The diagnosis and management of sinusitis: A practice parameter update

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These parameters were developed by the Joint Task Force on Practice Parameters, representing the American Academy of Allergy, Asthma and Immunology; the American College of Allergy, Asthma and Immunology; and the Joint Council of Allergy, Asthma and Immunology.

The American Academy of Allergy, Asthma and Immunology (AAAAI) and the American College of Allergy, Asthma and Immunology (ACAAI) have jointly accepted responsibility for establishing "The diagnosis and management of sinusitis: a practice parameter update." This is a complete and comprehensive document at the current time. The medical environment is a changing environment, and not all recommendations will be appropriate for all patients. Because this document incorporated the efforts of many participants, no single individual, including those who served on the Joint Task force, is authorized to provide an official AAAAI or ACAAI interpretation of these practice parameters. Any request for information about or an interpretation of these practice parameters by the AAAAI or the ACAAI should be directed to the Executive Offices of the AAAAI, the ACAAI, and the Joint Council of Allergy, Asthma and Immunology. These parameters are not designed for use by pharmaceutical companies in drug promotion.

Published practice parameters of the Joint Task Force on Practice Parameters for Allergy and Immunology include the following:

1. Practice parameters for the diagnosis and treatment of asthma. J Allergy Clin Immunol 1995;96(suppl): S707-S870.
2. Practice parameters for allergy diagnostic testing. Ann Allergy 1995;75:543-625.
3. Practice parameters for the diagnosis and management of immunodeficiency. Ann Allergy 1996;76:282-94.
4. Practice parameters for allergen immunotherapy. J Allergy Clin Immunol 1996;98:1001-11.
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These parameters are also available on the internet at: http://www.jcaai.org.

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The Joint Task Force has made a concerted effort to acknowledge all contributors to this parameter. If any contributors have been excluded inadvertently, the Task Force will ensure that appropriate recognition of such contributions is made subsequently.

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CLASSIFICATION OF RECOMMENDATIONS AND EVIDENCE

Category of evidence

Ia Evidence from meta-analysis of randomized controlled trials
Ib Evidence from at least one randomized controlled trial
IIa Evidence from at least one controlled study without randomization
IIb Evidence from at least one other type of quasiexperimental study
III Evidence from nonexperimental descriptive studies, such as comparative studies
IV Evidence from expert committee reports or opinions, clinical experience of respected authorities, or both

Strength of recommendation

A Directly based on category I evidence
B Directly based on category II evidence or extrapolated recommendation from category I evidence
C Directly based on category III evidence or extrapolated recommendation from category I or II evidence
D Directly based on category IV evidence or extrapolated recommendation from category I, II, or III evidence

NR Not rated

PREFACE

Sinusitis is one of the most commonly diagnosed diseases in the United States, affecting an estimated 16% of the adult population annually. It extracts an overall direct annual health care cost of $5.8 billion. Total restricted activity days increased from 50 million per year during 1986 through 1988 to 73 million per year during 1990 through 1992.[1] Sinusitis also significantly affects quality of life in some symptom domains even more than other chronic diseases, such as chronic obstructive pulmonary disease, angina, and back pain.[2]

Because of the importance of sinusitis, the Joint Task Force on Practice Parameters, representing the American Academy of Allergy, Asthma, and Immunology, the American College of Allergy, Asthma, and Immunology, and the Joint Council of Allergy, Asthma and Immunology, developed the first set of ''Parameters for the diagnosis and management of sinusitis,'' which was published in 1998.[3] Much has happened since then with respect to new concepts in diagnosis and management and new insights into pathogenesis. For these reasons, it was decided that a revision-update was indicated.

Four documents comprise this present practice parameter on sinusitis: (1) an executive summary that reviews, in narrative format, the key clinical issues considered in the parameter documents; (2) a management algorithm with narrative annotations designed to assist clinical decision making; (3) a document listing only numbered summary statements that is intended to promote rapid review and identification of material comprehensively discussed in the final document; and (4) the complete guidelines document, which is organized so that the numbered key summary statements precede relevant supporting text and citations of evidence-based publications. This format provides a ready reference for any physician who evaluates and treats a patient with suspected sinusitis. In particular, the algorithm and its accompanying annotations are designed to present a global and useful approach to both diagnosis and management. Clinical decision points are clearly shown, and each of these proceeds stepwise to logical implementation strategies. If further justification is required at any step in the algorithm, the evidentiary-based guidelines text can and should be consulted. In addition,

The diagnosis and management of sinusitis: A practice parameter update

guidance about appropriate referral of refractory cases, either because of treatment failure or for further investigation of possible associated conditions, is provided.

The great majority of patients with sinusitis seek care from their primary care physician. Various subspecialists (allergists and otolaryngologists) also see patients with sinusitis, especially patients who are more difficult to treat. It is incumbent on all physicians treating sinusitis to be knowledgeable concerning the latest information on pathophysiology, diagnosis, and management, especially in light of the rapidity with which infective organisms are able to change their character.

This practice parameter includes anatomic, allergic, immunologic, and physiologic considerations, as well as clinical diagnosis, differential diagnosis, diagnostic testing, and treatment. Predisposing factors, such as allergy, upper respiratory tract infections, anatomic abnormalities, immotile cilia syndrome, cystic fibrosis (CF), immune deficiencies, and environmental factors, will be addressed. Medical and surgical therapies will be discussed.

An initial draft of parameters was prepared by a work group of experts in the field who carefully reviewed the current medical literature. This material then underwent extensive peer review, revision, and annotation by external reviewers and by the Joint Task Force on Practice Parameters for Allergy and Immunology, a national panel of allergist-immunologists appointed by its cosponsoring organizations: the American Academy of Allergy, Asthma and Immunology; the American College of Allergy, Asthma and Immunology; and the Joint Council of Allergy, Asthma and Immunology. The parameters were reviewed and approved by the cosponsoring organizations and thereby represent an evidence-based, broadly accepted consensus opinion.

The Joint Task Force is grateful for the cosponsoring organizations' financial support and encouragement. The Joint Task Force would especially like to thank the many individuals who have donated substantial time and effort in producing this document that is intended to improve the quality of care of many millions of patients with sinusitis.

