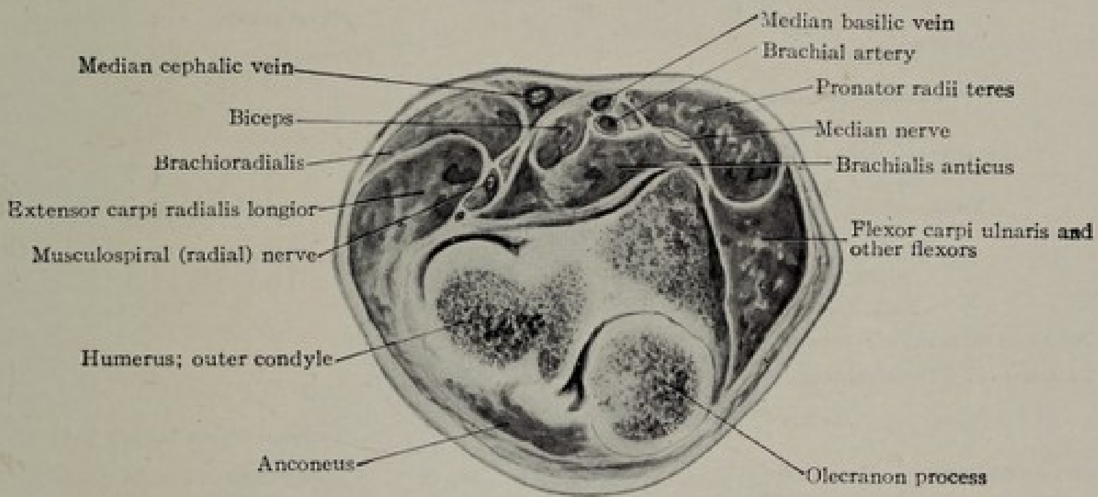


FIG. 657.—Transverse section through the olecranon process.

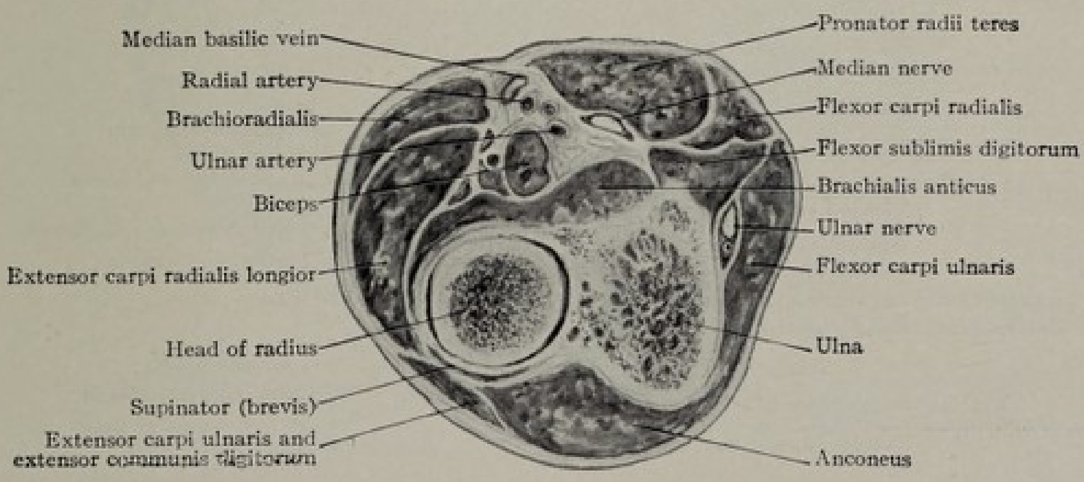


FIG. 658.—Transverse section through the head of the radius.

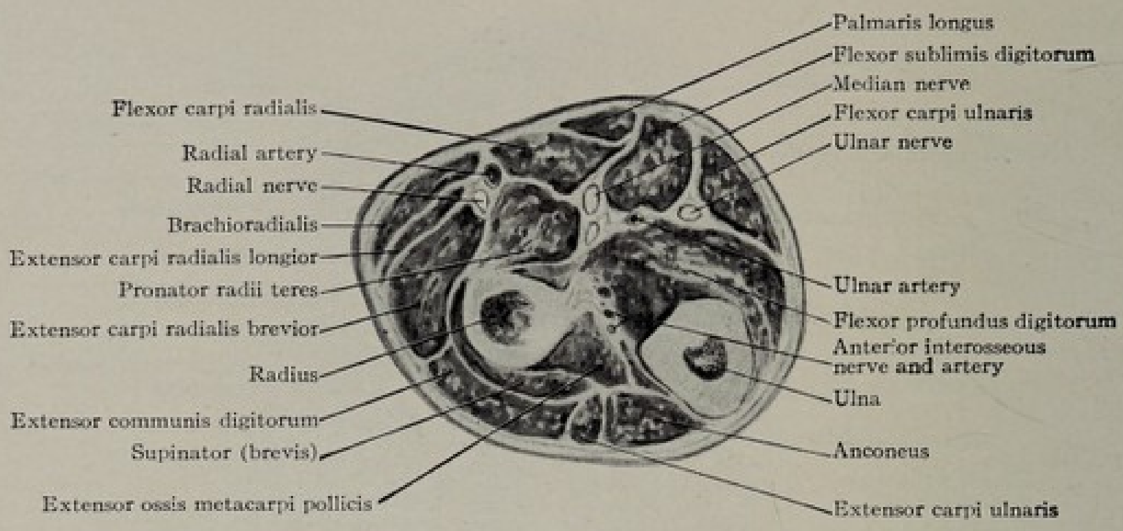


FIG. 659.—Transverse section through the upper third of the forearm.

