Wounds, with a discussion of what constitutes rational treatment / by Frederic Griffith.

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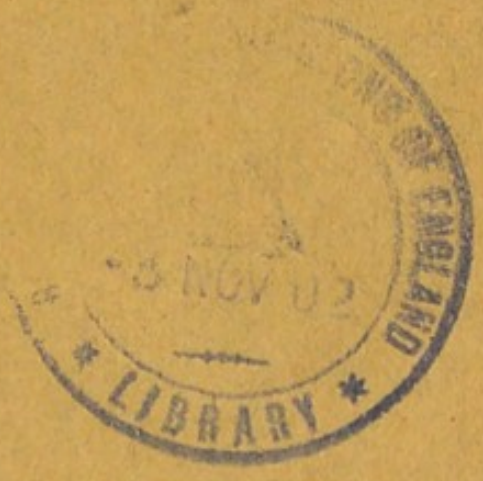

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WOUNDS, WITH A DISCUSSION OF WHAT CONSTITUTES RATIONAL TREATMENT.*

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THE subject of wounds must ever remain of great interest to the surgeon, for the consideration of them in one form or another makes up the bulk of his work in practice. My purpose is to write with especial reference to the conditions governing the healing of granulating wounds.

A wound, as commonly defined, is a solution of continuity of the soft parts. Direct mechanical violence is usually implied as being the acute cause of wounds but microbic action in the form of ulceration is likewise able to cause a chronic form of wounding. Besides being acute or fresh, chronic or old, wounds, according to their relation to the body surface, are designated as open, when the skin or mucous surface is divided proportionately to the tissues beneath, and closed or subcutaneous, when there is little or no break in the epithelial tissue covering.

Classified descriptively, wounds are contused, lacerated, incised, punctured, poisoned and burned. Owing to the teaching that gunshot injuries should always be probed for the purpose of locating and removing a lodged missile or fragments of clothing or other extraneous matter which might be carried past the point of entrance, it was deemed necessary by the older writers to

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specially designate them; wounds from this source are, however, easily classified under the heads of contused, lacerated or burned. Grazing missile wounds and the form of friction wound known as a brush burn will also naturally come under the divisions of either contused or burned wounds. Since discovery of the part which various forms of pus micro-organisms play in complications of wound healing was made, the condition known as poisoned wound is generally restricted to the injuries inflicted by poisonous snakes and animals, while the term "infected" is used indiscriminately when referring to all forms which have become contaminated by germ life.

The pathology of wounds is the pathology of inflammation, which, with the complications arising therefrom, ranges the entire field of disease change. According to the nature of the implement causing it will the kind of wound produced be determined; falls and blows from blunt instruments cause subcutaneous wounds of a more or less contused nature. Sharp instruments give rise to open wounds and may be simple stab, punctured, or incised, or when more complicated, be contused and lacerated. Punctured wounds are usually deeply incised in character and present some contusion; tooth wounds partaking of the same nature. Contusions follow to a degree all wounds, whether open or closed, due to blows, and are manifested by an area of necrosis which varies according to the force of the blow, the passage of the keenest knife-blade through the tissues of the body leaves behind a track of destroyed cells.

In severe cases of contused and lacerated wounds the injured parts are frequently benumbed and paralyzed so that the patient feels no pain.

The size of a wound does not determine its im-

portance, for a minute break in the skin or mucous surface may allow infection which will prove fatal to the life of the individual concerned. Other factors which lend to the importance of wounds are, location, depth and the condition of the borders. Penetration into joints, cranial, thoracic, or peritoneal cavities add greatly to danger of wounds of these parts from shock or infection.

Local effects of wounds give rise to impairment of function, pain, gaping, when open, hemorrhage, infection taking place, active inflammation followed by suppuration occurs, ulceration, gangrene, erysipelas, tetanus, or diphtheria.

The early constitutional symptom of wound is shock, later conditions, save that of embolus from comminution at the time of injury, will depend upon the nature of the bacteriological infection supervening.

Shock, according to Dr. Shrady, is a jar to the equilibrium of the entire sympathetic system, of which mere pain is oftentimes an insignificant part. Mitchell, Morehouse and Keen add to this enfeeblement of the heart's action through the mediation of the medulla oblongata and the pneumogastric nerves, or to a general functional paralysis of nerve centers, both spinal and cerebral, or finally to combination of both causes. Mr. Longmore characterizes it as the instinctive emotion of alarm which supervenes upon an injury and which he noted particularly after gunshot wounds.

Contusion by pressure is well illustrated in some cases of compression during child-birth; the mother's vagina and the child's scalp showing the effects. Burns and scalds, lacerated and contused wounds such as occur in machinery and railroad accidents, are also commonly followed by this condition. Shock is the commonest cause of early death after an injury, and while young

people react very well and females better than males, infants and nervous women are very susceptible to its influence.

