Current concepts in management of sinus disease

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All the paranasal sinuses originate embryologically from the lateral nasal wall or ethmoid air cells. This common development also determines the ability of the paranasal sinuses to function normally. Disease affecting the common drainage area of the sinus ostia, the ostiomeatal complex, also affects the function of the closely associated paranasal sinuses. Therapy directed toward any sinus without efforts to identify and correct the pathologic process of the ostiomeatal complex often leads to less-than-satisfactory results.

Determination of the etiology of chronic paranasal sinus disease depends on the clinical history, endoscopic rhinoscopy, and computerized imaging. Therapy is directed toward relief of the sinus ostial obstruction and restoration of the normal mucociliary clearance. After medical therapy has failed to reverse the pathophysiology of acute or chronic paranasal sinus disease, surgical intervention may be considered.

Recently developed technology has provided better insight and understanding of the functioning of the sinuses. As a result, the diagnosis and management of paranasal sinus disease have evolved considerably in the past few years. The concept that the ethmoid labyrinth and the middle meatus are primarily involved in most instances of sinus abnormality is not

new, but had been little heeded because most physicians depended on routine sinus x-ray films and anterior rhinoscopy to diagnose and follow the treatment of sinus disease. Obvious clinical signs and symptoms of sinus disease were often disregarded when unsupported by these routine studies. The advent of endoscopic rhinoscopy and computed tomography (CT) now makes it possible to confirm clinically any suspected pathologic processes in the middle meatus and ostiomeatal complex. Physicians are now more aware that this is the region to which therapy for acute and chronic sinus disease should be directed. Relieving obstruction of the sinus ostia and reestablishing mucociliary clearance of the paranasal sinus system restore normal physiology.

Embryologic development

At birth, the nasal chamber and the ethmoid sinus are indistinguishable. All the sinuses originate from the embryonic ethmoid labyrinth or nasal chamber as diverticula. This common development helps to explain why the drainage of all the sinuses is centered about the ethmoid sinus cells.¹

The maxillary sinus probably is an extension of the middle meatus or middle ethmoid cells. In the adult, the maxillary sinus occupies the body of the maxilla beneath the orbit and over the maxillary molar and premolar teeth. The frontal sinuses develop from the anterior ethmoid air cells. They extend into the frontal bone and are usually separated by a bony septum. Each frontal sinus drains via its nasal frontal duct into the middle meatus of the nose.

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The sphenoid sinuses develop from the posterior ethmoid cells and extend into the sphenoid bone. The sphenoid sinus is composed of two cavities separated by a septum. The carotid arteries, cavernous sinus, optic chiasm, hypophysis, and olfactory tract are important adjacent structures. The sphenoid ostia drain to the sphenoidal-ethmoid recess, which is high in the posterior aspect of the nose.² The remaining eight to ten thin-walled air cells that together have pneumatized the ethmoid bone (medial to the orbits, anterior to the sphenoid sinus, inferior to the anterior cranial cavity, and posterior to the lacrimal bone) make up the ethmoid labyrinth. Each air cell opens into the middle meatus by its own small ostium, which generally measures from 1 mm to 2 mm in diameter.²⁻⁴

The region of the lateral nasal wall to which all sinuses, except the posterior ethmoid and sphenoid cells, drain in common is referred to as the *ostiomeatal complex*. Its adjacent anatomy includes the hiatus semilunaris, the uncinate process, the ethmoid bulla, and the middle turbinate.^{5,6} The ostiomeatal unit is made up of the maxillary sinus ostium and infundibulum.⁷

The paranasal sinuses and the nasal cavity are lined with similar respiratory epithelium, except that the respiratory epithelium of the sinus cavities is thinner and contains fewer mucus-secreting goblet cells and glands.^{2,8-10} The cilia of the epithelial cells move the secreted mucus toward the nasal cavity through the sinus ostia, making them self-cleaning.^{2,8} Normal sinus physiology depends on patent ostia, functioning cilia, and quality and quantity (viscosity, amount) of secretions. The most important factor in the pathogenesis of sinusitis appears to be patency of the ostia. Viral upper respiratory tract infections complicated by bacterial infection and allergic rhinitis predispose to sinus occlusion by increasing mucosal edema at or near the sinus ostia. Chemical irritants, hyperplastic rhinitis with or without polyp formation, nasal septal deformity, and neoplasms are less common predisposing factors.^{6,11-13}

