PARANASAL SINUSITIS:

ORBITAL AND INTRACRANIAL COMPLICATIONS

Robert S. Munford, M.D.

Parkland Memorial Hospital
Medical Grand Rounds
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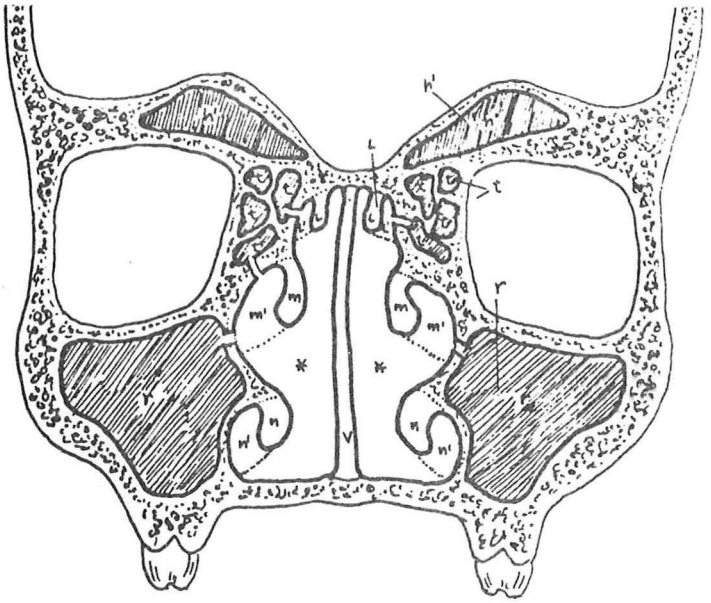
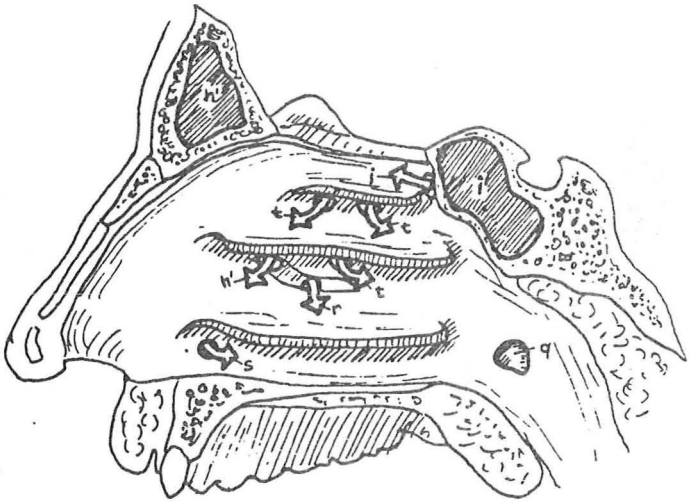
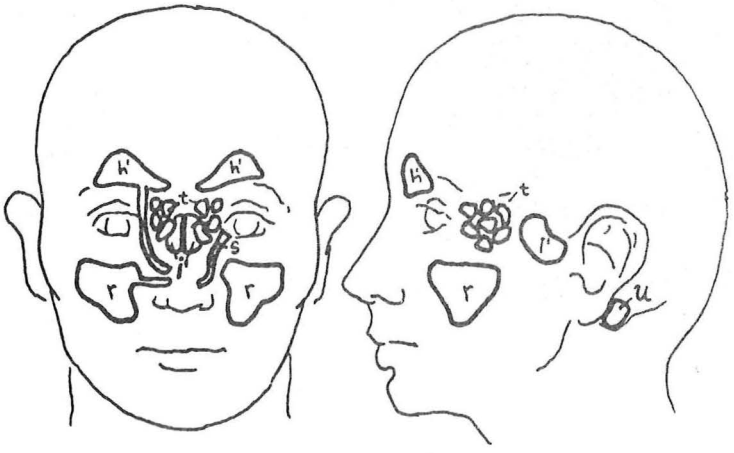




LEGEND:

h' - *frontal sinus*
i' - *sphenoid sinus*
L - *superior turbinate*
m - *middle turbinate*
n - *inferior turbinate*
q - *opening of Eustachian tube*
r - *maxillary sinus*
s - *nasolacrimal duct*
t - *ethmoid sinus*
u - *mastoid*
v - *nasal septum*



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A. *Paranasal sinus anatomy, embryology* (2)

The paranasal sinuses develop during the late months of fetal life and during childhood, as growths of the nasal mucosa into the maxilla, ethmoid, and sphenoid bones. At birth the maxillary and ethmoid sinuses are present, the sphenoid is rudimentary, and the frontal sinuses do not exist. The frontal and sphenoid sinuses begin to develop around age 8 years and continue to enlarge until the late teens or early twenties.

The sinuses vary greatly in size and shape among individuals, and in a given individual the sinuses on the two sides are usually not symmetric.

The sinus epithelium is pseudostratified, ciliated, with columnar and cuboid cells. It contains globlet cells which secrete mucous, forming a biphasic mucous blanket. A thin, watery layer is in direct contact with the cilia, underlying a thick, viscous layer (the "blanket"), much as in other parts of the respiratory tract.

Each sinus has at least one orifice; accessory ostia occur in many individuals. Frontal, anterior ethmoid, and maxillary ostia open into the middle meatus, while the posterior ethmoid and sphenoid ostia drain into the superior meatus. The ostia of the maxillary sinuses do <u>not</u> provide dependent drainage. The size of the ostium seems to affect 1) clearance of mucous - more efficient clearance may occur with sniffing than with blowing, although neither maneuver is effective unless the maxillary ostium is in a dependent position, 2) the pO_2 within the sinus, which in turn may influence ciliary function (8,9).

B. *Host defense mechanisms, risk factors for sinusitis*

The sinuses are probably continuously exposed to bacteria in inhaled air, and each sinus empties into a contaminated passage. Bacterial clearance appears to be achieved by the mucous blanket, and depends upon ciliary motion to a great extent. Patients with defective ciliary motility (related to absence of either dynein arms or radial spokes) experience recurrent bouts of sinusitis (10,11).

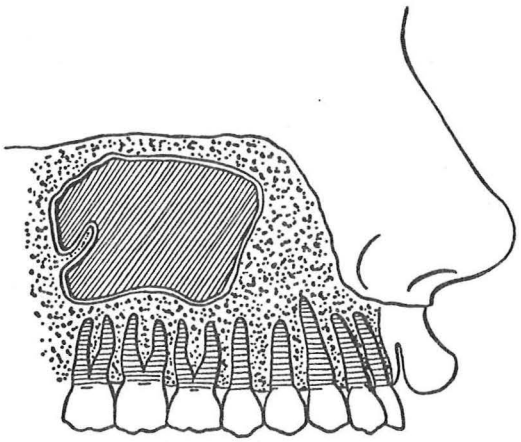
Muramidase (lysozyme) is also present in sinus secretions, and may have some local anti-bacterial action. Both local and systemic antibody also appear to enter sinus secretions, though this has received little study (12).

Bacterial sinusitis usually follows some alteration in the sinus mucosa:

- acute viral URI -- may cause mucosal cell death and impair ciliary activity. Other systemic viral infections may also be associated with sinusitis, e.g., infectious mononucleosis (13).

- allergic rhinitis -- leads to edema and obstruction of the ostium, may be associated with polyp formation.

- temperature changes, drying of mucosa.
- barotrauma (diving) -- affects frontal sinuses especially (14) -- introduction of water into sinuses may also occur. Sinusitis is not more common in flyers than in non-flyers (15).
- noxious agents - gases.
- foreign bodies -- especially in children.
- dental infections -- especially in adults. 1st and 2nd molars lie in floor of maxillary sinus in most individuals.
- trauma to ostium -- including nasotracheal intubation and N-G tubes.
- septal deviation, hypertrophied turbinates, nasal polyps and tumors -- presumably lead to sinusitis by obstruction to drainage. Should be excluded specifically in subacute or chronic sinusitis.
- systemic disease. Hypogammaglobulinemia (16), cystic fibrosis (abnormal mucous production), Wegener's granulomatosis, Kartagener's syndrome (immotile cilia).



Approximately average relations of the maxillary sinus and the roots of the teeth.

Fig. 1, from ref. 5.

C. *Sinusitis*

Definition: Inflammation of one or more paranasal sinuses

1. Pathophysiology. Loosely constructed, there are three phases (17): they may follow an alteration in the sinus mucosa and/or ostial obstruction.

   a) Hyperemia, increased mucosal edema, a few polymorphonuclear cells. Increased serous secretions. Usually returns to normal.

   b) Secondary bacterial infection. Bacterial multiplication, more vigorous influx of PMNs, increase in intrasinus pressure, hypoxia and hypercapnia of sinus secretions.

   c) Failure to achieve drainage may lead to further increases in intrasinus pressure, with subsequent bony erosion and escape of pus through wall of sinus.

   The experimental evidence for this sequence derives from several studies in man, using specimens obtained by needle puncture of the maxillary antrum.

      1) Patients with allergic rhinitis have increased ostial resistance (defined experimentally as the cm of H_2O pressure within the maxillary sinus which is required to overcome ostial obstruction) (18). Antral secretion is serous in quality.

      2) In one careful study, the presence of pus in the acutely inflamed sinus correlated with culture of 10^3 or more bacteria per ml from the sinus aspirate, or with isolation of a virus or fungus from the sinus:

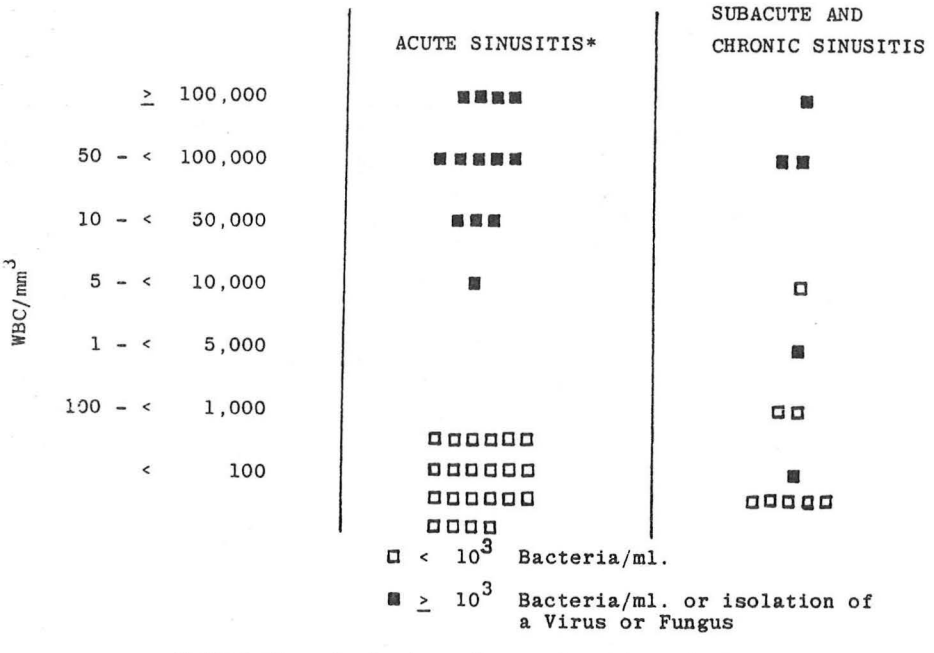


Fig. 2, from Ref. 19

Relation between Culture Results and Antral Leukocyte Counts before therapy

* Including Aspirates of asymptomatic volunteers

3) Investigators have found decreased oxygen tension in the gas aspirated from maxillary sinuses infected with bacteria (9), and other workers found an interesting difference between purulent and non-purulent sinus secretions (20):

SINUS SECRETIONS

	Non-purulent	Purulent
Mean pO_2	96	.05
Mean pCO_2	39	> 76
Mean pH	7.4	6.8
⊕ Gram stain	2/14	10/13

Table 1. Data combined from references 20 and 41.

