Introduction

The diagnosis and subsequent treatment of rhinosinusitis in the pediatric population has undergone dramatic changes in the last twenty-five years. Even in the early 1970’s, the diagnosis of acute or chronic sinusitis in the pediatric population was rare (Hopp). Today, the diagnosis is relatively common, a likely consequence of an improved understanding of the pathophysiology, etiology, and treatment outcomes for this disease. Even with its increased prevalence over the past two decades, controversy still exists concerning its pathogenesis, presentation, diagnosis, and treatment. As the signs and symptoms of pediatric rhinosinusitis are often subtle and the fact that the history is often limited to observations of the parents with a physical examination dependent on the cooperation of the child, there is greater emphasis on newer diagnostic modalities in evaluating childhood rhinosinusitis (Kennedy). Indeed, pediatric rhinosinusitis continues to be a rapidly evolving and controversial topic for the otolaryngologist.

Anatomy

The maxillary sinus is the first of the paranasal sinuses to begin development in the human fetus. They begin as outgrowths of the lateral nasal wall about day 65 of gestation. These sinuses slowly enlarge in utero but are not demonstrated on plain films until the infant is 4 to 5 months of age. Growth of these sinuses is biphasic with the first period of considerable enlargement during the first 3 years and the second phase between 7 and 12 years of age. During this second phase, the pneumatization extends laterally to the level of the lateral wall of the orbit and inferiorly into the alveolar process in conjunction with the eruption of permanent dentition. Slow expansion of the maxillary sinuses continues until age 18 to reach adult dimensions with an average capacity of 14.75 mL (Miller). The maxillary sinuses drain into the middle meatus.

The ethmoid cells begin development later in the third month of fetal development. The anterior ethmoids form as evaginations of the lateral nasal wall with
the posterior ethmoids forming in the fourth month of gestation from outgrowths in the superior meatus. At birth these cells are fluid filled and are difficult to visualize on X-rays. By one year of age, the ethmoids can be detected on plain films and subsequently rapidly enlarge to reach adult dimensions by age 12. The cells number 4 to 17 cells on each side with an average total volume of 14-15 mL (Miller). The anterior ethmoid air cells drain into the middle meatus whereas the posterior cells drain into the superior meatus.

The frontal sinus begins development during the fourth month of gestation as an upward extension of the most anterosuperior ethmoidal cells. The frontal sinus is rarely visualized radiographically prior to age 5 or 6 after which it slowly grows to reach an adult size by late adolescence with a total volume of 6-7 mL. The pneumatization of the frontal sinus is variable with a developmental failure of one of the sides in 4-15% of the population. The frontal sinus drains into the frontal recess.

The sphenoid sinuses originate during the fourth gestational month as paired evaginations of the mucosa in the superoposterior portion of the nasal cavity. They remain as small indentations in the sphenoid bone until age 3 when further pneumatization begins. Growth becomes rapid to reach the level of the sella turcica by age seven and reach an adult size by age 18 with a total volume of 7.5 mL (Miller). The sphenoid sinus drains into the superior meatus along with the posterior ethmoid air cells.

The sinus mucosa consists of pseudostratified ciliated, columnar epithelial cells, goblet cells, and submucosal glands that produce a protective mucous blanket. The mucosal blanket traps bacteria and noxious materials, which are carried by ciliary motion to the ostium and into the nose for elimination. The orientation of the cilia within a given sinus is specific as secretions are propelled towards the natural sinus ostia and from there to the nasopharynx and oropharynx where they are subsequently cleared by swallowing. This mucosa is similar to that found in the nose and tracheobronchial tree (Hopp).

Pathophysiology and Pathogenesis

For normal physiologic function of the paranasal sinuses, the ostia must be patent, the cilia should be functioning effectively, and the secretions should be normal (Ott). Retention of secretions in the paranasal sinuses can be due to one or more of the following: obstruction of the ostia, reduction in the number or impaired function of the cilia, or overproduction or change in the viscosity of secretions (Wald). According to current understanding of sinus physiology, the primary sinus abnormality for initiation of rhinosinusitis is obstruction of the osteomeatal complex by mucosal edema or mechanical obstruction (Ott, Wald). Various local, regional, or systemic factors may lead to an obstruction of the osteomeatal complex. Local and regional factors include nasal septal deviation, nasal polyps, anatomic variants such as choanal atresia or concha bullosa, foreign bodies, edema attributed to viral infections, allergic inflammation, and nonallergic rhinitis. Systemic factors can include ciliary dyskinesia syndromes, cystic fibrosis, and immunological deficiencies. Other factors that have been attributed to the etiology of pediatric rhinosinusitis include air pollution, gastroesophageal reflux, day care attendance, and enlarged adenoids (Lusk). Although many conditions can lead to obstruction of the natural ostia, viral upper respiratory tract infections and allergic
inflammation are by far the most frequent causes (Wald). Obstruction of the natural ostia by any of these predisposing factors can result in hypoxia of the involved sinus which leads to ciliary dysfunction and abnormal movement of mucous from the sinus (Ott). Bacteria in the upper respiratory tract are then able to multiply and invade the mucosa of the obstructed sinus (Ott).