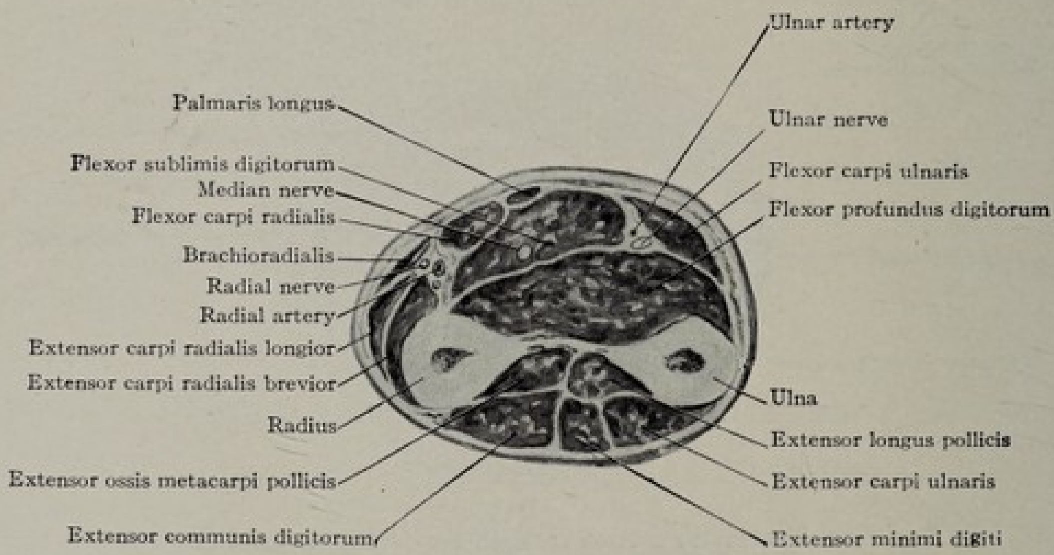


FIG. 660.—Transverse section about the middle of the forearm.

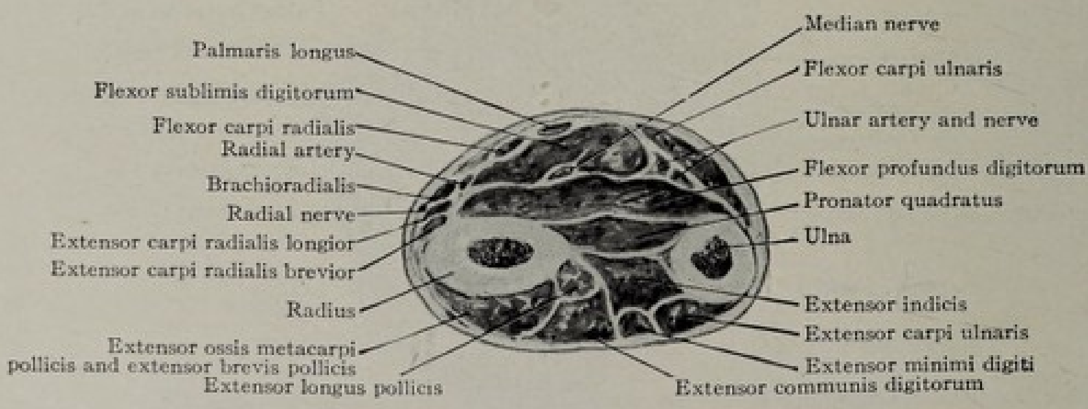


FIG. 661.—Transverse section of upper part of lower third of forearm.

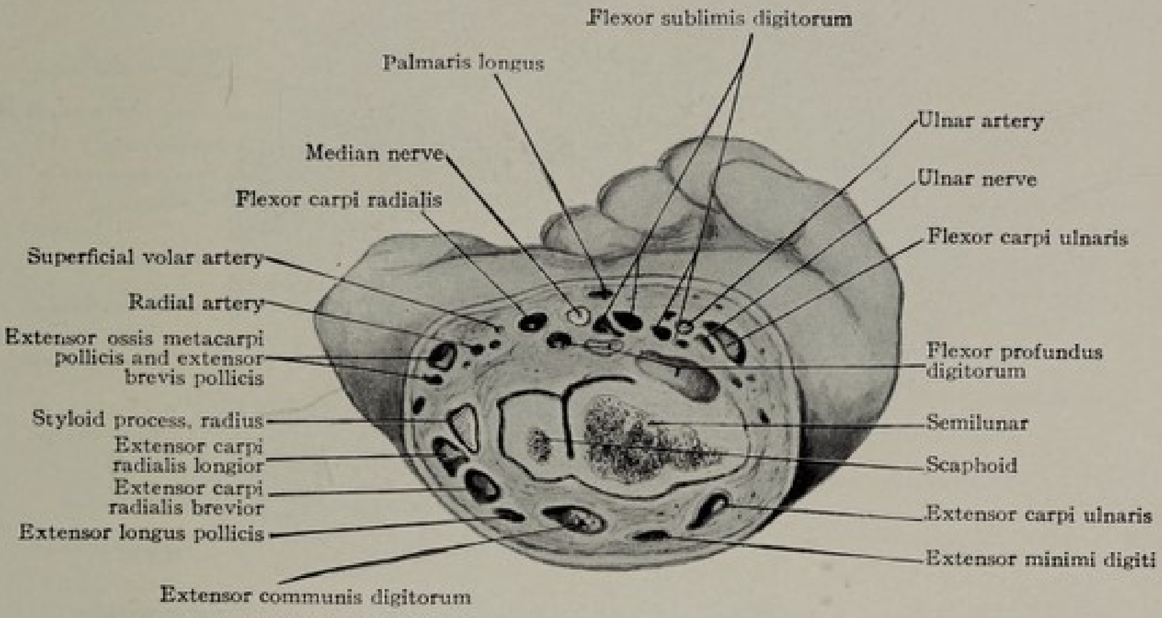


FIG. 662.—Transverse section through the wrist-joint.

