

Gangrene.
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REFERENCE HANDBOOK OF THE MEDICAL SCIENCES.

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GANGRENE. (SURGICAL.)—The term gangrene, and its synonyms, mortification and sphacelus, are employed by the surgeon to denote the death and, in most cases, the subsequent decomposition of a circumscribed portion of tissue on some exposed part of the body. Necrosis is a term extensively used by surgeons to denote the death of a circumscribed portion of bone, whilst pathologists employ it to express the death of a portion of tissue, belonging to some internal organ, that has been cut off from its necessary blood supply. Such necrosis is unaccompanied by bacterial decomposition; it is absorbed and replaced by the formation of blood-vessels and new tissue.

ETIOLOGY AND PATHOLOGY.—A general division of the causes of gangrene into traumatic, physical, and infectious may be made, but it is evident that, whether the local death of a part is produced by mechanical violence or by other causes, the result must be the same—namely, an interference or arrest of the nutrition of the part due to obstruction of the circulation. Nutrition is interfered with, or arrested, by *obstruction in the arteries*, such as occurs in cases of gunshot wounds; by ruptures due to mechanical violence; by compression or ligature; by disease of the arterial coats; by pressure of a tumor in the adjacent tissues, or by a thrombus; by *obstruction in the capillaries*, which may produce complete anæmia of the part, and which is due to pressure upon the capillary walls by tumors, by extravasated blood or fibrin, or by superficial pressure from bandaging. The observation that tight bandaging would occasionally produce gangrene is as old as Hippocrates, who distinctly refers to it. Anything, therefore, which will produce long-continued stasis in the capillary circulation of a part,—whether it be mechanical violence, inflammatory change, the internal administration of certain drugs, the action of chemicals, or some obstruction in the veins sufficiently pronounced to prevent completely the return circulation,—must necessarily result in gangrene of that part.

Let us now examine these causative states somewhat in detail. Obstruction to the arterial circulation occurs in consequence of gunshot, lacerated, and incised wounds, whenever the artery is torn or cut, and this obstruction results in gangrene whenever the collateral circulation fails to become established. The plates accompanying this article, from the "Medical and Surgical History of the War of the Rebellion," show cases of this kind with great distinctness. Pressure upon arteries during the treatment for aneurism has also produced gangrene. Surgeon Fessenden, of the Marine Hospital Service, has reported a case* in which compression was applied to the popliteal artery, just above an aneurism of that vessel, for one hour, when pulsation ceased in the tumor; three days later, it was noticed that sensibility was lost in the foot and leg, which became very much discolored, and there occurred blebs on the foot; a day later the entire foot and leg were gangrenous, and amputation was performed.

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* U. S. Marine Hospital Reports, 1882, pp. 160-162.

in them that the effect of diminished cardiac power is most manifest, especially in the parts remote from the heart. Chronic exhaustive diseases, senile and general debility, therefore, are important factors in the production of gangrene. Gangrene from the administration of ergot is produced by the effect of the drug on the arterioles through the vaso-motor nerves, whereby these vessels are permanently diminished in calibre. The experiments of Holmes (1870) showed the effect of ergot upon animals to be manifested in the capillaries, as witnessed in frogs, and Péton (1878) observed the contraction of the retinal vessels in man. Péton believes that this effect is produced, independently of any influence upon the vaso-motor system, by the direct action of the drug upon the muscular fibres. Nikit, however, in 1878, denied this, and his investigations have led him to confirm the usually accepted theory. In recent years we have learned to distinguish some infectious causes of gangrene, and also to recognize the fact that carbolic-acid solutions are, in certain cases, competent to induce this condition. Farther on, we will consider these matters more in detail.

Ergotism, as a cause of certain epidemics of gangrene in man, was first described by Dodard in 1676, then by Saviard in 1694, and by Noel in 1710. The disease appeared in Switzerland in 1676, according to Langius and Quassond. It also appeared in Dauphiné in 1709. Duhamel, in the "Mémoires de l'Académie Royale de Paris" for 1748, states that the disease was accompanied by very great mortality, "not more than four or five out of one hundred and twenty who had been attacked escaped with life." Péreira (1840) thinks that this affection was known at a still earlier period, and he quotes a passage from Sigebert to support his views (South): "1089, a pestilential year, especially in the western parts of Loraine, where many persons became putrid in consequence of their inward parts being consumed by St. Anthony's fire. Their limbs were rotten and became coal-black, they either perished miserably or, deprived of their hands and feet, were reserved for a more miserable life." It is stated that "the bread which was eaten at this period was remarkable for its deep violet color."

Notwithstanding the general concurrence of opinion as to the effects of ergotism on man, it has often been denied that it produced any such effect upon animals. Block, in 1811, fed nine pounds of ergot daily to twenty sheep for four weeks without any visible effect, and twenty sheep of another lot ate thirteen and a half pounds daily for two months without injury. Thirty cows took twenty-seven pounds daily for three months, and the only apparent effect was to injure the quality of the cream (Péreira). Tessier, however, in 1776, visited those countries in which the epidemic had prevailed, or was then present, and found that, although the quantity necessarily varied, yet it finally produced the gangrenous affection ("Mémoires de la Société Royale de Médecine," 1776, 1777-78). Instances are not wanting of the prevalence of gangrene as an epidemic among animals in the United States. Dr. Salmon, Chief of the Bureau of Animal Industry of the Agricultural Department, in a recent report on this subject (1885), has shown conclusively that many so-called epidemics of the "hoof-and-mouth disease" of cattle are really epidemics of ergotism. He found much ergot in the heads of "red-top" grass, in timothy, and in the chess or "cheat," as well as in rye; and in the particular epidemic in Kansas which called out the inquiry, the ergot was found in the hay fed to the diseased animals in the proportion of about one to every seventy-five pounds. In these cases there were sloughing ulcers of the mouth, ulcers in the rectum, with diarrhoea, a temperature of 101° to 104° F., and a line of demarcation above the hoof in some cases as high as the middle of the leg, and not infrequently the ends of the tails became gangrenous and dropped off. In an exhaustive review of the history of epidemics of gangrene from ergotism, Dr. Salmon cites many instances to show that nearly all the domesticated animals have suffered from the effects of this poison. As bearing upon the question of treatment, it is interesting



