peripheral blood should prove a preventive of relapses, blackwater fever itself may possibly be greatly diminished by the tartar emetic treatment.

CASE IV.—*Benign Tertian Gametes disappearing from the Blood after the Intravenous Injection of Tartar Emetic.*

A European male from Assam, admitted for malarial fever for which he had taken quinine; he had had no fever after admission. Only the quinine-resisting extracorporeal fully developed parasites were present in the peripheral blood, and were easily found on three consecutive days. On the fourth morning 8 cg. of tartar emetic were given intravenously. A blood slide taken that evening showed after a long search one benign tertian gamete with distinct chromatin body and pigment, but with an incomplete outline as if it was breaking up. A careful search on the following four days showed no malarial parasites. During this time he received two further doses of 10 and 12 cg. respectively of tartar emetic intravenously, after the last of which he felt some nausea. He has now left hospital, but I hope to be able to follow him up.

This case indicates that the drug has a destructive effect on the gametes of the benign tertian as well as the malignant tertian variety of malaria, and makes it probable that it will act similarly on the quartan form, which is rare in Calcutta.

THE X-RAY DIAGNOSIS OF GAS IN THE TISSUES.

BY

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THE war has added a new and important rôle to those already performed by the *x* rays, namely, the early diagnosis of the presence of gas in a wound.

The subject has previously been mentioned in at least two short articles—by Woodburn Morrison¹ and by Ledoux-Lebard.² But as time goes on, and experience with this serious condition increases, we have become more and more impressed with the importance of the *x* ray findings, both in regard to the much earlier diagnosis of the presence of gas which can be made by this method than by any other, and also by the definite information given as to the extent of tissue involved.

We here deal with a number of interesting examples of this condition, in several of which the early warning given the surgeons, through the *x*-ray findings, probably saved the limbs, if not the lives, of the wounded men. At the same time it must be noted that the interpretation of the skiagrams of such cases is not without its own particular pitfalls.

Where the typical clinical symptoms—the tender, swollen tissues, which on palpation give the characteristic crepitation; the foul odour about the wound; the rapid, thready, pulse, and greyish drawn appearance of the face of the toxic patient—are well marked, the surgeon, naturally, does not need to rely on the *x* rays for diagnosis; but even in such cases, where possibly amputation of the limb is the only treatment giving any hope of saving the patient's life, most valuable information may be supplied by the *x* rays as to the extent of the tissues involved.

On the other hand, a number of cases have been observed in which the presence of gas in the wound was entirely unsuspected till revealed by the rays during the routine examination for pieces of metal or for fractures. Figure 1 is an instance; the gas appears as white spaces in front of the humerus. All cases in which gas was reported by the radiographer were immediately operated on, and very free drainage established. The presence of gas was confirmed in every case. In several of them (Case 1) the gas continued to spread for a time, even after free drainage was established; in others the patients made an uninterrupted recovery.

We cannot but feel that the results, particularly in the former cases, might have been far different than they proved to be had it not been for the timely warning supplied by the skiagrams. The quantity of gas found in the

tissues is no criterion of the virulence of the infection. We have several times seen patients where, according to the radiogram, much gas was present, do quite well on opening up the tissues, whereas in other cases where but little gas was found, the infection spread with such rapidity as seriously to endanger the patient's life. A consideration of the clinical findings, in conjunction with those afforded by the *x* rays, will, in most cases, give a clue to the virulence of the infecting organism. A high temperature and other indications of toxæmia, and the presence of gas (even in minute quantities), is always indicative of virulent infection; whereas, when no clinical signs of intoxication are present, even comparatively large quantities of gas in the tissues may be considered to be due to organisms of but low virility.

It is not our intention to deal here with the bacteriological side of the question. In all our cases cultures were made from matter taken from the wounds. This was done, with one exception, by means of swabs, and in all these cases the results were negative. In this one case (Case 1), however, pieces of the infected muscle were sent to the laboratory; the result was a pure culture of *B. aerogenes capsulatus*. This was obtained in anaerobic agar medium. No aerobic culture was made. It is intended that, at this hospital, in future all cultures of such cases will be made according to this method.

When gas is present it usually appears in the skiagram as bubbles, varying in size, and arranged in strings (Fig. 2), or scattered broadcast through the tissues (Fig. 3). In one case (Fig. 4) it lay as a clear layer under the skin and between the muscle sheaths. In another it lay in thin layers widely scattered through the tissues about the wound. Occasionally it appears as large, irregular spaces in the wounded area. A case in which the presence of gas was first diagnosed by the *x* rays before any clinical evidence was visible except some swelling of the leg which might have been due to an ordinary septic wound is shown as Fig. 5. These are cases in which the difficulty of differentiating between the shadows caused by the gas in the tissues, and those caused by the wounds themselves, are particularly marked. Only experience, and a general consideration of the case, can help in arriving at a correct diagnosis.

