

## Review article

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# Management of sinusitis in the asthmatic patient

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**Objective:** To describe pathophysiologic links between sinusitis and asthma; to identify means of diagnosing sinusitis in the asthmatic; to discuss the management of asthmatic patients with sinusitis, both medical and surgical; to examine the outcome of managing the asthmatic patient with sinusitis.

**Data Sources:** Prospective and retrospective data from the author's experience was evaluated. Medline database was searched from January 1, 1994, using the keywords "asthma" and "sinusitis" without restriction to species or language; 48 articles identified. Relevant articles referenced in retrieved sources, current texts in otorhinolaryngology and sinus disease were also utilized.

**Study Selection:** From data source abstracts, pertinent articles (33) and book chapters meeting the objectives of our paper were intensively reviewed.

**Results:** Clinical and experimental studies indicate that sinonasal inflammation can result in worsening of lower airway disease, while the exact nature of this relationship remains debated. Regardless of mechanism, identification of the asthmatic patient with chronic sinusitis using the techniques of nasal endoscopy and CT scanning can lead to treatment of sinusitis with overall sinus and asthmatic disease improvement. Proper management is first medical, while surgical approaches are reserved for persistent cases. Traditional, more radical, surgical approaches have shown good results overall, while newer techniques of functional endoscopic sinus surgery which respect anatomy and mucosal function are less studied but expected to result in similar or better long-term outcome.

**Conclusions:** Sinusitis and asthma coexist and impact on one another at many different levels. Proper identification of the asthmatic patient with chronic sinusitis can be readily discerned by an accurate and thorough history and physical examination including nasal endoscopy and CT scanning. Proper medical and surgical management of sinusitis in the asthmatic patient can result in both improved sinonasal and asthmatic symptoms with fewer physician visits and decreased need for medication.

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## INTRODUCTION

Sinusitis and asthma are both significant health problems in the United States. Data from the National Health Survey indicate that sinusitis afflicts

14.7% of the United States population. Both sexes and all income groups and races are approximately equally affected.<sup>1</sup> While asthma occurs in only approximately one-third as many patients (5.14% of the general population), it has resulted in an ever increasing morbidity and mortality<sup>2</sup> increasingly impacting the US economy with a direct and indirect cost of 4.5 billion dollars in 1985 increasing to 6.2 billion dollars in 1990.<sup>2</sup>

Also significant is the impact that these illnesses have on patients' over-

all physical and mental health. Using the Medical Outcome Study Short-form 36-Item Health Survey, individuals with sinusitis have been found to have significantly increased bodily pain and diminished social functioning, as well as a worsened perception of general health, more problems with work or other daily activities, and diminished vitality.<sup>3</sup> Indeed, patients with sinusitis have less favorable outlooks on their general health than patients with angina and have significantly more bodily pain than those with back pain or sciatica.<sup>3</sup> Not unexpectedly, those with sinusitis and asthma together have even lower vitality scores, and lower assessments of functioning at work and in daily activities.<sup>3</sup>

While the medical, economic, and social impact of each disease is significant, the combination of the two is clearly greater than the sum of its parts. In this review, we will set out to discuss the links between these two illnesses, as well as methodology for the diagnosis of chronic sinusitis in the asthmatic, medical and surgical management of the patient, and the expected outcomes. Overall, it is our belief that a thorough history and physical examination including rigid intranasal endoscopy and CT scanning can identify the asthmatic patient with sinusitis and that excellent management of asthmatic patients with sinusitis can favorably impact all these critical areas: medical, economic, and social.

## LINKS BETWEEN SINONASAL DISEASE AND ASTHMA

Eighty percent of patients with asthma have rhinitis, while 5% to 15% with

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perennial rhinitis have asthma, and 53% to 75% of children with asthma have been found to have abnormal sinus radiographs.<sup>4-6</sup> Is this relationship between these two diseases causal or merely an epiphenomenon of the same infectious or immune-mediated disease affecting the entire respiratory tract? The question has interested physicians for centuries. Galen in the second century advocated purging the nostrils of secretions (dripping from their seat of origin in the brain) in order to relieve the lower breathing passages.<sup>7</sup> From then until the 17th century, sinonasal disease as a cause of asthma was accepted as certainty and never questioned. When anatomic study in the 1600s, however, failed to confirm the conduit from the skull to the lungs through which secretions would flow, acceptance of this mechanism fell into disfavor.<sup>8</sup>

Renewal of this theory occurred, however, in the late 1800s and early 1900s when studies began to demonstrate a causality between pathology in the nose and lungs. Kratchner, a French physiologist, in 1870<sup>9</sup> showed increased lower airway resistance in cats when stimulating the noses with a number of irritants including SO<sub>2</sub>, ether, and cigarette smoke. Dixon in 1903 produced bronchoconstriction with electrical nasal stimulation in cats; a response that was obliterated by sectioning the vagus.<sup>10</sup> Voltolini in 1871 reported a case of a patient whose asthma resolved after polypectomy.<sup>11</sup> And in an article entitled "Asthma as a nasal reflex," Greenfield Sluder in 1919 described asthma as mediated by the "sympathetic" [autonomic] nervous system in reflex from the nose. He presented eight cases where irritants applied to the sphenopalatine ganglion worsened asthma, while topical cocaine applied to some improved it.<sup>12</sup>

Since then, debate has continued to rage. Studies casting doubt on the existence of a sinonasal bronchial reflex include Hoehne and Reed,<sup>13</sup> Rosenberg et al,<sup>14</sup> and Schumacher et al.<sup>15</sup> Hoehne and Reed, in 1971, applied histamine solutions or ragweed particles to the

nasal mucosa of eight patients with ragweed allergy and asthma. Despite a severe hay fever response in all, no change in FEV<sub>1</sub> occurred in any until particles were inhaled orally or placed on the base of tongue. They concluded that "ragweed asthma is not initiated through an allergic reaction in the nose," but, in fact, "if obstruction of airways in asthma arises through reflex mechanisms, the sensory arc of this reflex originates below the oropharynx."<sup>13</sup> Rosenberg in 1973 pointed out similar findings when ragweed particles were applied to nasal mucosa in challenge testing.<sup>14</sup> Schumacher et al in 1986 in a placebo-controlled, non-randomized, double-blind study did not demonstrate a nasobronchial reflex in normal patients, nor patients with stable asthma and allergy.<sup>15</sup> Findings such as these led Friday and Fireman to conclude "there are no data to support a nasobronchial reflex as a factor in chronic asthma."<sup>16</sup>

