the hand was again rendered ischaemic, and kept in that condition with quiescent muscles for ten minutes; the hand became cold, but there was no pain, simple ischaemia having, as described above, no appreciable effect in this respect. Abduction movements of the index finger were then performed as before; there was painful fatigue after about sixty-five movements; the pain was removed as before by readmission of the blood. The usual well-known flushing occurred after the period of ischaemia; sensations of tingling gradually developed somewhat later.

Effects of Continuous Muscular Tension.

Experiments were also performed with the middle finger flexor muscle kept voluntarily contracted to sustain the ergograph weight at a certain level instead of making a series of consecutive lifting efforts as already described; graphic records of the behaviour of the muscle were made. Continuous motor effect failed to preserve the initial level beyond a certain time, which varied according to the weight employed, etc.; then came a general progressive decline, varied by minor irregularities in the slope of the tracing, until after a time the weight sank back to the resting position. This "fatigue" is attended by comparatively little subjective disturbance, even in the ischaemic arm. There was disinclination to keep up the tension of the muscle, which seems to need more and more voluntary effort, with some discomfort and aching—the latter felt chiefly in the upper arm and the finger—probably attributable not to the muscle itself but to the mechanical conditions connected with the fixed position of the limb and pressure on the skin of the finger by the loop at the end of the cord which supports the weight. There is evidently a notable difference as regards pain production between an alternately contracting and relaxing muscle doing mechanical work and the condition of sustained tension necessary to maintain the weight at certain levels. Similar results were obtained with the abductor indicis.

Relation to Pains of Angina Pectoris, Intermittent Claudication, etc.

It need hardly be pointed out that the foregoing observations have a close bearing on the problems associated with the production of the pain of angina pectoris, showing as they do how readily acute pain can be excited in skeletal muscle working with lack of blood supply, the pain developing while the contractile power, though to some extent weakened, is still sufficient to execute movements of considerable range and energy—that is, long before complete fatigue.

There is every reason to believe that processes of the same nature, with a similar production of pain of varying grades of severity, up to the agonizing suffering of fully developed angina, occur in cardiac muscle compelled to work with a blood supply that is inadequate—absolutely or relatively to the amount of work which the arm has to perform. Sir James Mackenzie has emphasized the conception of anginal pain as an expression of exhaustion of the cardiac muscle, commonly associated with a defective coronary blood supply and a susceptible nervous system. He has laid stress on the production of the symptoms of heart failure—pain, breathlessness, giddiness, faintness—as expressions of impaired functions of organs which fail to receive a blood supply adequate to the needs of their normal activities in consequence of a defective output of blood from the heart, the latter itself suffering from insufficient blood supply to its muscular walls; heart failure is thus recognized, not by direct examination of the organ itself, but by the functional effects of diminished blood supply to various organs.

It may be added that the results of the present experiments have an obvious application to the phenomena of the condition called "intermittent claudication," as seen in the legs of men and horses, in which muscular exertion is interrupted by attacks of pain, loss of power, coldness of the limbs, etc. These symptoms can be definitely explained: in consequence of blocking of the main artery, or disease or spasm of the vascular walls, the blood stream has been reduced to such an extent that, while it may suffice to supply the muscles in the resting state, it is quite inadequate for their greater requirements during activity—the results (pain, etc.) of the defective blood supply are of the same nature and mechanism of production as those demonstrable in the ischaemic arm of the healthy subject.

THE CLINICAL, PATHOLOGICAL, AND RADIOLOGICAL ASPECTS OF INFECTION OF THE TEETH AND GUMS.*

BY

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Historical.

SEPTIC absorption from the teeth and gums must date from the earliest period of man's history, for the examination of ancient skulls shows that dental sepsis has ever been present. The clinical symptoms resulting from infection of the teeth and gums must have afflicted the human race during its whole existence, and it is very remarkable that the causation of these symptoms escaped recognition for so long a period. The recognition of the clinical symptoms resulting from oral sepsis is quite modern.

Disease of the teeth and gums was described by H. A. Fauchard in 1740, and from that date much has been written on the subject. In 1875 John T. Riggs gave a full description of the disease in an address read before the American Academy of Dental Surgery on "Suppurative inflammation of the gums and absorption of the gums and alveolar process," and the disease "pyorrhoea alveolaris" is often called "Riggs's disease."