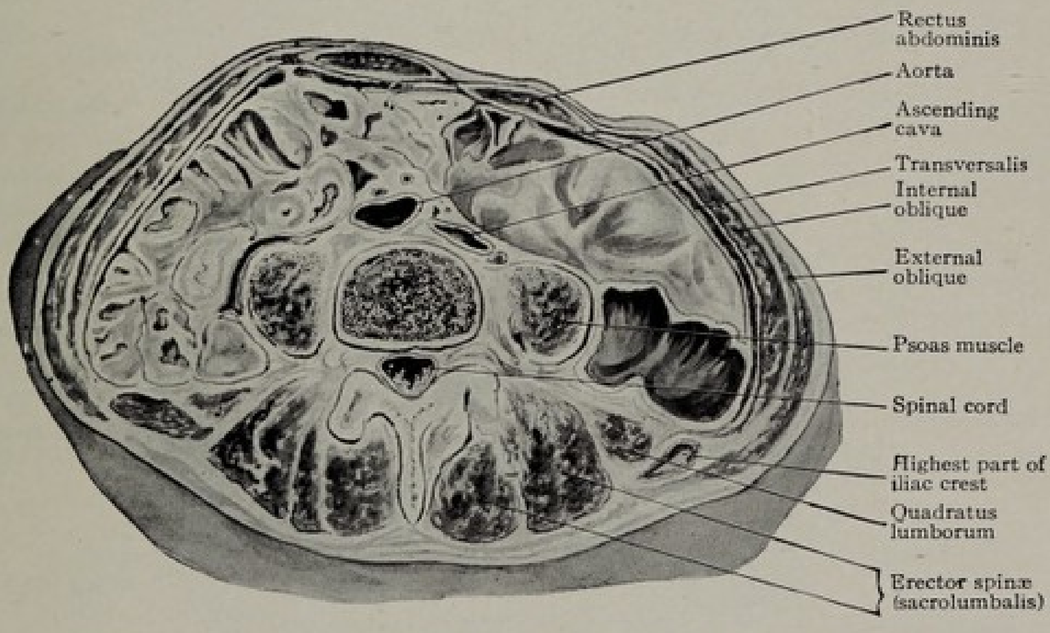


FIG. 663.—Horizontal transverse section through the body of the fourth lumbar vertebra.

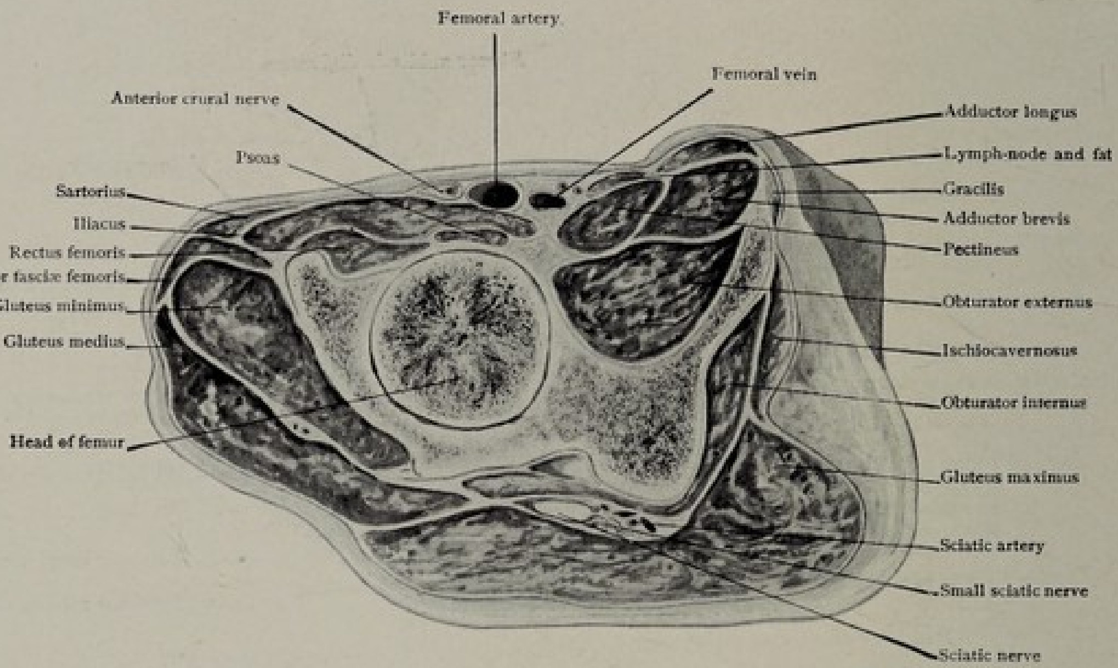


Fig. 664.—Oblique section of the upper part of thigh parallel to and just below Poupart's ligament.

