FIG. 14.—Showing bullets and shrapnel balls radiographed at the distances mentioned in inches.

bullets and shrapnel balls of the same calibre are being dealt with.

A key radiographic table is prepared by making radiographs of the bullet or shrapnel ball at the following distances from the plate: 0, 1, 2, 3, 4, 5, 6 in. (Fig. 14.)

The diameter of the bullet or ball casts a shadow the width of which is proportional to its distance from the plate, no matter at what angle the missile may be lying. The length of the bullet forms no guide.

A measurement of the uniformly cylindrical portion of the bullet is made with a fine pair of dividers; the latter are then transferred to the key plate and compared with the shadows; the shadow which they fit exactly, decides the depth of the bullet. The same method applies to the shrapnel ball, provided it is not more than very slightly deformed.

ANATOMICAL LOCALIZATION OF A METALLIC FOREIGN BODY AND RECONSTRUCTION OF ITS TRACK.

Captain Crymble²⁴ has shown the practical possibility of combining radiographic results with the information which can be obtained from a study of sectional anatomy. By this combination the actual anatomical position of a foreign body can be determined in addition to its depth from the surface or relation to neighbouring bony points. To attain this object he has employed a series of original coronal and horizontal sections of the body, and also the atlas of cross section anatomy of Eycleshymer and Shoemaker. By marking the vertical and lateral positions of the foreign body on a reconstruction of the part of the body concerned, obtained by replacing the sections in position, the sections corresponding to the position of the missile and the track leading thereto are selected.

Application of the depth measurement from the surface, or observation of the relation of the bone to the surface of the section of the body actually occupied by the missile, then allows the definite anatomical structure enclosing the foreign body to be determined.

The structures involved throughout the entire length of the track may also be worked out by the employment of a reconstruction viewed from the anterior aspect, and another viewed from the lateral aspect. On these the positions of the entry wound and of the foreign body are marked respectively. If no bone lesion is present the positions of the entry wound and of the foreign body are connected by a straight line. Where a bone lesion is present the line is carried from the wound to the bone lesion by a straight line, and from this point a second straight line connects the position of the bone lesion with that of the foreign body. Reference to the anterior reconstruction will then give the lateral position of the track in any section, and reference to the lateral reconstruction will give the sagittal or antero-posterior position in any section.

Crymble points out that the method is seldom needed in dealing with the limbs, but it is more useful in regions like the hip or the great body cavities. Further, anatomical localization both of the track and the missile is of extreme importance in prognosis and treatment in injuries to the head, and also affords a valuable means of studying the functions of the brain.

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ON SOME ANAEROBES FOUND IN WOUNDS AND THEIR MODE OF ACTION IN THE TISSUES.

BY

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THE literature on the anaerobes is beset with so many contradictory statements that it is impossible to construct from it an accurate account of the reactions of even the better known organisms. Experience has shown that this confusion is due almost entirely to the investigation of impure cultures, for, with the establishment of a more exact and rigorous technique, the features of individual species are found to become more clearly defined, and previously existing discrepancies tend to disappear altogether.

A CLASSIFICATION OF ANAEROBES.

All the anaerobes isolated from wounds are probably faecal in origin. They give vigorous fermentation reactions in the presence of organic material, and according to their biochemical activities they may be divided into two main groups—the saccharolytic group and the proteolytic group.

I. The Saccharolytic Group.

The members of this group vigorously decompose a variety of carbohydrates with the production of acid and gas, but they are only feebly proteolytic. The group comprises:

1. *B. welchii*. (Synonyms: *D. aerogenes capsulatus* of Welch and Nuttall; ¹ *B. perfringens* of Veillon and Zuber; ² *B. phlegmonis emphysematosae* of Fraenkel.³)
2. *B. tertius*. (Synonyms: *Bacillus* Y of Fleming; ⁴ *B. von Hübner* IX or *B. rodella* III of Robertson.⁵)
3. *B. fallax* of Weinberg.⁶
4. *B. aerofetidus* of Weinberg.⁷
5. *B. oedematiens* of Weinberg.⁸

Pasteur's *Vibrion septique* would seem to belong to this group, but it is omitted because we have had as yet no opportunity of establishing its characteristics.

