culous lesion, then that patient, and also those subsequently inoculated, might all develop localized tuberculous foci at the sites of inoculation. If a single bottle containing multiple doses of an injectable preparation had been used for the injection of an entire series it would naturally be regarded as the source of the trouble.

Summary

The investigations recorded show *inter alia* that (a) 0.5 per cent. phenol, used as the preservative in biological products, kills all non-sporing bacteria (including tubercle bacilli) within seven days; (b) contamination on the external surface of the rubber cap of a bottle of a biological product can be introduced into the contained fluid when the cap is pierced by a needle; (c) any contamination of the needle or in the syringe may infect the entire contents of such a bottle; (d) such contamination may occur through inadequate sterilization, droplet infection, or contact with infected material after sterilization.

The dangers of "droplet" infection in inoculation work and the efficacy of alcohol and ether as antiseptics in such work are discussed.

A simple test is described to ensure satisfactory sterilization in autoclaves.

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NASAL SINUSITIS IN CHILDREN*

BY

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Oto-laryngology in children presents many problems still unsolved. No longer is the ear and throat department of a children's hospital a mere clearing-house for tonsils and adenoids and discharging ears. The oto-laryngology of childhood has become almost a separate specialty, demanding of its practitioners a knowledge of paediatrics as well as of diseases of the ear, nose, and throat. Foremost among the problems confronting the student of this new subject is that of nasal sinusitis. Suppurations in the nasal sinuses of the adult have been so extensively studied and treated that the "nasal" patient often comes with his own ready-made diagnosis of "sinus" which he now fears, just as the ear patient has long feared "mastoid." Nevertheless, sinusitis in children has attracted attention only within the past ten years or so, and even to-day receives little or no mention in standard textbooks. The frequent failure of the tonsil and adenoid operation has driven us to investigate the nasal sinuses, and in doing so we have found that adenoids are not the only cause of persistent nasal discharge. Sometimes, indeed, the removal of adenoids may actually aggravate the complaint. What, then, is the present state of our knowledge of the problem, and what aspects of it may we profitably discuss to-day?

Anatomy and Development of the Nasal Sinuses

The maxillary sinuses and the ethmoidal cells are present at birth, having made their first appearance during the fourth month of intra-uterine life. The frontal and sphenoidal sinuses also appear about the fourth month.

* Read in opening a discussion in the Section of Oto-rhino-laryngology at the Annual Meeting of the British Medical Association, Aberdeen, 1939.

At birth the frontal sinus is virtually an anterior ethmoidal cell, and it does not reach the frontal region until the age of 5 years, from which time it continues to develop until the fourteenth or fifteenth year. The sphenoidal sinus at birth is a tiny pocket on the anterior surface of the body of the sphenoid. By the fourth year it is a definite cavity, with an ostium, but is still very small, and full development is not attained until after the age of puberty. On anatomical grounds, therefore, one might expect infections of the frontal and sphenoidal sinuses to be rare in childhood, and clinical observation proves that this is so. In speaking of sinusitis in childhood we assume that it is located in the maxillary or ethmoidal sinuses, or in both. The maxillary sinus, or antrum, as it is often called, is at birth a small bean-shaped cavity in the cancellous mass which forms the ascending process of the maxilla, but there are wide individual variations of size and shape.

A passing reference must be made to acute osteomyelitis of the maxilla, a serious though fortunately rare disease of infants, arising from infection of one of the dental follicles and involving the surrounding cancellous bone. It may cause extensive necrosis or orbital abscess, but it does not arise in the antrum, as was formerly believed.

Frequency of Sinusitis in Childhood

Sinusitis is now generally regarded as a common disease of childhood. Many observers have investigated the maxillary sinus as a matter of clinical routine, and they have found pus in the cavity in a surprising number of patients. Dean (U.S.A.) demonstrates sinusitis in 15 per cent. of patients; Thorkilsen (Denmark) in 8 per cent.; Mollison (London) in 22 per cent.; and Cantor (Australia) in 67 per cent.—to mention at random only a few of the published records. The extreme frequency of sinusitis in Australia will be discussed later. As regards post-mortem evidence of the incidence of sinusitis, a most illuminating report is that of J. H. Ebbs (1938). He examined the sinuses in 496 necropsies of children under 12 years of age and ascertained that 63 per cent. of the series had pus in the ears or sinuses. In 30 per cent. one or more of the sinuses contained pus. The sinus most often affected was the maxillary (29 per cent.); the ethmoidal cells were involved in 13 per cent. In all cases there was evidence of former sepsis and not merely a post-mortem change.