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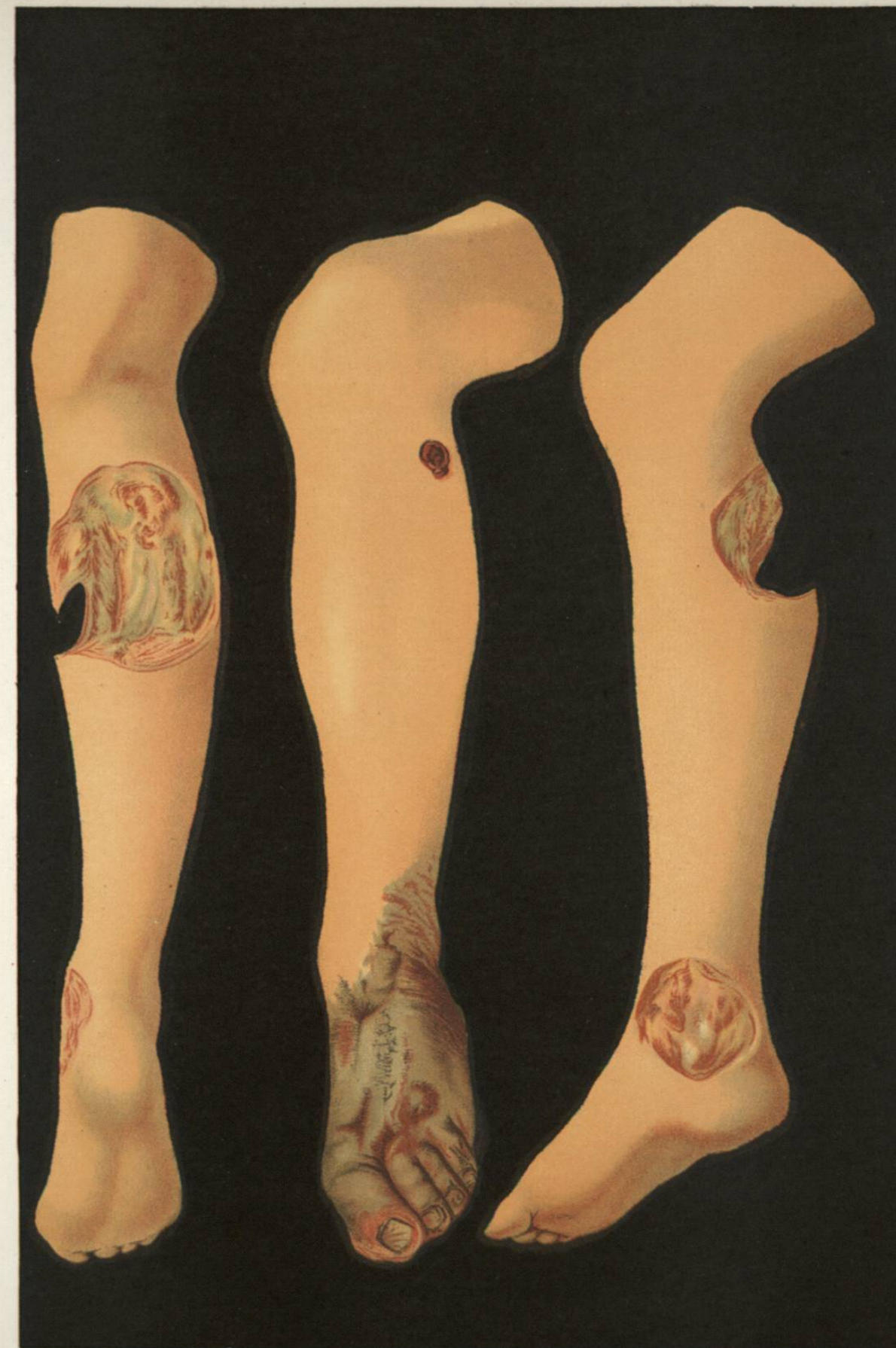
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to note that Dr. Salmon considers that ergot in hay may be prevented by cutting the grass before the seeds have formed.

The first effect of extreme cold upon the tissues is the contraction of the capillaries to the smallest practicable degree. A certain amount of blood serum is actually frozen and the capillary is ruptured, the circulation is not resumed when the parts are thawed, and gangrene results. Gangrene thus produced is usually of the dry variety, although, when the venioles or the larger venous trunks are frozen, by reason of the failure of the return circulation, moist gangrene is produced. Direct destruction of cells by caustic chemicals may produce gangrene of distal parts, through failure of both supply and return of blood. Gangrene of the perineum may occur from extravasated urine (Green, 1884), as even normal urine is highly irritating; but in such cases there must have been local inflammation and consequent death of the adjacent cells. Urine which has undergone putrefaction, being loaded with the putrefactive bacteria, is often very speedy in its action, especially as the tissues themselves are weak in their power of resistance; while not absolutely devitalized, they are yet in a state of extreme inertia. It is well known that the power of resistance to the entrance and subsequent development of the pathogenic bacteria is variable, and that, for instance, in cases of convalescence from such exhaustive diseases as typhoid, typhus, and the severer exanthemata, fatal forms of so-called blood-poisoning are apt to make their appearance; this condition, while perhaps immediately dependent upon diminished cardiac power, is one of deficient innervation; for insufficient nutrition of the nerve centres is necessarily manifested in weakness of muscular tissues throughout the body.

Obstruction of the veins, it will be seen, is very rarely a direct cause of gangrene; pressure or occlusion of the superficial veins alone will scarcely produce it, unless there is constitutional predisposition, as above set forth, for the deep veins will still carry away a large share of the return blood current. When gangrene does result from compression or ligature of superficial veins, it is by the production of stasis in the capillaries; to this cause we must refer the cases produced by tight bandaging, and, indeed, all of similar character, except those of venous thrombi.

MOIST GANGRENE.—This form of gangrene, also called acute gangrene, hot gangrene, inflammatory gangrene, is always preceded by inflammation. The part is at first swollen and painful, there is almost always inflammation of the veins (phlebitis), and the moist condition depends upon the obstruction to the return circulation, by which the water is left in the tissues.

