Introduction:

Sinusitis in the pediatric population has become a common diagnosis in the last 10 years. The definition of Sinusitis in general terms is the inflammation of the lining of the paranasal sinuses. Acute sinusitis most often manifests as a complication of viral upper respiratory tract infection of which a child averages 6 to 8 per year. It is estimated that 5 to 13% of children experience sinusitis.

Sinusitis is classified on the basis of duration. It can be acute (duration less than 30 days), subacute (2-3 months), or chronic (more than 2-3 months). Acute sinusitis is most likely infectious whereas chronic may be a combination of infectious and noninfectious.

The primary therapy for the pediatric patient with sinusitis is medical. In the case in which the sinusitis is recalcitrant to maximal medical management or they develop complications the role of functional endoscopic sinus surgery has evolved. This is still a controversial area and it will be reviewed.

Development/Embryology:

The sinus develop during gestation as four paired paranasal invaginations of the nasal cavity. The maxillary sinus are the first of the human paranasal sinuses to develop. This begins as a bud along the inferolateral surface of the ethmoid at around gestational day 65. The ethmoid cells develop during the third and fourth fetal months as evagination of the lateral nasal wall in the middle meatus region. The ethmoid and maxillary sinuses are pneumatized soon after birth. The sphenoid sinus originates during the third fetal month as a paired evagination in the sphenethmoidal recess. The sphenoid sinuses are pneumatized at approximately age 3. Embryologically the frontal sinus starts to envaginate from the anterior ethmoid cells at 4 months gestation and are pneumatized by age 6.
Radiographically the maxillary and ethmoid sinuses are evident in early infancy, the frontal sinus become evident at age 6 and the sphenoid by age 8.

The development of the nose and paranasal sinuses after birth are directly linked with the development of the facial part of the skull and dentition. The structures of the anterior ethmoid and middle meatus; like the uncinate process, ethmoid infundibulum, hiatus semilunaris and bulla ethmoidalis are thought to be well developed in the newborn. They are used as constant anatomical landmarks.

Pathophysiology:

As we know the sinuses are made up of four sinuses: paired maxillary, paired ethmoid, frontal and sphenoid sinuses. The nasal cavity contains three turbinates for humidification of the air. They have significant expansive capacity. The posterior ethmoid cells and sphenoid sinuses drain into the superior meatus. The maxillary, frontal, and anterior ethmoid sinuses drain into the middle meatus, which contains the osteomeatal complex.

There are three conditions which are necessary for the sinuses to function normally. These are a patent ostia, normal mucociliary function and normal quality and quantity of secretions. Impairment of any combination of these three conditions can lead to chronic or recurrent sinus disease.

The conditions that contribute to obstruction of the ostia can be divided into two classes: mechanical and systemic. The mechanical obstruction comes from polyps, synchia, deviated nasal septum, turbinate hypertrophy, inflammatory edema or nasal tumor. The inflammatory edema is probably the most common and is usually the result of upper respiratory tract infections or inhalant allergy. The second function mentioned is normal mucociliary function which can be altered by viral infection and primary ciliary dyskinesis. This leads to inadequate clearance of secretions leading to ostial obstruction. The allergic inflammatory disease which is regulated through IgE- mediated release of histamine results in mucosal edema and increased production of nasal secretions. Now if you have a disorder in one or more of these three functions and then introduce a pathogen, sinusitis will develop. There are also a few systemic illness in children that make them prone to developing sinusitis. Some well known conditions are cystic fibrosis, immune disorders, primary ciliary dyskinesia, immotile cilia syndrome and cyanotic heart disease.

There are also some who suggest the existence of a noninfectious sinusitis. The inflammation is a noninfectious response involving numerous inflammatory cells which are responsible for the release of mediators capable of damage in the mucosal integrity.