Other investigators have arrived at different conclusions. Kaufman and Wright in 1969 instilled silica particles into the noses of ten nonatopic subjects with significant increase in airway resistance.<sup>17</sup> Atropine obliterated this effect. They also showed that electrical current applied to cranial nerve V resulted in bradycardia and apnea, an effect again obliterated by atropine.<sup>17</sup> Togawa and Ogura in a 1966 study of 121 subjects without asthma or allergies found decreased lung compliance and increased pulmonary resistance with increasing nasal obstruction related primarily to septal deviations.<sup>9</sup> In animals and man, occlusion of one nostril has been shown to cause a relative decrease in ventilation of the ipsilateral lung; while in rabbits, chronic unilateral nasal obstruction causes a thoracic deformity with reduced volume in the ipsilateral thorax, implying laterality of the reflex.<sup>18</sup> Yan and Salome in 1983 reported that in patients with active rhinitis who were challenged with intranasal histamine, one-half showed a decreased FEV<sub>1</sub>, suggesting that a certain threshold of nasal disease severity may be necessary to provoke a reflex.<sup>19</sup>

Anecdotal evidence for such a reflex also exists. George Joseph Smith and his "brides in the bath" is a famous forensics case wherein Mr. Smith allegedly lured three successive wives into a bathtub, and, placing one arm behind the knees, immersed the head with the other. This resulted in a rush of water into the nose, triggering a massive sinonasal cardiopulmonary reflex and death.<sup>20</sup> Sudden reflex cardiac arrest from water entering into the upper respiratory tract is a recognized cause of death by forensics experts. "Sudden sniffing death" is a similar example where sudden death occurs from sniffing certain irritants such as airplane glue, solvents, etc for the "high" produced.<sup>21</sup>

Other studies have suggested that the sinonasal bronchial reflex, if it exists, may not be mediated by the autonomic nervous system but through other mechanisms. Harlen, et al pointed to the eosinophil, noting histopathologic similarities between paranasal respiratory epithelium and bronchial epithelium in asthmatic patients, including the degree of infiltration with eosinophils.<sup>22</sup> Inflammatory mediators such as leukotrienes, prostaglandin D<sub>2</sub>, and histamine have also been implicated by either a systemic effect resulting from irritation of sinonasal mucosa; by a local effect, stimulating irritant receptors in the nose or sinuses and setting off a reflex arc<sup>23</sup>; or by microaspiration, particularly during sleep.<sup>24</sup>

While the arguments continue to rage regarding the existence of a sinonasal bronchial reflex and the particular mechanism involved, one thing appears consistently throughout the literature: appropriate and effective treatment of sinusitis in most patients can result in improvement or stabilization of a patient's lower airway disease. This has been previously well described using medical and traditional surgical procedures such as intranasal sphenoidectomy and Caldwell-Luc,<sup>6,25</sup> and more recently utilizing newer techniques of functional endoscopic sinus surgery.<sup>26,27</sup> Similar find-

ings have been noted in children as well as adults.<sup>28,29</sup>

There is however, clearly a group of patients where treatment of sinusitis does not result in the improvement one would hope; where a presumed sinonasal bronchial reflex arc doesn't seem to exist. It is this same group of patients who continue to experience problems with recurrent and chronic sinus infections as well as asthma despite excellent and appropriate medical/surgical therapy. With respect to this group of patients, F. W. Davison in 1966 coined the term "mucosal misbehavior,"<sup>30</sup> while we have resurrected the term "reactive airways disease," commonly found in textbooks throughout the 1930s to the 1960s to describe the upper and lower airways responding pathologically as one unit.<sup>31</sup> The term refers to a systemic respiratory mucosal disease; mucosa in the lower airways and in the upper airways responding in a hyperreactive manner to the slightest environmental stimulus, whether allergen or not. These patients may be particularly difficult to manage for the allergist, pulmonologist, and the otorhinolaryngologist. It is likely that genetic predisposition will prove to be a significant factor in the pathophysiology of patients with this problem.

#### DIAGNOSIS OF SINUSITIS IN THE ASTHMATIC PATIENT

Sinusitis refers to any inflammatory condition occurring in the paranasal sinuses. Acute sinusitis, defined as symptomatic inflammation of the paranasal sinuses lasting no longer than 6 to 8 weeks and occurring fewer than four times a year is usually readily diagnosed in the asthmatic patient with new complaints of facial pain, tenderness, fever, and discolored nasal drainage. More challenging to diagnose is the patient with chronic sinusitis whose symptoms may be more vague and subtle, persisting more than 8 weeks at a time and four or more times a year.<sup>33</sup> Because of the clear importance of excellent management of chronic sinusitis in the asthmatic patient, accurate, sensitive diagnosis is

key. In the past, physicians relied on only crude instrumentation with nasal speculum examinations and plain sinus radiographs alone, leading, undoubtedly, to missed cases of disease. Over the last 10 years, we have seen a "rhinology revolution" leading to greater technical sophistication and greater understanding of chronic sinusitis as a disease in and of itself, so that sensitivity from a good history and physical examination, including nasal endoscopy, is high and missed diagnoses unlikely. Combined with CT scanning of the paranasal sinuses, virtually all cases can be appropriately identified and treated.

