rapidly and produce poisonous substances, by which the adjacent living tissue is destroyed and rendered a suitable medium for the further multiplication of these bacilli.

8. *B. tetani* was not found in films made from the discharge in any one of the six cases of this series in which it was present.

9. The recognition of *B. tetani* by purely microscopical methods is complicated by the fact that slender Gram-positive rods bearing an absolutely terminal spore may be occasionally found in pure cultures of *B. oedematis maligni* and *B. aerogenes capsulatus*. Moreover, pure cultures of tetanus bacilli, especially cultures on egg medium, contain many atypical forms.

10. If broth is inoculated with material from the wound in a case of tetanus, and incubated under anaërobic conditions, the presence of *B. tetani* can often be satisfactorily demonstrated by animal inoculation. Such a broth culture should be examined at intervals, and two or three weeks may elapse before *B. tetani* can be demonstrated.

11. The presence of *B. tetani* was demonstrated in the discharge from the wounds of two patients who did not develop signs of tetanus. Both had received prophylactic injections of antitetanus serum.

12. The discovery of *B. tetani* in the wounds of a patient who had not developed tetanus would obviously be an indication for one or more prophylactic injections of antitetanic serum. But the practical utility of such a procedure is limited by the difficulty and delay which attend the bacteriological recognition of this bacillus. Now, *B. tetani* belongs to the same group of anaërobic bacteria as *B. aerogenes capsulatus* and *B. oedematis maligni*. All three have probably a common source, and the conditions favourable to their growth within a wound are probably identical. The demonstration of either *B. oedematis maligni* or *B. aerogenes capsulatus* is a relatively simple matter and does not involve much delay. The discovery of either of these bacilli might with advantage be followed by a prophylactic injection of antitetanic serum.

13. A prophylactic injection of antitetanic serum should be given before any considerable operation is performed on a patient with a gangrenous wound.

THE

TREATMENT OF ACUTE TOXAEMIA SECONDARY TO GAS GANGRENE BY THE INTRAVENOUS INJECTION OF A SOLUTION OF HYPOCHLOROUS ACID.

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(Report to the Medical Research Committee.)

It has been our experience that soldiers whose wounds are infected by a gas-producing organism sometimes suffer from a condition which can only be described as an intense toxæmia and which frequently proves fatal.

Such cases present features as follows: The patient is admitted to hospital suffering from a wound of one of the extremities; there is extensive infection by a gas-producing organism, and it is obvious that the infected part must be amputated as soon as possible.

In some of these cases, although the operation is carried out, it is found that the general symptoms and signs of toxæmia do not abate but develop and deepen till death ensues; the following two cases are illustrative of these facts:

CASE A.

A sergeant-major, admitted on October 15th, 1915, suffering from a gunshot wound of the left upper arm a short distance below the shoulder-joint. There was a complicated compound fracture of the humerus, and the

brachial artery was divided. The wound was infected by a gas-producing organism, and the infection was spreading in the surrounding tissues. His general appearance was that of a man who was suffering from severe hæmorrhage; he had an intense grey pallor, and this was the more extraordinary because inquiry showed that the loss of blood had not been excessive; his features were distressed. The pulse was 130, the temperature (see Chart) 97° F., and the respirations 24. He was suffering from the condition of general toxæmia which so closely resembles shock. It was decided that amputation was necessary, but the operation was delayed for some time in the hope that matters might improve. After some hours there was no improvement and disarticulation through the shoulder-joint was carried out.

At the operation the fact was confirmed that the loss of blood was not severe, for the vessel at its site of division was twisted into a fibrous cord.

The post-operation history was disappointing, not as regards the local condition—for no trace of infection developed in the stump—but in regard to the general condition. The pallor remained, and, if anything, deepened; there was a faint underlying tinge of jaundice, there were profuse perspirations and occasional rigors, the pulse-rate increased to 150, the respirations quickened from 24 to 60, unconsciousness developed, and he died on the fourth day following the operation. After the amputation of the diseased limb there was no local site which could be regarded as the source and origin of the poisoning from which the man was suffering. A process of reasoning led to the conclusion that there was proceeding either a septicæmia or a toxæmia which had originally been instituted from the infected wound. A blood examination was carried out by Captain Ellis, but no organism could be isolated. The process was apparently, therefore, a toxæmia.

CASE B.