Microbiology:

Most pediatric sinusitis develop after viral upper respiratory tract infections. The are usually superinfected with a bacterial pathogen. The pathogens in acute childhood sinusitis are the same as those described in adults: Streptococcus pneumoniae, non typable Hemophilus influenzae, and Moraxella catarrhalis and Staphylococcus aureus. They are also the same pathogens as in Acute
otitis media linking the two infections together. Studies that have suggested a role for organisms like coagulase negative staphylococci, other alpha-hemolytic (non-pneumococcal) streptococci, propionibacterium and corynebacterium species, and various anaerobes have only demonstrated the sensitivity of their culture techniques in isolating skin and oral normal flora. Most pediatric texts remark that Streptococcus pneumoniae, Hemophilus influenzae, and Moraxella catarrhalis (in high numbers) are normal flora in a young child. It is common (60% of two year olds), but not normal since these children have the symptoms of sinusitis.

Chronic sinusitis has a predominantly anaerobic flora. Most commonly anaerobic gram-positive cocci, staphylococci and streptococci, with occassional bacteroides. The aerobes are culture 35% of the time with Hemophilus less prevalent than with acute infections.

**Diagnosis:**

Sinusitis is a common pediatric diagnosis. It can be acute or if persistent for more than 3 months be classified as chronic disease. It is estimated that 0.5-5% of upper respiratory tract infections are complicated by acute sinusitis. The majority of these episodes resolve spontaneously, resolve with antihistamine and decongestant therapy, or require only a single course of antibiotics. Compounding the issue is that 10 to 15% of the children experience seasonal or perennial allergic rhinitis by 16 years of age.

The diagnosis of pediatric sinusitis has went through significant changes in the last 10 years. There is still much controversy in the diagnosis of chronic sinusitis and recurring sinusitis. The emphasis must be placed on history and physical examination. In especially younger children the symptoms and the radiologic findings may be quite confusing. The diagnosis should be based on a combination of clinical history, findings on the physical examination, laboratory results and the radiologic findings. The younger the child the more nonspecific the findings compared to older children and adolescents whose symptoms more parallel adults.

The most common symptoms in young children is rhinorrhea both anterior and posterior(77%), otitis media(66%) and cough(48%). Malodorous breath is also common. A frequently missed finding is morning periorbital edema. The symptoms which are common to adults such as headache, facial pain and fever are much less common in children. Sinusitis commonly follows and upper respiratory infection and respiratory allergies.

With recurrent sinusitis the presence of inadequate initial therapy must be taken into account or the presence of systemic and local factors. The recurrence of 3 episodes in 6 months or 4-5 episodes in a year require more extensive clinical evaluation. They can have local factors such as polyps, deviated septum, foreign body or allergic problems. If the patient has host-defense mechanism, then one would also anticipate other sites of infection such as recurrent otitis or infections involving the lower respiratory tract. Patients with serum and secretory IgA deficiency, the most common immunoglobulin deficiency, have a history of recurrent sinopulmonary infections. This also seen with patients with functional antibody deficiency syndromes with IgG subclasses may manifest as recurrent acute and chronic sinusitis. Kartagener's syndrome with immotile cilia syndrome have frequent sinus problems and are often diagnosed with electron microscopy of the cilia.
Chronic sinusitis persists for greater than 3 months. Patients have similar symptoms to acute sinusitis except more constant nasal discharge or posterior nasopharyngeal secretions manifesting as chronic nasopharyngitis. These patients develop suborbital venous congestion, the so called ocular "shiners." Otitis media and asthma are often related to chronic sinusitis. Again local and systemic reasons can be the cause.

**Evaluation:**

The most common clinical scenario is the persistence of the signs and symptoms of the upper respiratory tract infection beyond the typical 7 to 10 days without overt improvement. Symptoms noted do not allow distinction of acute viral infection of the upper respiratory tract from sinusitis because no single symptom is specific for the diagnosis of sinusitis.

A peripheral blood white cell count and the differential and sedimentation rates are usually of no clinical value. Nasal smears are thought to be of some value. They will have a large number of PMN especially with intracellular bacteria. One must be aware of the high number of PMNs present in a simple viral infection. The presence of mucopurulent material in the middle meatus is confirmative of the diagnosis of acute sinusitis. Nasal and throat cultures correlate poorly with cultures of sinus aspirates. Because of the invasive nature of aspiration of the sinuses, it is not routinely used for the diagnosis of acute childhood sinusitis.