The condition, now well recognized, which followed wounds where much cellular tissue is involved, known as fat embolism, in which escaping oil globules from crushed fat cells with the debris enters the circulation, causing obstruction, was previous to the last five or ten years set down to shock.

A degree of loss of function after wounding of a part follows as a necessity, the continuance depending upon the tissue and the extent of the injury.

Pain is a generally constant symptom following wounds, but the amount varies with the locality; wounds of the face and extremities being more painful than those of the trunk. The state of the individual's mind at the time of wounding is also a factor in determining the amount of pain felt. From abstraction or when laboring under great excitement at the time of wounding, pain may be held in abeyance; it is usual, however, for it to come on at once and continue until the parts are put at rest. Nerve trunks severed in wounds may, after the first agonizing pang is felt, cause adjacent parts to become painless; later, owing to inflammatory reaction extending along the trunks, pain will develop, becoming after a few days severe and continuous.

Gaping in open wounds depends upon the tissues affected and the direction of the wound. Nélaton has given the following order in which tissues retract, namely, skin, elastic tissue, cellular tissue, arteries, muscles, fibrous tissue, nerves, cartilage. Tension also affects the amount of retraction to a degree. In a case which I saw of cellulitis of the arm extending from the shoulder to the wrist of a laboring man, and in which a

single incision for purposes of drainage from top to bottom along the back of the arm had been made, gaping at the elbow was full four inches in extent. The fact that direction of the wound in relation to the muscular fibers of the parts varies the amount of retraction, is taken advantage of by Dr. McBurney in his operation upon the abdominal wall. By incising each layer separately in the direction of the muscular fibers involved he secures least strain and gaping of the operative wound. In general wounds made parallel to the long axis of the body gape less than those which are at right angles or transverse.

Bleeding accompanies all wounds, though the amount varies with the location and the extent of the injury; wounds of the face, from the number of vessels presen and of the scalp owing to the dense structure which in addition to vascularity allows little contraction of the severed vessels, are noteworthy from the free hemorrhage following their infliction. Lacerated and contused wounds are followed by comparatively little loss of blood, owing to the fact that torn and twisted vessels bleed less than those which are smoothly cut.

Inflammation being closely associated with both the pathological and reconstructive processes, it was impossible until the discovery of the factor of pus-micro-organisms, to make a correct deduction of when the destructive gave way to the restorative function.

To properly understand the healing of wounds of any sort it is necessary to notice particularly the rôle which inflammation plays in the reparative process. Formerly considered to be a disease distinct in itself, writers upon this subject, while differing in their explanations of some of the accompanying phenomena, are to-day generally agreed that inflammation represents a series

of structural changes following the reaction of a part to an irritant. While the completed cycle occurs most often under the influence of micro-organisms or their products, any form of irritation is sufficient to excite some of the phenomena. Wound healing, therefore, becomes a process of balancing between a mechanical change in the relationship of tissue-texture or destruction of it, and repair. Considered in this light the process is simplified, and the principle, being the same for all forms of wounds, becomes one of mere adaptation.

For purposes of demonstration we will take a case of incised wound as a typical example of what occurs during wound repair. Assuming a healthy body with a clean-cut wound in which the parts are free from germ infection, foreign bodies or clotted blood, and the several cut tissues have been replaced in correct apposition, after a period of quiescence varying from a few moments to a number of hours, a preliminary state occurs which Cheyne observed after making an incision in a frog's foot placed on the stage of a microscope, verified by other observers. He says that in the immediate neighborhood of the wound the circulation is arrested and the movement of the pigment ceases; at the margin of the stasis the blood passes through the capillaries slowly and with difficulty, while the blood vessels in the neighborhood are dilated, and there is increased flow of blood. Exudation of serum and migration of corpuscles takes place, and then the activity subsides and the process of repair commences by entanglement of corpuscles in the *liquor sanguinis*. Coagulation occurs, or in other words the wound surface becomes covered with lymph. Organization and cicatrization completes the process.

