

## NASAL SINUS DISEASE IN INFANTS AND YOUNG CHILDREN, INCLUDING BACTERIOLOGIC STUDY.\*

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All of the pathologic and bacteriologic work mentioned herein was done by Doctor Armstrong, pathologist for the head specialties in the University Hospital.

The importance of the work in sinusitis in infants and young children is always made plain to us by reviewing some of our cases. We think of the first case that was responsible for our work in this subject. It was a boy eight years of age who had multiple arthritis; he was confined to bed; he could not feed himself. In January, 1917, I removed his tonsils and adenoids and examined the nasal sinuses, and reported no pathologic condition present. Two months later he was no better. A second examination of the sinuses was made, and a negative report sent to the orthopedic surgeon. Four months after this, the boy was again seen, and he was still no better. The orthopedic surgeon told me if we did not find the focus of infection that every joint in his body, including the temporomandibular would soon be ankylosed. With such a serious problem before us, a third complete examination was made. It showed involvement of the ethmoids right, and the ethmoids and sphenoids left. This condition was eradicated. This resulted in the disappearance of all acute joint trouble. Not only did he not have any acute trouble in his joints but the condition was so quiescent that the usual orthopedic treatment for ankylosis was instituted with very satisfactory results. Recently the

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boy attempted football on his crutches. There was evidently a family organism, as his brother, who did not come under our care, died of multiple arthritis with ankylosis of every joint including those of the spinal column and jaw.

There was another case, eighteen months old, with a posterior cleft operated twice by good surgeons, with infection and bad results, where postoperative healing took place perfectly after the eradication of the sinus infection.

Then a case of seven years of age that had had since one year of age a tendency to develop a temperature of 101, with evidence of respiratory infection without apparent cause—more noticeable when he has a cold, but is present when he does not have one. The removal of the tonsils and adenoids diminished the number of attacks only; six months after their removal he had an irregular temperature, ranging from normal to 102 degrees without the patient giving any sign of having fever. A chronic bilateral nasal sinus infection was treated eighteen months ago, with a complete disappearance of his trouble.

Then there was the case of noma sixteen months old that died, and the postmortem revealed an unsuspected necrosis of the ethmoids; of a patient four and one-half years old relieved of cyclic vomiting by treatment of a left Highmorian empyema; of a baby twenty months old relieved of a miserable nasal discharge, by treatment of the nasal sinuses; of a child eleven years old with asthma, and left sphenoidal empyema—one year after the drainage of the sphenoid reporting no asthma.

Then there are cases of nephritis, headache, neuralgia of the fifth nerve, neurotrophic disturbances, especially in infants, chorea, pulmonary infections, laryngitis, improved if not apparently cured by the treatment of nasal sinus disease.

None of these cases have been under our care alone. Most cases were referred by the Department of Pediatrics, or Orthopedic surgery, for study. In every case, a Pediatrician or Orthopedic Surgeon, or both were associated with us in the handling of the case. The best thing that can be said about this work is that these men have been satisfied with the results. In short, I think we may safely say that the orthopedic sur-

geon expects us to find the focus of infection in all of his children suffering from infectious arthritis.

In all cases of infectious arthritis in infants and young children studied by us during the last eighteen months, the source of infection has been in the upper respiratory tract. It has been in the nasal sinuses, or faucial or pharyngeal tonsils.

In no case were the teeth the source of the infection, or the gall bladder, or the appendix. We get the impression from our cases at least that in children, continued search of the throat and nose should be kept up if the infection persists. We never return a case of systemic infection to the pediatrician or orthopedic surgeon without a request for the return of the patient if any acute trouble appears; we get these patients back frequently and find a sinus is not draining properly, or we have overlooked a diseased cell. The results of repeated examination and treatments have been most satisfactory.

We have found that our methods of diagnosis in this class of cases are so unsatisfactory that it is only by exercising the greatest patience, and making one examination after another, and not giving up until the acute trouble in the joint has disappeared, that we secure our good results.