Definitions

The Consensus Panel for the Management of Rhinosinusitis in Children met in Belgium in 1996 to help standardize the proper definitions associated with pediatric sinusitis. The preferred term for this disorder is rhinosinusitis which acknowledges the fact that most sinus infections start in the nasal passages as a continuum of disease (Clement). As explained by the Consensus Panel, it is not possible to differentiate rhinitis from sinusitis based on clinical grounds alone. Isolated rhinitis can exist and is quite common (i.e. in allergic or specific rhinitis), but isolated sinusitis is rare. (Clement).

Acute rhinosinusitis, as defined by the Consensus Panel, is a sinus infection that has complete resolution of symptoms within 12 weeks (based on a clinical basis only). This definition assumes that there is no intermittent upper respiratory infection during this three month time (Clement). Acute rhinosinusitis is further divided into severe or nonsevere forms based on the symptomatology of the child (Clement). Chronic rhinosinusitis is defined as a sinus infection with low grade symptoms and signs that persist for more than 12 weeks, although acute exacerbations can occur in the setting of a chronic infection. The most common clinical picture seen in pediatric patients is an acute exacerbation in the setting of chronic rhinosinusitis (Clement). Recurrent acute rhinosinusitis consists of repeated acute episodes, with the signs and symptoms completely resolving between the episodes. In patients who are being treated with antibiotics, it is often difficult to differentiate on clinical grounds chronic rhinosinusitis from its acute form (Lusk).

Clinical Presentation

The diagnosis of rhinosinusitis is usually based on the clinical evidence and, as discussed earlier, the duration of the symptoms. The history and physical examination is vital to the proper diagnosis and subsequent management. Unfortunately, commonly recognized symptom complexes apparent in adults such as facial pain, headache, and fever are uncommon in the pediatric population (Wald). In addition, the symptom complex varies and in young children, the sinuses are difficult to directly visualize in an office setting.

The first and perhaps most common clinical setting is that of a viral upper respiratory tract infection. Also known as the common cold, the signs and symptoms can mimic those of rhinosinusitis. According to Lusk, it is virtually impossible to differentiate between an upper respiratory tract infection and rhinosinusitis during the first 7 to 10 days of symptomatology. Symptoms can include rhinorrhea which is usually serous but may become mucopurulent. Nasal congestion is common and cough is
usually present. The patient may also experience low grade fevers, malaise, and headaches. The key to the diagnosis of a viral upper respiratory tract infection is the brevity of symptoms. A typical upper respiratory tract infection usually resolves within 10 days although lingering cough present only at night is a common residual symptom of an upper respiratory tract infection or an indication of cough-predominant asthma. Acute nonsevere rhinosinusitis should be suspected in patients with persistent cold symptoms past ten days. Symptoms are strikingly similar to those of a viral upper respiratory tract infection and include rhinorrhea of any quality, cough (dry or wet) which is usually present during the daytime but often worse at night, low grade fevers, fetid breath, and painless morning periorbital swelling. The periorbital swelling is intermittent and painless. Facial pain is typically absent (Wald, Clement, Ott, Lusk).

A second, less common, presentation is an upper respiratory tract infection that is more severe than usual. In this setting, a diagnosis of an acute severe rhinosinusitis should be considered. Symptoms usually occur after ten days of typical nonsevere symptoms however the symptoms may occur earlier in the course of the disease. Symptoms of acute severe rhinosinusitis include high fever (usually over 39.0°C), a purulent and copious nasal discharge, and associated periorbital swelling and facial pain. The periorbital swelling may involve the upper or lower eyelids and is most obvious in the early morning after waking. A less common complaint is a headache usually described as a feeling of fullness or dull ache behind or above the eyes, most often reported in children over five years of age. Less commonly, there may be dental pain referred from the sinus infection (Wald, Clement, Ott, Lusk).

Diagnosis

The diagnosis of pediatric rhinosinusitis is usually based on a combination of the history, physical examination, laboratory investigations, and radiological findings. The physical examination in pediatric patients with rhinosinusitis is often unrewarding. The physical examination is limited by the inaccessibility of the paranasal sinuses as well as the uncooperative nature of the pediatric patient. Evaluation on anterior rhinoscopy may reveal a mucopurulent discharge from the osteomeatal complex, however this assessment is difficult to perform on a child (Younis). Younger patients may tolerate evaluation by an otoscope which may demonstrate nasal mucosal edema, erythema, or possibly purulent discharge in the nose. Examination in the oropharynx may reveal moderate injection of the oropharyngeal wall with postnasal drainage in the posterior pharynx. Occasionally there may be tenderness with palpation over the paranasal sinuses. Assessment of the face may reveal appreciable periorbital edema or dark discoloration of the lower eyelids. Flexible and rigid endoscopy may provide a more complete evaluation in an older, more cooperative child. The most specific findings for acute rhinosinusitis in a child include mucopurulence from the middle meatus (after topical vasoconstriction), periorbital swelling, and facial tenderness (Wald).

