BACTERIOLOGIC DIAGNOSTIC AIDS IN ACUTE OTITIC DISEASE AND ITS COMPLICATIONS.*

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The frequent reference to the bacterial nature of the infection, in the discussions concerning diagnosis and prognosis of acute otitic disease and its complications, has naturally prompted the inquiry to what extent this information is of value to the clinician. If any rules can be formulated, in order to inspire confidence, they must have the broad base of practically uniform result obtained by a variety of observers under different environment and methods, rather than the narrower base of individual effort, no matter how efficient this may be. Many a competent worker with wide experience in his specialty has failed to see certain phases of a condition noted by another of possibly more limited activity. Such conditions are possibly unusual or exceptional, but by no means justify an assumption of inefficient methods or lack of proper observation. When an eminent worker in different environment reports bacteriologic results varying from our own, these possibilities must be incorporated in the broad rules established for the guidance of all, and an error in technic cannot be assumed to account for the difference in experience.

A knowledge of the nature of the original infection is undoubtedly of value, and the occurrence of an infection of the general blood stream also has diagnostic significance of no mean importance, but the broad experience of the clinician demonstrates that dogmatic rules concerning the meaning of one or other bacteriologic factor are bad. This is no attempt to belittle laboratory help in diagnosis and prognosis; quite the contrary. The best service from these aids is obtained with a full knowledge, not only of their value, but also of

*Read before the Ninth International Otological Congress, at Boston, August 12-17, 1912.

their limitations, and it is to a brief consideration of both that attention is invited.

The subject of bacteriologic diagnostic aids in acute otitic disease and its complications may be subdivided as follows:

1. Bacteriology of acute middle ear infection and its complications. (a) Types of infection and relative frequency of each. (b) Prognostic significance of the respective types.

2. Bacteriology of secondary infection of blood current following acute otitic disease. (a) With sinus thrombosis. (b) Without sinus thrombosis.

3. Value of blood culture in diagnosis. (a) Positive cultures. (b) Negative cultures.

4. Conclusions.

1. Bacteriology of acute middle ear infection and its complications.—Modern literature quotes the result of an exceedingly large number of investigations concerning this point, and while observers vary more or less in experience as to the relative frequency of one or other type of infection, the general opinion is fairly uniform. All bacteriologists in this field appreciate the difficulties of differential diagnosis in spread specimens made immediately after paracentesis, and the advantage of a culture made in addition to the spreads is obvious.

- (a) Types of infection and relative frequency of each.—The order of relative frequency of infection is found to be as follows: *Streptococcus*, 50 per cent; *staphylococcus aureus* or *albus*, 14 per cent; *pneumococcus*, 14 per cent; *streptococcus mucosus*, 10 per cent; and the remaining 12 per cent showing no organism or one or other of the following: *Proteus* group, colon group, diphtheria bacilli, anerobic organisms and unidentified bacteria. Approximately 20 per cent of the specimens show mixed infections which seem least common with *pneumococci* and next with *streptococci*. These figures agree in the main with those of Libman¹ and others quoted by him, excepting a somewhat larger relative number of *staphylococcus* infections. This would seem explained by the fact that the figures were obtained in private and not hospital practice.

- (b) Prognostic significance of the respective types.—Impartial consideration favors the view that, while a prognosis cannot be based on the nature of the infecting organism, some infections are more liable to produce complications than others. The *streptococcus* is certainly the most frequent invader

of the mastoid and deeper structures. The streptococcus mucosus and the staphylococcus are next in the order of frequency, the former, however, usually produces a far more virulent process. The pneumococcus, it was believed, rarely caused mastoid involvement and has never been seen in sinus thrombosis by some. With due regard to the difficulty in differentiating streptococci and pneumococci, this cannot be held to explain the publication of cases of pneumococcus bacteremia of otitic origin with and without sinus thrombosis.

While Netter, Jürgens, Leutert and others strongly maintain that the streptococcus is the only organism which causes pyemia, Hasslauer² mentions six cases of pneumococcus sinus thrombosis in a series of fifty-four cases, and one case of the Friedlander organism in the same series. He also quotes cases of Zaufal, Brieger, Condamnin, and Weichselbaum.

Urbantschitsch³ also credits Brieger with the statement that pneumococcus bacteremia occurs as the result of otitic disease with and without sinus thrombosis, and that it gives rise to multiple suppurations in the various organs.

