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Modern Surgery - Chapter 8. Mortification or Gangrene

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VIII. MORTIFICATION, GANGRENE, OR SPHACELUS.

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

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

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

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

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

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

Nancrede says, in his very valuable work on the "Principles of Surgery": "Yet, let accidental inflammation have preceded the final blocking of an artery, or let ligation of the main artery cause gangrene because the collateral

* "Principles of Surgery."

circulation cannot become developed, and if an aneurysmal sac is so situated as to interfere with a free return of venous blood and lymph, this anemic gangrene will in both instances prove moist and not dry."

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

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

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

Non-senile Dry Gangrene.—An embolus may cause dry gangrene in rare instances. If it does so, it is probable that the blocking was not at once complete. When an embolus lodges in an artery and causes dry gangrene, the case runs the following course: sudden severe pain at the seat of impaction, and also tenderness; pulsation above, but not below, this point, after obstruction has become complete; the limb below the obstruction is blanched, cold, and anesthetic; within forty-eight hours, as a rule, the area of gangrene is widespread and clearly evident; the limb becomes reddish, greenish, blue, and then black; the skin becomes shriveled and its outer layer stony or like horn because of evaporation. The entire part may become dry; but usually there are spots where some fluid remains, and these spots are soft and moist, and the dead tissue, where it joins the living, is sure to be moist. The moist areas become foul and putrid, but the dry spots do not. In dry gangrene, at

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

Treatment of Non-senile Dry Gangrene.—When injury or blocking of a healthy artery causes us to fear the onset of dry gangrene, the patient should be placed in bed and the part elevated a little, kept wrapped in cotton-wool and surrounded with bottles filled with warm water. If gangrene begins, wait for a line of demarcation, and while waiting dress the dying and dead parts antiseptically, wrap the extremity in cotton and keep it warm, and see to it that the patient gets plenty of sleep and nourishment. It is also advisable to give tonics and stimulants. When a line of demarcation forms, amputate well above it.

Senile gangrene, chronic gangrene, Pott's gangrene (Fig. 53), is a form of gangrene due to feeble action of the heart plus obliterating endarteritis or atheroma of peripheral vessels. The vessels do not carry a normal amount of blood, and may at any time be occluded by thrombosis. In a drunkard, or in a victim of syphilis or tubercle, the changes supposed to characterize old age may appear while a man is young in years. It was long ago said, with truth, "a man is as old as his arteries." Senile gangrene most often occurs in a toe or the foot.

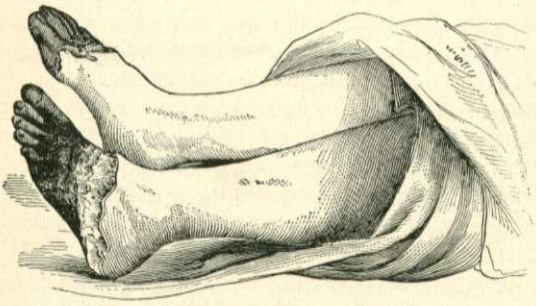

Fig. 53.—Senile gangrene of the feet (Gross).

Symptoms.—A man whose vessels are in the state above indicated is generally in feeble health and has a fatty heart and an arcus senilis (a red or white

line of fatty degeneration around the cornea). His toes and feet feel cold and numb, and they "go to sleep" very easily, and he suffers from cramp of the legs and feet. He is dyspeptic and short of breath, and his urine is frequently albuminous. The arteries are felt as rigid tubes, like pipe-stems. He is in danger of edema of the lungs and of dry gangrene of the toes. A slight injury of a toe—for instance, cutting a corn too close—will produce extensive inflammatory stasis followed by thrombosis, which completely cuts off the blood-supply and causes gangrene of the part. Gangrene is usually announced by the appearance of a purple and anesthetic spot, followed by a vesicle which ruptures and liberates a small amount of bloody serum and exposes a dry floor. In the parts about the gangrenous area there is often burning pain. The tissues immediately adjacent to the dead spot are in a condition of edema and stasis, the parts being purple, the color disappearing slowly under pressure and returning slowly when pressure is removed. The parts a little further removed are hyperemic, the color disappearing rapidly on pressure and returning rapidly when pressure is removed. The dead parts do not putrefy at all or do so but slightly, hence the odor is never very offensive and is usually trivial. They are anesthetic, hard, leathery, and wrinkled, and resemble a varnished anatomical specimen or the extremity of a mummy (hence the term mummification). Before the line of demarcation forms there is burning pain; after it forms pain is rarely present. If embolism or thrombus in a diseased vessel caused the gangrene, the pain is severe at the point of impaction. In senile gangrene the periphery is always dry, the part nearer the body being generally somewhat moist. The process may be very limited or it may spread up to the knee. As it spreads the area of hyperemia advances at the margin, the area of stasis follows, and the zone of gangrene becomes more extensive. When tissues are reached the blood-supply of which is sufficiently good to permit of inflammation, Nature tries to limit the gangrene by the formation of a line of demarcation. A line of demarcation may begin, but prove abortive, the tissue mortifying above it. This proves that tissue near the line is in a state of low vitality. When a limited area is gangrenous, constitutional symptoms are trivial or absent; but when a large area is involved, the fever of septic absorption exists. Death may ensue from exhaustion caused by sleeplessness and pain, from septic absorption, or from embolism of internal organs. In many cases of senile gangrene clots are formed in the superficial femoral artery or its branches (Heidenhain), an observation it is important to bear in mind when amputating.