Currently utilized diagnostic procedures for acute rhinosinusitis include transillumination, ultrasonography, plain radiography, and aspiration of the sinuses. The increased thickness of both the soft tissue and bony vault in children under age 10 limits the clinical usefulness of sinus transillumination. As a result, most authors conclude that
transillumination is of no value in diagnosing rhinosinusitis in children (Lusk, Wald, Ott,). Controversy still exists concerning the value of ultrasound examination, however this modality also appears to have little benefit for children (Lusk, Ott).

Radiography has been traditionally used to determine the presence or absence of sinus disease. Standard views include the Water’s, Caldwell, lateral, and submentovertex views. A number of criticisms have been made towards the use of plain radiographs in diagnosing pediatric rhinosinusitis. First, the ethmoid sinuses on plain radiographs are often poorly visualized and mucosal disease present in this anatomic location is often unrecognizable on plain radiography (Ott). Second, differences of opinion remain concerning what findings on plain radiography are indicative of disease. Varying degrees of mucosal thickening (2 to 6 mm) and the presence of air-fluid levels have been used as criteria for diagnosis (Ott). However, thickening may not be indicative of bacterial infection, instead it may be the result of allergic or nonallergic rhinitis. In addition, underdeveloped sinuses may be misinterpreted as opacification because of the variation of size and symmetry in children. Mucosal redundancy can also mimic sinus opacification on plain radiographs. For these reasons, many investigators have argued that plain radiographs are unreliable in children, especially those under the age of one (Ott).

McAlister et al. prospectively compared the usefulness of plain radiographs with coronal CT scans in pediatric patients with symptoms of chronic rhinosinusitis. Forty-five percent of children with normal plain films demonstrated abnormalities on CT scans and 34% of the children with abnormal plain radiographs had normal CT scans. Thus, McAlister concludes not only are plain radiographs unreliable as screening tools, the radiographs underestimate and overestimate the amount of sinus disease noted on CT scanning. These findings do not negate the use of plain radiographs particularly in the event of acute rhinosinusitis where air-fluid levels may be demonstrated. If air fluid levels are noted on plain radiographs, these patients have positively correlated sinus aspirates 75% of the time (Wald).

Given the problems associated with plain radiography, many suggest that if the history and physical examination suggests acute rhinosinusitis, it is reasonable to forego plain radiographs and treat the condition. However, if the symptoms and physical examination are inconclusive, plain radiography may play a role. Criteria have been suggested to aid in the appropriate use of plain radiographs for assisting in the diagnosis of pediatric rhinosinusitis. First, it is suggested not to order radiographs under the age of one. Second, it is important to be familiar with the normal development of the sinuses in children prior to reading the films. Third, upright radiographs are of more benefit than supine. Fourth, radiographs should be ordered only if symptoms are prolonged and unusually severe (Ott).

Computed tomography scanning provides an excellent tool for evaluation of sinus disease, particularly in cases of chronic rhinosinusitis. The CT can demonstrate disease that is not shown on routine X-rays. While CT scanning may demonstrate disease not shown on plain radiographs, the scan may not reveal the extent of disease actually present (Younis). Nonetheless, in patients who have failed optimum medical management or are planning for surgical intervention, computed tomography remains the gold standard for rhinosinusitis evaluation. CT scans are not necessary for the management of children...
with uncomplicated acute bacterial rhinosinusitis. The indications for obtaining a CT scan are similar to those for sinus aspirates discussed below.

Confirmation of the diagnosis of rhinosinusitis can be made by culturing an aspirate of the sinus secretions. While not completely free of morbidity as these children typically require a general anesthesia, a properly performed sinus aspiration allows for precise identification of the offending pathogen as well as the sensitivities of the organism to appropriate antibiotics. Indications for sinus aspiration in children include clinical unresponsiveness to conventional therapy, sinus disease in an immunosuppressed patient, severe symptoms such as headache or facial pain, and life threatening complications such as intraorbital or intracranial suppuration at the time of clinical presentation (Wald). Unfortunately, nasal, oropharyngeal, and nasopharyngeal cultures correlate poorly with cultures of sinus aspirates. Therefore, it is not recommended to undertake these cultures as guides to the bacteriology and therapy of acute or chronic rhinosinusitis (Wald). Additionally, there is no consensus on whether middle meatal cultures can substitute for sinus punctures. (Lusk).

Microbiology

Knowledge of the bacteriology of sinus aspirates can aid in the proper selection of antibiotics against the offending organisms. A study of fifty children with acute maxillary rhinosinusitis has shown that the pathogens found in sinus secretions were similar to those found in adults. The predominant organisms include Streptococcus pneumoniae, Moraxella catarrhalis, and nontypeable Hemophilus influenzae. Rarely, viruses and anaerobes are isolated from these patients (Wald). These same organisms are also found in cases of chronic rhinosinusitis with the exception that greater numbers of anaerobes, Streptococcus, and Staphylococcus species have been isolated.

There is controversy concerning whether there is normal flora within the paranasal sinuses. Animal data suggest that a noninfected sinus is sterile, however, similar studies have not been performed in asymptomatic children. In adults, sinus aspirates from 12 asymptomatic patients revealed bacteria similar to those pathogens found in patients with maxillary rhinosinusitis (Ott).

