Sinusitis, an infection of the paranasal sinuses, has been linked to allergic rhinitis, asthma, and nasal polyps. Sinusitis is a common complication of allergic rhinitis, which can lead to inflammation of the sinus mucosa, obstruction of the sinus opening or ostium, and generally favorable conditions for bacterial growth. Sinusitis can trigger asthma. Stimulated nerves in an infected sinus may result in parasympathetic stimulation to the bronchial tree and in smooth muscle contraction. Sinusitis may be a cause of nasal polyps, which are common when sinusitis complicates allergic rhinitis and even more common in nonallergic rhinitis. Treatment of sinusitis strives to eliminate infection and promote drainage. Ampicillin or amoxicillin is the antibiotic of choice. All patients with sinusitis should be treated with antibiotic to encourage drainage. Fluids, expectorants, and decongestants, both oral and topical, should be used. As many as half of patients with sinusitis also have marked rhinitis (either allergic or nonallergic), nasal polyps, or swollen, edematous mucosa; these patients should also receive topical steroids, such as flunisolide. Flunisolide promotes drainage and aeration by decreasing inflammation, swelling, and the influx of white blood cells. Persistent sinusitis may need to be treated surgically. (J ALLERGY CLIN IMMUNOL 1988;82:950-6.)

Sinusitis, or infection of the paranasal sinuses, is increasingly recognized as a common and subtly presenting disease. It accounts for hundreds of thousands of lost days of work and places a great financial burden on individuals and the national health care system. The U.S. Department of Health and Human Services estimated that in 1981, 31 million people suffered from sinusitis, which is more than suffered from arthritis (27 million) or hypertension (25.5 million). Many patients with sinusitis have experienced the discomfort, fatigue, and lassitude characteristic of the disease.

New evidence points to a link between sinusitis and asthma. This link parallels the better-known connections between sinusitis and other respiratory conditions, notably upper respiratory tract infection and allergic rhinitis. Sinusitis and nasal polyps also appear to be linked. In this article, the nature of sinusitis in adults will be reviewed, and the links between sinusitis and allergic rhinitis, asthma, and nasal polyps will be explored.

STRUCTURE AND FUNCTION OF THE SINUSES AND THE DEVELOPMENT OF SINUSITIS

Fig. 1 shows the paired paranasal sinuses surrounding the nasal cavity. Each sinus drains through an ostium on the side of the nose. The drainage, which removes microorganisms and foreign particles from the sinuses, is continuous under normal conditions because of the constant movement of the mucous layer, which is propelled by the underlying cilia. Various conditions (Table 1) can predispose a person to sinusitis. The most common predisposing factors are upper respiratory tract infections, allergic rhinitis, and rhinitis medicamentosa. However, the common characteristic shared by all the listed conditions is the mechanical obstruction of the sinus ostium. Sinusitis of the maxillary antra is the most common form of the disease, probably because the base of the maxillary sinus is below the floor of the nasal cavity in adults, and its ostium is at the highest point of the sinus (Fig. 2). Therefore, for secretions to leave the maxillary sinus for the nose, ciliary action must move the secretions in a cephalad direction (against gravity) to the ostium, or the antrum must be completely full so that the contents will spill over.

Decreased ciliary movement and increased mucus production as a result of inflammation are common in many of these conditions. The outcome is often the
Sinusitis in adults

edematous obstruction of the sinus ostium, setting the stage for secondary bacterial infection and the conversion of mucus to mucopus. Mucopus further impairs ciliary function and increases the swelling around the ostia during discharge, thus creating a vicious cycle.

In sinusitis, cilia are often lost, but ciliary function remains. Usually, when the ostia reopen, the restored mucociliary function drains the affected sinus and the sinusitis resolves spontaneously. Unless the damage to the mucosa is severe, the number of cilia returns to normal after infection.1

THE DIAGNOSIS OF SINUSITIS

In the history of an adult patient suspected of having acute sinusitis, the most important clue is the continuation of symptoms after a typical cold has subsided. The nasal discharge is no longer clear, becoming yellow or green. Purulent secretions may be seen most often in the middle meatus, the drainage site of the maxillary sinus. Fever may persist and chills may develop. Pain in the forehead may be associated with maxillary sinusitis, and the discomfort may worsen when the patient bends or strains.

Chronic sinusitis is more difficult to diagnose, because pain and systemic symptoms are rare. Nasal obstruction, purulent postnasal drainage, chronic cough, hyposmia, sore throat, and unpleasant breath are the most common signs. Physical examination of the patient with chronic sinusitis will often reveal an edematous nasal mucosa bathed in mucopus.