Unfortunately, the distinction between purulent and non-purulent secretions was made qualitatively (appearance of aspirate), without actual WBC counts. There may be several explanations for the low pO_2, high pCO_2 found in sinuses with purulent secretions: a larger number of bacteria, metabolism by pus cells, or decreased mucosal blood flow caused by increased pressure within an obstructed sinus. Whatever the mechanism, it is likely that these changes impair ciliary function, and they may actually facilitate growth of *H. influenzae* and *S. pneumoniae*, the two most common pathogens found in acute bacterial sinusitis. Both of these pathogens grow well in a high CO_2, low O_2 environment (29,30).

4) Ostial resistance in patients with acute sinusitis is increased above normal, but not much above the levels found in patients with allergic rhinitis (18). Only one study of this comparison has been performed, however, and no study has compared ostial resistance or patency measurements with secretion analysis (quantitative culture, WBC count, Gram-stain, pO_2, pCO_2, pH) in the same patients.

5) Patients with chronic sinusitis, which often develops if drainage is not achieved, have a higher frequency of obstructed ostia and higher ostial resistance than patients with acute sinusitis (21).

2. Symptoms /signs. Fever (usually < 38.5°C, 101.5°F), nasal discharge plus pain:

Maxillary sinusitis -- cheek or dental pain common

Ethmoid sinusitis -- pain between eyes, over bridge of nose

Frontal sinusitis -- often associated with ethmoid sinusitis. Pain above eyebrows, with supraorbital tenderness.

Sphenoid sinusitis -- usually infected as part of pansinusitis. Supposed to cause headache directed to vertex of skull.

In maxillary sinusitis, the typical symptoms of pain, fever, and discharge actually correlate poorly with the presence of infection as determined by aspiration of maxillary contents (19); the same is probably true for infection of the other sinuses.

3. Diagnosis. Definitions of "acute sinusitis" have varied considerably in the past. Some authors use the presence of appropriate symptoms (see above), others use the presence of sinus secretion, still others distinguish between purulent and non-purulent secretions. Positive sinus secretion cultures have also been used, though rarely quantitatively or in association with a quantitative estimate of sinus secretion purulence. The best study to date is that of Evans et al. (19), which will be mentioned frequently in this discussion.

a) X-ray. Adequate radiographic evaluation of the paranasal sinuses requires at least four basic projections. These are the Caldwell, Waters, lateral and submentovertex views.

VIEW	BEST FOR
Caldwell	frontal, ethmoid
Waters	maxillary
lateral	sphenoid, anterior and posterior walls of frontal, maxillary
submentovertex	sphenoid, ethmoid

Some have recommended a fifth view (with affected sinus in dependent position), but the additional benefit from this view is disputed (24).

Changes sought are mucosal thickening, a fluid level, opacification, and expansion or destruction of bone.

Abnormal radiographic changes occur in a significant percentage of asymptomatic young adults. In one study of airforce personnel, abnormal findings (mucosal thickening of 10 mm or more, air-fluid level, or pus aspirated from the sinus cavity) occurred in 4% of those examined, all of whom were asymptomatic (15). Another study reported similar findings (22). Barotrauma (flying) did not seem to be a factor. Sinus films may be particularly difficult to interpret in young children (23).

The best correlation between radiographic findings and aspirate results was obtained by Evans et al. (19), in their study on maxillary sinusitis:

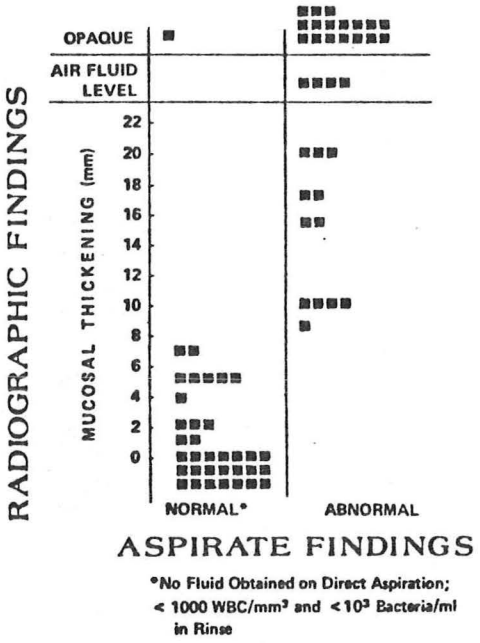


Fig. 3 , from ref. 19.

Radiographic Findings and Results of Sinus Puncture

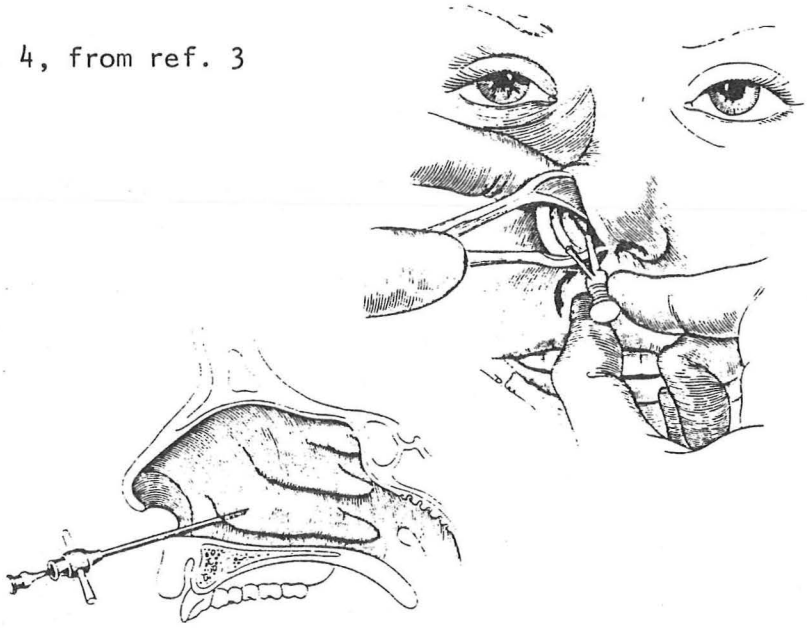
Other workers, comparing radiographic changes with the results of maxillary sinus irrigation, found a rough correlation between mucous membrane thickening on X-ray and the presence of secretion at irrigation -- secretion was found in 86% of the totally opaque sinuses, and in 41% of the sinuses with only 1-3 mm mucous membrane thickening (24).

Role of x-ray:

- confirmation of clinical diagnosis of sinusitis
- clue to possible extension beyond sinus-bone erosion
- cysts, tumors

b) Lavage. Sinus lavage has been advocated as a diagnostic/ therapeutic procedure. For maxillary sinusitis, lavage is usually performed through a trochar introduced transnasally, under the inferior turbinate (angling superiorly) or via the canine fossa. For the purposes of accurate secretion cytology and bacteriology, this is the optimal diagnostic maneuver. Its role in therapy is disputed.

Fig. 4, from ref. 3



Transnasal approach to maxillary sinus aspiration

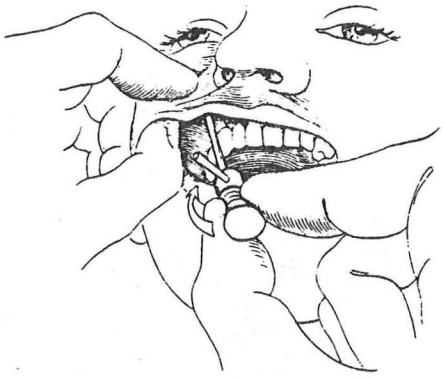
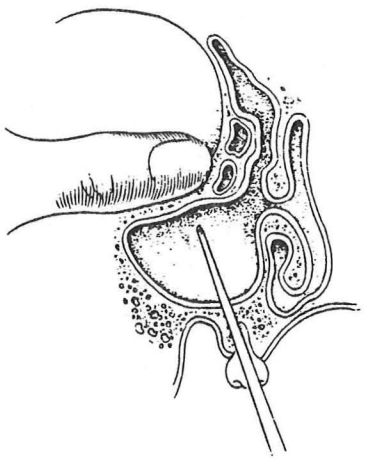


Fig. 5, from ref. 3

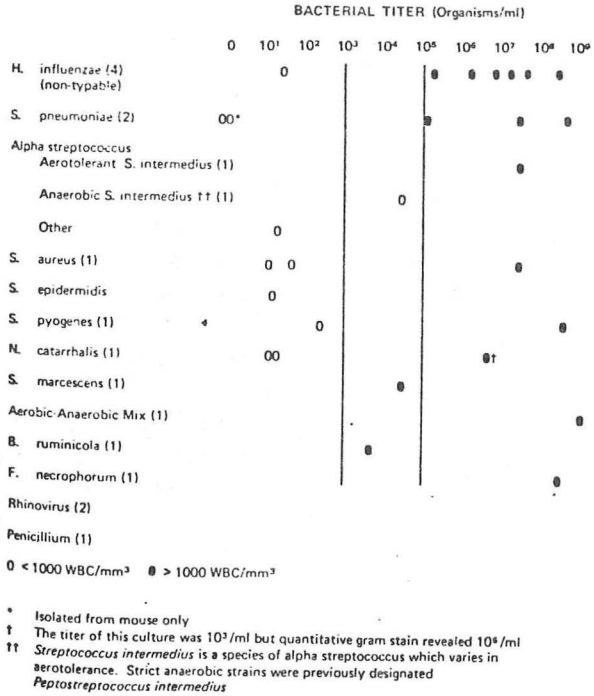


Canine Fossa approach to maxillary sinus aspiration

c) Transillumination. There are at least two studies which support the usefulness of this procedure in the evaluation of maxillary sinusitis. Evans et al. (19) found that 14 of 15 (93%) antrums with normal transillumination were normal on aspiration, while 24 of 24 opaque antrums were abnormal. "Dullness" (less than normal transillumination, but some light transmitted) was not helpful. They placed the light source on the orbital rim and inspected the palate for transmitted light. Another technique, with the light inside the mouth and the orbital rims inspected for transillumination, was accurate in predicting the presence of fluid in 68% of the patients studied by McNeill(25).

d) Sinusoscopy, radionuclide scanning, thermography, and echography have recently been utilized to evaluate sinus abnormalities (26-28).

