Diagnosis and Management of Rhinosinusitis

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Rhinosinusitis is inflammation of the nasal passages and contiguous sinuses. Most patients with rhinosinusitis are seen and managed initially by primary care physicians. When rhinosinusitis becomes recurrent or when complications develop, patients are usually referred to an otolaryngologist for more intensive or invasive therapy. Recurrent rhinosinusitis carries significant morbidity, and potential orbital and intracranial complications can be dangerous or even deadly. For these reasons, it is important for all physicians to understand the etiology, clinical course, and danger signs of this disease.

ANATOMY AND EMBRYOLOGY

The paranasal sinuses consist of four independently draining cavities on each side of the face. These cavities are the ethmoid, maxillary, frontal, and sphenoid sinuses.

Ethmoid Sinuses

The ethmoid sinuses are present at birth and continue to enlarge to near adult size by age 12 years.[1] The ethmoid sinuses are separated laterally from the contents of the orbit by a very thin bony layer, termed the *lamina papyracea*.

The basal lamella of the middle turbinate, or concha, divides the ethmoid sinuses into two distinct structures: the anterior and posterior ethmoidal complexes. The anterior ethmoidal complex comprises all cells and clefts that open and drain anteriorly and inferiorly to this lamella. The ethmoidal bulla is the most anteriorly located ethmoidal air cell and is located on the lamina papyracea of the orbit.[2] The posterior ethmoidal complex (**Figures 1** and **2**) comprises those cells and clefts that drain posteriorly and medial to the lamella (or attachment) of the middle turbinate to the base of the skull and medial orbital wall. The patterns of mucociliary transport of secretions and embryologic development differ in these two complexes.[2]

The ostiomeatal complex is a functional unit for drainage consisting of the ethmoidal bulla, uncinate process, infundibulum, hiatus semilunaris, maxillary sinus ostium, and recesses around these structures (Figures 1 and 2). The uncinate process is a ridge-like bony process of the middle meatal wall anterior to the ethmoid bulla.[2] The infundibulum, a funnel-shaped space between the ethmoidal bulla and the uncinate process, ultimately receives drainage from the frontal and maxillary sinuses. The hiatus semilunaris is the crescent-shaped opening between the ethmoidal bulla and the uncinate process through which the infundibulum drains into the middle meatus and subsequently into the nose.

Maxillary Sinuses

The maxillary sinuses develop as an inferolateral outpouching of the infundibulum during the third fetal month. This sinus represents pneumatization of the maxilla, and the sinus is occasionally compartmentalized by septa. The natural ostium of the maxillary sinus is located in the superomedial wall of the sinus and drains into the inferior (maxillary) portion of the infundibulum, exiting through the hiatus semilunaris into the middle meatus. Rapid growth of the maxillary sinuses occurs between birth and age 3 years and then again between ages 7 and 12 years.[1]

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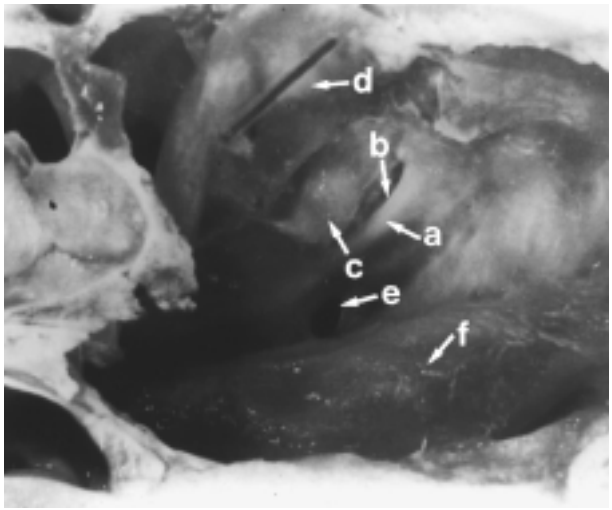

Figure 1. Photograph of the posterior ethmoidal complex. a = uncinate process; b = hiatus semilunaris leading into the infundibulum; c = ethmoid bulla; d = basal lamella of the superomedially displaced middle turbinate; e = accessory ostium of the maxillary sinus; f = inferior turbinate.

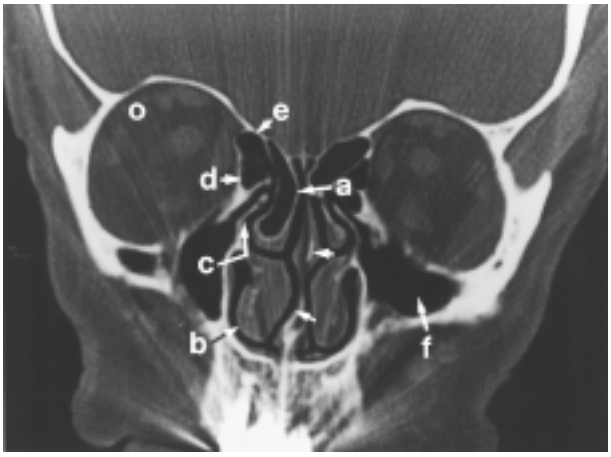

Figure 2. Computed tomography scan of the posterior ethmoidal complex. a = basal lamella of the middle turbinate (the pneumatized middle turbinate or concha bulbosa is evident); b = inferior turbinate; c = uncinate process; d = ethmoid bulla; e = roof of ethmoid sinus or fovea ethmoidalis; f = maxillary sinus; o = orbit; white arrows = nasal septum.