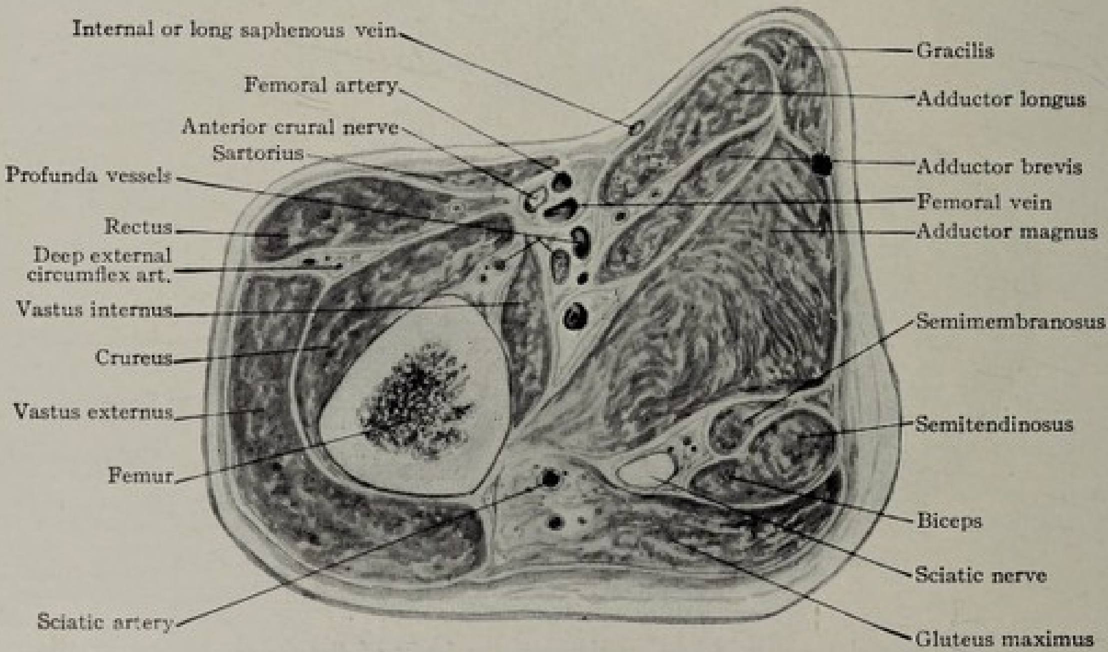


Fig. 665.—Transverse section of thigh high up through Scarpa's triangle.

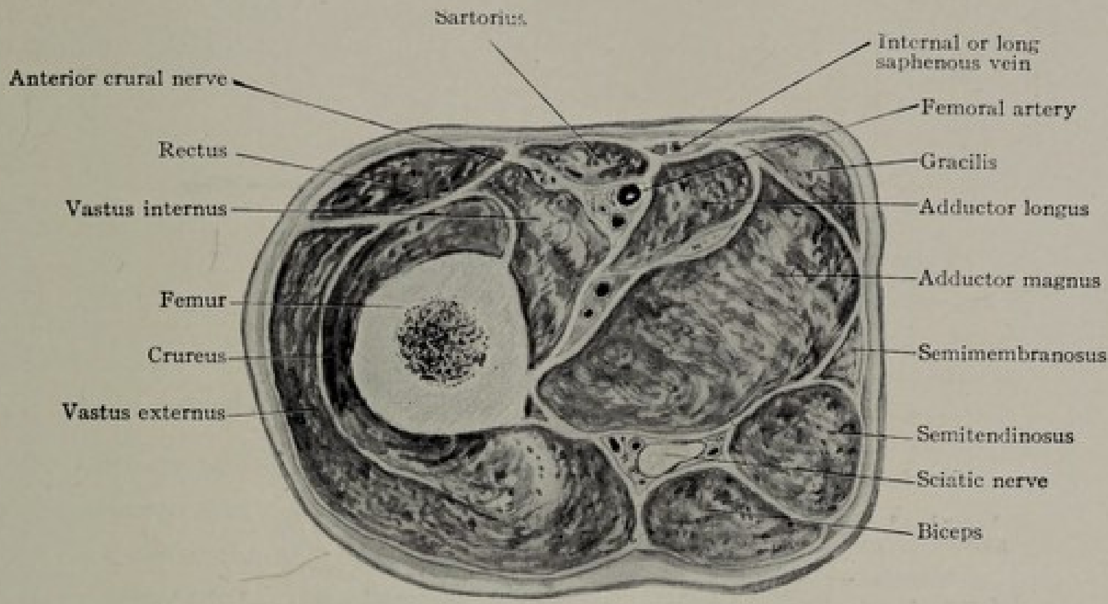


FIG. 666.—Section of thigh about at the apex of Scarpa's triangle.