Key to this revolution has been the development and utilization of the rigid nasal endoscope (Fig 1). Originally developed from a modified cystoscope in 1902 by Hirschmann and Valentin, these physicians, followed a year later by Reichert, were able to introduce the scope directly into the maxillary sinus.<sup>26</sup> Hirschmann followed this work with the first surgical procedure performed on the ethmoid sinuses using the endoscope in 1904.<sup>26</sup> Despite this, acceptance of nasal endoscopy was slow to come. New endoscopes developed by Professor H. H. Hopkins in 1951 to 1956 with improved resolution, large field of vision, and accurate color, led to a renewal of interest in endoscopy of the upper airways in the 1970s.<sup>26</sup> The work

of Messerklinger in the 1960s and 1970s and subsequently Stammberger in Austria and Kennedy in the United States has led now to a systematic approach using the endoscope for diagnosis of disease of the lateral wall of the nose.<sup>26,34</sup> Indeed, use of the rigid intranasal endoscope has identified nasal pathology in almost 40% of patients deemed normal using traditional rhinologic examination.<sup>35</sup>

The technique that has been developed to examine the lateral wall of the nose involves effectively three passes of the endoscope in the decongested and anesthetized nasal cavity.<sup>34</sup> A 4-mm 30-degree scope has been found to provide the most useful view and the greatest information in the average patient, though narrower diameter 2.7 mm scopes are available for narrower noses and different angled scopes for unique situations. In all passes, the examiner is noting the appearance of the mucosa. One looks at the color: is it pale or hyperemic? Is it edematous or hypertrophic? Are there polyps or pus present? One looks at quantity and the quality of the mucus present. Is it clear or opaque? Thick or thin? Discolored as in active infection or tenacious as in allergic fungal disease? And finally, one looks at the structures for contributing anatomic abnormality such as turbinate septal contact, massive concha bullosa, or medially rotated uncinate or evidence of past, as with acces-



Figure 1. Rigid intranasal endoscopes providing visualization at 0, 30, and 70 degree angles. Karl Storz Endoscopy-America, Culver City, CA. Reprinted with permission.

sory maxillary ostia, or present infections. If pus is seen in the middle meatus, cultures can be obtained using a "micro" cotton-tip applicator and antibiotics chosen based on organism and sensitivity (Fig 2).

Specifically, diagnostic nasal endoscopy is performed in three passes on each side of the sinonasal cavity.<sup>34,36,37</sup> The first pass of the scope is along the nasal floor and into the nasopharynx allowing for careful examination of the inferior meatus and turbinate. Mucus trailing into the nasopharynx is followed for evidence of origin in the sphenoid or posterior ethmoids, if coursing over the torus tubarius, or from the middle meatal structures, if coursing below the torus. A second pass is made between the middle and inferior turbinates, examining the inferior portion of the middle meatus, and the fontanels for evidence of bulging or accessory maxillary ostia. This pass then continues by rolling the scope medially into the sphenoethmoidal recess located medial to the middle and superior turbinates where the slit-like or

oval sphenoid sinus ostium can be examined. Finally, the third pass is made as the scope is withdrawn. Now the structures of the middle meatus can be examined with greater detail by rolling the scope laterally examining the infundibulum, uncinate and the ethmoid bulla.

Accompanying this revolution in our ability to visualize the sinuses clinically has come new ability to visualize the sinuses radiographically. While traditional roentgenograms of the sinuses can provide valuable information in certain situations with reasonable detail of the frontal and maxillary sinuses in particular, the sinus computed tomographic scan as pioneered by Zinreich,<sup>34</sup> now provides us with unprecedented detail of the soft tissue and bony anatomy of the paranasal sinuses (Fig 3). The information it provides is particularly important when dealing with patients with chronic sinusitis, especially when considering surgical intervention. Maximum information is gained from images obtained in the coronal orientation in 3-mm in-

crements printed with a "bony" window. Such information has also led to a greater understanding of the importance of the "ostioameatal complex," that common drainage pathway for the maxillary, frontal, and anterior ethmoid sinuses.

With new understanding of nasal anatomy and physiology obtained with the endoscope and the CT scanner has come also newer understanding of how the patient is affected with sinusitis. This allows us to probe more completely historically for subtle symptoms of sinusitis not previously appreciated. In the past, we looked only for pain, congestion, fever, drainage. We now know to ask regarding alterations in the sense of smell, cough, fatigue, and otologic symptoms such as ear clicking, fullness, and hearing loss. Such questions allow us to historically precisely identify the patient with sinusitis and avoid the "shotgun" approach advocated by some, simply because the patients asthma is difficult to control.

#### MANAGEMENT OF THE ASTHMATIC WITH SINUSITIS

Sinus health in any patient depends on mucous secretion of normal viscosity, volume, and composition; normal mucociliary flow to prevent mucous stasis and subsequent infection; and open sinus ostia to allow adequate drainage and aeration. While defect of any of these elements can result in acute, recurrent acute, or chronic sinusitis, **ostial blockage is key in the cycle for the vast majority of sinusitis in asthmatic patients and nonasthmatic patients alike.** With ostial obstruction comes decreased aeration of the sinus with a stagnation and thickening of mucus and rapid secondary bacterial infection. Bacterial infection then accelerates the process leading to further local inflammation with damage occurring to lining respiratory epithelium and increasing tissue edema and worsening ostial obstruction. Key to breaking this cycle is relief of ostial obstruction by reduction of tissue edema and inflammation and control of superinfection thereby reducing mucous stagnation



Figure 2. Endoscopic photograph illustrating mucosal congestion of the middle turbinate (MT) obstructing the middle meatus with pus (arrows) seen in the middle meatus in acute sinusitis. LNW = Lateral nasal wall. From Cummings CW, et al, ed. Otolaryngology-head and neck surgery, update 1. St. Louis: CV Mosby Company. Reprinted with permission.



Figure 3. Coronal CT image at the level of the uncinate process illustrating soft tissue thickening in the region of the ostiomeatal complexes bilaterally (white arrows). Slight soft tissue thickening is seen in the left maxillary sinus floor (black arrowheads).

and allowing sinus aeration and damaged, inflamed mucosa to regenerate.

