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Original Articles.

GAS BACILLUS INFECTIONS IN CIVIL PRACTICE.*

BY ERNEST L. HUNT, M.D., F.A.C.S., WORCESTER, MASS.

SINCE the description by Welch and Nuttall in 1892 of the *Bacillus aerogenes capsulatus* and its recognition as an occasional cause of rapid and fatal septicemia, usually preceded by local death and decomposition of tissues at the site of its entrance, pathologists have met with it at the autopsy table from time to time and surgeons much less frequently in the operating room or ward. W. W. Keen,¹ veteran of three American wars, quotes Bowlby to the effect that it is practically unknown in Great Britain and adds, "The same is true in the United States. Personally I never saw a single case in the Civil War, and but one in civil life since then." The lesions of this organism, though infrequently seen, had come to be greatly dreaded—in Welch's 46 cases the mortality had been 59%—even before the great war came to let loose its terrible destructive agents under conditions which favored wound infections of the most desperate and unusual character, and of

a virulence hardly dreamed of by the present generation of surgeons, educated as most of them were in civil hospitals in an aseptic age. Nor had the experiences of the Russo-Japanese or Boer War prepared the medical mind for what was to occur in Belgium and northern France, where the much tilled soil teemed with bacteria of many kinds, being particularly rich in that group of spore forming anerobes, of which the tetanus and gas bacilli are the most prominent examples. Thus, during the great retreat from Belgium and the subsequent trench warfare, before the medical forces were organized to combat it effectually, gas gangrene was a constant menace and claimed its thousands of victims, at least 70%¹ of the wounds being contaminated with material bearing spores of these germs. Through this enormous experience, however, the clinical manifestations and pathology became thoroughly understood, and the surgical treatment standardized, so that the incidence of gangrene in adequately treated cases dropped from a very high figure to a fraction of 1%.²

That gas bacillus infections are more common in traumatic cases occurring in civil practice than pre-war literature had led us to suppose has been impressed upon me both by experience at Worcester City Hospital since my return and by looking up certain cases of which

* Read before the Worcester District Medical Society, December 10, 1919.

I had knowledge prior to entering military service. Thus, from our experience in medico-legal autopsies on abortion cases, Dr. F. H. Baker and I had come to accept Dr. Welch's suggestion that cases of so-called air embolism were, in reality, cases of gas bacillus septicemia; sudden deaths in convulsions with cyanosis being characteristic, as the following two cases well illustrate.

(1) — A young married woman living in a rather old and ill-kept tenement house attempted to produce abortion with a piece of glass tubing like a drinking tube. She had a chill that night, but next day, being disappointed with results, repeated the attempt and while in the act developed a convulsion and expired almost immediately. Autopsy and rabbit inoculation established the etiology. Frothy blood throughout the body was the striking feature of the post-mortem findings.

(2) — On a very hot day a few summers ago I was called to investigate the death of a young Finnish woman. The relatives denied all knowledge of pregnancy or attempted abortion, but the husband admitted that she received a visit from an unknown woman two days previously. During the previous night complained of weakness, slept poorly and flowed slightly. Restless with increased flowing after midnight. Had pains all the forenoon but refused to have a physician called. About 3.30 P.M., after taking ergot from a physician who was too busy to come, was seized with a convulsion, lapsed into unconsciousness and expired at 4.25. An ordinary douche bag with blood stained tip was found in her trunk. The bed was soiled with putrid smelling blood. Autopsy showed that a miscarriage had occurred and that death was due to gas bacillus septicemia.

Referring to the City Hospital records, I find that in six years prior to July, 1919, there have been four cases of gas gangrene following trauma of the extremities, three of which were treated by multiple incisions and antiseptics, with two deaths and one treated by amputation at the shoulder, with recovery. It should be added that the diagnoses in these cases were based on the clinical findings and not confirmed by cultures.

Since August 1, 1919, there have been three cases of gas gangrene on the services of Drs. F. W. George, G. H. Hill, and the writer. As these are characteristic of the types of injury in which this infection is encountered, a brief résumé of each is worth considering.

CASE 1. E. J., male, 11 years old, admitted

August 8, 1919. Injury—Jumped from top of fence to catch limb of tree, missed, fell to roadside, driving elbow into dirt, the lower end of humerus being pushed out through the skin anteriorly about $1\frac{1}{2}$ inches. Much roadside dirt was drawn into wound.

