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FRONTAL SINUS INFLAMMATION

SENIOR THESIS

BY

ROLLAND R. BRADY

EMBRYOLOGICAL DEVELOPMENT

The question of the embryological development has been discussed both pro and con for years. Some authorities state it is present before birth, others say it is not present until several months after birth.

I have taken extracts from two leading authorities as to the embryological development of the frontal sinus. First that presented by Schaeffer. (1) - He states, that as early as the end of the third or beginning of the fourth month of embryonic life one sees evidence of beginning of an extension of the middle nasal meatus in a ventro-cephalic direction. This extension is the beginning of the recessus frontalis and is strictly speaking, the first step in the formation of the frontal sinus and certain of the anterior group of ethmoid cells.

He continues by saying:- It is a well established fact that the frontal sinus develops variously:- (1) by a direct extension of the whole recessus frontalis, (2) from one or more of the anterior group of ethmoidal cells which have their point of origin in the frontal furrows, and (3) occasionally from the ventral extremity of the infundibulum ethmoidal, either by direct extension or from one of its cellular outgrowths. The frontal sinus is frequently unilaterally or bilaterally present in duplicate or triplicate, indicating a genesis from more than one of the eforementioned areas. Thus embryologically speaking the

frontal sinus, in many instances, is an anterior ethmoid cell, which has grown sufficiently far into the frontal region to be topographically a frontal sinus.

He further states that one must always bear in mind that the frontal sinus is genetically and topographically speaking ethmoidal before it is frontal, and in this sense is conspicuously present at birth in all cases.

As for the presence or absence of the nasofrontal duct. Schaeffer sums it up by stating that if the frontal sinus develops from an anterior ethmoidal cell or cells, the adult cavity will more frequently have a nasofrontal duct and the tortuosity of the duct will depend on which cell it developed from. But, on the other hand, if the frontal sinus develops from the frontal recessus there will in all likelihood be no true nasofrontal duct.

After birth the various outpouchings from the recessus frontalis continue to extend their boundaries and the one destined to form the frontal sinus comes in contact with the frontal bone. Extension takes place by simultaneous growth of the sinus and reabsorption of the cancellous bone. By the eighteenth or twentieth month the sinus has "eroded" into the frontal bone and by the middle of the third year the cupola of the sinus is above the level of the nasion.

Skillern (2) states that the frontal sinus cavity is not present in the newborn, but makes its appearance in the orbital plate between the first and third year and up to the sixth or seventh year reaches only the size of a pea. He further states

it does not commence by direct reabsorption of the frontal bone but by an upward expansion of an air passage from the anterior ethmoid labyrinth, which gradually forces its way into the diploe of the squamous portion of this bone. Then at the end of the seventh to ninth year this sinus may be recognized as a distinct separate cavity above the root of the nose internal to the supra-orbital ridge.

ANATOMY

Skullern (2)

The frontal sinus, lying in the ascending ramus of the frontal bone, takes the shape of a pyramid with the base lying inferiorly. It possesses three walls: an inferior, a posterior, and an anterior. We will assume that the normal sinus extends from the median line to the supra-orbital notch, and from this point by a concave line back to the median line.

This may vary from complete absence of the sinus to its spreading to extensive proportions; thus it may extend laterally to the superior orbital process of the maxilla bone or superiorly to a point high up on the vertex or posteriorly to the lesser wings of the sphenoid. The shape may be regular, but it is usually extremely inclined to the opposite, assuming all sorts of fantastic forms and directions, depending upon the amount of reabsorption the bone has undergone. It is apparently

quite independent of its fellow on the opposite side, as one side may be fully developed, while the opposite side practically fails; indeed, the two sides are never exactly similar. The left side is usually larger than the right.

The two sinuses are separated by a bony septum which may be considered a direct extension of the nasal septum. The relative size and shape of the sinus depends much upon the position of this septum, as it is capable of showing great deviation at the expense of the cavity toward which the deviation occurs.

The boundaries of the normal sinus would then be: in front by the supra-orbital portion of the frontal bone, behind by the cerebral wall, and below by the orbital plate of the same bone. The inferior wall or base is not flat, but is the shape of a small inverted pyramid, with an ostium at the apex. This aperture is known as the frontal ostium of the frontal sinus.

