

THE ACCESSORY SINUSES OF THE NOSE IN THEIR RELATION TO THE CRANIAL NERVES.

DR. LOUIS G. KAEMPFER, New York City.

Unless the signs are unequivocal it is not difficult for one whose experience in these conditions is limited to overlook an infected accessory sinus. The diagnosis is often laid to one of the more striking complications while the true cause of the patient's trouble is not discovered. This is especially so in those cases in which there is involvement of one or more of the cranial nerves. The object of this paper will be to epitomize the relations between the nasal accessory sinuses and the cranial nerves in the hope that the danger of untreated and unoperated disease of the sinuses will be more apparent and send these patients to the rhinologist before important structures are permanently impaired or life is jeopardized.

Scattered throughout the literature are reports of autopsy findings in cases of fatal meningitis, in which pus, unsuspected during life, was found in the nasal accessory sinuses. As interest has developed in the field of rhinology and as the sinuses have become more accessible to the surgeon such reports have become less frequent.

Berger was the first to point out the relationship existing between the accessory sinuses and the optic nerve. Since then many investigators have taken up the subject and the literature is rich in instances of cranial nerve complications in sinus disease.

The nasal accessory sinuses are not fully developed until after puberty, therefore, although it occurs in children and is being more often recognized, accessory sinus disease is comparatively infrequent in the early years of life. It is possible that many of the long-standing cases whose time of origin the patients cannot remember began in childhood. In the main, however, it is a disease of adult life.

To review very briefly the topography of this region. There is an arbitrary division, generally accepted, into an anterior and a posterior group of cells. The anterior group consists of the frontal, maxillary and anterior ethmoidal cells; the posterior group consists of the posterior ethmoid and sphenoid cells. In a general way their names identify their places in the skull, but they are capable of such bizarre anomalies of situation that it is safe to say that no two individuals are alike and indeed the opposite sides of the same individual may be totally unlike.

The frontal sinus occupies, in the classical instance, the supra-orbital ridge and extends backward over the orbit only a very short distance. It is divided from the sinus of the other side by a thin, vertical plate of bone in the median line of the body. Sometimes the sinus may be so large as to fill out most of the frontal bone. Below it may extend, in the roof of the orbit, as far back as the sphenoid and laterally as far out as the zygoma. The sinus may be entirely absent or it may be absent on one side and present on the other. The writer has seen such a case in which the symptoms were referred to the side of the absent sinus. The wall between the sinuses may be considerably off the median line; so much so that a sinus situated on one side will belong to the other side and must be approached through the other nostril. There may be a dehiscence in the septum between the two sinuses and an infection in one sinus will quickly involve the other. The dehiscence may amount to an entire absence of the septum, making but one sinus.

The ethmoid cells are an anterior group opening into the infundibulum, and a posterior group opening into the superior meatus of the nose. They do not communicate with each other.

The anterior ethmoid cells are situated below and behind the frontal sinus. Their outer boundary is the inner wall of the orbit. In some instances the most anterior cell of this group is enormously developed and extends in an upward and outward direction into the frontal bone. In this case the frontal sinus is very small or absent. Such a cell is known as a *bulla frontalis*.

The posterior ethmoid cells belong to the posterior group of nasal accessory sinuses. They are also bounded externally by the inner orbital wall. They are fewer in number and smaller than the anterior ethmoid cells and show variations in size, extent and situation with regard to the sphenoid cells. They may be large and extend backward at the expense of the sphenoid cells. When they are small their place is occupied by large sphenoid cells. The cells of one group may overlie those of the other group or they may be in a different horizontal plane.

The maxillary sinus occupies the cavity of the superior maxilla and opens into the infundibulum. It also varies in size and in the thickness of its walls. These, if thin, render its relation to the orbit and to the fifth nerve much more intimate, and the danger of involvement of these structures in infection of the maxillary sinus much more imminent than, when in a small sinus with thick walls, they are protected by a thick layer of bone. The most frequent divergence from the normal is absence of the floor of the sinus in the region of the alveolar process and the projection of the teeth

directly into the sinus, their roots being covered only by its lining mucous membrane. This occurs usually in the region of the second bicuspid and first molar teeth and is the etiological factor in the large group of cases of maxillary sinus disease of dental origin.

The sphenoid cells, the most important from the viewpoint of relationship with intracranial structures, occupy the body of the sphenoid bone. There are ordinarily two, divided in the median line by a thin, vertical partition which is subject to the same variations as those described for the septum between the two frontal sinuses. A large sphenoid sinus will sometimes extend for a greater or less distance into the greater wing or downward into the base of the pterygoid process or, as above described, forward into the ethmoid.