4. Microbiology. To obtain cultures of sinus contents, one must either cross the skin (frontal sinus) or a contaminated mucous membrane (the other sinuses). Because of its relative accessibility, and its frequent involvement in sinusitis, the maxillary sinus has been most extensively studied. There is agreement that transnasal or canine fossa puncture is preferable to aspiration through the maxillary ostium to obtain accurate culture data, and that there is a poor correlation between nasal discharge and sinus content cultures (17). Though rarely performed, even by students of sinusitis, quantitative cultures may allow one to distinguish bacterial contamination from disease:



* Isolated from mouse only
† The titer of this culture was 10^3/ml but quantitative gram stain revealed 10^8/ml
†† *Streptococcus intermedius* is a species of alpha streptococcus which varies in aerotolerance. Strict anaerobic strains were previously designated *Peptostreptococcus intermedius*

Fig. 6, from ref. 19

Titers of All Bacteria Isolated from Antral Specimens and Their Relation to Antral Leukocytosis.

In this study, isolates with less than 10^3 colonies/ml were not associated with antral pus; these probably can be regarded as contaminants.

A simple, semi-quantitative estimate of the significance of bacteria in sinus contents can be obtained from a Gram-stain of the aspirated fluid. One or more organisms per oil field corresponds roughly to greater than 10^4 - 10^5 organisms/ml. The Gram-stain can also be used to give a rough estimate of the number of polymorphonuclear cells in the secretion (19), and it can give the initial clue to the presence of actinomycosis.

One may summarize a large number of studies on the microbiology of acute bacterial sinusitis (reviewed in ref. 17) as follows: (1) In most series, 10 - 25% of the sinus aspirate cultures are negative. To some extent, this finding probably reflects improper (or insufficient) culture technique, particularly with respect to anaerobic cultures. (2) Of the positive cultures, *H. influenzae* (non-typable (19)) and *S. pneumoniae* are the dominant pathogens. *S. aureus* is an infrequent isolate (less than 10% of positive cultures) from sinus aspirates, but it is found in some 25% of nasal cultures from normal individuals. Other streptococci and Gram-negative organisms account for a small percentage of the positive cultures. In contrast to chronic sinusitis, anaerobes are uncommonly isolated from patients with acute sinusitis (19 : for another view, see 31). Few workers have attempted to isolate viruses from patients with acute sinusitis. Evans et al. recovered rhinovirus from the antral aspirates of two patients with acute sinusitis; one was treated with clindamycin and subsequently grew *H. influenzae* from the same sinus, while the other also grew *S. pneumoniae* (low titer) from the specimen yielding the rhinovirus.

Uncommon causes of acute sinusitis include actinomycosis (33,34), tuberculosis (rare) (35), and fungi.

5. Therapy. Conservative (medical) therapy centers on three problems: relief of pain, drainage of sinus contents, and eradication of pathogenic microbes.

Relief of pain can be achieved by the usual analgesics; codeine or even morphine may be required in some patients. Application of moist heat over the affected sinus is said to benefit some patients.

Sinus drainage may be facilitated by nasal decongestant or vasoconstrictor (0.25% - 0.5% phenylephrine nose drops q 4-6 h for 2-4 days; longer use may elicit rebound vasodilation). Systemic decongestants or antihistamines may be helpful without the rebound phenomenon. Correct positioning of the head may facilitate drainage. Some recommend inhalation of warmed air that is saturated with water (not steam).

The role of antibiotics in the treatment of acute sinusitis is uncertain. Several facts contribute to this uncertainty:

1) There is no definitive, non-invasive method to distinguish bacterial from non-bacterial sinusitis. X-rays can be helpful to the clinician when they are definitely abnormal, but sinus puncture with appropriate examination of aspirated secretions is required to establish a definitive bacterial etiology.

2) In almost all studies of antimicrobial efficacy in sinusitis therapy, sinus puncture for diagnosis has been accompanied by lavage with sterile saline. This itself may be therapeutic. Moreover, repeat puncture (+/- lavage) is necessary to monitor the effect of the antibiotic being tested.

   When antibiotic therapy has been compared with placebo in patients who also receive antral puncture and lavage, there has been no significant difference noted in clinical outcome (38,39).

3) If sinus mucosal blood flow is impaired during purulent sinusitis (as might be concluded from studies on secretion pO_2 and pCO_2 cited above) no drug can achieve significant concentrations in sinus secretions. None of the studies of "achievable concentrations" of antimicrobial agents in sinus contents during sinusitis appear to have considered this obstacle (for references, see 17).

There is evidence that sinus concentrations of antibiotic exceeding the MIC of the offending pathogen may have an antibacterial effect in sinus secretions:

Table 2: RELATIONSHIP BETWEEN SINUS ANTIBIOTIC CONCENTRATION AND ISOLATION OF PATHOGENS:

Sinus secretion antibiotic concentration	Sinus secretions with growth/Total sampled				
	azidocillin	pen V	tetracycline	doxycycline	total
< MIC	9/10	6/7	2/2	2/2	19/21 (90%)
> MIC	4/7	4/10	3/8	3/8	15/33 (45%)

MIC = minimal inhibitory concentration

Data refer to sensitive organisms only. Aspirates were obtained on day 2 or 3 of therapy, 2-3 hours after latest dose of oral antibiotic.

From ref. 41

These data should also be viewed cautiously, since the sinuses with highest antimicrobial concentrations may also have been those with best drainage (less sinus pressure, better mucosal blood flow, better mucosal clearance, etc.).

Given these uncertainties about the efficacy of antimicrobial therapy, the choice of an antimicrobial agent for uncomplicated acute sinusitis is logically based on existing knowledge of the major pathogens: *H. influenzae* and *S. pneumoniae*. Ampicillin or amoxicillin thus would be reasonable choices (doses of 500 mg QID or 250 mg QID, respectively). A large number of other agents have been used with apparent success, including erythromycin, doxycycline, and penicillin V -- as indicated above, these studies used antral lavage in addition to antimicrobial therapy.

DRAINAGE of an infected sinus appears to be the critical feature of therapy. Antibiotics may play a role in clearance of bacteria once drainage is achieved, and may help limit infection to the involved sinus.

6. Chronic sinusitis. Chronic sinusitis (usually defined as sinusitis of more than 3-4 weeks' duration) differs from acute sinusitis in certain important respects:

   a) The organisms isolated in greatest numbers from chronically infected sinuses are anaerobes (largely anaerobic streptococci and bacteroides species). Staphylococci are also frequently isolated, though usually in small numbers (32). *H. influenzae* and pneumococci are found infrequently.

      Features of chronic sinusitis which may encourage anaerobic growth include poor drainage and increased intrasinus pressure, with low oxygen tension due to decreased mucosal blood flow. Almost all chronically infected sinuses are obstructed. See "pathophysiology" above [C.1].

      As with acute sinusitis, the role of antibiotics in the therapy of chronic sinusitis is uncertain. Oral antibiotics which should be effective for the usual flora include cephalexin and dicloxacillin (40). However, the focus of management should be upon achieving adequate drainage. Predisposing structural abnormalities (such as polyps, septal deviation, tumors, cysts and foreign bodies) should be excluded.

      An organism which has been found recently in patients with sinusitis is *Eikenella corrodens*, a pathogen which has several interesting features (36): 1) in sinus secretions, it has usually been found in association with other organisms (mixed cultures), 2) these infections have been indolent (though not without complications), 3) the organism has an unusual

antibiotic susceptibility pattern -- susceptibility to penicillin, chloramphenicol and ampicillin but resistance to semi-synthetic penicillins, clindamycin, and gentamicin. *E. corrodens* is part of the normal human oral flora; it has been isolated from other head and neck infections (37). Sinus aspirates should be cultured in 10% CO_2 in order to detect this pathogen.

b) A useful description of the histologic changes during chronic sinusitis:

> "*If the infection cannot be overcome by the host tissues, a disease process develops in which destruction and inflammation proceed concomitantly with attempts at healing. Histologically this process is characterized by an inflammatory exudate of both polymorphonuclear and mononuclear cells, stromal edema and polyp formation, fibrosis, an increase in the number of goblet cells, a loss of the ciliated cells, squamous metaplasia of the lining columnar epithelium, and an osteoblastic or osteoclastic response in the surrounding bone. Tissue eosinophilia and edema can be recognized in most cases of chronic purulent infection superimposed on allergic rhinosinusitis.*" (7).

The mucosa of the chronically obstructed sinus may continue to secrete fluid into the sinus, leading to gradual expansion of the sinus contents and erosion (or pressure-absorption) of the wall of the sinus. Uninfected,this process is called a mucocoele; infected, it is a pyocoele or mucopyocoele. These abnormal masses do not usually cause sudden or acute symptoms, but they cause some of the more common orbital and intracranial complications of sinusitis,particularly in adults (42).

D. *Complications of acute and chronic sinusitis*

1. Orbital extension.

a) Anatomical factors. Bacterial sinus infections extend into the orbit by contiguous spread or by venous channels.

Paranasal sinuses surround the orbit on three sides, often with only a paper-thin plate of intervening bone.

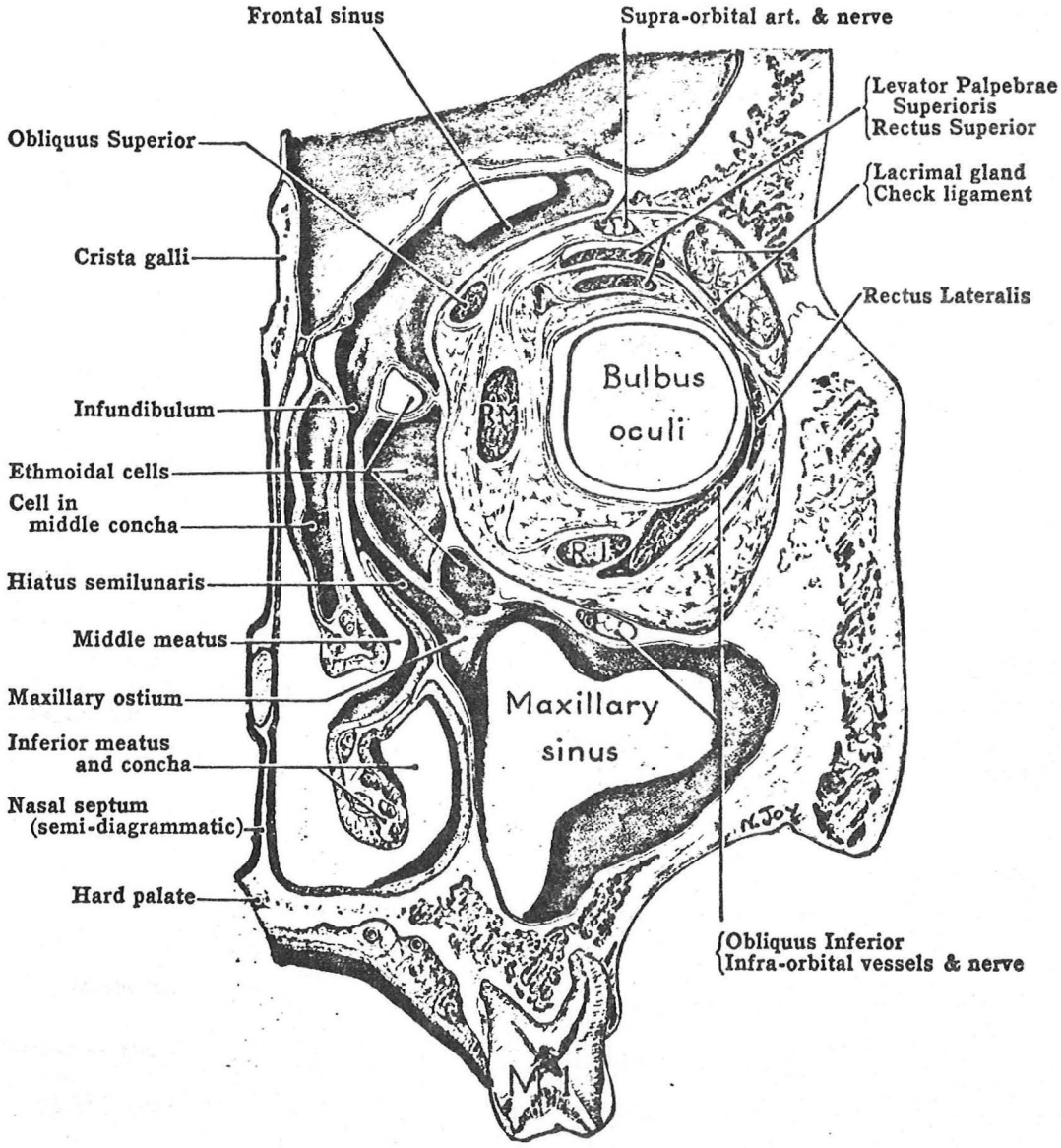


Fig. 7 , from ref. 4.