Medical Management

In the past, treatment for acute maxillary rhinosinusitis consisted of sinus aspiration and irrigation (Wald). With the current availability of antimicrobial agents that are effective against the offending pathogens, antibiotic therapy is considered the standard treatment of rhinosinusitis today. Antibiotic usage should only be considered for those patients that meet the clinical criteria for bacterial rhinosinusitis, as a viral upper respiratory tract infection is at least 20-200 times more common than bacterial rhinosinusitis and increasing numbers of drug resistant bacteria are being isolated. A recent study revealed that 16.1% and 28.6% of Streptococcus pneumoniae isolates were penicillin-intermediate and penicillin-resistant respectively (Academy Guidelines). At UTMB, 35% of Streptococcus pneumoniae isolates are penicillin resistant. Even when strict clinical criteria are met approximately 40-60% of rhinosinusitis episodes will
resolve without the use of antibiotics. This is a similar pathophysiologic picture as patients with acute otitis media (O’Brien). However, the objectives of antibiotic therapy in treating a bacterial rhinosinusitis include the achievement of a rapid clinical cure, sterilization of the sinus secretions, prevention of suppurative complications, and prevention of chronic sinus disease (Wald).

Recommendations by the American Academy of Otolaryngology for initial therapy for children with acute nonsevere rhinosinusitis that have not received antibiotics in the past 4-6 weeks include amoxicillin/clavulanate, amoxicillin (45-90 mg/kg/day), cefpodoxime proxetil, or cefuroxime axetil. Azithromycin, clarithromycin, erythromycin, or TMP/SMX are acceptable if the patient has a known immediate type I hypersensitivity reaction to beta lactams. These antibiotics have limited effectiveness against the major pathogens of acute rhinosinusitis and a failure rate of 25% is possible (Academy Guidelines).

Recommendations for initial therapy for children with mild disease who have received antibiotics within the previous 4 to 6 weeks or children with moderate disease without prior antibiotics includes amoxicillin/clavulanate, high dose amoxicillin (80 to 90 mg/kg/day), cefpodoxime proxetil, or cefuroxime axetil. Clindamycin is appropriate if Streptococcus pneumoniae is isolated. Moderate disease in children receiving antibiotics in the previous 4 to 6 weeks should be treated with amoxicillin/clavulanate or combination therapy (amoxicillin or clindamycin plus cefpodoxime proxetil or cefixime).

Consideration of the side effect profile of any of the antimicrobial agents should be considered in cases of nonsevere acute rhinosinusitis as spontaneous resolution can be expected to occur in 40-60% of cases (Wald). Additionally, knowledge of local resistance patterns of rhinosinusitis pathogens is important in selecting the proper initial antimicrobial agent. If no improvements occur in 48 to 72 hours, the antibiotic should be changed to a beta-lactamase stable agent as there are increasing numbers of beta-lactamase resistant strains of H. influenzae and M. catarrhalis as well as resistant Streptococcus pneumoniae species. Such "switch therapy" for patients without improvement in 72 hours varies depending on the likely pathogen. Children continuing effective antibiotic therapy and continue to be symptomatic may need further evaluation and identification of the offending organism (Academy Guidelines).

An oral beta lactamase stable agent such as amoxicillin-clavulanate, cefixime, cefuroxime, or cefpodoxime should be used as initial therapy for acute severe rhinosinusitis. At UTMB, cefixime is no longer an acceptable second line agent as it is no more beneficial than penicillin for Streptococcus pneumoniae due to increased resistance patterns. Total therapy length should be from 10-14 days which can be prolonged to one month if the symptoms have improved but not resolved completely (Clement). Patients with severe illness or with suspected or proven suppurative complications should be treated intravenously with an agent active against beta lactamase producing pathogens. Cefotaxime or ceftriaxone with the addition of clindamycin to cover drug resistant Streptococcus pneumoniae is acceptable.

Clinical improvement is expected rapidly in most patients with properly selected antimicrobials. If the patient does not improve or worsens in 48 hours, clinical reevaluation is appropriate. If the diagnosis is unchanged, sinus aspiration may be considered or a change to a more active antimicrobial agent may be prescribed (Clement).
For chronic rhinosinusitis, a four to six week course of a beta lactam stable antibiotic is appropriate, with three weeks of therapy being the minimum (Ott).