If the clinical symptoms and signs point to sinusitis, sinus roentgenograms are indicated. The correlation between antral puncture, which can demonstrate infected sinuses, and roentgenographic appearance is good. Fig. 3 shows normal paranasal sinuses (A) and the changes characteristic of true sinusitis, including mucosal thickening ≥6 mm in adults or ≥4 mm in children (B), an air-fluid level (C), or opacification (D).

Sinusitis and Allergic Rhinitis

Sinusitis is a common complication of allergic rhinitis. The allergic process results in nasal mucosal edema that can obstruct the sinus ostium.2 Furthermore, inflammation in the sinus mucosa increases the production of sinus mucus, often impairing the mucociliary apparatus. The combination of ostial obstruction and slowed mucociliary movement provides favorable conditions for bacterial growth and the re-

SINUSITIS AND ASTHMA

A link between sinusitis and asthma was first suggested in the nineteenth century. As far back as 1870, the connection between nasal irritation and bronchoconstriction was demonstrated in animals when irritants applied to their nasal mucous membranes led to bronchoconstriction. The bronchoconstriction could be abolished by resection of the vagus nerve. In the 1920s and 1930s, many studies pointed to sinusitis as the trigger of bronchial asthma. The connection presumed receptors in the nose, nasopharynx, and sinuses that were stimulated to cause bronchoconstriction. Evidence for such a connection in man came in a study performed in 1969, in which the mucosa of the nose and nasopharynx of healthy subjects were exposed to silica particles. Lower airways resistance increased significantly, and the effect was abolished by atropine administration. Thus the evidence seems unequivocal that reflexes originating in the nose and nasopharynx can result in bronchoconstriction and increases in lower airway resistance.

Sultant sinusitis. To avoid such infection, allergic rhinitis should be treated promptly.

Until these latter studies were performed, the work from the 1920s and 1930s had fallen into some disrepute. Sinus changes were thought simply to reflect a disease of the entire respiratory membrane, and the treatment of sinusitis per se would have little effect on the course of lower respiratory tract disease. Now, with the demonstration that treatment of sinusitis improves the asthmatic condition, the link between the two diseases appears well established.

Three possibilities have been suggested to explain how sinusitis could cause bronchial asthma. First, bacterial seeding of the lungs from the sinuses could occur as mucopurulent material drips into the pharynx from an infected sinus and involves the mucous membranes of the trachea and bronchi. This could cause secondary bronchitis, resulting in asthma. Second, sinusitis could enhance the β-adrenergic blockade present in patients with bronchial asthma, resulting in an increase in the hyperirritability in the bronchial tree.

The third theory—reflex bronchospasm acting through the parasympathetic nervous system—is supported by many experimental studies. Afferent nerve fibers from the nose and sinuses form part of the trigeminal nerve. Collaterals from trigeminal fibers
TABLE II. Characteristics of patients with sinus disease and asthma

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Percentage</th>
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<tr>
<td>Sinusitis preceded asthma</td>
<td>&gt;90%</td>
</tr>
<tr>
<td>Two thirds were nonatopic based on history and skin tests</td>
<td></td>
</tr>
<tr>
<td>90% had nasal polyps</td>
<td></td>
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<tr>
<td>&gt;50% were aspirin sensitive</td>
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<tr>
<td>&gt;90% were receiving corticosteroids</td>
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enter the reticular formation, where connections may be made to the dorsal vagal nucleus. This gives rise to efferent parasympathetic fibers to the bronchi. Stimulation from an infected sinus could result in parasympathetic stimulation to the bronchial tree and in smooth muscle contraction.

We have evaluated some 80 adults who have coexisting sinus disease and bronchial asthma (Table II). More than 90% of the patients with sinusitis and asthma said that the sinusitis preceded the asthma. Two thirds of them were nonatopic on the basis of personal and family histories and the lack of immediate skin test reactivity to a battery of inhalant allergens common in St. Louis.

Ninety percent of these patients had nasal polyps, >50% were aspirin sensitive, and >90% were taking oral corticosteroids on a continuous basis. The development of the triad of nasal polyps, asthma, and aspirin sensitivity is sequential. Most of these patients have a history of perennial nonallergic or vasomotor rhinitis with unusually profuse rhinorrhea. Intense nasal congestion follows, often with sinusitis, and then polyps develop. Bronchial asthma then develops, followed, finally, by aspirin sensitivity.

With medical or surgical therapy for sinusitis, 70% of the patients noted subjective improvement in their asthma, finding it better controlled and more easily managed. Sixty-five percent could reduce their intake of oral corticosteroids significantly, and one third of these could eliminate the oral corticosteroids.

