

Section of **Odontology**

President—A. H. PARROTT, O.B.E., M.D.S.Birm.

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Bacteriæmia and Oral Sepsis

By S. D. ELLIOTT, M.B.

ABSTRACT.—Transient streptococcal bacteriæmias are a frequent sequel to dental extractions especially when the mouth is the seat of severe chronic gum infection. Bacteria may also gain admission to the blood-stream in such cases irrespective of operative procedures and probably as the result, in many instances, of minor degrees of gum injury such as is produced by biting on a loose tooth. Acute apical infections do not appear to be especially associated with blood infection of this kind, the focus of infection here apparently being effectively “walled off” by the associated inflammatory reaction.

Of the two factors, infection and trauma, involved in the production of these post-operative bacteriæmias, infection appears to be the more important since, when it is marked, very slight degrees of gum injury are sufficient to produce blood-stream invasion. In the complete absence, however, of the type of trauma induced by the “rocking” of a tooth during its removal, extraction may be accomplished without producing a heavy bacterial shower in the blood.

Usually these transient bacteriæmias produce no permanent ill-effect, but there is some evidence that, occurring in subjects with abnormal heart valves, they may lead to subacute infective endocarditis. Thirteen cases are reported where the valvular infection appeared to result from a post-operative dental bacteriæmia.

Prevention of such bacteriæmias may be achieved by the reduction or elimination of infection and trauma. Complete elimination of the gum infection is difficult although preliminary treatment of the gum margin by some measure such as cauterization may lessen it and lead to a reduction of the post-operative bacterial shower. Similarly, by manipulating an infected tooth as little as possible during its extraction the incidence or degree of blood infection may be decreased.

RÉSUMÉ.—Les extractions dentaires sont souvent suivies de bactériémies streptococciques passagères, surtout en présence d'une infection grave chronique des gencives. Les bactéries peuvent aussi atteindre la circulation indépendamment de toute intervention chirurgicale, probablement souvent comme suite de légers traumatismes des gencives, tels que ceux qui se produisent en mordant sur une dent branlante. Les infections apicales aiguës ne semblent pas être associées spécialement avec ces bactériémies, car le foyer d'infection semble être “*emmuré*” par la réaction inflammatoire qui les accompagne.

L'infection semble être le plus important des deux facteurs, l'infection et le traumatisme, qui produisent ces bactériémies, car, si l'infection est grave, un traumatisme très faible des gencives suffit pour amener l'invasion du sang. Toutefois, dans l'absence complète du traumatisme produit par le “*balancement*” d'une dent pendant l'extraction, l'opération peut être accomplie sans produire d'émission sérieuse de bacilles dans le sang.

En général ces bactériémies passagères ne produisent pas de dommage permanent, mais il y a des raisons pour croire que quand elles surviennent chez des sujets avec des valvules cardiaques anormales elles peuvent être suivies d'endocardite infectieuse subaiguë. L'auteur rapporte 13 cas où l'infection valvulaire semble être la suite d'une bactériémie dentaire post-opératoire.

Ce genre de bactériémie peut être évité par la réduction ou l'élimination de l'infection et du traumatisme. L'élimination complète d'une infection gingivale est difficile, mais celle-ci peut être diminuée par des mesures préliminaires telles que la cautérisation du rebord gingival, ce qui diminue l'émission postopératoire de bactéries. La fréquence et la gravité de l'infection du sang peuvent également être diminuées en évitant toute manipulation inutile d'une dent infectée pendant son extraction.

ZUSAMMENFASSUNG.—Zahnextraktionen werden häufig von einer vorübergehenden Streptokokken-Bakteriämie gefolgt, besonders bei schweren chronischen Zahnfleischinfektionen. In solchen Fällen können Keime auch unabhängig von operativen Eingriffen den Blutstrom erreichen, öfters wahrscheinlich infolge leichter Zahnfleischverletzungen, wie sie beim Beissen auf einen lockeren Zahn vorkommen. Akute Apikalinfektionen scheinen nicht besonders mit Blutinfektionen dieser Art einherzugehen da der Infektionsherd anscheinend durch die begleitende entzündliche Reaktion "abgesperrt" ist.