Operation about three hours after injury—benzine and iodine preparation. Skin wound enlarged and fringes trimmed away, counter incision made posteriorly above external condyle, dislocation reduced, wound wiped thoroughly with 5% dichloramine-T and partly closed with gauze drainage; dry dressing, and posterior right angle splint. One thousand units of tetanus antitoxin given.

August 9, temperature 100° , pulse 80, complaint of pain in arm; hand warm and of good color. August 10—pain very severe; temperature 103° during night, required morphine. Arm swollen and reddish brown in color, several blisters about wound. On withdrawing wick, a reddish, thin, foul smelling, frothy fluid oozed out and tissue crepitation could be felt extending to mid-humeral region. Discoloration of skin extended to level of deltoid insertion in front and to shoulder in back. Under light ether, axillary vessels were tied and a no-flap shoulder joint amputation done, cutting away devitalized skin well up on posterior surface of shoulder. Under Carrel-Dakin irrigations and careful dressings, which for days required gas-oxygen anesthesia, patient made a good recovery and is well today. Cultures showed a spore bearing rod which fermented dextrose agar in seven hours. X-ray showed focus of gas at elbow extending up arm.

CASE 2. W. R. A., male, 20. Admitted November 15, 1919. While riding in a side car of motorcycle collided with a truck, sustaining severe compound fracture of both bones of right leg at middle, and simple fracture of both bones of left leg. Entered in severe shock and considerably depleted of blood by hemorrhage. Refused amputation. Bleeding was controlled by tourniquet. Most of muscles and anterior tibial vessels were severed. Wound cleaned of street dirt, trimmed and thoroughly irrigated with quantities of saline solution followed by iodine, packed lightly, dressed, put in pillow and side splints. Fifteen hundred units tetanus antitoxin. Later put up in posterior wire splint and cast applied to the other leg. Saline intravenous at operation.

November 16—Symptoms of acute anemia were marked and he was transfused, receiving 450 cc. of citrated blood from a Group IV donor, which was followed by a chill and sweating for about one hour; thereafter he seemed much improved. Right foot cold and no pulsation felt. During early afternoon complained of great pain in leg. Wound inspected again at 5.10 P.M.; tissues dry, no odor noted, but

there was swelling about the knee. At 10.20 P.M., an odor as of decaying flesh noticed and there was a reddish streak along the course of the internal saphenous vein. Tissue crepitus could be felt extending eight inches above the patella. Smears showed Gram-positive rods with spores. General condition much less favorable. Amputation with coincident transfusion decided upon and attempted under gas oxygen, with death on the table. Highest range of temperature 103°; urine, 1030, many casts and leucocytes.

CASE 3. C. H. W., 53, farmer. November 22, 1919, ran gloved hand into corn husking machine at 11.50 A.M., arrived at hospital about 1 P.M. Refused amputation by advice of his employer, although the left hand was extensively crushed and lacerated, the details of injuries being compound dislocation of second and third metacarpal joints, compound comminuted fracture of fourth metacarpal bone and compound fracture of fifth metacarpal at the carpometacarpal joint, deep palmar arch was destroyed and tendons of little finger torn away. The usual accident room cleansing and repair was done and 1500 units of tetanus antitoxin given. All the next day he complained of pain. At 9 A.M. on second day, dressing was removed revealing well developed gangrene with skin nearly black as high as wrist and reddish brown to elbow with tissue crepitus extending four inches above elbow. Amputation at mid-humerus was done and patient is making a good recovery. Cultures in glucose agar gave gas production and the growth showed the usual type of organism, associated with diplococci.

That we were taken somewhat unawares by the fulminant character of the invasion in the first two cases may be conceded—in the third, though thoroughly warned, yet the involvement had reached the mid-humeral region when discovered. It is fair to state also that in cases 2 and 3 it was the judgment of the surgeons that the injuries called for amputations but, as occurs so often, the patients' reluctance to sacrifice a limb jeopardized their lives. That three such cases should occur in the space of four months is a sufficient warning that others may be looked for and compels the attention of those who do traumatic surgery to a detailed understanding of the points upon which an early diagnosis may be based, full knowledge of how to meet it, and courage to act promptly when the need appears.

To begin with, one should always have in mind the fundamental conditions which determine its occurrence and govern its prevention.

Firstly, these anaerobes occur in natural ferti-

lizers, garden soil, street dirt or anything which may be soiled thereby, such as clothing, shoes, tools, carriages, automobiles, horses' hoofs, etc. Consequently, patients with wounds in which contamination by such materials can have taken place must be regarded as potential gangrene cases.