The sugar reactions which have been found to hold good after a long series of observations are given in the following

abbreviated table, and would appear to furnish valuable evidence in the differential diagnosis of individual organisms from other members of the group. There are four types of *B. welchii* which differ from each other according to their reaction in inulin and glycerin. This finding confirms the observations of Simonds.⁹ *B. tertius* resembles *B. welchii* in its sugar reactions, but ferments mannite and salicin in addition. *B. aërofetidus* does not ferment saccharose, and *B. fallax* attacks lactose only after several days, while *B. oedematiens* ferments dextrose, levulose, and maltose only, resembling the individuals of the proteolytic group in this respect. Certain strains of *B. welchii* are slightly proteolytic, and produce small quantities of amino-acids, and *B. aërofetidus* carries the digestion of protein still further, for it produces a very fetid odour in cultures. In neither case, however, is the proteolytic activity at all comparable to that which characterizes the members of the second group.

TABLE I.

		Dextrose.	Levulose.	Maltose.	Saccharose.	Lactose.	Mannite.	Glycerin.	Inulin.	Salicin.	Amygdalin.	Glycogen.
<i>B. welchii</i> I	...	+	+	+	+	+	-	-	-	-	-	+
" II	...	+	+	+	+	+	-	-	+	-	-	+
" III	...	+	+	+	+	+	-	+	-	-	-	+
" IV	...	+	+	+	+	+	-	+	+	-	-	+
<i>B. tertius</i>	...	+	+	+	+	+	+	-	-	+	+	+
<i>B. fallax</i>	...	+	+	+	+	-	-	-	+	+	-	+
<i>B. aërofetidus</i>	...	+	+	+	-	+	-	-	-	+	-	+
<i>B. oedematiens</i>	...	+	+	+	-	-	-	-	-	-	-	-

II. The Proteolytic Group.

This comprises—

1. *B. sporogenes* of Metchnikoff.¹⁰
2. *B. histolyticus* of Weinberg.¹¹
3. *B. putrificus coli* of Biensstock.¹²
4. *B. cadaveris sporogenes* of Klein.¹³
5. *B. tetani* of Nikolaier.¹⁴

The individual members of this group digest protein very vigorously, but have a restricted range in the matter of carbohydrate fermentation. *B. histolyticus* breaks down protein as far as the amino-acid stage, whereas the other members of the group push digestion still further to the ammonia stage. They all ferment dextrose, levulose, and maltose. It is probable that *B. sporogenes*, *B. putrificus coli*, and *B. cadaveris sporogenes* are closely related, if not identical.

The term *B. oedematis maligni* of Koch is intentionally omitted from the above list, for we believe that the organism described as such by English writers during the war is really *B. sporogenes* of Metchnikoff. It is significant, too, that no mention of Koch's organism appears in German literature published since the outbreak of war. Its place seems to have been taken by a bacillus which has been described independently by Aschoff¹⁵ and by Conradi,¹⁶ and which is taken by those observers to be a human form of Rauschbrand. It is of interest in this connexion to note that Nicolle,¹⁷ as the result of serological tests, considers the *Vibrio septique* of Pasteur to be closely allied to, if not identical with, the bacillus of Rauschbrand. The organism of Conradi and Aschoff is said to produce in animals a solid oedema of the type which is so characteristic of Weinberg's *B. oedematiens*, but the strong saccharolytic powers attributed to it distinguish it from the latter.

THE INCIDENCE OF ANAEROBES IN WAR WOUNDS.

The production of a gaseous cellulitis in the tissues surrounding a wound is practically certain evidence of anaerobic infection, although it must be noted that the infiltration of gas may often out-distance the microbic invasion in the tissues. It is not uncommon to find no microscopical or cultural evidence of organisms in the oedema fluid taken from crepitant subcutaneous tissues at some distance from the wound. Another feature of anaerobic growth is the necrosis it produces in the in-

vaded part. Quite apart from wounds which show these clinical manifestations, the majority of open wounds treated at a base hospital in France give cultural evidence of the presence of anaerobes. Out of 100 open septic wounds of all grades of severity examined at intervals of from two to twenty-two days after the receipt of the injury two-thirds showed the presence of *B. welchii*, and almost one-half showed the presence of *B. sporogenes* (see Table II). It is unusual to find only one anaerobe in a wound. In the vast majority of cases the anaerobe infection is a mixed one, the most frequent combination being *B. welchii* with *B. sporogenes*.