A private, admitted on October 30th, 1915, suffering from a gas-infected wound of the right leg. Generally he presented an appearance very similar to that of Case A—an intense pallor as though from severe loss of blood, restlessness and sweating; the temperature was 97° F., and the pulse 140. The right limb below the knee was extensively infected with a gas-producing organism; the bones were not injured, but the main blood vessels were involved. It was decided that amputation was necessary, and this was carried out through the knee-joint under spinal anaesthesia. After the operation the stump did well, but the general condition was far from satisfactory; the temperature rose and remained high; the pulse increased in rapidity and became weaker. On the morning of the second day after the operation the patient seemed better, but immediately after being dressed he collapsed and died.

We have chosen these cases at random from amongst others. To our minds they are illustrations of cases suffering from intense toxæmia. The removal of the original and local source of the toxæmia was not sufficient to counteract the malady, for the poison had acquired so firm a hold that its continued activity led to the death of the patients. The counteraction of the toxæmia formed a very distinct problem, and while it was under consideration Professor Lorrain Smith of Edinburgh suggested to us that eusol, which contains 0.5 per cent. hypochlorous

CASE A.—Gas gangrene: disarticulation through the shoulder-joint on October 15th. D, Death.

CASE B.—Gas gangrene: amputation through the knee-joint on October 30th. A, Admission; O, operation; D, death.

CASE C.—Gas gangrene; wound opened up on November 5th; amputation below the shoulder-joint on November 6th, injection of 40 c.cm. eusol at the same time. The chart shows the temperature taken every half-hour on the day on which the operation was performed and the following day. O, Operation. E, Eusol 40 c.cm. injected intravenously.

acid, might be used intravenously to combat the action of the toxin. We immediately put the suggestion into execution, and it is the result as demonstrated in three cases which we now record. Professor Lorrain Smith and those associated with him had advised us of certain experiments they had carried out proving that eusol containing 0.5 per cent. hypochlorous acid could be injected intravenously into rabbits in amounts up to 25 c.cm. without any ill effects arising.

We repeated these experiments and assured ourselves of a similar result. Thus safeguarded, we proceeded to use the solution intravenously in the treatment of toxæmia secondary to wound infection with a gas-producing organism.

CASE C.

A private was admitted on November 5th, 1915. Forty-eight hours before admission he had been struck by a bullet on the right forearm just below the elbow. The wound was dressed, but he could not be evacuated from the trenches until about twenty-four hours later.

On admission, there was found to be a gaping and ragged wound of the forearm below the elbow-joint; the bones were not broken; the main blood supply was interrupted, as no pulse could be felt in either radial or ulnar vessels. The wound was sloughing, and apparently infected by a gas-producing organism. The general condition was bad; he had an unhealthy toxic appearance, and was somewhat blanched. The temperature was 100° F., and the pulse 120.

As there was some evidence of a collateral circulation being established, attempts were made to conserve the limb. Under anaesthesia the wound was thoroughly opened up; various fascial planes were exposed, and the parts were freely dressed with eusol.

On the morning of November 6th the patient was distinctly worse; sleep had been broken and imperfect. His general appearance was decidedly grave; he was blanched as though from a severe haemorrhage, with a yellowish discoloration of the skin. He was slightly delirious. The pulse-rate was 150, and the temperature had fallen to sub-normal, 98° F. The local condition was correspondingly worse; there was complete arrest of circulation in that portion of the arm distal to the wound. There was emphysema from the centre of the upper arm to the neighbourhood of the wrist; there were patches of a bluish discoloration of the skin, and the muscles in certain parts showed distinct necrosis.

At 3 p.m. the arm was removed just below the shoulder-joint, and immediately after the operation 40 c.cm. of eusol were injected intravenously. From this time the temperature rose almost continuously for three hours, and at 7 p.m. it had reached 102° F.; the pulse-rate likewise correspondingly increased from 120 to 160. Immediately after operation it fell from 150 to 120 and then rose again. From 7 p.m. until midnight the temperature remained at about 102° to 101° F., and the pulse remained about 160 (see Chart). Soon after midnight the temperature began to fall until at 8 a.m. on November 7th it had reached 99° F.; the pulse likewise fell from 160 to 108.

During November 8th, 9th, and 10th there were successive rises of temperature, usually occurring in the early morning and accompanied by corresponding increase in pulse rate. On November 15th the temperature fell to normal and remained so.