Von den beiden Faktoren, Infektion und Verletzung, die diesen postoperativen Bakteriämien zugrunde liegen, scheint die Infektion der wichtigste zu sein, da bei starker Infektion ganz geringe Verletzungen genügen, um eine Blutinvasion zu erzeugen. Bei völliger Vermeidung von Verletzungen, die durch "Schaukeln" eines Zahnes während der Extraktion erzeugt werden, kann die Extraktion ohne grosse Ausschwemmung von Bakterien in das Blut ausgeführt werden.

Während diese vorübergehenden Bakteriämien gewöhnlich keine Dauerschädigungen zur Folge haben, können sie bei Kranken mit abnormen Herzklappen nachgewiesenermassen zu subakuter infektiöser Endokarditis führen. Es werden 13 Fälle mitgeteilt, bei denen die Herzklappeninfektion anscheinend die Folge einer postoperativen dentalen Bakteriämie war.

Solche Bakteriämien können durch Verminderung oder Beseitigung von Infektion und Trauma verhütet werden. Eine restlose Beseitigung der Zahnfleischinfektion ist schwierig, obwohl sie durch Vorbehandlung des Zahnfleischrandes mittels Kauterisation oder einer ähnlichen Methode vermindert werden kann, so dass die postoperative Ausschwemmung von Bakterien vermindert wird. In ähnlicher Weise können die Häufigkeit und die Schwere der Blutinfektion durch möglichst geringe Manipulation bei der Extraktion eines infizierten Zahnes vermindert werden.

Sources and Contributory Factors in Production of Bacteriæmia

THE conception of bacteriæmia, that is, the presence of bacteria in the blood-stream, has for long provided a convenient working hypothesis in explaining the mechanism by which secondary infective lesions are produced in the body at a distance from a single primary focus; yet it is remarkable in how comparatively few instances in these conditions there is direct bacteriological evidence of blood-stream invasion. In conditions where an infective process is in intimate relationship with the blood-stream—as in an acute suppurative thrombophlebitis—it is easy enough to imagine how a bacteriæmia will occur. In more chronic conditions, however, when a local inflammatory reaction has resulted in an attempt by the surrounding tissues to "wall off" the focus of infection, ingress of bacteria into the neighbouring blood-vessels and thence into the general circulation cannot always be assumed to occur in the absence of some other contributory factors.

Experimental work with animals summarized by Haines (1937) has shown that bacteria are frequently to be found in the blood without apparently producing any ill-effects. The organisms often gain entrance into the blood-stream from some part of the alimentary tract and contributory factors influencing the production of a bacteriæmia have been found to be starvation, fatigue, and the nature of the diet. Similar apparently innocuous bacteriæmias have been observed in man although here the determining factor has usually been observed to be trauma applied to a focus of infection. Seifert (1925) investigated a large series of cases in which there had been interference, either operation, re-examination of wounds, or changing of dressings in an infected area. Transient blood-stream infections were shown to occur in 45 out of 78 acute infections but in only 12 out of 67 chronic infections. It is worthy of note that he found operations on bones to be especially liable to be succeeded by a

bacteriæmia. Similarly Lehmann (1926) recovered bacteria, in this case *Cl. welchii*, from blood cultures made immediately following curettage in 18 out of 100 consecutive abortions, while Barrington and Wright (1930) showed that manipulations of the urinary tract, such as are produced by the passage of a catheter in the presence of infection, frequently lead to invasion of the blood-stream by *B. coli*.

Blood Cultures following Dental Extractions

The mouth provides a focus of infection frequently exposed to minor degrees of injury which might be expected to lead to bacterial showers in the blood. The evidence for the occurrence of bacteriæmia following tonsillectomy is rather conflicting although I have recently concluded an investigation on this point, as yet unpublished, which has convinced me that blood-stream infection does, indeed, frequently occur. In 1935, Okell and I published a report on the result of blood cultures made in a series of otherwise normal subjects immediately following dental extractions. 138 patients were investigated in this way, blood for culture being taken from an arm vein immediately before and within five minutes following operation. It is not easy to classify the different varieties of oral sepsis, gum and apical infections being rarely mutually exclusive conditions. Our cases were therefore divided roughly into three groups, A, B, and C, according to the severity of the gum infection and the number of teeth extracted.