Clinical Manifestations

Recurrent Nasal Colds.—The most frequent complaint is that the child is "constantly catching cold" or is "never without a cold." It must be remembered, however, that many children find it difficult to learn how to use a handkerchief. They prefer to sniff back the mucus as it accumulates, and the discharge is more frequently post-nasal than nasal; indeed, anterior rhinoscopy may reveal nothing abnormal. If every child could be trained at an early age in the art of nose-blowing (using the handkerchief, needless to say, as a receptacle and not as a clamp) there would be fewer cases of sinusitis.

Cough is another common symptom, and many cases suffer from recurrent attacks of bronchitis. When it is realized how readily pus from the nose finds its way into the lower air passages one wonders why bronchitis (and bronchiectasis) is not a constant sequel. It has been clearly proved that when this relationship does exist the sinusitis is the primary lesion. Nevertheless, this source of bronchial infection is sometimes ignored or overlooked by the paediatrician.

Nasal obstruction and mouth-breathing are often observed in children with infected sinuses. In many such cases adenoids are present, and still more frequently the adenoids have been removed but the symptoms have persisted. Naturally, the removal of a large obstructing mass of adenoids will favour drainage of the sinuses, but it will not cure the child when the original source of all his trouble has been a sinusitis. The nasal obstruction may be due to engorgement of the turbinal, especially if nasal allergy is present.

General Aspect.—As regards the general condition of the child who suffers from sinusitis, he is often listless and apathetic, easily tired, and devoid of the spirited energy of the normal child; he may suffer from headaches and sleeplessness; he may have that pale and puffy appearance suggestive of nephritis, and very often the mother states that "the bridge of his nose is swollen."

Sinusitis and the Tonsil-Adenoid Disease

It is unfortunate that a clearer distinction is not drawn between (a) enlargement, and (b) infection, of the lymphatic tissues of the pharynx and nasopharynx, for the two are by no means synonymous. In spite of voluminous expressions of opinion, we have no fixed criterion either of the extent of physiological enlargement or of what constitutes a "septic tonsil." We are certain, however, of two facts which have an intimate bearing upon the subject under discussion. First, we cannot hope to cure nasal discharge by removal of tonsils; and, secondly, when adenoids coexist with sinusitis they are a secondary infection, and operation, if indicated, is only part of the treatment. It is true that adenoiditis may give rise to persistent nasal discharge, curable by removal of adenoids. But if sinusitis is suspected it demands investigation, and if infection is discovered the treatment must consist in a direct though not necessarily surgical attack upon the sinus itself.

Allergy in Relation to Sinusitis

It has become a rule in treating sinusitis in adults to ascertain whether there is any coexistent allergy, and this rule applies even more strongly in children. The child who suffers from nasal discharge and who begins his day by sneezing some twenty times or more is obviously a subject of some form of allergy. Apart from such definite signs, and the pale oedematous turbinates which suggest an allergic irritant, allergic sinusitis of minor degrees is commonly noted. Allergy in children constitutes a problem by itself. Suffice it to say, for the purposes of this discussion, that in children under 5 years the food factor is usually responsible, and in older children one of the many varieties of inhaled allergen.

Ethmoiditis and its Complications

As already stated, the maxillary sinus is far more often involved than any other. Maxillary sinusitis may coexist with ethmoidal infection, or the stress of the infection may fall upon the ethmoidal cells. The first sign of ethmoiditis may be swelling and oedema of the tissues of the orbit, with proptosis, and the appearance may strongly resemble that of cavernous sinus thrombosis, especially when accompanied by prostration and high fever. As I am dealing with the far more common maxillary sinusitis, only one fact regarding the treatment of ethmoiditis may be mentioned. Radical operation is not always required, and indeed it may be a dangerous procedure, as the channels of possible infection between the nasal and cranial cavities are numerous and patent in early life.