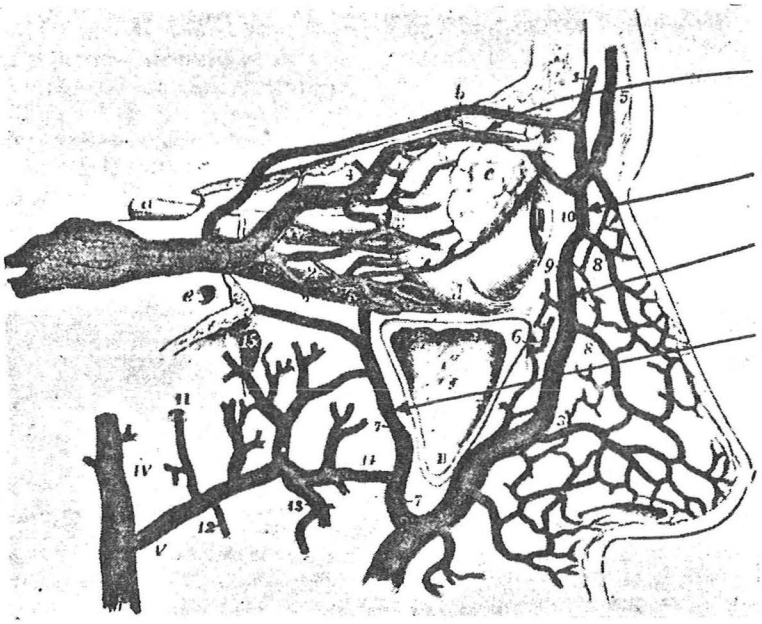
Sinuses and orbit in coronal section.

Infection may spread directly from sinus to orbit by several mechanisms:

1. Defects in the intervening bone (congenital dehiscences, trauma-induced defects).
2. Osteitis of intervening bone
3. (Muco)pyocoele

} Erosion of bone, periosteal abscess

The ophthalmic venous system is devoid of valves. This results in a two-way communication between the face, nasal cavity, pterygoid region, and sinuses



Note connections: 1) facial vein → superior ophthalmic vein → cavernous sinus 2) ethmoidal br. of superior ophthalmic vein → cavernous vein 3) deep facial vein, connecting with inf. ophthalmic vein, pterygoid plexus

Fig. 8, from ref. 6
Venous drainage of nose, orbit, pterygoid plexus. (See Fig. 12)

The cavernous sinus is formed, like the other intracranial sinuses, as a separation of the two layers of the dura. It is a cavernous network; there are veins anterior and posterior to the pituitary which connect each cavernous sinus with its counterpart on the opposite side (61).

b) Occurrence. Orbital complications of sinus infections occur most commonly in children and adolescents. The age distribution of patients with orbital complications of sinusitis in the practice of two ENT surgeons in Pennsylvania from 1970-1973 may be representative:

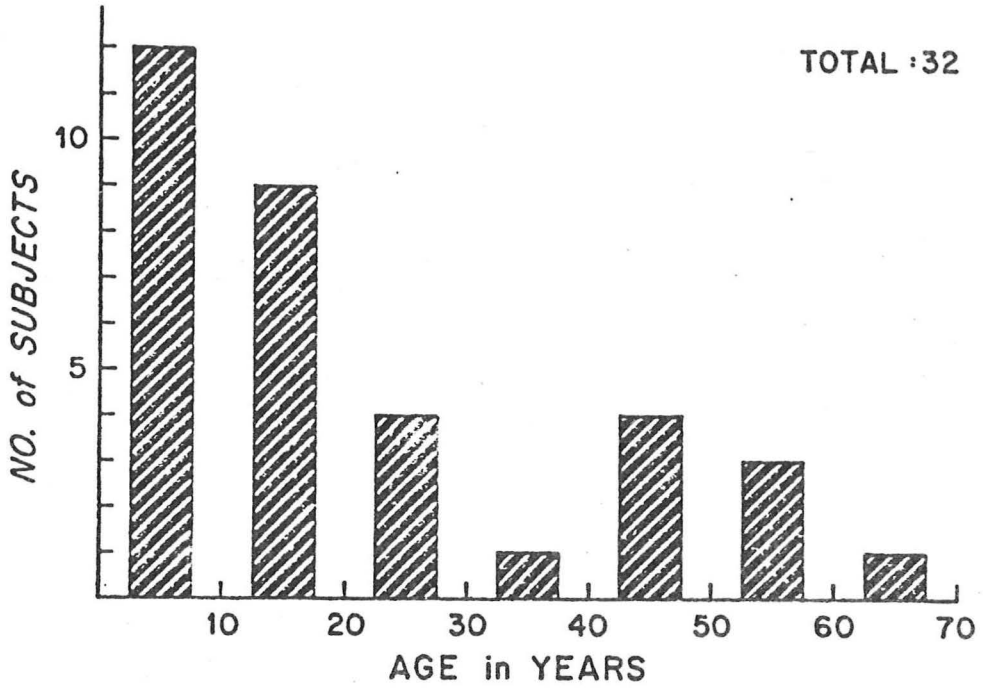


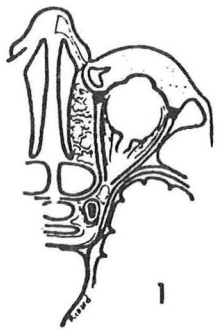
Fig. 9 , from ref. 52

Age Distribution of Patients with Orbital Complications of Sinusitis .

It has been estimated that 60% of all orbital inflammatory processes is secondary to sinus disease (49).

c) Clinicopathological classification. A useful classification of these disorders has been proposed by Smith and Spencer (48), and modified by Chandler (49). [See Table 3].

1) Inflammatory edema. Swelling of the eyelids may occur as the result of sinusitis without actual orbital infection. This is thought to occur because of impedance to venous drainage caused by obstruction to flow through some of the collaterals of the superior ophthalmic vein. The area of the eyelid which first becomes edematous may be a clue to the exact site of disease: for example, infection of the ethmoid sinuses first produces edema over the frontal process of the maxilla just above the internal palpebral ligament with later extension in a lateral direction. The eyelids are not tender. There is no impairment of visual acuity or extraocular movement. There may be slight proptosis of the globe. Management is directed toward the primary sinus infection.



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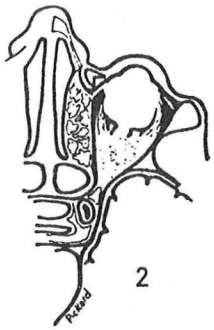
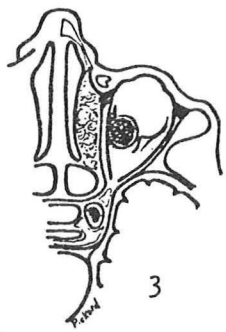


2

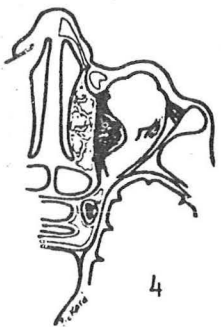
2) Orbital cellulitis. This is diffuse edema of the orbital contents and actual bacterial invasion of the adipose tissue, without abscess formation. The eyelids are swollen and usually tender. If late, some impairment of visual acuity may occur. Extraocular movement is limited by surrounding edema, and there is proptosis and chemosis. No lateral or vertical displacement of the globe is present. When treated promptly with antibiotics,orbital cellulitis usually resolves promptly, without surgical intervention. In some patients, delayed treatment allows the process to proceed to orbital abscess. Orbital cellulitis occurs most commonly in children with ethmoid sinusitis (51,53).



3

3) Orbital abscess. A discrete collection of pus. Proptosis, chemosis are more pronounced. There is usually complete ophthalmoplegia and often severe impairment of vision. Sometimes the pus drains spontaneously through the lid.

See Case 1 (page 33).



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4) Subperiosteal abscess. Here pus collects between the periorbita and the bony wall of the orbit. The most helpful clinical clue is displacement of the globe. Since the most common primary sites for this process are the ethmoidal and frontal sinuses, displacement tends to be lateral or downward. A variation of this process is the infected mucocoele (="mucopyocoele"), which may erode through the orbital wall to cause a periorbital abscess--most commonly arising from the ethmoid or frontal sinuses.

See Case 2 (page 34).

Drawings from ref. 49

5) Superior Orbital Fissure Syndrome. This and the Orbital Apex Syndrome are not included in Chandler's classification, but they logically would come at this point. As the name implies, the Superior Orbital Fissure Syndrome results from involvement of the structures which pass through this fissure in the sphenoid bone: cranial nerves III, IV, VI, V_1, the ophthalmic vein, sympathetic nerves. The earliest symptom is often neuralgia, followed by dysesthesia or total anesthesia, in the distribution of V_1.

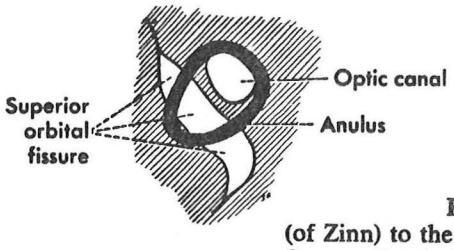
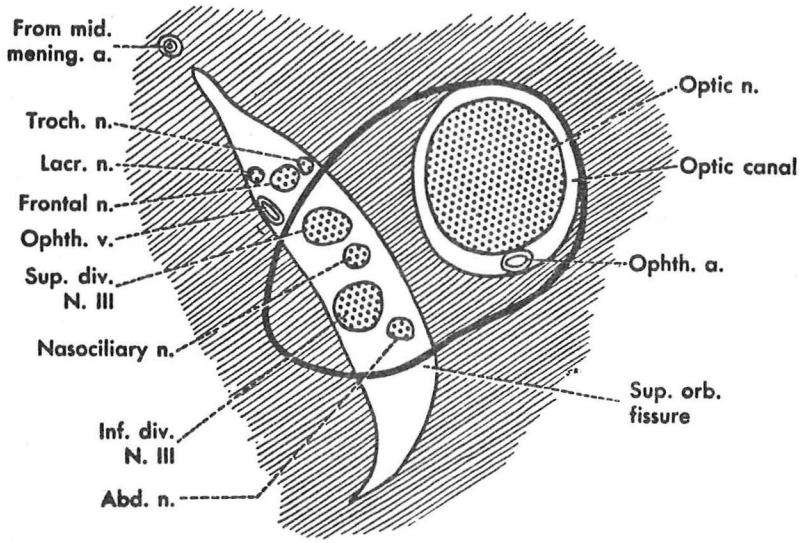


Fig. 10 , from ref. 5

Relation of the anulus tendineus (of Zinn) to the optic canal and superior orbital fissure; the latter extends higher and farther laterally than is apparent from this angle. Right orbit, viewed from the front.