TABLE I.—STREPTOCOCCAL BACTERIÆMIA FOLLOWING EXTRACTION OF TEETH IN 138 CASES.

Case group	Type	Cases examined	Result of blood culture after extractions	Streptococcal colony counts. Average of aerobic and anaerobic cultures				
				<1 c.c.	1-5 c.c.	6-10 c.c.	11-15 c.c.	>15 c.c.
A	Marked gum disease ; multiple extraction	40	30+ 10- (75%+)	5	17	2	2	4
B	Moderate gum disease ; multiple extraction	60	42+ 18- (70%+)	14	21	4	1	2
C	Without detectable gum disease ; extraction of one or more teeth	38	12+ 26- (34%+)	3	9	—	—	—

+ indicates that streptococci were present in the blood culture.

- indicates that no streptococci were present in the blood culture.

c.c. = per cubic centimetre.

In Group A, those considered to be of a severe type of oral sepsis and in which a massive extraction was carried out, the post-operative blood cultures from which streptococci were recovered reached as high a figure as 75%, while in Group C, comprising patients without obvious gum infection but in whom one or two teeth were extracted on account of caries, positive cultures were obtained in 34% of cases. The organisms recovered from the positive blood cultures were nearly always streptococci of the non-hæmolytic type. The bacteriæmia was apparently quite transient : In 10 cases when a positive culture was obtained directly after extraction, a third specimen was taken at a period varying from ten minutes to eight hours after operation. After these intervals the blood was always found to be sterile.

Bacteriæmia in Relation to Dental Sepsis

The most unexpected and, in our opinion the most interesting, of our findings, was that in 12 cases streptococci were recovered from a specimen of blood taken before operation. All these cases were of a severe type of gum infection. We never isolated organisms from the blood taken before operation in the group of 38 clean

cases, Group C, or from control blood cultures from a group of 30 healthy young adults. Thus, in 110 cases of pyorrhœal disease 12 (10.9%) were found to have a streptococcal bacteriæmia irrespective of operative procedure. In three instances where streptococci were found in the blood both before and immediately following operation, a third specimen was taken one to six hours later, but was then always found to be sterile. One imagines that the inflammatory reaction following upon extraction closes down the field of absorption of organisms from which there had probably been a previous intermittent leakage into the blood-stream.

These results as regards bacteriæmia both before and following dental extraction have since been confirmed by numerous other workers. (Fish and Maclean, 1936, Round, Kirkpatrick and Hails, 1936, Southworth and Flake, 1938, Bulleid, A. (unpublished observations)).

Blood Cultures following Dental Manipulation

We were impressed throughout by the importance of the degree of manipulation of the teeth during extraction in determining to some extent the degree of bacteriæmia following operation and we suggested that mastication or brushing the gums might lead to a similar result. With the help of Mr. Dudley Buxton and Mr. Sinclair at University College Hospital and Mr. Rumsey and Mr. Smith at Addenbrooke's Hospital, Cambridge, I have recently been engaged in trying to establish the least degree of dental injury necessary to produce a blood-stream infection. In this way I hoped to find some link between our pre- and post-operative bacteriæmias. In this investigation two blood samples have been taken *before* extraction, before and immediately after "rocking" one tooth with forceps.

TABLE II.—STREPTOCOCCAL BACTERIÆMIA FOLLOWING DENTAL MANIPULATION.

Type of case	Number of cases examined	Result of blood-culture after "rocking" one tooth
Marked gum disease	21	18 (streptococci present) 3 (streptococci absent) 86% (streptococci present)
Without detectable gum disease	20	5 (streptococci present) 15 (streptococci absent) 25% (streptococci present)

The result in the case of septic mouths has been to produce a streptococcal bacteriæmia in 18 out of 21 cases investigated, i.e. 86% of cases. One of these cases had a positive blood culture before as well as after manipulation. In the case of clean mouths when one carious tooth has been "rocked", five out of 20 cases (25%) have shown positive blood cultures after manipulation.