EXECUTIVE SUMMARY

Sinusitis, defined as inflammation of one or more of the paranasal sinuses, is characterized as acute when lasting less than 4 weeks, subacute when lasting 4 to 8 weeks, and chronic when lasting longer than 8 weeks. Recurrent sinusitis consists of 3 or more episodes of acute sinusitis per year. A noninfectious form of chronic sinusitis is termed *chronic hyperplastic eosinophilic sinusitis*. Viral upper respiratory tract infections frequently precede subsequent bacterial invasion of the sinuses by *Streptococcus pneumoniae*, *Haemophilus influenzae*, and *Moraxella catarrhalis*. These organisms can also be found in chronic sinusitis, as well as *Staphylococcus aureus*, *Pseudomonas aeruginosa*, and certain anaerobes. Fungi are being recognized increasingly as a factor in chronic sinusitis, particularly in the southeast and southwest parts of the country.

Prominent symptoms of acute sinusitis include nasal congestion, purulent rhinorrhea, facial-dental pain, postnasal drainage, headache, and cough. Chronic sinusitis symptoms are similar but might be even more subtle. Pain is much less a feature of chronic sinusitis. Clinical signs of both acute and chronic sinusitis include sinus tenderness on palpation, mucosal erythema, purulent nasal secretions, increased pharyngeal secretions, and periorbital edema. There is an overlap in these symptoms with those of perennial rhinitis, and there is a frequent need to perform imaging procedures to confirm the diagnosis. Because of this overlap, some have suggested the use of the term *rhinosinusitis*.

Imaging techniques can provide confirmatory evidence of sinusitis when symptoms are vague, physical findings are equivocal, or clinical disease persists despite optimal medical therapy. The imaging technique of choice is computed tomography (CT) because it can demonstrate abnormalities both in the ostiomeatal complex and the sinus cavities.

Laboratory evaluation of acute, chronic, or recurrent sinusitis might include nasal cytology, nasal-sinus biopsy, or tests for immunodeficiency, CF, or ciliary dysfunction. Nasal cytology is useful in the clinical evaluation of conditions associated with sinusitis, including allergic rhinitis (AR), eosinophilic nonallergic rhinitis (NAR), neutrophilic rhinitis, and vasomotor rhinitis (VMR). Sinus secretions can be obtained for culture in adults by means of either an aspiration of the maxillary sinus or an endoscopically directed catheter placed at the middle meatus. For children, sinus secretions should be obtained by means of aspiration only.

A number of factors associated with sinusitis should be considered. Probably the most common is viral upper respiratory tract infections. There is both clinical and experimental evidence that ongoing AR might ultimately lead to or augment acute bacterial sinusitis. NAR was found in 26% of patients with chronic sinusitis. Recently, gastroesophageal reflux disease (GERD) has been suggested as a cause of sinusitis, and there are several studies in children and adults indicating that medical treatment of GERD results in significant improvement in sinusitis symptoms. Tests for immunodeficiency, including quantitative immunoglobulin measurement, functional antibody tests, and HIV testing, might be useful if either congenital or acquired immunodeficiency is suspected in cases of recurrent sinusitis. Quantitative sweat chloride tests and genetic testing for diagnosis of CF should be considered in children with nasal polyps, colonization of the nose and sinuses with *Pseudomonas* species, or both and in those who had chronic sinusitis at an early age.

Diseases associated with sinusitis are otitis media and bronchial asthma. Although no direct causal factor between sinusitis and asthma has been found, a number of studies in both children and adults suggest that medical management, surgical management, or both of sinusitis results in objective and subjective improvement of asthma.

The primary therapy for acute bacterial sinusitis is antibiotics. The choice is based on predicted efficacy, cost, and side effects. A 10- to 14-day course is generally

adequate for acute disease, although shorter courses are indicated for newer antibiotics. If there is no improvement in 3 to 5 days, then an alternative antibiotic should be considered. The role of antibiotics in chronic sinusitis is controversial. For chronic infectious sinusitis, a longer duration of therapy might be required, with possible attention to anaerobic pathogens. In the case of chronic noninfectious sinusitis, sometimes referred to as *chronic hyperplastic sinusitis*, consideration should be given to systemic corticosteroids.

Concern has been raised about the overdiagnosis of sinusitis and unnecessary treatment with antibiotics. Appropriate criteria for the use of antibiotics are symptoms of sinusitis for 10 to 14 days or severe symptoms of acute sinus infection, including fever with purulent nasal discharge, facial pain or tenderness, and periorbital swelling.

Intranasal corticosteroids as an adjunct to antibiotic therapy might be helpful in treating recurrent acute and chronic sinusitis. Other adjunctive therapy, such as antihistamines, decongestants, saline irrigation, mucolytics, and expectorants, might provide symptomatic benefit in selected cases. The use of intravenous immunoglobulin (IVIG) is indicated only in patients with proved functional impairment of humoral immunity. The beneficial effects of aspirin desensitization on aspirin-sensitive patients with sinusitis and asthma have been reported.

Medically resistant sinusitis might respond to appropriate nasal-sinus surgery. In instances of localized persistent disease within the ostiomeatal complex, functional endoscopic sinus surgery might result in significant improvement.

Consultation with a specialist should be sought when (1) there is a need to clarify the allergic or immunologic basis for sinusitis, (2) sinusitis is refractory to the usual antibiotic treatment, (3) sinusitis is recurrent, (4) sinusitis is associated with unusual opportunistic infections, and (5) sinusitis significantly affects performance and quality of life. Consultation is also appropriate when concomitant conditions are present that complicate assessment or treatment, including chronic otitis media, bronchial asthma, nasal polyps, recurrent pneumonia, immunodeficiencies, aspirin sensitivity, allergic fungal disease, granulomas, and multiple antibiotic sensitivities.