Prevention of Senile Gangrene in the Predisposed.—Such a patient must avoid injuring his toes and feet. Cutting his corns carelessly is highly dangerous, and any wound, however slight, requires rest and antiseptic dressing. The victim of general atheroma must wear woolen stockings, put a rubber bag containing warm water to his feet on cold nights, and attend to his general health. A little whiskey after each meal is indicated, and occasional courses of nitroglycerin are desirable.

Treatment of Senile Gangrene.—When gangrene occurs, if it is limited to one toe or a portion of several toes, if it is a first attack, if there is no fever or exhausting diarrhea, if there is no tendency to pulmonary congestion, if the appetite is fair and sleep refreshing, it is best to avoid radical interference.

Await the formation of a line of demarcation. While awaiting the line of demarcation dress the part antiseptically and raise the foot several inches from the bed and surround the part with bottles of moderately warm water. Very warm water may do harm. Give the patient nourishing diet, stimulants, and tonics; see to it that he sleeps, and during the spread of the gangrene watch for fever, diarrhea, pulmonary congestion, and kidney failure. When a line of demarcation forms, dress with warm antiseptic fomentations and iodoform, and every day pick away dead bits with the scissors and forceps. In many cases healing will occur; but even when the parts heal, the patient will always be in deadly peril of another attack. If the gangrene shows a tendency to spread, if it involves more than a portion of several toes, if it is not a first attack, if there is sleeplessness, fever, exhausting diarrhea, anorexia, or a strong tendency to pulmonary congestion, do not delay, but at once amputate high up. If the gangrene shows no tendency to limit itself, or if the patient develops sepsis or exhaustion, at once amputate high up. The best point at which to amputate is above the knee, so that the deep femoral artery, which rarely becomes atheromatous, will nourish the flap and gangrene will not occur. It has been pointed out that the superficial femoral artery and its branches often contain a clot. Never amputate below the tubercle of the tibia. Some operators disarticulate at the knee-joint. Heidenhain affirms that so long as the gangrene is limited to one or two toes we should merely treat it antiseptically, elevate the limb, and wait for the dead part to be cast off spontaneously; if, however, it extends to the dorsum or sole of the foot, we should amputate at once above the knee. He further states that gangrene of the flaps almost always occurs in amputations below the knee, and high amputation is indicated in advancing gangrene with or without fever.* When amputation has been performed and the Esmarch band has been removed and no arterial bleeding takes place from the superficial femoral artery, a clot is lodged in that vessel. If such a condition exist, insert into the artery a fine rubber catheter or a filiform bougie and break up the clot. When blood flows we are sure that the clot has been washed out.†

Moist or Acute Gangrene.—In moist or acute gangrene (Fig. 54) the dead part remains moist and putrefies. As Nancrede points out, there are two forms of moist gangrene: "that limited to the areas actually killed by a traumatism, with some surrounding tissue which dies," and "that which tends to spread widely, this latter being usually caused by specific micro-organisms, an intense, widespread, pyogenic inflammation resulting, involving the subcutaneous and intermuscular cellular planes, by strangulation of the vessels of which all blood-supply to the remaining soft parts is destroyed."‡

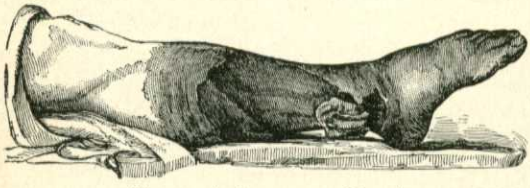

Fig. 54.—Acute gangrene (Gross).