Plain radiography is the most common method used by the pediatrician for the diagnosis of acute sinusitis. In comparison with the CT scan these two methods in chronic childhood sinusitis has lead to questioning of the efficacy of plain radiography for the diagnosis of this condition. The correlation is good between total opacification and air-fluid levels of the maxillary sinuses on plain films and CT. The ethmoid are unidentifiable on plain radiography and will not be picked up on plain films. Plain films do allow sinusitis to be identified but the amount of disease is hard to quantitate. Another problem with plain radiography is the different criteria used by radiologist as being diseased. Various degrees of mucosal thickening (2-6 mm), opacification, or air- fluid levels have all been used as criteria for diagnosis. Underdeveloped sinuses may be misinterpreted as being opacified. Air fluid levels are frequently not present since uncooperative children often necessitate the film to be taken in a supine position. There is often a lack of correlation between symptoms and radiologic findings.

In children with a recent or current infection of the upper respiratory tract without signs and symptoms of acute infection have a high frequency of abnormalities on plain films. The reverse is also often seen when the child is very symptomatic and normal films will be present. It has been found that plain radiographs are unreliable in children younger than 1 year of age. However for the pediatrician plain films are helpful in the diagnosis of acute sinusitis when it is unclear or as a method to follow resolution or unresponsiveness to therapy. But if the results from the history and physical examination are strongly suggestive it is reasonable to forego plain radiography and proceed with treatment. The plain film is nonsensitive and possibly nonspecific imaging media for evaluation of the young child with sinusitis.

Of limited usefulness is sinus transillumination, ultrasound and endoscopic examination (in younger children.)
CT scans are the "gold standard" for the establishment of sinusitis. But the CT scan must be critically evaluated. It may be too sensitive in demonstrating virally-mediated and "post-infectious (residual or resolving) inflammatory" changes in the sinuses. There is an impressive radiographic lag (6 - 12 weeks) in clearing of the sinuses, after microbiologic and clinical cure occurs as seen in adult studies. Now if you superimpose the multiple viral infections that children have nearly all children will have some sort of abnormality on CT. The CT is a just a "snap-shot in time."

Potential surgical candidates must have axial and coronal CT scan. The CT scan must be of good quality because even slight variations from normal are critical. The CT scan must be coronal cuts of 3-4 mm with appropriate bone windows. The CT scan demonstrated pathologic variations and the ever critical ostiomeatal complex. The imaging should be performed only after intensive medical management if symptoms persist or complications develop.

The findings usually underestimate the findings seen in the operating room. Occasionally the patient with definite symptoms and clinical picture of sinusitis with minimal disease one CT may still benefit from surgery. The CT scan usually does not indicate frontal sinus disease even though this is usually prominent feature in children with inadequate treatment.

Cystic fibrosis children are a unique situation. They have been found to have a unique feature on CT scan. The patients had medial displacement of the lateral nasal wall in the middle meatus and uncinate process demineralization.

Nasal endoscopy is difficult to perform on children adding to the difficulty in diagnosis and the post operative care. The uses of Medazolam (.25mg) instilled intranasally in most children allow endoscopic examination.

The decision to perform surgery usually is made on the basis of the combined diagnostic criteria of appropriate symptoms, physical examination findings, and CT imaging results.

**Therapy:**

In acute sinusitis therapy can be approached in two ways. The first approach is to treat patients with amoxicillin for 10 to 14 days. It an initial 2 week period of therapy fails, an additional course of a beta lactamase resistant antibiotic (such as a second-generation cephalosporin or Augmentum) should be started. A second approach is based on the increasing number of Beta-lactamase-producing organisms. A considerable number of H. influenzae and M. catarrhalis organisms have been reported to produce beta lactamase in acute sinusitis. This treatment includes initial management with a beta lactamase resistant antibiotic for 7 to 10 days beyond resolution of symptoms. This will usually be a duration of 2 to 3 weeks. Additional treatments with topically applied or orally administered decongestants, isotonic saline nose drops, spray or irrigation, steroid inhalants, antihistamines, and topically applied or orally administered anti-inflammatory medications.