Another pitfall to be avoided is the differentiation between surgical emphysema and gas in the tissues of the thoracic wall. Fortunately it is but rarely that both conditions are present at the same time. This did occur, however, in one of our cases, and Fig. 6 shows surgical emphysema of the chest wall in a case of hæmothorax.

Then, again, there are the shadows of normal structures which must be kept in mind when making a diagnosis; as, for example, in Fig. 7, where the shadows caused by the normal popliteal space are shown; and, in Fig. 8, showing the presence of a bursa under the quadriceps extensor tendon.

In conclusion, let us again indicate the two points which appear to us to be of the utmost importance regarding the diagnosis of gas in the tissues by the *x* rays:

1. It supplies a means of making an earlier and more definite diagnosis than can be made by any other method.
2. In cases where an amputation is under consideration, the rays will give information as to the extent of the tissues involved, and, by so doing, may obviate a further operation later on, which might otherwise be necessary owing to the fact that the first operation did not include all the infected tissue.

CASE I.

Pte. F. H. Wounded in the right shoulder. Temperature 102°, pulse 103. X-ray report: Fracture of scapula, and some damage to neck of humerus. No metal present. A small quantity of gas present in the posterior axillary fold.

Treatment.—Free drainage, and excision of all gangrenous tissue. In spite of this treatment, the gas (which, previous to the report from the *x*-ray department, was entirely unsuspected) continued to spread rapidly. The spread was finally stopped by the use of hypochlorite dressings and the intravenous injection of eusol. He was discharged to England some three weeks later.

CASE II.

Private G. C. Perforating wound 3 in. above the knee. Exit wound on inner side of the popliteal space. X-ray report: No metal present. Small gas pockets above the knee-joint. There is a large quantity of gas between the muscle sheaths and under the skin from the knee to the ankle (Fig. 4). Temperature 100°, pulse 84.

Treatment.—Free drainage. Gas escaped. Discharged to England a week later. Temperature 98°, pulse 80.

J. D. MORGAN AND G. VILVANDRÉ: X-RAY DIAGNOSIS OF GAS IN THE TISSUES.

(Descriptions in Text.)

FIG. 1.

FIG. 2.

FIG. 3.

FIG. 4.

FIG. 5.

FIG. 6.

J. D. MORGAN AND G. VILVANDRÉ: X-RAY DIAGNOSIS OF GAS IN THE TISSUES.

FIG. 7.

FIG. 8.

HAROLD BLACK: DETECTION OF GAS IN THE TISSUES BY X RAYS.

FIG. 1.—The round white area overlapping the neck of the humerus is due to a collection of gas.

FIG. 2.—At the upper left corner of the skiagram the point of a bullet is seen, surrounded by an area of lightness due to gas.

CASE III.

Pte. A. S. There was an irregular incised wound on the inner side of the left calf. X-ray report: Two pieces of metal and gas present (Fig. 3).

Treatment.—Metal removed and free drainage established. Temperature 104°, pulse 140. Peroxide bath given. A few days later he was discharged to England.

CASE IV.

Pte. F. N. was wounded in the upper part of the left calf. There was considerable swelling. The presence of gas was not suspected. Temperature 102°, pulse 120. X-ray report: Several pieces of metal, and gas, present.

Treatment.—The metal was removed, and the wound freely opened. The temperature was then 103°. On the following day the temperature was 104°, pulse 144. As the patient's condition continued to get worse, amputation was performed. On the following day temperature 102°, pulse 110. A week later the patient was discharged to England; temperature 100°.

CASE V.

Here, too, the presence of gas was diagnosed by the x rays (Fig. 5) before any clinical evidence was visible, except some swelling of the leg, which might have been due to an ordinary septic wound.

CASE VI.

Pte. A. M. was wounded in the knee, near the head of the fibula. X-ray report: No metal present. The skiagram suggested the presence of gas in the anterior portion of the knee-joint, above the level of the patella. Temperature 102°, pulse 116. Next day temperature 101°, pulse 112. He was discharged to England.

CASE VII.

Pte. A. G. was wounded about the middle of the patella. X-ray report: Some damage to the lower pole of the patella. A piece of metal lies just below and internal to this bone. No gas was noticed at the subsequent operation. The recovery was uninterrupted, the temperature being normal after the fifth day.

Again, compare with these last two the following:

CASE VIII.

In this case no wound was present. The shadow of the air space (Fig. 8) was probably caused by a bursa under the tendon of the quadriceps extensor.

Fig. 6 shows surgical emphysema of the chest wall in a case of haemothorax.

Fig. 7 is a skiagram of a normal knee, showing the shadow caused by the popliteal space.

CASE IX.

In this case there were no clinical signs which suggested the presence of gas. This was, however, diagnosed by the x rays (Fig. 1). The infection did not spread after free drainage had been established.

REFERENCES.

- ¹ *Archives of Radiology and Electrotherapy*, December, 1915.
- ² *Journal de Radiologie et d'Electrologie*, July-August, 1916.

THE DETECTION OF GAS IN THE TISSUES BY X RAYS.