Healing of wounds has been particularly

studied by Thiersch, Gassenbauer, Recklinghausen, Ziegler and Marchand, and while some counting granulation as a distinct process, it can writers distinguish two kinds of wound healing, be shown that granulation is a mere excess of that which takes place after agglutination in a coapted, incised wound. Tillmanns, describing the macroscopic phenomena occurring in this form of healing, commonly called healing by primary intention, states that the borders of the wound become agglutinated by a coagulum made up of blood and lymph, which during the course of the next four to eight days causes a definitely established union to take place. The coagulum in and around the wound spaces becomes replaced by new cells and blood-vessels, the former of which gradually change into the fibrillar connective tissue making up the cicatrix. In the case of small wounds or slight loss of substance, there is usually developed as a result of coagulation, a crust beneath which the completed healing of the wound takes place. Skinning over of the wound proceeds from the borders by proliferation of the cells of the rete Malpighii and of the sebaceous glands, if the later still exist in the surface of the wound. The young cicatrix at first forms a fine red line which gradually becomes white and softens, so that the scars of many wounds which unite by primary intention often disappear in the course of time. Where loss of substance requires that space should be filled up, as in badly contused and lacerated wounds, or where there has been loss of tissue and it has been impossible to obtain direct adhesion of the divided parts and also in those which have become infected by micro-organisms, healing by second intention or granulation formation takes place with phenomena somewhat as follows: Until the end of 24 hours the various tissues may be distin-

guished; later the outline is obscured by the gelatinous lymph and by a process of fatty degeneration. The wound being filled up with a reddish yellow fluid, a mixture of blood-serum and lymph, cellular infiltration from the borders of wandering connective tissue cells takes place, increasing until the blood coagulum is entirely replaced. About the third day the wound cleft is found to be filled with tissue almost entirely made up of round-cells, with a small amount of intermediate substance and remains of blood coagulum. Later come large epithelioid cells, being the forerunners of granulation tissue formation and fibroblasts which change into the fibers of the fibrillar connective tissue. Note that these original fixed connective tissue cells and the endothelium of the vessels are the principal sources of cicatricial formation. Nucleii in different stages of division can be demonstrated in the fixed connective tissue cells and in those of the endothelium of the vessels as they undergo rapid proliferation. Some of these newly formed tissue cells can also become wandering cells. The regenerative process within the new-formed tissue mass is likewise carried on by the fixed tissue cells. The leucocytes present either perish by being absorbed by the growing tissue cells or they wander back into circulation. Some of the protoplasm of the wandering cells is used as cell material in both the scar formation and the regenerative process carried on in the original fixed tissue cells.

Reinke believes that further development is possible in those wandering cells which make their appearance after the proliferation of the fixed cells has begun, they being always noteworthy for the great vital energy displayed.

Ribbert holds that single nucleated lymphogenic leucocytes are capable of taking part in the

new framework tissue formation by their action of assisting to cover lymph spaces with endothelium.

Marchand states that fibrin is produced by substances liberated by the death of the white blood corpuscles, that the polynucleated cells are retrogressive in nature and have developed from those with a single nucleus, and that further than this they take no part in the formation of new tissue. Sherrington and Ballance maintain that the cicatrix is formed from the cells of the plasma which are nourished by the protoplasm of the leucocytes.

Grawitz considers the so-called dormant cells as being all important in the process of wound repair; these cells which are previously invisible in the basement substance of a tissue become suddenly visible after an injury to the part, their multiplication giving rise to the embryonic germinal tissue from which the new fibrillar tissue of the scar is formed.

Ziegler's and Tillmanns' theory of the formation of fibrillar connective tissue derived from experiments shows that this tissue develops from the fibroblasts as follows: The formative cells are at first round; enlarging they become in appearance not unlike large, round epithelium, or they become elongated and possess one or more processes which anastomose repeatedly one with another. The number of these large cells increasing rapidly, they tend to become packed closely together. The fibrillar tissue is now formed in part directly from the protoplasm of these cells, consequently being of intercellular origin and from a homogeneous ground substance or stroma which had developed previously from the same source. Fibers begin to make their appearance from one or both sides of a cell, or from the extremity or in one of the processes,

the formed fibers uniting directly with those from adjoining cells. The nuclei together with a portion of the protoplasm persist and become fixed connective tissue cells. The direction taken by the fibers is usually the same over considerable areas.

The cicatrix is, in the beginning, rich in elongated cells, the remains of the earlier formative cells. The size of these cellular remains subsequently diminishes, the fibrous tissue becoming thicker when the scar is complete. New vessel formation proceeds hand in hand with the tissue growth, in fact, renders further tissue building possible.

Nutriment first comes from escaping plasma, as Thiersch has shown that intercellular circulatory systems may be injected through the blood vessels, proving an intimate and ready connection.

Vessel formation proceeds from preexisting vessels by sprouting or budding. A capillary loop is first noticed to have a granular accumulation of protoplasm at one portion of its course; this increases until it becomes a solid protoplasmic filament which contains a nucleus. This simple or branched process becomes joined either to another end sprout or with the wall of a vessel, or it may arch back and unite with the wall of the vessel from which it sprang. Processes from the spindle- or club-shaped or branching formative cells of the intercellular tissue may join with the vessel sprouts, and thus the material in the formative cells will help in the formation of new blood vessels.