There were other changes to be noted in addition to those in pulse and temperature. The general appearance improved by leaps and bounds; the ashy pallor disappeared within twenty-four hours, to be replaced by a slightly flushed appearance. The respirations altered strikingly; previous to operation and injection of eusol the respirations were deep and slightly stertorous, such as gave us the impression of a sense of air hunger. Subsequent to operation and injection they became quicker, shallower and less noisy. Shortly after operation and injection the restlessness disappeared and the patient slept comfortably.

The further progress was one to complete recovery.

Immediately before the injection of eusol was given blood was taken for bacteriological examination; both aerobic and anaerobic cultures were negative.

CASE D.

A private, admitted on November 16th, 1915. About twelve hours before admission he had sustained a bullet wound through the left arm about the level of the elbow joint. There was considerable bleeding and a tourniquet was applied. Beyond a simple dressing nothing further was done, and the patient was sent into hospital with the tourniquet still in position.

On admission it was found that the brachial artery was severed immediately above its division; the vessel was tied. There was no definite evidence of infection in the wound, but it was thoroughly opened up and treated with eusol. There were signs that an adequate collateral circulation might be established.

CASE D.—Gas gangrene; wound opened up on the morning of November 17th, amputation same evening. Injection of eusol 40 c.cm. at 3.15 p.m. on November 18th. A, Anaesthetic; wound opened up, etc. M, Morphine, gr. 2. O, Operation. D, Digitalin, gr. 1/16. S, Saline, 3 pints. E, Eusol, 40 c.cm., intravenously at 4 p.m.

On the morning of November 17th the general condition of the patient was unsatisfactory; he had had a restless night, and there was some evidence of gas in the neighbourhood of the wound. The wound and fascial planes around were further opened up. He was pallid and slightly jaundiced, restless, and sweating slightly.

At 10 p.m., on dressing the wound, it was found that the condition had become much more extensive. There was gas throughout the forearm and extending upwards along the vessels as far as the axilla. It was obvious that operation was necessary, and at 11.30 p.m., the arm was amputated below the shoulder-joint and partly through the infected area. After the operation there was evidence of collapse; the temperature fell to 98° F., the pulse was 126.

Stimulation was carried out with saline, 3 pints subcutaneously, and digitalin $\frac{1}{10}$ grain.

During the morning of the 18th the condition became more serious; the temperature continued to fall, and reached 97° F.; the pulse increased to 126-124; the respirations were full and stertorous, resembling a condition of air hunger. The general appearance was one of pallor with a tinge of jaundice. At 2 p.m. the condition had become so serious that it was obvious that something further ought to be tried, therefore at 3.15 p.m. 40 c.cm. of eusol were injected intravenously with a Record syringe. Before injection a blood examination was made, but no organism was isolated.

At 4 p.m. the temperature was 98.6° F. and the pulse 136; there was no obvious change in general condition. At 4.30 p.m. the temperature was 100° F. and the pulse 136; at 5 p.m. the temperature was 101° F. and the pulse 136; and at 7 p.m. 102.5° F. and 140 respectively. By this time also there was a change in the general condition; he was sleeping peacefully; respiration was quicker and quite quiet; his colour had improved, and the pallor was replaced by a slight flush.

By midnight the temperature had begun to fall and was 100° F.; the pulse was 120.

On November 19th his condition was greatly improved; the temperature was 99° F., the pulse 100; he was sleeping well and taking nourishment, and the local part looked well.

The further progress was one to uninterrupted recovery.

Some of the facts in regard to this case call for special attention. The operation of removal of the arm did not produce any benefit; in fact, after it the general condition grew steadily worse. The collapse was so intense that it was thought to be the result of loss of blood; but the reaction after the intravenous administration of eusol was so correspondingly great that we had no hesitation in saying that the alarming symptoms were the result of an intense toxæmia. The eusol was not given until sixteen hours had elapsed from the time of operation; and before the drug was given we were agreed that the prognosis was absolutely hopeless.

CASE E.