* Deutsche medicinische Wochenschrift, 1891, p. 1087.

† Severeanu. See Mancozet's report before the second Pan-American Medical Congress.

‡ Nancrede's "Principles of Surgery."

In a case of gangrene the parts remain moist, either because the main artery has become suddenly blocked, and the tissue fluids are not urged by sufficient *vis a tergo* to cause them to flow out of the limb, or because the main vein is blocked. It may arise in a limb after ligation, obstruction, or destruction of its main artery, main vein, or both; after long constriction, as by a tight bandage; after crushes and lacerated wounds; and after thrombosis of the vein. Moist gangrene may follow acute inflammation, or may be due to local constriction (strangulated hernia), crushing, chemical irritants, heat, and cold.

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

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

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

Treatment of Moist Gangrene.—In extensive moist gangrene of a limb, if the condition is of the form described as mild, in which there are not severe symptoms of sepsis and in which the gangrene is not rapidly progressive, wait for a line of demarcation, and amputate clear of and above it. While

waiting for the line to form, dress the dead parts antiseptically, wrap the extremity in cotton, apply warmth, and slightly elevate the limb. Give opium, tonics, nourishing food, and stimulants. In the severe form of moist gangrene (really foudroyant gangrene), amputate at once high above the gangrenous process. In inflammatory gangrene, such as is sometimes associated with phlegmonous erysipelas, relieve tension by incisions, cut away the dead parts, brush the raw surface with pure carbolic acid, dust with iodoform, and dress with hot antiseptic fomentations. Stimulate freely, administer nourishment at frequent intervals, and treat the patient in general as we would a case of sapremia, or suppurative fever. A gangrenous wound is treated as pointed out in the section on Sloughing.

Acute microbic gangrene, fulminating gangrene, emphysematous gangrene, gangrenous emphysema, gangrene foudroyante, or **traumatic spreading gangrene,** results from a virulent infection of a wound. The condition may be due to a mixed infection with virulent streptococci and organisms of putrefaction; or to infection with the bacilli of malignant edema, and putrefactive organisms. Some cases are due to the *bacillus of malignant edema* alone; some are due to the *bacillus aërogenes capsulatus* of Welch and Flexner. The injury is usually severe—often a crush which destroys the main artery and renders an anastomotic circulation impossible. In such severe accidents the limb is much swollen and the pulse below the seat of injury is imperceptible, and the surgeon is often at this time uncertain whether to amputate at once or wait. Emphysematous gangrene is commonest after compound fractures, and begins within forty-eight hours of the accident. The extremity becomes enormously swollen from edema and gas. The gangrene does not begin at the periphery, as does ordinary moist gangrene, but at the wound edges, which turn red, green, and finally black; the extremity soon undergoes a like change and becomes mortified. The skin peels off, emphysematous crackling, due to gas formed and retained in the tissues, can be detected over large areas, and the extremity becomes anesthetic and pulpy. The gases formed in the tissues are sulphid of hydrogen, sulphid of ammonium, volatile fatty acids, and ammonia. Great fetor is soon noted. The gangrene spreads up and down from the wound, and red lines, due to lymphangitis, run from above the wound. The adjacent lymph-glands swell, and in thirty-six hours the gangrene may involve an entire limb. No line of demarcation forms. The system is soon overwhelmed with ptomaïns, and the patient suffers from putrid intoxication, with delirium, and often passes into profound collapse with coma and subnormal temperature. Traumatic spreading gangrene must not be confused with erysipelas. In erysipelas the color is red, pressure instantly drives it out, and on the release of pressure it at once returns. In early gangrene the color is purple, pressure fails to drive it out at all or only does so very slowly, and if the surface is blanched by pressure, on the release of pressure the color crawls slowly back. Sometimes emphysematous gangrene, in the form of gangrenous cellulitis, follows a trivial injury such as a puncture, the entrance of a splinter, an abrasion, or a slight cut. The region about the injury becomes red, then livid, and finally green or black. Enormous swelling takes place, partly due to edema, partly to gas, and the swelling and discoloration spread rapidly. Red lines subsequently becoming greenish run toward enlarged lymphatic

glands above the gangrenous part. The tissues are rapidly separated and destroyed and the bone is often quickly exposed and infected. The symptoms point to overwhelming sepsis. There is high fever and delirium, and coma and death are apt to ensue. The patient may die in from twenty-four to forty-eight hours.