The sphenoid sinus is cubical in shape and has six walls. The posterior wall is fused in the adult with the occipital bone; the inferior wall forms the roof of the nasopharynx. The mesial or internal wall is the septum between the two cells and the anterior separates it from the ethmoid and the cavity of the nose. The natural orifice of the sinus is in the anterior wall.

The external wall is the groove for the cavernous sinus and the carotid canal. The superior wall contains the cella turcica and the grooves for the lodgment of the optic chiasm and the optic nerve. It is these walls which are of greatest interest in the study of the involvement of the cranial nerves in diseases of the sinuses.

Onodi has gathered a large series of cases in which he has shown the radiographic pictures and has covered almost all the possible variations in size, contour and situation of the sinuses of the nose. This unstable anatomical relationship affords the possibility for most unusual and apparently unrelated groups of symptoms, all caused by the same etiological factor.

In addition to the variations in the situation and arrangement of the cells, which determine the symptoms of the individual cases, there is another factor of still greater importance that determines largely whether or not the infection is to be confined to the sinus or is to spread to the neighboring structures. This factor is the thickness of the sinus wall. If the neighboring structures are separated from the infected cell by a thick wall of bone there is little likelihood of direct extension of the inflammatory process. On the other hand, a thin, bony wall offers less resistance to an infection of the same virulence. In this connection the enormous importance of dehiscences in the bony wall will be brought to mind.

The mucous membrane of the frontal sinus can be in direct contact with the dura over the frontal lobe. A dehiscence in the lamina papyracea of the ethmoid leaves its mucous membrane in direct con-

tact with the orbital periosteum and the cellular tissue of the orbit. The mucous membrane of the sphenoid may be in direct contact with the dura, or with the sheath of the optic nerve.

The Relations of the Cranial Nerves.—First Nerve: The olfactory bulb lies on the cribriform plate of the ethmoid and the nerves are distributed in three groups over the upper part of the septum, the roof of the nose and the superior and middle turbinates. Their function is practically always affected, either through the congestion of the mucous membrane in which they lie, or directly by extension of the infective process.

Second Nerve: The optic nerve is the most important cranial nerve that comes into relationship with the nasal accessory sinuses. The intimacy of this relationship depends upon the size and distribution of the sinuses and the thickness of the bone between them and the nerve.

The optic nerve, in its course from the chiasm, goes forward and outward and enters the orbit through the optic foramen, which is a canal formed by the roots of the lesser wing of the sphenoid. Usually it is separated from the sphenoid by a fairly thick layer of bone. This varies greatly in different individuals. Where the sinus is small there may be twenty millimeters or more of bone between it and the nerve. In other instances the bony wall may be as thin as paper. Sometimes there is a dehiscence in the wall of the canal and the mucous membrane of the sinus is in direct contact with the prolongation of dura that forms the outermost layer of the sheath of the nerve. Where the sinus is greatly developed and the dehiscence is large the nerve abuts into the cavity of the sinus, covered only by the sphenoidal mucous membrane. Depending upon the arrangement of the cells, the nerve may traverse either the sphenoid or the posterior ethmoid sinuses, or both.

The wall of the canal (optic foramen) can be formed from the wall of the sphenoid or when the posterior ethmoids are large, or extend far back, or overlie the sphenoid, of the wall of the ethmoid cells. At times, when the arrangement of the cells is very irregular, those of one side may extend so far across the median line as to be in relation with the optic nerve of the opposite side. Zuckerkandl illustrates specimens in which both frontal sinuses were in relation with one optic nerve and formed part of the wall of the canal.

Pathology: In suppuration of the accessory sinuses the nerve may be affected (a) by extension of the inflammatory process, (b) by pressure from an orbital cellulitis or an orbital phlegmon, (c) by changes in its circulation.

(a) The path of the infection may be either by direct continuity through the bony wall or through a dehiscence in it; or by way of the lymphatics that pass through the cribriform plate with the olfactory nerves; or by way of the veins.

There is an extensive communication between the veins draining the nose and the accessory sinuses and those of the dura and pia, through the pterygopalatine plexus, the junction of the anterior and posterior ethmoidal with the superior ophthalmic veins and through emissary veins into the frontal sinus. The veins of the orbit, of the nasal cavity and of the pterygoid plexus empty posteriorly into the cavernous sinus. Anteriorly they communicate with the veins of the face, through the plexus around the lachrymal sac, the angular and the superior orbital veins. The central vein of the retina empties either directly into the cavernous sinus or, through the sphenomaxillary fissure it passes into the pterygoid plexus.