Decongestants are thought to increase ostial patency yet has questionable impedance on mucociliary clearance. The saline irrigation and steam treatments appear to have only anecdotal benefits. Supposedly, therapeutic benefit is due to moisturizing the inflamed mucosa and
softening the nasal crusts. Antihistamines are only considered with concomitant allergy due to
the interference in clearance of secretions by thickening the mucous. Inhaled steroids are often
used as adjuncts to treatment of sinusitis especially if component of nasal allergy. If symptoms
persist or worsen 48 to 72 hours after the initiation of the antibiotic treatment, the patient should
be re-examined and future test run to rule out complications. Operations are rarely indicated in
acute sinusitis unless there is a complication or is in conjunction with underlying chronic
sinusitis. It has been found that seizure disorders and asthmatics have a decrease in attacks with
the treatment of sinusitis.

FUNCTIONAL ENDOSCOPIC SINUS SURGERY (FESS):

The major operative differences in children are the anatomic size of the surgical area and the
extent of pneumatization of the individual paranasal sinuses involved in the disease process.

Patients in whom conservative therapy including maximal medical therapy, adenoidectomy, and
allergy treatments have failed and continue to have frequent recurrent or chronic episodes of
sinusitis are candidates for FESS. The conservative FESS technique dictates that the extent of the
procedure performed be proportional to the extent of the disease present. Mucus membrane
disease in children is frequently limited to the ostiomeatal complex (omc). Children with even
more extensive disease seem to resolve with the restoration of adequate ventilation and drainage
to the OMC area.

The use of functional endoscopic sinus surgery is often better than the conventional approaches.
Children must have maximal medical management for an extended period of time even before
FESS is contemplated. The child should have extensive documentation the sinusitis is truly
recalcitrant to optimal therapy.

To prevent postoperative complications all children must be screened for factors that suggest
hematologic abnormalities, recent ASA or ibuprofen intake. The most common cause of FESS
complications is poor visibility secondary to excessive bleeding.

The "mini FESS" is the best approach to acute and chronic pediatric sinusitis. All children
procedures are performed under general anesthesia. The positioning of the patient is important.
The child fovea ethmoidalis and cribriform should be at 90 degrees from the table and the head
straight forward. This is an important safeguard and helps avoid penetration of these structures. It
is also recommended that the surgeon sit at a 90 degree angle to the patient.

The surgical requirements in children are much more exacting than in adults. Only special
pediatric operative instruments should be used. The 2.7 mm telescope with a high-intensity light
source should be available, especially to start the case.

The injection is performed with lidocaine with 1:100,000 epinephrine. Care must be taken to
limit the injection to no more than 7 mg/kg. The injection is placed into the greater palatine
foramen and root of the middle turbinate. The maximal safe dose of lidocaine/epinephrine is
according to weight and only the proper amount should be available on the surgical set up. After
the injection pledgets soaked in oxymetazoline are placed in the middle meatus. Cocaine is rarely used in a child less than 16 due to its cardiac side effects.

The steps are the removal of the lower portion of the uncinate process followed by the creation of a middle meatus antrostomy using the natural ostium of the maxillary sinus and then inspection of the interior mucosa of the bulla ethmoidalis.

The floor of the maxillary sinus is not necessarily at the level of the floor of the nasal cavity, care must be taken in surgery directed at the maxillary sinus prior to age eight. The use of inferior meatal antrostomies should be avoided for functional and also anatomical reasons. There are risk to the tooth buds and the spongiotic bone under the floor of the sinuses.

The uncinate process is taken down from lateral to medial using a back biter. The sickle knife is not used since it makes cuts medial to lateral risking the lacrimal system and the orbit. The inferior turbinate may be located high up on the lateral nasal wall, resulting in the uncinate process being in closer proximity to the papyraceous lamina. Many times a ball tipped seeker is used first to place within the infundibulum to minimally displace the uncinate anterior medially which will assist in getting the back biter in place. The OMC is then found within 1 to 2 mm of the anterior uncinate as it inserts into the lateral nasal wall. The natural ostium is almost always in the most anterior and superior portion of the fontanelle. If residual lower uncinate is left in place this frequently causes obstruction and the need for revision.