By a process of liquefaction necrosis the solid interior is tunneled, until, meeting with another excavation extending from the opposite end or opening out into a pouch forming in the end of a protoplasmic filament, the capillary loop is com-

pleted. The walls of all are at first homogeneous, but nuclei later develop with gradual separation into flat cells which soon become well formed endothelium. By the addition of some of the formative cells the vessel walls are greatly strengthened. Tillmanns believes that the protoplasmic processes from which vessels are formed are made up from the cells of previous vessels and from white blood corpuscles which have passed through the capillary walls.

After the scar has become well formed a shrinkage in the newly formed connective tissue takes place with a consequent disappearance of a portion of the vessels; this causes the red color of the scar to blanch.

From a consideration of that which has gone before it will be seen that it becomes a mere incident, depending wholly upon the nature of the wound, whether more or less of the formative connective tissue is required to fill up the loss of substance following the injury. The granulation formation in an open wound is in nowise different from the vessel loop formation which takes place in a coapted incised wound. The repair of wounds of non-vascular tissues, such as the cornea or cartilage, is practically the same process as that for the vascular. In the case of the cornea there is to be found an intricate system of canals which, being associated with numbers of wandering cells, constitute the groundwork of progressive repair.

The perfect repair of wounds tends to a complete restoration of the destroyed tissue. Wounds of the skin, when injury to the deeper layers has not taken place, if the wound be clean with the development of a delicate scar, may be replaced by almost perfect skin formation save for the hair follicles and sweat glands which will not be reproduced. Much discussion at one time arose

amongst the older writers, some of whom claimed that the rete mucosum could not be reproduced after wounding in the skin; but by observing the scars of wounds in negroes it was determined that rete mucosum containing the color pigment of the skin is readily renewed, as shown by the frequency of dark pigmented scars, sometimes blacker than the surrounding skin, occurring in this race. The best formed cicatrices after wounds of the intestines never have produced in them the glands of Lieberkuhn. Ponfick claims that he has seen renewing of liver and kidney substance of animals take place after wounding. That nerve tissue often renews in its entirety is shown by the repeated operations required for neuralgic affections. Mr. Haighton demonstrated the same thing by an experiment; he cut one of the eight pairs of nerves in a dog, later he cut the other side without any ill effects arising, but when both sides were simultaneously cut death followed immediately. Brown-Séquard has seen regeneration take place after division of the spinal cord in a pigeon. Muscle tissue destroyed is replaced by tendon. Astley Cooper found that wounds of the costal cartilages were invariably replaced by bone formation.

Morbid changes occurring in scar tissue may take the form of an overgrowth of the connective tissue element with a resulting extreme condition of deforming contraction. Keloid is a commonly recognized tumor-like formation, occurring upon the site of a cicatrix made up of hypertrophied fibrous elements. Cicatricial ulcers sometimes occur to complicate the progress of a healing wound; they are made up of hypertrophied fungous granulations. According to some observers two layers of granulation tissue are to be noted microscopically in a healing wound, the more superficial made up of vertical capillaries

and the deeper containing a transverse meshwork of vessels from which the former originate, coming through a structure more or less dense according to age. Malposition, arising from excess of irritation of the ground network, is the source of this condition.

Pressure paralysis or neuritis sometimes follows the healing of a wound, from nerve filaments becoming caught in the scar tissue. Malignant change from a cause at present unknown at times alters the course of healing wounds.

The treatment of wounds, called by Humphrey the corner-stone of surgery, has marked the epochs of medical advance from a mystic art to a basic science. In tracing the course which physicians followed out in their dealings with wound injuries from the earliest times, one cannot fail to be impressed with the nearness of empiric knowledge to latter-day proven facts. Every procedure had in it a principle which, while often hidden beneath false practice, seems in the light of our time to have been formed upon the highest intelligence. The factor which above all determines wound healing is the presence or absence of friction, or, taken in its broadest application, irritation. Whether it be due to mass motion of the wounded parts, or to the cellular destruction caused by pus germs, failure to secure perfect results will assuredly occur.

In setting forth this principle the author lays no claim to originality, for little thought is necessary to make it apparent that, from the time of Hippocrates to the present, prevention of mechanical irritation to wounded parts has been the aim in treatment. Balsams and oils continue to hold their favor, as they have from the beginning, for the treatment of wounds; the principle involved in the "pouring on of oil" being that of lubrication. Addition of aromatics and spirits which

came to be associated, whether understood or not at the time, were clearly attempts to secure antisepsis. How far we have advanced in our clearer vision beyond that of the itinerant surgeons of the Middle Ages who individualized themselves by seeking distinctiveness in the composition of their wound applications, may be shown by the fact that we have to-day no one antiseptic upon which surgeons are agreed that we can safely rely upon all occasions in the treatment of wounds. Bearing this thought in mind the writer would plead rather for a simple treatment, based upon principles calculated from reason that each one may develop for himself.