The interior of the sinus is usually not smooth, but shows various irregularities, particularly at the junction of the posterior and inferior walls. Partial septa hiding great recesses are often seen, sometimes making the sinus appear to be double.

The communication between the frontal sinus and the nose is formed by the frontal ostium which lies at the posterior inferior portion of the inferior triangle in a position corresponding to the posterior or cerebral wall of the sinus. The

ostium may empty directly into the nose or into an enclosed duct which leads into the nose. (ductus nasofrontalis)

The blood supply is through the ostium from branches of the sphenopalatine artery. The venous circulation anastomoses in several directions: (a) externally into facial vein; (b) internally into the nose; (c) posteriorly into dura; (d) internally into orbit.

HISTOLOGY

Schaeffer. (I)

The mucous membrane of the paranasal sinuses and cells is composed of a stratiform ciliated columnar epithelium, invaded by numerous lymphoid elements, resting on a very delicate basal membrane and tunica propria. Indeed, the latter is firmly adherent to the underlying periosteum, especially so in frontal and maxillary sinus. The glands, mucous in type, are few and scattered as compared with the glands of the nasal fossa.

In spite of the extreme delicacy and thinness of the mucous membrane of the paranasal sinuses and its firm adherence to the periosteum, it is readily influenced and greatly thickened by pathologic process.

The current produced by the cilia of the epithelium of the frontal sinus is toward the ostium which communicates with the nasal fossa.

PHYSIOLOGY

Schaeffer (I)

The physiology of the frontal sinus is not clearly understood and several theories have been advanced but none of them are generally accepted. I shall enumerate several of these theories with minor discussions.

1. Aids in humidifying and warming inspired air. It has been definitely proven, especially by Clasen and Braune, that during respiration there is a certain amount of air change in the paranasal sinuses. Good ventilation of the paranasal sinuses is essential to health and is normally maintained.
2. To maintain proper equipoise of the head by pneumatization of some of the bones. Authorities dispute this because the pneumatization of the head bones is not equal.
3. Exert influence upon vocalization. This is unlikely because the ostia are so small and not infrequently encroached upon by neighboring parts that it doesn't seem likely they would influence it any.
4. Supply moisture in form of mucous to the nasal fossa. This is disputed because the mucous membranes are so sparsely supplied with glands that an insufficient amount of moisture would be supplied.

ETIOLOGY

Skillern (2)

The numerous investigations of the etiological factors causing sinusitis has led to many theories being advanced. Because of the lack of definite proof, I shall only enumerate some of the theories advanced and not attempt to discuss them.

1. Through direct invasion of the healthy sinus by pathogenic bacteria.
2. Through extension of inflammation from neighboring parts.
3. As a result of Tuberculosis, Syphilis, Malignant tumors, and latent Empyema.
4. Through the blood and lymph channels.
5. Through traumatism---exposure to cold, sea bathing, automobile riding, etc.
6. Through foreign bodies.
7. Through contamination from the pus of overlying sinuses.

PATHOLOGY

Skillern (2)

When the mucous membrane becomes first infected, there results an intense hyperemia and swelling, due to the outpouring of serum into the submucous connective tissue layer, which may be so great as to occlude the lumen of the sinus. The swelling encroaches more and more on the cilia, causing them to wave more and more slowly until, if the pressure is sufficient, they cease altogether. During this stage no secretion is formed, because

the lining membrane has not been penetrated by the exudate. This stadium is followed by edema, caused by the pressure on the blood-vessels.

As the cilia have become motionless, the mucosa is no longer able to throw off the secretion which is continuously forming within the glands and, by osmosis, through the epithelium, in the event of inflammation. This inflammatory exudate is composed of serum, mucous, leucocytes, and exfoliated epithelium. Micro-organisms may or may not be present. The exudation in the beginning is scanty, becoming serous or serous-bloody, depending upon the infection.