Sensory fibers to the sinuses originate from the trigeminal nerve. Parasympathetic and

sympathetic fibers jointly provide autonomic control of the sinus mucosa. Stimulation of the parasympathetic nerves causes secretion by the mucous and serous glands and dilation of the blood vessels. Sympathetic innervation maintains a tonic vasoconstrictor action; further stimulation results in additional vasoconstriction. Homeostasis of these autonomic functions may prevent ostial occlusion.^{8,10}

Once the ostia are obstructed by edema, the rich circulating blood supply may absorb the atmospheric gases in the sinus, thus producing a negative pressure inside the sinus. In a paranasal sinus, the pressure differential results in vascular engorgement, mucosal edema and, frequently, the transudation of fluid.¹³⁻¹⁶

Stasis of secretions in the sinuses leads to inflammation and infection. The normal pseudostratified columnar epithelium undergoes hyperplastic changes with a thickening of the submucosal tissues and increased goblet-cell population. The thickened mucous membranes and increased mucous production lead to further ostial obstruction. This pathophysiologic process may be reversed through the body's natural defenses or with therapy, but it may recur with each new insult to sinus homeostasis.^{1,17}

The most common cause of chronic sinusitis is an unresolved acute sinusitis. Prolonged or repeated episodes of acute sinusitis may lead to fibrosis and irreversible mucosal changes near the ostia, resulting in chronic sinusitis.¹³ Anatomic changes, such as deviated septum, concha bullosa (ethmoid air cells within the middle turbinate), turbinate hypertrophy, paradoxical middle turbinate (abnormal deflection toward the middle meatus), polyps, and foreign bodies, also commonly contribute to sinusitis. It is most important anatomically that the paranasal sinus ostia not be jeopardized by their adjacent structures. Uncommon syndromes and diseases, such as immunodeficiency states and immotile cilia syndromes, are less important factors in chronic sinus disease, but must also be considered.^{2,6,14}

The ostiomeatal complex is relatively narrow, and it is exposed to a significant amount of inhaled particulate matter that impacts onto the anterior surface of the middle turbinate.

If this particulate matter causes inflammation or edema (or both), the potential exists for obstruction in the ostiomeatal complex, leading to impaired function of the closely related sinuses.^{7,18}

Ostiomeatal passages that are already narrowed by congenital abnormalities, trauma, or tumor are prone to inflammation and edema, resulting in obstruction, predisposing and leading to chronic disease in the maxillary, ethmoid, and frontal sinuses.^{7,18} Studies have shown that the incidence of concha bullosa is three times greater in persons with chronic sinusitis than in the unaffected population.⁷ Because of the close association of the ostia of the other sinuses and the ostiomeatal complex, it is quite probable that most all bacterial infections of the paranasal sinuses, except perhaps those of dental origin, start with ethmoiditis.^{1,5,6,11}

Diagnosis

Clinical presentation and history

Clinical presentation of acute sinusitis often is nonspecific, and signs and symptoms listed by different authors vary. Findings may be difficult to distinguish from those of the common cold, influenza, or allergic rhinitis. Purulent nasal discharge, facial pain or tenderness, and nasal obstruction are the most common features of the acute process. Fatigue, cough, disorders of smell and taste, pain with mastication, fever (in approximately 50% of cases in adults), headache, epiphora, and edema of the eyelids are additional signs and symptoms of the acute sinusitis process.^{14,18}

Chronic sinusitis is associated with purulent nasal discharge, protracted nasal congestion, and facial pain.¹⁴ Headache has not been readily accepted as a symptom of chronic sinusitis. Currently, leading endoscopic sinus surgeons are cautiously suggesting the possibility that chronic headache patterns are directly associated with long-standing sinus disease.^{11,19-21} Another formerly controversial opinion now becoming accepted is that obstruction of sinus ostia can lead to absorption of atmospheric gases within the sinuses, producing a negative pressure or vacuum.^{11,13,15,16,22}

In a previous study,²³ McIntire and Hoyt in-

vestigated the role of chronic ethmoid sinusitis as an etiologic factor in chronic cephalgia and identified a particular headache pattern. The characteristic symptom patterns that were described by the subjects of the study indicated that the headache was usually perceived as a constant pressure in one or several areas: the frontal, retro-orbital, temporal, vertex, maxillary, or occipital region of the head. Symptoms woke the patient or were present when the patient awoke. The headache was more noticeable when changes in barometric pressure occurred, and symptoms usually worsened when the subjects had upper respiratory tract infections or were exposed to cold air or noxious environmental stimuli, such as tobacco smoke and some perfumes.