The effectiveness of antihistamines and decongestants (singly or in combination) applied topically or administered orally in the treatment of acute or chronic rhinosinusitis has not been adequately studied. Additionally, no double blind controlled studies have been performed to evaluate the effectiveness of isotonic saline nose drops, saline sprays or irrigations, steam inhalations, or nasal steroid medications (Ott). The reported benefits of topical decongestants such as oxymetazoline or phenylephrine in shrinking the nasal mucous membrane, improving ostial drainage, and providing symptomatic relief should be weighed against the possibility of inhibiting ciliary motion. By inhibiting ciliary motion, topical decongestants may delay clearance of infected material. In addition, by decreasing blood flow to the mucosa, topical decongestants may lower oxygen tension and impair diffusion of antimicrobials into the sinuses. The use of antihistamines have been considered mainly in cases of concomitant allergic rhinitis. There use, however, may actually interfere with the clearance of secretions as these agents are known to dry the mucosal secretions of the sinuses (Ott). Reports of benefit from physiologic saline and steam treatments are only anecdotal. Supposedly, therapeutic benefit is due to moisturizing the inflamed mucosa, softening the nasal crusts, and direct removal of purulent material. The role of nasal steroids in the treatment of rhinosinusitis, likewise, has also been inadequately addressed. These agents may have a role for children with chronic, nonpurulent rhinosinusitis, especially those with an established diagnosis or strong suspicion of allergic rhinitis (Clement). The effectiveness of mucolytics such as iodinated glycerol has primarily been studied on sputum in lower respiratory tract disorders in adults. Although their use in pediatric rhinosinusitis has not been well studied, the similarities of cough, tenacious mucous, and recurrent bacterial infections suggests these might have a therapeutic role. Despite its wide clinical use, guaifenesin has not been proven efficacious (Zacharisen).

Additional studies may be warranted in children with recalcitrant rhinosinusitis. Underlying conditions such as allergy, immunodeficiency, ciliary immotility disorders, and gastroesophageal reflux must be considered. Respiratory allergy is the most frequent of these underlying conditions (Clement). Thus, in children with chronic or recurrent acute rhinosinusitis with a suggestive history and physical examination, allergic assessment should be performed for patients who continue to worsen despite avoidance and simple pharmacological measures. A history of nasal symptoms such as sneezing, itching of the nose, ears, and eyes coupled with physical examination findings of an allergic nasal crease, pale swollen turbinates, or other evidence of atopy such as eczema, urticaria, or asthma should elicit an allergic assessment (skin prick testing, nasal smear, radioallergosorbent testing, or a trial of treatment) (Clement). An immunologic assessment (complete blood cell count, quantitative immunoglobulin levels, immunoglobulin G subclass level in serum, and antipneumococcic titers), ciliary dismotility assessment (mucosal biopsy), and a cystic fibrosis workup (sweat chloride test) is advisable particularly in cases with children that have recurrent sinopulmonary infections (Clement). Cystic fibrosis, in particular, should be considered in any child that is found to have nasal polyposis. Extended pH probe
monitoring for gastroesophageal reflux and treatment of known gastroesophageal reflux disease may be warranted in children with recalcitrant rhinosinusitis (Bothwell).

Surgical Management

Patients with acute rhinosinusitis rarely will ever need surgical intervention except in those cases that are complicated by orbital or nervous system complications. Subperiosteal abscess, orbital cellulitis, or intracranial abscess must receive aggressive surgical management (Stankiewicz). For patients with nonresponsive recurrent acute or chronic rhinosinusitis that fail to improve with maximal medical therapy, surgical intervention may be necessary.

In children with rhinosinusitis with moderate to severe nasal obstruction caused by adenoid hypertrophy, adenoidectomy has been shown to be beneficial. However, given the size of the research trials involved, definite conclusions cannot be drawn as to the efficacy of this form of treatment (Clement).

Septoplasty is another potential treatment for the symptoms of rhinosinusitis. Septal deviation significant enough to nasal obstruction and ipsilateral sinusitis is an uncommon finding. However, in selected patients, a limited septoplasty may be a reasonable surgical procedure.

Antral aspiration and lavage generally require general anesthesia in children and is indicated in cases of a severe, unresponsive or complicated condition. The indications for antral lavage are the same as for sinus puncture discussed previously. Antral lavage is usually not a viable therapeutic modality for the treatment of rhinosinusitis because it involves only the maxillary sinus and not the ethmoid or other sinuses. The technique does remain a valuable diagnostic tool in the immunocompromised patient or in select patients where the disease is limited to the maxillary sinus.

The Caldwell-Luc procedure is an uncommon procedure for treatment of pediatric rhinosinusitis due to concerns of potential damage to the unerupted permanent dentition and the uncommon finding of sinus disease sufficient enough to benefit from removal of the diseased sinus mucosa.

The nasal antral window (inferior antrostomy) was popularized in the past as a less aggressive and more effective method of treating rhinosinusitis than the Caldwell-Luc procedure. The nasal antral window is used to promote sinus drainage and ventilation and is often placed in the inferior meatus. According to Lusk and Stankiewicz, the inferior antrostomy has not been a successful modality for treating rhinosinusitis. Reasons cited include that the cilia continue to beat towards the obstructed natural ostia and the potentially diseased ethmoid sinuses are not addressed. Additionally, a significant number of windows have been found to lose patency with a subsequent recurrence of rhinosinusitis. Exceptions for placing an inferior antrostomy include ciliated dysfunction and cystic fibrosis as gravity likely plays a larger role in enhancing sinus drainage via the dependent window thereby increasing its efficacy (Lusk).