The key to relief of ostial obstruction is medical therapy, while the key to medical therapy is accurate choice and duration of antibiotics. This ideally includes culture-directed antibiotics or empiric-directed antibiotics if no cultures are possible. Table 1 provides a list of the most common organisms seen in acute sinusitis as identified by sinus aspirates on 339 patients over 15 years by Gwaltney et al.<sup>38</sup> *S. pneumoniae* and *H. influenzae* together account for 76% of positive cultures. In the past, these organisms were most amenable to amoxicillin, however with *H. influenzae* resistance seen now between 20% and 52%<sup>39,40</sup> and increasing

*S. pneumoniae* resistance to penicillin, other choices become more important. Guidelines from the International Conference on Sinus Disease: Terminology, Staging and Therapy<sup>40</sup> in the adult with acute and recurrent acute sinusitis are: trimethoprim-sulfamethoxazole DS (bid), loracarbef (400 mg bid),

amoxicillin/clavulanate potassium (500/125 mg tid), and cefuroxime axetil (250 mg bid). Duration of therapy is controversial. A 10-day course has been shown to eradicate pathogens by puncture studies in 95% of patients,<sup>33</sup> while some advocate 14 days or longer in order to alter the sinusitis cycle sufficiently to prevent recurrence, though acknowledging the risk of increased antibiotic resistance.<sup>40,41</sup>

While controlling infection in the asthmatic patient with sinusitis is paramount to recovery, oral and topical decongestants with their alpha-agonist effect and mucocervicants, which thin secretions, are beneficial to many with acute sinusitis for the symptomatic improvement they provide. It is unclear whether they exhibit a beneficial effect in speeding relief from infection or prevention of future infections. Topical agents such as phenylephrine 0.5% or oxymetazoline 0.05% must always be used with caution because of the rebound vasodilation and congestion occurring after use and potential for rhinitis medicamentosa with prolonged use. Tolerance to oral decongestants such as phenylpropanolamine and pseudoephedrine does not occur, so these are safe for long-term use. Combination medications of the mucocervicant guaifenesin with a decongestant are readily available and useful.

More problematic for most with asthma will be the issue of chronic sinusitis. The key here again, as in acute disease, is appropriate selection of antibiotic therapy. The bacteriology of chronic sinusitis is less well defined and only now beginning to be understood. In the past, the importance of anaerobic bacteria such as *Peptostreptococci* and *Veillonella* species, as well

Table 1. Predominant Pathogens in Acute Maxillary Sinusitis<sup>38</sup>

| Bacterial Species               | Positive Cultures No. (%) |
|---------------------------------|---------------------------|
| <i>Streptococcus pneumoniae</i> | 52 (41)                   |
| <i>Haemophilus influenzae</i>   | 79 (35)                   |
| Anaerobes                       | 16 (7)                    |
| Streptococcal species           | 16 (7)                    |
| <i>Moraxella catarrhalis</i>    | 8 (3.5)                   |
| <i>Staphylococcus aureus</i>    | 7 (3.0)                   |
| Other                           | 3 (3.5)                   |

as *Staphylococcus* species has been emphasized.<sup>42</sup> More recently the clear importance of gram negative enteric organisms, specifically *Pseudomonadaceae* and *Enterobacteriaceae* families in this disease is beginning to be underscored. In a 1994 study, Bolger, utilizing endoscopically guided culture techniques in patients with chronic sinusitis, found 21/71 (29.6%) dominant clinical isolates to be gram negative enteric bacteria, confirming unpublished data of other rhinologists using similar techniques (Table 2).<sup>42</sup> The obvious importance of such data is a need to adjust antibiotic therapy in empiric treatment, and ideally to obtain endoscopically guided cultures in these patients. Therapy duration needs to be long, at least 21 days to eradicate the organisms thoroughly.

While in the past, practitioners generally frowned upon direct culture of secretions from the nose of a patient with sinusitis, use of the endoscope and microtip cotton applicator reduces the amount of contamination from the nasal vestibule and allows for direct culture of mucopurulent secretions at their source in the sinus ostia, or in the case of a previously operated patient, within the sinus itself.<sup>42</sup> While microbiologic comparison studies between antral puncture and endoscopically guided cultures are lacking, endoscopic approaches clearly offer several benefits. First, they allow the obtaining of cultures from any sinus, not just the maxillary as with antral puncture. Second, they allow the physician to simultaneously perform a direct and detailed

examination of the status of the sinonasal mucosa at the time and in the location the culture is obtained. Finally, endoscopic techniques offer the most direct approach to culture of the sinuses without the morbidity associated with canine fossa or inferior meatus antral puncture.

In the patient with allergy as well as asthma and sinusitis, adequate management of the allergies may assist with control of sinus mucosal inflammation. Agents such as antihistamines and mast cell stabilizers and, possibly, immunotherapy may all be beneficial in the patient with sinusitis as in the patient with rhinitis. Proper patient selection is essential as use of antihistamines results in drying of the mucosal membranes and thickening of mucus with theoretical worsening of mucous stasis.