Blood cultures before dental manipulation.—In one case of severe gum infection streptococci were isolated from the blood sample taken before as well as after manipulation of a tooth. Eighteen cases of this group had sterile blood cultures before operation and in two cases blood samples were obtained only following manipulation; streptococci were recovered from one of these cultures, the other being sterile. Of the 20 cases without gum infection, blood samples were taken before manipulation from 11 only; all these cultures were sterile although streptococci were isolated from four following manipulation.

Bacteria other than streptococci isolated from blood samples taken before and after dental manipulation.—In three out of the 21 cases of marked gum disease, *Staphylococcus albus* was recovered in addition to *Streptococcus viridans* from the blood after manipulation of a tooth. In another case of this group diphtheroids were isolated in addition to streptococci. Organisms other than streptococci were never isolated from the blood of the cases without gum diseases.

The type of case in which a bacteriæmia has been induced with the greatest consistency has been that in which there was severe gum infection with "pocketing"

and the teeth loose to start with. In one such case a loose premolar was subjected to two lateral movements, an excursion of about $\frac{1}{8}$ in. The amount of tissue damage must have been minimal, yet a bacteriæmia was produced. It is thus easy to imagine that very slight degrees of trauma in a mouth the subject of marked gum infection are sufficient to produce blood invasion. Round, Kirkpatrick and Hails (1936) have indeed, reported positive blood cultures in two out of 10 cases following the chewing of hard sweets; this result was only produced in the subjects of marked infection. It would appear that of the two factors—infection and trauma—necessary in the production of this type of bacteriæmia, infection is the more important since it has been shown in the foregoing experiments that by reducing the degree of gum infection and inducing a constant or possibly increasing degree of trauma (since the manipulation of a carious tooth in an otherwise clean mouth usually produces more tissue damage than that of a loose tooth in a pyorrhœal mouth) the bacteriæmia rate following manipulation has been reduced from 86 to 25%. If, on the other hand, we consider cases when the degree of infection is approximately similar but where the degree of trauma to the tissues is varied, there is no comparable variation in the incidence of post-traumatic bacteriæmia. In the case of *massive* extractions in severe gum infection, bacteriæmia followed in 75% of cases; while following the manipulation of a *single* tooth in a similar case group, 86% yielded positive blood cultures. This increase in the latter group was probably due to an improved blood culture technique (Elliott, 1938), which was adopted in the manipulation experiments.

Acute apical infection.—A second line of inquiry resulting from this work has been to determine the relative importance of various types of dental infection in their relationship to blood-stream invasion. Chronic apical and surface infections are, I believe, rarely mutually exclusive conditions and cannot be easily studied apart from each other. Acute apical infections, however, do occur fairly frequently in otherwise clean mouths, and I am at present investigating the incidence of bacteriæmia in relation to this type of infection. So far, only 12 cases have been investigated, but positive blood cultures following manipulation and extraction of the tooth have been obtained in only four out of 12 cases examined, an incidence no greater than that obtained following the removal of one or two carious teeth from a clean mouth. Non-hæmolytic streptococci were recovered from the blood on three occasions and *Staphylococcus albus* once. Apparently the acute inflammatory reaction “walls off” the infected focus from the general circulation in the same way that after massive extractions it closes down the field of absorption.

Blood cultures before operation.—In one instance *Staphylococcus albus* was isolated from the blood sample taken before operation, the post-operative culture from this case being sterile. The pre-operative cultures from the remaining 11 cases were sterile.

The Remote Effects of Bacteriæmia of Oral Origin

It may be asked whether these transient bacterial invasions of the blood-stream are of any pathological significance. As regards their remote effects, they usually produce no ill result unless there is some pre-existing abnormality of an organ or tissue, such as a joint or heart valve, which renders it more than normally liable to infection. There are, I believe, orthopædic surgeons who are unwilling to allow their patients to undergo dental operations whilst the subject of acute joint lesions. There is some evidence that bacterial infection of the heart valves may follow dental operations, especially where there has been some pre-existing valvular abnormality either as the result of a congenital defect or rheumatic infection (Rushton 1930, Abrahamson 1931). What appears to be a significant proportion of patients with subacute infective endocarditis date the onset of their immediate illness from some dental operation. Of course, one has to be wary in the interpretation of such histories since dental operations are

common and subacute endocarditis correspondingly rare amongst the general population; but I should like to bring to your attention a few cases where the history has seemed to me very suggestive.