The next advance in knowledge resulted from the development of bacteriology and its application to the investigating of the varieties of organisms causing dental sepsis. Galippe and Professor Miller did valuable pioneer work in this respect from 1884 to 1894. The work of Pasteur and Lord Lister on the great influence of bacterial infection in the causation of disease prepared the way for the recognition of the far-reaching effects of the toxic absorption resulting from the organisms found to be associated with dental infections.

Dr. William Hunter, a distinguished Fellow of this Society, was the pioneer amongst physicians in recognizing "the relation of dental diseases to general diseases," and he read an important paper bearing this title before the Odontological Society of Great Britain in 1900. It is not too much to say that the appreciation to-day of dental sepsis as one of the commonest and most important causes of general diseases is very largely due to the unceasing and untiring work of Hunter in this department of medicine.

The Bacteria Causing Infection of the Teeth and Gums.

Professor Miller of Berlin in 1900 carried out a series of brilliant researches on the bacteria found in connexion with dental infections. He found no less than twenty different bacteria in twelve cases of pyorrhoea; amongst them were streptococci, staphylococci, bacilli of various kinds, and leptothrix. Recently, J. McIntosh, Warwick James, and P. Lazarus-Barlow have isolated a bacillus which they believe to be the cause of dental caries and have named *Bacillus acidophilus odontolyticus*.

In this discussion we are mainly concerned with the organisms occurring in dental infections, the absorption of which, or their toxins, gives rise to general disease. There seems to be no doubt that it is the streptococcus infections which are almost entirely responsible. The streptococci found in mouth infections are usually classified into three groups, from their behaviour when grown on media containing blood.

1. *The Haemolytic group* cause severe toxæmia, and are found in the anaemias resulting from dental sepsis.

2. *The Viridans group* includes those streptococci which are associated with rheumatic affections. *Streptococcus salivarius* and *S. faecalis* belong to this group. They are both toxic, producing general toxæmic symptoms, and may give rise to arthritis, fibrositis, and other rheumatic affections. Arthritis and cardiac lesions have followed the inoculation of rabbits with the living organism in either case. Each of them has been found in malignant endocarditis.

3. *The indifferent group of Streptococci* are not toxic to guinea-pigs, and their association with rheumatic conditions is doubtful.

4. *Gram-negative cocci* are found associated with dental infections, but they are not usually toxic, and some of these types have probably been described as staphylococci in earlier writings.

* Paper read to open the discussion held at the Medical Society of London, December 11th, 1922.

5. *Staphylococci* are not usually found in dental infections, but often in the post-nasal space.

In the infections of the teeth and gums the same streptococcus is not necessarily found in different cases, nor can the local disease be constantly transmitted from an infected patient by inoculation of the healthy gums of another person; so that Koch's postulates of a specific infection are not satisfied. The infecting organisms are variable and the infection may be mixed, so that the problem of dental sepsis is a complicated one.

Evidence for the Conclusion that the Teeth and Gums are the Source of Infection.

It must not be hastily assumed because a patient is suffering from symptoms such as arthritis, fibrositis, anaemia, or some affection which is commonly associated with dental sepsis, that the teeth are the cause of the illness. Every case must be approached with an open mind and no preformed opinion.

There are many other foci of infection which may produce diseases identical with those resulting from dental sepsis; in other words, a streptococcal toxæmia may be due to a great many causes other than dental. Thus the tonsils, the nasopharynx, the intestine, and the urogenital tract may all be foci of infection for pathogenic streptococci or other organisms. Careful examination should always be made to determine if these other foci of infection may safely be excluded.

The practice of extraction of apparently healthy teeth merely because a patient is suffering from a disease which is often due to a dental infection cannot be too strongly condemned. There should always be strong evidence that the teeth are primarily and directly responsible for the disease in other organs before their extraction is justifiable.

The Signs of Unhealthy Conditions of the Teeth and Gums.

The presence of gingivitis is shown by an unhealthy spongy condition of the gums, which bleed readily and have a congested free margin. Often congested hyperplastic projections occur between the teeth. These are particularly well marked in scorbutic conditions and have been described as "buds." Tartar and dirty collections may be present between the free surface of the gums and teeth. Pressure on the gums may cause pus to ooze up from between the gums and teeth if pyorrhoea is present. Local swellings of the gums due to periosteal abscess may occur. The teeth themselves may show marked caries with gingivitis around them. An important clinical symptom often present is a sweet sickly smell of the breath.