ALGORITHM OF SINUSITIS PRACTICE PARAMETERS (Fig 1)

Annotations to the algorithm

1. Symptoms suggestive of acute sinusitis
   - Acute sinusitis typically presents as a persistent upper respiratory tract infection (10-14 days without improvement).
   - In adults prominent symptoms include nasal congestion, purulent rhinorrhea, postnasal drainage, facial or dental pain, headache, and cough, frequently with a more severe nocturnal component.
   - Any patient with orbital swelling or pain, swelling of the forehead, and/or diplopia should be urgently scheduled for evaluation.
   - Children with acute sinusitis might also exhibit increased irritability and vomiting occurring in association with gagging on mucus, prolonged cough, or both.
   - In all age groups less frequent symptoms associated with acute sinusitis include fever, nausea, malaise, irritability, fatigue, halitosis, hyposmia, and sore throat.
2. Office visit
   - Review medical history for diagnosis of sinusitis and underlying risk factors.
   - General examination includes an evaluation for signs of upper airway and sinus inflammation associated with nasal mucosal edema, purulent secretions, and increased localized blood flow. Typical clinical signs include tenderness overlying the sinuses, dark circles beneath the eyes, and/or periorbital edema. Pharyngeal erythema, lymphoid hyperplasia, and purulent material in the posterior pharynx are also frequently observed.
   - Nasal examination in patients with acute sinusitis might reveal mucosal erythema and purulent secretions. Nasal endoscopy, whether performed with a rigid or fiberoptic instrument, offers a significantly better view than a nasal speculum. Nasal polyps might contribute to nasal congestion and can be a source of recurrent sinusitis by obstructing the sinus ostia. In adults nasal polyps might be associated with nonsteroidal anti-inflammatory drug sensitivity and asthma. Nasal polyps are relatively uncommon in children, and their presence should prompt evaluation for possible CF. Ear examination in patients with suspected acute sinusitis frequently will reveal middle ear effusions and associated eustachian tube dysfunction.
   - Acute or chronic sinusitis might initiate or worsen asthma and bronchial hyperresponsiveness. Accordingly, chest auscultation and other objective measurements of airflow obstruction, such as office spirometry, should be considered in any patient with possible sinusitis and cough.
   - Patients with obvious acute sinusitis should be carefully reviewed for any possible evidence of complicating factors, including the presence of facial swelling–erythema over an involved sinus, visual changes, abnormal extraocular movements, proptosis, periorbital inflammation–edema–erythema, any suggestion of intracranial involvement, or central nervous system involvement manifested as abnormal neurologic signs.
   - In general, radiographs are not necessary in making the diagnosis of acute sinusitis, and plain radiographs have significant false-positive and false-negative results. Occasionally, imaging studies might be useful to support the diagnosis or provide evidence of the degree of mucosal involvement, thereby guiding more aggressive therapy. Plain radiographic signs compatible with sinusitis include greater than 6 mm of mucosal thickening in the

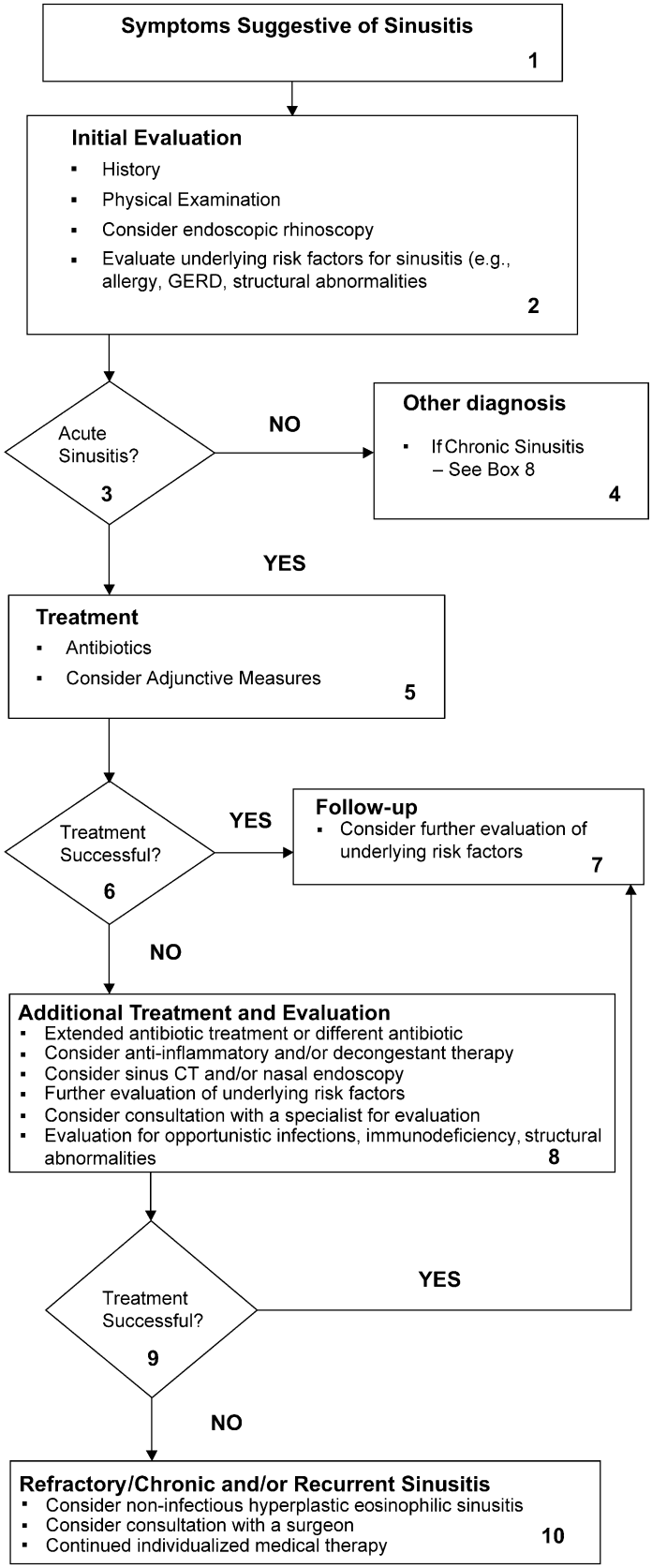

FIG 1. Algorithm of sinusitis practice parameters.

maxillary sinuses in adults (>4 mm in children), greater than 33% loss of air space volume within the maxillary sinuses, or opacification–air-fluid levels in any of the paranasal sinuses. Occipitomental view radiographs might be helpful in screening adults and children older than 1 year of age but have inadequate sensitivity. A limited coronal sinus CT scan, with a focus on the ostiomeatal complex, might be helpful and should be considered if imaging is deemed necessary. Axial and coronal sinus CT is indicated in suspected orbital involvement, and sinus magnetic resonance imaging (MRI) can provide useful information with related soft tissue involvement.