Symptoms.—There will be a history of an injury and of antecedent inflammation, and there will be an absence of pain in the part that is actually gangrenous, although the adjacent parts, where the inflammatory blush is present, will be the seat of acute pain. Characteristic changes in color will take place: the part will be at first livid, then bluish, and finally completely black. Then, again, there will be swelling of a boggy character (œdematous), sometimes accompanied by emphysematous crackling. It is sometimes said that sensation is not destroyed; but this, when seemingly present, is only the well-known phenomenon of a person's experiencing, in a wounded or severed nerve, sensations which he refers to the peripheral area of distribution of that nerve. In the beginning the odor is imperceptible, but as the putrefactive change progresses the odor becomes "sweetish," and finally stinking in the highest degree. Constitutional symptoms of toxæmia are usually present, and in advanced stages of this condition great prostration is noted, even collapse; diarrhœa may be present, and in exact proportion to the degree of fever there will be the profound rigors and profuse sweatings of pyæmia; but if the gangrene is not extensive and is well localized, there may be little general disturbance. In cases in which the disease is protracted, the septic fever pursues its usual course, and the well-known typhoid condition of the system will be pres-

ent, the various symptoms of which need not be here described.

There is little difficulty in the *diagnosis* of this affection, but in the lax condition of the skin of the aged, with its enfeebled circulation and diminished vitality, there is sometimes doubt whether the blackness of the surface is due simply to ecchymosis or to gangrene. When the gangrene ceases to advance there is usually seen, encircling the part, a series of vesicles, or sometimes a mere line of redness. This redness becomes deeper, the epidermis over it falls off, the dead part begins to shrink away, and nature commences, by the rapid consolidation of the inflammatory exudate, to prevent further absorption of any septic material by the lymphatics. This line of redness (termed the "line of demarcation") is a narrow band of granulation tissue, which, like all granulation tissue, is characterized by the absence of lymphatics, and hence is incapable of absorbing septic material. The line of demarcation gradually extends entirely to the bone, in case an extremity is involved, and the dead soft part finally drops off. So long a time is required for the bones to undergo this process that they are usually seen protruding, and the case is seldom left to nature beyond this point.

Treatment.—When gangrene is threatened the treatment should be directed toward its prevention; *i. e.*, the inflammation should be combated, and the return circulation favored by massage and external heat. There is no single remedy so generally applicable and so prompt in its effects as external heat. The part, after gentle friction, may be enveloped in hot flannel, which should be changed frequently, or bottles of hot water may be applied. Another plan, which is preferred by some, is to irrigate the threatened part with hot water. But if this plan is adopted, it is necessary, if any good is to be accomplished, that the water used shall be as hot as can be borne. Thus the feeblest circulation may often be encouraged so that it once more becomes strong, and the effect of these measures in keeping alive the collateral circulation in cases in which the main artery is occluded from injury, operation, or disease is often beneficial in the highest degree. The old axiom that "heat is life, and cold is death" is nowhere more applicable than in these cases. When stasis is manifest by the presence of œdema, and by the boggy feel of the tissues, broad punctures, made deeply through the tissues, are of great service. The patient should be supported with tonic and stimulant remedies according to individual judgment. When the gangrene has become complete, local remedies are of no avail except to favor the production of sloughs, to hasten their separation, and to render the odor less offensive. Among these may be mentioned solutions of bromine, Labarraque's solution of chlorinated soda, and solution of the bichloride of mercury. The mass can be rendered quite innocuous by deep injections of the bromine solution. When the line of demarcation is fully established, operative interference is then demanded.

DRY GANGRENE.—In this form of gangrene there is neither venous obstruction nor failure of the lymphatics, and the fluids of the part are carried back into the system as fast as formed. As the arterial supply is gradually cut off, a drying or mummification of the tissues results. This condition frequently occurs in those who are suffering from starvation or who are subject to gout (Cheilus); it also occurs in those who have exhausted themselves by excessive debauchery. There is frequently an absence of inflammatory symptoms, and the gangrene may develop suddenly without premonition. There is usually organic disease of the heart and arteries. This is the chronic gangrene of Travers (South).

Symptoms.—Corrugation and shrinking of the soft parts, and gradually deepening color, until the whole mass is of a coal black; pains of varying severity usually precede the discoloration, sometimes lasting for several weeks. Occasionally pain is absent, and the patient simply experiences a sensation of coldness and numbness in the part. As the gangrene progresses, constitutional symptoms are manifested, there are great mental depres-

sion, unquiet sleep, palpitation of the heart, epigastric pain, and occasionally an intense internal cold (Chelius). Sometimes the distinctive characteristics between dry and moist gangrene are so obscure that it is difficult to place the case in one class or the other (Moore: "International Encyclopedia of Surgery," 1882).

The treatment is essentially the same as that already recommended for the moist form of the disease.

The prognosis is unfavorable.

SENILE GANGRENE.—This gangrene, which is usually of the dry variety, is almost wholly due to arterial obstruction, the pathology of which has already been discussed; but the obstruction is long in forming, and the



FIG. 2267.—Dr. Hamilton's Case of Senile Gangrene.

progress of the disease is slow. The description which Percival Pott gave of the affection, as it occurs in the foot, was so striking that for a long time it was known as Pott's disease of the toe; but, as the disease occasionally attacks the hands, the name was manifestly inappropriate. The condition of the arteries in these cases is one of "ossification," or, rather, of calcification, which results in a complete loss of elasticity of their walls, and consequent diminution of the blood supply. The bead-like feel of the radial pulse, in the aged, gives the observer a palpable object-lesson in senile calcification. The statement has been made that certain seasons specially predispose to senile gangrene, and the winter is alleged to be the season most favorable to its production, owing to the astringent effect of the cold; but there are no statistics to bear out this assertion, and the writer considers the case by no means made out.