In a large number of patients who habitually clean their teeth carefully little or no evidence of a dental infection can be found from an external examination; this point cannot be too strongly emphasized. On many occasions I have seen teeth and gums, apparently perfectly healthy, in which radiographic examination disclosed dangerous peri-apical necrotic lesions. Sir Frank Colyer truly says, in his book on *Chronic General Periodontitis*:

"It is not safe to judge the extent of the disease from clinical appearances only, and it is necessary to call in the aid of skiagraphy in order to ascertain how far bone destruction has proceeded."

The gums may appear healthy, and yet there may be an extensive disease of the alveolar process around the roots of the teeth, and considerable bone destruction, the involved area being heavily infected with pathogenic streptococci. The grave clinical effects resulting from infected bone are well known, and from observation of a large number of cases which have been carefully investigated by bacteriological and radiological methods I am strongly of opinion that the general clinical effects produced by dental infections are accounted for by the extent and nature of the disease of the bone in the neighbourhood of the teeth, rather than in the gums or teeth themselves, though these latter are the primary causes of the bone disease.

It cannot be insisted upon too strongly that in every case of illness in which the teeth may be primarily responsible—even if external appearances of the teeth and gums are healthy—a radiographic examination should be made to ensure that the alveolar process around the teeth is also healthy.

Radiographic Evidence.

Careful photographs of the teeth and surrounding jaw, taken so that two or three teeth only are included in each plate, will show in detail the exact condition of the roots of the teeth and surrounding bone.

The periodontal membrane of a tooth may be swollen, and the alveolus may show superficial erosion, such as occurs with advanced age, but the most important evidence of all is the presence of necrosis of bone in a more or less spherical area around the apex of the tooth.

These apical lesions are commonly called "apical dental abscesses." The term is a bad one, because there is no pus present, and, most important of all, they give rise to no pain. The term "apical granulomata" has been used; this also is bad, because the microscopical appearances are not those of a granuloma.

When a tooth is extracted with an apical dental lesion, a mass of solid gelatinous substance is found adherent to the apex. This contains pathogenic streptococci and necrotic substance with very few leucocytes. The term "peri-apical bone necrosis" would accurately describe the condition actually present.

In my opinion the "peri-apical bone necroses"—the so-called "apical dental abscesses"—are the most serious lesions found in connexion with dental sepsis, and it is these which give rise to the gravest general disease resulting therefrom. It is probable that from these lesions there is a constant flow into the blood stream of either virulent streptococci or their toxins, and the anatomical position of the lesions prevents an adequate supply of leucocytes and bactericidal body fluids to the part.

An interesting example of the deadly effect of even a small peri-apical bone lesion may be cited here.

CASE I.

In 1919 a patient, aged 46, had been under my care for some months, suffering from the effects of long residence in the tropics. He was in fairly good health and then developed an irregular pyrexia. No evidence of malaria was found and the pyrexia did not respond to quinine. A systolic murmur was present in the apical cardiac area, which was of old standing. A blood culture made by Dr. J. Matthews showed a streptococcal infection. Although the teeth had been pronounced perfectly healthy by an experienced dental surgeon an x-ray examination was made, and this revealed the presence of a "peri-apical bone necrosis" round one of the lower central incisor teeth. Extraction of the affected tooth showed a marked infection with streptococci, identical in characters with those found in blood culture. The patient developed additional cardiac valvular lesions and was seen in consultation with me by Sir William Hale-White. The condition was obviously one of infective endocarditis, and this subsequently terminated fatally.

If lesions of this kind are present, the maintenance of health is obviously impossible; some serious general disease is bound to result if it has not already appeared. In my opinion if a lesion of this kind be present no compromise is permissible—the affected tooth must be extracted.

Gardner of America has asserted that extraction of the tooth is not a sufficient safeguard and advises a preliminary trephining of the alveolar process over the peri-apical lesion. The diseased area is then curetted, the tooth extracted, and the infected area sterilized by the application of a suitable antiseptic. In this country the simple extraction of the affected tooth is, I think, considered adequate, and trephining and curettage are not thought necessary.

Where "peri-apical bone necroses" are present the affected tooth is usually dead, and this is an important indication. Attention must here be called to the very common occurrence of this dangerous lesion in connexion with crowned teeth. So common is this occurrence in my experience that I have no hesitation in condemning the procedure of crowning teeth.

Does the Simple Erosion of the Surface of the Alveolar Process around Teeth Call for Extraction?

Each case must be judged on its merits. If there are no obvious symptoms of streptococcal toxæmia, I should say that the answer to this question is No. The presence of gingivitis without bone disease around the teeth should be amenable to treatment and does not necessarily call for extraction.