Every individual has power of healing equally developed over his whole body. Rest of the part, in the broad sense, is the main factor in production of perfect healing for the individual concerned. It has been stated that wounds of the face and scalp heal quicker than other parts owing to increased blood supply. This is fallacious, for practically all tissues have capillaries, and it is these vessels which are the important factors where healing is taking place. I have found that a wound of the back or the leg equally deep as one of the face or scalp will heal as quickly as the latter, when I have secured rest and freedom of the part from irritation. Again, I find in my work that when I am not clean in a wound treatment, those of the face or scalp suppurate as quickly as do other parts. A sterile wound whose parts have been closely coapted without constriction by sutures, or subsequent outpouring of fluid, as when incised, is generally conceded to have been placed in the best condition for rapid healing, so far as it lies in the surgeon's power so to place it.

Friction during the progress of healing of a wound surface is manifested by the outpouring

of fluid. Profuse during the early constructive period, it becomes lessened as the granulation formation proceeds, until ceasing the untoward reaction of the wound surface to irritation from motion, bacteria, applications, or dressings is shown by fungoid formation upon the surface which slowly changes into coarse-grained, contracting scar-tissue.

To allow the escape of fluid from a wound various methods of drainage have been devised. The early surgeons, aware that hemorrhage not only endangered life but interfered with healing, employed boiling oil and the cautery, both certainly perfect antiseptics but giving rise to increased wounding by burning.

The theoretical knowledge of control of hemorrhage by ligation existed early, as is shown by the writings of Galen and Celsus, but appears not to have been practised until 1560, when it was brought forward by Paré. While this was an advance in one way it was disastrous for future surgical practice, as it opened the way for germ infection to the wounds so treated. In reading the older writers the one great fault in their technical treatment of wounds seems to have been the absence of thorough mechanical cleansing of the wounded parts. Thinking as they did that they were dealing with a structureless miasma, instead of solid particles, we find some excuse for failure of comprehension of the principal cause of liquefaction during wound healing. Franciscus Arceus, who flourished in 1580, was well aware of the necessity for dry wounds. Writing at this time he says "wounds are not healed before they are dry, as writeth Hippocrates."

Arceus to enhance what Paré had done by ligation invented the method of leaving the ends of a ligature long to provide for drainage and to facilitate its removal; the recognized value of this

procedure causing it to continue to be used until the time of Lister proved that it was what was put into a man which defiled him. Arceus was in some respects far in advance of his time, for, though apparently ignorant of the true cause of suppuration, he gave general directions to cleanse the filth away from the wound to be treated. His method of treating scalp and face wounds is worthy of consideration; after applying a "digestive" made of the whites of eggs and turpentine, he fixes the wounded parts by numerous closely laid turns of a thread. Speaking of "tow and lint," the dressing advised for mechanical absorption, he declares it to be but the practice of barbers who go only by " a certain common rule and use no judgment. Arceus used for drainage a fine linen strip dipped in white of egg.

From the setons, tents and a variety of other appliances for drainage of these times but little change was made until the middle of the last century, when Chassaignac invented tube drainage. Neuber of Kiel later introduced bone absorbable drains, which were improved upon by MacEwen, who suggested the employment of hollowed chicken bones for this purpose.

The method of capillary drainage by means of strands of horsehair, silkworm gut, braided silk or catgut, was brought forward by John Chiene, and in the last named substance we have set forth the first example of the principle of the absorbable drain. Kummel uses capillary tubes made of drawn spun glass, Esmarch and Neuber have suggested the employment of channel drains made by so suturing the skin as to form a sinus.

While any of the various methods recommended by surgeons are sufficient to allow the escape of the early watery products of wounding, nothing will drain pus perfectly. If we had any perfect method of drainage it would never

be necessary to wash out pus cavities. So-called drains act after the first capillary ooze has ceased by keeping the aperture open.*