Critical in the overall long-term control of mucosal inflammation in the asthmatic patient with chronic sinusitis is the use of topical intranasal steroids.<sup>32</sup> These agents result in reduced tissue edema and congestion and reduced tissue hyperreactivity locally in the nose and paranasal sinuses. Several agents have the added advantage of providing this significant local anti-inflammatory effect while having minimal systemic effect and, therefore, minimal side effects secondary to very low level of absorption. Such agents include beclomethasone dipropionate, flunisolide, fluticasone propionate, and triamcinolone acetonide. Maximum benefit usually takes several days to achieve. These agents, in general, are reserved for the patient with chronic sinusitis; however, the asthmatic patient with acute sinusitis may experience some benefit.<sup>33</sup>

Oral steroids with their extremely potent antiinflammatory effect and ability to stabilize mucosal hyperreactivity are extremely useful in the medication armamentarium for the asthmatic patient with chronic sinusitis but occasionally also with acute sinusitis.<sup>33</sup> Their benefit is 2-fold: stabilize the inflammatory response in the nose as well as the similar response occurring in the lungs either as a result of reflex

or overall "reactive airway disease." Their benefit is even greater in those patients with associated nasal polypsis such as with Samter's triad. The disadvantage is the not uncommon side effects associated with their use. Insomnia, mood swings, gastritis, and rare reports of rapid hip osteonecrosis can occur even with short courses, while prolonged steroid use can result in bone thinning, cataracts, and in extreme cases, Cushing's syndrome. Most asthmatic patients can be successfully managed with intermittent courses of steroids in a rapid taper, thereby avoiding the risks associated with long-term usage. Some, however, will require chronic use for reasonable benefit. While most patients and physicians would agree with Davison when he noted in 1969 that "steroid dependence is a pair of dirty words in the minds of many,"<sup>43</sup> physicians and patients must both fully understand the potential risks and true benefits of these medications and utilize them if necessary in light of this.

Surgical intervention for the asthmatic patient with sinusitis is reserved only for those in whom attempts at appropriate medical therapy including culture-directed antibiotics, decongestants/mucolytics, topical nasal steroid sprays, and tapers of oral steroids fail to clear sinus disease. These patients provide a daunting challenge for the otorhinolaryngologist, both as a consequence of the disease being treated and as a result of the patient's expectations. Patients with asthma and sinusitis need to understand that their diseases are medical diseases that require medications chronically to manage them. Surgery assists the patient to live more comfortably with their disease, but in most cases does not eliminate the disease entirely. Patients will still require chronic medications for their asthma and sinus disease, and will still experience intermittent flares of their sinusitis and their asthma. Indeed, during the immediate peri-operative period, patients will probably require a short course of steroids, or, if steroid-dependent, a boost in steroid dosage.<sup>37</sup> The goal of surgery is to reduce the medi-

Table 2. Predominant Pathogens in Chronic Sinusitis<sup>42</sup>

| Bacterial Species                | Positive Cultures No. (%) |
|----------------------------------|---------------------------|
| Enteric gram negatives           | 21 (29.6)                 |
| <i>Staphylococcus coag. neg.</i> | 15 (21)                   |
| <i>Staphylococcus aureus</i>     | 12 (17)                   |
| <i>Streptococcus pneumoniae</i>  | 4 (6)                     |
| <i>Haemophilus influenzae</i>    | 3 (4)                     |
| <i>Klebsiella pneumoniae</i>     | 3 (4)                     |
| <i>Enterococcus</i>              | 2 (3)                     |
| Other                            | 6 (8)                     |

cation need of the patient, possibly turning the steroid-dependent patient into a steroid independent patient, and to reduce the number of exacerbations of asthma so frequently occurring together with exacerbations of sinus disease.

Over the years, it has become apparent that such goals are reasonably attained. Older surgical techniques such as intranasal sphenoethmoidectomy, external sphenoethmoidectomy, and Caldwell-Luc have all been shown to reduce medication need and steroid dependence as well as episodes of exacerbation of both asthma and the sinusitis. Rackemann and Tobey in 1929<sup>44</sup> and subsequently Weille in 1933<sup>45</sup> provided early reports of such improvement in the modern literature. Slavin reported in 1982 that 28 of 29 experienced such improvement,<sup>25</sup> while Mings, et al<sup>31</sup> found that 65% of patients remained improved at 2 years following surgery and 85% of those remained improved at 5 years following surgery. Juntunen in 1984 reported a "dramatic improvement" in asthma with followup of 3 to 12 years in 15 children undergoing Caldwell-Luc.<sup>46</sup> English reported in 1986 on 205 steroid-dependent asthmatic patients of whom 40% discontinued steroids completely following intranasal polypectomy.<sup>47</sup>

While endoscopes and CT scans have clearly aided us in our ability to diagnose sinusitis, use of these instruments also has provided new understanding of disease of the paranasal sinuses resulting in dramatically new surgical approaches superseding older concepts and surgical techniques. A key example is how our concept of the epicenter of sinus disease has changed. In the past, the largest and most accessible of the sinuses, the maxillary sinus, was viewed as the major focus for disease throughout the sinuses. We now know the major focus resides in the common drainage area for most of the sinuses, the "ostiomeatal complex" (Fig 4).<sup>34</sup> This term refers collectively to various middle meatal structures including the uncinate process, ethmoid infundibulum, anterior ethmoid cells,

and ostia of the maxillary, anterior ethmoid, and frontal sinuses. Even seemingly minor changes in this area can result in further inflammatory changes occurring throughout the sinuses. So it is from here that disease spreads to the posterior ethmoids and to the maxillary and subsequently to the sphenoid and above to the frontal sinuses. Recent data have confirmed this pattern in children (R Lusk, unpublished communication). Such knowledge has now led to a shift from operations stressing the maxillary sinus such as Caldwell-Luc and nasoastral windows to procedures performed primarily on the anterior ethmoids and secondarily on adjacent sinuses. Using the endoscopes for visualization in these surgeries, this technique has been termed "functional endoscopic sinus surgery."<sup>34</sup>

Using knowledge based on Messerklinger's work in Austria in the 1960s, endoscopic sinus surgeons understand that mucociliary clearance within the

sinuses occurs with the beating of the cilia of the epithelium always toward the natural openings (Fig 5). This does not change despite surgery having been performed on the sinuses, so that older concepts of creating gravity-dependent drainage ports have given way to enlarging the natural openings. For example, inferior meatal windows or "nasoastral windows" have now been largely abandoned (except in unusual cases such as dysmotile cilia syndrome where gravity drainage remains important) in favor of middle meatal windows with enlargement of the natural ostium of the antrum. Windows placed in locations that do not encompass the natural opening into the maxillary sinus may enhance the risk of chronic infection via the "recirculation" phenomenon (Fig 6). Mucus, still being driven toward the natural opening of the antrum, once out of the sinus, cascades down the lateral wall of the nose only to become caught-up in the mal-