Subacute Infective Endocarditis following the Extraction of Teeth

Since we published our paper on bacteriæmia and oral sepsis in October 1935, out of 56 patients with infective endocarditis from whom I have received cultures of streptococci isolated from blood cultures, at least 13 gave a history of a recent dental operation preceding the onset of their illness. This does not represent a true index of the incidence of a history of dental operations in these cases since in many instances such information was not sought. Of these 13 cases, however, nine were admitted to hospital with fully developed infective endocarditis within eight weeks and all within six months of dental operations, from which all 13 patients dated the onset of their immediate illness. In seven cases the extractions were massive in character, upwards of six teeth being removed at a sitting. Seven patients had a definite history of pre-existing cardiac disease, which was of rheumatic origin in six and congenital in one; one case had a previous history of chorea.

TABLE III.—SIX CASES OF SUBACUTE BACTERIAL ENDOCARDITIS WITH HISTORIES OF DENTAL OPERATION PRECEDING ONSET OF DISEASE.

Age and sex	Previous cardiac abnormality	Previous dental disease	Dental operation	Interval between operation and onset of symptoms of infective endocarditis
28 years, male	Rheumatic carditis	Pyorrhœa	7 teeth extracted singly at weekly intervals	During dental treatment
40 years, male	Rheumatic carditis	Pyorrhœa	9 teeth extracted at 2 sittings	2 weeks
19 years, female	Patent ductus arteriosus	? pyorrhœa	12 teeth extracted at 2 sittings	Ten days
25 years, female		Caries	19 teeth extracted at 2 sittings	Indefinite < nine weeks
34 years, male	Indefinite	Caries	Dental "filling". Laceration of gum by drill	Two days
59 years, male		? pyorrhœa	9 teeth extracted at 1 sitting	Three weeks

In six cases, a more detailed history was available. These include two out of five cases of infective endocarditis in which post-mortem confirmation of the diagnosis was obtained, admitted to Addenbrooke's Hospital, Cambridge, under Professor Ryle during the last eighteen months. The first of these, a man aged 28 with a rheumatic history, had commenced having teeth extracted, singly and at weekly intervals, three months before admission. During the period of dental treatment he developed joint pains and generalized symptoms. He was admitted with a temperature of 102° F. and a positive blood culture from which a non-hæmolytic streptococcus was recovered. In the second of these cases there was also a history of rheumatism and dental extractions which had been carried out on two occasions eight weeks previously. Six teeth were removed at the first and three at the second sitting, two weeks after which the patient took to his bed. On admission there was marked pyorrhœa with several loose teeth and the man then had a positive blood culture.

For the histories of two further cases admitted to the London Hospital within the last six months, I am indebted to Dr. Rowlands and Dr. Wall. The first, a girl aged 19 with a congenital cardiac defect, gave a history of having had seven teeth extracted three weeks and five teeth two weeks before admission. She had typical signs of subacute bacterial endocarditis, a positive blood culture being obtained two days after admission. The second case, a girl aged 25, had no history of rheumatic fever or congenital heart disease, but three months before admission had 19 teeth removed in two sittings. Since then she had complained of feeling ill and had lost a stone in weight. There was a three weeks' history of joint swellings, and during

her stay in hospital she developed typical signs of infective endocarditis with a positive blood culture.

Dr. D. E. Bedford, of the Middlesex Hospital, permits me to quote two interesting cases, including one of a slightly different type, which were under his care. The first, a man aged 34, had no rheumatic history, but slight "heart trouble" had been recognized since childhood. He was in good health until, while having a tooth drilled by his dentist, the drill slipped and lacerated his gum, after which he suffered severe neuralgic pain in the face and jaw. Two days later he had shivering attacks and went to bed with a temperature of 100° F. He had a positive blood culture from which hæmolytic streptococci were recovered and infective endocarditis was diagnosed from which he succumbed. The second of Dr. Bedford's cases gave a more typical history, the extraction of nine teeth in a man of 59 being followed after three weeks by progressive weakness and loss of weight. The typical signs of infective endocarditis followed, this diagnosis being later confirmed by post-mortem examination which, however, failed to reveal any indication of pre-existing rheumatic valvular disease.