Treatment.—In acute spreading gangrene of an extremity following a severe injury no delay is admissible. To wait for a line of demarcation is to expect the impossible, and a delay dooms the patient inevitably to death. Amputation must be performed at once high up, the flaps should be brushed with pure carbolic acid, and then every effort is to be made to sustain the patient's strength by the administration of food and stimulants. Antistreptococcic serum may possibly be useful. In cases of acute spreading gangrene following trivial injuries it may be possible to arrest the process by free incisions, thorough drainage, hot antiseptic fomentations, stimulants, etc., but in some cases amputation is necessary. Some surgeons, notably Doerfler ("Münchener medicinische Wochenschrift," April 23 and 30, 1901), oppose amputation in cases of spreading gangrene following trivial or moderately severe injury. Doerfler maintains that cases which recover after amputation would have recovered if amputation had not been performed. From this positive statement I am obliged to dissent.

Hospital gangrene or sloughing phagedena is a disease that has practically disappeared from civilized communities. It formerly occurred in crowded, ill-ventilated hospitals. Some consider it traumatic diphtheria. Koch thinks it is due to streptococci. Jonathan Hutchinson says: "Hospital gangrene is set up by admitting to the wards a case of syphilitic phagedena." It may show itself as a diphtheritic condition of a wound, as a process in which sloughs which look like masses of tow form, or as a phagedenic ulceration. The surrounding parts are inflamed and painful, and buboes form in adjacent lymphatic glands. The system passes into a low septic state.

Treatment.—In treating hospital gangrene ether should be given, the large sloughs removed with scissors and forceps, the parts dried with gauze and cauterized with bromin. The surgeon should take a tumblerful of water and into it pour the bromin, which will fall to the bottom of the glass. The drug can be drawn up with a syringe and injected into the depths of the wound. The wound should be plentifully sprinkled with iodoform and dressed with hot antiseptic fomentations. When the sloughs separate, the sore can be treated as an ordinary ulcer. The constitutional treatment is that employed for sepsis.

Special Forms of Gangrene.—**Symmetrical** or **Raynaud's gangrene** arises in severe cases of Raynaud's disease. It is a dry gangrene. Raynaud's disease is a vasomotor neurosis, seen particularly in children and young female adults but sometimes met with in men. Chlorotic and hysterical women seem more apt than others to suffer from it. The condition is much commoner in winter than in summer, and cold seems to be an exciting cause. The essential cause of Raynaud's disease is uncertain. In some acute cases associated with fever, albuminuria, and splenic enlargement, it seems to be a part of an acute infectious disease. It can occur in a variety of toxic conditions and in a number of infectious diseases (typhoid fever, for instance). It may develop in the course of gout and also of diabetes. In many cases

neuritis exists; in some there is obliterative endarteritis of the peripheral vessels. Some cases seem to be purely hysterical. The fact that attacks of Raynaud's disease are sometimes accompanied by hemoglobinuria has suggested malaria as a possible cause. Raynaud's disease is characterized by attacks of cold, dead bloodlessness in the fingers or toes as a result of exposure to cold or of emotional excitement (local syncope). In the more severe cases there are capillary congestion and mottled, livid swelling (local asphyxia). In some few cases the skin of the face or trunk is attacked. Local syncope is thought to be due to vascular spasm, and local asphyxia to some contraction of the arterioles, with dilatation of the capillaries and venules. It is after local asphyxia that gangrene may appear. A chilblain is an area of local asphyxia. The patient complains of pain, tingling, numbness, coldness, and stiffness in the affected parts. Attacks of Raynaud's disease occur again and again, and may never eventuate in gangrene.

Raynaud's disease is rarely fatal and is often recovered from.

Raynaud's gangrene is most commonly met with upon the ends of the fingers or the toes, but it may attack the lobes of the ears, the tip of the nose, or the skin of the arms or the legs. Sometimes the disease is seen upon the trunk. When gangrene is about to occur the local asphyxia at that point deepens, anesthesia becomes complete, and the part blackens and feels cold to the touch. The epidermis raises into blebs, which rupture and expose dry surfaces. A line of demarcation forms, and the necrosed area is removed as a slough. Widespread gangrene from Raynaud's disease is rare; there is not often an extensive area involved—rather a small superficial spot. Recovery is the rule.