The presence of pyorrhoea alveolaris does not of itself demand extraction of the teeth. This should only be decided upon after considering the radiographic evidence in conjunction with the local symptoms of pyorrhoea. Also the gravity of the constitutional toxic symptoms resulting from the pyorrhoea will be an important factor. It must be remembered that sometimes pyorrhoea alveolaris may be a secondary symptom of some primary disease, such as dysentery, colitis, scurvy, etc., and if the general disease is cured the cure of the pyorrhoea may follow naturally.

The general factors which influence the effects of dental sepsis are:

1. *The Virulence of the Organism.*—Just as in other pathological infections—diphtheria, for example—a small lesion, if the organism is virulent, may produce very severe effects, or an extensive local dental lesion may give rise to little constitutional disturbance.

2. *The amount of toxins absorbed* into the circulation is an important factor. Everyone who is familiar with hospital out-patient practice has been impressed by the appalling dental sepsis observable by the naked eye in patients with no constitutional symptoms therefrom. The reason must be that there is free discharge of the toxins produced. On the other hand, an invisible deep-seated lesion with healthy gums may be associated with the most severe constitutional effects. The "time factor" is important. If there is only slow absorption the toxic effects will be slighter than with rapid absorption. The whole question is one of dosage with toxin.

3. *The Resistance of the Patient.*—This is a most important factor. Some patients, from constant absorption of toxins, become extremely sensitive, and a condition of anaphylaxis results. The recent work of Sir Almroth Wright on septicaemia is most interesting in this respect, since he has shown that in certain conditions of septicaemia the patient is incapable of developing bactericidal substances. Julius A. Toren of Chicago showed (1921) that in certain cases of dental infection and gingivitis a leucopenia occurred, and he regarded this as an anaphylactic phenomenon and a signal of danger. He concluded that in this condition extraction of many teeth was dangerous, and advised removal of not more than one at a time. This observation has a very important practical bearing.

Secondary Intestinal Infection.

Where dental sepsis is present and it has given rise to general disease, examination of the stool or intestinal washings shows in practically every case a marked preponderance of streptococci similar to those present in the dental lesion. This is an important factor in the consideration of the general effects produced by dental sepsis, for in most of these cases there is a secondary intestinal infection which may of itself cause similar general disease. This explains why in advanced cases of arthritis the disease may progress when the primary dental focus of infection has been eradicated.

The General Diseases caused by Infection of the Teeth and Gums.

Infection of the teeth and gums by reason of the streptococcal infection arising therefrom is undoubtedly one of the greatest sources of disease of adult life.

Acute streptococcal septicaemia and septico-pyæmia have not infrequently arisen from dental sepsis. The risk of this dangerous complication must always be borne in mind in connexion with the extraction of infected teeth in patients whose resistance to streptococcal infection is low. As already mentioned, a leucopenia is a danger signal.

Toxaemia is commonly associated with dental sepsis. It may be chronic, subacute, or acute. Chronic toxaemia is present in a great many of these cases, and in all where some general disease has resulted from the primary dental infection. There is a feeling of malaise and general ill health, a tendency to exhaustion on slight exertion, a pale and muddy complexion is common, and often some general pains in the hands and feet indicate an irritation of the peripheral nerves; frequently some symptoms of fibrositis or threatening arthritis occur. Insomnia, headache, and dyspeptic symptoms are common. In such cases a careful radiographic examination of the teeth should always be made.

Subacute toxaemia may give rise to intermittent pyrexia, with general constitutional symptoms of ill health, extending over months and years.

CASE II.

F., aged 32, recently seen by me, had had an irregular pyrexia for three years, the temperature in the evening commonly being 100° or 101°, and marked constitutional symptoms of ill health were present. Extensive bacteriological investigations had been carried out, with negative result, beyond the finding of a streptococcal infection in the stools. Vaccine treatment had been of no avail. An x-ray examination of the teeth showed two extensive periapical necroses, although to external appearances the gums and teeth were healthy and no toothache had occurred.

Extraction of the infected teeth by Sir Frank Colyer resulted in the complete disappearance of the pyrexia and restoration to good health.

In some cases pyrexia and general symptoms of ill health are followed by profound *acute toxaemia*, and a condition of stupor, delirium, and coma result.

CASE III.

M., aged 57, had had malaise and irregular pyrexia due to septic teeth. In consequence of this six teeth were extracted on July 24th, 1921. The operation was followed by a condition of profound toxaemia, the patient being in a "typhoid state" with pyrexia, stupor, and low delirium; there was slight splenic enlargement and a macular rash.