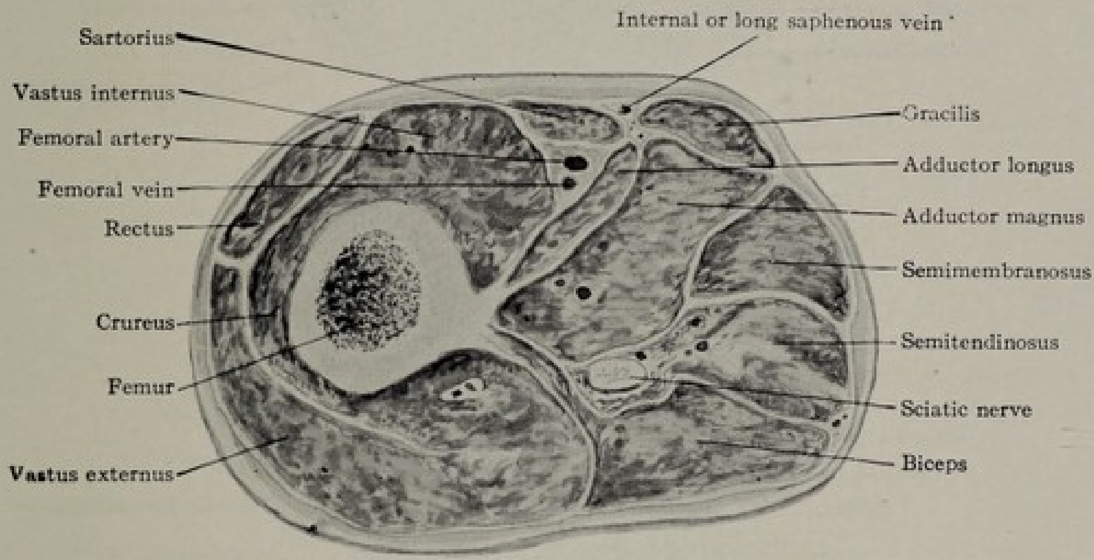


FIG. 667.—Section of thigh about the middle.

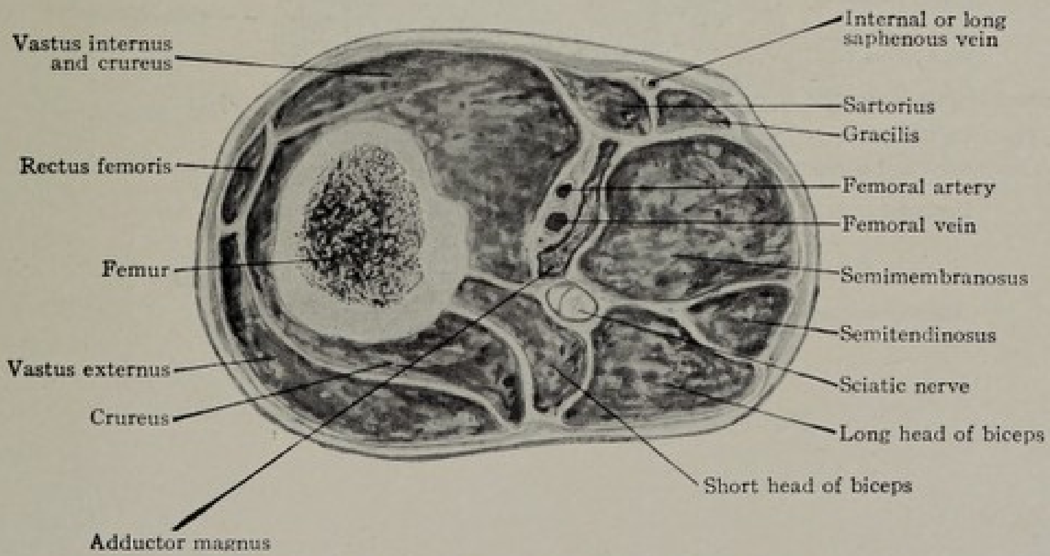


FIG. 668.—Section of thigh through its lower third.

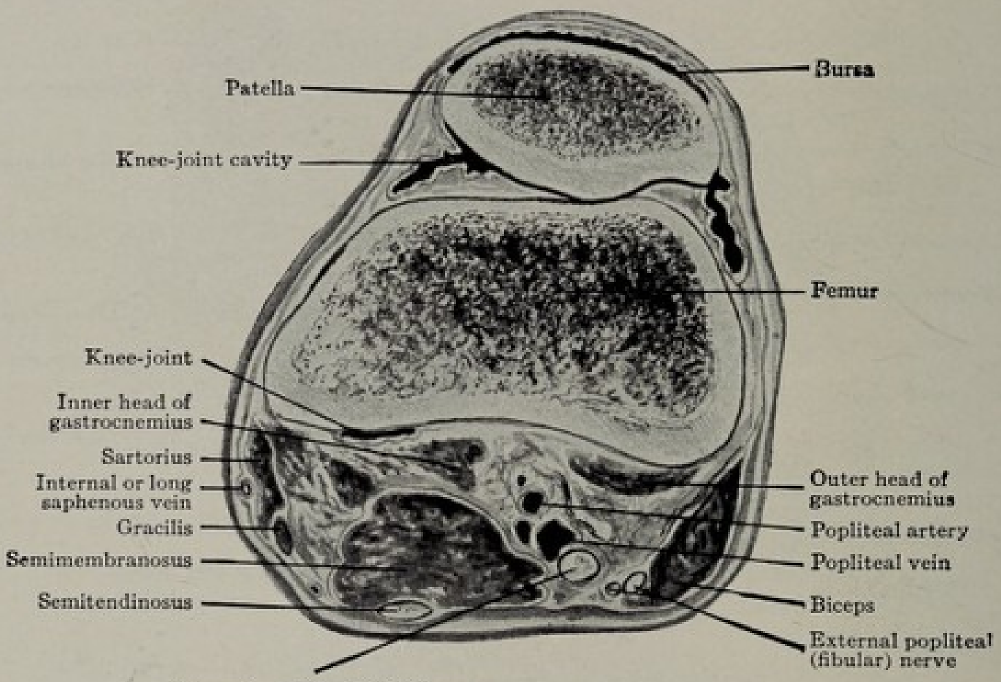


FIG. 669.—Transverse section through the patella.