General arrangement of the structures entering and leaving the back of the orbit.

Fig. 11, from ref. 5

This syndrome occurs most commonly as a complication of sphenoid sinusitis (46). See further discussion on page 30.

6) Orbital Apex Syndrome. This condition results from involvement of structures passing through both the superior orbital fissure and the optic canal. Thus decreased vision is a constant feature (46).

Causes of the orbital apex and superior orbital fissure syndromes other than acute infection have included trauma, neoplasm, and (even more rarely) syphilis and tuberculosis. The orbital apex syndrome has been reported as a complication of frontal pyocoele (57) and acute ethmoid sinusitis (58). See further discussion on page 30 (Intracranial complications, sphenoid sinus) and case 6 on page 38.

7) Cavernous sinus thrombosis (C.S.T.) This disorder may occur as orbital infection extends posteriorly along venous channels. More commonly, it results from infections of the nose or face (61,69) and it may arise inferiorly, by way of the pterygoid plexus, from the posterior teeth or tonsils, or from direct extension of infection from the sphenoid sinus (95).

The diagnosis of C.S.T. is difficult to make clinically without evidence for involvement of both eyes. Common helpful features include extreme toxicity and meningeal irritation or frank meningitis. Blood cultures are positive in approximately 1/3 cases (65). Septic pulmonary emboli may also occur. Mortality in reported series has approximated 70% (64).

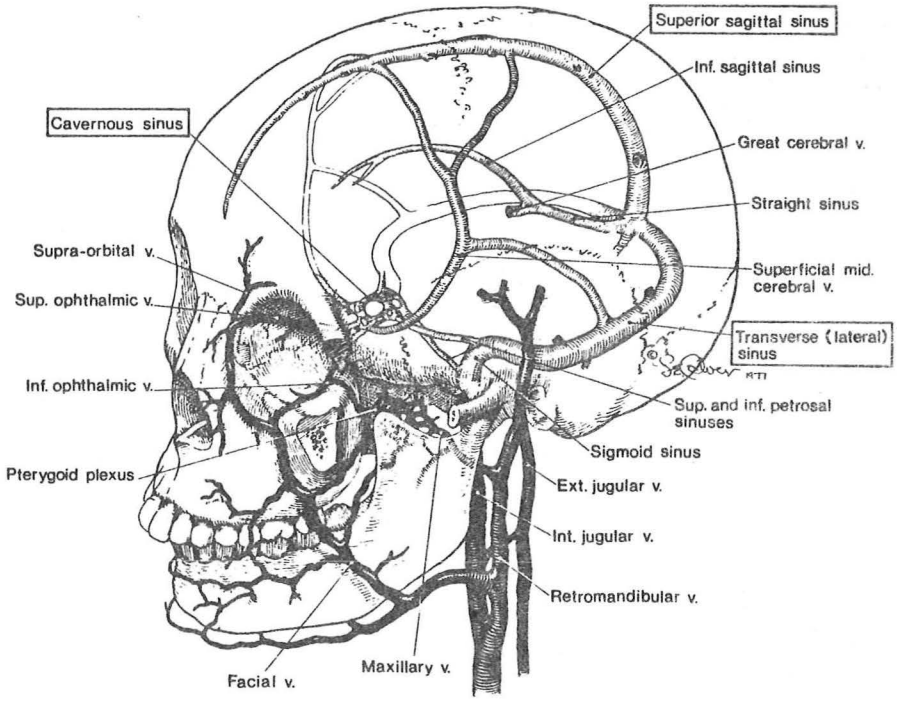


Fig. 12, from ref. 43

Important venous connections in the head.

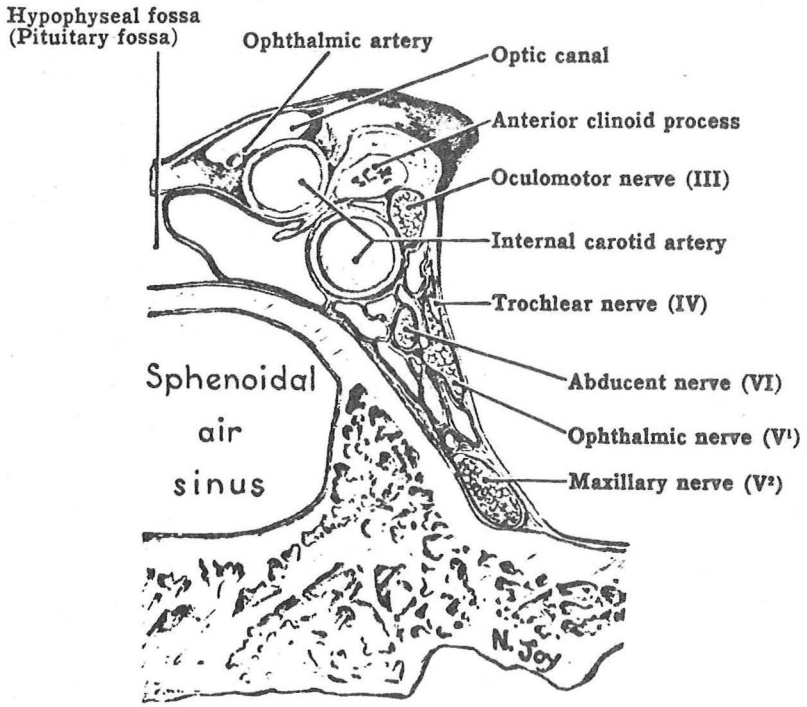


Fig. 13 , from ref. 4

Cavernous sinus and associated structures in coronal section.

C.S.T. is commonly associated with paresis of III. IV, VI, and V_1, V_2. Vision may not be impaired.

TABLE 3 : CLINICAL SIGNS IN ORBITAL COMPLICATIONS OF SINUSITIS

	Eyelid Edema	Proptosis	Chemosis	Lateral Displacement of Globe	Ophthalmoplegia Internal	Ophthalmoplegia External	Visual Loss	Contralateral Eye Signs	Meningitis
1. Reactionary edema	+++	+	+	0	0	0	0	0	0
2. Orbital cellulitis	+++	+++	+++	0	+	++x	0	0	0
3. Orbital abscess	+++	+++	+++	0/+	++	++	++	0	0
4. Subperiosteal abscess	+++	+++	+++	++	+	+	++	0	0
5. Superior Orbital Fissure Syndrome	+++	+++	+++	0	+++	+++	0*	0	+
6. Orbital Apex Syndrome	+++	+++	+++	0	+++	+++	+++*	0	+
7. Cavernous Sinus Thrombosis	+++	+++	+++	0	+++	+++	+ - ++	+++	++

0 - Uncommon; + - occasional; ++ - common; +++ - almost always; x - limitation of movement related to orbital edema, not cranial nerve paresis; * - by definition

NOTE: 1. Fundoscopic changes are variable. Changes in the disc reflect relative obstruction to arterial and venous flow. The presence or absence of venous pulsations may be helpful.
2. Pupillary response may be preserved in the presence of external ophthalmoplegia. Fibers which control pupil lie near the surface of the oculomotor nerve, and are thought to be less susceptible to ischemic injury than the deeper motor fibers (54).
3. A Marcus Gunn pupil (paradoxical dilatation of "bad" eye pupil when light is shined alternatively on "bad" and "good" eyes) reflects an afferent defect in optic nerve (55).

d) Diagnosis. There is considerable overlap in the eye findings in the disorders discussed above (see Table 1, preceding page). The most important clinical distinction is between orbital cellulitis (which usually can be managed with high-dose antibiotics) and the other disorders which may require surgical exploration of the orbit, or which may signal intracranial extension of the infectious process. The two most helpful findings appear to be lateral or downward displacement of the globe, a clue to periosteal abscess or other process invading the orbit from the ethmoid or frontal sinuses, and acute loss of vision, which often represents compression injury of the optic nerve. The onset of abnormalities in the opposite eye, particularly proptosis and chemosis, usually indicates obstruction to venous flow within the cavernous sinus.

Helpful diagnostic procedures include sinus and orbital x-rays, which can demonstrate an associated sinusitis and occasionally may define an area of bony destruction (good clue for contiguous spread into the orbit), and lumbar puncture (only inflammation of the posterior orbital structures or C.S.T. should produce CSF pleocytosis or meningitis). Most important, orbital CT scan appears to be extremely useful in defining collections of pus within the orbit. Orbital ultrasound may also be helpful.

e) Differential diagnosis:periorbital swelling: In addition to the disorders mentioned above, one should consider (56):

Facial cellulitis -- following, for example, a nasal furuncle. The veins of the nasal vestibules drain into the facial vein (see Fig. 7). Sinus x-rays are normal.

Lacrimal sac infections -- dacryocystitis is seen most commonly in infants and in adults over 40 years of age. It results from a blocked nasolacrimal duct, which may follow trauma. Excessive tearing usually precedes the acute infection. Swelling and erythema involve the medial aspect of both lids. Extraocular movements are usually normal. X-rays are unremarkable, unless there is evidence of trauma.

Trauma. Nasal and zygomatic fractures often produce periorbital swelling.

Lacrimal gland infections. Dacryoadenitis is a rare, usually unilateral condition. It may follow viral infections in children, or be associated with gonococcal infections in older persons. There is swelling and erythema over the upper outer third of the lid. Excessive tearing is absent.

Blepharitis. This common, usually bilateral, chronic inflammation of the margins of the lids occurs in two forms: staphylococcal and seborrheic. Symptoms include itching and burning of the lid margins with occasional swelling. Examination shows redness of the lid margins, with scales clinging to the lashes.

Differential diagnosis: unilateral exophthalmos:

1. Inflammatory -- disorders discussed previously
2. Endocrine -- Graves disease
3. Vascular -- hemorrhage, aneurysm
4. Traumatic -- fracture, rupture of the extraocular muscles, emphysema from sinuses
5. Tumors -- primary orbital tumors, metastases
6. Cysts -- congenital dermoid, parasitic, mucocoele
7. Relaxation of retractors of eyeball (as with extraocular muscle paralysis)

f) Bacteriology. *Staphylococcus aureus* has been isolated from pus or blood cultures in many patients with orbital complications of sinusitis (50,51), indicating that this pathogen may account for a significant percentage of orbital complications (in most reports, the bacteriology is not adequate to allow a conclusion regarding bacterial etiology). The "usual" pathogens of acute sinusitis (*S. pneumoniae*, *H. influenzae*) may also take part, especially in children, and beta-hemolytic streptococci have also been implicated (44). In orbital complications resulting from chronic sinus infections, one might expect anaerobes to have a major role (see below, pages 25 and 28).

g) Therapy. Empiric antimicrobial therapy should include a semi-synthetic penicillin, a cephalosporin, or clindamycin in order to provide therapy for *S. aureus*. If there is an associated meningitis, semi-synthetic penicillins (e.g., methicillin) should be used to achieve effective CSF levels of antibiotic. Reliable bacteriological data, acquired by culturing sinus contents or abscess fluid, allow simplification and/or correction of the antimicrobial regimen. In the patient with orbital extension related to chronic sinusitis, effective therapy for anaerobes would necessitate adding penicillin G, chloramphenicol, or clindamycin to the regimen.