All tests for enteric or typhus infections were negative, and it was clear that a severe streptococcal toxaemia was present.

On August 8th the patient was in a lethargic stuporose state, with mild pyrexia, and the condition was very grave.

Several unhealthy crowned teeth were still present, and it was decided to remove one of these each day. The removal of the remaining infected teeth was followed by disappearance of the toxaemic condition, and the patient made a complete recovery. Dr. Geoffrey Evans made a most careful study of this case, and we were both of opinion that the removal of the remaining infected teeth, even though the condition was most grave, held out the only hope of recovery.

Local Infective Conditions Resulting from Dental Infections.

Such conditions as stomatitis, tonsillitis, naso-pharyngeal infections, infections of the maxillary antra, cervical adenitis, and Ludwig's angina have been observed.

Blood Conditions.

A secondary anaemia, mild or severe in type, is a common result of dental sepsis. The more severe types of anaemia are associated with streptococci of haemolytic type. In many cases of pernicious anaemia a severe dental infection with haemolytic streptococci is present. Hunter does not regard dental sepsis alone as a sufficient cause of pernicious anaemia, but rather as a predisposing cause to which an additional factor is added.

Leucocytosis is commonly present, and usually the differential count approximates to the normal. It may show variations in different cases, and in the same case at different stages of the disease.

Some acute cases show a marked relative lymphocytosis. This may be a true lymphocytosis, or simply an apparent lymphocytosis, due to a polymorphonuclear leucopenia.

Thus, in one acute case the blood examination on July 22nd, 1922, showed a leucocytosis of 16,600, with 17.5 per cent. of polymorphonuclears and 79.5 per cent. of lymphocytes. On August 3rd the polymorphonuclears were 30 per cent. and the lymphocytes 65.7 per cent. On August 9th the polymorphonuclears were 64.29 per cent. and the lymphocytes 34.28 per cent.

Another similar acute case showed on February 9th, 1921, a normal differential count, and on April 20th the lymphocytes were 52 per cent. and the polymorphonuclears 44 per cent.

An increase of the eosinophilia is uncommon. Two cases, however, have come to my notice.

The first patient (Case I) gave, on August 24th, 1919, 20 per cent. of eosinophile leucocytes; on September 3rd 12 per cent.; on November 22nd 15.05 per cent., and on January 9th, 1920, 8.17 per cent.

Another patient, who had never resided in the tropics, showed 9 per cent. of eosinophile leucocytes in the differential count.

The presence of leucopenia in some cases has already been alluded to.

Cardio-vascular Complications.

Streptococcal infections of dental origin may cause phlebitis and venous thrombosis, and also arterio-sclerosis, which is not necessarily associated with an increase in the blood pressure. The changes in the arterial wall may give rise to narrowing of the lumen with symptoms of intermittent claudication, or even arterio-thrombosis.

Cardiac Conditions.—Tachycardia of toxic origin is often to be observed, and pericarditis, myocarditis, and myocardial degeneration may occur. Endocarditis when present may be of the simple type, such as occurs in acute rheumatism, but not infrequently dental sepsis gives rise to ulcerative endocarditis. Five such cases have been under my care during the past three years, where the origin of the infection appeared to be definitely the teeth.

Respiratory Complications.

The streptococcal infection may give rise to laryngitis, tracheitis, and bronchitis. Pleurisy and empyema were described by Hunter in 1900 as possible complications. Septic bronchopneumonia is a serious and not uncommon complication, and it may be followed by bronchiectasis, or lung abscess.

At the present time a patient is under my care in St. Mary's Hospital suffering from abscess of the lung the result of very severe dental sepsis. Attention has been called to the adverse influence of dental infections in cases of pulmonary tuberculosis by Dr. R. C. Wingfield.² He considers the removal of dental sepsis an essential preliminary in the treatment of pulmonary tuberculosis, and says that in such cases untreated oral sepsis may frequently turn the balance against the patient.

Gastro-intestinal Complications.

Dental sepsis is one of the commonest causes of gastric and intestinal dyspepsia. Hunter in 1839 laid stress on the frequency of toxic or infective gastritis, and he then expressed the opinion that dental sepsis was the probable cause of some cases of that rare condition "phlegmonous gastritis."