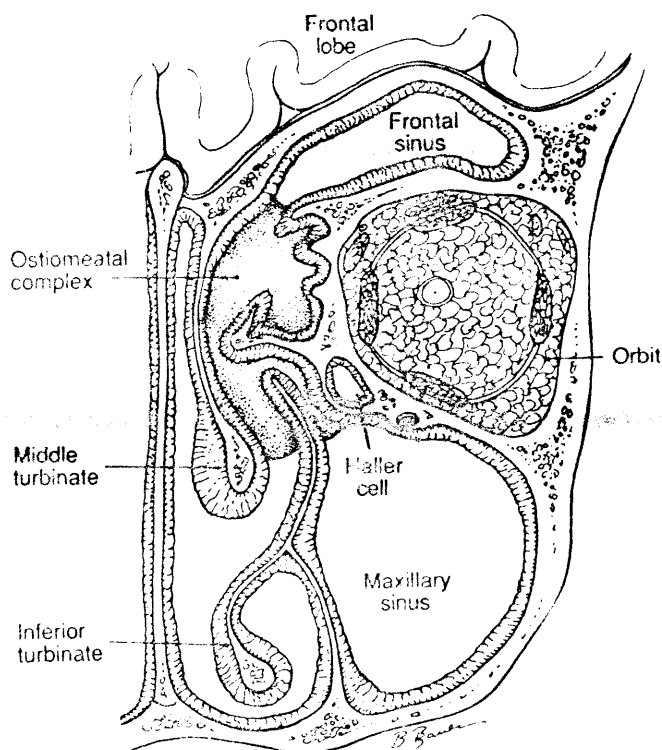


Figure 4. Coronal illustration of the left ostiomeatal complex and adjacent structures. From Kennedy, DW. Concepts of acute sinusitis. Medical Grand Rounds November, 1989, Volume XVI, Program 2. Baltimore: Johns Hopkins University Division of Continuing Medical Education. Reprinted with permission.

positioned surgical opening where it reenters the antrum and the cycle is established. Mucus in this recirculating pattern cannot be moved into the nasopharynx in the usual fashion and so is effectively stagnant, leading to chronic infection.

While our knowledge of ciliary motility patterns has improved our surgical techniques, so, too, has this knowledge increased our respect for the mucosa being operated upon. Traditionally, otorhinolaryngologists believed that chronic infection of the sinuses resulted in irreversible damage to the mucosal lining of the sinuses. This led to procedures such as the Caldwell-Luc being performed, requiring radical stripping of inflamed mucosa out of the sinus. It is now beginning to be understood that procedures such as this result in significant post-operative scarring and poor, slow regeneration of the mucosa with disordered mucociliary flow. New techniques have developed that emphasize the importance of mucosal preservation and the potential reversibility of the diseased mucosa when relief of obstructed sinus ostia is provided. Accompanying these new techniques, new instruments have been developed that allow the operator to cut the mucosa sharply, thereby minimizing mucosal tearing and stripping commonly seen with older instruments.

The results of functional endoscopic sinus surgery on the asthmatic patient are just starting to become known. Initial reports indicate success rates equivalent to the older procedures, with expectation that long-term results will surpass those previously seen. Stammberger reported on 54 patients with asthma and sinusitis who underwent functional endoscopic sinus surgery with slight to marked subjective improvement in 83%, results confirmed by pulmonary function tests.<sup>26</sup> Nishioka et al reported on 20 patients of whom 16 (80%) had marked improvement in asthma including an 81% decrease in emergency room visits for asthma in the first year following surgery.<sup>27</sup>

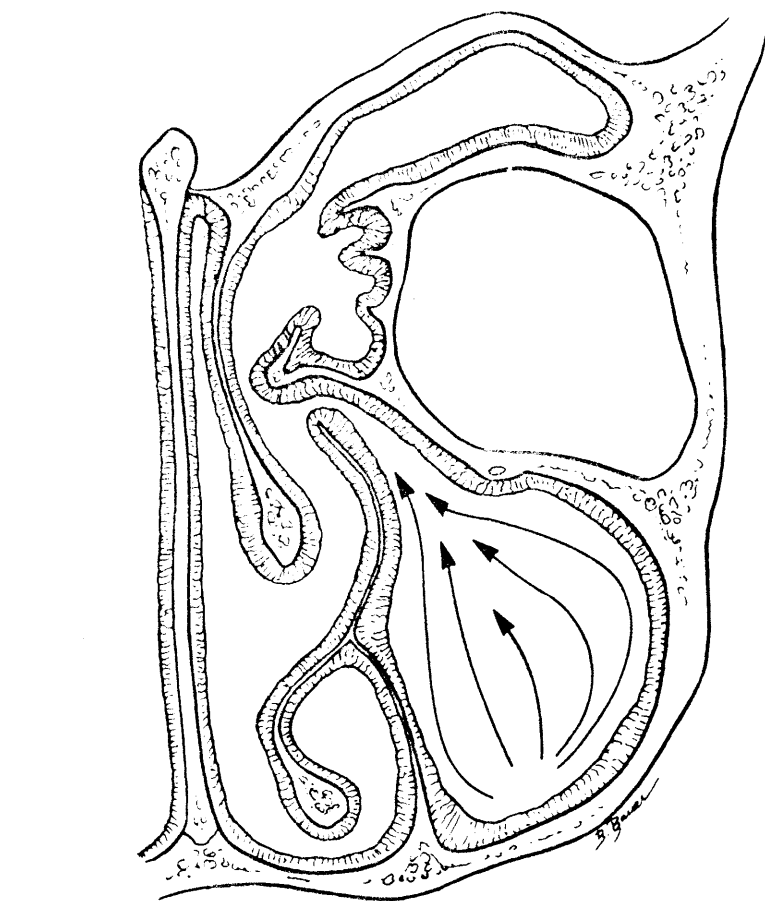


Figure 5. Mucociliary clearance in the left maxillary sinus occurring toward the natural ostium (arrows). From Cummings, CW, et al, ed. *Otolaryngology—head and neck surgery*, update I. 1989. CV Mosby Company, St. Louis. Reprinted with permission.

