GANGRENE

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by

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GANGRENE is the term applied to the death in bulk of the body tissues and may affect to a various extent, all the tissues involved but as a general rule the more superficial tissues are more involved than the deeper, including bone. The term gangrene is more particularly applied to death of soft tissues ; the dead mass being referred to as a sphacelus or slough, a similar change in bone being referred to as necrosis and the mass of dead bone as a sequestrum. Gangrene is always the result of the cutting off of the blood supply of the living tissues and in its extreme form where the heart ceases to act, the failure of the circulation causes death at the vital centres in the medulla and pons with the result that death, as it is popularly known, results in these cases. The cutting off of the blood supply may be primarily arterial resulting from sudden blockage of the lumen of the vessel or its occlusion from pressure from without or the gradual narrowing of the lumen by disease and sclerosis in the vessel wall ; a process which ultimately leads to thrombosis and complete obliteration of the lumen of the vessel. On the other hand the circulation may be retarded by pressure on the veins obstructing the return venous flow and the oedema so produced in the tissues may ultimately reach sufficient pressure to obliterate the arterial flow. Such a condition occurs in true mesenteric thrombosis or in strangulation of the intestine in acute obstruction. It may appear to you that a discourse on either local or general death cannot be of much interest to the surgeon for it is very obvious that what is dead is dead and can be removed only either by a process of nature or by the art of the surgeon. The natural process of separation of the sphacelus of gangrenous tissue is by a line of ulceration which forms at the junction of the living and dead tissue and eats from the surface towards the centre of the affected area, producing a thin red line of granulation tissue which is known as the line of demarcation. Provided no infection is present, this separative process takes place at the expense of the dead tissue and when this has been cast off, usually not for many weeks, the patient is left with a conical stump uncovered with skin and which always needs surgical operation to trim and cover it. Therefore it is the practice of most surgeons to amputate through

healthy tissue as soon as a line of demarcation has formed and so ensure a more rapid and less painful convalescence.

The signs of gangrene are a cold insensitive area, which may be dead white or black in colour according as to whether it is empty or full of retained blood, as a general rule retention of blood causes the gangrenous area to be dark in colour. As has been already pointed out, the gangrenous process results from the cutting off of the blood supply of the part and this may occur in any one of the three following ways :—

(1) Owing to disease of the cardiovascular system usually affecting the valves of the heart, an embolus may be carried down the blood stream until it lodges at the bifurcation of some vessel. In such a case the blood supply is suddenly cut off from the tissues beyond the point of blockage of the artery. There is intense pain at this point and as a result of the sudden cutting off of the arterial blood pressure, a reflux of venous blood into the area deprived of its blood supply. In addition there results that intense vascular spasm with oedema of tissues which always occurs with a lowering of the blood pressure. These two causes flood the damaged tissue with fluid and a *moist gangrene* results. Such a moist gangrene is primarily aseptic but unless great care is taken, pathogenic organisms will invade the dead tissue from the skin and cause sepsis to supervene when a septic moist gangrene results which presents a greenish-purple mass of stinking putrescence, semi-liquid and horrible.

(2) Where the blood supply is gradually cut off, due either to spasm or subsequent thickening of the inner coats of the vessel, with gradual obliteration of the lumen, gangrene will supervene ultimately, should slight trauma or infection occur. In such cases the arterial blood pressure has been gradually reduced as well as the volume of blood entering the tissues and the ultimate cutting off of the blood supply by the inflammatory process from tissues with adequate venous drainage results in the production of a dark mummified mass of *dry gangrene*. This is aseptic and usually remains so unless the infection causes suppuration to ensue when a moist septic gangrene develops. It should be noted that in this type of gangrene, the inflammatory reaction necessary to promote natural separation and a line of demarcation, is all too frequently sufficient to spread the gangrenous process and so a series of attempts at natural separation can be seen with a dull purple blush spreading beyond them into the dehydrated and exsanguinated limb beyond. Such a condition is sometimes described as a spreading or creeping gangrene and is commonly seen in old patients with arteriosclerosis. In this type of arteriosclerotic gangrene, it is often found as evidence both by arteriograms and visual evidence at operation, that the lower part of the femoral and popliteal arteries are completely obliterated by organised clot. For this reason, the treatment of this condition, even when involving only the digits of the foot, consists in the apparently drastic removal of the lower limb by circular amputation through the lower part of the thigh. Such an

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operation ensures some hopes of blood supply to the stump being adequate and obviates the necessity of making skin flaps whose blood supply is always precarious even in a healthy individual. Amputation below the knee joint is seldom justifiable in these cases and if practised, all too frequently results in gangrene occurring in the skin flaps and even in the deeper tissues of the stump.