Treatment of Raynaud's Disease and of Raynaud's Gangrene.—If an individual suffers from attacks of Raynaud's disease, every effort should be made to improve the general health and to avoid chilling the surface of the body. During the attack employ gentle massage, place the extremity in warm water, and, if pain is severe, give morphia hypodermatically. Amyl nitrite is without value in this condition. When attacks of Raynaud's disease are so severe as to threaten gangrene, put the patient to bed; if the feet are affected, elevate the legs slightly, wrap the extremities in cotton-wool, and apply warmth. If the hands are affected, wrap them in cotton-wool, elevate them slightly, and apply warmth. Massage is useful. When gangrene occurs, dress the part antiseptically until a line of demarcation forms, and then remove the dead parts by scissors, forceps, and antiseptic fomentations. If amputation becomes necessary, which will rarely be the case, wait for a line of demarcation.

Diabetic gangrene resembles in many points senile gangrene, but the dead portions remain somewhat moist and putrefy. Some attribute it directly to the presence of sugar in the blood. Some think diabetes causes gangrene indirectly by rendering the tissues less resistant to infection and less capable than normally of repair. Many hold that it is of neurotic origin, being the result of nerve degeneration. Heidenhain believes that it is due to arterial sclerosis. That most of the victims of diabetic gangrene suffer from arteriosclerosis is certain. It seems probable that the gangrene is due to infection of tissues predisposed to infection by the presence of sugar and weakened by changes in the nerves and blood-vessels. Diabetic gangrene is most

usually met with upon the feet and legs of elderly people, but it may arise at any age and may attack the genital organs, thigh, lung, buttock, eye, back, finger, or neck. It may affect only a single area, may attack several areas, or may be symmetrical. It may arise in any stage of diabetes, from the earliest to the latest. It may begin as a perforating ulcer. As in senile gangrene, a trivial injury is apt to be the exciting cause, but it may arise without any antecedent injury. If an injury is causative, a condition like cellulitis arises, spreads rapidly, and eventuates in gangrene. When the gangrene follows a traumatism, there are no prodromic symptoms. When it arises spontaneously in the skin, it is often preceded by pain of a neuralgic nature and attacks of "livid or violaceous discoloration of the skin, with lowered surface temperature and sometimes loss of sensation" (Elliot). Diabetic gangrene is often superficial, but may become deep if it follows an injury or ulceration. The gangrenous area is somewhat moist as a rule, but may be dry. The parts about are livid and may be covered with vesicles. It spreads slowly, but more rapidly than senile gangrene. There is little tendency to the formation of any line of demarcation, although occasionally spontaneous healing occurs.

Treatment.—Surgeons have become shy of amputating in such cases, but the experience of Kuster, of Berlin, proves conclusively that an amputation should be performed at once in diabetic gangrene of the leg, and should be done above the knee. If operation is performed below the knee, the flaps will become gangrenous. It has been noted that sugar will sometimes disappear from the urine after an amputation. Of 11 amputations by Kuster, 6 recovered and 5 died; and of these 5, 3 had albumin in urine as well as sugar.*

Heidenhain warmly advocates early high amputation, with the making of short flaps. When the patient dies after operation, he usually does so in coma. In any case after operation, treat the diabetes by means of drugs and diet. Codein is often of great value. If amputation is refused or if the gangrene is not upon an extremity, treat the gangrenous area by hot antiseptic fomentations, the daily removal of portions of dead tissue, the administration of antidiabetic drugs, and the use of suitable articles of diet. Never fail to examine the urine in every surgical case, and especially in every case of gangrene, for diabetes might be present when it had not been suspected.

Operations on Diabetics.—Surgical operations upon diabetics are regarded as very dangerous and are employed by most surgeons only in emergencies. In operations upon such subjects gangrene may arise in the wound or diabetic coma may develop. It is important to remember that glycosuria may result from a surgical condition (head injury, sepsis, etc.), and this temporary diabetes will be relieved by operation. I have seen it in appendicitis, and in such cases operation is not contraindicated, but is imperative. Llewellyn Phillips in a recent article ("Lancet," May 10 and 17, 1902) refers to the temporary glycosuria produced by injury and sepsis. He thinks that diabetes may directly cause cataract and balanoposthitis, but produces gangrene indirectly by causing nerve degeneration and arteriosclerosis. Phillips points out that a surgical condition and glycosuria may exist independent of and uninfluenced by each other, and many such cases can be operated upon,

* See the convincing article of Charles A. Powers, in Amer. Jour. of Med. Sciences, Nov. 11, 1892.