Surgery is generally indicated if there is pus within the orbit or an undrained adjacent sinus. As a general rule, the acute onset of loss of vision constitutes an indication for surgical intervention, if loculated pus can be identified. Unfortunately, surgery in the infected, edematous orbit tends to be very difficult.

C.S.T. is treated with antibiotics in high dose, combined with drainage of identifiable primary foci of infection in the sinuses and/or orbit. Regarding surgical therapy: "Nature seems to have been aware of her mistake when she constructed the cavernous sinus, because she hid it so carefully that not only was man late in finding it but he has never been able to attack it surgically with any success" (O.J. Dixon, 1926 (62)).

Anticoagulant therapy of C.S.T. is controversial. Anticoagulants are not generally used in the U.S. for treatment of C.S.T.

Antibiotic therapy should be continued for approximately 4 weeks, since relapse occasionally occurs with shorter courses of therapy (64).

2. Intracranial extension.

a) Via cavernous sinus thrombosis, with involvement of intracranial venous sinuses. Subsequent developments may include meningitis, brain abscess, obstruction of sigmoid and lateral sinuses, and subdural empyema. Case report 3 illustrates the diagnostic and therapeutic difficulties which this process may present.

See Case 3 (page 35).

Subdural empyema (collection of pus in the "potential space" between the dura and arachnoid) usually develops quickly and progresses rapidly. This explains the failure of the process to wall off or (usually) to extend into the brain as an abscess. It is also interesting that the arachnoid seems to be rather impervious to toxins and pus, so that many patients escape without severe cortical damage (72). The pus may vary in consistency from watery to thick, and may collect diffusely over the frontoparietal convexities or in the sylvian fissures. Spread to the base of the brain is limited by the anatomical obliteration of the subdural space at the base. Actual bacterial meningitis is rarely found. The CSF formula is that of a parameningeal focus of infection: 25 to 500 or so cells, mixed polys and lymphs, high protein, normal sugar. However, the CSF may remain normal (66).

The most common source of primary infection in patients with subdural empyema is paranasal sinusitis. The series of patients studied in England by Bhandari and Sarkari from 1954 - 1968 is representative:

Source of Infection		Number of Cases
Paranasal sinus		20
frontal	- 13	
ethmoid	- 1	
multiple	- 6	
Orbital cellulitis		2
Otogenic		12
Other		3

From ref. 72

Other primary infections include meningitis (infants: infected subdural effusion), post-operative infection, and hematogenous seeding of subdural hematoma (66). In all series, subdural empyema following sinusitis has occurred largely in individuals 10-20 years of age, with a striking male predominance (66,68,72,74).

It appears that almost every patient with subdural empyema will have headache and fever. Most will also have hemiparesis or hemiplegia. Altered consciousness and vomiting are common. Over half of the patients have papilledema; less than half have seizures (66,68). In contrast to subdural empyema, hemiparesis and papilledema do not occur commonly in bacterial meningitis in the adult. These findings should suggest subdural empyema, parenchymal involvement, and/or cortical venous thrombosis (66,75).

Associated conditions may include cellulitis of the scalp, epicranial abscess, extradural abscess, and thrombosis of cortical venous sinuses. The process may also extend along bridging veins to cause brain abscess (see below).

Infection may spread from the frontal sinus to the subdural space by different routes. The rarity of obvious erosion of the posterior wall of the sinus in patients studied at autopsy with subdural empyema led Courville (71) to suggest that spread via veins is more likely. In contrast, 50% of Hitchcock's cases (68) had osteomyelitis of the frontal bone. As our case illustrated, subdural empyema can arise via C.S.T. secondary to maxillary/ethmoid sinusitis as well.

The most helpful diagnostic procedure in the past has been cerebral arteriography. The findings sought largely reflect displacement of arteries away from the subdural collection (69, 70). In 3 recent studies, carotid arteriography was diagnostic in 19 of 22 (72), 17 of 17 (66), and 9 of 13 (68) patients studied prior to surgery.

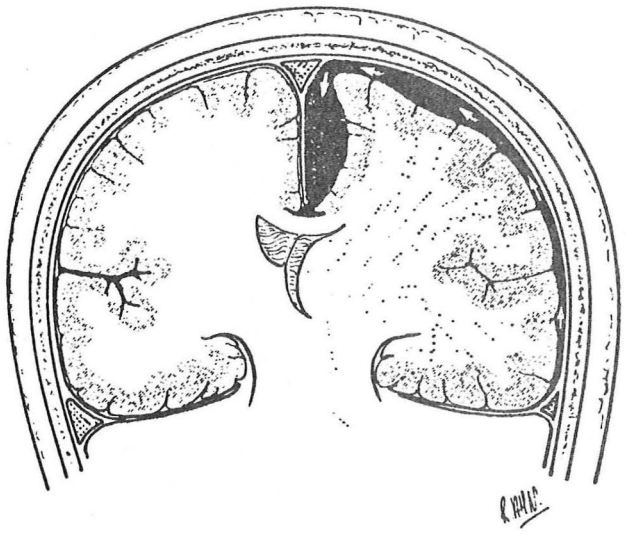


Diagram to show:—(a) Extension of pus over cerebral convexity to collect in the parafalcine space; (b) Lateral displacement of the superior cerebrum and contralateral displacement of the mid-line structures below the falx.

Fig. 14 , from ref. 70
Illustrates the typical location of subdural empyema over the convexity of one hemisphere and along the falx. The pus can work its way below the falx to involve the opposite side. Extension to the base is uncommon.

In patients with no localized focus within the subdural space, additional dye injections with oblique views are recommended (70). The CT scan may also be helpful, although there has been little reported experience with this method in patients with subdural empyema.

The most common causative bacteria are anaerobic and aerobic streptococci and *S. aureus*. Other anaerobes have also been implicated (67). *H. influenzae*, *S. pneumonia*, and enteric Gram-negative rods are found in subdural empyema in infants and children (73); in this age group subdural empyema occurs most commonly as a sequel of bacterial meningitis.

Subdural empyema is a true neurosurgical emergency. Adequate drainage can often be achieved by placing burr holes at appropriate places. If there is parafalcine localization of pus, craniotomy is usually performed. Appropriate empiric antibiotic therapy would be a semi-synthetic penicillin plus chloramphenicol, both in high dosage.

Mortality in reported series ranges from 27% to 35%. Excluding cases admitted to hospital deeply comatose, Bhandari and Sarkari had only 6 deaths in 27 patients (22%). Neurological recovery was complete in 13 of their cases; 2 had seizures which were controlled medically, and 12 had residual neurological signs (only 4 were seriously disabled). Others have had a similar experience (66,68). It thus appears that this potentially devastating disease may have a benign outcome if diagnosis and therapy are achieved promptly.

b) Via contiguous spread from infected sinus.

1) Frontal sinus. Obstruction of the nasofrontal duct during frontal sinusitis may allow pus to form under pressure within the sinus.

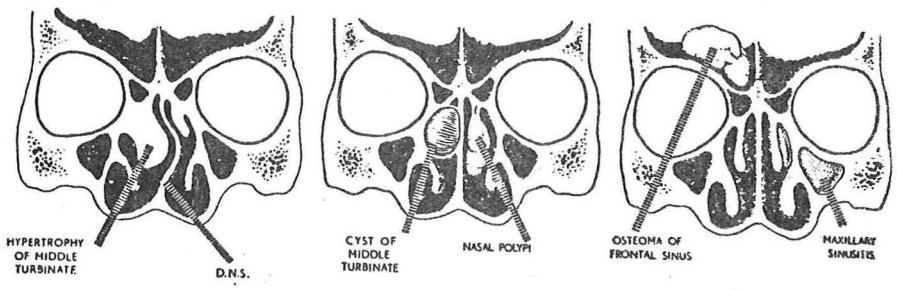


Fig. 15 , from ref. 89

Diagram to illustrate mechanical and infective factors producing obstruction of the fronto-nasal duct.

Erosion of the thin walls of the sinus may occur inferiorly into the orbit, anteriorly to allow pus to point beneath the scalp, or posteriorly to cause cerebritis, brain abscess, epidural abscess, subdural empyema, or meningitis. Posterior spread may also occur via septic thrombophlebitis of the emissary veins, with retrograde spread to the subdural space. (See above).

Because of the severity of these potential complications, patients with frontal sinusitis should be followed closely and hospitalized if febrile and experiencing moderate to severe frontal pain (90). Therapy included IV antibiotics in high doses, plus trephination in the involved sinus if no clinical improvement occurs within 24-48 hours or if a complication seems imminent.

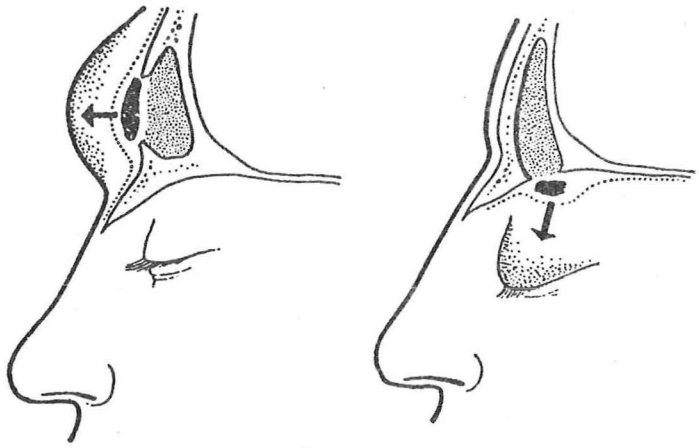
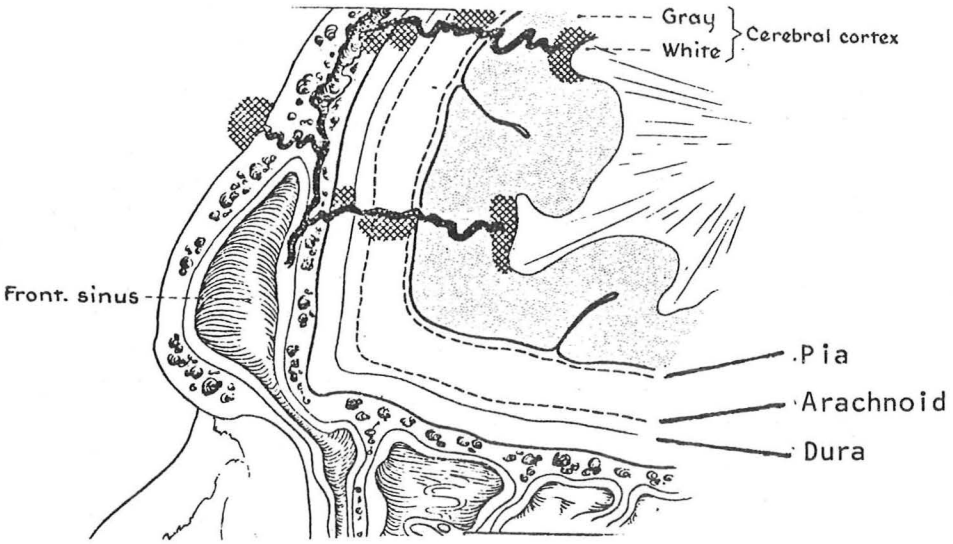


Fig. 16, from ref. 89

Brain abscess occurs more commonly as a result of frontal sinusitis than other sinus infections. The sinusitis may be acute, as in our case #4, or (more commonly) chronic. The usual bacteria isolated from brain abscesses secondary to frontal sinusitis are streptococci (anaerobic and aerobic) and *S. aureus*, although the latter is less frequently found in brain abscesses than in the other complications of sinusitis discussed above. Bacteroides and aerobic Gram-negative rods have also been implicated (78 , 80). The most interesting recent bacteriological information has come from England, where 20 of 34 streptococcal isolates from brain abscess or subdural empyema were found to belong to Lancefield's group F (*S. milleri*), ordinarily a mouth organism (79).