In no case of our series was the lingual tonsil found to be the source of infection. Our adult orthopedic service is not one-tenth as large as that of children, nevertheless in the adults we have found the focus in several cases to be in the lingual tonsil. With our present series of cases, we are not prepared to exclude either lingual tonsil, gall bladder, appendix, etc., as foci in children, but we do feel our results indicate the necessity of continued search in the nose and throat.

Occasionally, elevation of temperature and increased joint disease has been noted following operation on, or treatment of the sinuses. This, we have found to be due to injury of the joint during treatment or operation, and not to any added infection.

All serious cases were examined for syphilis, and where this condition was found they were excluded from our study.

Diagnosis of sinus disease. The most common symptom in our cases of nasal sinusitis, has been sneezing. In infants especially, does sneezing seem to be a very common symptom.

But few of our cases have not had this symptom well developed. There are, however, many other conditions besides sinus disease which cause sneezing in children. Other prominent symptoms are recurrent stoppage of the nose, frequent colds, nasal discharge and headache. The history of postnasal discharge so common in the adult, is conspicuous by its absence. A condition characterized by listlessness, poor appetite, underweight, poor color, so commonly caused by diseased tonsils and adenoids, which persists after the removal of the tonsils and adenoids with a negative report from the pediatrician so far as a systemic condition is concerned, is very suspicious of sinus disease. It is our custom to ask the parents of children who have had tonsils and adenoids removed, to bring the patients back to us if the result of the operation is not satisfactory—in that, the child does not improve as it should. If the pediatrician fails to find any trouble outside of the upper respiratory tract, the cause of the patient being below par is probably in the sinuses, and the removal of the sinus disease will bring about that conspicuous improvement which so commonly follows the tonsil and adenoid operation.

Direct inspection of the nose is very unsatisfactory in infants and young children. The nasopharyngoscope helps very much. We usually make the examination at a time when anesthetic is being used for removal of the tonsils and adenoids. With the child on its back, and the nasopharynx kept clean by suction a fair examination can be made. We have diagnosed a unilateral sphenoidal trouble by this procedure alone in a child of eleven. In infants it is necessary to familiarize ourselves with the normal nose, as the color and comparative thickness of the turbinate is quite different from that of the adult. Transillumination is naturally unsatisfactory.

The X-ray examination is very necessary because it is the only way of telling definitely whether a given sinus is present or not, and if present its size. The variations in the sizes of infants' and children's sinuses are so great as to leave us completely at sea without this picture. We would not puncture an antrum of Highmore without first determining whether or not it was present, and if present, its size, and the location of its floor. With such a plate before us, we believe that the antrum in infants, if of notable size in the plate, may be punc-

tured and irrigated without danger. For operative work a good plate is very essential. For diagnosing the pathologic condition of the sinuses, radiography is very unreliable. In this class of patients, the thickness of bone interferes with X-ray work. The bone surrounding the sinuses being cancellous does not give the clear picture we get in the adult. At any rate, our interpretations of the plates have not been correct in a large percentage of the cases. In two cases clear pictures were secured with pus in a sinus.

Having found what sinuses are present, the diagnosis of sinus disease is still a very difficult one. It is only by repeated examinations of the nose, careful study of the case from every angle that a proper diagnosis can be made. We feel that the bacteriologic investigation of the sinuses is a very important aid. Especially is this true of the Highmorian antrum which, next to the ethmoids, we have found most frequently diseased in the class of cases under consideration. In the diagnosis of obscure sinus disease it has given us the most satisfactory results.

The macroscopic examination of the washings from the sinuses is not reliable. An antrum puncture may be made in the ordinary way, and the fluid coming from the nose may be perfectly clear and still the antrum be filled with thick pus. Or the washings from the antrum may contain numerous macroscopic particles which may be, on one hand, made up of pus cells with virulent organisms; or, on the other hand, pure mucus without pus cells or virulent organisms. Ordinary antrum puncture and the washings of the contents of the sinus into the nose, we do not feel is satisfactory; certainly, for purposes of bacteriologic examination it is for numerous evident reasons a very unsatisfactory procedure. Our method in making the bacteriologic examination of the sinuses will be described later in this article.