SINUSITIS AND NASAL POLYPS

First described more than 3000 years ago, nasal polyps are the most common mass lesions encountered in the nose. Despite this long history and their frequent occurrence, many questions remain unanswered concerning the incidence, pathogenesis, and treatment of nasal polyps. The most common theories put forward to explain their formation are infection and allergy. Because nasal polyps in uncomplicated allergic rhinitis are very uncommon, most allergists today favor infection as the most likely cause. They are more common when sinusitis complicates allergic rhinitis, and are even more common in nonallergic rhinitis.

Nasal polyps seem to be outgrowths of the nasal mucosa, and are typically smooth, gelatinous, semi-translucent, round or pear shaped, and pale (Fig. 4). Most nasal polyps arise from the ethmoid sinuses, which have ostia of only 1 to 2 mm in diameter, making them more susceptible to occlusion by mucosal edema or the growth of polypoid granulation tissue.

Many patients with sinusitis associated with nasal polyps have a long history of symptoms of perennial rhinitis. The age of onset has been found to be between 14 and 81 years. The distribution of polyps between the sexes is fairly even between ages 20 and 70 years, but the overall male predominance is 3 to 1. In one study, all the patients had nasal blockage, 75% had hyposmia, 60% had rhinorrhea, 60% had sneezing, 65% had postnasal drainage, 35% had facial pain, and 25% had itching. Symptoms frequently worsen under the influence of physiologic stimuli, such as temperature changes, fumes, odors, dusts, and chemicals.

Nasal polyps frequently recur. In one study of 200 patients, 115 had recurring nasal polyps. Recurrence is more likely in patients with a long history of polyps; in older patients; in patients who have eczema, asthma, or aspirin sensitivity; and in those who have lost their sense of smell. Although the proportion of patients with sinusitis who have nasal polyps is not large, as many as 65% of patients with nasal polyps also have sinusitis. The polyps interfere with the proper drainage and aeration of the antrum, thus causing chronic sinus infection with the ensuing vicious cycle of infection and nasal polyposis. Furthermore, the constant irritation from the sinus infection may encourage the growth of the polyp by causing the nasal mucosa to duplicate in the form of a polyp.

NASAL POLYPS AND ASTHMA

The association of nasal polyps and asthma is well established. In one large study, 20% of patients with
nasal polyps also had asthma. In the same study, 32% of the patients with asthma had nasal polyps. In another study of 211 patients with nasal polyps, 70% had asthma and 29.4% had allergic rhinitis.

**MEDICAL TREATMENT OF SINUSITIS**

Sinusitis is a form of an abscess, and like an abscess, it should be treated to eliminate the infection and to promote drainage. The treatment of sinusitis in adults differs from that in children, in that medical therapy in children generally suffices and surgery is usually not necessary. The antibiotic of choice is either ampicillin or amoxicillin, because the organisms that cause acute or chronic sinusitis are sensitive to these drugs and adequate mucosal and sinus levels are obtained.2 Trimethoprim-sulfamethoxazole may be used with penicillin-sensitive patients. To ensure eradication of the infection, treatment should last 3 to 4 weeks. If the course of treatment is too short, recurrence is common. Sinusitis can persist, with purulent material in the sinuses that contains high titers of bacteria; the persistence of the disease can only be excluded by obtaining follow-up radiographs.

Along with the antibiotics, all patients with sinusitis should also receive treatment to promote drainage, including fluids, expectorants, and decongestants, both oral and topical. Often as many as half the patients with sinusitis also have marked allergic or non-allergic rhinitis, nasal polyps, or markedly swollen, edematous mucosa; in addition to the other medications, these patients should also receive topical steroids, such as flunisolide or beclomethasone. Topical steroids decrease the inflammatory response, and in so doing reduce swelling and the influx of white blood cells. These actions, in turn, promote drainage and aeration of the sinuses and hasten the elimination of the sinusitis.

**SURGICAL TREATMENT OF SINUSITIS**

When sinusitis is persistent or recurs despite appropriate medical therapy, surgical intervention is probably required. The surgeon must relieve the obstruction of the ostia, resect inflammatory or infected tissue, and provide an airway with drainage for all the nasal or sinus compartments. As seen in Table III, a variety of surgical procedures are used for treating chronic and acute sinusitis.

The intranasal antrostomy, or "nasal antrostomy," is a permanent opening created surgically in the most dependent portion of the inferior meatus. This restores drainage to the maxillary sinus that has an obstructed or congenitally small natural middle meatal ostium. Performed with the patient under local anesthesia, this procedure may produce major benefits.

The Caldwell-Luc operation by a sublabial approach provides excellent exposure of the entire maxillary antrum, including the medial wall of the maxillary sinus. It provides a better opportunity for the removal of diseased tissue and allows entry into the ethmoid sinuses in the transantral ethmoidectomy procedure. The operation includes the performance and maintenance of an intranasal antrostomy for drainage, because the Caldwell-Luc incision is sutured closed when the procedure is finished.