Frontal Sinuses

The frontal sinuses begin to develop in the fourth fetal month as an anterosuperior pneumatization of the frontal bone extending from an air-filled space in the middle meatus, termed the *frontal recess*. The frontal sinuses are indistinguishable from the anterior ethmoid air cells for much of early childhood, and do not reach adult size until age 12 years.

The frontal sinuses are compartmentalized by irregular septa and have irregular bony margins. The absence of these scalloped margins radiographically may be a sign of chronic infection or of bony erosion from an expanding mucocele (inspissated mucus within a blocked sinus cavity). The frontal sinuses drain into the frontal recess through the mucosa-lined nasofrontal ostium. From the frontal recess, secretions may pass directly into the middle meatus or indirectly through the superior aspects of the infundibulum and hiatus semilunaris.[1]

The posterior and inferior walls of the frontal sinus contain a network of valveless veins, which connect with the intracranial and orbital compartments, respectively. Frontal sinusitis may extend into the intracranial or orbital areas via theses routes. Acute frontal sinusitis is the most common etiology of epidural and brain abscess secondary to sinus disease.[1]

Sphenoid Sinuses

The sphenoid sinuses begin as evaginations of the sphenoethmoidal recess at birth. Pneumatization of the sphenoid bone does not begin until age 3 years, and by age 7 years the sphenoid sinus usually extends to the sella turcica. The sphenoid sinus drains through a single ostium into the sphenoethmoidal recess in addition to the posterior ethmoidal air cells.[1]

As the sphenoid sinus pneumatizes the surrounding bone, several structures come to lie as indentations in the lateral wall of the sinus, separated from the air sinus by a thin layer of bone. These structures include the venous cavernous sinus, the carotid artery, and the first, third, fourth, fifth, and sixth cranial nerves. Bone surrounding these structures may be thin or dehiscent. Ophthalmoplegia, visual loss, mental status changes, and other signs of intraorbital or intracranial complications of sinusitis may be the first manifestations of acute sphenoid sinusitis.

PATHOPHYSIOLOGY

The sinuses are lined with stratified or pseudostratified ciliated columnar epithelium that contains mucous and serosanguinous glands. Secretions supply the mucous necessary to warm and humidify inspired air.[1] Cilia move the secretions to the respective sinus ostia and help to clean the nose and sinuses (in addition to coughs and sneezes) of pollutants or other environmental factors that can cause irritation as well as benign or malignant histopathologic changes over time.[3] Obstruction of the ostia can lead to recurrent acute rhinosinusitis or chronic infection. Additionally, because

of the intimate relationship between the sinuses and the orbit and intracranial cavity, infection and inflammation of the sinuses can lead to disabling or even lethal consequences.[1]

Anatomic variations in some or all of the structures of the ostiomeatal complex in combination with coexisting conditions (eg, allergies, immunodeficiency, chronic infection, polyps) can cause mechanical blockage of paranasal sinus drainage, resulting in secondary bacterial infection.[2] Although symptoms of maxillary or frontal sinusitis (ie, pressure over the cheeks or forehead) may predominate clinically, sinus infection usually begins as inflammation and obstruction in the areas of drainage in the ostiomeatal complex.[4] Current theory is that most sinus disease begins in the anterior sinuses (ie, anterior ethmoidal complex, frontal and maxillary sinuses). The posterior ethmoidal cells become involved late in the course of chronic sinusitis and are less significant in the pathophysiology of sinusitis. [2]

Rhinosinusitis may be classified as noninfectious or infectious disease. Noninfectious etiologies include allergies and other environmental factors (eg, pollutants) and physiologic or age-related causes (eg, vasomotor rhinitis, hormonal changes). Infectious rhinosinusitis may becaused by viral, bacterial, fungal, or other infectious agents.[5,6] Physicians must remember that the etiologies of rhinosinusitis are not mutually exclusive. Allergy or environmental pollutants may exacerbate chronic or recurrent acute viral or bacterial rhinosinusitis, and vice versa.[5]

DIAGNOSIS

A diagnosis of rhinosinusitis can be established with a thorough history and confirmed by physical examination. Because treatment for the various causes of rhinosinusitis differs in several respects, it is important to determine the etiology of sinus disease even though the symptomatology may be similar.[5]

Clinical Presentation and Patient History

Table 1 summarizes some of the major differences in presentation between the two most common etiologies of rhinosinusitis, allergic and bacterial. It is not unusual for patients to have both conditions concurrently. The signs and symptoms of all types of rhinosinusitis include nasal congestion (wet feeling or pressure in the nose), obstruction (stuffy nose), fluctuating rhinorrhea, sneezing, headache, and facial pressure (especially upon bending over or laying down).[5] A family or personal history of asthma, hay fever, eczema, or food intolerance may suggest possible allergic rhinosinusitis. A history of recurrent upper or lower respiratory tract infections (ie, pneumonia, rhinosinusitis), other infections (ie, urinary tract infection), or a history of multiple sinus surgeries may be suggestive of an underlying primary immunologic deficiency (IgG subclass deficiency or IgA deficiency). Patients with a history of allergy or immune deficiency are doomed to failure with medical or surgical treatment unless their underlying problem is addressed.