Diagnostic imaging and nasal endoscopy

Current methods of ensuring accurate identification of acute and chronic sinus disease require not only the history and clinical picture, but also the judicious use of diagnostic imaging and nasal endoscopy. The concept that a physician can look into the nose with a nasal speculum and diagnose sinusitis is invalid.⁷ Findings of intranasal edema, inflammation, and sinus tenderness depend on the stage of the disease. In the chronic disease state, the mucosa sometimes can appear almost normal.¹⁰ Because the ostiomeatal complex is poorly visualized by anterior and posterior rhinoscopy, routine sinus x-ray films, and even tomograms and CT scans, these modalities may provide little clinical information.^{1,12,24}

Plain x-ray films of the sinuses may aid in the diagnosis of acute sinus disease and in determining the extent of the sinus pathologic process, but they reveal very little about the underlying causes of chronic sinus disease.⁷ Plain x-ray films provide poor visualization of disease in the ethmoid sinuses. Therefore, the significance of chronic sinus disease had often been underappreciated until the late 1980s.^{6,7,12} Physicians who have depended on nasal endoscopy rather than routine sinus x-ray films, however, continued to recognize the importance of disease in the ethmoid complex in chronic sinusitis.^{7,24} The vast majority of patients who have symptoms and complaints

suggesting a pathologic sinus condition do not have massive disease. If the clinician highly suspects chronic sinusitis and routine sinus films show no abnormality, CT in the direct coronal plane is indicated.^{6,11,12} Some physicians are advocating a screening coronal CT scan as a replacement for standard plain x-ray sinus studies.²⁵

In studies of patients with chronic sinus complaints, CT demonstrated that the most common site of involvement was in the anterior ethmoid cells and middle meatus.^{6,7,12,24} Computed tomography can be quite helpful in revealing anatomic abnormalities in, or adjacent to, the ostiomeatal complex, such as concha bullosa and septal deformities and spurs. The timing in performing sinus CT is important because the intent is to determine the underlying cause of disease, not the extent of disease during an acute episode of sinusitis. It is most often advised that CT be performed after medical therapy has had time to clear the acute disease so that the underlying pathologic process can be seen more readily. For the best results in obtaining useful CT information regarding chronic sinus changes, it is important to obtain both coronal and sagittal cuts with triple magnification of the ethmoid sinuses and windowing similar to that used in examining lung parenchyma.^{7,12}

Shortcomings of CT scanning make nasal endoscopy even more valuable in confirming clinically suspected sinus disease. Such shortcomings are as follows:

- Minimal disease in the ostiomeatal complex not well delineated by CT can cause obstruction of the adjacent sinus ostia;
- Computed tomography tends to underestimate the extent of ethmoid sinus disease; and
- Computed tomography may show an absence of abnormalities in some patients with clinically significant disease, such as small polyps, purulent drainage, and inflamed and edematous mucosa seen endoscopically.^{6,7,24}

Rigid fiberoptic nasal endoscopy will reveal pathosis in approximately 40% of patients originally thought to have no abnormality after traditional methods of anterior and posterior rhinoscopic examination. (That number is exclusive of patients with chronic sinusitis symp-

toms who have moderate to severe deformity, allergic rhinitis, or a history of sinus surgery.) Nasal endoscopy techniques are most helpful when they can be used to identify limited underlying causes of diffuse sinus disease. Therefore, the key use of nasal endoscopy is in locating anatomic abnormalities and inflammation in the ostiomeatal complex that persist after adequate medical therapy. Such findings will identify the underlying cause of the sinus disease.²⁴

When performing endoscopic rhinoscopy, the physician first explains the proposed procedure to the patient, then administers a vasoconstrictor (a topical spray or packing) to the nasal mucosa. (A mild [4%] cocaine solution has the added benefit of achieving topical anesthesia; otherwise, an additional anesthetic agent is mixed with the vasoconstricting medication.) Rigid fiberoptic endoscopes of varying diameter with lenses at different angles and illumination by a cool light fountain are passed under direct visualization to examine the nose internally. A small, flexible endoscope attached to a television camera, videocassette recorder and videoprinter may also be used. The flexible endoscope affords better patient tolerance, yields more information, and creates a permanent record.