The current state of the surgical technique for treatment of rhinosinusitis is functional endoscopic sinus surgery (FESS). The technique frequently involves opening the osteomeatal complex and removal of sinus disease with minimal manipulation of the
surrounding normal tissue. The treatment of pediatric rhinosinusitis by this method is a very controversial issue and has as many proponents as opponents. According to the opponents, pediatric rhinosinusitis is analogous to recurrent acute otitis media and is actually part of the same disease process. The surgical equivalence of tubes in recurrent otitis media has none in rhinosinusitis with some arguing that FESS is equivalent to a mastoidectomy for acute otitis media. Opponents also argue that even gross radiographic or extensive mucosal disease has been repeatedly shown to be reversible. They contend that the indications for surgery—a unabated rhinorrhea, failure of maximal medical therapy, and an abnormal CT scan, do not bear scientific scrutiny. They contend that the precise population of children most likely to benefit from surgery has not been delineated. In addition, the small space of the nasal cavity and the proximity of the lateral nasal wall to the contents of the orbit and anterior cranial fossa make serious complications a very real possibility.

Advocates of surgical treatment have a careful approach that is variable between surgeons. According to their approach, the patient qualifies for surgery when medical therapy has failed, as determined by the pediatrician and surgeon. A thorough medical workup is often undertaken with consideration given to immunologic, allergic, asthmatic, and reflux disease in the child. Extensive sphenoidectomy is usually not necessary in children. Typically, an anterior ethmoidectomy with a maxillary antrostomy is often sufficient. The proponents often cite excellent results with surgical treatment of chronic and recurrent acute rhinosinusitis. A recent study determining the safety and efficacy of FESS in children with chronic rhinosinusitis reported that 71% of patients were considered normal by their parents at one year postop (Wald). Additionally, a meta analysis of FESS for chronic and acute rhinosinusitis revealed an 89% success rate with a complication rate of 0.6%. A preoperative CT scan with coronal sections is essential in defining the location and extent of the disease as well as the pertinent anatomy of the proposed endoscopic site.

While many may argue specific indications for or against surgery, the Consensus Panel for pediatric rhinosinusitis lists the following for absolute indications for FESS: 1) complete nasal obstruction in cystic fibrosis due to massive polyposis or closure of the nose by medialization of the lateral nasal wall, 2) antrochoanal polyp, 3) intracranial complications, 4) mucoceles or mucopyoceles, 5) orbital abscess, 6) traumatic injury in the optic canal, 7) dacryocystorhinitis due to sinusitis and resistant to appropriate medical treatment, 8) fungal sinusitis, 9) some meningoencephaloceles, and 10) some neoplasms (Clement). Possible indications are for children with chronic rhinosinusitis that persists despite optimal medical management (2-6 weeks of adequate antibiotics and treatment of any concomitant disease) and after exclusion of any systemic disease (Lusk).

Complications of Rhinosinusitis

Complications of rhinosinusitis in children have steadily decreased over the years due to improvements in diagnostic aids and therapeutic techniques. Improved radiographic modalities such as CT scanning coupled with newer surgical techniques have favorably changed the prognosis of patients with complicated rhinosinusitis.
Nonetheless, the potential severity of complicated sinus disease makes appropriate recognition and early treatment imperative.

The most common complications in rhinosinusitis are orbital infections (Gurucharri). Infections from the sinus can spread to the orbit through the arteries, veins, or lymphatics but most often spread by direct extension through a dehiscence in the lamina papyracea (Lusk). Chandler has divided the progression of sinusitis-induced orbital infections into five stages. The classification aids in the assessment of severity of the disease and the development of a plan of therapy. Stage I is a periorbital inflammatory edema, in which cellulitis of the eyelid may occur with or without edema of the orbital contents. Obstruction of venous channels is usually the cause and there is no loss of vision or limitation of extraocular mobility.

Stage II is associated with orbital cellulitis in which diffuse edema, chemosis, proptosis, and pain is present. There is no abscess formation and ophthalmoplegia or globe fixation may occur by muscle edema or spasm although there is usually no mobility limitation. Visual loss is usually mild due to corneal edema.

Stage III involves a subperiosteal abscess, or purulent material between the bony wall of the orbit and the periorbita. Swelling is generally circumscribed with displacement of the globe in a lateral or downward direction. Orbital cellulitis is also present and is manifested by a limitation of extraocular mobility secondary to edema or spasm. Vision is typically decreased.

Stage IV is defined as an orbital abscess. It is thought to develop secondary to extension of infection into the orbital site with inflammatory edema, fat necrosis and abscess formation. Proptosis and chemosis are severe but the globe is not usually as displaced as with a subperiosteal abscess. Ophthalmoplegia and visual impairment are usually present with complete ophthalmoplegia and visual loss present in 13% of patients secondary to ischemia or optic neuritis.

Stage V is cavernous sinus thrombosis which is due to extension of phlebitis into the cavernous sinus. This produces a progression of symptoms initially involving the orbit and subsequently involving the opposite eye. Marked proptosis and fixation of the eyeball is usually present. Extraocular muscle limitation is typically caused by involvement of the third, fourth, and sixth cranial nerves. Meningitis may also take place (Gurucharri).