Table 1. Signs and Symptoms of Allergic Versus Bacterial Rhinosinusitis

Sign or Symptom	Allergic	Bacterial
Rhinorrhea/Postnasal drip	Clear*	Purulent
Nasal obstruction	Generalized (bilateral)	Focal or generalized
Significant headache/ Facial pain	Generalized (bilateral)	Focal or generalized†
Cough	Dry/clear	Productive/purulent
Significant sneezing	Yes	No
Nasal and/or eye pruritis	Yes	No
Family or personal history of allergies (ie, asthma, food intolerance, hay fever, eczema)	Yes	No

*Significant eosinophilia may produce discoloration of mucous secretions; nasal smears may be helpful in confirming diagnosis.

†Headaches are less bothersome or nonexistent in patients with chronic rhinosinusitis (especially in patients with nasal polyposis).

Physical Examination

The rhinologic examination begins with a thorough external examination of the face and orbital structures. The clinician should inspect and palpate the bones over the forehead and midface for any tenderness or signs of orbital or facial complications from sinusitis, such as periorbital erythema or edema, abnormal extraocular movements, proptosis, or enophthalmos. The patient should be evaluated for the presence of diplopia or any changes in visual acuity.

In the hands of an experienced clinician, fiberoptic examination of the nose and paranasal sinuses is the most reliable and cost-effective means of evaluating patients in the outpatient setting. However, in the absence of fiberoptic nasopharyngoscopy equipment, the practitioner may use an otoscope to carefully

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examine the anterior one third of the nasal vault, the caudal septum, and the anterior tip of the inferior and middle turbinates. Before and after decongestion with oxymetazoline spray, the nose should be examined for the presence of edema, turbinate hypertrophy, polyps, septal deviation, or purulent discharge emanating between the turbinates and the adjacent septum. At the conclusion of the physical examination, the oral cavity and oropharynx should be inspected for the presence of any ulcerations or defects of the soft or hard palate, tenderness of the upper teeth, or polyps in the oropharynx (ie, antrochoanal polyp).

Differential Diagnosis

The presence of a neoplasm in the paranasal sinuses should be suspected in any patient who has sinus symptoms accompanied by progressive pain and intranasal bleeding. Computed tomographic (CT) scanning of these patients is imperative because prompt referral is indicated if signs of bone erosion are present. Treatment is generally radical surgery involving a partial or complete maxillectomy and postoperative radiation therapy and/or chemotherapy.

Not uncommonly, headaches secondary to migraines, neuralgia, and/or vasculitis are misdiagnosed as rhinosinusitis.[7] Therefore, migraine headaches must be included in the differential diagnosis. Most of these patients have a history of photophobia, phonophobia, and nausea in the presence of a normal rhinologic and/or CT evaluation of the paranasal sinuses. Cluster headaches are a migraine variant that typically has ipsilateral nasal congenstion as part of the symptom complex. Various analgesics are commonly used for treating migraine headaches. The physician should be familiar with the indications for these medications as well as their potential side effects.[8]

COMPLICATIONS

The complications of rhinosinusitis may be intraorbital or intracranial.

Intraorbital Complications

Intraorbital complications are classified into five types based upon their location and degree of penetration within the orbit. These types are: preseptal cellulitis, orbital cellulitis, subperiosteal abscess, orbital abscess (**Figure 3**) and/or cavernous sinus thrombosis. If diagnosis and appropriate treatment are not instituted in a timely manner, progressive lid edema, erythema, chemosis, and proptosis may result and culminate in ophthalmoplegia and blindness. In addition to the hazards of these complications to vision and extraocular movements, the occurrence of these complications creates further potential for intracranial spread.[1]

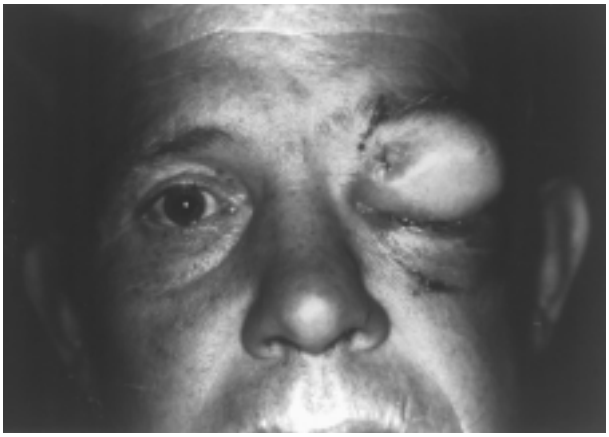

Figure 3. Photograph of a patient with a left orbital abscess.