A private was wounded in the calf of the right leg by a shrapnel bullet on the afternoon of December 6th, 1915. He was admitted to hospital on December 7th about midday. The neighbourhood of the wound was found to be infected by a gas-producing organism. The general condition was bad; there was pallor as though from loss of blood; the temperature was 100° F., and the pulse 120. Arrange-

CASE E.—Gas gangrene; amputation through the knee-joint on the afternoon of December 7th. Injection of 70 c.cm. eusol. The chart shows the variation of temperature at each half hour during the first six hours after the operation. o, Operation; 70 c.cm. eusol intravenously.

ments were made to have the wound opened up, but pressure of work rendered it impossible to have this done until 2.30 p.m. (two and a half hours after admission). At this, the second, examination it was found that the condition had become much graver: the leg below the knee was enormously swollen; it was as resonant as a drum from knee to toes, and signs of infection had extended along the line of the femoral vessels as far as the centre of the thigh; there was an entire arrest of circulation in the foot and leg. The general condition was correspondingly worse; the temperature had reached 102.5° F., and the pulse-rate was 130.

Half an hour later, when the patient was in the operating theatre, a further advance had been made which

we could hardly have believed possible in so brief a space of time. In places the skin of the leg was becoming mottled as the result of actual tissue necrosis; the gas infection of the thigh had extended upwards as far as the groin. The general condition had become correspondingly worse. Disarticulation through the knee-joint was performed by the Stephen Smith method; it was necessary to cut through infected tissue, but former experience had told us that this could be done. The cutting of the flaps revealed green, foul-smelling subcutaneous tissue; free incisions were made along the whole length of the femoral artery as far as the groin; the knee-flaps were left open and drainage of the thigh wounds was thoroughly secured. Before the patient left the theatre 70 c.cm. of eusol were injected intravenously; the dose was larger than usual because from our former knowledge of such cases we took an exceedingly grave view of this case.

His history after operation exceeded even our most sanguine expectations; there was no further appearance of gas formation or gangrene, and forty-eight hours after operation his pulse-rate had fallen to 88. His condition in the future never gave us the slightest cause for anxiety. Under usual circumstances we should have regarded this case as very likely to prove fatal, or at least to have recovered only after a prolonged period of debility.

Blood Cultures.—These were made for both aerobic and anaerobic organisms. For the aerobic ordinary plates of 1 per cent. glucose agar were employed, and 1 c.cm. of blood was introduced. Three kinds of anaerobic cultures were made use of in each instance: (1) Plates as above, but grown in a carbon monoxide atmosphere; (2) 1.0 c.cm. of blood in litmus milk in a Buchner tube; (3) 1.0 to 2.0 c.cm. of blood in an ordinary shake culture in deep 1 per cent. glucose agar tubes.

COMMENTARY.

There is really very little which we wish to add of the nature of a commentary. The position, briefly, is as follows: We were faced by the fact that men suffering from an infection of their wounds by a gas-producing organism frequently succumbed to what to our minds appeared to be an intense and progressive toxæmia. The first two cases (A and B) which we have described are illustrative of such a condition.

We found extreme difficulty in antagonizing and treating these toxæmias. Following Professor Lorrain Smith's suggestion, we are now using intravenous injection of a solution containing 0.5 per cent. hypochlorous acid (eusol) for this purpose, and, to our minds, the results which we have obtained most thoroughly justify the adoption of the method. We have quoted three cases illustrative of the treatment (Cases C, D, and E). Before the injection of the hypochlorous acid solution these were, in our opinion, as dangerously ill as the two illustrative cases (A and B) which we have described, and we believe that the eventual recovery which the three (C, D, and E) made was due to the action of the hypochlorous acid.

A striking feature of Cases C and D is that at the time of the operation the patients were in a condition of collapse, as was evidenced by the progressive fall in temperature and the general state. In Case D the collapse continued for fourteen hours after the operation. The disappearance of the signs of collapse took place after the intravenous injection of eusol. In both cases (C and D) the injection was followed by an immediate rise of temperature. This is to be looked upon as a sign of reaction, for even during the pyrexia a clinical improvement became evident, and the fever was a precursor of steady recovery.

Case E indicates that it may sometimes be advantageous to give a larger dose. In a note on the successful treatment of a case of puerperal septicaemia by intravenous injection of eusol, published by Lorrain Smith, Ritchie and Rettie, it is stated that an injection of 100 c.cm. eusol was given, and this was repeated after twenty-four hours without any indication of untoward effect on the patient.¹

The solution employed for injection was eusol containing 0.5 per cent. hypochlorous acid, to which was added 8.5 grams of sodium chloride per litre. The solution was carefully standardized before injection. The injection was made by means of a Record syringe into the median basilic vein. In two instances 40 c.cm. of hypochlorous acid (eusol) were injected; we were prepared to repeat the injection, but the recovery was so progressive that

repetition was not necessary. In the third case 70 c.cm. of cusol were injected.