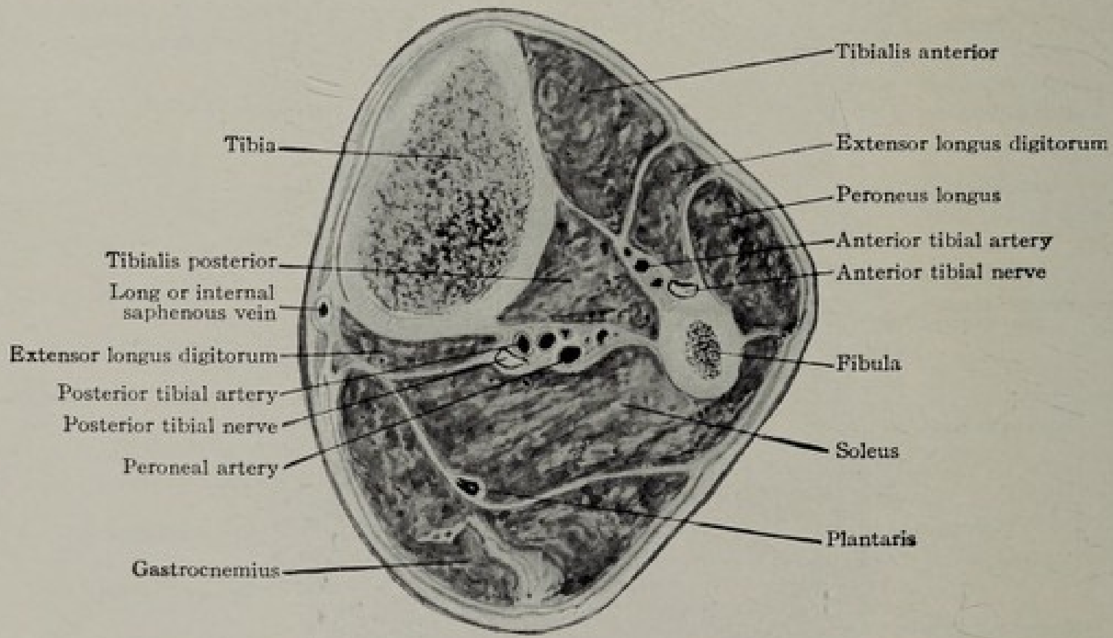


FIG. 670.—Section through upper third of leg.

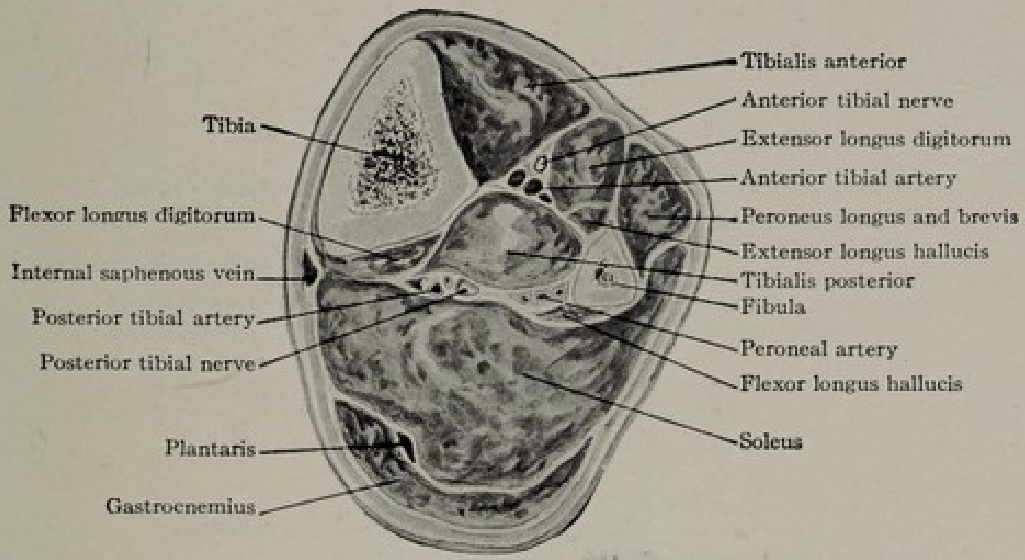


FIG. 671.—Transverse section through the middle of the leg.

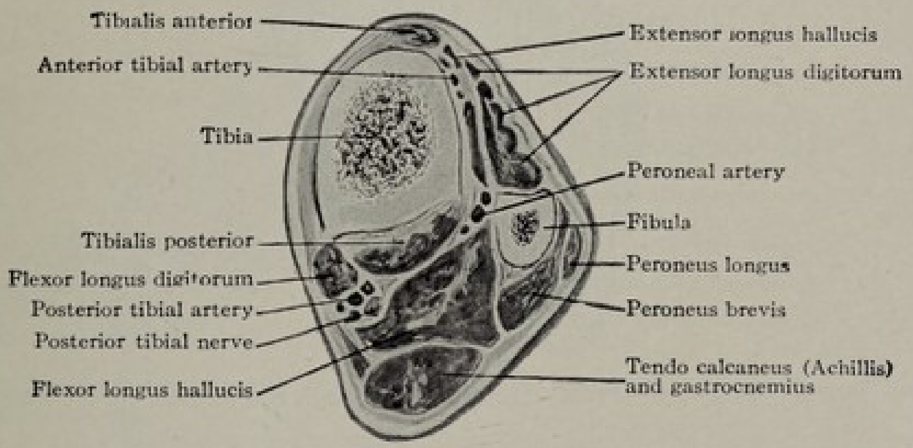


FIG. 672.—Transverse section through the lower third of the leg.