Intracranial Complications

Intracranial complications include meningitis, epidural abscess, subdural abscess, brain abscess, sagittal sinus thrombosis, and cavernous sinus thrombosis.[1] The differences and subtleties of the various complications are beyond the scope of this article, but any patient with a history of rhinosinusitis who presents with a high fever and increasing headaches (with or without nuchal rigidity) and/or mental status changes should be suspected of having a potential intracranial complication. Immediate CT evaluation and referral to the appropriate specialist (otolaryngologist, neurologist, or neurosurgeon) is essential to minimize the chances for significant morbidity or mortality. [1,6]

TREATMENT

Rhinosinusitis may be classified by the frequency or duration of inflammatory changes into the following categories: acute, subacute, recurrent acute, chronic, and acute exacerbation of chronic rhinosinusitis.[3,6] In addition to understanding the indications for the various approaches to the treatment of rhinosinusitis, it is important for the physician to take an organized, step-by-step approach to the management of each patient with this complicated disease. **Figures 4, 5,** and **6** present algorithms for the diagnosis and management of sinusitis patients. Because most cases of rhinosinusitis in patients who present to the generalist's office are of viral origin, antibiotics should not be given unless purulent rhinorrhea lasts more than 5 days or total nasal symptoms last more than 10 days.

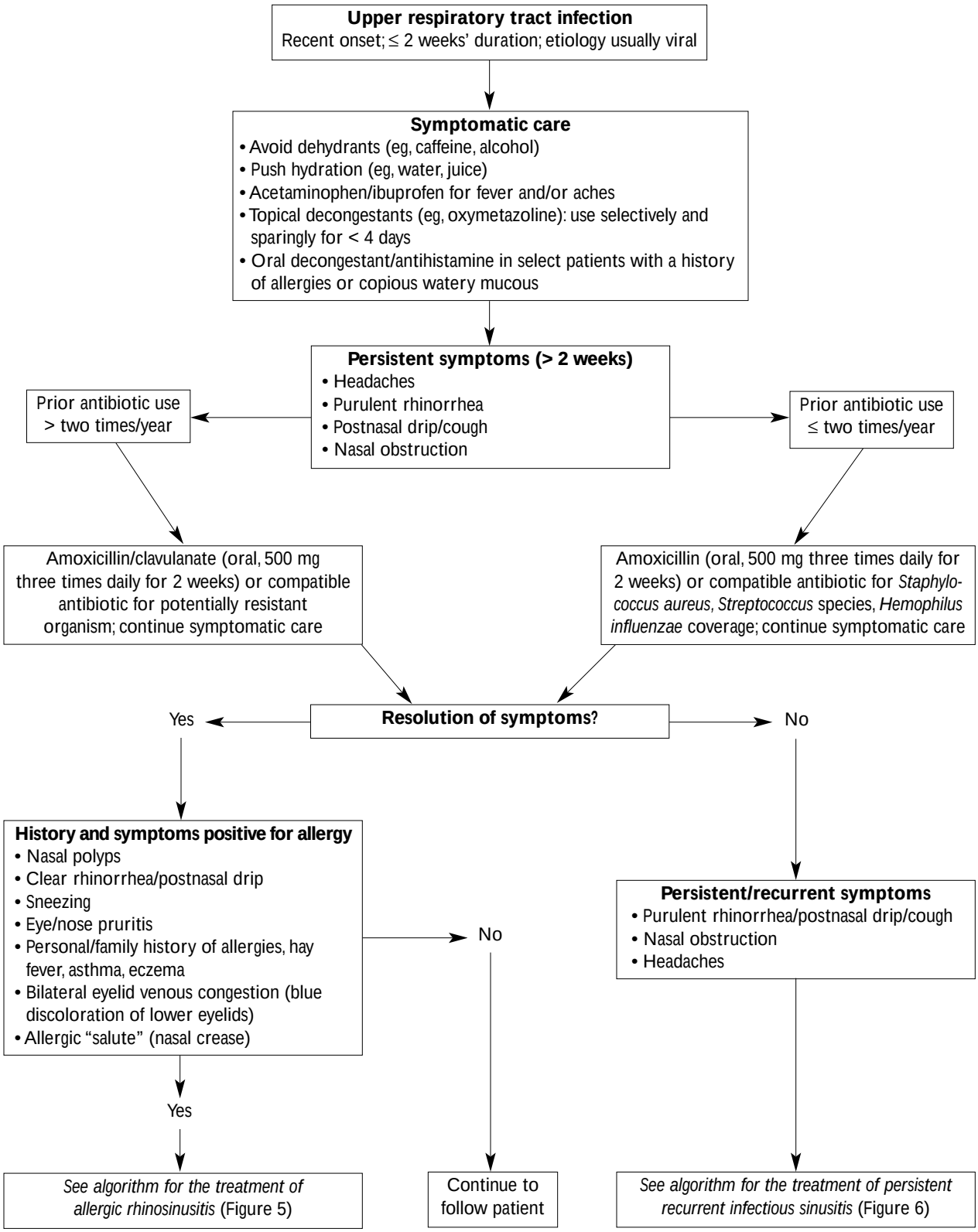

Figure 4. Algorithm for the diagnosis and treatment of upper respiratory tract infection.