In contradistinction to these open wounds, we have had the opportunity of examining a large series of bloody effusions resulting from penetrating wounds of the pleura and lung. In most of the open septic wounds the anaerobes are implanted into, or come in contact with, damaged muscle, whereas in the thoracic injuries just mentioned, which might be looked on as closed wounds, the organisms carried in have to develop in a collection of ordinary blood. Out of 500 specimens of hæmothorax fluid examined, 195 proved to be septic, and 44.6 per cent. of these were infected with anaerobes. Here, again, *B. welchii* is the most common infecting anaerobe, and the combination of this organism with *B. sporogenes* is frequent.

The anaerobes tend to remain localized to the tissues during life, and it is only seldom that they can be found in the circulating blood. On the other hand, cases have been recorded from time to time of so-called metastatic gas gangrene in which anaerobes have developed in some position at a distance from the infected tissue. This would seem to occur in a focus which has suffered slight damage, as from continuous pressure or from the introduction of a hypodermic needle, and it is certain that the organisms must have been conveyed through the blood stream. It is quite frequent, however, for anaerobes to become disseminated through the blood stream immediately before death. Out of 40 cases in which death resulted from wounds which were proved to be infected with anaerobes, the heart blood taken from one to twenty hours after death gave a positive cultural result on twenty-five occasions. In 20 of these cases *B. welchii* was found (that is, in 80 per cent.), and in 15 (that is, 60 per cent.) *B. sporogenes* was present.

TABLE II.

	Total Examined.	Total Septic.	Infected with Anaerobes.	Infected with <i>B. welchii</i> .	Infected with <i>B. sporogenes</i> .
Open wounds 2 to 22 days old	100	100	72%	66%	48%
Hæmothorax fluids	500	195	87 = 44.6%	71 = 36.4%	14 = 7.1%
Post-mortem heart blood	40	36	25 = 69.4%	20 = 55.5%	15 = 41.6%

THE PATHOLOGICAL PROCESS PRODUCED BY ANAEROBES IN THE TISSUES.

The incidence of anaerobic infection in wounds during the present war would seem to be determined by two factors. The first is the unavoidable soiling of a wound by earth or by clothing infected with faecal organisms. Secondly, the destruction of tissues produced in and around a wound by the modern missile gives rise to just those conditions which are most favourable for anaerobic growth.

The implantation of anaerobes in a focus of dead organic material is directly comparable to the inoculation of an artificial culture, and it is for this very reason that a laboratory study of the activities of anaerobes in artificial media is of service in determining the nature of the earlier pathological processes which follow infection of the tissues. In the wound, just as in the test tube, the members of the carbohydrate splitting group of anaerobes are the first to develop. The glycogen which is found in living healthy muscle is rapidly converted after death into dextrose and a small fraction of isomaltose. Both these substances are vigorously fermented by such an organism as *B. welchii*, and it is because of their presence that the organism in question so readily establishes itself in damaged muscle.

This early fermentation in muscle results in the formation of acid and gas. The latter consists of a mixture of

carbon dioxide and of hydrogen in varying proportions. It often develops with astonishing rapidity, and may become clinically evident four to six hours after the receipt of the wound. The appearance of crepitation in the subcutaneous tissues is probably due to gas which has escaped from sub-jacent infected muscle.

The gas may accumulate under considerable pressure, and, in so doing, it adds to the embarrassment of a circulation which is already impeded by the presence of inflammatory exudate.

Coincident with the production of gas is a formation and setting free of various organic acids. The acids which occur in the *in vitro* fermentation of carbohydrates by *B. welchii* retard and finally inhibit the growth of the organism, and, unless there is a high amount of available protein present, the culture dies out rapidly. If, however, some method be adopted of neutralizing the acid as that is formed, as, for example, by the addition of calcium or of magnesium carbonate to the culture, then the growth is not only much more luxuriant but its vitality is considerably increased.

In infected tissues such a neutralization is brought about by the inflammatory exudate, for the buffer salts of the serum constitute an absorbing reservoir which will take up any excess of free acid, and it is only when this considerable reserve is used up, if ever this does happen, that one can expect to find an increased hydrogen ion content of the circulating blood.

There is, however, another contributing factor to the neutralization of acid, a factor which comes into operation in the later stages of bacterial growth. The early rapid growth of the saccharolytic group is succeeded by the more gradual development of members of the proteolytic group. The protein constituents of the damaged tissues are attacked by the digestive ferments elaborated by organisms of this second group, and are broken down by successive stages. The final product consists largely of ammonia bodies, and it is these that help to counteract the acids resulting from carbohydrate degradation.