Dench,⁴ Alexander,⁵ Rolly⁶ and Hoffman⁷ also describe interesting cases.

It does not seem reasonable to suppose that the pneumococcus is less virulent in the ear than elsewhere, and there is ample evidence of its tendency to general systemic infections in the communications of Desguin,⁶ Meyer,⁹ Carr,¹⁰ Adams¹¹ and Claude Sourdél.¹²

2. Bacteriology of secondary infection of blood current following acute otitic disease.—The most frequently encountered organism in the blood stream is the streptococcus; the next in order of frequency is the staphylococcus; third, the streptococcus mucosus, and finally the pneumococcus. In other words, the relative frequency of the different organisms in causing general systemic infection is nearly the same as that noted in the original extension of the inflammatory process. This relative frequency must not be confused with the relative severity or virulence of the resulting infection.

The virulence of the infection cannot be gauged by the organism any more than can the probability of extension, but in a general way it may be said that the streptococcus mucosus is the most virulent, with the other more frequent ones in the

following order: Streptococcus, staphylococcus, and pneumococcus.

The manner in which the infection gains access to the general circulation is still the subject of more or less controversy.

(a) General infection with sinus thrombosis.—It is generally recognized that certainly in the majority of instances a sinus thrombosis is the direct cause of the general systemic infection when this follows acute otitic disease. Otologists have mapped out a fairly clear clinical picture of this complication, and its prompt and accurate recognition is the rule rather than the exception. In the exceptional instances, however, where the clinical evidence is not typical and where there is a suspicion of intercurrent disease, not due to the otitic infection, the bacteriologic aids undoubtedly offer assistance. Unfortunately the claim that a bacteremia indicates thrombosis, and the absence of a bacteremia indicates the probable absence of involvement of the sinus, has too many exceptions to make it a practical working rule. Oppenheimer's¹⁶ belief that a persistent streptococcemia in cases of chronic middle ear disease indicates an infected sinus thrombosis, quite agrees with personal experience and has the support of the majority of observers, but this does not hold good in acute otitic disease.

(b) General infection without sinus thrombosis.—Laboratory experience coupled with accurate clinical description offers ample evidence that, while sinus thrombosis is the most frequent manner of invasion of the general circulation, still, general infections do occur without sinus thrombosis, as shown by positive blood cultures and metastases without the characteristic symptoms of thrombosis of the sinus. In a number of cases of this kind, with local attention to the pyemic abscesses, close observation failed to show clinical evidence of sinus thrombosis, and with gradually decreasing bacteremia full recovery resulted without exploration of the sinus. On the whole, general infections without sinus thrombosis often end fatally, irrespective of the type of infection. While Leutert,¹⁸ Jansen, Schencke, Heine and others maintain that a sinus thrombosis is the only origin of otitic pyemia, the experience detailed above is supported by accumulating evidence in recent literature that an infection of the general blood stream can occur without involvement of the sinus, and in this connection Koerner's description of osteophlebitic origin is note-

worthy. While such infection without sinus involvement is admittedly infrequent, it seems unreasonable to infer improper observation on the part of those describing it, as Jansen and others would have us believe.

Hoffman¹⁴ reports a case of double mastoid involvement of meninges and pyemic abscesses without involvement of sinus or jugular bulb. Chmourlo¹⁵ also opposes Leutert's theory with the statement that the two types of otitic pyemia are met with, and that the infection without sinus thrombosis occurs through the lymphatics. Urbantschitsch⁸ also believes that a general infection of lymphatic or osteophlebitic origin may occur without sinus thrombosis, and supports Koerner in distinguishing between otitic pyemia with and without sinus phlebitis, claiming that sinus thrombosis is more apt to occur in the chronic cases. He describes in detail a general bacterial infection where death occurred nine days after the onset of the acute otitis with rapidly increasing staphylococcus bacteremia, persistently high temperature without chills or remissions and no metastatic foci. On autopsy, characteristic lesions were found in the heart, kidneys and retina, with perfectly normal sinuses. H. Luc,¹⁷ Rimini,¹⁸ Gilbert,¹⁹ Zebrowski,²⁰ F. Müller,²¹ Wild,²² Kobrack²³ and others all describe cases which seem to distinctly demonstrate general infection without affection of the sinuses. Hayman²⁴ undertook extensive experimental work in the matter of sinus thrombosis and otogenic pyemia, and many of the results may be of distinct clinical value, as follows:

1. Experimentally, infectious sinus thromboses are best produced by way of the external wall of the sinus, through the application of an infected tampon.