Treatment

Antibiotics

Antibiotics are the keystone in medical therapy of sinus disease, whether given orally to outpatients or given intravenously to the hospitalized patient who is in a toxic condition. An oral decongestant, such as pseudoephedrine hydrochloride or phenylpropanolamine hydrochloride, often in combination with a mucolytic, is also indicated in the treatment of acute and chronic sinus disease. Topical sympathomimetic agents can be useful in the treatment of acute sinusitis, but they should be used only for the initial few days of therapy. Topical nasal steroids are helpful when used in the treatment of allergic rhinitis, rhinitis medicamentosa, and possibly when treating chronic sinusitis. Antihistamines are contraindicated unless there is a strong allergic component present because they dry and thicken the mucus,

causing further obstruction of the sinus ostia.¹⁴

In the treatment of acute sinusitis, antibiotic therapy should be directed toward the most common pathogens: *Streptococcus pneumoniae*, *Haemophilus influenzae*, and *Branhamella catarrhalis*.^{14,26} Anaerobic bacteria (*Bacteroides* sp, anaerobic gram-positive cocci, *Fusobacterium* sp, etc), *Staphylococcus aureus*, *Streptococcus pyogenes*, and gram-negative bacilli are other pathogens in acute sinusitis.¹⁴ *Staphylococcus aureus* and other staphylococcal organisms are also more commonly found as a cause in chronic sinusitis, along with alpha-hemolytic streptococci and *Haemophilus* sp. Sinusitis of dental origin is likely to be caused by an anaerobic mixture of *Bacteroides* sp and anaerobic gram-positive streptococci.^{14,26}

Empiric therapy is appropriate for treatment of acute sinusitis because routine sinus aspirations are technically difficult and dangerous, and are not indicated unless the patient's condition is complicated or refractory. Ampicillin, amoxicillin, amoxicillin-clavulanate potassium, cefaclor, cefuroxime axetil, and trimethoprim-sulfamethoxazole have all been shown to be clinically effective as empiric therapy in acute sinusitis.

The length of the treatment course has not been clearly established, but a 10- to 14-day course is the usual recommendation because shorter courses are associated with treatment failures. Even much longer courses may be required in chronic sinusitis. Antistaphylococcal or augmented penicillins and doxycycline may be helpful in treatment of chronic sinusitis.^{14,26} Clindamycin may be of use in the treatment of an anaerobic component, and quinolone antibiotics may be helpful if one suspects gram-negative bacilli refractory to other therapy. In addition, surgery is often necessary in patients with fungal sinusitis or resistant bacterial infections.¹⁴

In the author's previously reported study,²⁷ mucous samples were taken from the ethmoid sinuses of 57 patients in whom chronic sinus disease had been diagnosed between Aug 10, 1988, and Sept 5, 1989, and cultured aerobically. Cultures of mucous samples from five patients showed no growth. There were 68 bac-

terial isolates from the remaining 52 patients: *Staphylococcus* sp, 33 cultures; *S aureus*, 15 isolates; gram-negative bacilli, 12 isolates; *Streptococcus* sp, 7 isolates; and group D enterococcus, 1 isolate. Of the oral drugs with empiric potential in the treatment of chronic sinusitis that were tested, ciprofloxacin, trimethoprim-sulfamethoxazole, and cefuroxime had the greatest percentage of effectiveness against the bacteria tested for antibiotic sensitivity. Seventy percent of the isolates obtained were resistant to penicillin, ampicillin, and tetracycline.

Osteopathic manipulative treatment

It has been long recognized that osteopathic manipulative treatment (OMT) can achieve autonomic nervous system homeostasis and promote improved blood and lymphatic circulation. Therefore, OMT should be included in the treatment of sinusitis. In a previously mentioned study,²³ 31% of the patients indicated that their sinus disease symptoms often included the upper posterior cervical and occipital region of the scalp. This region does not derive its sensory innervation from either the first or second divisions of the trigeminal nerve but from the upper posterior division nerves.