The initial treatment for sinusitis is always medical. Measures include hydration, avoidance of dehydrants (eg, caffeine, alcohol), and warm humidification. In cases of acute rhinosinusitis, topical decongestants may be used sparingly to reduce turbinate hypertrophy and improve sinus drainage and breathing.

Bacterial Rhinosinusitis

Although cost is a factor in choosing an antibiotic for acute bacterial sinusitis, it is also important to consider the increasing incidence of resistant forms of bacteria (eg, β-lactamase–producing bacteria). *Streptococcus* species, *Hemophilus influenzae*, and *Moraxella catarrhalis* are common microbes in acute rhinosinusitis.[9] The American Academy of Otolaryngology–Head and Neck Surgery (Alexandria, VA) recommends antimicrobial therapy for a minimum of 2 weeks in acute or subacute cases.

In chronic sinusitis there is usually a mixed aerobic and/or anaerobic flora. Common organisms in chronic cases include *Pseudomonas* species (gram-negative) and *Staphylococcus* species, *Peptostreptococcus* species, and *Propionibacterium* species (gram-positive anaerobes).[10] Patients who have reached this stage of disease have a higher incidence of drug-resistant infection. A careful history of prior antibiotic use is therefore important. Occasionally, endoscopically guided cultures from the ostiomeatal complex or affected sinus cavity (in cases of previous surgery) may be helpful in establishing the appropriate antimicrobial therapy.[11] In chronic rhinosinusitis recommendations are for longer periods of antibiotic therapy (2 to 6 weeks). Patients with chronic sinusitis also have a higher incidence of irreversible anatomic obstruction of the sinus pathways needing surgical correction.

Antibiotics approved for treatment of rhinosinusitis include: amoxicillin/clavulanate, cefprozil, cefuroxime axetil, ciprofloxacin, clarithromycin, loracarbef, levofloxacin, and trovafloxacin.

Allergic Rhinosinusitis

For allergic rhinosinusitis, a multidisciplinary approach is crucial. For preventive treatment, topical corticosteroid sprays and/or cromolyn sodium sprays can be used on a long-term basis as local desensitizing agents without significant threat of systemic absorption or side effects. The patient should be advised that these sprays generally take at least 1 week to take effect. Corticosteroid sprays should be used as directed for a minimum of 1 month before efficacy can be ascertained. If effective, the patient should be instructed to use the spray indefinitely, discontinuing usage for 2 to 3 weeks every 3 or 4 months to minimize atrophy or drying of the mucous membranes and minor epistaxis. Additionally, oral or topical antihistamines may be used as needed on days when breakthrough symptoms occur with corticosteroid sprays alone. Nonsedating oral antihistamines may offer additional allergic control with greatly reduced anticholinergic side effects.[12]