2. The agents may reach the blood current without mediation of a thrombosis. The formation of a thrombus at the site of the infection is not absolutely necessary for the occurrence of an otogenic pyemia.

3. The thrombi may contain bacteria from the start, the agents as a rule having entered from the outside; but they may have been derived from the blood.

4. The contents of the thrombi in bacteria are variable; the ends as a rule are poorer in bacteria.

5. It is a noteworthy fact that the experimental infectious sinus thromboses show a pronounced tendency towards a spon-

taneous cure. The organization processes start at any early stage. At the end of about seventeen or eighteen days, originally infectious thrombi had become organized, or recanaliculated, although in some cases the external sinus wall had been completely destroyed by the infection.

6. From the macroscopic behavior of the sinus wall no positive conclusions can be drawn as to the sinus contents, nor does the macroscopic appearance of a thrombus afford any information as to its benign or malignant character.

7. Aseptic interventions upon the sinus do not lead to thrombosis.

8. In the presence of experimental bacteremia, aseptic interventions upon the sinus, which are otherwise tolerated without any harm, were observed to lead to extensive thrombosis.

He concludes that direct invasion of organisms into the blood current is certainly possible without sinus thrombosis, and adds that surgical intervention upon the normal sinus, if a bacteremia exists, will be followed by thrombosis which may seriously complicate the course of the experiment.

Thus the detailed personal experience seems amply supported by clinical and experimental data, and it would seem wrong to assume that infection of the general blood stream cannot occur without sinus thrombosis, though this is without doubt the most common mode of infection.

If sinus thrombosis is to be made a foregone conclusion in general infections of otitic origin, then logically a venous thrombosis of a large vessel near the point of entrance of any infection must be insisted on, and this is far from general experience. The exposure of the sinus and its direct connection with the infected wound is obviously not an indifferent procedure, and for this reason it is important to appreciate that a bacteremia or evidence of infection of the general blood current is not sufficient evidence alone to justify such operative procedure.

3. Value of blood cultures in diagnosis.—In cases of acute otitis without or with mastoid involvement, irrespective of the grade of toxemia, microorganisms are usually not present in the circulation, and blood cultures are sterile. In exceptional instances positive blood cultures are obtained, and owing to the subsequent clinical course and convalescence there is no valid reason to believe that an unrecognized thrombosis

of the sinus existed. This experience is corroborated by Duel and Wright²⁵ and others. As previously detailed, some of the most virulent and rapidly fatal cases of general infection following acute otitic disease occur without involvement of the lateral sinus or jugular bulb, and the bacteremia is accompanied by a train of symptoms quite different from that noted in sinus thrombosis, which should permit a differential diagnosis.

Cases are not uncommon in which an acute otitis develops during an acute infectious disease, such as scarlet fever for example. In an instance of this kind a positive blood culture may be referable to such disease and not to an extension of the otitic infection to the general circulation via the sinus or other channel. Bennecke²⁶ obtained positive blood cultures in 32 per cent of scarlet fever cases. A. Knyvett Gordon²⁷ claims that the ear infection in scarlet fever may be through the general blood stream. The postmortem investigations of Strauch²⁸ may be of interest in this connection. He demonstrated streptococci in the blood in 79 per cent of cases of scarlet fever. In measles the blood contained bacteria in 64 per cent. In diphtheria, organisms were found in the blood in 45 per cent of the cases. In meningitis from all causes 50 per cent had positive blood cultures. In propagated meningitis, half the cases being due to ear infections, organisms were found in the blood in over 84 per cent, pneumococci and staphylococci being the predominating types. An extension of the infection to the general circulation may also result from a secondary meningitis, a brain abscess, an extradural abscess, or even from a metastatic focus in a distant part of the body. It is essential to remember that these are exceptional instances, but they seem to demonstrate that a positive blood culture must not be accepted alone as positive evidence of a sinus thrombosis.

In the large majority of cases an infection of the general circulation following acute otitic disease means a thrombosis of the sigmoid sinus, but the bacteremia is accompanied by classic clinical symptoms as described by McKernon,²⁹ and the diagnosis rests on these symptoms in the presence of a bacteremia and not on the bacteremia alone.