Microscopical.---- The cilia appear absent in parts, but upon the whole are fairly well retained. The superficial glands are enlarged. The mucosa is enormously thickened, owing to the extensive edematous infiltration. Some round-cell infiltration is present in the stroma, but particularly around the blood-vessels. The deeper layers appear but little involved.

Acute Purulent.--- The acute purulent inflammation principally affects the superficial layer of the mucosa, while in chronic disease all of the layers of the mucosa undergo pathological changes. The mucosa is diffusely hyperaemic, swollen, and covered with a greater or lesser amount of purulent secretion. If the secretion is thin, no exudate may be present, owing to the drainage which has occurred through the ostium.

Microscopical. --- The epithelial surfaces show marked papular irregularities, occasionally presenting areas of true granulation tissue. Large surfaces are present in which the cilia have become entirely lost. Round-cell infiltration is particularly marked directly below the surface, gradually shading off as the deeper layers are approached, except around the blood-vessels and glands. The secretion does not consist entirely of leucocytes, but also contains the debris of exfoliated epithelium.

Generally speaking, what applies to one sinus is equally applicable to another, so far as the pathology is concerned. Regarding the frontal, however, individual points maybe emphasized. If the structures entering into its drainage passages are favorably situated to insure a patulous opening of sufficient size, even though swelling incidental to inflammation occurred, we should naturally expect this sinus to react physiologically, at least as the others but many factors influence this cavity which do not affect the others.

We must recollect that the frontal ostium often empties into a narrow tube (ductus nasofrontalis), while the others have their outlets situated directly in one of the nasal passages. The nasofrontal duct is susceptible to occlusion by swelling of the anterior portion of the middle turbinate, thus offering a more or less impermable barrier to the outflow of exudate.

Deviation of the septum exercises no little secondary influence in this respect from the mere mechanical obstruction of the middle nasal passage, which is doubly emphasized when inflammation sets in on that side.

It must be remembered that direct primary infection of the sinus mucosa is not necessary to set up inflammation within the sinus. This can be accomplished by inflammatory approximation of the mucosa outside of the sinus leading to the ostium, thereby preventing the ingress and egress of air. The negative pressure thus occasioned, by its sucking action causes the mucous membranes to react in no uncertain manner, giving rise to serous inflammation and to purulent inflammation should pathogenic organisms be present.

SYMPTOMS

Skillern (2)

The outstanding symptoms of frontal sinus inflammation are headache and pain. These vary to a large degree. It may assume a feeling of fullness or heaviness over the frontal area or may be of a sharp, burning, lancinating or throbbing pain. It does not run an even course but is subject to all kind of vagaries.

The seat of the pain is usually situated in the region of the affected sinus, and later radiates over the area supplied by the supra-orbital branch of the Trigemini nerve. Should the

disease continue unchecked, other collateral branches of this nerve are involved, giving pain in the vertex, temporal region, or even the occiput and posterior muscles of the neck, although this is rare.

The patient is subject to sudden remission or exaceberation. These remissions are influenced by almost every act of the individual, as suddenly stooping over or turning the head quickly. The pain is usually increased by blowing the nose, coughing, straining at stool, or in fact, any condition which increases congestion to the head. Mental work increases the headaches, and tobacco and alchohol tend to cause remission.

The usual history of a case is that while headache is a constant sympton, the intense pain is felt shortly after arising in the morning, lasting two or three hours and then ceasing as suddenly as it started.

Skillern (2) explains this by stating: (1) that when in the recumbent position during the night, the blood-pressure is equalized, the mucosa becomes turgid and the two mucosal surfaces encroach upon each other. The lumen of the sinus is obliterated. (2) . While lying in bed the ostium is in unfavorable position for drainage and allows the secretion to accumulate. The purulent secretion irritates the mucosa, thus increasing the congestion. Thus the congestion results in presure which causes the severe pain and as soon as the patient assumes upright position and drainage is established, the pain disappears.

Another prevailing symptom is tenderness on pressure. Skillern (2) states that "Pressure on the pathognomonic point (the inferior wall near the inner canthus of the eye) is always present." Hajek, Heitger, and Hansel (3) state sensitive areas, in addition to the above as follows --- pain or tenderness elicited by tapping or pressing finger over anterior wall of the frontal sinus, or special areas as near the root of the nose, and an area behind the supra-orbital notch, which are extremely sensitive.