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(With Special Plate.)

To Colonel Gilbert Barling, Consultant Surgeon to the Southern Command, I am indebted for the suggestion to record the experiences we have had in the Birmingham Base Hospital at Hollymoor of the x rays detection of gas in the tissues.

It has been shown that gas gangrene may assume various forms and be due to different organisms.

At Hollymoor few cases of the acute or rapidly spreading form have occurred, and in these the diagnosis has been only too obvious without the help of the x-ray department. The less malignant form has been seen more commonly, and the object of this note is to emphasize the value of x rays in diagnosis.

In the last six months there have been nine cases radiographed by my assistant, Sergeant Brailsford, in which he has demonstrated the presence of gas. When these cases were sent for x-ray examination there was in most instances no suspicion that any gas was present, and in no case was it clinically certain. The demonstration of the presence of gas was a great help to the surgeon in the treatment of the cases, and it is obvious that, by dealing with the condition in its early stages, much relief was given to the wounded patients, and a large amount of destruction of the tissues must have been obviated.

The appearances of gas in the tissues are similar to those we are accustomed to see on pictures of normal body cavities that contain air—namely, a black area on the negative or a white area on the positive, which contrasts with the surrounding greyness.

The size of the area of blackness or whiteness varies naturally with the amount of gas present. In some of the cases it was a single spot less in size than a threepenny piece (1.6 cm. in diameter); in others it was as large as a florin (2.8 cm. in diameter). In most of the cases there were several spots present, and these were apparently isolated from one another. When the areas were small their outline was more or less oval and the margins sharp.

These gas bubbles are very clearly shown on the negatives, but, being small, they are very difficult to reproduce. I have chosen two of the cases, in which the gas collections were large, for illustration.

An interesting point in the cases is that in every case in which gas was shown on the negative the culture made from the pus or foreign body showed the *Bacillus perfringens*. In some of the cases no gas could be detected at the operation when the tissues were opened up, but the constant finding of this bacillus on culture confirmed the x-ray diagnosis.

Another point of interest is the length of time or latent period between the date of the injury and the detection of the gas. In one case this was almost five weeks.

The patients presented no unusual clinical features. All had a moderate pyrexia, all complained of pain. Tenderness was present on pressure over the affected areas, but no crepitation could be felt.

After operation a speedy recovery was the rule.

I append a summary of the cases made for me by Sergeant Brailsford, to whom I am much indebted. I also wish to express my thanks to the surgeons in charge of the cases for their permission to publish them.

CASE I.

Pte. L. Wounded in left thigh on April 4th; admitted April 17th. Radiographed on April 18th. Bullet shown at depth of 3½ in. with gas. The next day another radiograph showed that the gas had increased, the shadow being about the size of a florin, whereas the previous day it was about the size of a sixpence.

On April 20th Colonel Gilbert Barling removed the bullet, but no gas was detected at operation. Culture from the bullet showed *Bacillus perfringens*.

CASE II.

Pte. C. Wounded July 1st; admitted July 6th. A radiograph on July 6th showed (Fig. 1) a large piece of metal in the axilla at a depth of 2½ in., with a large area of gas overlapping the shadow of the neck of the humerus.

The metal was removed by Mr. Hewetson on July 7th; gas obvious at operation. Culture from the metal revealed *Bacillus perfringens*.

CASE III.

Sergeant D. Wounded in shoulder July 25th; admitted August 7th. Radiograph on same day showed fracture of fifth and sixth ribs, with bullet at depth of 1½ in.

Another radiograph made on August 19th showed small gas bubbles. Bullet removed by Colonel Barling; no gas detected at operation. Culture showed *Bacillus perfringens*.

CASE IV.

Pte. N. Wounded in thigh on July 31st; admitted August 6th. Radiograph on August 7th showed bullet and gas. The bullet was removed by Mr. Savage on August 8th; gas was noticed at the operation. Culture grew *Bacillus perfringens*.

CASE V.

Pte. L. Wounded in thigh August 26th. Radiograph on September 29th showed (Fig. 2) fracture of femur, many metallic fragments, and a gas bubble around the shadow of a bullet (upper left corner of print).

Operated on by Major Tweedy September 30th. Culture showed *Bacillus perfringens*.

CASE VI.

Cpl. S. Wounded August 31st; wound opened up in France. Admitted September 6th. Continued slight secondary haemorrhage. Pain in wound severe. Radiograph on September 13th showed shrapnel bullet 2½ in. deep, with gas in the muscles.

Opened by Mr. Lewis Graham the same day. Bullet removed, but no gas observed. Culture from bullet revealed *Bacillus perfringens*.

CASE VII.

Rifleman J. Wounded September 3rd; admitted September 21st. Radiograph on September 25th showed comminution of scapula and of the head of the humerus, many metallic fragments, and several gas bubbles.

On September 26th Major Tweedy opened up the area; no gas was detected. Culture showed *Bacillus perfringens*.