Secondly, as these organisms may be both saccharolytic and proteolytic, the glycogen and protein of muscle offer suitable pabula for their growth, but they cannot develop in normal muscle because of the oxygen which is being constantly supplied by the unimpaired circulation of blood; consequently, an essential to their active development is muscle tissue which from trauma, constriction or other cause has become devitalized. Therefore, severe injuries, like compound fractures, shell or gunshot wounds, which lacerate muscles as well as introduce the germs, are most favorable to the development of the disease. This is particularly true if the major blood supply is seriously impaired either by traumatization of vessels, prolonged application of tourniquet, tight bandages, etc.

Thirdly, being anaerobes, their growth is favored by closure of the wound and symbiosis with the pyogenic germs. As they produce gas a closed wound interferes with its escape, favors its spread along fascia planes and between muscle bundles where by its pressure the tissues are further devitalized.

Fourthly, besides producing gas, their growth hemolyzes blood, produces a toxic substance, and a foul, putrid, sanguinous fluid. This toxin is the probable cause of the sudden fatal termination so often seen, although apparently a generalized infection with emphysema occurs shortly before death and is more likely to occur early where large veins are included in the traumatized tissue.

Fifthly, chlorine solutions have been shown to neutralize or destroy this toxin.

Sixthly, if the conditions are favorable to this growth, it takes place rapidly so that such wounds must be observed very frequently until the danger period is past.

Seventhly, being spore bearers, they may remain latent in healed tissue for many months and gangrene may result when a secondary operation is undertaken.

In applying these principles it should always be understood that there are several varieties of gangrene producing germs and the clinical

manifestations are not always classical. As Christopher³ remarks, "The clinician should consider it a disease of multiple etiology in which the chief symptom is not always the same."

It is also to be recognized that wounds known to be infected with these organisms, may not, and often do not develop the disease, nevertheless, cases in which the disease may be developing must be closely and vigilantly studied.

CLINICAL MANIFESTATIONS OF THE DISEASE.

To my mind the earliest and most suggestive symptom is *pain in the affected limb*, which is wholly out of proportion to what would ordinarily be expected in such a wound and develops within a few hours—much earlier than does that of ordinary sepsis. With this is a moderate temperature and a disproportionately high pulse and respiration. In addition to the pain there is local swelling, complaint that the bandages are too tight, and possibly numbness of the extremity below the wound. The skin becomes reddish brown in color and blebs develop near the wound. The skin edges turn dark and the area is exquisitely tender. Here the x-ray may confirm the presence of gas deep in the wound and it is usually detected first in neighborhood of a foreign body if one remains in the tissues. A reddish brown ooze soon occurs, smears of which show many Gram-positive, large rods with oval ends and frequently containing spores. Cultures from this in deep glucose agar develop gas in five to seven hours, with fracture of the agar and separation of the fragments. Tissue crepitus can usually be felt and in general corresponds in distribution to the area of dull reddish discoloration, but swelling and crepitus may extend beyond the discoloration beneath normal looking skin. The patient's mind is usually alert and clear, vomiting is rare. Taylor's explosive stage is reached in from 24 to 36 hours, when the distention of tissues is intense; foul, putrid, foamy discharge oozes from the wound and the condition is very evidently a gangrenous process. The stage of systemic intoxication rapidly merges in to the stage of septicemia, and death ensues.

Pratt⁴ attributes great diagnostic value to an early board-like hardness of the limb below the wound which he interprets as a segmental cadaveric rigidity. I have not personally observed this sign.

TREATMENT.

We have to consider treatment under two phases, which are determined by the period at which the case comes under observation and may be preventive or curative accordingly.

Preventive. This obviously begins with the one who renders first aid at the scene of accident and is of course largely beyond control. Should a trained person be present he may render great service by cutting away clothing, protecting the wound by a clean dressing lightly applied and supportive splinting. *He may do grave harm by reducing a protruding bone or applying tourniquet or splints unnecessarily or too tightly.*

At operation the surgeon should determine the bacteriologic condition of the wound by swabbing the interior and having smears stained and examined at once. The presence of Gram-positive rods and their relative numbers should warn him as to his procedure though their absence should not wholly allay his fears. He should cause cultures in deep glucose agar to be made by inoculating with the swab and a bit of the injured muscle. These should be put in the incubator forthwith and inspected for gas within six or seven hours. He then must thoroughly cleanse the wound, lay it open freely, remove all foreign matter, cut away traumatized skin fringes and muscle ends, ascertain condition of blood supply, being very careful to avoid important trunk vessels, preserving such bony fragments as are well attached to periosteum and needed to establish continuity of the repair process. Attention to the muscle ends is of first importance and they should be trimmed down to healthy tissue which can be recognized by the occurrence of bleeding and the normal color. It is necessary to get into all recesses of the wound and clean it up. Carrel-Dakin tubes wound with gauze should then be inserted to the innermost recesses and retained by an occasional fine catgut stitch with care that they shall not unduly press upon the blood supply, pack rest of wound lightly with gauze, apply strips of gauze bandage soaked in sterile vaseline to skin, apply a liberal, soft, absorbent dressing and wire hammock splints if they are available, avoiding undue constriction at any point. Probably it is best to use Dakin's solution by hourly flushing. Inspect limb at least at four-hourly intervals; if any of the symp-