- Nasal cultures are not reliable for establishing the diagnosis of sinusitis or for determining a specific causative microorganism. Maxillary antrum aspiration for culture is definitive but is indicated only when precise microbial identification is essential. Obtaining cultures of the middle meatus through endoscopically directed culture has shown promise in adults but not in children.

3. Acute sinusitis
   - Acute sinusitis is defined as symptoms and signs for less than 4 weeks. The diagnosis of acute sinusitis is based primarily on the clinical history, the physical examination, and possibly other ancillary evaluations, including nasal cytology or radiographic imaging. In most instances the diagnosis is made presumptively, and treatment is initiated. Clinical improvement usually occurs promptly; complete resolution of symptoms might require 10 to 14 days.
4. Other diagnoses

Differential diagnoses include the following:

- AR and NAR;
- viral upper respiratory tract infection;
- nasal polyps;
- sinonasal tumors;
- nasopharyngeal tumor, granulomata, dental infections;
- enlarged or infected adenoids in children.

5. Treatment

Antibiotics:

- Amoxicillin often is the drug of choice for children and adults. It is generally effective, inexpensive, and well tolerated. Trimethoprim-sulfamethoxazole can be used as an alternative drug in adults. Resistance is more commonly seen in children, and it is recommended that the clinician refer to their local biogram profile of antibiotic resistance. For patients who do not respond to amoxicillin, high-dose amoxicillin-clavulanate (90 mg/kg amoxicillin and 6.4 mg/kg clavulanate, not to exceed 2 g every 12 hours) is recommended. For patients allergic to or intolerant of amoxicillin, alternatives include cephalosporins, macrolides, or quinolones.
- Acute sinusitis generally responds to treatment for 10 to 14 days. Some physicians continue treatment for 7 days after the patient is well to ensure complete eradication of the organism and prevent relapse. It is important to instruct the patient to complete the course of antibiotics.
- A reasonable approach would be to start the patient on amoxicillin for 3 to 5 days and determine whether the signs and symptoms are improving. If the patients symptoms are improving, continue this treatment until the patient is well for 7 days (generally a 10- to 14-day course). If after 3 to 5 days the patient has not shown improvement, switch to a different antibiotic, such as high-dose amoxicillin-clavulanate or cefuroxime axetil.

Corticosteroids:

- The use of nasal corticosteroids might be helpful in patients with acute and chronic sinusitis.
- Although efficacy has not yet been proved, the short-term use of oral corticosteroids as an adjunct in treating patients with acute sinusitis is reasonable when the patient fails to respond to initial treatment, demonstrates nasal polyposis, or has demonstrated marked mucosal edema.

Saline-mucolytics:

- Saline nasal sprays or lavage might be a useful adjunct by liquefying secretions and decreasing the risk of crusting near the sinus ostia.
- There is no conclusive evidence that mucolytics, such as guaifenesin, are useful adjuncts in treating acute sinusitis.

α-Adrenergic decongestants:

- Topical decongestants (eg, oxymetazoline and phenylephrine) and oral decongestants (eg, pseudoephedrine) reduce mucosal blood flow, decrease tissue edema and nasal resistance, and might enhance drainage of secretions from the sinus ostia.
- The use of topical decongestants beyond 3 to 5 days might induce rhinitis medicamentosa, with associated increased congestion and refractoriness to subsequent decongestant therapy.

Education:

- The following comfort measures might be helpful: adequate rest, adequate hydration, analgesics as needed, warm facial packs, steamy showers, and sleeping with the head of the bed elevated.
- Prevention measures might include appropriate treatment of allergies and viral upper respiratory tract infections and avoidance of adverse environmental factors, such as relevant allergens, cigarette smoke, pollution, and barotrauma.
- Patients should be instructed to phone if symptoms worsen (eg, especially with headache or high fever) or if symptoms have not improved within 3 to 5 days of treatment (see annotation 10).

6. Treatment successful?

Complete response:

- Patient is improved symptomatically to near normal.

Partial response:

- Patient is symptomatically improved but not back to normal at the end of the first course of antibiotics.

Poor response:

- Patient has little or no symptomatic improvement after the first course of antibiotic therapy.

7. Follow-up
   - No further evaluation for resolved uncomplicated sinusitis.
   - Consider further evaluation of underlying risk factors, such as allergic rhinitis (AR) and NAR and structural abnormalities.
8. Additional treatment and evaluation
   - For partial response, continue antibiotic treatment for another 10 to 14 days or consider antibiotic choices listed under ''poor responses.''
   - For poor response to treatment with amoxicillin or trimethoprim-sulfamethoxazole or in regions with a high incidence of antibiotic resistance, an antibiotic should be prescribed that covers resistant bacteria. Appropriate choices include high-dose amoxicillin-potassium clavulanate, cefuroxime, cefpodoxime, cefprozil, and cefdinir. Quinolones, macrolides, and ketolides might also be a consideration.
   - Sinusitis that fails to improve after 21 to 28 days of initial antibiotic treatment might be caused by pathogens not adequately covered by prior antibiotics, the presence of nasal polyps, or noncompliance. The use of broader-spectrum single agents, such as high-dose amoxicillin-potassium clavulanate, cefuroxime, or cefpodoxime should be considered with or without the addition of anaerobic coverage with clindamycin or metronidazole.
   - Reinforce the comfort and prevention measures outlined in Annotation 5.
   - Consider sinus CT scan if not already done.
   - Underlying risk factors should be evaluated in a more detailed manner.
   - Consider consultation with an allergist-immunologist for treatment of underlying allergic factors and evaluation of unusual pathogens and immunodeficiency. For structural abnormalities, consultation should be sought with an otolaryngologist.

Recurrent sinusitis:

- Repeated episodes of acute sinusitis typically 3 or more times per year.
- Patients with chronic or recurrent sinusitis should be evaluated for underlying inflammation, allergy, immunodeficiency, and anatomic abnormalities.