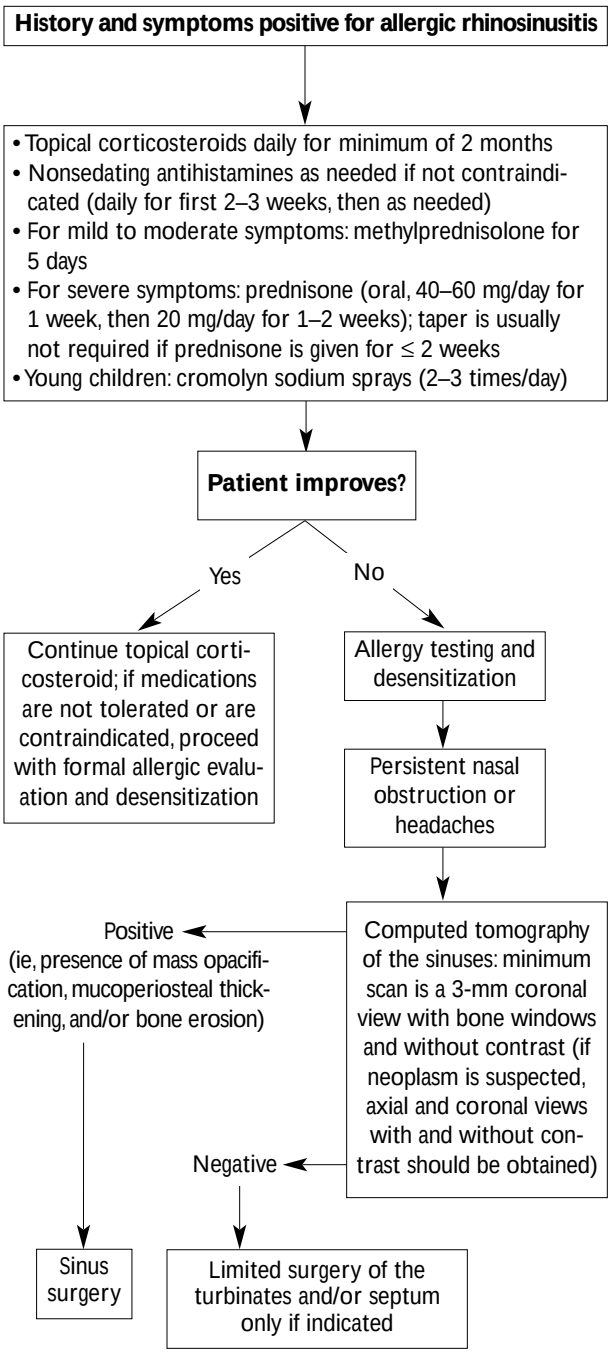

Figure 5. Algorithm for the treatment of allergic rhinosinusitis.

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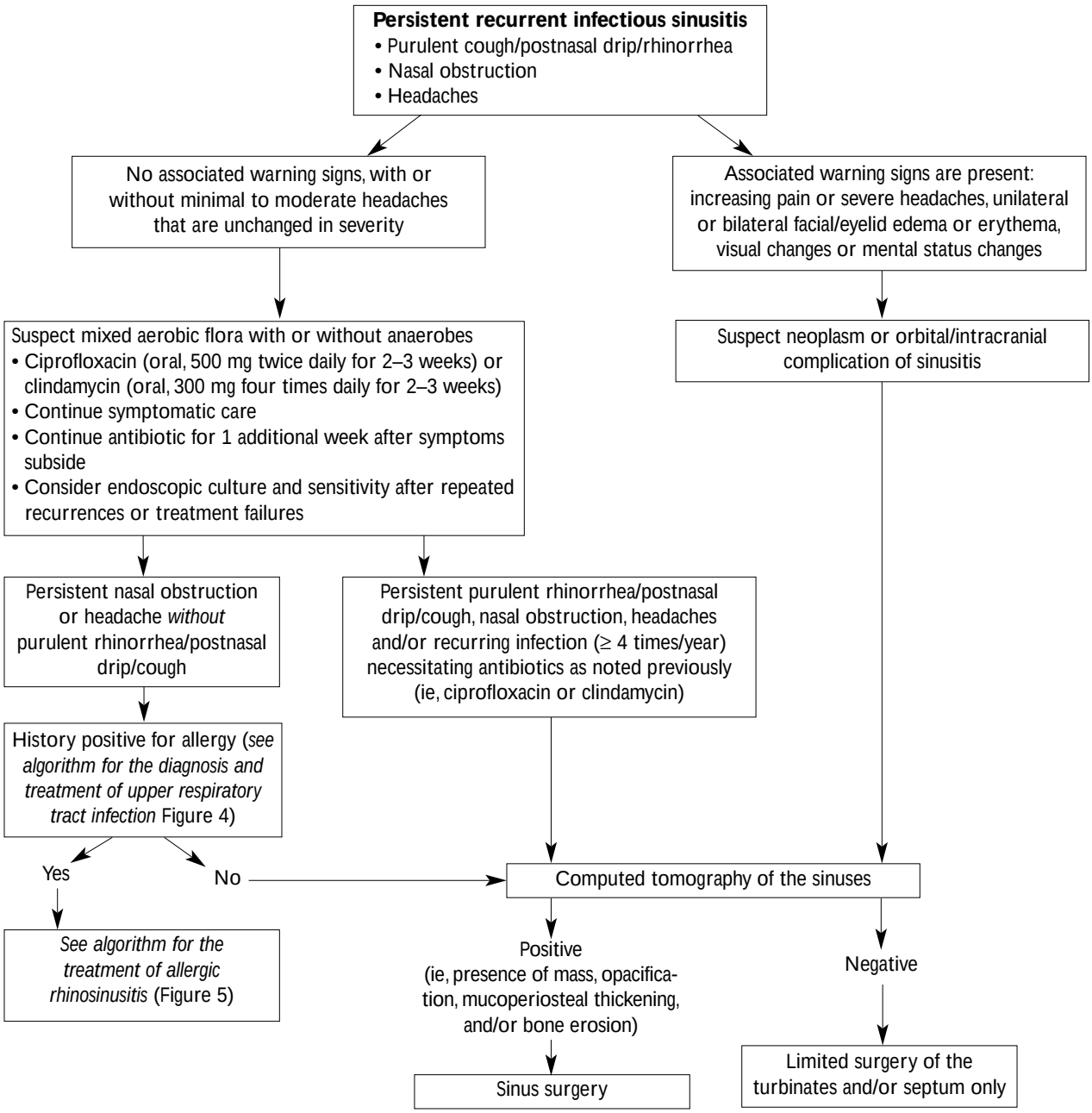

Figure 6. Algorithm for the treatment of persistent recurrent infectious sinusitis.