Gastric and duodenal ulcer probably result from septic infection, and the trend of opinion at the present time is that dental sepsis is a most important cause. In my experience it is rare to find a case of gastric or duodenal ulcer in which an adequate explanation of the cause cannot be found in the condition of the teeth and gums, and I should say that dental sepsis was much the most important etiological factor. The work of Rosenow in America gives strong support to the view that gastric and duodenal ulcer arise from streptococcal dental infection, and he has produced gastric and duodenal ulcer in animals from inoculation with cultures of human dental streptococci.

Appendicitis is, in many instances, due to a streptococcal infection, and several cases have recently been under my care in which the primary infection appeared undoubtedly to arise from the teeth.

Enteritis, with symptoms exactly like paratyphoid fever, including enlargement of the spleen and similar pyrexia, may undoubtedly result from streptococcal dental infections. The differential diagnosis can only be made by complete bacteriological investigations, and by the recognition of the dental disease for which often radiological examination is necessary. Three cases of this kind have been under my care.

Colitis, simple and ulcerative, is frequently due to a streptococcal infection, and in many of these cases the primary focus is undoubtedly connected with the teeth. Peri-apical dental necroses will often be found in intractable cases of colitis. Dr. N. Mutch³ has called attention to the frequency (84 per cent.) of pathogenic streptococci in the colon in an analysis of 200 cases of arthritis. In 52 per cent. of these cases he concluded that the primary focus was a dental infection.

Renal Complications.

Nephritis has been described by many writers as sometimes resulting from dental sepsis.

Liver Complications.

Toxic conditions of the liver are well known to result from streptococcal infections, and frequently slight jaundice and evidences of hepatic disturbance are observed in cases of dental infection. There can be no doubt that hepatic efficiency is often impaired as the result of the toxæmia from dental sepsis.

Skin Complications.

Rashes of an erythematous, urticarial, papular, and eczematous type have been observed. Purpuric rashes may occur, especially where the streptococci are of the haemolytic type.

Eye Complications.

Conjunctivitis, iritis, irido-cyclitis, episcleritis, retrobulbar neuritis, have all been described as resulting from dental infections. Undoubtedly vascular lesions, such as thrombosis of the central artery or vein of the retina, may be so caused. Of special interest is retinitis. Dr. Batty Shaw has recently called attention to the great importance of the toxic factor in this condition, and undoubtedly dental sepsis is not infrequently the cause.

Nervous Diseases.

The toxæmia from dental infections may give rise to cerebral conditions such as abnormal mental states, melancholia, etc., and it is possible that inflammatory conditions, such as meningitis, may be so caused.

Spinal cord diseases, such as combined sclerosis with its associated anaemia, disseminated sclerosis, etc., are often due to toxic causes, and dental sepsis must be included amongst these.

Peripheral neuritis may occur from the streptococcal toxæmia of dental origin, and the sensory symptoms, tingling, and numbness of the hands and feet are of common occurrence. Local neuritis, such as sciatica, brachial neuritis, etc., is a common result of dental sepsis, but these are better included under the fibrositis group, because the cause is rather a perineuritis than a primary involvement of the nerve fibres.

Rheumatic Conditions.

In a paper published in the BRITISH MEDICAL JOURNAL (June 4th, 1921) I called attention to the great importance of infection of the teeth and gums in the causation of rheumatic conditions such as fibrositis and infective arthritis.

Fibrositis.—The streptococcal infections so arising may give rise to the various forms of fibrositis—namely, panniculitis, inflammatory conditions of fasciae, and aponeuroses—as occurs in lumbago and myalgic conditions; inflammations of tendons and ligaments, such as stiff neck, tender heels due to involvement of the plantar ligaments, Dupuytren's contractions of the palmar fascia; inflammations of tendon sheaths, arterio-synovitis; bursitis; Heberden's nodes; finger pads; fibrous nodules in subcutaneous tissue; local perineuritis and neuritis, as in sciatica and brachial neuritis. Fibrositis in some of its forms is the commonest occurrence in cases of dental and gum infections.

Non-specific infective arthritis, which includes the forms known as rheumatoid arthritis, arthritis deformans, osteoarthritis, and chronic villous arthritis, is generally due to a streptococcal infection. Dr. Beddard, in a paper before this Society in October, 1918, expressed the opinion that 90 per cent. of these cases were due to infection arising from the teeth, and my personal experience agrees with this view.

It is well known that in cases of non-specific infective arthritis numerous bacteriological examinations have shown that no living organisms are to be found in the joints. It is probable that the streptococcal toxins give rise to the inflammatory conditions. The recent work of Dr. W. E. Gye, and Dr. E. H. Kettle has shown that marked proliferative changes can occur in organs such as the spleen, through the action of colloidal silica, without the presence of living micro-organisms.