The most important thing in the treatment of nasal sinus disease in infants and young children is the removal of the adenoids and diseased tonsils if present. It is necessary to remove the tonsils if they are diseased, as well as the adenoids.

In one of our cleft palate cases, two years of age, hemolytic streptococci were recovered from each antrum. This youngster had a history of having had erysipelas. He had two dis-

charging ears, each being due to a hemolytic streptococcus. A rabbit injected with a culture of streptococcus from the antrum showed marked toxemia in twenty-four hours, from which it recovered, and later an arthritis developed, which persisted for two months. Two months after the injection the animal was killed, and the findings were as follows: Chronic bursitis, fibrosis of the right lung, endocarditis; a hemolytic streptococcus was isolated from the joints and heart. The interesting thing about this case is that for six or eight weeks after the removal of the adenoids, and by using various kinds of treatment, we were unable to eradicate the nasal sinus disease. We did not want to remove the tonsils because of the scar tissue which would form and perhaps interfere with the successful closure of the posterior cleft. After six or eight weeks of treatment it seemed perfectly plain that it was a question of either removing the tonsils or not eradicating the sinus disease. The tonsils were removed. After the removal of the tonsils the same nasal treatment was continued, and several weeks after, the sinuses were found sterile. One ear had become healed; the other ear was very much improved. The clinical symptoms of the sinus disease had disappeared. From the tonsils the same hemolytic streptococcus was recovered. The only possible way to get rid of the sinus disease in this instance was to remove the tonsils.

Up to July 1, 1918, we had examined the sinuses of two hundred and thirty-four children, thirteen years of age or younger, suffering from adenoids. Many of them had also chronic tonsillitis. In 15 per cent of these cases an infection of one or more sinuses was found. These sinus infections were not treated, only the tonsils and adenoids removed, and the patients were asked to return in four or six weeks for examination. Only seven cases returned for examination; five out of the seven were found to be apparently free of sinus disease. The disappearance of the sinus disease was due to the removal of the tonsils and adenoids.

Since July 1, last, we have investigated the sinuses in one hundred and forty-five cases with adenoids, or with adenoids and chronic tonsillitis. Of these one hundred and forty-five, sixty-five had some definite sinus disease, the infection in many instances being exceedingly mild and in some instances very

virulent. The bacteriologic findings in these cases will be discussed later. These patients had their tonsils and adenoids removed and were asked to return in four or six weeks for examination. Six returned, and of these four were found to have no sinus disease.

We feel that the first thing in the treatment of sinus disease is the eradication of adenoids, and of diseased tonsils if present. Sinus disease in children yields particularly well to treatment. The method of Haskins and Coffin we have found to be exceptionally excellent. Especially has the Haskins' treatment proven successful in our posterior cleft cases. We do not hesitate with our Highmorian sinus cases to make an opening in the inferior meatus very small, so that it will close in twenty-one days. Through this opening a canula may be introduced for the purpose of this irrigation or for the use of the Coffin treatment.

Naturally, operative work on the turbinates or destruction of the sinuses is to be avoided in infants and young children. Only rarely is it necessary to resort to such procedure. As I view it, that would be indicated only in those very severe cases of arthritis or systemic infections where local treatment and climatic influence seemed to be of no avail. Those children who are suffering from sinus disease and who can be sent to a high and dry climate are certainly very much benefited.

We had one arthritis case in a young child two years ago that in spite of our treatment did not heal until hot dry weather. Then the nasal condition disappeared with the usual marked improvement in the arthritic condition.

Our most interesting work during the past year has been a study of the bacteriology of sinus disease in this class of cases.

Before undertaking to explain our findings in diseased sinuses it seemed wise to familiarize ourselves with the bacterial findings in healthy sinuses. Skillern says that in health the sinuses are sterile and quotes the work of Körner, who, in twenty-one autopsies on bodies dead not more than two hours, found them to be sterile in every instance. But we were not dealing with dead bodies, and it was necessary to study the efficiency of our technic together with the bacteriology of the sinuses. Consequently, all of the children who came into the clinic for chronic tonsillitis and adenoids were

carefully studied for evidence of sinus disease, and those in which the findings were negative were subjected to the same bacteriologic examinations as those in which they were positive.