That surgeons were ever fully aware of the dangers arising from contained fluids in wounds may be shown by the statement of Lindpainter who, writing in the pre-antiseptic days from Nussbaum's clinic, said it was a standing rule at that time not to suture scalp wounds as rather inviting erysipelas to attack the individual. The other scourges of surgical practice, namely, purulent edema, suppuration, hospital gangrene and tetanus were recognized as arising from retained fluids within wounds. So real was the danger from this source that Pirogoff gave voice to the generally accepted opinion of the time when he said that "the results of wounds are dependent upon chance." In Nussbaum's clinic 80 per cent. of all wounds treated were attacked by hospital gangrene, and erysipelas was so frequent that it was expected. In 17 cases of amputation, 11 died in one year as a result of pyemia developed from virulent wound infection. A complicated fracture meant amputation, which, if not done promptly, meant purulent infection, hospital gangrene or septicemia and a rapidly fatal termination. At Volkmann's clinic at Halle the mortality in complicated fractures was 40 per cent. for him and his predecessors for many years, and in 1871-72 the numbers of victims to grosser infection of their wounds led him to close the wards of the hospital for a time. In 1870, hospital gangrene was the most frequent wound complication, but it is now never seen. Believing that the air was at fault in causing contamination of wound fluid, Schede proposed a method of allowing healing to proceed under a blood clot; recommending that the wound cleft be allowed to fill

*New York Med. Jour., Feb. 16, 1901.

up with blood, which forming a moist clot becomes gradually absorbed and replaced by scar tissue if sepsis does not interfere.

With the idea in view of removing the danger from retained wound fluids there arose a number of surgeons who advocated the so-called open method of wound treatment, Kern of Vienna at the beginning of the last century being of the first. This practice was revived by Bartscher and Verzin in 1856, who simply stopped hemorrhage, then applied damp cloths to the wound surface until granulation was well advanced, when the parts were drawn together and held by adhesive strips. Rose, whose results have been dwelt upon by Kronlein, adhered to Bartscher's and Verzin's method but in addition daily washed out the wound. Healing by scab formation is closely allied to the open method of wound treatment as carried out by Bouisson, who dried wounds by blowing currents of air upon them for periods of fifteen minutes three or four times a day. This he called "ventilation treatment." If the retention crust softened to release fluid, powder, such as starch, alum or flour was dusted upon the open surfaces to cause renewed crusting. Neudorfer employed pulverized salicylic acid mixed with starch or zinc oxide as dusting powders to cause crust formation by rubbing them up with the wound fluids. Kocher advised the use of dusting powders for the purpose of absorbing fluids, recommending bismuth subnitrate powder mixed with a small quantity of water. Burow of Königsberg in 1859 attempted the cure of wounds by drawing them together with adhesive straps after allowing them to thoroughly glaze by exposure to the air for a number of hours previous to closing. So manifestly inadequate were the results obtained by the methods in vogue that Gamgee writing of 100 years ago said that primary union

after amputation was scarcely dreamed of; the ligature for hemorrhage but partially and imperfectly employed, and dressers required to sit up all night to flour discharging wounds. As late as 1875 we find Nussbaum assailing hospital regulations which limited poor patients to but nine weeks' stay in the wards after operations upon the breast which required from three to six months to heal.

The new life given to surgery by Joseph Lister, who, instructed by the researches of Pasteur, Schwann, VonDusch, Tyndall, and preeminently by Robert Koch, demonstrated the practical control of germ life upon a wound surface, came none too soon. In spite of concerted opposition of many who believed with Tait that "the wholesale and reckless application of the germ theory is alike mischievous and misleading," wound treatment instead of resting upon chance became subject to fixed laws. Advancing from the use of balsams and oils certainly to a degree antiseptic though directly injurious when used at boiling temperatures, to carbolic spray, oil, and putty mass, we see these in turn giving way to the watery solutions of carbolic acid and bichlorid of mercury.

An appliance which to-day, though in general use for preparing instruments and dressings, has not had its powers of germ destruction fully developed, is hot water. From time to time surgeons have endeavored individually to set forth its value as a direct application to wound surfaces. Poiseuille, by his experiment upon the web of a frog's foot, demonstrated the rationale of hot water treatment of wounds. He found that if the foot be covered with water heated to 104° F. the rapidity of the current in the capillaries is so much increased that the form of the corpuscles becomes indistinguishable, proving

thereby that unless the water is of high temperature infected wound surfaces by absorption of the products of germ growth would be harmed instead of benefited by the use of this agent. Varick uses water at a temperature slightly below that of the boiling point and has demonstrated that when protection from scalding of the skin is secured by care in handling, the deeper tissues will be unharmed by the heat save for the formation of a coagulation membrane which causes oozing to cease and the wound to become glazed by the cooking of the albuminous elements in the superficial capillaries. Varick founds his treatment upon his experiments with serum albumin which coagulates at a temperature of 183° F. He demonstrates that water under this degree of heat should not be used in wound treatments if best results are to be obtained. In the treatment of tuberculous joint wounds by boiling water used with precaution to prevent scalding of skin surfaces, we have a method of great value. Dr. Stephen Smith has recited to me the history of a case of old suppurating sinus of the knee-joint which, while doing well under this form of treatment, nearly precipitated a suit for malpractice, owing to sloughing which followed scalding of the other leg from the draining water. O'Callaghan in upholding hot water treatment, stated that true antiseptic surgery meant absolute cleanliness and that his success was due to flushing wounds with hot water at 118° F. Hemostatic action without coagulating film protective formation may be secured by the use of water as hot as may be borne without pain: 125 to 140° F.