(a) Positive cultures.—A positive blood culture following acute otitic infection indicates a general systemic infection of otitic origin, excepting the instances where the bacteremia is

due to a current infectious disease, scarlet fever for example, or possibly to a complicating infection in another part of the body, pneumonia for example. Finding the same organism in the blood that was previously demonstrated in the ear is corroborative but not necessarily positive proof of otitic general infection. As streptococci are often found in the blood in scarlet fever, a streptococemia found with a complicating otitic infection in this disease cannot necessarily be ascribed to otitic origin of the general infection. Positive cultures with a clinical picture of pyemia usually indicate thrombosis of the sinus and form the large majority of the general infections of otitic origin in which metastatic foci are common. Positive cultures with a clinical picture of septicemia indicate a general infection without thrombosis of the sinus and are exceptional. Metastatic foci are rare. Some are quite mild infections and are overcome without difficulty. Others are most virulent and rapidly fatal with characteristic lesions in the heart, kidney, spleen and other organs.

(b) Negative cultures.—While negative blood cultures are uncommon when sinus thrombosis has occurred, they are possible, and for this reason repeated cultures are essential if suspicious clinical symptoms exist. McKernon³⁰ states that in the presence of typical clinical symptoms of sinus thrombosis it is not always wise to wait for a positive blood culture; at the same time the routine use of blood cultures would probably often avoid unnecessary sinus exploration.

A thrombus may be quite firm and may contain but few organisms, and even, if infected to a greater extent, its firm character may prevent infection of the general blood stream. It is also possible for detached portions of an infected clot to cause metastatic foci in distant parts of the body without infecting the general circulation. When suggestive symptoms occur, a negative blood culture may for the moment be used as an argument against sinus thrombosis, but if these symptoms continue, repeated cultures are necessary, as previously stated, and the former negative culture can have no weight whatever in the diagnosis.

4. Conclusions.—Acute otitic infections are due chiefly to the streptococcus, with the other more common organisms in the following order: Staphylococcus, pneumococcus, streptococcus mucosus, etc., A prognosis concerning the probability

of extension or virulence of the infection is not justified by the type of infection. A bacteremia denotes infection of the general blood current, but in itself is not sufficient for a diagnosis of sinus, bulb or vein involvement. While sinus thrombosis is the most frequent cause of positive blood cultures in the cases under consideration, exceptions are too frequent to justify such conclusion. Cases of bacteremia with and without sinus phlebitis present different clinical pictures, and the positive blood culture does not aid in the differential diagnosis. Negative blood cultures do not necessarily exclude a sinus thrombosis, and suggestive symptoms should call for repeated cultures. Intercurrent diseases or complications of the original causative disease with fever may occur during the course of the otitic infection. The blood cultures may aid in the differential diagnosis as detailed, but careful clinical observation and other laboratory aids as indicated are often of even greater service. Acute articular rheumatism shows a negative blood culture, while a pyemic joint is usually associated with a bacteremia. Pneumonia is usually accompanied by characteristic physical signs, and possibly a bacteremia of other type than the otitic infection. Typhoid shows a leucopenia and relative lymphocytosis, with possibly characteristic organisms on blood culture and a positive Widal reaction; while an extension of the otitic infection shows a leucocytosis and relative polynucleosis, with possibly a positive blood culture of the organism found in the ear. Tuberculosis also shows a leucopenia and relative lymphocytosis, and even a positive diazo reaction at times, but the blood cultures are sterile and a von Pirquet may be positive. Fluctuating temperature, headache and local neuralgia, due to an unrecognized acute nephritis, may develop during the convalescence of a scarlet fever mastoid. As a streptococcemia is not infrequent in this disease, its discovery might lead to a diagnosis of sinus phlebitis, if the rule is accepted that a bacteremia invariably indicates this condition. The value of the leucocyte count, particularly of the differential count, in surgical otology, as previously detailed by McKernon⁸¹ and myself,⁸² has recently been employed by Urbantschitsch⁸³ in a careful analysis of seventy-five cases. He also attaches much importance to the determination of the coagulation period of the blood, and details twenty-three cases. In all cases with sinus thrombosis the coagulability was increased,

whereas in those with general infections without sinus thrombosis, the coagulability was retarded.

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