Symptoms.—After some months or weeks of pain or otherwise unpleasant sensations in the part, a small bluish spot appears on one of the toes, frequently at the root of the nail, and the spot becomes black; from this point the discoloration slowly spreads to the adjoining toes, and finally, if the patient survive long enough, the whole foot and leg become involved. Sometimes the line of demarcation is formed near the centre of the foot, but more often the patient succumbs under the combined influence of the nervous exhaustion produced by the pain

and of the failure of the digestion. The pain accompanying the disease is a prominent symptom, and gives the patient more immediate concern than the fear of losing the limb, or even life itself. The accompanying figure, taken from a photograph of a patient under the care of Dr. John B. Hamilton, at the Providence Hospital, shows the stage of the disease at the time of her death. The notes are as follows: Elizabeth B., aged eighty-five, admitted to hospital April 13th, for a contusion of the knee, which, however, had left no trace; the pain in the toes and foot had been constant and harassing. Three weeks later, a blue spot was noticed on the dorsum of the second toe. The spot gradually spread until it included the great toe, as shown in the photograph, and the patient died July 20th, 1885.

Treatment.—This has been well formulated by Van Buren. "The treatment of senile gangrene is limited to a judicious husbanding of the patient's vital resources, looking to a possible self-limitation of the disease, after which a cure may be completed by amputation." To husband the patient's resources it is necessary, along with stimulating and supporting measures, to control the pain; here there is nothing more philosophical in its action than the hydrochlorate of cocaine injected into the painful tissue. In these cases, as in the foregoing varieties of gangrene, external heat will be found advantageous.

SYMMETRICAL GANGRENE (Relapsing Gangrene).—This affection, probably first accurately described by Raynaud ("De l'Asphyxie locale et de la Gangrène symétrique des Extrémités," 1862), is exceedingly rare. According to Raynaud, the disease occurs chiefly in chlorotic and nervous individuals of early adult life, patients in convalescence from typhoid fever and similar exhausting disease. Moore ("International Encyclopedia of Surgery") has seen a case presumably dependent upon this cause, and the appearance of the parts affected is shown in the plate which accompanies the doctor's article.

"The disease most frequently attacks the fingers—rarely the toes, tip of the nose, and external ear; often, for months beforehand, the affected parts suddenly become white, bloodless, without feeling, dead; the skin is strongly wrinkled and shrunken, the ends of the fingers appear thin and conical. The temperature of the parts is sunken, and the muscular movement is as though paralyzed. If this state extend over a whole extremity, the pulse becomes imperceptible. After a variable time there follows a painful reaction; itching arises, and the feeling of overfilling of blood; the skin becomes bluish-red. Severe pains precede the proper outbreak of gangrene. The extremities become bluish-white, violet, dark, livid, marbled; they are insensible but very painful, and icy cold; then small vesicles appear which fill with sero-purulent liquid, and are usually destroyed, so that the cutis becomes laid bare. Even now, the part may be restored; but for the most part, after a time the attack returns, and then the fingers show numerous small, white, depressed, and hard cicatrices on their extremities, which are found specially in front of and beneath the nails, and form conical callosities. If the ischæmia is of longer duration, there follows from the consecutive hyperæmia a true mummification, which terminates with the falling-off of the last phalanx" (Wagner).

DIABETIC GANGRENE.—The impoverished condition of the blood in cases of diabetes mellitus favors the production of gangrene, and it has been specifically named as a variety, although without any very good reason. As well might gangrene occurring in the progress of any chronic disease be separately named, and in most articles on the subject of diabetes the occurrence of gangrene is mentioned as among the complications of that disease.

"Spontaneous gangrene of the lower extremities, with obstruction of one or more arteries of the limb, is not infrequent in diabetes" (Marchal de Calvi). "Ulcerated surfaces are slow to heal, and gangrene supervenes sometimes spontaneously, but more often as the result of some trifling injury" (Tyson; "Pepper's System of Medicine," vol. ii.). The treatment of gangrene, when it occurs as a complication of diabetes, does not differ in any striking

respect from that which is suitable for other types of gangrene or for diabetes when not accompanied by this complication.

GANGRENE DUE TO INFECTIOUS CAUSES.

DIPHTHERITIC GANGRENE.—This form is usually named as one of the varieties, but, like the last mentioned, it has no valid claim to be considered a distinct affection. By some, indeed, it is regarded as gangrenous diphtheria, by others as a variety of hospital gangrene. Diphtheritic patches resulting in gangrene are sometimes seen in the edges of the sore resulting from the incision in tracheotomy; and when hospital gangrene is present in a hospital ward, wounds are frequently seen with the tough, fibrinous diphtheritic patch springing therefrom. In these cases the constitutional poisoning seems more severe. This form of gangrene is due to infection by the Klebs-Löffler bacillus, which is known to be the specific cause of diphtheria; and the constitutional disturbance which is referred to as a characteristic feature in these cases is, doubtless, the result of the profound toxæmia that always accompanies diphtheria.

The treatment of diphtheritic gangrene is the same as that of hospital gangrene, which will be mentioned in detail.

NOMA.—This is a gangrene affecting the pudenda and cheeks of young children from the age of weaning to that of puberty. Nurslings seem to have an immunity from it. When confined to the cheeks and mouth, it is variously termed *gangrenous stomatitis*, *gangræna oris*, *carcerum oris*, *gangrenopsis-stomato-necrosis*, *necrosis infantilis*, *buccal anthrax*, *water canker*, *sloughing phagedæna* of the mouth, and by the Germans *Noma* and *Wasserkrebs*; by the French *gangrène de la bouche*. The disease has been known for a long period, and was first described by Carolus Battus, of Amsterdam. Van Swieten (1699) recognized the disease as *gangrene*. Wiseman (1676) mentions the disease as *noma*, which he describes as "a deep Ulcer that eats and spreads without Tumor, but hath a Rottness and Putrefaction joined with it."