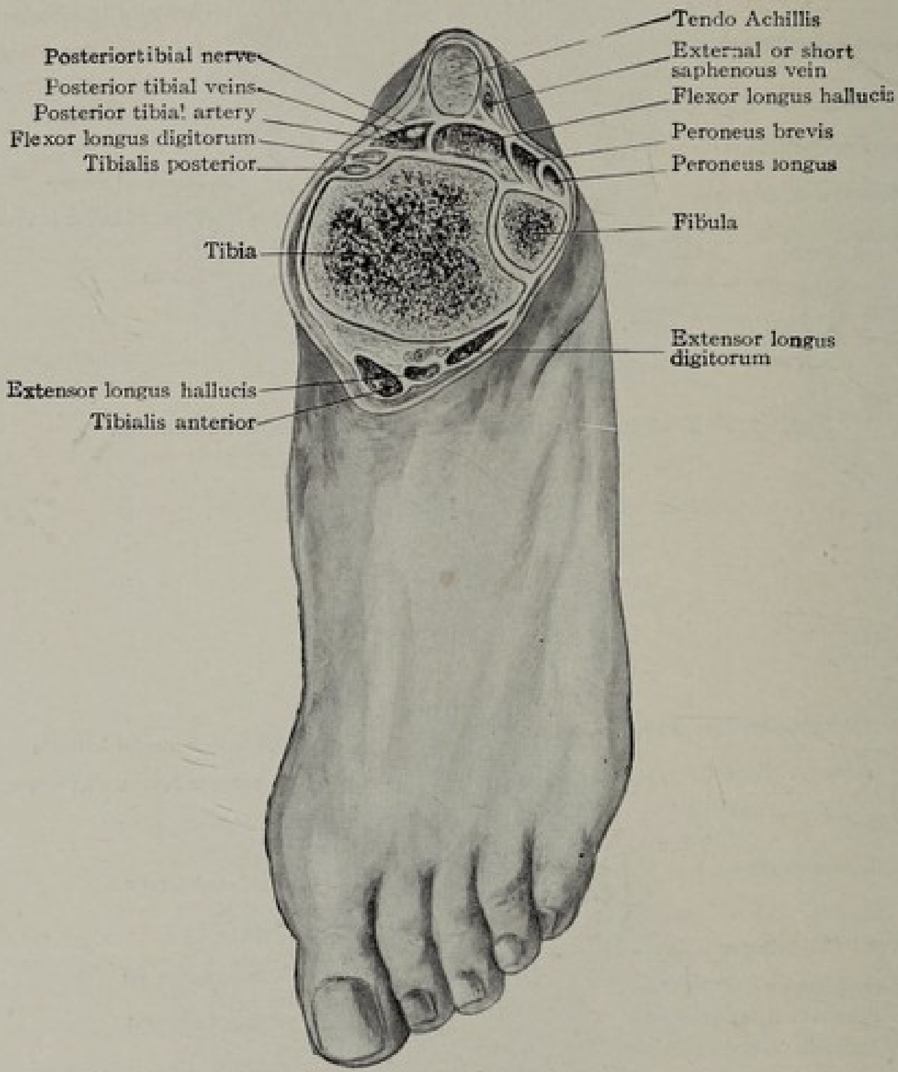


FIG. 673.—Transverse section through the ankle.