The appropriate diagnosis is based on an accurate history, physical examination, laboratory results, and radiographic examinations. Histories consistent with rhinosinusitis and a physical examination revealing periorbital or orbital inflammation suggest complicated sinus disease. Ophthalmological evaluation is mandatory and intravenous antibiotics are typically given with ceftriaxone or cefotaxime as initial first line agents with a consideration given to cover anaerobes and Staphylococcus species with clindamycin or a combination of oxacillin and metronidazole. Surgical intervention should be considered for any patient with abscess formation, worsening visual acuity, loss of vision, progression of orbital involvement, progression to the opposite eye, and persistent high-grade fever despite 24 hours of medical treatment. The surgical procedure depends on the location of the abscess and the primary site of infection. External ethmoidectomy, endoscopic sinus surgery, frontal sinus trephines, or Caldwell-Luc procedures may be employed.
Intracranial complications of rhinosinusitis may be life threatening. Infection spreads intracranially by extension along anatomic pathways, retrograde thrombophlebitis, or direct inoculation. Intracranial complications secondary to sinusitis include meningitis, epidural or subdural abscess, cavernous sinus thrombosis, and cerebral abscess.

Intracranial complications must be suspected in patients with histories consistent with rhinosinusitis and physical examination findings consistent with altered neurologic function. Immediate treatment is similar to that of orbital complications with the neurosurgeon, ophthalmologist, and infectious disease specialist playing a prominent role in the child’s initial management. Of note, a lumbar puncture should not be performed as this may precipitate brainstem compression.

The main complication of long standing sinus disease is a mucocoele. These are destructive masses secondary to local expansion and are usually identified by CT scan. Management is surgical with endoscopic or open sinus procedures indicated depending on the location. Occasionally, infection in the sinuses may result in osteomyelitis of the surrounding bony walls. This will require long term intravenous antibiotic therapy and occasionally surgical drainage of the infected sinus with debridement of the infected tissues (Gurucharri).

The Role of Allergy in Rhinosinusitis

The prevalence of allergy in the United States has been estimated at 15-30% of the general population. Allergy is a contributing factor in, if not the primary cause of, recurrent acute rhinosinusitis and chronic rhinosinusitis in allergic patients. Similar to the pathophysiology of viral induced rhinosinusitis, allergy evoked sinusitis is hypothesized to arise from mucosal edema, resulting from the inflammation induced by the allergic reaction. This edema leads to obstruction of the sinus ostia, mucostasis, local tissue hypoxia, and subsequently growth of bacteria within the sinus leading to rhinosinusitis (Cook).

Differentiation between infectious and allergic symptomatology is essential in order to correctly diagnose and treat these two conditions. Symptoms suggesting allergy include itching mucous membranes of the upper aerodigestive tract, clear rhinorrhea, and other remote symptoms of allergy including eczema and food intolerance. Overlap occurs with infectious rhinosinusitis as both conditions can lead to nasal congestion, stuffiness, fluctuating rhinorrhea, sneezing, cough, behavioral changes, and headaches with facial pain or pressure. Indeed, the two conditions can be present within the same patient, however in most instances, it is believed that allergic disease with mucosal edema is the primary etiology with infection occurring secondarily (Cook).

Other historical clues may lead to the diagnosis of allergy. Infantile colic, numerous formula changes with vomiting and diarrhea, poor sleeping habits, and irritability are common occurrences in the allergic infant. Pertinent history also includes a frequently runny nose or constant cold symptoms, eczema, recurring upper respiratory tract infections, cough, wheezing, otitis media, and a diagnosis of attention deficit hyperactivity disorder (Cook).
Physical signs of allergic children can include “allergic shiners”, characterized by puffy, bluish discoloration of the lower eyelids. Allergic children also often display very long silky, uneven eyelashes as well as conjunctivitis. The external nose may frequently display a supratip horizontal nasal crease owing to the “allergic salute”, a gesture that is performed by wiping the nose vertically with the palm. The lips are often cracked and chapped because of chronic open mouth breathing which is the result of nasal obstruction. The skin of the anterior cheeks often reveals a rash resembling eczema, often seen with food allergic children. Examination of the oropharynx reveal erythema along the faucial arches, edema of the uvula, and hypertrophy in Waldeyer’s ring. Collections of lymphoid tissue along the posterior pharyngeal wall is also a prominent finding in allergic children. Eustachian tube dysfunction and subsequent otitis media with effusion is common in children with allergy. Thus, any child requiring more than one set of tubes should raise the suspicion of allergy as a potential etiology. Chronic cough and bronchial asthma are quite common. Indeed, over 85% of these children are allergic to the dust mite (Cook). Feeding irregularities, colic, bloating, and nocturnal emesis are also potential signs of childhood allergy. Finally, atopic dermatitis, urticaria, and eczema are also presenting signs of an allergic diathesis in the child.

Diagnostic tests for allergy are performed to confirm the diagnosis that has been made clinically. Because adverse reactions to food in children is common, a detailed history about the child’s eating habits helps direct the diagnostic effort. One of the most helpful tools is a 2-4 week food diary. Analysis may provide insight into potentially allergy inciting food products. A double blind placebo controlled food challenge is considered by many to be the gold standard in the diagnosis of food hypersensitivity, however the open feeding challenge test with natural food produces reliable results and is quite effective in the office setting (Cook).