The disease is attended by great mortality, but as it usually comes on while the patient is suffering from some other affection, it is difficult to determine its relative fatality with precision. The affection, whether it appear on the cheek or on the vulva, is almost invariably unilateral. It begins as an inflammation attended by great exudation, ulceration is set up, the exudate dies, and the general appearances of circumscribed gangrene due to obstruction of the arterioles are present. In the mouth the disease usually begins at the frenum of the lip, but rarely on the outside of the cheek (Chelius), and as the œdematous inflammation extends the ulcerative process is carried down to the bone and alongside of the nose, and frequently involves the whole Schneiderian membrane. Occasionally the disease begins on the gums at the alveolar border (Cohen). At the pudenda the disease usually commences at the labial margin, and extends to the clitoris, nymphæ and hymen, and sometimes to the urethra, when the pain on micturition is acute; the inflammation is rapid, and the tissues speedily fall out by sloughing, the disease spreads to the perineum, to the anus, the thigh, and to the mons veneris, and, as is the case when the disease affects the mouth, the sloughing is deep and frequently extends quite to the bone. Sometimes the affection beginning at the mouth is later on developed at the vulva, and frequently the *noma* is ushered in with general constitutional symptoms, such as rigors with fever; but more commonly its onset is masked by the particular affection from which the child has been suffering; but always, in the later stage of the affection, there is great prostration, with feeble pulse and chlorotic countenance. When the affection is on the pudenda, there is great pain in all movements of the lower extremities, and the child usually assumes of its own accord the dorsal decubitus, and the legs are widely separated. There are retention of urine, owing to the severity of the urethritis, and constipation. There is rapid emaciation, and the patient

sinks under the "typhoid condition" so constantly present in the later stages of the other forms of gangrene. Cohen remarks that in *noma* of the mouth pulmonary gangrene is often observed as a complication, as is also enterocolitis. When *noma* affects the mouth alone, there is great variability in the degree of constitutional sympathy, some patients being able to sit up and play, while others are hopelessly comatose from the outset. Hemorrhage from the facial or from the pudendal branches of the pubic may occur; but in this variety, as in other forms of gangrene, the arteries are plugged by septic thrombi long in advance of the loss of tissue. The disease in most cases is more than likely due to a long thread-like organism of the leptothrix type which has so far resisted cultivation on ordinary media.

The treatment of *noma* is both local and constitutional. For the local treatment such measures should be adopted as are likely to arrest the advance of the disease into sound tissue, and to this end nothing suffices but the application of the most decisive escharotics like the Paque-lin cautery or fuming nitric acid. Quinine and iron, stimulants in the form of milk punch and liquid food are always indicated; when the stomach becomes irritable, nutritive enemata should be employed.

HOSPITAL GANGRENE.—This form of gangrene, known also under the various names of *hospital phagedæna*, *gangræna nosocomialis*, and *pourriture des hôpitaux*, was the scourge of military hospitals in the pre-antiseptic era. To-day it is absolutely unknown, the vast majority of living surgeons having had no clinical experience with it. Whether its spread was due to the agency of a specific micro-organism, or to an acquired virulence of the well-known pathogenic microbes in victims rendered specially susceptible by lowered vital resistance, remains a matter for speculation. Because of its great rarity we must turn to the writings of the older authors for a clinical picture of the disease. Mr. Guthrie graphically describes it as follows: "A wound attacked by hospital gangrene in its most concentrated and active form presents a horrible aspect after the first forty-eight hours. The whole surface has become of a dark-red color, of a ragged appearance, with blood partly coagulated, and apparently half putrid, adhering at every point. The edges are everted, the cuticle separating from half to three-fourths of an inch around, with a concentric circle of inflammation extending an inch or two beyond it; the limb is usually swollen for some distance, of a white, shining color, not peculiarly sensible except in spots, the whole of it being œdematous and pasty. The pain is burning and unbearable in the part itself, while the extension of the disease, generally in a circular direction, may be marked from hour to hour; so that in from another twenty-four to forty-eight hours nearly the whole of a calf of a leg, or the muscle of a buttock, or even the wall of the abdomen may disappear, leaving a deep great hollow or hiatus of the most destructive character, exhaling a peculiar stench which can never be mistaken, and spreading with a rapidity quite awful to contemplate. The great nerves and arteries appear to resist its influence longer than the muscular structures, but these at last yield; the largest nerves are destroyed, and the arteries give way, frequently closing the scene, after repeated hemorrhages, by one which proves the last solace of the unfortunate sufferer. . . . The joints offer little resistance; the capsular and synovial membranes are soon invaded, and the ends of the bones laid bare. The extension of this disease is in the first instance through the cellular structures. The skin is undermined and falls in, or a painful red and soon black patch is perceived at some distance from the original mischief, preparatory to the whole becoming one mass of putridity, while the sufferings of the patient are extreme."

The surface of the wound soon becomes a sticky, pulpy mass of a grayish color. This substance cannot be wiped off, and it resists the usual washings. If, at this stage, the further progress of the disease be not arrested, the patient succumbs, as from a fatal form of septicæmia. The disease was very prevalent in the military hospitals

of our Civil War; an extended account of it may be found in the surgical volumes of the "Medical and Surgical History of the War of the Rebellion," by Otis (see Plate XXIX., Figs. 1 and 3).

Treatment.—The treatment should be prophylactic, constitutional, and local. The first of these should have reference to the rules of antiseptic and aseptic wound treatment and to the rules of hygiene that bear on the subject of overcrowding; and when the disease first appears in the wards containing other wounded, it is important promptly to isolate those who are affected. The constitutional treatment should be directed to the free use of stimulants and good nutritious food. The local treatment directed to the gangrene when it invades the wounds should be of the most radical kind. The sloughing tissues should be removed by means of the curette and scissors, and the actual cautery should be applied freely. Bromine, fuming nitric acid, and subnitrate of mercury were extensively and successfully used by the older surgeons.

MALIGNANT EDEMA is one of the forms of gangrenous inflammation due to the invasion of a wound by the bacillus of malignant oedema. The organism morphologically resembles the Bacillus anthracis, though it differs from it in being motile, and in that it is strictly anaerobic. It is mostly found in rich garden soil, from which it is isolated by inoculation into animals. It is apt to invade all kinds of wounds—incised, lacerated, punctured. Instances are given of the disease following the sting of insects and penetration from a hypodermic needle. Malignant oedema is regarded as one of the most fatal forms of gangrene. The changes in the tissues are very rapid, a circumstance that led French writers to adopt the name *gangrène foudroyante*. The changes in the tissues are marked by an abundant exudate and by the formation of gas, both of which exert pressure upon the surrounding blood-vessels, and thus favor the development of gangrene. The clinical picture is best described by Park as follows: "Malignant oedema is known by the brownish discoloration of the overlying skin, which is streaked with blue where the overfilled veins show through it, while the underlying tissues are sodden with fluid and more or less blown up by the gaseous products of decomposition, so that the finger detects a firm crepitus, as is common in subcutaneous emphysema. From the wound, if one there be, flows a thin, foul-smelling secretion, which may also be expressed from the deeper layers. That the neighboring lymph spaces and nodes are actively involved is evident from the enormous swelling of the latter, as well as from the general condition of the patient. The rapid elevation of temperature with but trifling remissions remains constant until shortly before death. The tongue early becomes dry and cleaves to the palate, its surface being covered with a thick, foul fur. Patients early become apathetic, complaining only of pain and burning thirst. Delirium and coma usually precede death, which may occur in even so short a time as from fifteen to thirty hours. After death the cadaver bloats quickly and putrefaction goes on with amazing rapidity."