(3) Infection of the tissues by micro-organisms such as the clostridium welchii, etc., or even the more homely staphylococcus, may, by the toxaemia so produced or the pressure of effusion in areas poorly supplied with blood, produce an extensive liquefied necrosis of an infective type. Such cases are well exemplified in gas gangrene and carbuncle and are examples of *primary infective gangrene* which I do not propose to deal with to-day. In addition, as mentioned above, secondary infection occurs not infrequently in both moist and dry gangrene which are primarily aseptic in type and such *secondary infective gangrene* always calls for prompt surgical intervention to save the patient's life. Clinically therefore, we see that we are faced with dry and moist types of gangrene and that the moist type may be either aseptic or septic.

Let us now turn to a consideration of the aetiology of gangrene and for this purpose I append a table which epitomizes the main aetiological factors of this distressing condition.

1. Gangrene symptomatic of Cardio-Vascular Disease.

(A) Thrombotic	(i) From disease of the vessel wall
	(a) Senile
	(b) Non-Senile
	(ii) From pressure without on the vessel wall
	(iii) Traumatic (see below)
(B) Embolic	
(C) Neuropathic	(i) Spasmodic—Raynaud's disease
	(ii) Toxic—ergot—carbolic
	(iii) Bed sores—trophic ulcers

2. Traumatic Gangrene

- (A) Direct
- (B) Indirect

3. Thermo-Chemical Gangrene

- (A) Burns and scalds—heat
- (B) Frost-bite—cold
- (C) Escharotics

4. Infective Gangrene

- (A) Acute inflammatory — pyogenic organisms. Carbuncle — Cancrum Oris — Noma vulvae — Phagedaena — Spreading subcutaneous gangrene
- (B) Gas Gangrene—anaerobic organisms

5. Toxic Gangrene — diabetic gangrene

You may have noticed in your clinical experience that all these patients suffer from intense pain which is worse at night and causes sleeplessness and extreme mental distress and yet you know that gangrene produces death of tissue which is insensitive. How then, can we reconcile this condition of pain with the fact that insensitive dead tissue has resulted from the pathological cessation of the blood supply? The answer is to be found in the fact that in the ischæmic tissues the pain from imperfect oxygenation of the nerve endings is very considerable; as you may have noticed in your own extremities on a very cold day when the tingling and pain which accompanies the returning circulation causes extreme discomfort. Any variation in the congestion of the limb will cause a temporary increase of pain and so the elevation of the part on getting into bed at night or leaving it in the morning causes exacerbations of pain which are distressing and prevent rest. It is extremely difficult to treat this condition. Usually such patients will sleep more comfortably if the limb is left exposed to the colder air or hangs dependent from the bed but this is by no means always the case. Narcotic drugs often have to be resorted to and of these the most satisfactory in my experience is *Nepenthe*, 15-30 minims at night but often *morphia* has to be used. If as occurs where thickening and disease of the arterial walls are present, as in arteriosclerosis, diabetes and syphilis, or where a continual spasm of the arterial walls as in *thrombo-angitis obliterans* and more rarely in *Raynaud's disease*, results in their consequent thickening with subsequent clotting in the vessels, as happens in cases where there is disturbance of the nervous control or where certain poisons such as *ergot* produce a similar result, the blood supply is gradually cut off and dry gangrene results. Similarly, where division of the vessels to a part with an end blood supply such as the finger or appendix occurs either from accident or infection, then gangrene results which in the case of a digit is usually of the dry type and is known as indirect traumatic gangrene.

Mesenteric thrombosis, so called, offers two very interesting illustrations of different types of gangrene as well as an explanation of the very different clinical signs which are described as characteristic of this distressing condition. Embolus occurring in the mesenteric vessels usually in a patient suffering from valvular disease of the heart, results in sudden cessation of the circulation to a part of the intestine with ischæmia, oedema and colic, while the more commonly occurring thrombosis of the mesenteric veins frequently associated with a failing right heart leads to congestion and oedema, gradually developing with a feeling of discomfort and the passage of blood-stained stools. This latter is the type of true mesenteric thrombosis and the one in which conservative treatment is indicated and often successful for true gangrene of the bowel seldom occurs in such cases. Similar changes occur in the early stages of strangulation of the bowel by bands or in an external hernia but owing to the tightness of the stricture surrounding the congested bowel, obstruction of the arterial flow is induced by the oedema in the mesentery and gangrene

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of the strangulated coil of intestine develops fairly rapidly. A similar change is seen in many cases of acute appendicitis due to cutting off of the arterial flow in the appendicular artery and in all these cases of course, infection of the dead tissue rapidly occurs with resultant spreading peritonitis. Similar changes are met with in acute suppurative osteitis (osteomyelitis) where the pressure of the exudate in the Haversian canals rapidly strangulates the blood supply, irritates the peripheral nerves and so causes rapid death of the bone associated with intense pain and toxæmia.