When the infection passes directly through the bone there is first caries and necrosis of the bone with perforation of the wall between the sinus and the optic canal. When the path of the infection is by way of the circulation there is first hyperemia, edema of the tissues surrounding the nerve sheath, hemorrhage, emboli and thrombophlebitis. In any instance the process may progress to a basal meningitis with thrombosis of the ophthalmic veins or cavernous sinus; or extra-or intra-dural abscess.

(b) When an orbital inflammation is present, either an abscess, a cellulitis or a phlegmon, there is pressure on the nerve caused by an increase in the orbital contents. This pressure results in congestion and edema of the nerve sheath with destruction of the tissues of the nerve. When there is edema of the retrobulbar tissues exophthalmos results.

(c) There may be atrophic changes in the nerve due to pressure on its nutrient vessels or as the result of thrombophlebitis of the ophthalmic veins.

Direct involvement of the optic nerve usually occurs in disease of the posterior ethmoid or sphenoid sinuses. In disease of the other sinuses there is more often an orbital inflammation with secondary involvement of the optic nerve.

Symptoms: In the severe cases the picture is that of an acute fulminating retrobulbar neuritis with rapid onset, severe pain and rapid and complete loss of vision. In these cases prompt operative interference alone can save the life of the patient. Many of the severe cases die, however, of basal meningitis or cavernous sinus thrombosis. In those that recover after oper-

ation there is usually quite rapid return of vision. In some cases there is some impairment of vision.

In the less severe cases there is amblyopia, central scotoma, color scotoma and contraction in the visual and color fields. Birch-Hirschfeld says that the enlargement of the blind spot is an early and an important symptom. According to Zentmayer the central scotoma occurs before there is any diminution of vision.

Contraction of the color fields is not confined to those cases in which there is extension of the inflammation beyond the sinuses. Routine examination of patients suffering from ethmoid and sphenoid disease will show contraction of the red and green fields in almost every case.

After the removal of the cause by intranasal operation the symptoms practically always disappear in their entirety. In rare instances optic atrophy may occur early and then there is no improvement in vision even after the removal of the offending cause.

Eye changes not only accompany sphenoid and ethmoid disease but can be found, though with less frequency in disease of the frontal and of the maxillary sinuses. Onodi reports bulbar and periorbital neuralgia, dacryocystitis and hyperemia of the disc with fullness of the retinal veins in frontal sinus disease; and orbital phlegmon with thrombophlebitis of the pterygoid and ophthalmic plexuses in maxillary sinus disease. Ziehm and Kuhnt report iritis after maxillary sinus infection.

The order of frequency in which there is involvement of the optic nerve with its concomittant symptoms is first in disease of the sphenoid sinus, less frequently in disease of the posterior ethmoids, then in disease of anterior ethmoids and of the maxillary sinus least frequently in disease of the frontal sinus.

The optic neuritides of nasal origin are usually unilateral. Bilateral optic neuritis can, of course, be caused by double sinus disease but that is of very unusual occurrence. Double optic neuritis is rather cerebral than orbital or nasal in its origin. Because of the peculiar anatomical relations sometimes pertaining the sinus disease and the optic nerve lesion may be contralateral. Even when there is caries or necrosis of the bone the optic nerve is not always involved. This is explained by the varied relationships, already referred to, between the optic nerve and the sinuses.

The Oculomotor Nerves: The third, fourth and sixth nerves can be considered together. Behind the orbit they lie in the cav-

ernous sinus, the third and fourth on its outer side, the sixth at about its center to the outer side of the carotid.

The outer wall of the sphenoid sinus is very thin and, as has already been shown, forms for a considerable part of its extent, the inner boundary of the sphenoidal fissure.

The same pathological processes as were discussed under the optic nerve pertain here. Inflammation in the contiguous sphenoid or posterior ethmoid cells will cause a collateral edema, perhaps a cellulitis by direct extension with pressure on the nerve trunks in the fissure or after they have entered the orbit.

Cases have been reported of temporary derangement of the ocular muscles in accessory sinus disease which disappeared when the sinus disease was cured. Hoffman reports paralysis of the third nerve, Fisch of the fourth and sixth nerves and Panas of the fifth and abducens nerves in sphenoid disease. In Rouge's case, in which there was purulent periostitis of the body of the sphenoid and pus in the sphenoid sinus, there was basal meningitis and blindness with divergent strabismus. Russel reports a case of sphenoid sinus suppuration with gradual loss of vision and ptosis of the upper lid. Lapersonne and Baumgarten both mention transitory and permanent pareses of the ocular muscles in sphenoid suppuration.

Fifth Nerve: The trigeminus is of interest in connection with the accessory sinuses in the light of the explanation of some of those persistent and severe facial neuralgias of unknown origin, which are apparently not amenable to any sort of treatment. It is possible, from this viewpoint, to obviate in many instances that last desperate resort in the attempt to relieve these sufferers—the Gasserian ganglion operation.