"Diagrammatic representation of the venous system as the 'highway' of extension of suppuration from the sinus mucosa to adjoining structures."

Fig. 17 , from ref. 2

As might be expected, brain abscess secondary to frontal sinusitis (whether the result of contiguous spread or venous infection) is usually located in the frontal lobe. There may be an associated osteomyelitis, meningitis, epidural abscess. or subdural empyema.

Sinusitis is the primary source of brain abscess in only 10-15% of reported cases (77,80). Other sources include ototic infections, pulmonary infections, and infections in patients with right to left cardiac shunts.

The reported series of brain abscesses are organized so that is is difficult to dissect out the patients with brain abscess secondary to sinusitis from those with brain abscess related to other primary infections (77,80,81). It appears, however, that patients with sinusitis-related brain abscess may present in either of two general ways. First, patients may have obvious acute sinusitis, with the signs and symptoms of intracranial extension superimposed on those of sinusitis. (The patient who clutches his L forehead with his L hand but cannot talk or move his R arm). Second, patients may present with signs and symptoms related to brain abscess, related to sinusitis in the past (or undiagnosed, relatively asymptomatic at present). It is the latter group of patients that pose the greater diagnostic challenge, and in whom skull x-rays can reveal the extremely important clue: frontal/ethmoid opacification.

As many authors have noted, including Samson and Clark in their review of the Parkland experience with brain abscess from 1961 to 1971, there are patients with brain abscess who have few signs to suggest an intracranial infectious process. This contrasts distinctly with subdural empyema, as discussed above.

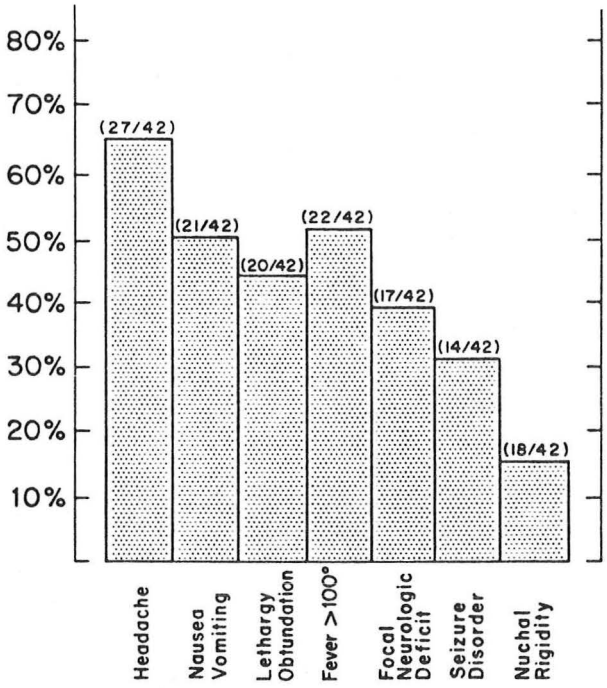


Fig. 18 , from ref. 80

Presenting symptoms in 42 cases of brain abscess managed at Parkland Memorial Hospital.

Diagnosis of brain abscess has been greatly improved by technitium brain scanning and CT scanning (82-84). A large experience comparing the two techniques has not been reported, but some workers feel that the brain scan may show early intracerebral infection ("cerebritis") at a time before abnormalities are detectable by CT scan.

The role of anaerobic organisms (mainly streptococci) in brain abscess is well-documented. Aerobes also play an important part (*S. aureus*, aerobic streptococci, Gram-negative organisms).

Death occurs as the result of an expanding mass with increasing intracranial pressure. Surgical therapy of brain abscess is usually extirpative though surgery is sometimes postponed until a capsule has formed around the pus. High-dose antibiotics are recommended; 4 weeks is

a reasonable length of therapy. Because of the possibility of staphylococcal involvement in brain abscess associated with frontal sinusitis many would use a semisynthetic penicillin in combination with chloramphenicol continuing methicillin, at least until cultures fail to document staphylococcal infection. Others use penicillin plus chloramphenicol; still others recommend gentamicin, penicillin, and chloramphenicol (77,85-88). Ideally aspiration of the abscess for culture should precede initiation of antimicrobial therapy; this is often impractical and there are reports that antimicrobial therapy does not appear to interfere significantly with the isolation of organisms from brain abscess cavities (78).

Cranial osteomyelitis may occur in the bone surrounding any of the sinuses, but it most commonly follows frontal sinusitis. Accumulation of pus in the frontal sinus may cause septic thrombophlebitis of the valveless diploic veins, which may lead to infection of the frontal bone and rapid spread within the marrow. The following description illustrates many of the important pathophysiological features of this complication:

> "*The pathology and pathogenesis of this disease have been fairly well agreed upon since 1931. Basically, this is a thrombophlebitis of the mucosal vessels which spreads into the vascular system of the bone surrounding the sinuses. Once the Haversian system of the inner and outer tables of the sinus are involved, there is a rapid necrosis and focal coalescence into large areas of decalcified, decomposing bone. The general spread is externally to the outer table which can result in a cortical breakthrough and the subperiosteal abscesses first described by Potts. Inferior extension results in involvement of the upper ethmoid cells, roof of the orbit and periorbital abscesses with chronic draining fistulas. It has been noted for some time that periosteum and dura are remarkably resistant to the osteomyelitic process. This explains why many patients have survived serious intracranial complications despite a rapidly progressing disease.*"
> (89)

Most authors distinguish between abscess due to rupture of the frontal sinus and that associated with true osteomyelitis (Potts' Puffy Tumor); the latter may appear at some distance from the sinus as a rather indolent process, confusing the unwary (see fig. 19):

Fig. 19 , from ref. 92

Potts Puffy Tumour

A similar mechanism probably accounted for the multiple pericranial abscesses in our patient (Case 3) with C.S.T. and subdural empyema: the diploic veins cross suture lines, so that frontal osteomyelitis may be complicated by distant areas of osteomyelitis or periosteal abscesses.

Another serious complication of frontal osteomyelitis is epidural abscess. Case 5 illustrates how indolent and apparently benign this process can be. The dura may provide a relatively resistant barrier to the further spread of infection.

The diagnosis of frontal osteomyelitis may be made by x-ray. Bone scan may be useful. Treatment is primarily surgical (extirpation of infected bone) with a long (at least 3-4 weeks) course of antimicrobial therapy. Anaerobic/aerobic streptococci and staphylococci are the most commonly implicated pathogens.

Osteomyelitis rarely occurs following maxillary sinusitis in adults. The maxilla has minimal marrow space and an excellent blood supply with many arterial anastamoses, factors which are thought to prevent infection in this bone. In infants, osteomyelitis of the maxilla may develop as a result of maxillary sinusitis or molar root abscess (93).

2) Sphenoid sinus. There are 12 major structures directly adjacent to the sphenoid sinus: dura mater, pituitary gland, optic chiasm, cavernous sinus, internal carotid artery, III, IV, and VI cranial nerves, V_1 and V_2 branches of V, sphenopalatine ganglion, sphenopalatine artery, and pterygoid canal (97). It is not surprising, therefore, that sphenoid sinusitis or abscess (or mucocoele, or neoplasm) are frequently associated with orbital and cranial nerve abnormalities. One syndrome commonly associated with sphenoid masses is the Superior Orbital Fissure syndrome (see above, page 17). The structures

which pass through the superior orbital fissure (cranial nerves III, IV, VI, V_1, ophthalmic vein, sympathetic nerves) are more closely related to the sphenoid sinus than others (optic nerve, V_2). Recurrent cranial palsies (especially III) have been associated with sphenoidal mucocoeles (96).

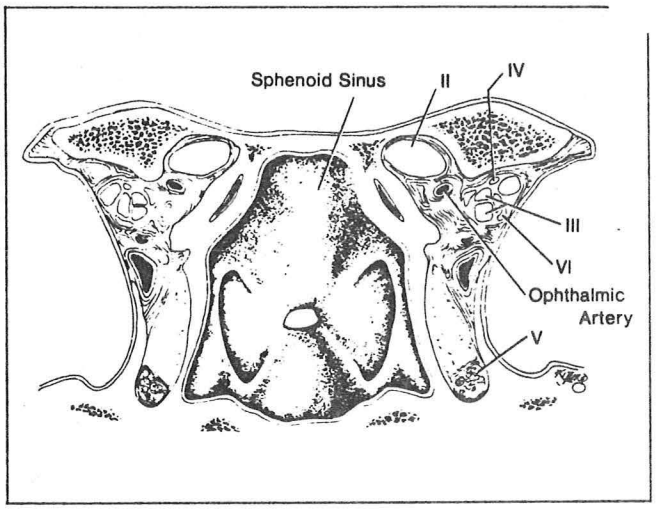


Fig. 20 , from ref. 97

Structures of orbital apex rest just lateral to sphenoid sinus allowing for early involvement by pathologic processes arising in sinus.

Sphenoid sinus abscesses have been associated with intracranial extension and pituitary abscess (94,95), as well as with orbital extension and C.S.T. (95). All authors emphasize the ease with which sphenoid sinus infection may be overlooked in favor of the more obvious maxillary, ethmoid,and frontal infections.

Hypopituitarism or visual field defects in a patient with meningitis should suggest pituitary abscess.

See Case 6 (page 38).

c) Via arterial seeding of the meninges. Probably the most common intracranial manifestion of acute sinusitis is bacterial meningitis, usually developing either by contiguous spread or via seeding of the meninges during bacteremia. The usual pathogens causing meningitis by the latter route are those which usually cause bacterial meningitis (!) -- in the adult, *S. pneumoniae* is much more commonly the culprit than *H. influenzae*, although both cause acute sinusitis. The *H. influenzae* from sinus infections (when tested) have been non-typable, while those isolated from CSF are almost always type b.

Sinus x-rays should be done in patients with bacterial meningitis - especially if not caused by *H. influenzae* or *N. meningitidis*:

1) frontal opacification or air/fluid level: sinusitis, CSF leak, or blood
2) sphenoid opacification: sphenoid sinusitis with meningitis; ? abscess; CSF leak
3) enlarged sella: ? pituitary abscess
4) mastoid air cell opacification: mastoiditis, ? related parameningeal focus
5) skull fracture

Cranial nerve abnormalities (especially abnormalities of the nerves controlling gaze) occur not infrequently in patients with bacterial meningitis (75). In the patient with concomitant sinusitis, involvement of the orbit is suggested by the ancillary findings (proptosis, chemosis, eyelid swelling) discussed in section D.1.