Treatment.—The treatment of this decisive form of gangrene should be of the most radical character. When the disease is recognized in a wound on a limb, the member should be amputated at once well above the limits of the disease. In situations where amputation cannot be practised, excision of the affected tissues should be practised at once and the wound dressed with antiseptics. The strength of the patient should be maintained by stimulants, nutritious diet, and supporting treatment.

SPREADING TRAUMATIC GANGRENE.—The last of the infectious forms of gangrene to be noted is known under the names of spreading traumatic gangrene, fulminating gangrene, or gangrenous emphysema. It results most generally in cases of rupture of the principal vessels supplying a part of a limb, with sudden arrest of the blood supply; or in those cases of traumatism in which intense, rapidly spreading inflammation appears. In either condition the rapid death of the part and the spread of the

disease process to contiguous healthy structures are due to the sudden development of a mixed infection by micrococci and bacilli. The putrefaction set up by these micro-organisms is often accompanied by the liberation of gas, the presence of which is noted by emphysematous crackling in the subcutaneous tissues as the process spreads beyond the diseased area. As a result of the sudden development of bacterial decomposition, poisoning by ptomaines, with constitutional symptoms of profound toxæmia, is early noticed. The treatment in such cases demands prompt amputation of the limb implicated, at a safe distance within the sound tissues; or rapid and thorough destruction of all gangrenous parts with the curette and actual cautery, in those situations which do not admit of amputation. (See Plate XXIX., Fig. 2, and Plate XXX.)

AINHUM.—This is a form of gangrene of unknown origin, more frequently seen in men than in women. It has been met with in the East and West Indies, but it is more frequently observed among negroes on the west coast of Africa. The affection is usually limited to the little toe, although it has occasionally been observed in the little finger. It begins by the occurrence, on the plantar surface, of a fissure which encircles the toe near the web. As the fissure deepens, gangrene of the soft parts occurs, with a rarefying osteitis of the bones. The disease is very gradual, the process lasting as much as ten years in some instances. It usually ends in spontaneous amputation.

CARBOLIC-ACID GANGRENE.—The watery solutions of this antiseptic drug used in surgical practice have been known to cause gangrene when persistently applied, especially to fingers and toes. The evaporation of the water, in the solution, which takes place during the prolonged application of compresses so saturated, tends to concentrate the agent in the dressings; hence the well-known effects of the strong solutions, such as blanching, numbing, etc., which lead ultimately to gangrene. So many cases of gangrene from this source have been reported in recent medical literature that topical applications of the drug to the parts mentioned should be practised with extreme caution.

John B. Hamilton.
Revised by Louis A. La Garde.

GARLIC.—**ALLIUM.** "The bulb of *Allium sativum* L., fam. *Liliaceæ*" (U. S. P.).

Garlic is a compound bulb, globose-ovoid, an inch or two in diameter, of a white or red-brown color and a very strong alliaceous odor and taste. The drug proceeds wholly from cultivated plants.

Garlic contains as its active principle—either already formed or produced, as in mustard, etc., by the addition of water—a very irritating, pungent, and volatile oil, *sulphide of allyl*, similar to that of the onion and others of the genus and belonging to the same group with the oils of mustard and other *Crucifera*.

It is now and then given with some advantage, as an antispasmodic, and sometimes as an expectorant in chronic bronchitis and pharyngeal or laryngeal catarrh. Internally taken, garlic, like the onion, etc., is an aromatic and carminative, and scents the breath with sulphur compounds during elimination.

There is an official syrup, of twenty-per-cent. strength, which is to be made from the fresh bulbs. Of this the dose is a half-ounce. The fresh juice is also often given in half-drachm doses. The fresh bulb is sometimes crushed and applied to the chest as a rubefacient.

Garlic is likely to be dropped from the next edition of the Pharmacopœia.

Henry H. Rusby.

GASSERIAN GANGLION, OPERATIVE REMOVAL OF THE.—The Gasserian ganglion is associated with the large sensory root of the fifth cranial nerve. It is situated in a depression near the apex of the petrous portion of the temporal bone. The sensory root of the fifth nerve enters it from behind, while the smaller motor root of the nerve passes under it, without having any connection with it, to join the inferior maxillary nerve.



GANGRENE FOLLOWING A SHOT LACERATION OF THE FEMORAL ARTERY.
(FROM THE MEDICAL AND SURGICAL HISTORY OF THE WAR OF THE REBELLION.)

Garlic.
Gasteln.

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MALIGNANT ŒDEMA is one of the forms of gangrenous inflammation due to the intrusion of a microbe by the bacillus of malignant œdema. The organism morphologically resembles the bacillus anthracis, though it differs from it in being mobile, and in that it is strictly anaerobic. It is mostly found in fresh matter, from which it is isolated by inoculation into animals. It is apt to invade all kinds of wounds—infected, lacerated, punctured. Instances are given of the disease following the sting of insects and penetration from a hypodermic needle. Malignant œdema is regarded as one of the most fatal forms of gangrene. The changes in the tissues are very rapid, a circumstance that led French writers to adopt the name *gangrène foudroyante*. The changes in the tissues are marked by an abundant exudate and by the formation of gas, both of which exert pressure upon the surrounding blood-vessels, and thus favor the development of gangrene. The clinical picture is best described by Park as follows: "Malignant œdema is known by the brownish discoloration of the overlying skin, which is streaked with blue where the overfilled veins show through it, while the underlying tissues are swollen with fluid and more or less blown up by the gaseous products of decomposition, so that the finger detects a firm crepitus, as is common in subcutaneous emphysema. From the wound, if one there be, flows a thin, foul-smelling secretion, which may also be expressed from the deeper layers. That the neighboring lymph spaces and nodes are actively involved is evident from the enormous swelling of the latter, as well as from the general condition of the patient. The rapid elevation of temperature with but trifling remissions remains constant until shortly before death. The tongue early becomes dry and cleaves to the palate, its surface being covered with a thick, foul fur. Patients early become apathetic, complaining only of pain and burning thirst. Delirium and coma usually precede death, which may occur in even so short a time as from fifteen to thirty hours. After death the cadaver swells quickly and putrefaction goes on with amazing rapidity."