although operation should be avoided if there is serious disease of some important organ (the liver, for instance). Phillips, in the valuable article referred to, insists that the percentage of sugar is not a measure of the degree of danger; that albuminuria adds greatly to the danger; that the presence of acetone in the urine, and also the presence of ammonia, gives a bad prognosis. Phillips's conclusions as to when to operate and when to refuse operation are as follows ("Lancet," May 10 and 17, 1902): An operation for malignant disease in a diabetic can be performed if the operation would be proper on a non-diabetic individual. Large abdominal tumors can be removed. Cosmetic operations are justifiable if the general health is good and there is not marked arterial disease or nerve degeneration. Operation is justifiable in all emergencies without regard to the condition of the urine. In a diabetic with a surgical malady it is often possible to lessen danger by preliminary treatment. Only an operation of the greatest urgency should be performed if over 1 gram of ammonia is excreted during twenty-four hours; and if aceto-acetic acid or much albumin is present, every case but the most urgent should be postponed and subjected to medical treatment.

I would add to the conclusions of Phillips that the anesthetic is a danger to the kidneys irritated by the secretion of sugar, and it is desirable, when possible, to use local anesthesia, or, as Robt. T. Morris advises, nitrous oxid and oxygen ("Medical News," June 29, 1901).

Gangrene from Ergotism.—Ergotism is a diseased condition resulting from eating bread made with rye which has been attacked by a fungus (*Claviceps purpurea*). In former days it was not unusual to have epidemics of ergotism from time to time, but at present the disease is found in individuals or at most in a few of a community. Ergotism is very rare in the United States. It is never seen in unweaned children. The ingestion of ergot in quantity sufficient to produce chronic poisoning causes tonic contraction of the peripheral blood-vessels, degeneration of the inner coat, and thrombosis of some arterioles. It is also maintained that degeneration of the posterior columns of the spinal cord takes place.

The eating of bread made of diseased rye provokes gastro-enteritis, the evidences of which are abdominal pain of a crampy character, vomiting, diarrhea and exhaustion. The patient complains of formication and itching of the skin of the extremities; severe, cramp-like, and tingling pains in the limbs, and disorder of vision. The pulse becomes small and slow. In some cases very painful spasms attack the muscles of the extremities and finally tonic spasm is noted and the patient probably perishes from exhaustion after developing general convulsions and passing into coma. In other cases certain areas exhibit "gradual blood-stasis" (Osler), anesthesia, and finally gangrene. The gangrene is dry and peripheral. It usually affects the fingers or toes, but may involve an entire limb, and may be symmetrical. Chronic ergotism is usually recovered from, but acute cases die in from seven to ten days.*

Treatment.—Ergotism is treated by forbidding the eating of the poisonous bread, allaying gastro-enteric inflammation, favoring elimination and administering nourishment and stimulants. If gangrene is threatened, endeavor to prevent it by gentle massage and the application of warmth. If superficial gangrene occurs, dress with hot antiseptic fomentations and elevate

*Pick, in Heath's "Surgical Dictionary."

the part, and every day take scissors and forceps and remove the loose crusts. If deeper and more extensive gangrene arises, wait for a line of demarcation and amputate above it.

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

In a more severe frost-bite the affected part becomes purple and covered with vesicles, and gangrene may or may not follow. When a part has been badly frozen the peripheral portion dries. The part is deprived of all blood because of contraction of the vessels and because plasma coagulates at a few degrees above freezing. Cold disorganizes the blood, breaking up white corpuscles with the liberation of fibrin ferment and coagulation of plasma, and destruction of red corpuscles with the liberation of hemoglobin subsequently takes place. The thrombosis which is established prevents circulation, and the tissue-cells are damaged beyond repair. The part is bloodless and anesthetic, and a line of demarcation forms. Hence we note that severe frost-bite causes dry gangrene. If a part which is not so badly frozen is brought suddenly into a warm atmosphere, hyperemia takes place when the blood runs into the frosted tissues, blebs form, and moist gangrene may result. Areas of superficial gangrene are not uncommon.

Treatment of Frost-bite and of Gangrene from Frost-bite.—A frost-bite in which the skin is livid and not as yet gangrenous should be treated by frictions with snow or rubbing with towels soaked in iced water. As the skin becomes warmer and congestion disappears the part should be wrapped in cotton-wool. A sufferer from frost-bite should not suddenly be brought into a warm room. When gangrene follows frost-bite, if only small areas are involved, allow the dead parts to come away spontaneously, applying in the mean while hot antiseptic fomentations. If separation be delayed by cartilage, ligament, or bone, cut through the retaining structure. If amputation becomes necessary, await a line of demarcation, as it is not possible to be certain how high tissue damage extends, and to amputate through devitalized parts would mean renewed gangrene.