There are three "pearls" for verifying the natural maxillary sinus ostia:

- 1. The natural ostia do not lied in the same plane as the lateral nasal wall. Their anterior lips are more lateral than the posterior lips; that is, they lie in the oblique plane.
- 2. Accessory ostia tend to be perfectly circular, whereas the natural ostia are a variant of oval.
- 3. The natural ostia are almost always anterior and or superior to accessory ostia.

The most common cause of FESS failure is opening the middle meatus antrostomy that is not in continuity with the natural ostium. The purulence that escapes through this diseased drainage pathway then reenters the ineffective but larger accessory ostium, a phenomenon called recirculatory phenomenon. By creating the window by removing the uncinate may be adequate. If enlargement is required, only the posterior fontanelle should be removed. The anterior fontanelle is rarely more than 1 to 2 mm in length and when undisturbed, protects the lacrimal duct. The posterior fontanelle is up to 20 mm and often encompasses the accessory ostia of the maxillary sinus. When making the posterior cut from the natural ostia, make it close to the roof of the sinus and incorporate any accessory ostia. Sharply remove the large lower flap to create the maxillary antrostomy. With the 0 degree scope the bulla is identified and its lower medial portion is removed creating a functional opening that includes its natural ostia. If there is continued mucosal abnormalities more comprehensive surgery is preformed on the anterior and posterior ethmoid cells using the Messerklinger technique. This limited surgery usually is adequate to treat most children with recalcitrant sinusitis. Revisions may be undertaken with all important landmarks intact.
The sphenoid sinus needs to be entered for a variety of conditions such as infection, mucopyocele, mycetomas, or suspect neoplasms.

The approach to the sphenoid sinus is very precarious despite improved vision with the endoscopes. The vital anatomic structures behind the anterior sphenoid wall is variable. The internal carotid artery may be located immediately behind the wall when dehiscent, or be covered only by thin bone. The optic nerve is minimally protected. Also to be remembered are the pituitary gland and the trigeminal nerve which are rarely injured but in close proximity. The identification of the anterior wall of the sphenoid is essential.

This can be verified by two methods. First, on the medial side of the superior turbinate, the natural ostium of the sphenoid sinus is visualized. A measurement from the natural ostium to the anterior nasal spine is obtained. This measurement is then used in the surgical field lateral to the superior turbinate to the suspect posterior ethmoid wall. When the posterior ethmoid cells exists that superiorly overrides the sphenoid sinus (Onodi cells), the second measurement would be greater than the measurement to the natural ostium. The safest entry to the sphenoid is inferiomedially. Using careful dissection the wall is cleansed of all bony and mucosal septations. A rigid instrument, such as a straight suction, is placed in the inferiomedial quadrant. It is advanced as far posterior and inferiomedially then swept medially towards the septum fracturing the superior turbinate. This will expose a very consistent near-vertical fracture line which the authors (parson et al) call the 'ridge'.

Medially to this is the ethmoid fontanelle or the mucosa lateral to the superior turbinate. This will expose the natural ostia. Enlargement of the natural ostia is done using a curette taking down the lateral 'ridge' in a posterior to anterior direction. This approach is functional enlarging the natural ostium. This anterior anatomy is very consistent from young toddlers to senior citizens. In the pediatric patient, there are no standard measurements for size of the ethmoid cavity or distance relationships with regards to the sphenoid sinus. The dissection must be meticulous with strict attention to anatomic landmarks. Upon completion of the surgery packing is usually avoided and stents for the septum will be removed at the time of the first post operative cleaning.

Post Operative Management:

Postoperative medications consist of oral antibiotics, topical nasal decongestant, a topical nasal steroid, and saline nasal spray. Pediatric FESS is a staged procedure with the second stage in 2 weeks for operative cleaning. This waiting period allows sufficient healing of the surgical site but is not long enough for excessive synechia formation.