The use of in vitro diagnostic testing is helpful in diagnosing inhalant allergies. Radioallergosorbent tests exhibit excellent sensitivity and specificity for inhalant allergies however their use for food allergies is less defined. The analysis of nasal smears can be helpful in confirming the diagnosis of allergy as one may recover numerous eosinophils in the nasal secretion of the allergic patient. In vivo diagnostic testing via skin testing remains an excellent confirmatory test for allergy that has a high sensitivity and specificity.

Treatment for allergic disease should be prophylactic and regular. The aim of therapy is to reduce or eliminate the inflammation that is the result of inflammatory mediators. Theoretically, avoidance of the antigen should be the only therapy required, however avoidance of aeroantigens is impractical. Removing stuffed animals from the bedroom, encasing pillows and mattresses in allergy proof materials, vacuuming frequently, and using a high-efficiency particulate air filter system may help decrease the antigenic load to the child within the house. Pets should not be allowed in the house of allergic patients and the rooms of the house should be kept air conditioned with the humidity ideally between 35%-40%.

Pharmacotherapy via the use of antihistamines, topical nasal steroids, and mast cell stabilizers remain important tools in the treatment of allergic disease. The use of cetrizine in children as young as two years of age is quite effective as well as convenient. Other new antihistamines have proven equally as efficacious. Clemastine (Tavist) may
be used in infants under two years of age (Cook). Cromolyn can be used safely in children of all ages and is typically used topically. Topical steroids inhibit both the early and late stages of inflammation and, as a result, are exceedingly useful for allergic rhinitis. Fluticasone has been used safely in children as young as four years of age showing excellent efficacy and a high therapeutic index. Studies evaluating the safety and efficacy of nasal steroids in children under the age of four are currently being performed.

Immunotherapy is also a valuable tool in the treatment of pediatric allergy and may prevent long-term sequelae in asthmatic patients as well (Cook). Immunotherapy is generally applied after allergen avoidance fails and the patient’s symptoms are not well controlled with pharmacotherapy.

The Role of Asthma in Rhinosinusitis

Asthma patients probably represent the largest group of individuals in whom pediatric rhinosinusitis can have a negative impact on overall health (Manning). The incidence of asthma has increased dramatically over the last two decades which has created a large cohort of individuals on high dose steroids and bronchodilators. Upper respiratory infections, including rhinosinusitis, may be more prevalent in these individuals and has been postulated as a trigger for outbreaks of reactive airway disease. While the association of asthma and rhinosinusitis has been discussed, the cause-effect relationship has not been established. The premise of this association is that sinus mucosal disease effects bronchial hyperreactivity. Four theories have been proposed to explain this link. First, rhinosinusitis causes dripping of mediators into the trachea, a situation that worsens asthma. Second, nasal-sinus reflexes in rhinosinusitis exacerbate asthma. Third, cough in patients with asthma is a major symptom of rhinosinusitis and fourth, antibiotic and surgical treatment of rhinosinusitis resolves exacerbations of asthma (Ott).

Current evidence refutes the theory that aspiration of mediators or nasal-sinus reflexes cause rhinosinusitis in patients with asthma. A recent study found an absence of pulmonary aspiration of a radionuclide that was previously placed in the sinuses of patients with asthma and rhinosinusitis. Other studies of nasal challenges with histamine and methacholine in patients with asthma revealed no increase in resistance of the lower airway (Ott). A factor that does support the association of asthma and rhinosinusitis is the frequent occurrence of cough patients with these diseases. One theory postulates that cough receptors are present in the paranasal sinuses and the tracheobronchial tree. The literature supports the concept that cough is the predominant manifestation of cough-variant asthma however there are a lack of studies separating whether these patients are coughing as result of the sinus or pulmonary disease processes.

Investigators have suggested that antibiotic treatment of rhinosinusitis in patients with asthma resolves the symptoms of asthma. Rachelefsky et al noted a strong correlation between resolution of sinus disease and the ability to discontinue bronchodilator therapy in a group of 48 children with rhinosinusitis and asthma. Friedman et al studied 7 children with poorly controlled asthma and rhinosinusitis and demonstrated improvements in pulmonary function tests with resolution of the rhinosinusitis in 5 of the
patients. Oliveira et al demonstrated that bronchial hyperresponsiveness could be improved in children treated for their concomitant rhinosinusitis. Finally, numerous studies in adults and children have documented the effectiveness of controlling asthmatic symptoms and reducing the need for asthma medications in patients undergoing sinus surgery (Park).

These results certainly support the fact that aggressive treatment of rhinosinusitis is warranted in patients with difficult to control asthma. Additional research needs to be performed to further answer whether sinus disease exacerbates underlying asthma or is an etiologic factor in the development of asthma in selected patients.

Conclusion

Pediatric rhinosinusitis remains a diagnostic dilemma in many children. Newer technology has helped us diagnosis and allowed us to treat patients that were previously inadequately or not treated at all. While the management of pediatric rhinosinusitis is primarily aggressive medical therapy, surgical management is appropriate for certain patients. Further inquiry is required to expand our understanding of the etiology and natural history of sinus disease in children with additional insight into defining the indications for specific forms of medical and surgical therapy.

Bibliography