Rhinitis:

- Patients with suspected AR in conjunction with sinusitis should be evaluated for the presence of IgE sensitization to inhalant allergens.
- Emphasis of therapy for AR includes environmental control, pharmacotherapy, and, in selected patients, allergen immunotherapy.
- Other rhinitic conditions (vasomotor, nonallergic rhinitis–eosinophilia syndrome [NARES], and rhinitis medicamentosa) might also lead to sinusitis, and the consultant must be capable of differentiating these conditions and initiating an appropriate course of therapy.

Immunodeficiency:

- Referral to an allergist-immunologist is particularly indicated in patients with chronic or recurrent sinusitis associated with such conditions as otitis media, bronchitis, bronchiectasis, or pneumonia and in patients who have undergone prior surgical procedures and continue to experience sinusitis. This evaluation might include measurement of quantitative serum IgG, IgA, and IgM level and assessment of specific antibody responses to protein and polysaccharide antigens, such as tetanus toxoid or pneumococcal polysaccharide vaccine.

9. Treatment successful?
   - See Annotation 6.

Follow-up

- See Annotation 7.

10. Chronic sinusitis
    - Signs and symptoms compatible with sinusitis persisting 8 weeks or longer.
    - Consider a noninfectious form of sinusitis. Chronic hyperplastic eosinophilic rhinosinusitis does not respond to antibiotics and is marked by a preponderance of eosinophils and mixed mononuclear cells, with a relative paucity of neutrophils. A course of systemic corticosteroids might have to be considered.
    - If the patient has a significant nasal septal deviation that compresses the middle turbinate into the ostiomeatal complex or obstruction of the sinus outflow tracts caused by middle turbinate deformity or the presence of accessory structures that block sinus drainage, consider consultation with an otolaryngologist. The presence of obstructing nasal polyps, after an appropriate course of treatment that might include a trial of oral corticosteroids, is also an indication for referral. Finally, a patient with recurrent or chronic symptoms and radiographic evidence of ostiomeatal obstruction despite aggressive medical management might also benefit from surgical intervention.
    - Evaluation should include coronal sinus CT with extra cuts through the ostiomeatal complex to clarify the extent of disease and specific location or locations.
    - Evaluation might also include nasal-sinus biopsy in suspected cases of neoplasia, fungal disease, granulomatous disease, or tracheal biopsy for evaluating ciliary structures, function, or both.
    - In general, every effort should be made to maximize medical treatment for underlying rhinitis before proceeding with surgical intervention.
    - Contemporary surgical therapy involves chiefly functional endoscopic sinus surgery.
    - Most patients benefit from continued individualized medical therapy, including, when indicated, allergy management, after surgery.

COMPLETE GUIDELINES AND REFERENCES

Definitions, anatomic considerations, sinus physiology, and microbiology

Definitions

Summary Statements

Summary Statement 1: It has been suggested that the term *sinusitis* be replaced by *rhinosinusitis*. **NR**
Summary Statement 2: Sinusitis is defined as inflammation of one or more of the paranasal sinuses. The most common cause of sinusitis is infection. Classification of sinusitis is frequently based on duration of symptoms, the specific sinus involved, or both. **NR**
Summary Statement 3: The most commonly used classification is as follows **(NR)**:

a. Acute sinusitis: symptoms for less than 4 weeks consisting of some or all of the following: persistent symptoms of an upper respiratory tract infection, purulent rhinorrhea, postnasal drainage, anosmia, nasal congestion, facial pain, headache, fever, cough, and purulent discharge.
b. Subacute sinusitis: (unresolved acute) symptoms from 4 to 8 weeks.
c. Chronic sinusitis: symptoms for 8 weeks or longer of varying severity consisting of the same symptoms as seen in acute sinusitis. In chronic sinusitis there should be abnormal findings on CT or MRI. Some patients with chronic sinusitis might present with vague or insidious symptoms.
d. Recurrent sinusitis: 3 or more episodes of acute sinusitis per year. Patients with recurrent sinusitis might be infected by different organisms at different times.

Summary Statement 4: A noninfectious form of chronic sinusitis is termed *chronic hyperplastic eosinophilic sinusitis*. **NR**

Although it is not universally accepted, the suggestion has been made that the term *rhinosinusitis* might be more applicable than *sinusitis* for the following reasons[4-6]: rhinitis typically precedes sinusitis; sinusitis without rhinitis is rare; the mucosa of the nose and sinuses are contiguous; and symptoms of nasal obstruction and nasal discharge are prominent in sinusitis. Rhinitis associated with sinusitis can be allergic, bacterial, viral, or perennial nonallergic. Sinusitis is classified as acute, subacute, chronic, and recurrent. It should be emphasized that this classification is entirely arbitrary, and the medical literature is unclear on this point. Most treatment modalities are directed to acute and chronic sinusitis. In acute sinusitis symptoms are present for less than 4 weeks. Symptoms consist of some or all of the following: persistent symptoms of an upper respiratory tract infection, purulent rhinorrhea, postnasal drainage, anosmia, nasal congestion, facial pain, headache, fever, and cough. Subacute sinusitis, also referred to as *unresolved acute sinusitis* is the development of manifestations of minimal-to-moderate signs of sinus inflammation without an overt upper respiratory tract infection or abrupt onset of symptoms. It might speak to inadequate or partial therapy of acute sinusitis or simple inattention to acute problems. Chronic sinusitis is defined as persistent sinus inflammation for greater than 8 weeks. An operational definition of chronic sinusitis is persistent inflammation documented with imaging techniques at least 4 weeks after initiation of appropriate medical therapy in the absence of an intervening acute episode.[7] In contrast to acute sinusitis, the role of bacterial infection in chronic sinusitis is less certain.[8] Recurrent sinusitis includes 3 or more episodes of acute sinusitis per year.