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Fexofenadine, loratadine, and cetirizine have not been associated with the arrhythmias that had been associated with some drug-drug interactions involving previous classes of nonsedating antihistamines (eg, terfenadine).

If medical treatment is contraindicated or if medical therapy fails to control allergic rhinosinusitis symptoms, the patient may be a candidate for allergic evaluation and consideration for immunotherapy.[13]

Allergic Fungal Sinusitis

One less common, yet important, etiology for rhinosinusitis is allergic fungal sinusitis (AFS), first described approximately 16 years ago.[14] Differentiating AFS from invasive fungal sinusitis or chronic bacterial sinusitis is important because the prognosis and treatment of these three conditions are very different.

AFS results from colonization of the paranasal sinuses

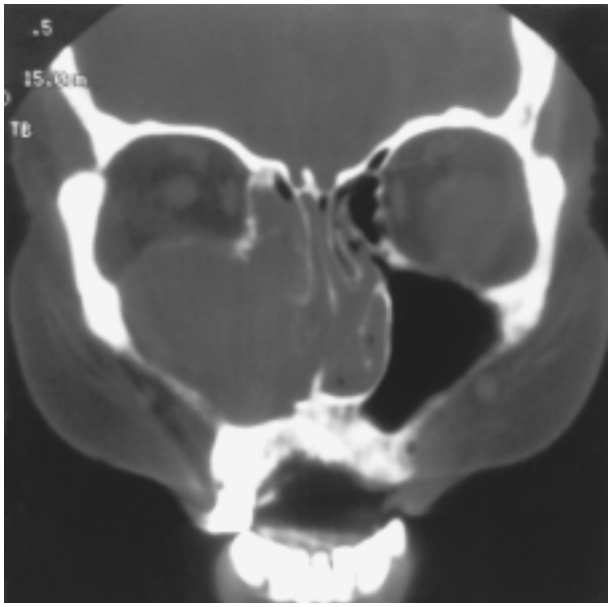

Figure 7. Computed tomography scan of a patient with the typical findings of a right maxillary mucocele and nasal polyps. The heterogenous content in the maxillary sinus is consistent with the inspissated mucous that is frequently seen in cases of allergic fungal sinusitis.

by fungi. The fungal proliferation results in an intense immune response without any evidence of mucosal invasion. This allergic response, rather than the microbial effects, causes the pathology in AFS. Histologically and etiologically, this disease is a near cousin of allergic bronchopulmonary aspergillosis, although *Aspergillus* may not be the only organism that causes AFS.

AFS usually presents in adolescents and young adults. AFS is closely associated with nasal polyps and generally affects multiple sinuses with a unilateral predominance. Nasal smears show an intense number of eosinophils. Patients usually have a rubbery, tenacious mucus that sometimes is very difficult to suction.[15]

Treatment involves intensive allergy treatment (including oral corticosteroids and immunotherapy) after thorough surgical débridement of all the inspissated mucus from the involved sinus cavities (**Figure 7**). Surgical débridement is important because this procedure removes the vasoactive amines that are involved in perpetuating the local inflammatory response. Adequate surgical débridement frequently involves extensive sinus surgery.

When to Refer for Surgical Evaluation

When medical treatment fails or is incomplete, adjunctive surgical treatment becomes an option and patients should be referred to an otolaryngologist for evaluation. Generally, the symptoms that are helped by surgery include persistent or worsening headaches, nasal obstruction, and recurrent or persistent purulent rhinorrhea unresponsive to 2 to 4 weeks of medical management. Asthmatic patients whose symptoms are exacerbated by a concomitant infectious rhinosinusitis may benefit from surgery. The presence of a significant unilateral nasal obstruction associated with nasal bleeding, periorbital or facial soft tissue inflamation, and/or visual or mental status changes may suggest a complication or neoplasm. These patients should have an immediate CT scan and be referred to a specialist.

Table 2. Absolute and Relative Indications for Sinus Surgery

Absolute indications
Intraorbital or intracranial complications of adult rhinosinusitis
Mucocele or mucopyocele formation with bone erosion and intraorbital or intracranial extension
Invasive or allergic fungal rhinosinusitis
Tumor in the nasal cavity or paranasal sinuses
Relative indications
Recurrent acute bacterial sinusitis
Bilateral extensive and massive obstructive nasal polyposis
Subacute or chronic adult rhinosinusitis unresponsive to reasonable medical therapy
Certain concomitant illnesses (eg, connective tissue disorders, diseases involving the airways, immunodeficiency conditions)

There are four absolute and four relative indications for sinus surgery (**Table 2**).[16,17] A high index of suspicion is necessary in diagnosing patients who are potential candidates for sinus surgery. Failure to diagnose patients correctly and provide appropriate treatment may result in disastrous consequences.

Absolute indications for surgery. The presence of a mucocele or mucopyocele with bone erosion and intraorbital or intracranial extension is an absolute indication for surgery, as is the presence of a tumor in the nasal cavity or paranasal sinuses. Intraorbital or intracranial complications of adult rhinosinusitis are also absolute indications. These complications include Pott's puffy tumor (ie, pericranial abscess) from frontal sinusitis, subperiosteal or intraorbital abscess, and intracranial (ie, epidural, subdural, or brain) abscess.