Unpublished data from Kennedy et al identified 118 patients with chronic sinusitis of whom 42 (36%) had asthma and underwent endoscopic sinus surgery. With an average follow-up of 12 months, 36/42 (86%) were improved overall while three were unchanged and 3 were worse. Asthmatic symptom scores improved significantly. Of 24 patients on oral steroids, 19 decreased their dosages, three maintained the same dose, and two increased their dosage (unpublished communication. D. W. Kennedy, D. C. Lanza, M. Hassab). In a second series of 36 patients with asthma and sinusitis who underwent endoscopic sinus surgery, 26 patients were followed for an average of 18 months. In this group, 21/26 (81%)

showed subjective improved with respect to asthma while 3/26 (12%) were unchanged (unpublished communication, D. W. Kennedy, D. C. Lanza, and M. Hassab).

## CONCLUSION

Asthma and sinusitis are inexorably linked in a yet to be clarified sinonasal bronchial reflex in some and in an overall reactive airway "mucosal misbehavior" disease in others. What is clear however, is that accurate and appropriate diagnosis of chronic sinusitis in the asthmatic patient followed by effective treatment will improve both the patient's sinus condition and the asthma in approximately 70% to 80%. Advances in the field of rhinology over the last 20 years leading to routine use



Figure 6. Endoscopic photograph of the left middle meatus illustrating recirculation of pus (small white arrows) between an accessory opening into the maxillary sinus (A) and the natural opening (N) of the sinus. Scarring is seen between the middle turbinate and the septum from previous surgery. MT = left middle turbinate.

of the endoscope and CT scan now allow for a high degree of accuracy in diagnosis of sinusitis. Similar advances have led to new surgical techniques with hope for better long-term improvement in both diseases. Key to all patients will be excellent medical care requiring utilization of appropriate antibiotic therapy guided by cultures and with awareness of the emerging importance of gram negative organisms in chronic sinusitis now being identified. Topical nasal steroids with their high level of safety and efficacy are also cornerstone to therapy. While oral steroids, realizing their potential risks, will also be utilized. With excellent medical and surgical management, one can expect decreased medication need, decreased occurrences of emergency room visits and hospitalizations, and, therefore, decreased overall cost to the healthcare system.

## REFERENCES

1. Benson V, Marano MA. National Center for Health Statistics. Current estimates for the National Health Interview Survey-1993. Vital and health statistics. 10(190). Washington, DC: Government Printing Office, 1995.
2. Weiss KB, Gergen PH, Hodgson TA. An economic evaluation of asthma in the United States. *N Engl J Med* 1992; 326:862-6.
3. Gliklich R, Metson R. Asthma and sinusitis as comorbidities on SF-36 testing. *Otolaryngol Head Neck Surg* 1995;113:104-9.
4. Slavin RG. Sinopulmonary relationships. *Am J Otolaryngol* 1994;15: 18-25.
5. Rachelefsky GS, Goldberg M, Katz RM, et al. Sinus disease in children with respiratory allergy. *J Allergy Clin Immunol* 1978;61:310-4.
6. Slavin RG, Cannon RE, Friedman WH, et al. Sinusitis and bronchial asthma. *J Allergy Clin Immunol* 1980; 66:250-7.
7. McFadden ER. Nasal-sinus-pulmonary reflexes and bronchial asthma. *J Allergy Clin Immunol* 1986;78:1-3.
8. Schneider KV. Liber primus de catarrhis. Wittenberg, 1660, as cited in McFadden ER. Nasal-sinus-pulmonary reflexes and bronchial asthma. *J Allergy Clin Immunol* 1986;78:1-3.
9. Togawa K, Ogura JH. Physiologic relationships between nasal breathing and pulmonary function. *Laryngoscope* 1966;76:30-63.
10. Dixon WE, Brodie TG. The bronchial muscles, their innervation and the action of drugs upon them. *J Physiol (Lond)* 1903;29:93-7.
11. Slavin RG. Asthma and sinusitis. *J Allergy Clin Immunol* 1992;90:534-7.
12. Sluder G. Asthma as a nasal reflex. *JAMA* 1919;73:589-91.
13. Hoehne JH, Reed CE. Where is the allergic reaction in ragweed asthma? *J Allergy Clin Immunol* 1971;48:36-9.
14. Rosenberg GL, Rosenthal RR, Norman RS. Inhalational challenge with ragweed pollen and ragweed-sensitive asthmatics. *J Allergy Clin Immunol* 1983;71:302-10.
15. Schumacher MJ, Cota KA, Taussig LM. Pulmonary response to nasal-challenge testing of atopic subjects with stable asthma. *J Allergy Clin Immunol* 1986;78:30-5.
16. Friday GA, Fireman P. Sinusitis and asthma: clinical and pathogenetic relationships. *Clin Chest Med* 1988;9: 557-65.
17. Kaufman J, Wright GW. The effect of nasal and nasopharyngeal irritation on airway resistance in man. *Am Rev Respir Dis* 1969;100:626-30.
18. Drettner B. Pathophysiological relationship between the upper and lower airways. *Ann Otolaryngol* 1970;79: 499-505.
19. Yan K, Salome C. The response of the airways to nasal stimulation in asthmatics with rhinitis. *Eur J Respir Dis* 1983;128(Suppl):105-9.
20. Patow CA, Kaliner M. Nasal and cardiopulmonary reflexes. *Ear Nose Throat J* 1984;63:22-8.
21. Angell JJE, Daly M. Nasal reflexes. *Proc R Soc Med* 1969;62:1282-93.
22. Harlen SL, Ansel DG, Lane SR, et al. A clinical and pathologic study of chronic sinusitis: the role of the eosinophil. *J Allergy Clin Immunol* 1988; 81:867-75.
23. Stone BD, Georgitis JW, Matthews B. Inflammatory mediators in sinus lavage fluid [Abstract]. *J Allergy Clin*