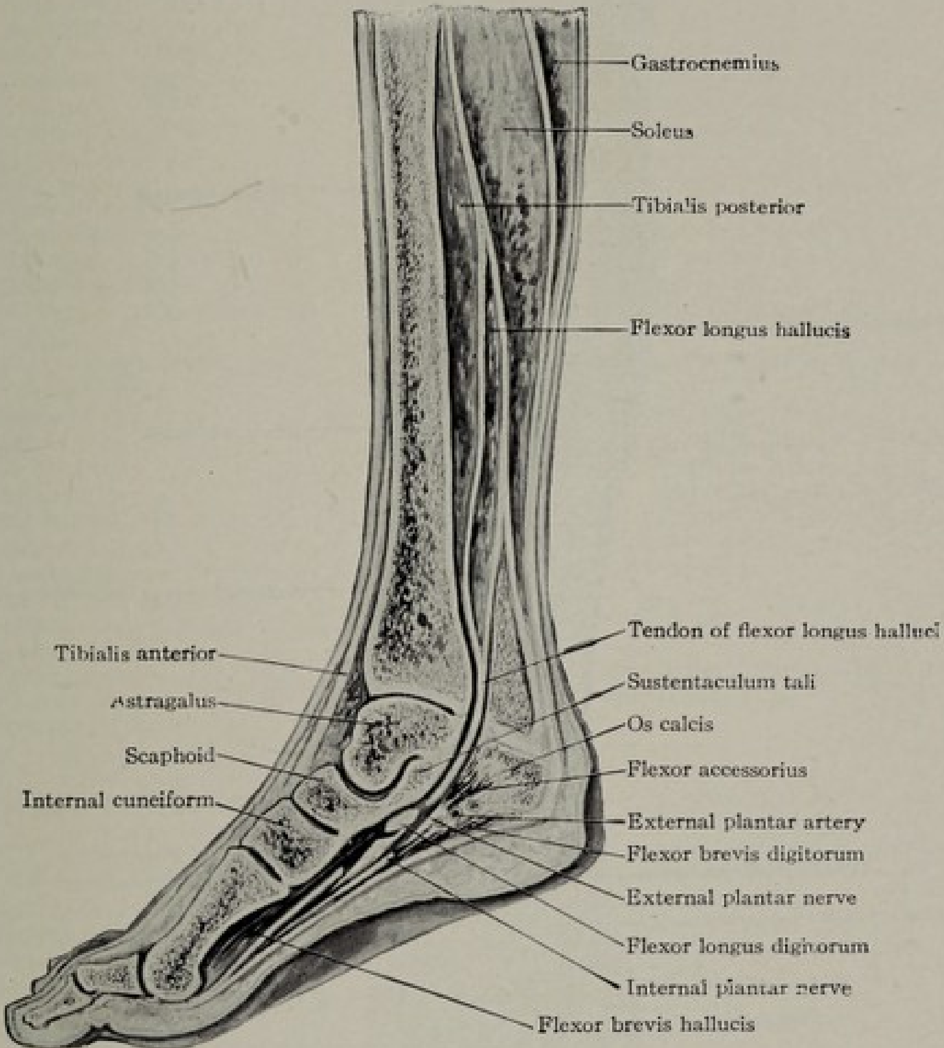


FIG. 674.—Anteroposterior section through the tibia and first metatarsal bone.

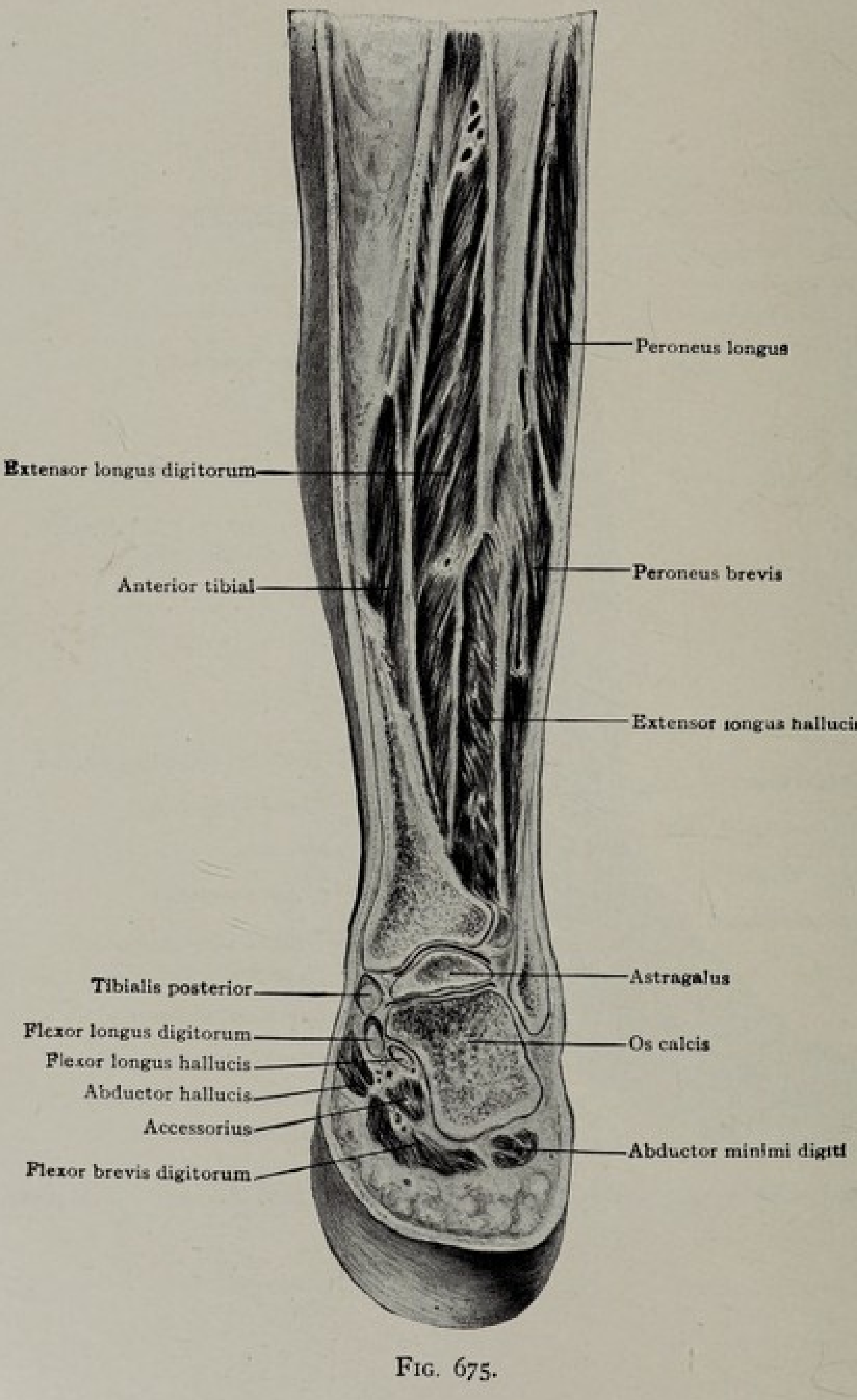

Peroneus longus
Extensor longus digitorum
Anterior tibial
Peroneus brevis
Extensor longus hallucis
Tibialis posterior
Astragalus
Flexor longus digitorum
Os calcis
Flexor longus hallucis
Abductor hallucis
Accessorius
Abductor minimi digiti
Flexor brevis digitorum

Fig. 675.

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