We found it practicable to concentrate our attention upon the antra because, with the exception of the ethmoid cells, they are the most frequently diseased and the most uniformly developed in young children and of all the nasal sinuses are the most easily accessible. While the child is anesthetized for the purpose of the tonsillectomy the antra can easily be examined without inconvenience or danger.

A trochar is passed into the antrum through the antromental wall, and through this a long blunt pointed needle attached to a glass syringe was inserted. One to three cubic centimeters of sterile normal salt solution are thrown into the antrum and drawn out. The solution is forced in and out of the antrum several times, so as to loosen up any pus which might be clinging to the sinus wall. The presence of pus or mucus was noted and cultures were made from the washings.

An effort was made to rule out the possibility of contaminating the antra as much as possible by cleaning the mucous membrane of the nose with pledgets of sterile cotton and washing with 50 per cent alcohol, before passing the trochar through the wall. In a number of cases the middle meatus was painted with a solution of methylen blue, with the idea of ascertaining whether or not the salt solution might flow out through the ostium with positive pressure and be drawn back in again with negative pressure, thereby contaminating the washings. In no case was there the slightest tint of blue obtained in the washings.

If contamination should occur, either at the point of entrance of the trochar or through the ostium during the administration of the anesthesia, the bacteria found in the culture would have been such as are normally found in the nose. In this connection a knowledge of the normal flora of the nose in our native surroundings is of value. In examining the noses of one hundred and sixty nurses in our hospital for diphtheria carriers, record was made of the bacteria present. The staphylococcus was found in every case, an encapsulated diplococcus in seventy-three, diphtheroid bacilli in fifty-nine, micrococcus catarrhalis in seventeen, gram negative bacilli in



ninety-three, bacillus subtilis in seven, and in only three instances the streptococcus pyogenes.

In infants and young children examined, the washings from the antra varied from perfectly clear fluid without any trace of cloudiness to thick white pus which could only with difficulty be drawn through the aspirating needle. In some instances the washings contained varying amounts of clear glary mucus which on microscopic examination was seen to contain no pus cells. In still other cases the antra contained both mucus and pus. Out of the fifty-four apparently normal sinuses examined, pus was found in but two cases and mucus in eight.

As soon as the normal salt solution was aspirated from the antrum the presence or absence of pus and mucus was noted and a small amount of the contents was smeared over the surface of a blood agar plate and the remainder transferred to beef infusion bouillon. Care was taken to use enough media so that it would not be diluted more than 10 per cent by the addition of the washings from the antrum, and not more than 1 per cent or 2 per cent if any considerable amount of pus or mucus was present. For the first thirty or forty cases, two bouillon cultures were made, one an aerobic culture and the other a partial tension culture, but the two gave such uniform results that the partial tension culture was abandoned at this time.

No routine examination of sinuses other than the antra have been made excepting in those instances where it was deemed of especial importance to study the upper and posterior sinuses. These were the cleft palate cases, the arthritic cases, and those cases where an upper or posterior sinus was suspected of being the etiologic factor in some constitutional disorder. Here an attempt was made to determine the bacteriologic conditions of these sinuses by inserting a long slender catheter into the middle meatus and so placing the tip that by suction secretions could be drawn into the catheter just as they flowed from the sinuses. Whatever material was collected in this manner was immediately transferred to the culture media. Naturally, this method is unsatisfactory in that contamination from the lower portion of the nose is sure to take place and that one never feels certain that pathogenic bacteria may not be present in

the sinuses and yet not be obtained in this way. However, in the absence of a better method we feel this procedure to be very useful.