Surgery is also indicated in cases of invasive or allergic fungal rhinosinusitis. In cases of invasive fungal

disease, radical debulking of the infected soft tissue is necessary to improve the efficacy of intravenous antifungal therapy. In cases of AFS, removal of thick inspissated allergic mucin is necessary to maximize the efficacy of medical therapy with corticosteroids and allergy treatments.

Relative indications for surgery. Recurrent acute bacterial sinusitis is a relative indication for surgery; however, whether this form of sinusitis is truly a surgical problem is controversial. The number of infections a patient can tolerate before she or he wishes to proceed with surgery is quite variable. In general, if infections take longer to clear (ie, more than 2 to 3 weeks) and become more frequent (ie, more than four or five infections per year), then surgery may be indicated. Surgery may also be beneficial for adult patients with subacute or chronic rhinosinusitis, with or without acute exacerbation, that is unresponsive to reasonable medical therapy. As is true for recurrent acute disease, the timing of surgical intervention is individualized for each patient.

Patients with obstructive nasal polyposis may benefit from surgery. Patients in whom nasal obstruction is the only presenting symptom can often be treated effectively with corticosteroids. Patients with extensive bilateral polyposis may be at risk for developing complications, however, and should be recommended for surgery. These patients include those with massive obstruction that is associated with other symptoms and unresponsive to medical therapy, and/or with obstruction associated with bone erosion or mucocele formation.

The presence of certain concomitant illnesses in conjunction with rhinosinusitis may make surgical intervention advisable. Such illnesses include connective tissue disorders (eg, Wegener's granulomatosis, sarcoidosis), diabetes mellitus, immunodeficiency conditions (eg, HIV infection, chemotherapy, organ transplantation), cystic fibrosis, congenital syndromes with involvement of sinus infections, mucociliary dysfunction, and reactive airway disease (ie, asthma with concomitant rhinosinusitis).

Surgical considerations. The degree of sinus surgery is determined by the patient's symptoms and the severity of sinus disease as determined by CT evaluation. A coronal CT (3-mm cuts with bone windows and without contrast) is the minimum examination that is necessary. CT should only be performed after an adequate trial of medical therapy or if a complication of neoplasm is suspected.

Surgery procedures commonly performed for patients with rhinosinusitis include correction of a septal deviation (septoplasty), reduction of the inferior and/or middle turbinates to improve nasal air flow (turbinoplasty or submucous resection), and sinus surgery (ie, ethmoidectomy and/or frontal, maxillary, and sphenoid sinusotomy) to facilitate drainage and ventilation of the affected sinuses.

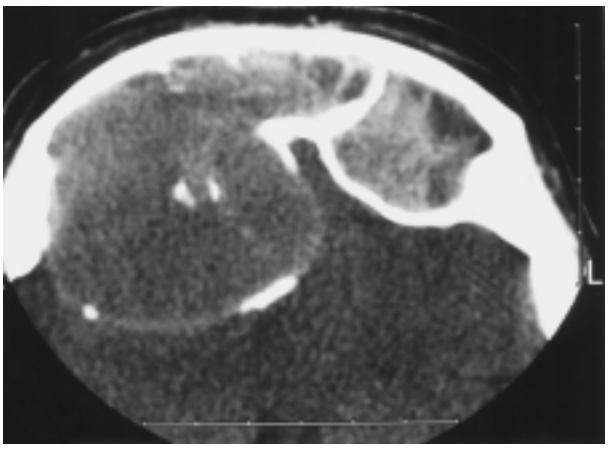

Figure 8. Computed tomography scan of a patient with a significant frontal sinus mucocele that expands the posterior wall of both frontal sinuses and displaces the right frontal lobe of the brain.

Endoscopic sinus surgery, introduced into the United States in the late 1980s, represents a major advancement in terms of cost-effectiveness and reducing surgical morbidity.[5,18] In the hands of a well-trained and experienced surgeon, an endoscopic approach is as safe as any other approach to the paranasal sinuses. Today endoscopic surgery is the method of choice for paranasal sinus surgery by most rhinologic surgeons. Surgery can usually be limited to a transnasal approach in the outpatient setting even for more advanced stages of disease with extensive polyposis and bone erosion (**Figure 8**).

CONCLUSION

Rhinosinusitis is a common problem seen by primary care physicians and otolaryngologists. The complicated anatomy of the paranasal sinuses and the multiple etiologies of rhinosinusitis contribute to the complexity that the physician often faces in trying to ameliorate or eradicate this disease in affected patients. A full understanding of the fundamental elements of rhinosinusitis and the treatments available for the various types of rhinosinusitis is important. Appropriate and timely referral for specialty care should result in the definitive management of recalcitrant rhinosinusitis when medical management alone fails or in cases in which a complication or malignancy is suspected. **HP**

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