The location of the secretion is usually between the middle turbinate and the lateral wall of the nose, when the patient is in the recumbent position it flows into the nasopharynx.

The appearance of the nose will show more or less swelling and hyperemia of the nasal mucosa. As the condition continues diffused or circumscribed hypertrophies and polypi are formed in the region of the outlet of the naso-frontal duct. At times there are varying degrees of hypertrophies at the anterior end of the middle turbinate.

The sense of smell is diminished or lost on the affected side, but it is purely a mechanical affair, due to the swelling of the mucous membranes and swelling of the middle turbinate against the septum.

Hajek, Heitger and Hansel (3) in addition state edema on the anterior wall of the frontal sinus and upper eyelid. The edema of the forehead is elicited by pressure over the anterior

wall of the frontal sinus and in the upper eyelid by disappearance of the sulcus between the orbital wall and the upper lid.

DIAGNOSIS

This is accomplished by a series of findings and symptoms. The presence of pain or headache over the frontal area is suggestive. Tenderness over the upper and inner canthus of the eye is again suggestive, but one must be on guard for individuals who are prone to exaggerate their symptoms or findings obtained in this method.

Another suggestive finding, as an aid to diagnosis, is the appearance of headache early in the morning and lessening or subsiding during the late morning and reoccurring again the next day in the same manner.

Intra-nasal examination will reveal the discharge escaping from the ostium of the frontal sinus. If not plainly visible will be in the middle meatus, again due to congestion or hypertrophy of the mucosa, there may be little or no drainage present.

Transillumination is another aid to diagnosis. By placing a small electric lamp well up under the frontal ridge, and having the patient in a darkened room, one is able to ascertain whether sinuses are clear or cloudy. In a normal frontal sinus the sinus is lighted up well and transilluminated, while in a diseased one the sinus will not be easily transilluminated.

The last and one of the most valuable aids to diagnosis is the xray. When properly interpreted it is of much value.

One should not attempt to interpret a roentgen film without accurate understanding of the same.

TREATMENT

Skullern (2)

The treatment in acute frontal sinus will depend upon the phase the affection has assumed. In the acute state the patient usually complains of a severe cold with symptoms referable to frontal sinus involvement. To combat this condition, two methods are indicated. (1) to procure drainage, (2) to reduce swelling and inflammation.

Skullern states it is best to order patient to bed, cold or heat to the head, giving aspirin, grs.xx, every two hours, and giving calomel gr.iv, at bed time. Also advising the patient not to over exert himself, either mentally or physically, and, above all, to avoid all alcohol, tobacco or draughts where in there is a possibility of reinfection.

The after treatments consist in daily application of cocaine to the region of the middle nasal passage with subsequent lavage. Thus attempting to maintain as free ventilation of accessory sinuses as possible. Acute sinusitis should heal in ten to fourteen days.

In one of the more recent articles on non-operative treatment is one written by Arthur W. Proetz (4) in which he gives the so-called Displacement treatment. The object of this

treatment is to slowly introduce some form of medicated oil into the nostril while the patient is in the supine position. Then with gentle suction the fluid displaces the mucous and exudate within the sinus cavity and tends to aid in restoring the mucosal membrane to its original condition.

The summary under this article states:

1. This method introduces fluid into the sinuses without trauma.
2. A valuable therapeutic agent by employing the appropriate solution.
3. By using radiopaque oils it can be used in connection with exray for diagnosis.

Some cases do not respond to general treatment and so more radical measures are indicated. Skillern (2) states there are two choices left. (1) Infraction of the middle turbinate; (2) High resection of the anterior end of the middle turbinate. In considering which method to use, anatomical configuration of the nose must be considered. If the space between the septum and the middle turbinate be narrow, one can not do an infraction because of lack of room.

Technique of Infraction of Middle Turbinate.

(1) with 2% cocaine-adrenalin solution shrink anterior end of the inferior turbinate and anesthetize anterior portion of the middle turbinate and septum. Wait five minutes, and bend applicator and cocainize thoroughly as much of the processus uncinatus

and hiatus semilunaris as possible.