The results of our sinus examinations are summed up in the following table:

	No. of cases	Antra washings, clear	Antra washings contain mucus	Antra washings contain pus	Antra cultures sterile	Antra cult. contain bacteria hemolytic strept. neg.	Antra cult. hem. strept., pure culture	Antra cult. hem. strept. and other bacteria
Clinically antra apparently normal.....	55	44	3	8	39	13	1	2
Per cent.....	..	80.	5.4	14.5	70.9	23.6	1.8	3.
Antra would have been considered normal but for blurred X-ray plates .....	43	25	8	10	24	17	2	....
Per cent.....	..	58.1	18.6	23.2	55.8	39.5	4.6	....
Positive local evidence of sinusitis. No systemic lesions.....	12	2	8	2	....	6	3	3
Per cent.....	..	16.6	66.6	16.6	....	50.	25.	25.
Arthritis cases, conditions presenting, after removal of tonsils, etc.	12	....	10	2	....	....	6*	6
Per cent.....	..	....	83.3	16.6	....	....	50.	50.
Chronic otorrhea cases..	8	3	4	1	5	1	....	2
Per cent.....	..	37.5	50.	12.5	62.5	12.5	....	25.
Cleft palate cases.....	7	4	1	2	2	4	....	....
Per cent.....	..	57.1	14.2	28.5	28.4	57.	....	....
Osteomyelitis cases.....	3	1	2	....	1	1	1	....
Per cent.....	..	33.3	66.6	....	33.3	33.3	33.3	....

We had all together fifty-five cases in which, prior to the antra puncture there was no reason, either systemic or local, for suspecting nasal sinusitis. Of these only two, or less than 4 per cent, had pus in the antral washings; 8, or approximately 15 per cent, had clear mucus in the washings, and 44, or 80 per cent, had neither pus nor mucus. In these cases there was a very close similarity between the macroscopic and cultural

\*One of these cultures was obtained from the ethmoid cells.

findings, for it may be seen by referring to the table that 39, or 70 per cent, of 55 cases were sterile. That three, or 5 per cent, contained a hemolytic streptococcus, and 24 per cent contained organisms other than hemolytic streptococci.

I have placed in a separate group those cases which gave no definite evidence of sinusitis before the taking of X-ray plates when one or more sinuses were found to be blurred. Of these there were forty-three. The washing of the antra showed no evidence of pus or mucus in 58 per cent. Mucus was present in the washings in 24 per cent of the cases, and in 18 per cent of the cases pus was found. Here again the cultural tests are in close accord with the macroscopic results of the antral washings: 55 per cent of the cultures were sterile, 4.6 per cent contained a hemolytic streptococcus, and the other 40 per cent contained various organisms such as are often found in the nares.

Out of the ninety-eight cases comprising these two groups, cultural tests showed that bacteria were present in the antra in thirty-five cases or altogether in fifty-one antra. Out of this number the staphylococcus was found in forty-five, the pneumococcus in thirteen, unidentified gram negative bacilli in eight, diphtheroid bacilli in seven, micrococcus catarrhalis in seven, hemolytic streptococcus in five, staphylococcus viridans in one, and Friedlander's bacilli in two.

The most interesting group was a series of twelve arthritis cases. These were all cases in which the arthritis had failed to clear up after the removal of the tonsils and adenoids. The source of the trouble was sought in the sinuses. The youngest of these cases was three years old, the oldest thirteen years. The improvement in the joint condition following treatment of the sinuses was in each instance most satisfactory. Here the findings are in marked contrast to those above. Nine of the twelve had definite pus in the antra, two had thick glary mucus, while in the other case thick pus was found in the ethmoid cells, but washings from antra were not obtained. In eleven of these cases a hemolytic streptococcus was found in the accessory nasal sinuses.