The Prevention of Bacteriæmia of Dental Origin

Can anything be done to prevent these bacteriæmias of dental origin? It seems clear that, occurring in subjects with pre-existing cardiac abnormalities, such blood infections, although transient, entail a definite risk of subsequent valvular infection. Since we know that in severe pyorrhœa slight degrees of dental trauma, such as might be occasioned by biting on a loose tooth, commonly lead to a bacterial shower in the blood-stream, it is apparent that under those conditions there is probably an almost constant intermittent leakage of organisms from the mouth into the blood. Scrupulous attention to oral hygiene would seem indicated, therefore, especially in subjects with any cardiac abnormality. Massive extractions of teeth should not be countenanced in such patients, and when dental extractions are essential, a minimum of manipulation or "rocking" of the tooth with forceps should be employed during its removal. An indication that, by avoiding preliminary "rocking" of a tooth in a badly infected mouth, extraction can be achieved without the production of a demonstrable or, at any rate, a heavy bacterial shower is suggested by two simple experiments that Mr. Dudley Buxton and I carried out. In the first case, one of severe pyorrhœa, an incisor was removed without "rocking" and with a minimum of trauma to the gums; a sample of blood taken for culture immediately after was sterile. Ten minutes later a premolar in the same case was "rocked" with forceps and a further blood sample taken before extraction of the tooth. From this latter blood culture a growth of streptococci was obtained. In the second case, also one of severe pyorrhœa, a loose lower premolar was "rocked"; a quantitative blood culture made immediately after revealed a streptococcal colony count representing approximately 58 organisms per cubic centimetre of blood. After a short interval, eight teeth were extracted from the same patient, with a minimum of manipulation which was possible here since all the teeth were loose to start with; a further quantitative blood culture made immediately after the extractions revealed approximately only five organisms per cubic centimetre of blood. These experiments suggest that the preliminary "rocking" of a tooth is immediately responsible for the subsequent post-operative bacteriæmia which may be reduced or avoided altogether by extraction without manipulation, even in cases of marked gum infection. Fish and Maclean (1936) contend that the organisms found in the blood after dental extractions probably originate in many instances from the heavily infected gum margin whence they are pumped by the mechanical action of "rocking" into the dental pulp, the apical tissues, and general circulation. They suggest, therefore, that the gum infection in the neighbourhood of the teeth to be extracted should be reduced by preliminary cauterization of the gum margin. Mr. Dudley Buxton and I have tried the effect of preliminary cauterization on the production of subsequent post-operative bacteriæmias

but only as yet in an insignificant number of cases. Five cases were treated by preliminary cauterization of the gum margin surrounding a tooth to be manipulated. The actual cautery was used and cauterization made as thorough as possible. Three of these cases gave positive blood cultures after manipulation and in two the blood was sterile. In two of the cases where a sterile blood sample was obtained the tooth involved had been a canine or an incisor, while positive cultures were obtained following cauterization and manipulation of an incisor, a canine, and a premolar.

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Discussion.—Dr. E. W. FISH said the knowledge that a bacteraemia might follow the extraction of a tooth in a case of acute alveolar abscess was of great importance, since that was an emergency operation which one might be called upon to perform on a patient with endocarditis. In cases of simple endocarditis the patient should not be allowed to brush the teeth and gums or chew hard food. In such cases he had been in the habit of packing the interdental spaces very gently with a paste of zinc oxide and oil of cloves on wisps of cotton-wool and changing this dressing every few days. If a tooth had to be extracted the operation was preceded by a dose of prontosil and the gum margins were thoroughly cauterized.

Mr. JOHN BUNYAN said for oral hygiene he advocated rubber instead of bristle brushes. These could not lacerate and did stimulate the tissues. At the same time the patient irrigated the interdental spaces and pockets by using a glass syringe and a weak hypochlorite solution.