To assist in carrying off draining fluids and for protection and support of wounded parts various forms of dressings are employed. The most common are dry and moist sterile gauze, or the same impregnated with bichlorid or carbolized

solutions; gauze which has been treated with iodoform or some of the various dusting powders; patent lint and absorbent cotton. A substance which has gained a well recognized place as an adjunct dressing is rubber tissue, but it is seldom put to its best use, namely, as a protective coming in direct contact with the wound surface. Rubber tissue as now made is membranous in quality and comes nearest to being the ideal application to a wound surface; applied in the form of small, narrow strips, laid on like shingles protection to the granulating surface is afforded while allowing escape of discharge to take place. Wounds which may be closed the entire length of their skin surfaces give little concern to the surgeon after having been rendered sterile, accurately coapted and put to rest, while those which are more or less open require his best thought to obtain rapid healing, the value of a method being proven by early restoration with resulting well-formed scars which show no tendency to undergo morbid change or progressive contraction.

An application to an open wound, whether it is made during the early relaxed stage from the direct injury which caused it, at a later period when the reparative forces are progressing under forming granulations, or into the final scar tissue formation, quickly shows its value as an adjunct in removing extraneous matter. This is all that the best so-called healing agents can do. Nature will repair so long as cell vitality remains in the parts and the best the surgeon can do is to secure rest, coapt and set the soft parts as he sets and fixes fractures of the bones, prevent the infection of the parts by germs, which is the most common form of wound irritation, and then adhere strictly to a policy of non-interference with the reparative process, unless for some good reason. Rest in wound treatment is not sufficiently

demanded as a routine. A scab upon a sterile wound becomes a perfect splint and when possible under these conditions should be encouraged, but the reckless use of the numberless forms of dusting powders which, caked over wound surfaces, irritate more than they absorb, proving their inadequacy, cannot be commended. Too often from this method, and from the various scabbing mixtures applied most frequently to wounds about the face and scalp, result mere walled-in chambers of media for pus development.

Rest of the hands by means of slinging is not sufficiently demanded from patients suffering from wounds of these parts. Aside from the manifest comfort to be derived from this, there is less danger of becoming infected if free, or of increased infection if pus germs are already present by reason of engorgement from lowering the limb.

Various are the direct applications in the form of solutions which surgeons are in the habit of advising to be made to wound surfaces. Of the carbolic and bichlorid solutions it must be said that they are required to be too strong, and hence become irritants in themselves, aside from any virtue they possess of destroying germ life. Watery solutions, made directly or upon saturated cloths of gauze, fail of their purpose by the amount of relaxation and maceration which they cause. If an outer covering of sheet rubber tissue be applied the condition is made worse by a direct bid for pus development being made. Heat, moisture and the presence of the germs are the three factors necessary for pus development upon a wound surface; the germs themselves are ever present, and to supply the other factors in the combination by this too common practice simply

furthers the process, and the wound heals in spite of and not by the assistance of the dressing.

Moisture should never be applied to an open wound continuously in the form of a dressing; a dry wound is a half healed one and it is fallacious to suppose that moist gauze will drain pus any more than dry. A wound which requires dressing must, if it lead into an abscess cavity, be washed out sufficiently often to prevent refilling and to induce continuous contraction.

Gauze, patent lint, or cotton used either dry or moist to open sterile wound surfaces prove their irritating properties by destroying the glaze, increasing discharge and by adding to the purulent discharge in an infected one, as may be proven by comparison with the use of membranous tissue applied in the manner which has been described. An agent by whose use I have been enabled to obtain clean wounds causing least irritation and thereby securing most satisfactory healing is hydrogen dioxid. According to Houssell of Tübingen a 3 per cent. hydrogen dioxid solution is equal in power to a - to 1,000 bichlorid solution, acting on bacteria suspended in aqueous solutions; but hydrogen dioxid is superior to it in media, rich in albuminous fluid, but poor in cells. Where the latter predominate it is again on a par with the solution of sublimate. By this it is proven a recognized value as a germ destroyer for if used in solutions of 10 to 20 per cent. its power is pronounced yet without ill effect. In such strengths pain and danger from forcing living organisms within the deeper wound-spaces will be minimized when the solution is used in sinused wounds. In common practice the drug may be used in full strength or diluted to one-half or one-quarter its strength with sterile, cold water, with prompt and apparent benefit to an infected wound or to one which pre-

sented for first treatment appears to be clean, after a thorough but gently done mechanical cleansing of the parts as a preliminary routine precaution. Drying a wound with sterile gauze previous to suturing when this procedure is necessary, assists healing by removal of the capillary ooze, until the pressure of external dressing can be applied. Dr. Wyeth, before closing wounds in operations upon the breast and those of similar character, is in the habit of packing a piece of sterile gauze in the depths of the divided parts; suturing over this and leaving the last two or three loose to facilitate withdrawal of the gauze and secures the minimum of retained fluid by the application of steady pressure made by an assistant's hands until the dressings are in place.