In two cases of acute ethmoiditis with orbital infection which recently came under my notice careful intranasal curettage resulted in a profuse flow of pus and brought relief. The less acute cases of ethmoiditis respond well to repeated suction and instillation of weak ephedrine.

Value of Radiography

In assessing the usefulness of x-ray examination of the nasal sinuses in children two points must be remembered. A common cold or an allergic attack will cause opacity of the sinuses which may persist for some time. On the other hand, if the x-ray appearance is normal the sinus may be regarded as healthy, and consequently we have in radiography a reliable means of controlling the results of treatment. A radiograph is essential in every suspected case, and a single chin-nose view is enough as a rule. Much valuable work has been done on the radiography of the nasal sinuses in childhood. It may be mentioned in passing that transillumination, of little value in the adult, is useless in the child.

Treatment of Sinusitis in Childhood

Three cardinal rules should be observed in treating sinusitis: (a) treat the patient, and not merely the sinus; (b) deal with the allergic state, if present; (c) adopt conservative means—radical operations are seldom required.

Climate.—In every case the environment and mode of life deserve investigation. Certain climatic conditions favour the incidence of sinusitis. It is very common in Australia, especially on the south coast, where there are dust-laden winds and high day temperatures in summer, with a sudden drop of 20 or 30 degrees towards evening. The effect of climate upon many common diseases is a promising subject for research by some roving medical man. Many cases of sinusitis could be cured by change of climate, though such treatment is within the reach of few patients.

Hydrotherapy is another useful form of general treatment. The value of hot baths is recognized in Japan and in Finland, and one of our own laryngologists, Dr. James Adam of Glasgow, has drawn attention to the benefit derived from hot baths containing magnesium sulphate. In my experience this has been a useful adjunct in the treatment of sinusitis in children.

Nutrition is attracting widespread attention, and the importance of a well-balanced diet is fully appreciated. In the prevention and cure of sinusitis correct feeding plays a leading part. Vitamin deficiency favours nasal catarrh and all its unpleasant sequels. "Less starch and meat, more dairy produce and fruit," is the slogan oft repeated but as frequently neglected. It is hardly necessary to add that fresh air and sunshine are enemies of sinusitis.

Biochemistry of Sinusitis

Closely related to the problem of vitamins is that of chemotherapy. This is the treatment of the future, perhaps destined to supplant surgery, but as yet we know little about it. We know, for example, that a common cold may be alleviated by large doses of bicarbonate of soda, but so far as I am aware the pH of the blood and of the urine has not been estimated in any large series of cases. We also know that in certain catarrhal states there is deficiency of calcium and that sodium salts cause increased elimination of calcium, yet we are slow to make practical use of our knowledge. It has been found that a small dose of insulin will often abort a common cold; but how does it act? Sinusitis is a disease which may be cured by chemistry rather than by surgery, and this

aspect of the problem offers a fruitful field for research to the enterprising laryngologist who is prepared to take a wide view of his specialty. I have no personal experience of the use of potassium iodide as a "nasal aperient." This has been advised by Leathart (1938), who gives 1 to 3 grains daily for three months; he claims that sinusitis often responds favourably to the treatment without operation.

Local Conservative Treatment

The removal of nasal discharge is a most logical means of treating sinusitis, and it is best accomplished by suction. The Proetz method of suction displacement is less applicable in children than in adults. In children a small soft rubber catheter introduced into the nose and connected with a suction pump is the most satisfactory means of cleansing, and it may be used daily or twice daily with good results. Decongestion of the engorged mucosa by argyrol tampons is also very effective. A small roll of absorbent material, such as dentists use, is soaked in a warm solution of 10 per cent. argyrol in glycerin and introduced into the middle meatal region. A coloured thread is attached to the tampon so that it may be easily withdrawn a few hours later. The treatment is repeated daily or every second day. Having employed this method for over ten years I can vouch for its effectiveness in maxillary and ethmoidal sinusitis.