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disease process to contiguous healthy structures are due to the sudden development of a mixed infection of the vessels and bacilli. The putrefaction set up by these micro-organisms is often accompanied by the formation of gas, the presence of which is noted by irregular, spontaneous crackling in the subcutaneous tissues as the process spreads beyond the diseased area. As a result of the sudden development of bacterial decomposition, and owing to the presence of gas, with constitutional symptoms of a toxic œdema, is early noticed. The treatment in such cases demands prompt amputation of the limb impeding at a safe distance within the sound tissues; or rapid and thorough destruction of all gangrenous parts with cautery and actual cautery, in those situations which do not allow of amputation. (See Plate XXIX, Fig. 3, and Plate XXX.)

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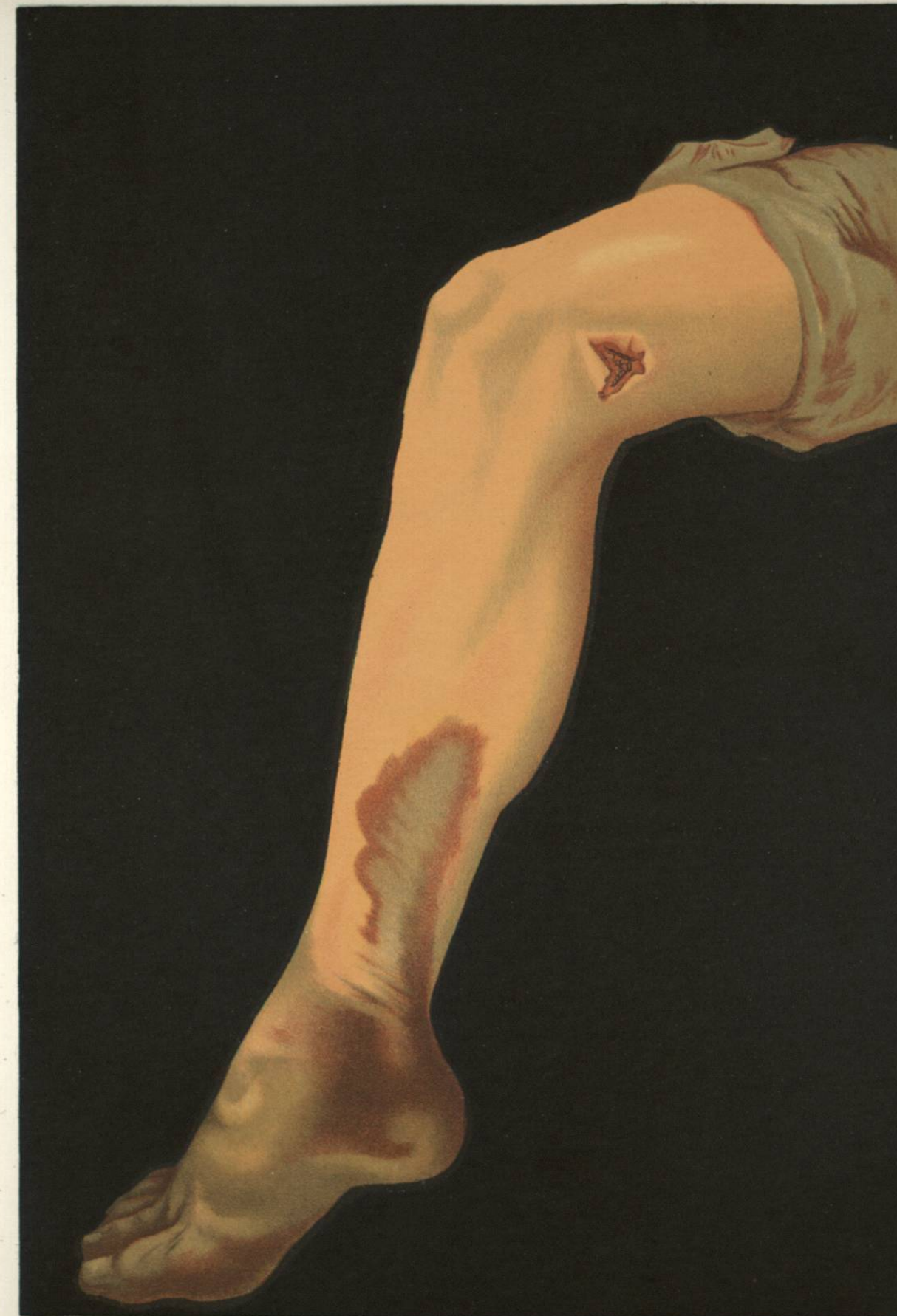
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GANGRENE FOLLOWING A SHOT LACERATION OF THE FEMORAL ARTERY.
(FROM THE MEDICAL AND SURGICAL HISTORY OF THE WAR OF THE REBELLION.)

Three branches proceed from the anterior border of the ganglion: the ophthalmic, the superior maxillary, and the inferior maxillary. They leave the skull through the sphenoidal fissure, the foramen rotundum, and the foramen ovale respectively. All three branches are nerves of sensation; the inferior maxillary is in addition a nerve of motion since it receives the motor root of the fifth nerve as stated above. It supplies with motor fibres the masseter, deep temporal, buccal, and internal and external pterygoid muscles.