When evaluating patient complaints, palpatory examination can detect definite tissue changes in this region. Subjective improvement in the patient's symptoms has been apparent after OMT administered to this upper cervical region, perhaps because these changes represent a viscerosomatic response mediated through the sympathetic afferent motor fibers from the superior cervical ganglion.²⁸

Surgery

Often, it is difficult for the physician to determine the patient's clinical response to the medical treatment of acute or chronic sinus disease. Diagnostic endoscopic rhinoscopy is very useful for objectively evaluating the therapeutic benefit of medical treatment, rather than relying on the patient's subjective complaints.²⁴ If the patient's clinical response to medical management of acute or chronic sinusitis is thought to be less than satisfactory, surgical intervention may be considered. Current indi-

cations for sinus surgery are different than those of 10 years ago; surgery is now being done for both more limited and more severe disease.

A wide gray area exists between indications for medical management of sinus disease and the need for obvious emergency surgery. The treatment of patients in this gray area depends on the surgeon's philosophy of the management of sinus disease, the patient's desires, and the frequency and severity of the infections.

Therapeutic decisions should not be based solely on CT findings. The physician must correlate CT and endoscopic findings with the clinical history to determine appropriate treatment.^{17,29} It must be remembered that while CT is valuable in diagnosing chronic sinus disease, it may show minimal changes in patients with significant clinical disease, and that as many as 40% of asymptomatic individuals may show mucosal thickening. Although CT is a good guide, the patient's clinical course as well as response to therapy are equally important in determining the need to proceed with surgery. If CT shows minimal disease and the patient has had an exhaustive course of medical therapy with less-than-satisfactory relief, surgery should be considered.^{12,19}

In the past, patients who had one or two episodes of acute sinusitis each year or pressure symptoms brought on with weather change or noxious insult to their nasal mucosa received treatment of their acute symptoms. However, they were left with little or no expectation of a lasting solution. Routine sinus x-ray films are of little diagnostic value in these patients. However, CT scans or a good endoscopic examination can usually reveal ostiomeatal residual disease that is unlikely to respond to medical therapy. Surgical intervention for the treatment of chronic rhinosinusitis is indicated in the patient who fails medical management, the patient who is at risk of complication, and the patient for whom the desire to change the clinical course and symptoms of sinusitis outweighs the disadvantages of surgery. As always, the surgical decision is ultimately the patient's.^{6,12,26}

Functional sinus surgery is directed toward patency of ostia. Sinus disease that in the past

might have been treated with extensive surgery may resolve when drainage is restored.^{5,6,29} The theory of functional sinus surgery has held up clinically, namely, that persistent ostiomeatal inflammation leads to recurrent sinusitis. It is now recognized that ethmoid sinus disease causes ostiomeatal obstruction and is a significant factor in the failure of both antrostomy and the Caldwell-Luc operation.^{6,18} As infection spreads from the ostiomeatal complex, it predominantly causes symptoms and the appearance of changes in the frontal and maxillary sinuses on plain x-ray films. Some surgeons may attempt to correct the secondary changes while overlooking the underlying pathologic condition in the ostiomeatal complex that is poorly shown on routine sinus x-ray studies and traditional anterior and posterior rhinoscopy. Therefore, operation on the frontal or maxillary sinuses without first evaluating the ostiomeatal complex, even in cases originating from dental disease, is not recommended.^{5,18,29}

Favorable prognosticators of surgical outcome in sinus disease include the following: localized disease, recurrent acute sinusitis, disease due to anatomic abnormalities, lack of previous sinus surgical intervention, and maxillary sinus mycetoma. Indicators of potentially unfavorable surgical results include immunodeficiency, immotile cilia, severe allergy, asthma and aspirin sensitivity, previous sinus surgery, and diffuse polyposis.

Intranasal sinus surgery carries a complication rate of 4% to 17%. Major complications include cerebral spinal fluid leak, blindness, and hemorrhage. Orbital hematoma, diplopia, subcutaneous orbital emphysema, intranasal synechia, antrotomy closure, and nasal lacrimal duct injury may also occur.³⁰

Conclusion

The diagnosis and management of sinusitis continue to improve with technologic advances, and especially as physicians gain greater understanding of the pathophysiology leading to sinus disease. Functional sinus surgery offers new hope to the patient who has failed to respond to conservative osteopathic medical treatment.

The author wishes to thank Anita G. Hoyt and Gary Hoff, DO, for assistance in preparation of this article.

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