Acute rheumatism is not commonly caused by dental infections, but several cases have been described. The organism found by Poynton and Paine in numerous cases of acute rheumatism closely resembles the *Streptococcus salivarius* and *S. faecalis* found in dental infections.

Gout.

In some cases of gout dental sepsis is important, and should be removed, as far as possible, in every gouty patient. Dr. Llewellyn has expressed the opinion that gout is the result of a toxic idiosyncrasy to certain toxic protein substances. Undoubtedly the streptococcal toxins of dental origin are in not a few cases the important causative factor.

Diabetes.

Streptococcal and other toxins may cause a toxic glycosuria, probably by impairment of the endocrine function of the pancreas. Dental sepsis is undoubtedly a factor in the causation of glycosuria in some cases, and it should always be removed in cases of diabetes. A rise in the carbohydrate tolerance has often been observed by me after the removal of dental sepsis in early cases of diabetes.

Scurvy.

This disease, due to vitamin deficiency, shows marked dental sepsis on its earliest appearance. During the war over 20,000 cases of scurvy occurred amongst Indian troops in Mesopotamia, many of which I personally examined, and in almost all very marked infection of the teeth and gums was present. The result of careful observation showed that if pre-existing dental sepsis was present in a marked degree, then such patients were very predisposed to develop scurvy.

TREATMENT.

The treatment of infections of the teeth and gums, and the diseases arising therefrom, does not come within the scope of this discussion. The most important general principles in the treatment of such infections have, however, been indicated, namely:

First, remove the focus of infection, either by extraction of teeth, or suitable treatment.

Secondly, it must be remembered that intestinal infections very frequently result from dental infection, and these may

require treatment by such measures as Plombière's colon irrigations, or an autogenous vaccine prepared from the streptococci found in the teeth and intestine.

Prophylaxis.

The early recognition of dental sepsis and its appropriate treatment would be one of the most important factors in greatly improving the health of the nation.

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REMARKS ON THE VALUE OF BUTYN AS A LOCAL ANAESTHETIC.*

BY

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For some years the experts connected with the Abbott laboratories of Chicago experimented assiduously to find a synthetic substitute for cocaine, and in 1918, with the collaboration of Professors Roger Adams and Oliver Kamm of the University of Illinois, butyn was discovered; in their opinion it fulfils all the requirements they had in view. The next step was to refer butyn to a committee of the Section of Ophthalmology of the American Medical Association under the chairmanship of Dr. Albert Bulson, jun., of Indiana, and after prolonged clinical investigation a report was published¹ early in 1922. The conclusions are summarized as follows:

1. Butyn is more powerful than cocaine, a smaller quantity being required.
2. It acts more quickly than cocaine.
3. Its action is more prolonged than that of cocaine.
4. Butyn in the quantity required is less toxic than cocaine.
5. It produces no drying effect on tissues.
6. It produces no change in the size of the pupil.
7. It has no ischaemic effect and therefore causes no shrinking of tissues.
8. It can be boiled without impairing its anaesthetic efficiency.

Unlike cocaine, it does not deteriorate quickly by keeping—an advantage to those practitioners who wish to have a supply ready in case of emergency. Still more important, it has no attractions for the drug taker.

Professor Adams in a letter tells me that his first experiments on toxicity were disappointing because he found that with mice butyn was two or three times as toxic as cocaine. But, on the other hand, its anaesthetic power was also two or three times as great as cocaine. Further experiments showed him that the comparative degree of toxicity varied with the size of the animal. For instance, with guinea-pigs the two substances are about equally toxic. In cats butyn is about 15 per cent. less toxic, and in dogs from 25 to 30 per cent. less toxic, than cocaine. In monkeys the toxicity of butyn is probably as low as 50 per cent. compared with cocaine; but these latter experiments are not yet completed. Professor Adams considers that it may be concluded that in man it is still less toxic. This view is supported by the fact that no toxic symptoms have occurred in America although butyn has been used in many cases. The low toxicity of butyn was confirmed by the committee of the Section of Ophthalmology of the American Medical Association.² In the opinion of the manufacturers butyn is probably considerably less than half as toxic as cocaine.

Tests.

Dissolve 1 gram of butyn in 10 c.cm. of water. Separate portions of the solution yield a white precipitate with potassium mercuric iodide solution; a brown precipitate with iodine solution; a brown precipitate with gold chloride solution; and a yellow precipitate with picric acid solution. A portion to which barium chloride solution is added gives a white precipitate (distinction from procaine).