The distribution of the sensory branches of the ganglion is as follows: The ophthalmic branch supplies the eyeball, the lachrymal gland, the conjunctival mucous membrane and that of the nasal fossa, and the integument and muscles of the eyebrow, forehead, and nose. The superior maxillary supplies the integument of the temple and part of the cheek, and the gums and teeth of the upper jaw. The inferior maxillary supplies the integument of the temple, external ear, lower part of the face, and lower lip, the teeth and gums of the lower jaw, and a part of the tongue. It also has a motor function as above mentioned.

The Gasserian ganglion has been of anatomical importance ever since its nature was recognized by Hirsch in 1765. The very great surgical interest which is now felt in this structure, and which is less than ten years old, is due to three facts. The fifth or trigeminal nerve is affected in neuralgia more often than any other nerve. The attacks of pain recur after operations upon the three divisions of the nerve, whether the operation be a simple nerve-stretching, or a division of the nerve, or a resection of a portion of the nerve, or a tearing out of as much of the affected nerve as possible, as advised by Thiersch. The removal of the Gasserian ganglion, first performed by Rose in 1890, affords the patient permanent relief from his neuralgia. It seems like a wanton act to open the skull, burrow in at the base of the brain, and tear out this great ganglion, but desperate conditions demand desperate remedies. Rose removed the superior maxilla and trephined the skull, putting the pin of the trephine in the foramen ovale. His patient recovered with the subsequent loss of an eye, and counted herself happy to be free from the neuralgia even at that price.

Other surgeons soon improved the technique of the operation. Hartley in America, and Krause in Germany, working independently, showed that the skull can be opened, and the ganglion removed by turning downward a flap of skin and bone from the temporal region. In a recent article upon this subject, Krause thus details the steps of the operation as performed by himself:

The patient is in a half-reclining position, with the head held exactly forward or turned a little toward the affected side, so that the blood may flow from the wound. Chloroform is used, if the patient's condition permits. Only dry sponges are employed. A flap of skin, fascia, muscle, periosteum, and bone is cut from the temporal region, and reflected downward. The base of this flap is about 1.5 inches wide and overlies the zygomatic process. Its height is 2.5 inches, and its greatest breadth is 2 inches. The dura mater is not opened. When all bleeding has been stopped by compression and ligature, and the flap, wrapped with gauze, has been reflected downward on the cheek, well out of the way, the dura is separated from the skull down to the bottom of the middle fossa, and the middle meningeal artery is exposed and ligated in two places and then divided. There is usually considerable venous hemorrhage due to the separation of the dura from the base of the skull. This can be controlled by pressure. The next step in the operation is the lifting up of the brain by means of a long retractor, and the dissection of the second and third branches of the fifth nerve from their origin in the Gasserian ganglion to their exit from the skull through the foramen rotundum and the foramen ovale. Then the ganglion itself is freed, at least above and below and backward, until the fifth nerve comes into view. The first division of the fifth nerve, the ophthalmic nerve, is then cut off close to the ganglion, no attempt being made

to dissect it free, on account of the danger of injury to the third and fourth cranial nerves, which are intimately associated with it. As these nerves supply the muscles of the eye their injury would be a serious calamity. The fifth nerve is next seized with a pair of clamps close behind the Gasserian ganglion. The second and third divisions are cut off close to their foramina of exit. The ganglion and as much of the root of the fifth nerve as can be twisted out with it, is torn from the brain. The stumps of the second and third divisions are pushed outward through the foramina so as to prevent any union of divided nerve fibres. Inspection of the cavity occupied by the ganglion should prove to the operator that the removal has been a complete one. All bleeding is then to be controlled, and the flap of bone and soft parts replaced. The operation lasts usually from one and one-half to three hours. In a favorable case the patient can get up in one or two weeks and be discharged from the hospital in three weeks.

The two chief dangers of the operation are hemorrhage and prolonged pressure of the brain. The mortality of the operation is variously reckoned at from ten to twenty per cent. The patient awakes from his narcosis absolutely free from neuralgia. This is in striking contrast to the recovery after operations upon the peripheral nerves, since after these operations the attacks of pain recur for a few days in gradually diminishing intensity.

So far as is known removal of the Gasserian ganglion invariably gives permanent relief from the neuralgic attacks, although as the operation has been performed only in the last few years, one must not speak too positively. The numbness and partial paralysis of the muscles of mastication of the side operated upon are a small price to pay for relief from the fearful attacks of pain which these patients have been compelled to endure.

Edward Milton Foote.

GASTEIN.—A picturesque valley in the Duchy of Salzburg, Austria, famous for its mineral springs. It is an arm of the Salzbach Valley, and is about twenty-five miles long by a little more than a mile wide. Its sides are formed by two ranges of mountains which extend to the right and left from the two peaks, Nassfeld-Tauern, 7,820 feet high, and the Ankogel, of 10,700 feet. The situation is romantic, near the region of the glaciers, and at an elevation of about 3,000 feet. In the midst of the valley flows the dashing little river Ache, which forms two beautiful waterfalls near the village of Wildbad-Gastein, now the principal resort. The climate is mild and uniform, the variations in temperature being slight. It is claimed that the thermometer has never risen above 86° F. in summer and seldom above 70°. The barometric changes are also slight, averaging 29.50 inches pressure for the year. Rainy days are, however, rather numerous in the summer.

The thermal springs are eighteen or twenty in number, and are said to have been known as early as the seventh century. Many of them are designated by such names as the Fürstenquelle, the Hauptquelle, the Doctor's-Quelle, and the Spitalquelle. Seven of the springs issue from the solid granite rock or from artificial clefts; the others flow from stratified beds of feldspar, gneiss, and mica. Their deep origin is probably in the heart of the great Ankogel. The temperature of the springs ranges from 87° to 160° F., with but slight variation at any season. The waters are rich in the variety of their mineral salts, but they are very dilute. Of sodium sulphate, the most abundant ingredient, there is but 1.51 grains in a pint, while of calcium carbonate and sodium chloride, the next most abundant ingredients, there is only 0.36 grain each. Oxygen is found in 30.89 per cent. and nitrogen in 69.11 per cent.

The waters are employed almost entirely for bathing, for which purpose many public and private institutions have been erected. Their fame is said to have originated from the cure of Duke Frederick, of Austria, in 1436. Much of the efficacy attributed to them belongs no doubt to the bracing mountain atmosphere.