(2). Waiting ten minutes- introduce a Thompson scissors or blade directly beneath the anterior attachment of the middle turbinate as far as can be pushed without meeting firm obstruction and holding them in as vertical a plane as possible, sever the turbinate from its attachment.

(3). Introduce a blunt mucous elevator between the processus uncinatus and middle turbinate and press the latter forcibly toward septum; a crackling noise will indicate that the turbinate has been fractured at its attachment.

(4). Ascertain if the frontal sinus is accessible to the sound and, if so, what position the sound must be bent.

(5). Introduce cannula and wash out the sinus with warm boric acid solution.

Technique of Resection of Anterior Third of Middle Turbinate.

(1). Cocaine as before.

(2). Use scissors as in retraction.

(3). Introduce snare, the loop bent downward and work the end of the instrument well upward until it is firmly in position at the superior extremity of the cut in the middle turbinate. Firm pressure is applied to the handle of the loop, a sudden jerk will announce that the turbinate has been severed.

(4). Introduce a nasal cannula and irrigate the cavity.

The advantages of the Infraction method over the Resection method are:-

1. Lessened danger of infection.
2. Requires much less time.
3. The ethmoid cells are not opened.
4. Little or no postoperative swelling, with its attending danger

Another of the intra-nasal operative procedures is that introduced by Halle.(9), Halle removed the anterior-superior spine which forms the anterior portion of the floor of the frontal sinus, thereby, creating a large and permanent opening into the nose.

The advantages of the intra-nasal operation is questionable but I sincerely feel that every patient who does not respond to conservative intra-nasal methods should be given the benefit of a intra-nasal operation in hopes of relieving the condition without performing an external operation.

The indications for an external operation are generally accepted but I shall list the indications as given by two different authorities. First that given by Skillern, (2). He divides then into two groups, the relative and absolute. The relative indications are:- (a) when the X-ray shows a large sinus with many ramifications; (b) when, despite frequent irrigations, the pus continues fetid; (c) when headache continues with no apparent change in the secretion. Absolute indications: (a) when the subjective symptoms are severe enough to interfere with business pursuits of the patient; (b) when severe exacerbations occur; (c) in

abscess and fistula formations; (d) in threatened cerebral and orbital complications; (e) actual appearance of complications.

Herbert Tilley (13), gives as the indications for a primary external operations as follows: (1) . A very narrow nasal cavity preventing free access of the ethmoidal region. (2) . A tortuous frontonasal canal which proves to be impassable by a suitable curved probe, even after removal of the agger or other anterior ethmoidal cells in the neighborhood of the canal. (3) . An extensive, irregular and loculated sinus. (4) . Attacks of subacute periostitis of the anterior or of the antero-inferior wall of the frontal sinus associated with tenderness on pressure over those regions and possibly with edema of the upper eyelids. (5) . Symptoms of subdural abscess always demand a radical operation.

A secondary external operation is indicated when: (1) . the intranasal measures have failed to relieve the chief symptoms e.g., headache and profused discharge, especially if this be fetid. (2) . The desire of the patient to be freed from the discharge which has not been cured or minimized by endonasal operation.

Before the days of rhinoscopy the operation universally practised was simple trephining with external drainage. Later, improvement was made by enlarging the nasofrontal duct so as to aid drainage through the nose. About 1882 the method in vogue was resection of the anterior wall with an attempt to obliterate the frontal sinus. Kocher. (5) .

Ogston (6) was the first to practice removal of the anterior ethmoid cells bordering on the uncinatè process through the break in the anterior frontal sinus wall.

Luc (7) further modified this procedure by putting in a rubber drainage tube, bringing it out through the nose and closing the original wound.

Coakley (8) removed the entire anterior wall, curetted the mucous membrane thoroughly and packed the frontal sinus so granulation would set in and obliterate the cavity.

Of the more modern methods in use today, Hajek, Heitgar and Hansel (3) make a distinction between (a) Simple Trephination and (b) Radical Operations.