Bilateral intranasal sphenoethmoidectomy may be very beneficial in cases of pansinusitis. The procedure is performed with the patient under local anesthesia to decrease bleeding and improve operative visualization. The middle turbinate is excised after all the polypos are removed. A beaded probe is then inserted into the nose at an angle of 30 degrees from the floor of the nose, and the sphenoid fossa is encountered at about 7 cm from the nostril margin. The posterior ethmoid cells are removed with forceps and a probe tip is placed in the sphenoid orifice. With the probe as a guide, the sphenoid face is removed by the forceps. The posterior and anterior ethmoid cells are then completely removed. The forceps are withdrawn, diseased maxillary tissue is removed, and an intranasal antrostomy is performed. No nasal packing is required unless a submucous resection is necessary. The patient may usually be discharged on the same day.

Transantral ethmoidectomy is helpful for patients with massive maxillary disease, particularly in cases in which the ethmoid labyrinth is poorly developed or in which there is little disease in the ethmoid vaults. A Caldwell-Luc anterior maxillary antrostomy is performed through a sublabial incision. The interior of the maxillary sinus is visualized and most of the anterior wall is taken down. Next, the upper medial wall of the maxillary sinus is approached halfway along the border between the medial and superior walls of the maxillary sinus. The ethmoidal labyrinth is then entered and an orderly exenteration of cells is performed.

Endoscopy is being more widely used than ever before for both the diagnosis and treatment of sinus disease.6,7 Endoscopes have a variety of angles of...
Surgical removal of the nasal polyps, or polypectomy, may be needed if the mechanical obstruction is marked, particularly when associated with sinusitis. Antrochoanal polyps may interfere with respiration and thus require surgical removal. Although a solitary noncancerous nasal polyp may be reversible, the progression of the pathologic process may lead to multiple, obstructive nasal polyps, which are usually associated with concomitant infection in the ethmoid and other sinuses. Once there is radiologic evidence of such multiple polyps, it is rare for the polyps and the sinusitis to resolve without surgery.

The aim of polypectomy is to remove the polyps as completely as possible to improve nasal aeration and to drain the infected sinuses. These actions, along with antibiotic treatment, are designed to eliminate the sinusitis that often accompanies the polyps. To prevent the recurrence of polyps, the sinusitis must be eradicated. Also, preoperative systemic steroids are often given to reduce the recurrence rate of polyps and to prevent serious sequelae, including asthma, a common condition in patients with nasal polyps. Furthermore, topical flunisolide after polypectomy reduces the recurrence of nasal polyps.

CONCLUSION

Sinusitis is a very common and troublesome disease. It is a frequent complication of allergic rhinitis and probably plays a role in the development of asthma and nasal polyps in many patients.

Sinusitis can be effectively diagnosed by careful observation of clinical symptoms and signs and by radiographs that demonstrate mucosal thickening, air-fluid level, or opacification. Treatment for sinusitis strives to eliminate the infection and promote effective drainage of the sinuses. Antibiotics, fluids, expectorants, and decongestants should be used for all patients with sinusitis. Those with more severe cases should also receive topical steroids. Topical steroids, such as flunisolide, are very effective in shrinking nasal polyps, thereby eliminating ostial obstruction, and in shrinking edematous swollen nasal mucosa, facilitating drainage from the sinuses.

REFERENCES


DISCUSSION

Dr. Meltzer: Does freezing or amputation of swollen turbinates cause any positive or negative physiologic changes?
Dr. Naclerio: The answer depends on the cause of the hypertrophy of the turbinates. If it arises secondary to a deviated septum, which is subsequently repaired, these techniques may be effective. They are not effective, however, for allergic rhinitis. Patients with allergic rhinitis who have this operation undergo about a month of nasal sloughing and intense nasal obstruction, followed by about 6 months of improvement. However, the next year the symptoms return as intensely as before.

Dr. Busse: Is the use of corticosteroids during active sinusitis of concern?

Dr. Slavin: There is no contraindication whatsoever to the use of either topical or systemic corticosteroids at the usual doses in patients with sinusitis.

Dr. Busse: When you prescribe a topical corticosteroid, does the half-life of the agent enter into your decision?

Dr. Slavin: It is good to know that topical corticosteroids have quite short half-lives and do not remain for long in the body. Flunisolide has the shortest half-life of any of the topical corticosteroids, only 1.8 hours. Also, flunisolide does not accumulate in the body, nor does it cause adrenal suppression with long-term treatment, as some other corticosteroids do. All these safety features are reassuring.