toms detailed above appear, or the culture shows gas production, do not hesitate to remove dressings at each inspection. At least once daily take smears from inside the wound for bacterial count.

Antitoxin. Numerous antitoxic sera were used by the French as prophylactic and curative agents with encouraging results. Sacquippée⁵ advises that treatment begin at once with a polyvalent serum, followed by the serum for the particular strain of bacillus as soon as that is determined by his method of inoculating guinea pigs with material from the wound, against known antitoxins—the pig that gets the right one lives, the rest die. In 191 cases of the disease 86.91 recovered. Preventive value is also claimed for the polyvalent serum.

Antitoxin cannot, however, be said to have gained widespread confidence, nor is it at present available for general use. Prompt and thorough operative treatment is still the only safe reliance and its efficiency is so high that it can be safely neglected for *no other method*.

TREATMENT AFTER DISEASE HAS DEVELOPED.

This is, of course, operative, the type of operation must depend upon the stage the disease has attained when it is recognized, and the choice of operation requires nice judgment on the part of the surgeon. If it be discovered in the early, local stage, the procedure should be free opening of the involved areas with careful anatomical separation of fascia layers down to the bone, avoiding major circulation channels, and excising all the devitalized muscle, which can be recognized by its brick red color, friability and failure to contract when pinched or cut. It may be necessary to excise the entire belly of a muscle or a whole muscle group. Most writers advise long longitudinal, but Hugh Cabot⁶ advises transverse incisions. Then carry out the Carrel-Dakin method as advised above.

If not recognized until the explosive stage, when the limb is massively swollen, crepitant and discolored, the wise operator will unhesitatingly amputate by the guillotine method well above the involved areas although at times the extension may be greater on one side than the other and the amputation may be oblique, saving enough skin for a secondary covering in.

With these methods of treatment, even without the aid of preventive serum, gas gangrene

is a preventable complication. The difficulty is that in civil practice we are not accustomed to anticipate its occurrence, so are satisfied with less radical primary treatment, protecting against tetanus by means of that valuable antitoxin. In the light of our experience at Worcester City Hospital it seems to me that we must disabuse our minds of complacency in respect to this infection and carry it upon our consciences to make our preliminary treatment of wounds of this character 100% efficient, and our post-operative care sufficiently keen and wide-awake to detect it while it is yet in the local stage, thereby saving our patients from mutilating operation or loss of life.

[NOTE. In the discussion following the reading of this paper Dr. B. H. Alton reported a case now under his care at Memorial Hospital caused by a gunshot wound of the popliteal space, which he had saved by mid-thigh amputation. He pointed out the importance of acidosis as a factor in the rapidly fatal character of the disease and said that 1000 cc. of 2% sodium bicarbonate solution intravenously was of greater value than transfusion. He also remarked that in his case the infection seemed less virulent than the many he had experienced on the Flanders front.

Dr. P. H. Cook said that roentgenologists distinguish two forms of gas infiltration, one being characterized by extension along fascia planes perhaps in but one sector of a limb, the other characterized by extension also through the muscles in the interfibrillar spaces, giving a massive emphysema involving whole muscle or muscle groups. The former offers more favorable opportunity for conservative surgery while the latter requires extensive operation or amputation.]

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- ⁴ Prat: Presse Médical, March 24, 1917. Abst. Jour. A. M. A.
- ⁵ Sacquippée and De Levergne: Paris letter, Jour. A. M. A., Jan. 24, 1918.
- ⁶ Hugh Cabot's letter in Keen's "Treatment of War Wounds."

THE "COMMON COLD" IN RELATION TO CERTAIN MICROORGANISMS AND ITS TREATMENT WITH BACTERIAL VACCINES.

BY CLEVELAND FLOYD, M.D., BOSTON.

THE term "common cold" is used in this connection to describe the infection of the various respiratory passages seen so commonly here in the winter.