Noma.—Noma is a rapidly spreading gangrenous process which is most apt to begin upon the mucous membrane of the gums or cheeks. Noma of this region is known as *cancrum oris*. Occasionally it begins in the ears, the genitals, or the rectum. When it attacks the vulva it is called *noma pudendi*. It may originate in the mouth and subsequently attack other regions. Noma is a very rare disease, is chiefly met with in children between the ages of three and ten, but it can attack older persons. (O. Zusch, in "Münchener medicinische Wochenschrift," for May 14, 1901, reports a case in a man sixty-six years of age.) It occurs in girls oftener than in boys. The disease is most frequently encountered in children recovering from an acute disease. It is seen after scarlatina, typhoid, pneumonia, dysentery, and especially after

measles; in fact, Osler says that over one-half the cases follow measles. Children of tuberculous tendencies seem more liable than others. Young children who live amid filth and squalor in damp and ill-lighted apartments are most prone to suffer, but that such conditions are not essential to the genesis of the disease is shown by the report of an epidemic of noma in the Albany Orphan Asylum. In this excellently situated, well-lighted, and well-ventilated building the children are carefully fed and cared for, and yet sixteen cases of noma occurred after an epidemic of measles. (See "An Epidemic of Noma," by Geo. Blumer and Andrew MacFarlane, in "Amer. Journal of Med. Sciences," Nov., 1901.) The disease is thought by many to be due to pus organisms. Lingard describes a bacillus which he considers causative. Blumer and MacFarlane conclude that the disease begins as a simple infection and a mixed infection takes place later. The mixed infection is not always due to the same organism, but is usually due to a long organism of a leptothrix type ("Amer. Journal of Med. Sciences," Nov., 1901).

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

Treatment.—Administer an anesthetic and destroy the gangrenous area with the Paquelin cautery. In noma of the mouth chloroform is used instead of ether because the hot iron is to be applied in a region surrounded with anesthetic vapor and ether vapor is inflammable. In noma in some other region ether can be given. After cauterization directions are given to wash the part every few hours with peroxid of hydrogen, irrigate it with hot salt solution or boracic acid solution, and dress it with compresses soaked in Labarraque's solution (Blumer and MacFarlane, in "Amer. Journal of Med. Sciences," Nov., 1901). Nourishing food is given at frequent intervals, alcohol is administered, and strychnin is used to combat weakness. If the surgeon succeeds in arresting the gangrene it will probably be necessary later to perform a plastic operation in order to replace loss of substance.

Sloughing is a process by which visible portions of dead tissue are separated. These visible portions are called "sloughs"; if they were large, they would be called "gangrenous masses." A large septic slough is a gangrenous mass; a small gangrenous mass is a slough; there is no difference in the process, which corresponds to the formation of a line of demarcation.

Treatment.—Sloughing requires thorough and frequent irrigation with an antiseptic fluid, removal of the sloughs, and antiseptic treatment. An irrigator can be improvised from an ordinary bottle (Fig. 55). Antiseptic fomentations are applied until granulation is well advanced. In some cases continuous irrigation with a hot antiseptic fluid is useful; in other cases continued immersion in a hot antiseptic solution is employed.

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

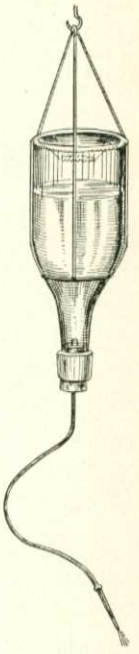

Fig. 55. — Improvised apparatus for the irrigation of a wound.

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

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

The **acute bed-sores of Charcot** are seen during certain diseases and after some injuries of the nervous system. These sores are usual over the sacrum in acute myelitis, and may appear in four or five days after the begin-

ning of that disease or the infliction of an injury upon the spinal cord. The surgeon sees acute bed-sores upon the buttock of the paralyzed side after brain-injuries, and over the sacrum in spinal injuries. Some believe these sores are due to vasomotor disorder; but others, notably Charcot, attribute them to disturbance of the trophic nerves or centers.