The symptom-based definition of chronic sinusitis has been recently brought into question. In one study more than 50% of patients with a strong history of chronic sinusitis had a normal CT scan. However, it is still debated whether CT also provides the definitive diagnosis of this disorder. A reevaluation of the way chronic sinusitis is defined and diagnosed appears necessary.[9] Chronic sinusitis can be divided into infectious and hyperplastic categories. Chronic infectious sinusitis might be due to anaerobic bacteria, such as gram-positive streptococcus, bacteroides, and *Fusobacterium* species or *S aureus*. It is generally associated with a significant influx of neutrophils. A noninfectious form of chronic sinusitis, sometimes termed *chronic hyperplastic eosinophilic sinusitis*, is marked by a preponderance of eosinophils and mixed mononuclear cells, with a relative paucity of neutrophils. It is often associated with nasal polyps, asthma, and aspirin sensitivity.[10]

Anatomic considerations

Summary Statements

Summary Statement 5: The sinuses develop at different ages during childhood. **B**
Summary Statement 6: The optic nerve, cavernous sinus, and carotid artery are adjacent to the sphenoid sinus. Tumors and infection in the sphenoid sinus might present with involvement of these structures. **B**
Summary Statement 7: Because of the location of the frontal and sphenoid sinuses, infection of these sinuses has a greater propensity to cause intracranial complications. **A**
Summary Statement 8: The maxillary, anterior ethmoid, and frontal sinuses drain through the ostiomeatal complex and are dependent on this region for normal ventilation and mucociliary clearance. **B**
Summary Statement 9: The anterior ethmoid sinuses and middle meatus (ostiomeatal complex), as a result of their location, are most frequently involved in sinusitis. **D**
Summary Statement 10: Anatomic abnormalities of the nasal septum or within the ostiomeatal complex might predispose toward the development of sinusitis. **B**

Development. The maxillary sinus is the first to begin significant pneumatization between birth and 12 months. The floor of the maxillary sinus reaches the level of the floor of the nose by approximately 12 years of age. Rudimentary ethmoid sinuses are present at birth and reach adult size at 12 to 14 years of age.[11] Development of

the frontal and sphenoid sinuses begins later than that of the ethmoid sinuses, and complete pneumatization is not achieved until mid to late adolescence.[12] Although the degree of pneumatization of all sinuses is highly variable, the variability in pneumatization of the frontal and sphenoid sinuses is greater than that of the ethmoid and maxillary sinuses.[13] The frontal sinus is hypoplastic or completely absent in about 15% of the population, and the sphenoid sinus is rudimentary (conchal or presellar pneumatization) in 26% of patients. There is evidence to suggest that sinusitis in childhood might inhibit sinus development.[14] Because of their later development, frontal or sphenoid disease is uncommon in childhood.

Anatomy. The anterior ethmoid, frontal, and maxillary sinuses all drain into the middle meatus through a relatively convoluted and narrow drainage pathway (ostiomeatal complex) rather than by simple ostia. The ethmoid sinuses themselves consist of a honeycomb of cells lying medial to the orbital structures and varying between 4 and 17 air cells in number. They might also pneumatize to a variable extent above (supraorbital) or below (infraorbital) the orbit. The ethmoid sinus is divided into an anterior group of cells (draining into the middle meatus) and a posterior group of cells (draining into the superior meatus).[15] The maxillary sinus lies between the teeth and the orbit on both sides and drains into the middle meatus through a channel in its supramedial aspect. The paired frontal sinuses arise from the region of the anterior ethmoid and extend superiorly into the forehead. Valveless veins that pass through the posterior wall of the frontal sinus might allow the spread of frontal sinus infection intracranially, particularly in acute infection. The sphenoid sinuses are also paired and lie posterior and slightly inferior to the posterior ethmoid cells. They drain by separate ostia into the sphenoethmoidal recess on either side of the nasal septum posteriorly. The optic nerve courses over the sinus laterally and superiorly. The carotid artery indents the sinus laterally, and the sinus has an intimate relationship with the cavernous sinus, as well as the dura of both the anterior and middle cranial fossa.

The anatomic arrangement of the sinuses makes the frontal anterior ethmoid and maxillary sinuses dependent on the ostiomeatal complex for their ventilation and muciliary clearance. Significant obstruction of this complex can predispose to the development of sinusitis. Because ethmoid anatomy is extremely variable and dependent, to some extent, on the position of the nasal septum, there is a potential for anatomic variations to cause ostiomeatal obstruction, although the importance of anatomic variations in predisposing to chronic sinusitis either by means of redirection of airflow or by means of direct compression is still debated.[16,17] In some situations the ethmoid cells might pneumatize into the head of the middle turbinate (concha bullosa), and extreme middle turbinate aeration might narrow the ostiomeatal complex. The location of the anterior ethmoid sinuses and middle meatus makes the ostiomeatal complex particularly at risk from environmental exposures, and this region is typically the first and the most frequently involved region in chronic sinusitis. Indeed, low-grade edema and inflammation can persist within this region, resulting in intermittent episodes of inflammation in the dependent sinuses. When such edema does not respond to medical therapy, endoscopic surgical intervention might be required.

Sinus physiology

- The sinuses are air-filled cavities with classical, pseudostratified, ciliated columnar epithelium interspersed with goblet cells. The cilia sweep mucus toward the ostial opening. Obstruction of sinus ostia might lead to mucous impaction and decreased oxygenation in the sinus cavities.
- During obstruction of the ostia, the pressure in the sinus cavity can decrease, which in turn causes the symptom of pain, particularly in the frontal region.

The sinus cavities are air filled, with classical, pseudostratified, ciliated columnar epithelium interspersed with goblet cells. The cilia sweep mucus toward the ostial opening. Blood flow in the maxillary sinus is roughly estimated to be 100 mL/100 g tissue per minute, which is similar to that found in the nose but higher than that found in the brain. Obstruction of the ostia can lead to mucous impaction and decrease oxygenation in the sinus cavities. This in turn might lead to further complications (discussed in further sections). There is limited gas exchange in the sinuses when there is ostial obstruction, and then the oxygen concentrations can decrease to close to 0% with purulent secretions but not with nonpurulent secretions. The growth of bacteria is facilitated in this anaerobic environment.