The streptococci from this group of cases were tested for their action upon sugars. All fermented lactose and salicin and were without action on mannite and inulin, and were

therefore classified as streptococcus pyogenes. They were also tested for their virulence by inoculating rabbits. Three to four cubic centimeters of forty-eight-hour beef infusion bouillon cultures were injected intravenously into well grown young rabbits. Three of the animals died from acute toxemia in periods varying from one to four days. At autopsy the livers, spleens and kidneys were found to be large and hyperemic, and showed areas of focal degeneration. Two of the rabbits had pneumonia. The streptococcus pyogenes was isolated from the heart blood and from the spleen of all three of these rabbits. Four of the animals survived the acute symptoms and were apparently well, but after periods varying from four to six weeks developed arthritis and were killed. Each one of these four rabbits had one or more knee joints involved. The pathologic changes found in the involved joints were practically identical in every instance. The animal while living held the joint stiff and refused to use it in moving about. The tissues surrounding the joints were swollen and slightly hyperemic; the bursa and synovial sacs contained a marked increased amount of fluid, which was thick and milky, and the synovial membrane was slightly thickened. From the joint fluid of three of these rabbits a hemolytic streptococcus which fermented salicin and lactose was cultured. The cultures from the joints of the other were sterile, however, a gram positive micrococcus arranged in pairs and short chains was found in sections prepared from the tissues surrounding the joint.

In each of these last four rabbits the maxillary sinuses were carefully opened and studied. In two cases both sinuses appeared to be normal. Cultures made from one was sterile, and from the other contained only a sparse growth of staphylococcus. In the other two rabbits the sinuses were definitely diseased; the mucosa was reddened and thickened. Cultures revealed a hemolytic streptococcus in the antra of both.

Two of those chronic diseased rabbits had endocarditis and one of the others a small focal abscess in the wall of the left ventricle. The heart of the other seemed to be free from disease. Unfortunately, microscopic sections were made from the viscera of only two of these rabbits—both showed degenerative parenchymatous changes in the liver, spleen and kid-

neys; in the case of one animal quite marked, in the other, very slight.

The rabbit inoculated from one case of arthritis never developed any symptoms. The dose used was probably too small. Those inoculated from three other cases are yet living, but the requisite time for the development of arthritis has not as yet elapsed.

In the beginning of this work the purpose of animal inoculation was merely to test the virulence of the organism under consideration. When the first animal developed arthritis the idea that the hemolytic streptococcus found so uniformly in the diseased sinuses of arthritis cases might have a selective affinity for joint tissue naturally suggested itself. It now seemed unfortunate that the first four rabbits had died during the acute stages of toxemia. From this time the dose was decreased, and two animals were inoculated, one with four and the other with three cubic centimeters of twenty-four hour cultures of the streptococcus. It was hoped that by this procedure at least one of them would develop chronic symptoms. Four rabbits were also inoculated with hemolytic streptococcus from acute mastoiditis cases, and one with a hemolytic streptococcus from a diseased sinus in a cleft palate case. Two of these also developed arthritis. While our series is as yet too small to warrant the drawing of any definite conclusions it hardly seems probable that any peculiar selective action is here demonstrated.

During this period twelve infants suffering from posterior palate clefts were bacteriologically investigated. We do not operate for the closure of posterior clefts in children until we are sure the nasal sinuses are not infected. Nasal sinus disease, if present, is almost sure to cause sloughing. Haskin's method of treating sinus disease is particularly efficient in this class of cases. In only seven were the antra sufficiently developed to justify an antra puncture's being made. Five of the seven cases had viable bacteria in one or both antra. However, in only one case was the hemolytic streptococcus found. This child had had erysipelas and later developed double mastoiditis. From the mastoid cells pure cultures of hemolytic streptococci were obtained. Of the remaining four cases three had only one diseased antrum. The staphylococcus was

found in all of these, the pneumococcus in two and the streptococcus viridans in one. In the remaining case a clinical examination showed a very evident sinusitis, the nose being continually full of pus and the mucosa red and hypertrophic. Pure cultures of pneumococci were found in both of the antra.

The pneumococci from all three cases were tested for their virulence. In the case of definite sinusitis the animal died of acute toxemia in eighteen hours. A similar dose from the other cases was without apparent effect.

In the five cleft palate cases where cultures were made only from the middle meatus one gave practically a pure culture of hemolytic streptococcus. Organisms from the other four cases were such as are habitually found in the nose.