Treatment of Bed-sores.—The "ounce of prevention" is here invaluable. From time to time, if possible, alter the position of the patient, keep him clean, maintain the blood-distribution to the skin by frequent rubbing with alcohol and a towel, keep the sheet clean and smooth, and in some situations use a ring-shaped air-cushion to keep pressure from the part. When congestion appears (*paratrimma*, or beginning sore), at once use an air-cushion or a water-bed and redouble the care to frequently change the position of the patient. Not only protect, but also harden, the skin. Wash the part twice daily and apply spirits of camphor or glycerol of tannin; or rub with salt and whiskey (℥ij to Oj); or apply a mixture of ℥ss of powdered alum, f ℥ij of tincture of camphor, and the whites of four eggs; or paint with corrosive sublimate and alcohol (gr. ij to ℥j); or apply tannate of lead or equal parts of oil of copaiba and castor oil; or paint upon the part a protective coat of flexible collodion.

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

Ludwig's Angina (*Angina Ludovici*).—This disease is a streptococcus infection about the submaxillary gland and the cellular tissue beneath the mucous membrane of the floor of the mouth and of the upper portion of the neck. The inflammation eventuates in suppuration and gangrene. The disease arises as a painful swelling in the neighborhood of the submaxillary gland. The swelling rapidly increases, involves the neck and floor of the mouth, causes great difficulty in opening the mouth and in swallowing and may lead to edema of the glottis.* The constitutional symptoms are those of septicemia or pyemia. The disease may arise in an apparently healthy man or during or after an infectious fever. The streptococci enter from the mouth by way of abrasions, wounds, ulcerations, or dental caries. It may be caused by delayed development of the third molar, necrosis of the tooth and alveolar process taking place and an abscess forming (G. G. Ross, "Annals of Surgery," June, 1901).

* Tillman's "Text-book of Surgery," translated by B. T. Tilton.

Treatment.—At once incise below the body of the lower jaw, open the submaxillary space, cut away gangrenous tissue, paint the wound with pure carbolic acid, pack with iodoform gauze, and apply hot antiseptic fomentations. The constitutional treatment is that of septicemia.

Carbolic Acid Gangrene.—Dressings moistened with a solution of carbolic acid of a strength of from 3 to 5 per cent. may, if wrapped for a number of hours around a finger or toe, cause dry gangrene. There is but little danger when such dressings are applied to the tissues of the trunk, because these thicker tissues are better nourished and cannot be completely surrounded with the wet dressings. The application of strong acid rarely causes gangrene, but Lévan found 14 reported cases in which it did (J. Lévan, in "Centralbl. f. Chir.," August 14, 1897). The continuous application of a weak solution is very dangerous and ought never to be employed. The author has seen 3 cases. Harrington saw 18 cases of gangrene in 5 years in the Massachusetts General Hospital, and collected 132 cases from literature ("Boston Med. and Surg. Jour.," May 2, 1901). Carbolic acid gangrene is due to great exudation into the cellular tissue, blocking the circulation (Housell), and the production of arterial thrombi, a condition to which the patient is predisposed by the injury and often by tight bandaging. The dressing is frequently applied by a druggist; it produces anesthesia of the part, and the dressing is often not removed for days although gangrene may be progressing beneath. In the author's 3 cases there was no smokiness of the urine or any other evidence of absorption of the drug.

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

Post-febrile Gangrene.—Dry or moist gangrene may follow any fever, but is most frequent after typhoid (may follow typhus, influenza, measles, scarlet fever, etc.). Keen tells us that the gangrene resulting from arterial obstruction is apt to be dry, and that from venous obstruction is usually moist. The same observer has collected 203 cases.* It is most usual in the lower extremities, but may appear in the upper extremities, cheeks, ears, nose, genitals, lungs, etc. Some writers have assigned as the cause weakness of cardiac action, but most observers believe an obstructing clot is the usual cause. This clot may come from the heart, but is in most cases secondary to endarteritis due to the action of the toxins of the bacilli of the specific fever. Keen shows that in some cases gangrene is due to obstruction of peripheral vessels and not of a main trunk. In rare cases gangrene arises after thrombophlebitis. Gangrene may begin as early as the fourteenth day of the fever, but usually appears late in the disease and may arise far into convalescence. In the course of a continued fever frequent examinations should be made to see that gangrene is not arising. Particular examination from time to time should be made of the lower extremities, and in young girls, of the genitals. If gangrene arises in an extremity, apply antiseptic dressings, wait for a line of demarcation, and then amputate. If gangrene occurs in other regions, remove the dead tissue and employ hot antiseptic fomentations.

* Keen on the "Surgical Complications and Sequels of Typhoid Fever."

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