Dissolve about 0.1 gram of butyn in about 5 c.cm. of water, add 2 drops of dilute hydrochloric acid and 2 drops of sodium nitrate solution (10 per cent.) and mix with a solution of 0.2 gram of betanaphthol in 10 c.cm. of sodium hydroxide solution (10 per cent.). A scarlet-red precipitate is formed (distinction from holocaine, which gives a white precipitate).

To a solution of about 0.1 gram of butyn in 5 c.cm. of water add 3 drops of diluted sulphuric acid and mix with 5 drops of potassium permanganate solution. The violet colour of the latter disappears immediately (distinction from cocaine).

Dissolve about 0.1 gram of butyn in 1 c.cm. of sulphuric acid. The solution is colourless (organic impurities).

Dissolve 0.1 gram of the salt in 10 c.cm. of water and saturate with hydrogen sulphide. No coloration or precipitation occurs (salts of heavy metals).

Incinerate about 0.5 gram of butyn accurately weighed. There is not more than 0.2 per cent. residue.³

Early in 1922 I resolved to try butyn, but the impossibility of getting it in England caused some delay, and it was necessary to send to Chicago. Unlike some German substitutes, butyn, not being a derivative of cocaine, can be freely prescribed without restriction.

In Eye Work.

In ophthalmology butyn has been extensively used in the United States. Dr. H. S. Gradle, from an experience of more than 2,000 cases, finds it superior to cocaine and holocaine in eye surgery.⁴

My own experience is confined to about 60 cases, including operations for the extraction of cataract, dissection, iridectomy, removal of foreign bodies, and skin operations on the lids by infiltration. For operative work on the eye a 2 per cent. solution is used, but for profounder anaesthesia 4 or 5 per cent. Four applications should be made at intervals of two minutes. If a bloodless field is required, a drop or two of adrenaline solution (1 in 1,000) may be instilled after the last drop of butyn. The eye is then ready for operation. For operations on the skin of the lids 10 drops or more of a 0.5 per cent. solution may be injected subcutaneously with a hypodermic needle.

For all operative work on the eye, in my experience, butyn is most satisfactory, the anaesthesia being more profound and prolonged than when cocaine is used, and there are no after-effects. I sum up my present position with regard to butyn by saying that neither in the consulting room nor in the operating theatre have I found it necessary to resort to cocaine during the last nine months.

Butyn in Ear, Nose, and Throat Work.

Some 200 operations have been done, including septum resection, tonsillectomy, adenectomy, opening accessory sinuses, etc. It can be used in a 2 per cent. solution and applied topically. It acts efficiently and is superior to a 5 per cent. solution of cocaine. For profounder anaesthesia for major operations on the throat and nose, 5 per cent. may be used, and adrenaline can be added for all intranasal operations. Dr. Bulson of Indiana reports that still stronger solutions can be used in throat operations.⁵ For intranasal work he employs a 5 per cent. solution of butyn, with epinephrin, swabbed over the operative field and beyond, if possible.

"Within two or three minutes following the first application, flattened pledgets of cotton soaked with the solution, but from which the surplus has been squeezed out, are applied over the operative field and when possible over the source of the sensory nerve supply. These pledgets are removed after the end of five to eight minutes. Five minutes later the operation may be commenced with the assurance that in practically all cases the patient will suffer no pain or even discomfort."

I can find no record of butyn having been used as a spray. Nevertheless there seems to be no contraindication.

Butyn in Dentistry.

In dentistry butyn is notably satisfactory. There are none of the after-symptoms which sometimes occur with other local anaesthetics. Ten drops or more of a 1/2 per cent. solution are injected on opposite sides of the tooth to be extracted, with or without adrenaline, and after sixty seconds the tooth is ready to be removed. I quote the following from a report issued by the Abbott laboratories.

"In March, 1921, the first (dental) extractions under butyn anaesthesia were performed by a Chicago dentist. Following about 100 such cases, quantities of butyn were sent to a considerable number of dental practitioners in all parts of the country. These men used butyn in various concentrations for all types of dental anaesthesia. As their reports began to come in it was apparent that it was producing results of a far more satisfactory nature than had at first been expected. The dentists who were co-operating with us in this research simply had to tell their friends of the unusually fine results they were getting with this new

* Read at a meeting of the Bath and Bristol Branch of the British Medical Association, November 29th, 1922.