- Immunol 1990;85:222.
24. Brugman SM, Larsen GL, Henson PM, et al. Increased lower airways responsiveness associated with sinusitis in a rabbit model. *Am Rev Respir Dis* 1993;147:314-20.
  25. Slavin RG. Relationship of nasal disease and sinusitis to bronchial asthma. *Ann Allergy* 1982;49:76-80.
  26. Stammberger H. Functional endoscopic sinus surgery. Philadelphia: BC Decker, 1991.
  27. Nishioka GJ, Cook PR, Davis WE, McKinsey JP. Functional endoscopic sinus surgery in patients with chronic sinusitis and asthma. *Otolaryngol Head Neck Surg* 1994;110:494-500.
  28. Rachelefsky GS, Katz RM, Siegel SC. Chronic sinusitis in children with respiratory allergy: the role of antimicrobials. *J Allergy Clin Immunol* 1982;69:382-7.
  29. McFadden EA, Kany RJ, Fink JN, Toohill RJ. Surgery for sinusitis and aspirin triad. *Laryngoscope* 1990;100:1043-6.
  30. Davison FW. Rhino-bronchology. *Laryngoscope* 1966;76:1305-11.
  31. Mings R, Friedman WH, Linford PA, Slavin RG. Five-year follow-up of the effects of bilateral intranasal sphenoidectomy in patients with sinusitis and asthma. *Amer J Rhinol* 1988;2:13-6.
  32. Meltzer EO, Orgel HA, Backhaus JW, et al. Intranasal flunisolide spray as an adjunct to oral antibiotic therapy for sinusitis. *J Allergy Clin Immunol* 1993;92:812-23.
  33. Kennedy DW, ed. Sinus disease: guide to first-line management. Darien, Conn: Health Communications, Inc, 1994.
  34. Kennedy DW, Zinreich SJ, Rosenbaum AE, Johns ME. Functional endoscopic sinus surgery. *Arch Otolaryngol* 1985;111:576-82.
  35. Levine HL. The office diagnosis of nasal and sinus disorders using rigid nasal endoscopy. *Otolaryngol Head Neck Surg* 1990;102:370-3.
  36. Bolger WE, Kennedy DW. Nasal endoscopy in the outpatient clinic. *Otolaryngol Clin N Am* 1992;25(4):791-802.
  37. Lanza DC, Kennedy DW. Current concepts in the surgical management of nasal polyposis. *J Allergy Clin Immunol* 1992;90:543-6.
  38. Gwaltney JM, Scheld WM, Sande MA, Sydnor A. The microbial etiology and antimicrobial therapy of adults with acute community-acquired sinusitis: a fifteen-year experience at the University of Virginia an review of other selected studies. *J Allergy Clin Immunol* 1992;90:457-61.
  39. Senior BA, Radkowski D, Sprecher R, et al. Changing trends in pediatric supraglottitis: a multi-institutional review 1980-1992. *Laryngoscope* 1994;104(11 Pt 1):1314-22.
  40. Kennedy DW. International conference on sinus disease: terminology, staging, therapy. *Ann Otol Rhin Laryngol* 1995;104(10 pt 2 suppl 167):22-30.
  41. Bolger WE, Kennedy DW. Changing concepts in chronic sinusitis. *Hosp Pract Sep* 30, 1992:20-8.
  42. Bolger WE. Gram negative sinusitis: an emerging clinical entity? *Am J Rhinology* 1994;8:279-84.
  43. Davison FW. Chronic sinusitis and infectious asthma. *Arch Otolaryngol* 1969;90:110-5.
  44. Rackemann FM, Tobey HG. Studies in asthma: IV. The nose and throat in asthma. *Arch Otolaryngol* 1929;9:612-6.
  45. Weille FL. Studies in asthma. XVII. The surgical treatment of sinusitis in asthma. *JAMA* 1933;100:241-4.
  46. Juntunen K, Tarkkanen J, Makinen J. Caldwell-Luc operation in the treatment of childhood bronchial asthma. *Laryngoscope* 1984;94:249-51.
  47. English GM. Nasal polypectomy and sinus surgery in patients with asthma and aspirin idiosyncrasy. *Laryngoscope* 1986;96:374-80.

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## CME Examination

No 016-007

Questions 1-20, Senior BA and DW Kennedy 1996;77:6-19.

## CME Test Questions

1. Patients with sinusitis have:
  - A. Less favorable outlook on their general health than patients with angina
  - B. More bodily pain than patients with sciatica
  - C. Poor general health perception
  - D. Diminished social functioning
  - E. All of the above
2. Which of the following regarding the impact of sinusitis is not true?
  - A. Afflicts 15% of the United States population
  - B. Greater impact on patients of higher socioeconomic status
  - C. Both sexes are equally afflicted
  - D. All races are approximately equally affected
  - E. More than additive effect when combined with sinusitis
3. Which of the following regarding asthma and sinusitis together is true?
  - A. About 80% with asthma have rhinitis
  - B. About 25% with perennial rhinitis have asthma
  - C. Nearly all children with asthma have abnormal sinus radiographs
  - D. Surgical treatment of sinusitis adds to the overall costs of management of the asthmatic patient.
  - E. Sinusitis in the asthmatic patient does not significantly effect assessments of functioning at work or daily activities.
4. Theories linking disease in the sinonasal cavity and the lungs include all the following except:
  - A. A reflex mediated via the autonomic nervous system
  - B. A diffuse airway mucosal disease, i.e. "mucosal misbehavior"