It is probably just at this point that certain saccharolytic organisms become proteolytic, and throw in their lot with the real tissue digesting organisms.

The gas formed in the proteolytic stage of wound infection is malodorous because of the development of sulphuretted hydrogen and certain volatile bodies.

It is probably during the proteolytic period also that the toxic products are elaborated which give rise to the clinical condition of toxæmia. It is very unlikely that such a condition is established as the result of carbohydrate fermentation. The clinical picture of a man dying with anaerobic toxæmia is chiefly that of a rapidly progressive circulatory failure, and death may come so abruptly that it is often falsely ascribed to pulmonary embolism. It never bears a resemblance to that state of "air hunger" which clinical pathologists have proved to be associated with blood acidosis.

One may, then, summarize the pathological processes in an anaerobe-infected wound as being characterized by two main features—the production of gas and the death of tissue. Each of the two main groups of anaerobes above defined has its share in these processes, and the successive stages by which an anaerobe infection develops may be thus summarized:

1. The initial trauma in determining the death of tissue establishes a focus for growth. This is characterized by the latent period, which precedes any obvious clinical signs of anaerobic infection.

2. The first active phase of anaerobic infection consists in the development of the rapidly growing saccharolytic organisms, of which *B. welchii* is the chief. It is because of the richness of muscle in fermentable carbohydrate that this tissue provides such favourable conditions for the growth of organisms of the saccharolytic type. Their development results in the production of acid and gas. The gas accumulates first in the muscle and reaches the subcutaneous tissues by escape from the muscle. The pressure produced by gas and also by inflammatory oedema fluid leads to an anaemic condition in the tissues surrounding a wound, and this change initiates the second active period of anaerobic invasion. The muscle in the saccharolytic period is of a brick-red colour.

3. The second phase of anaerobic infection in a wound consists in active proteolytic digestion. This is characterized by death and digestion of the tissues. The process is

accompanied by the formation of sulphuretted hydrogen and of volatile substances, which give the penetrating putrefactive odour so typical of the later stages of infection. The previously red muscle becomes soft and diffuent. It may be stained black by a sulphide of iron formed by the interaction of sulphuretted hydrogen with the iron released from broken-down haemoglobin. The toxæmia which develops at this period results from the absorption of toxic substances produced in the breaking down of the protein molecule, and cannot be attributed to the acid which is formed in the breaking down of the carbohydrate molecule.

4. The final phase is that of successful bacterial invasion of the blood stream. It occurs in most cases just at, or immediately preceding, the death of the individual.

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Memoranda:

MEDICAL, SURGICAL, OBSTETRICAL.

THE VALUE OF PURE CARBOLIC ACID IN THE TREATMENT OF SEPTIC WOUNDS.

We are apt to forget the value of old remedies in the multitude of new ones, which, admirable and useful as they may be in many cases, are often not so well adapted for the particular purpose for which they may be employed. The special class of septic wounds referred to is that in which the destruction of soft tissues has led to ill-defined attached portions of dead skin, subcutaneous tissue, or muscles. Much of such tissue it may be possible to cut away, but there is always more or less left which Nature must detach itself, and so long as such necrosed tissue remains adherent it is a veritable hotbed for the development and multiplication of pathogenic and saprophytic organisms not only capable of exciting active local mischief but proving also a fruitful source for septic absorption. It is difficult to get at these deeply embedded organisms by means of any of the more modern solutions recently introduced, or by any of the various methods adopted in their employment. But to soak all necrotic tissue freely with pure carbolic acid is to effect complete sterilization.

Any who have tried this old Listerian practice—for it is to Lister that we owe it!—will bear out the statement that wounds so treated rapidly "clean up"; any advance of the acute septic process in the immediate neighbourhood of the necrotic tissue ceases; pain in the part is relieved; the temperature often falls, and, in every way, both the patient generally and the part locally show signs of rapid improvement.

I have been induced to draw attention to this old method because I have failed to notice any allusion to it in the many contributions that have recently appeared in the journals on the subject of septic wound treatment; and still more for the reason that the abundant opportunities which the present war has afforded of testing its value in the particular class of cases referred to have amply justified its use in the way originally suggested and employed by Lister.

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ADRENALIN IN ANGIONEUROTIC OEDEMA.

This disease, though rare, is very distressing and intractable. In the following case, that of a lady aged 39, it lasted for three years, and resisted all the reputed

¹ The Collected Papers of Joseph, Baron Lister, vol. ii, p. 38.