During obstruction of the ostia, the pressure in the sinus cavity can decrease, which in turn causes the symptoms of pain, particularly in the frontal region.[18] This pressure decrease can range from 20 to 30 mm H_2O, with the lowest pressure being -66 mm H_2O. Transudation might start when the pressure is less than 20 to 30 mm H_2O below 0. This decrease in pressure is preceded by a transient pressure increase caused by the increase in CO_2, whereas the decrease in pressure is principally caused by O_2 absorption.[19] However, in acute purulent sinusitis the pressure can sometimes be as high as 100 mm H_2O.[20] Purulent secretions have a low oxygen content, and the pain might be due to a combination of inflammation originating from the mucosa and pressure from the secretions on the inside walls of the sinus.

During deep sea diving, the change in sinus pressure can be very high, causing transudation, bleeding, and edema, especially when pressures exceed 350 to 500 mm H_2O. During flying, there is usually less change in pressure than diving. When there is obstruction of the ostia, changes in sinus pressure similar to those of diving can occur.

Microbiology

Summary Statements

Bacterial

Summary Statement 11: In acute sinus disease viral upper respiratory tract infections frequently precede

bacterial superinfection by *S pneumoniae*, *H influenzae,* and *M catarrhalis*. Both *M catarrhalis* and *H influenzae* can produce β-lactamase and thereby be resistant to penicillin and its derivatives. **A**

Summary Statement 12: The prevalence of penicillin-resistant *S pneumoniae* is increasing. Twenty-five percent to 50% of respiratory isolates of *S pneumoniae* are resistant to penicillin. **(A)** There is wide geographic variation.

Summary Statement 13: In addition to the organisms mentioned above, the most common bacterial species in chronic sinusitis are *S aureus*, gram-negative enteric organisms (including *P aeruginosa*), and anaerobes, such as *Prevotella* species and fusobacteria. **(A)** The role of infection in most patients with this disorder is controversial, and these culture results are similarly controversial and might reflect colonization only.

Summary Statement 14: In contrast to community-acquired sinusitis, the usual pathogens in nosocomial sinusitis are gram-negative enterics (eg, *P aeruginosa, Klebsiella pneumoniae*, *Enterobacter* species, *Proteus mirabilis*, *Serratia marcescens*, and bacteroides) and gram-positive cocci (occasionally streptococci and staphylococci). **A**

Fungal

Summary Statement 15: Fungal sinusitis can take one of 3 forms: allergic fungal sinusitis, mycetoma, or fulminant invasive disease. **A**

Summary Statement 16: Common causes of allergic fungal sinusitis are *Bipolaris* species, *Curvularia* species, *Aspergillus* species, and *Dreschlera* species. **A**

To determine the microbiology of sinus infection involving the maxillary sinus, the best measure, or gold standard, is to perform an aspirate of the maxillary sinus.[8,21] The nasal mucosa should be sterilized in the area beneath the inferior turbinate through which the trocar will be passed to insure that contamination is eliminated or reduced. Quantitative cultures should be performed or at least a Gram stain should be prepared to estimate the density of infection. Infection is documented when a bacterial species is recovered in a density of at least 10^3 to 10^4 cfu/mL.

Recently, there has been interest in and enthusiasm for obtaining cultures of the middle meatus endoscopically as a surrogate for cultures of a sinus aspirate. Although some studies have suggested good correlation between the pathogenic organisms isolated in the middle meatus and those in the maxillary sinus, further verification of this approach is warranted. In healthy children the middle meatus is colonized with the same bacterial species that are commonly recovered from children with sinus infections.[22] Accordingly, the recovery of such organisms in a symptomatic child cannot confirm the presence of infection. In adults the correlation between cultures of the middle meatus and the sinus aspirate has been reasonable.[23] The bacterial species recovered from the middle meatal samples of normal adults were coagulase-negative staphylococci in 35%, *Corynebacterium* species from 23% and *S aureus* from 8%.[24] The presence of *S aureus* as a presumed pathogen, as well as a common colonizer, can be confusing.

Bacterial. The microbiology of paranasal sinus infections can be anticipated according to the age of the patient, clinical presentation, and immunocompetency of the host.[25-37] In acute sinus disease viral upper respiratory tract infections frequently precede bacterial superinfection by *S pneumoniae*, *H influenzae*, and *M catarrhalis*.[25-27] Both *M catarrhalis* and *H influenzae* can produce β-lactamase and thereby be resistant to amoxicillin. Increasingly, *S pneumoniae* is resistant to penicillin; 25% to 50% of respiratory isolates of *S pneumoniae* will be intermediate or highly resistant to penicillin.[38,39] In adults with acute sinusitis, *S aureus* is another isolate from the paranasal sinuses.

Assessing the microbiology of chronic sinusitis has been particularly difficult. Aspirates are frequently performed immediately after or during a course of antimicrobials that has failed to eliminate the patient's symptoms. Furthermore, sterilization of the mucosa and quantitation of isolates are infrequently performed. The frequent recovery of coagulase-negative staphylococci, viridans streptococci, and diphtheroids are good examples of the dilemma. Often, patients are evaluated during acute exacerbations of chronic sinusitis, which explains the frequent recovery of *S pneumoniae*, *H influenzae*, and *M catarrhalis*. A large multicenter study to assess bacteriologic findings in adults with chronic bacterial maxillary sinusitis was recently reported.[37] The most commonly isolated anaerobes were *Prevotella* species (31%), anaerobic streptococci (22%), and *Fusobacterium* species (16%). The aerobes most frequently recovered included *Streptococcus* species (21%), *H influenzae* (16%), *P aeruginosa* (16%), *S aureus* (10%), and *M catarrhalis* (10%). In 2 small but recent series of patients with chronic sinusitis, the commonly recovered bacterial species included *S aureus*, β-hemolytic streptococci, *H influenzae*, and various gram-negative enterics, including *P aeruginosa*, *S marcescens*, and *Klebsiella oxytoca*.[23,33]

Three recent series of chronic sinusitis in pediatric patients have been reported.[34-36] Methods of obtaining material for culture were either an aspirate of the maxillary sinus[34-36] or an irrigation of the sinus cavity.[35] The microbiology of this disorder was described to include primarily *H influenzae*, *S pneumoniae*, *M catarrhalis*, coagulase-negative staphylococci, and α-hemolytic streptococci. Anaerobes were recovered from 40% and 13% of the specimens in 2 of these studies.[34,36]