Carbolic Gangrene. An interesting condition now rarely seen, is that of carbolic gangrene which in the days when strong carbolic compresses were employed, was not infrequent, the dead part being white and ischæmic. Some authorities maintain that the gangrene resulted from pressure of the bandage but in as much as these cases only constituted a small percentage among the patients treated with carbolic dressings and as further, such patients frequently showed general signs of carbolic poisoning it is possible that there was genuine toxic element when it occurred.

We have indulged in the melancholy task of discussing death and as ever, when death has resulted, that which is dead cannot be cured but only removed, either slowly by a process of nature ; ulceration at the line of demarcation between the living and dead tissues, or rapidly and far more painlessly by surgical operation ; for the natural process of separation which occurs is both tedious and very painful and exhausting to the unfortunate patient. It may seem profitless and uninteresting to discuss death, either partial or complete so let us turn to the far more interesting thought as to how such death arises and may possibly be prevented—a very much more cheerful prospect.

As already mentioned, gangrene results from the cutting off of the blood supply and this may occur possibly as a result of the detachment of a clot from the valves of the diseased heart, indicated by the sudden and terrible pain at the point where the clot lodges in the limb, which below that point becomes cold, blue and swollen. If prompt action is taken, the artery can be opened and the clot sucked out and the circulation re-established before actual gangrene has occurred but such operation must be performed within an hour or two of the clot occurring and even so is not always successful in saving the limb alive.

In other conditions, as we have seen, gangrene results from the gradual obliteration of the vessel by disease as in diabetes and syphilis and here the prompt and early recognition and the efficient treatment of these diseases may often save a patient's limb and even life.

In those cases where over-action of the sympathetic nervous system causes spasm in the walls of the smaller blood vessels, a condition which usually affects both lower limbs as in thrombo-angitis obliterans, and may

affect both upper limbs also as in Raynaud's disease, it is essential to ascertain whether or not fibrous thickening of the vessel walls has resulted from continual spasm before undertaking the removal of the sympathetic ganglia controlling the nerve supply to the vessel, an operation which gives most satisfactory results in those cases where spasm alone is present. In order to ascertain that spasm alone is causing the reduction of the blood supply and blanching and coldness of the limb, it is necessary to apply tests to see whether the cutting out of the sympathetic inhibitory influences will cause restoration of the circulation as exhibited by a rise in temperature and the appearance of a pink flush in the affected limb. This may be simply carried out either by immersing the limb in hot water or by exposing it to further cold and noting if any alteration occurs in the appearance of the limb so treated but best of all is to administer a spinal anaesthetic in the case of the lower limbs or to infiltrate locally the stellato ganglion in the upper limb which will knock out the sympathetic system and if a spasm alone is present, the pink flush over the whole limb and a rise in skin temperature will be very rapid and obvious and show that sympathectomy will give satisfactory, if not always permanent, results.

Where such gangrene has resulted from over use of ergot, or its ingestion with diseased rye in the bread, discontinuance of the drug or the ingestion of the diseased flour will be followed by amelioration of the condition, but it must be understood that what is dead is dead and the recovery of circulation in already dead tissue is not to be expected. In the case of *infective gangrene* different lines of treatment will have to be adopted according to the micro-organism which is causing the infection. Taking the common carbuncle where infection from the staphylococci on the skin results in death of the avascular fatty subcutaneous tissue with subsequent necrosis of the over-lying skin, the use of chemotherapy, especially penicillin, has made a tremendous difference in the outlook and almost abolished the mortality of what was once a very serious condition. In order to be successful, penicillin must be administered promptly, at least 40,000 units being given intramuscularly every three hours until the patient's general and local condition improves, usually in three or four days. It must however, be realised that in late cases where gangrene of the subcutaneous tissues has already occurred, such dead tissue will need surgical removal in order to clear up the condition ; for in such cases, penicillin is only an adjunct to efficient surgery.

Summary

I have endeavoured in the foregoing somewhat disjointed remarks to point out to you that localised death of tissues is not without interest to the surgeon but that the prevention of this condition is of more vital importance to the patient and presents more interesting problems to the surgeon than the removal of the dead tissue when gangrene has occurred.