Complications:

Major complications of endoscopic sinus surgery are classified into two broad categories: orbital and intracranial. Significant complications are usually the result of poor appreciation of anatomic relationships, poor visualization, or excessive bleeding. The use of FESS in pediatric sinusitis has generated few reports of complications. Minor complications were reported in 10% of the patients such as postoperative bleeding, ecchymosis, otalgia, dacrocystorhinitis. Adhesions were
the major postoperative finding which can lead to recurrent disease. In the pediatric population, the lack of reported CSF fistulas may be secondary to less extensive surgery, less developed sinuses (with thicker bone), or thicker dura.

Summary:

Pediatric Functional Endoscopic Sinus surgery is very controversial. There are proponents for solely medical management and then the proponent for limited endoscopic surgery. I believe that no one would take the liberal approach to this surgery as ethical or medically sound. Five to 15% of the pediatric population has had sinusitis. This may even be underestimating the incidence, but nearly all of these infections will clear with or without medication. Only the patient that has had maximal documented medical therapy or complications of sinusitis should be a candidate. One thing that may change this approach is the increasing incidence of drug resistance patterns. The multi-drug resistant pneumococci are increasing at a staggering rate. This is also starting to show up with H. influenza becoming less sensitive to antibiotics, with a noticeable upward creep in MIC's to beta-lactam and frank resistance to sulfa. M. catarrhalis is resistant to beta-lactam and clinical failures have been seen with the new generation cephalosporins. The net result is that chasing pediatric sinusitis with oral antibiotics is becoming increasingly difficult. The treatment should be based on cultures and sensitivities rather than empiric therapy.

Many recent articles have reviewed their results on pediatric sinus surgery which has been very favorable with few complications. Lazar et al out of 210 patients had a 79% relief of symptoms. 80% of asthmatic reported improvements in asthma after FESS. Failures were seen in patients who had refractory disease or had other systemic problems such as immunodeficiency, Cystic fibrosis or immotile cilia syndrome. Parsons et showed a greater than 80% improvement after FESS with his series of 550 patients. There is a definite role for pediatric endoscopic sinus surgery.

DISCUSSION

Comments on Grand Rounds of Jan. 18, 1995
On Pediatric Sinusitis and Surgical Treatment
By Ronald W. Deskin, M.D., UTMB Department of Otolaryngology

Healthy paranasal sinuses in children depend on good ventilation and drainage, good mucociliary clearance and normal systemic immunity. In children the development and maturation of these systems is a specific developmental process and sinusitis tends to be age related showing marked improvement in most cases by age seven to eight years.

In previous years little emphasis and importance was placed on the entity of pediatric sinusitis. In many areas this pendulum has now swung back to the point that surgical solutions are almost demanded for the problem of chronic rhinorrhea in children. The promotion of newer surgical techniques, some of which are unproven in the small child, new sinus imaging techniques, and the growing problem of working couples with children in day care who face a dilemma in keeping their children well enough to stay in day care so that the parents may work have all contributed to the attitude. The growing concern that sinus infections can effect the health of
children with chronic pulmonary disease has also brought sinusitis and its treatment to the foreground.

It is very difficult to define chronic sinusitis in children and how much recurrent sinusitis is too much. The work up, if conditions are appropriate, should include allergic evaluation, immune globulin evaluation and in some cases respiratory ciliary biopsy. Plain x-rays are of limited value and CT scans should not be ordered unless surgery is anticipated because of acute suppurative complications, evaluation of the child with chronic pulmonary disease who flares up with each episode of acute sinusitis, and in those children who have failed to respond to adequate medical management and who are felt to have true chronic disease affecting overall health and quality of life. This last indication is very difficult to define in children. Adenoidectomy and sinus irrigation may be helpful for improvement in the child under five to six years of age with recurrent purulent rhinorrhea and nasal obstruction symptoms.

After maximum medical management has been attempted and failed, surgical indications may be present. Endoscopic sinus surgery allows better visualization, eliminates the need for facial incisions and promotes physiologic drainage. Minimal endoscopic sinus surgery such as partial uncinate removal and opening of the ethmoid bulla may be adequate for most children who are candidates for endoscopic sinus surgery.

BIBLIOGRAPHY:


