

BACILLAEMIA DUE TO INFECTION WITH  
*B. FAECALIS ALCALIGENES*.

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Clinical Notes by

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In epidemics of disease due to the enterica group of organisms, especially when occurring among troops under war conditions, many cases are met with which are more or less atypical, and in which a diagnosis can only be reached with certainty by bacteriological methods.

More especially is this true under present conditions, when the disease as seen is frequently modified by previous prophylactic inoculation. Without a well-equipped laboratory to aid in the diagnosis, by means of haemoculture and serological tests, many cases of pyrexia due to other causes would undoubtedly be confused with this modified type of enteric, while others which clinically do not resemble enteric but are proved bacteriologically or serologically to be so, would be overlooked.

In speaking of making a diagnosis in enterica infections, I refer to the three types—*B. typhosus*, *B. paratyphosus* A, and *B. paratyphosus* B—as one group, and as causing one disease, namely, enteric. I am not here concerned with making a differential diagnosis between the three members of this group—which, of course, can only be done in the laboratory—but rather of differentiating between such an enterica infection and the various other pyrexias of unknown origin.

During the past nine months at this hospital I have had occasion to make blood culture examinations of considerably over a thousand cases of enterica and suspected enterica infections. In the course of this work I have on several occasions recovered in pure culture from the blood of such cases an organism which has up to the present time been regarded as more or less non-pathogenic—namely, the *Bacillus faecalis alcaligenes*.

During the height of the enteric epidemic last summer this organism was isolated only on a few rare occasions—two or three times by myself and a similar number of times by my colleague, Lieutenant Willmore. Recently, however, cases have occurred from whose blood I have isolated the same organism with almost sufficient frequency to constitute a mild epidemic, and quite frequently enough to identify it as playing a pathogenic part, and being the definite cause of a mild pyrexia in which the true condition is a bacillaemia. Further proof that the organism is the causative agent was given by testing the agglutination power of the blood of several of these cases against the various strains isolated, after waiting for a sufficient length of time for specific agglutinins to be formed. In this way it was found that agglutination occurred up to a dilution of 1 in 200 of the patients' serums with homologous and heterologous strains—in some cases in even higher dilutions—while control serums from normal patients failed to agglutinate the various strains, even in dilutions of 1 in 50. During March and April eleven cases have occurred whose blood culture yielded this organism.

It is quite possible that several other cases of pyrexia, which were thought to be modified enteric, though in them no connexion with the enterica group could be proved by blood culture, agglutination tests, or by examination of faeces, were really due to infection with this same organism. In this latter condition, as in enteric, blood cultures to be of value must be taken as early as possible in the pyrexial period. The initial pyrexial period is of short duration, lasting but two or three days. During the past two or three months most of the cases admitted to this hospital have come from camps more or less in the immediate neighbourhood, the men having been ill for two or three days when admitted. All cases sent in as suspected enterica—as most of these infections by *B. faecalis* have been—are blood cultured as soon as possible after admission, either on the day of admission or the day after. In any case the initial pyrexial period may easily have passed when this is done, so the blood culture in

many of these would be sterile. Until recently, infection with this organism not being recognized as a clinical entity, no further steps were taken to establish a relation between these cases and the organism in question, but subsequent pyrexial periods lending colour to the view that they were modified enterics, agglutination tests, and faeces examinations were carried out, but in several instances no connexion with the enterica group could be proved.

Some of these cases might well, then, be assumed to be unrecognized cases of infection with *B. faecalis alcaligenes*. This assumption is further borne out by the fact that since we have recognized that this organism may give rise to a definite pathological condition, I have tested the agglutination titre of the serum in some of the above-mentioned doubtful cases, and have found that in two or three of them the titre ran up to 1 in 400 for this organism, while for the members of the enterica group it was practically nil, what little agglutination for this group was present being no more than would be expected in inoculated subjects.

The points which I consider worthy of note in recording these cases are, first, that infection with this organism may clinically be mistaken for modified enteric, from which it can only be diagnosed with certainty by haemoculture or serological tests; and secondly, that an organism which has hitherto been regarded as practically non-pathogenic may invade the blood stream, and so give rise to a definite train of symptoms—a disease of which the dominant sign is pyrexia.

With regard to its pathogenicity, it is quite probable that in colder and more temperate climates the organism merely occurs as a harmless member of the intestinal flora, but that in climates such as this, where gastrointestinal disturbances are rife—especially among fresh troops who are exposed to unusual hardships before becoming acclimatized—the catarrhal condition of the bowel so set up provides a *locus minoris resistentiae*, and the organism, hitherto passive and harmless, now assumes an active part and invades the blood stream.

Macé, in referring to Petruschky's original description of this organism, states: "Il se place tout au voisinage du *Bacille typhique* dont il a bien des caractères."<sup>1</sup> While Petruschky recognized its relation to the typhoid bacillus, the fact that it has so frequently been found to occur in the motions of healthy people and in contaminated matter, without, so far as I have been able to gather, being definitely described in relation to any disease, has undoubtedly led us to assume that it did not occur in a pathogenic part. Henderson Smith, in his recent article on the identification of the pathogenic members of the typhoid-colon group of bacilli, definitely mentions it as constituting a non-pathogenic group.

The characteristics of the strains isolated by me agreed with those given by Petruschky in his original description of the organism with one or two exceptions—namely, a variability in its motility, and, in the case of one strain, a rapid tendency to peptonize litmus milk. On some occasions the strains would be freely motile, and then for no apparent reason would on other occasions lose their motility while still remaining alive, as shown by their power to be subcultured. Probably this variability depended on some slight variability in the composition of the media on which they were grown. Apart from this they agreed in all other respects—that is, they were Gram-negative bacilli growing abundantly on agar-agar as a thick slimy growth, producing intense alkalinity in litmus milk (with the one exception noted), and alkalinity in such of the carbohydrates and alcohols as were at my disposal to grow them on. In peptone broth they rapidly produced turbidity, with a very thin transparent scum on the surface of the medium, and after a few days a deposit at the bottom of the tube. No liquefaction occurred in gelatine, and no indol was formed.

With regard to agglutination tests with this organism, having no electric shaker I had considerable difficulty in getting a homogeneous emulsion from agar cultures for the purpose of carrying out macroscopic tests. I found it necessary to centrifugalize the emulsion obtained by rubbing up the growth with normal saline, then to pipette off the supernatant fluid, and filter it through a sterile filter paper.

<sup>1</sup> Macé, *Traité pratique de bactériologie*, vol. ii, p. 250.

In this way a fairly homogeneous emulsion was obtained, but control tests in normal saline were always put up when carrying out agglutinations. It was usually found that a very slight amount of pseudo-agglutination occurred in these controls—nothing to be compared to the very definite agglutination in those that were positive.

As a further control I repeated the tests microscopically, and the process of agglutination became very apparent when watched under the microscope, thus eliminating any possibility of pseudo-agglutination being confused with the actual phenomenon.

The blood cultures were made as follows:

Five c.cm. of the patient's blood was drawn off aseptically from the median basilic vein and placed in 50 c.cm. of a 2½ per cent. solution of tauracholate of soda in distilled water. This was incubated for twenty-four hours; then plated out on MacConkey plates, which were again incubated for twenty-four hours. The agar used in making the MacConkey plates was specially prepared with pancreatized bullock's heart according to a formula by Lieutenant-Colonel Dudgeon.

Colonies from the MacConkey's plate were picked off into mannite litmus agar, stab stroke culture being made to note the presence of gas, if any, as well as the reaction of the organism on the mannite.

The absence of any acidity on this medium with a gradual production of alkalinity was sufficient to differentiate the organism from the enterica group in the preliminary examinations, the further characteristics being worked out later.

None of the strains isolated so far are agglutinated with stock (Lister Institute) typhoid or paratyphoid antiserum.

It might be as well to mention here that on the first occasion of its isolation I was rather inclined to think that I had recovered a Shiga-Kruse bacillus from the blood. Subsequent investigation showed that the organism was not connected with the dysentery group, nor was it agglutinated by Shiga antiserum.

Since writing the above I have isolated this same organism from a further series of ten cases. In five of these I repeated the blood culture examinations five days after isolating the organism, and in two of these I again recovered the organism in pure culture.

In the other three cases in which haemoculture was repeated the pyrexial period was passed at the time of taking the second culture.

In two of these cases I have examined the urine bacteriologically, but in each it proved sterile. On first meeting with these infections by *B. faecalis*, I was inclined to think they were cases of mild enterica in which the *B. faecalis* had entered the blood stream with an organism of the enterica group, and had outgrown the latter. But agglutination tests with the serums from these cases have failed to show any relationship with the enterica group, while, as stated above, a specific agglutinin is developed for *B. faecalis*. This, together with the fact that in all

these cases the organism has occurred in pure culture in the blood, is, to my mind, sufficient evidence that a genuine and specific infection occurs with this organism.

I am indebted to Lieutenant-Colonel Ledingham, consulting bacteriologist to the Mediterranean Expeditionary Force, for the following notes on the characteristics of the *B. faecalis* group, as well as for the notes on previously reported cases of this infection, and for the table of references.

#### *B. faecalis alcaligenes*.

The organism to which the name *B. faecalis alcaligenes* was given by Petruschky in 1896, in view of its intense production of alkali in litmus milk, was originally recovered by the same observer in 1889 from a specimen of stale beer; and later from human faeces. In many of the cultural tests at that time in vogue for the differentiation of organisms this bacillus agreed closely with *B. typhosus*, but was sharply differentiated therefrom by its property of ren-

dering litmus milk alkaline. At a somewhat later period the controversy which arose over certain observations by German workers, tending to show the possibility of transforming *B. typhosus* into *B. faecalis alcaligenes* and vice versa, again drew attention to this organism; but, as the observations referred to were discovered to be due to contaminated cultures, the matter has only a historical interest for us.

In more recent years the biological properties of *B. faecalis alcaligenes* have been fairly fully defined. Krencker (1905), for example, found that no fermentation took place in media containing glucose or lactose, while Klimenko (1907), who examined a fairly large number of

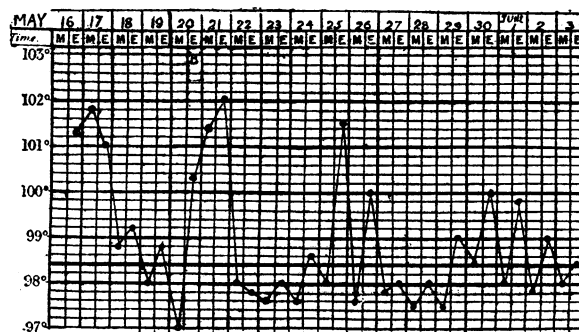
strains, recorded the fact that alkali production only occurred in glucose, galactose, cane sugar, lactose, raffinose, arabinose, and dulcitol.

It has also been established that the flagella of *B. faecalis alcaligenes* are always polar, and not peritrichal, as was originally stated by Petruschky. (N.B.—The sugar reactions given by Castellani (1912) for this organism are incorrectly stated.)

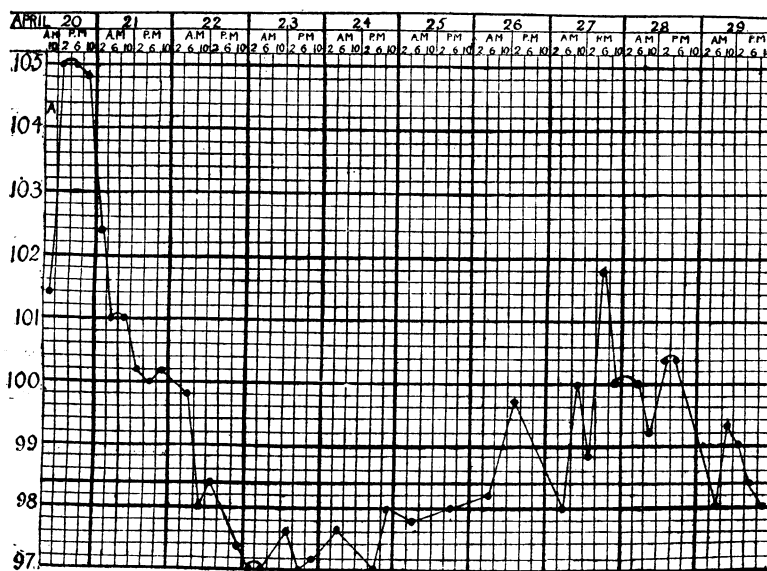
At the present time *B. faecalis alcaligenes* may be defined as an organism occurring in human dejecta, particularly in diarrhoeal or dysenteric

conditions, and either alone or in association with organisms of the typhoid-paratyphoid-dysentery group, or with non-lactose fermenters such as *B. proteus vulgaris*, Morgan's bacillus No. 1, etc. It produces turbidity in broth, sometimes with pellicle formation; it produces no indol, and does not ferment carbohydrates, media containing which being rendered intensely alkaline, as also is litmus milk. Gelatine is not liquefied, and there is no pigment formation, though a brownish growth on potato has been described.

*Pathogenicity for Laboratory Animals.*—The organism possesses little pathogenicity for guinea-pigs and mice, except possibly when inoculated intraperitoneally in fairly large amounts.



B = Blood culture taken.



A = Admission to hospital.



**Pathogenicity for Man.**—Definite evidence of the pathogenicity of this organism for man is very scanty, although there has been on the part of certain writers a tacit assumption of its association with a low form of gastro-intestinal disease. When found in the dejecta in diarrhoeal and typhoidal infections as the sole non-lactose fermenter, it has most commonly been regarded as simply an associated organism which has overgrown the more specific organisms and rendered their recovery impossible. In more recent years, however, a few cases have been reported in which this organism has been recovered from the blood, and has apparently been accountable for the symptoms in the respective cases.

Thus Straub and Kraus (1914) record two cases, of which the following are brief notes:

Female, aged 19 years, admitted January 6th, 1913. Pain on defaecation, with two or three stools a day, since middle of December, 1912. Stool formed, but containing mucus. On January 2nd pains in the umbilical region. Since January 4th vomiting of bilious watery material without blood. Little appetite. Temperature 39° to 40° C., pulse 130. Herpes labialis. Heart and lungs normal; abdomen tender on pressure, no distension; spleen not enlarged. Temperature fell by lysis from January 11th, and patient was discharged on February 8th. From the blood a pure culture of an organism allied to the *f. ecal* group, but liquefying gelatine, was recovered. Total leucocytes 4,500, with relative lymphocytosis. Serum of patient did not agglutinate *B. typhosus* or the two paratyphoid bacilli.

Male, aged 19 years. Admitted April 24th, 1913. Took ill on April 3rd with headache and rigors, but continued at work till April 14th. He then received ambulant treatment till April 24th. On admission he complained of stabbing pains in the chest, with cough, headache, and night sweats. Stools were regular. Temperature 39.9° C. Pulse 100. Spleen not palpable. Leucocytes 7,100, with 50 per cent. lymphocytes. Fever was continuous till April 30th, when a brief remission occurred. It continued, however, at 38° C. till May 12th, when it became normal. The patient was discharged on June 3rd. There is no record of haemoculture, but from the urine an organism giving all the characters of *B. faecalis alcaligenes* was recovered on May 17th. Twice during the pyrexia (on April 30th and May 3rd) the urine had been found sterile. This organism did not liquefy gelatine. The serum of the case did not agglutinate typhoid or paratyphoid bacilli, but agglutinated the homologous strain of *B. faecalis alcaligenes*, as well as that recovered from Case I, in a dilution of 1 in 1,000.

Rochaix and Marotte (1916) give a brief but concise account of two recent cases of benign typhoid-like illness in which typical *B. faecalis alcaligenes* was recovered from the blood.

The two patients complained of gastro-intestinal symptoms. During the first two or three days the temperature oscillated between 39° and 40° C., then fell progressively to normal in ten to twelve days. Blood culture performed on the day following admission gave a pure culture of *B. faecalis alcaligenes*. Six days later a second haemoculture proved negative. The serums of the two patients did not agglutinate paratyphoid bacilli, but agglutinated *B. typhosus* in 1 in 100 and 1 in 50 respectively. (Both cases previously vaccinated against enteric.) The homologous organisms were, however, agglutinated by the serums of the cases in 1 in 200 and 1 in 500 dilution respectively. Also the serum of the first patient agglutinated the organism recovered from the second case in 1 in 200 dilution, while the serum of the second patient agglutinated the organism of Case I in 1 in 1,000 dilution.

Two or three isolated and less authenticated cases are here omitted, and no evidence is on record of the occurrence of cases of this character in apparently epidemic form. The series of cases here recorded by Captain Shearman constitute the first record of what may be called an epidemic prevalence of infection due to *B. faecalis alcaligenes*.

#### Clinical Notes of Cases admitted into No. — General Hospital.

Nearly all the cases referred to by Captain Shearman were at first admitted into the Observation Ward of the No. — General Hospital, Egypt. This ward is one into which all cases of obscure pyrexia, in which no physical signs or symptoms are present to explain the occurrence of the fever when the patient first presents himself and in which in consequence there is a suspicion of enteric or typhoid fever, are received direct from the reception room. From this ward cases are weeded out day by day as an accurate diagnosis becomes possible.

The symptoms this group of patients complained of may be briefly summarized. In nine out of the eleven cases

there was a sudden onset with slight chill, severe headache, usually frontal but sometimes also felt in the occipital region, nausea, occasional vomiting, and general aching of the limbs. Abdominal pains with constipation were also usually complained of. In two of the cases the onset was gradual, but the symptoms complained of were those above enumerated.

On examination after admission there was very little to note except in a negative way. In all cases the face was flushed, the tongue furred, and all the usual phenomena of pyrexia were apparent. The pulse was under 100, and not dicrotic; nothing of note was found in the chest; the abdomen was slightly distended and tender on palpation, but no enlargement or tenderness of either liver or spleen was found. The urine was normal, and in each case the diazo test was negative. In one patient there was a diffused urticarial eruption, which disappeared in twenty-four hours, but returned a few days later.

The type of temperature recorded was interesting. In nine cases there was an initial period of pyrexia of from two to five days' duration, reaching a height of from 101° F. to 102° F., and falling by lysis. This was followed by a normal period of from two to five days, after which there was a second pyrexial period similar to the first, but lasting only two to three days, during which period there was a return of all the symptoms complained of at the beginning. In two cases there was a third rise of temperature similar to the first and second. In two cases no second pyrexial attack occurred.

Blood examinations, apart from the bacteriological findings, throw no light on the condition. The white cell count, with one exception, was in each case examined under 10,000 per c.cm., averaging about 8,800, and the differential count was normal.

No spirilla or malarial parasites were found. In one case a leucocytosis of 16,000 was found. As it is probable that cases similar to these are occurring elsewhere, and as in other places where paratyphoid fever is prevalent they might easily be taken for mild and unusual forms of that disease, it is important to call attention to their existence. The diagnosis, of course, depends entirely on the bacteriological findings.

Typical temperature charts from two of the cases accompany this note (p. 894).

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### CYTOLOGICAL EXAMINATION OF THE JOINT FLUID AS AN AID TO PROGNOSIS IN PENETRATING GUNSHOT WOUND OF THE KNEE.

BY

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THE treatment of gunshot wounds of the knee-joint continues to be one of the most pressing surgical problems of the day. Consequently any method whereby a juster opinion of the future progress of the case can be made on its first examination is likely to be of considerable use. This fact must be my excuse for presenting a manifestly incomplete account of the method I have adopted at a base hospital in France for over a year.

The pathological principle upon which it depends is simple. Damage having been done to the joint, Nature sets about repairing the damage, and the first step consists in sending leucocytes into the synovial fluid. Now, it is a fundamental fact in the pathology of inflammation that aseptic damage to a part is associated with migration of mononuclear leucocytes chiefly, septic damage with migration of polynuclear leucocytes. Moreover, up to a point where negative chemiotaxis comes into play, the heavier or more virulent the infection the greater the migration of polynuclears. Pus, which consists of