We wish to acknowledge our indebtedness to Lieut.-Colonel West, R.A.M.C.(T.), for permission to study these cases; also to the staff of the Canadian Mobile Laboratory, who carried out the necessary bacteriological work.

REFERENCE.

¹ BRITISH MEDICAL JOURNAL, November 13th, 1915.

NOTES ON CLOTHING AGAINST COLD.

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THE following brief notes are founded upon experience gained in Labrador and North Newfoundland during the last five-and-twenty years; they express not only my own opinion, but the winter practice of those who live and work in the countries mentioned.

The source of heat being the body, and the chilling of the body being the result of loss of heat, we design our garments against this issue, and I may say at once that we do not use india-rubber boots or any waterproofed garments.

Exercise being conducive to increased production of heat, we make our clothing very light and see that the material is as far as possible (1) thin and pliant, (2) wind and waterproof, (3) durable, (4) inexpensive.

We always use two layers of light material instead of one layer of heavy. We never use flannel or wool outside, but as it contains air spaces and can be woven thick, soft, and light, we use a thick undergarment and a very light outside one. The colder it is the thinner material we use for boots, because it is more pliable.

Jumper.

The general plan of the upper garment is always the same. To adapt it for use in Europe in mild climates where rain is frequent we should use light Willesden canvas outside, or Burberry or light waterproof rubber material. When very cold we wear a second loose one underneath. The essential point is that there shall be no draughts.

1. At the neck draughts are avoided by making the capot, or hood, continuous with the body piece.

2. Leakage in front is avoided by making the jacket in one piece and getting into it from below.

3. Leakage below is avoided by a canvas or webbing belt fastened on to the lower edge of the jacket, or heavy elastic sewed in, or a soft pliable thong running through a gusset.

4. Leakage through the arm is avoided by a rubber band round a reversed cuff inside (as shown in Fig. 1), or

FIG. 1.—Showing the jacket (jumper) and the hood (capot); also the harness for carrying gloves. The waist band and the left wrist band are open.

webbing strap sewn on the outside edge of the sleeve cuff, exactly as the belt is attached.

5. Leakage round the face is stopped by a draw string round the opening.

The best belt fastenings are without any buckle, but have glove push-fastenings and a thong going through an eye. They can be opened and closed in a moment with gloves on.

In hot weather the sleeves and belt can be loosened and the hood thrown back, so that the wearer has a cool light garment. It is a funnel through which air blows. There is no garment on earth to beat it; it cramps nothing, no snow can get inside, nor can rain, especially when two are worn. It is the next thing to a diver's suit when in use, and makes a splendid bag or sack when not in use. With No. 2 canvas it can be used as a wash-basin if wanted. The breath can also be kept in more or less to add to warmth at a pinch, if the capot is loose enough. We often carry light articles in our capots as we run along by the sledges. When in extreme cold we use two; one is often of mere calico over one of duffel or blanket. The canvas is easily cleaned from mud when dry. There are no folds to catch on obstructions.

Gloves and Mitts.

Our mitts, when we are shooting, have the right index separate. All our gloves are double, the outside being skin, or wind-proof material, light and soft, and water-tight if possible. The inside mitt is woollen and soft and thick. The glove always goes over the sleeve, and has a strap as well round the wrist (Fig. 2). The inside glove

FIG. 2.—T, Travelling glove or mitt. S, Shooting gloves. The strap at the wrist is of canvas or rubber; the upper strap is of canvas.

alone might have a separate index finger. Lastly, we suspend the outside mitts by a string round our necks, so that we can leave them dangling when we throw them off in a hurry.

Trousers.

For trousers we use the same material as for the jumper, canvas or "duck" (Fig. 3). We find the chest

FIG. 3.—Side and front view of trousers. The braces are sewn on to the trousers at the back. They are usually made of canvas, but might be of elastic. When desired the knee strap can be loosened and the trousers worn as running shorts outside the boots.

flap coming right up from the breeches a very great saving of heat. The back should also be above the waist; there can then be no leak of heat. The trouser always goes well inside the boot tops. We use no opening for urination—the trouser is all in one piece. A flap might be made if necessary, but we want no draughts.