Simple Trephination consists in opening the frontal sinus at a circumscribed place and establishing external drainage or combined external and intranasal drainage. The operator attempts to open the nasofrontal duct and aid in draining the sinus that way. The aftertreatment consists in irrigating the cavity with antiseptic solutions and in using cauterizing medicaments until the secretion disappears.

This operation is considered beneficial when: (1) as an introduction to a more radical operation, ie., operator can determine the condition of the mucous membrane and decide whether a more radical operation is advisable. (2) as a "diagnostic" trephination in rare cases where diagnosis is difficult, (3) in very acute and subacute empyemas of the frontal sinus in which sufficient drainage of the pus has not been produced by endonasal treatment.

The more radical methods are as follows: the Riedel operation. The anterior and lower walls of the frontal sinus are removed. He drains the wound externally and intranasally. This is the most radical operation of them all, and causes considerable criticism because of the resulting disfigurement, which is due to the removal of the bony orbital ridge.

The Killian operation consists of the complete removal of the anterior and interior walls of the frontal sinus, but avoids disfigurement by retention of the orbital bridge. This operation demands resection of the frontal process of the superior Maxilla, thus attacking the diseased ethmoid cells and at the same time gives a wider communication between the nose and frontal sinus.

Lillie and Anderson (11) of the Mayo Clinic advise the two stage operation. They believe in all cases of sinusitis that the ethmoids are involved as well as the frontal sinus, thus it is necessary to perform an intranasal operation on the ethmoid sinuses first, under local anesthesia, and wait one to two weeks for symptoms to clear up and if they do not do so proceed with the second stage of the operation which is the radical external operation. They have found that in performing the two stage operation many of the patients symptoms have subsided and it was not necessary to do the radical external operation. Then too, they found it shortened the period of convalescence and reduces the percentage of complications.

Carl M. Anderson (14) discusses the advantage of the Lynch type of external operation and states that it is particularly advantageous because scarcely any deformity results. He emphasizes the importance of the thorough removal of the floor of the sinus as well as all ethmoid and ethmoidal cells in the vicinity of the infundibulum. In the after treatment the tendency of the nasofrontal duct to close is obviated to a great extent by the use of dilators.

M.M. Cullon (10) employs a three stage operation. He believes that in practically all cases, in addition to a frontal empyema, there is empyema of the ethmoid, sphenoid and maxillary sinuses. He operates upon the antrum: then in a few weeks on the ethmoid and sphenoid. As the drainage from the ethmoid, the sphenoid and the antrum decreases, the patients general condition improves. The resistance for the final operation is greater and there is much less to do. Thus the operation is shortened, the shock is curtailed, and the area from which infection might arise is lessened.

He further states that the Killian operation has not proven a success because of two reasons. (1) the resulting deformity, (2) the tendency for recurrence years later. He believes the recurrences are due to (1) failure to remove all the diseased area, (2) failure to deal adequately with the paper plate, (3) failure to deal thoroughly with the ethmoid labyrinth.

William Mitholfer (12) believes that radical operations are not performed soon enough because of the tendency on the part of the operator to withhold from doing a radical operation. By waiting more tissue is involved and the result is that a more extensive operation is required than when one does a radical operation sooner. He also believes that the period of convalescence is shortened and the dangers of complications are reduced.

SUMMARY

1. Schaeffer has proven by studies of sections of the fetal head that the frontal sinus is present before birth, but does not obtain any size before the end of the first or second year.
2. The anatomical arrangement of the frontal sinus is varied and because of its markedly irregular outline is difficult to treat and cure.
3. That all cases of frontal sinusitis should be given the advantage of intranasal treatment and should not be subjected to an external operation until intranasal treatment has been given a fair trial.
4. External operations should be done when intranasal methods fail. I believe the two stage operation of Lillie and Anderson or the three stage operation of Gullom has advantage over the other operations because (1) some cases clear up without external operative measures, (2) in the majority of cases a generalized involvement of the other sinuses is present, and that they are in some cases responsible for reoccurrences.

5. I am not in sympathy with the Riedall or Killian operations because of the resulting deformity but in cases where it is a question of saving the patients life they may be advisable.

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