Subcutaneous wounds where impact has caused coagulation to take place, as after contusions and deep punctures, are best treated by moist dressings, but the value of the dressing lies solely in the degree of heat which is maintained. Extremes of temperature are required, as the chief virtue of the treatment lies in an inhibition of the assaults of germs within the outer layers of the skin gaining entrance to the deeper parts, and unless the action maintained is over and above the amount of maceration caused, the treatment becomes to the same degree useless or directly harmful. It is this principle which demonstrates the value of a daily, continuous submersion treatment for infected wounds by means of baths of either hot or cold water.

Summary.—The consideration of wounds in one form or another makes up the bulk of a surgeon's practice. The series of phenomena known as inflammation is intimately connected with wound repair and it is only since the discovery of the part which pus micro-organisms play that the relationship between the destructive and con-

structive processes in wounds has become clearly understood. From a consideration of the work of Thiersch, Ribbert, Recklinghausen, Ziegler, Marchand and others it becomes evident that that which takes place in a coapted, incised wound is carried out simply upon a more extended scale in an open one. The perfect repair of wounds tends to a complete restoration of the destroyed tissue. Morbid changes occurring in scar tissue when due to excess of friction or irritation during the repair are manifested by a commensurate overgrowth of the connective tissue element with resultant deforming contraction. Wound treatment seems to be based more upon the individual whim of the surgeon than upon the well-founded principles which time has proven. The one opponent to perfect healing of a wound is friction, and that this was clearly understood by the early physicians is demonstrated by their treatment of wounds by balsams and oils, later by the addition of bulkier bases constituting salves, thus affording support for lubrication. Every individual has powers of healing equally developed over his whole body. Rest of the part, in its broadest sense, with freedom from irritation is the end of treatment. The more delicate the manipulations of the surgeon during a wound treatment, the better will be the result gained. Splints are as necessary in the treatment of wounds of the soft parts if quickest possible healing is desired, as after fractures of the bones. To allow the escape of fluid from a wound surface various methods of drainage have been devised; when natural drainage is impossible, rubber tubes, wicking of gauze, rubber tissue, catgut, silk or horsehair may be used. It is an open question in regard to securing drainage of the peritoneal cavity after wounding; natural drainage or absorption seem to be in the line of reason. The power of the

peritoneum to repel attacks of germ invasion is great, much greater than that of muscle or subcutaneous tissue, and it would seem to be a distinct advantage in these cases to withhold foreign bodies in the form of so-called glass, gauze or rubber drains whose chief function appears to be that of exciting exudate, as a pus germ has a better chance to make a successful fight in a belly cavity floating around in a serum media than when closing with a phagocyte glued to an endothelial surface.

No appliance in use to-day will drain pus perfectly. By elevating the head of the bed one to two feet, securing the patient by slinging under the arm, Fowler of Broklyn causes gravity to assist drainage of the abdominal cavity with results unobtainable by other methods.

The furtherance of healing is secured by dry wounds and the correct principle was manifested by the older surgeons who allowed open wounds to first glaze before drawing their several parts together. Hot water used at proper temperatures may be made an important factor to assist in the healing of wounds. Antiseptic solutions applied to wounds act as irritants, owing to the strength required to destroy germs. Dusting powders are irritating to wounds, as proven by the discharge which they cause. The best direct application to a wound surface after cleansing the parts by hydrogen dioxid is membranous rubber tissue applied shingle fashion. The treatment of punctured wounds, which are ever endangered by the complication of tetanus, by forcible syringing of hydrogen dioxid acts in the manner of an antidote. Moisture in the form of wet dressings should never be applied to open wounds. Subcutaneous injuries created by wet applications should only be made through light dressings to allow rapid evaporation to take

place after each treatment, which should consist of immersion in solutions of the extremes of temperature. The virtue of this method is the inhibition of the activity of germ life, constantly active in the outer layers of the skin, by preventing its progress into the devitalized tissues beneath. The principle acts in a similar manner in the treatment by submersion for infected wounds.

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