This 77 year old woman with adult-onset diabetes mellitus was admitted to Parkland on 9/6/78 because of proptosis of the left eye with loss of vision. She had had surgery performed on the eye in 1976 for reasons which were unclear, but her vision had been "normal" at least until July, 1978, when her sight slowly began to deteriorate in the left eye. Approximately 1 week before her admission she developed swelling in the eye and a vague sense of numbness on the left side of her face. The swelling increased, fever developed, and when she became confused, she was brought to the hospital by her daughter. On examination she had marked proptosis of the left eye, with chemosis, periorbital swelling, and an immobile globe. There was no light perception in the eye. The right eye was normal except for diabetic retinopathy.

She was treated with methicillin and chloramphenicol with no improvement in her eye findings. Her confusion cleared with volume replacement; an LP revealed normal CSF. Initial CT scan showed orbital edema consistent with cellulitis. Repeat CT 5 days later showed worsening edema with displacement of the left medial rectus muscle away from the orbital wall. Orbital ultrasound the following day showed an abnormal collection medial and posterior to the globe, and orbital exploration was performed. At surgery approximately 3-5 cc of pus was found behind the globe. Culture grew only *S. aureus*; anaerobic culture was negative. One of three blood cultures drawn at admission grew *S. aureus*. With continued antibiotic therapy she became afebrile and was discharged. She has remained blind in the left eye.

Summary: Orbital abscess in a diabetic woman. Sinus x-rays were normal. The exact antecedents of the staphylococcal infection are unclear, as is the cause of her progressive blindness -- it seems unlikely that this was caused initially by the infection.

This 67 year old woman with adult onset diabetes was admitted to the medicine service following 5 days of pain in the left eye. She had had problems with the left eye in the past, including a retinal hemorrhage in 1976 with subsequent poor vision. The right eye was normal except for diabetic retinal changes. On admission she had chemosis, proptosis, and tearing of the L eye, with restricted movement of the globe. There was decreased vision in the eye, a sluggish pupillary reaction to light but a normal disc. The globe was displaced laterally. There was erythema over the maxillary sinus and impaired sensation in the distrubution of the ophthalmic and maxillary branches of the trigemical nerve. WBC count was 15,600 with 78 polys, 17 bands. CSF was normal. Admission diagnosis was orbital cellulitis secondary to maxillary sinusitis. ENT and Eye consultants concurred; therapy with cefazolin and gentamicin was begun.

On the second hospital day a CT scan revealed a soft tissue density in the left ethmoid sinus with lateral bowing of the medial wall of the orbit.

At surgery a mucopyocoele of the L ethmoid sinus was drained. *Acinetobacter calcoaceticus* was grown from the maxillary sinus; the orbit culture grew *Proteus mirabilis*. She was treated with trimethoprim-sulfamethoxazole after the Acinetobacter was shown to be sensitive to this combination in vitro. Resolution of the maxillary sinusitis followed but with total loss of vision in the left eye.

Summary: Diabetic with invasion of the orbit by ethmoidal mucopyocoele. Clinical clue to correct diagnosis was lateral displacement of the globe. Good response to drainage plus antimicrobial therapy.

CASE REPORT #3

This 21 year old man was admitted to PMH on April 4, 1976, because of right orbital swelling associated with acute pansinusitis. 3 weeks PTA he had had a "flu-like" illness, was bed-ridden for 1 week. He had been seen in the ER on two occasions during the week PTA and treated with decongestants for a "URI". At the time of admission there was edema and swelling over the right upper medial orbital area, extending over the root of the nose. There was no ophthalmoplegia. There was bilateral purulent (and apparently foul-smelling) discharge in the nose. X-rays showed an air-fluid level in the R maxillary sinus, an opacified L maxillary sinus, and cloudiness in the L ethmoid sinus. CSF was normal. Admission Dx: pansinusitis with R orbital cellulitis. Rx: ampicillin, Afrin, Dimetapp.

On April 6 he was clinically worse, with more pronounced R orbital swelling and definite proptosis. Methicillin was begun.

On April 7 he had higher temperature (103°F) and he appeared more lethargic. His L eye was beginning to swell. Chloramphenicol and gentamicin were added. That day he underwent bilateral orbital exploration and drainage of both orbits and ethmoid sinuses. Pus was found in the R orbit and ethmoid. Following surgery he became obtunded with prominent meningismus. Repeat LP showed CSF with 51 WBC (41 P, 10 L), 5 RBC. Cerebral arteriogram and brain scan, done to define a parameningeal focus of infection, were negative.

On April 9 he spiked again to 105°F. He was lethargic but oriented, with continuing meningismus. WBC count, which had been 9,000 on admission, was now 30,200 with a shift to the left. He returned to surgery on April 10 for re-exploration of the R orbit. Bilateral complete ethmoidotomies and sphenoidotomies were done; no pus was found. Repeat bilateral carotid arteriograms showed no abnormalities. The patient could not move his L leg, but he remained alert and able to count fingers. He developed multiple abscesses over the frontal and superior areas of the scalp; these were drained. Repeat LP showed CSF with 66 WBC (45 P, 21 L).

On April 16 he experienced respiratory arrest. He died on April 21.

Autopsy showed thrombosis of the cavernous sinus and both R and L sigmoid sinuses, with foul-smelling pus (without loculation) in the subdural space. There were also septic pulmonary emboli, and a diffuse subdural inflammation involving both cerebrum and spinal cord. Multiple organisms were grown from the subdural pus, including *S. aureus*, enterobacter, and several different anaerobes.

Summary: young man with untreated sinusitis following influenza A who developed R orbital cellulitis, septic cavernous sinus thrombosis, and sigmoid sinus thrombosis with subdural empyema. Multiple cranial abscesses probably related to infection in the diploic veins. Appropriate diagnostic procedures were performed to identify a continuing intracranial focus of infection, with negative results. Fatal outcome without surgery.

CASE REPORT # 4

This 18 year old man was transferred to PMH from another hospital on 9/27/78. Approximately 3 weeks PTA he apparently disturbed a pimple inside his R nostril, and was treated with tetracycline. This problem resolved, but one week before admission he developed L periorbital edema, with L retro-orbital headaches. He was given sulfacetamide ophthalmic drops and oral erythromycin, and apparently had an acute allergic reaction (history of allergy including asthma) with wheezing and an urticarial rash. He was hospitalized following this episode, and while in the hospital developed a stiff neck and fever. Four days before transfer a lumbar puncture revealed CSF with a protein of 89 mg%, otherwise normal. Although treated with high-dose IV penicillin, he deteriorated and was transferred when he was noted to become increasingly confused.

On admission to PMH he had temp of 103°F, L periorbital edema and erythema (apparently mainly confined to the eyelids), no chemosis or paralysis of extraocular movements, normal pupillary reactions, normal fundi with good venous pulsations, and no proptosis or chemosis. He tended to hold his L frontal area because of pain. There were no focal neurological deficits; he was lethargic and intermittently confused.

X-rays of the skull showed air-fluid levels in the L frontal and L maxillary sinuses, with a cloudy L ethmoid. LP revealed an opening pressure of 340 mm, 400 WBC (60 polys, 40 lymphs), 4000 RBCs, protein 40, glucose 46.

Admission Dx: L periorbital cellulitis, probably staphylococcal, secondary to maxillary/ethmoidal/frontal sinusitis. Latter probably related to prior intranasal staphylococcal infection. ? cerebritis, brain abscess. Rx: methicillin, chloramphenicol.

CT scan was essentially normal. Brain scan showed focus of uptake in the L frontal region. L maxillary sinus was tapped -- pure culture of *S. aureus*.

He developed R-sided focal seizure activity involving the face. This was controlled with anticonvulsants. He gradually improved, finishing a 28 day course of anti-staphylococcal therapy, and was discharged without residua of his infection. The L frontal sinus was not trephined and the air-fluid level gradually disappeared.

Summary: L frontal cerebritis and orbital cellulitis secondary to maxillary/ethmoid/frontal sinusitis with *S. aureus*. No evidence for cavernous sinus thrombosis clinically. Some would argue that the L eye findings reflected merely reactive inflammation (see above), since there was no proptosis or chemosis, only eyelid changes. Good outcome with appropriate antibiotic therapy, drainage of maxillary sinus.

CASE REPORT #5

This 19 year old man was first seen at PMH in October, 1978, when he came to the emergency room seeking treatment for a lump on his forehead with a draining sinus. He had been hospitalized in another town in 12/77 for frontal sinusitis with "scalp infection," and appeared to respond to antibiotics. In 2/78 he was again hospitalized, with persistent frontal sinusitis and a "scalp abscess", which was drained superficially. He then apparently did reasonably well for several months, but his forehead continued to drain pus and he finally came for additional evaluation here. He was afebrile with no focal neurological findings. Sinus films revealed maxillary, ethmoid, and frontal cloudiness on the right side. CT scan showed an epidural collection behind the right frontal bone; sagital reconstruction showed the collection to be adjacent and slightly superior to the frontal sinus. At surgery he was found to have a frontal mucopyocele which extended into the epidural space and also (?) had eroded into the subcutaneous tissue. Cultures of the pyocoele contents grew viridans streptococci; no anaerobes were found.

Summary: Epidural and pericranial abscesses following frontal sinusitis. Unusual that a mucopyocoele was found; otherwise a typical history for chronic epidural abscess.

CASE REPORT #6

This 68 year old woman with pulmonary and dermatologic manifestations of sarcoidosis since 1973 was admitted to the hospital on 12/12/77 with a three-month history of right temporal-frontal headaches and decreasing vision in the right eye. At that time she had been maintained on 35 mg prednisone qod for several months. There was no history of sinusitis or URI prior to this admission. On examination she was afebrile; pertinent findings included 2 mm proptosis of the right eye, decreased mobility of the eye in all directions, a Marcus Gunn right pupil, and decreased visual acuity. The left eye was normal.

Skull films were read as normal. She was seen in consultation by various services and diagnoses considered were temporal arteritis, sarcoid of the orbit, Tolosa Hunt syndrome, and a retroorbital mass. The ophthalmologic consultant favored the latter and considered the patient's findings to represent the "Orbital Apex Syndrome". On the 8th. hospital day tomograms of the orbit and sinuses revealed a large soft tissue mass within the right side of the sphenoid sinus, with apparent extension through the medial wall of the middle fossa and into the posterior orbit. Re-examination of the initial skull series also revealed a soft tissue density in the right half of the sphenoid sinus. Biopsy of the sphenoid contents that night disclosed fungal hyphae consistent with Aspergillus species. The following day surgical debridement of the sphenoid and ethmoid sinuses on the right side was performed. Culture grew *Aspergillus fumigatus*.

She was treated with a total of 1.5 gm amphotericin B and had an uneventful recovery, with resolution of the proptosis of the right eye. She did not regain useful vision in the eye.

Summary: Aspergillus infection of the sphenoid sinus, with extension through the wall of the sinus to involve structures at the apex of the orbit, including structures passing through both the superior orbital fissure and the optic canal: hence the "Orbital Apex Syndrome". Typically, slow recognition of sphenoid sinusitis as the source of the disease.

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