The sphenopalatine ganglion (Meckel's) is situated deep in the sphenopalatine fossa. Its sensory roots are derived from the superior maxillary branch of the fifth nerve and are usually two in number. Its motor root comes from the facial nerve. The latter arises from the geniculate ganglion of the seventh nerve in the aqueductus Fallopii, passes through the hiatus Fallopii on the anterior surface of the petrous bone and passing beneath the Gasserian ganglion enters the middle lacerated foramen. It is called the large superficial petrosal nerve.

The sympathetic root, the large deep petrosal nerve, is derived from the carotid plexus in the carotid canal and passing along the outer side of the internal carotid artery joins the motor root in the middle lacerated foramen.

The Vidian nerve formed by the junction of these two roots passes forward through the Vidian canal in the base of the pterygoid process of the sphenoid and entering the sphenomaxillary fossa passes into Meckel's ganglion.

The branches of distribution of the ganglion are to the orbit where they supply its periosteum; to the mouth where they are distributed to the hard and soft palate and to the tonsils; to the nose where they are distributed over its mucous membrane; and to the pharynx where they supply the mucous membrane of its upper part.

The sphenomaxillary fossa is a small triangular space bounded above by the body of the sphenoid bone and the orbital process of the palate bone, anteriorly by the superior maxilla and posteriorly by the pterygoid process and greater wing of the sphenoid. The floor of the sphenoid sinus is usually a very thin plate of bone and is all that separates the suppurating sinus from Meckel's ganglion. Sometimes a posterior ethmoid cell also enters into the formation of the upper boundary of the fossa. The maxillary sinus is in front of the fossa and is separated from it by bone of varying thickness. The ganglion, however, is not in contact with the maxilla, the sphenopalatine and the descending palatine arteries and their veins being in front of it and between it and the maxilla.

The process of the extension of an inflammation from the sinus to Meckel's ganglion is similar to that described above for extension to the optic nerve. Clinical evidence to support this view is found in cases reported by Roe and others and in the exhaustive investigations of Sluder. In a case that came under the writer's observation the first symptom was pain referred to the lower teeth. Some twenty-four hours later, when the writer first saw the case there was an acute maxillary sinusitis on the same side. There was then pain in the upper jaw. The pain continued during the course of the acute disease and was accompanied by herpes. The pain and herpes persisted until the natural orifice was enlarged surgically and good drainage established into the nose. A similar attack on the other side a few weeks later was also accompanied by pain in the lower teeth on that side but there was no herpes.

Sluder likens the sphenomaxillary fossa, in its relations to the nose, to an accessory sinus. He reports a large number of cases of a neuralgic syndrome—pain in the upper and lower jaws radiating around to the occiput and sometimes into the extreme-

ties. This pain is most severe at a point about five centimeters behind the tip of the mastoid and on a level with it. He has controlled the attacks by applications of cocain to the opening of the sphenopalatine foramen. In many cases there was sphenoid or ethmoid disease, a cure of which resulted in a permanent abeyance of the neuralgic attacks.

The prognosis in cases of cranial nerve involvement secondary to suppurative sinus disease is usually grave, especially in those cases that show involvement of the optic or motor-oculi nerves. This is so for the reason that once the wall of the sinus is passed and the orbit or the neighboring structures invaded, the possibility of meningitis with or without cavernous sinus thrombosis is always imminent. There is often some impairment of vision after involvement of the optic nerve but considering the gravity of the condition this can be discounted in the light of the conservation of the patient's life.

Where the fifth nerve is affected the prognosis, according to Sluder, is favorable. As soon as the offending sinus disease is removed the neuralgic attacks cease.

The treatment, after the process has passed outside the sinus is, in the case of orbital inflammation, wide external incision and an attempt to establish drainage through the nose from the affected sinuses.

Early operative interference in inflammatory sinus disease would, in most instances, prevent the process from getting outside the limiting bony walls of the sinus. As this fact has become more generally accepted it is only the most virulent and fulminating infections that get to this grave stage.

Conclusions: 1. Involvement of the nerve trunks and ganglia is possible by direct extension or by way of the blood and lymph streams.

2. The sinuses depart in their anatomical relations very frequently from the classical description and these variations may cause unusual and apparently unrelated groups of symptoms.

3. Symptoms of nerve involvement are always to be considered of deepest significance and may be the signs of profound involvement of important structures.

4. Early operative measures in disease of the accessory sinuses would prevent most of these cases from getting beyond the confines of the nose.

616 Madison Avenue.