As for the very popular and widely advertised "nasal drops," their number is legion. Most of them contain menthol and ephedrine in a basis of liquid paraffin. Doubtless they have their value, but they possess certain disadvantages. It has been shown by numerous workers that all interfere with ciliary action and that oily substances introduced into the nose may readily enter the lungs and produce what is known as lipoid pneumonia. The only solution which is said to be free from such disadvantages is a weak dilution of ephedrine. During the past fifteen years I have prescribed as nasal drops a 5 per cent. solution of gomenol in olive oil, with good effect and with no harmful consequence. The amount used for each instillation has not exceeded five drops into each nostril.

Of vaccine therapy I have no personal experience. Short-wave diathermy, when available, is a most valuable adjunct to other treatment. X-ray treatment also has its supporters, Rathbone reporting 57 per cent. cured and 28 per cent. improved.

Lavage of Maxillary Sinus

The puncture and washing out of the cavity is the generally accepted method of diagnosis and treatment. As the technique has been carefully described by Mr. Crooks (1938) one need only lay stress on a few points.

1. The patient should be lying down, with the head fully extended.
2. Local anaesthesia is not always satisfactory in children, and advantage may be taken of the general anaesthesia required for removal of adenoids.
3. A straight trocar and cannula is used, and after withdrawal of the trocar needle, a smaller cannula, connected to a syringe, is introduced through the larger cannula so as to secure a specimen of the antral contents.
4. Sometimes, especially in pneumococcal cases, the pus is too thick to pass the needle and must be ejected through the ostium and nose by forcible syringing.
5. The lavage, using normal saline, should be repeated at weekly intervals for two or three weeks. A single lavage may suffice, and the prospect of cure may usually be deduced from the result of the first washing.

Antrostomy and Radical Operation

It is generally acknowledged that operation is indicated in only a small percentage of cases of sinusitis in childhood. In such cases some authorities advise intranasal antrostomy, making a window in the middle or inferior meatus. For sinusitis in the adult, antrostomy often yields good results, but it is not to be advised in the child. Operation on the maxillary sinus of a child is a rare event, but when it is required it should be radical. Direct inspection of the sinus cavity and satisfactory drainage are the advantages of the Caldwell-Luc operation. The chief disadvantage in the child is the possibility of damage to the unerupted teeth and subsequent dental defect.

The question is fully discussed in a paper by my friend Dr. McArthur (1937) of Melbourne, who denies that the radical operation in children involves much risk to the teeth. It may be observed, parenthetically, that not only is sinusitis very common in Australia, but gross polypoid changes in the mucosa are found in most cases. McArthur has never hesitated to do a radical operation when circumstances warranted it, and he reports a series of forty cases, some of which had been unrelieved by endonasal antrostomy. Twenty of the patients were traced at a later date, and in only one had the canine teeth failed to erupt. Fifteen had the full complement of teeth, and in four cases there had been caries and some extractions. As regards nasal and bronchial symptoms, thirteen of the twenty cases were completely cured. McArthur advises that the opening in the canine fossa should be small and at a high level, with due avoidance of the infra-orbital nerve. Even if there did exist a slight risk of losing one or more teeth, it is a small price to pay for the cure of a crippling sinusitis. Nevertheless I repeat that, in this country at least, operation is seldom indicated. The majority of cases respond well to the conservative measures which I have mentioned.

Conclusion

May I here suggest the following debatable points for discussion:

1. Should routine lavage of the maxillary sinus be practised at tonsil-adenoid operations?
2. Is the sinus a focus of infection in arthritis, anaemia, nephritis, etc., in children?
3. What are the best lines of general treatment—dietetic, climatic, medicinal, etc.?
4. Of what relative value are the various local applications?
5. To what extent does radiography assist in diagnosis?
6. When is operation to be advised, and is radical operation justifiable?

Summary

An account is given of the anatomy and development of the nasal sinuses.

The frequency of sinusitis in children and its clinical manifestations are discussed.

The cardinal rules to be observed in treatment are laid down, and various methods described.

Certain debatable points are suggested as subjects of discussion.

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