In contrast to community-acquired sinusitis, the usual pathogens in nosocomial sinusitis are gram-negative enterics (eg, *P aeruginosa*, *K pneumoniae*, *Enterobacter* species, *P mirabilis*, and *S marcescens*) and gram-positive cocci (occasionally streptococci and staphylococci).[40-42]

It has been suggested that staphylococcal enterotoxin acting as a superantigen might trigger an enhanced immune response, resulting in polypoid formation and chronic sinusitis.[43]

Fungal. Fungal sinusitis can take one of 3 forms: allergic fungal sinusitis, fungus ball, or fulminant invasive fungal sinusitis. Both allergic fungal sinusitis and fungus ball are considered to be noninvasive forms of sinus infection. Classical allergic fungal sinusitis invariably occurs in immunocompetent patients with atopic disease, usually with nasal polyps and chronic nasal congestion and obstruction. The symptoms can be longstanding. In children there is frequently unilateral disease, and there might even be some facial deformity.[44] The material in the sinuses has a peanut butter–like consistency, and histologic examination shows fungal elements and abundant mucinous material. The pathogenesis is an immunologically mediated reaction to the presence of the fungal spores, which are acquired through inhalation of these common saprophytes.[45] A positive skin test response to the relevant organism is seen with an increase in total serum IgE levels.[46] There might be dramatic encroachment on adjacent structures (including the orbit and central nervous system) on the basis of expansion of the intrasinal contents.[46,47] True invasion of surrounding structures very rarely occurs. This clinical syndrome is observed in certain geographic areas more commonly than in others. In the United States it is most common in the south, southwest, and western regions of the country. Treatment involves a very complete surgical exenteration, with mucosal preservation and steroid therapy. The role of postsurgical antifungal therapy in this disorder has not yet been proved, but anecdotal reports suggest that it might be adjunctive. The most common fungi to cause this clinical syndrome are *Bipolaris*, *Curvularia*, *Aspergillus*, and *Dreschlera* species, although a wide variety of other fungi have been observed in a myriad of case reports.

Fungus ball typically occurs in the maxillary or sphenoid sinuses and is usually unilateral.[48] The symptoms of sinus infection are again chronic and might lead to nasal obstruction and headache. Although pressure necrosis can occur as the mass impinges on surrounding structures, invasion is rare. The principal way in which this entity is distinguished from allergic fungal sinusitis is by means of histologic examination, which shows dense accumulations of hyphae in concentric layers forming a fungus ball.[48] Eosinophilic mucin is not present. Surgical removal is indicated.

Invasive fungal sinusitis, a fulminant disseminated disease, is usually observed in immunocompromised patients, including diabetic patients, patients with leukemia or solid malignancies who are febrile and neutropenic (most of whom will have received broad-spectrum antimicrobial therapy), patients receiving high-dose steroid therapy (eg, patients with connective tissue disease or transplant recipients), and patients with severe impairment of cell-mediated immunity (transplant recipients or persons with congenital or acquired T-cell immunodeficiencies). Common clinical signs include fever, headache, epistaxis, and mental status changes. The patient might have insensate nasal ulcers. This symptom complex was formerly called *mucormycosis*.[48] Aggressive debridement and systemic antifungal therapy is warranted.[49,50]

There is an evolving literature of the potential for non-IgE immunologically mediated reactions to fungi to result in an inflammatory process in the sinuses.[51]

Clinical diagnosis

History

Summary Statements

Summary Statement 17: Acute bacterial sinusitis is suspected in patients in whom upper respiratory tract infection persists beyond 10 to 14 days. A history of persistent purulent rhinorrhea, postnasal drainage, and facial pain correlates with increased likelihood of bacterial disease. **A**
Summary Statement 18: Prominent symptoms of acute bacterial sinusitis include nasal congestion, purulent rhinorrhea, facial-dental pain, postnasal drainage, headache, and cough. **C**
Summary Statement 19: Predisposing factors for sinusitis include environmental exposures, genetic predisposition, AR, eosinophilic NAR, VMR, rhinitis medicamentosa, nasal polyps and other causes of ostiomeatal obstruction, CF, ciliary dyskinesia, cocaine abuse, and immunodeficiency. **D**
Summary Statement 20: The diagnosis of sinusitis is based on a combination of clinical history, physical examination, imaging studies, and/or laboratory tests. **D**
Summary Statement 21: The differential diagnosis of sinusitis includes AR, eosinophilic NAR, VMR, and vascular headaches-migraines. **D**

The diagnosis of sinusitis is based on a combination of clinical history, physical examination, imaging studies, and/or laboratory tests. Acute bacterial sinusitis is suspected in patients whose upper respiratory tract infection has persisted beyond 10 to 14 days.[52,53] Prominent symptoms in adults include nasal congestion, purulent rhinorrhea, facial-dental pain, postnasal drainage, headache, and cough.[54] Although all of these symptoms are nonspecific,[55-58] a history of persistent purulent rhinorrhea and facial pain appear to have some correlation with increased likelihood of bacterial disease.[54,55] Symptoms of acute bacterial sinusitis are similar in children but often also include increased irritability, even more prolonged cough, and vomiting that occurs in association with gagging on mucus.[59-62]

Less frequent symptoms include fever, nausea, malaise, fatigue, halitosis, or sore throat.

Chronic sinusitis symptoms are similar to those of acute sinusitis but might be even more subtle.[63,64] In fact, patients with rhinitis might not even perceive that they have chronic sinusitis; instead, they might only sense a mild increase in a subset of symptoms (eg, congestion and fatigue). Rather than expressing concern about a new problem, such a patient might simply complain that their usual medications for rhinitis are not effective. It is probable that headache attributed to chronic sinusitis could be a migraine equivalent.[65,66]

In reviewing a patient's history, the differential diagnosis of sinusitis (Table I) and predisposing conditions

TABLE I. Differential diagnosis of bacterial sinusitis*

Infectious rhinitis:
Viral upper respiratory tract infections
Allergic rhinitis:
Seasonal
Perennial
Nonallergic rhinitis:
Vasomotor rhinitis
Aspirin intolerance
Eosinophilic nonallergic rhinitis
Rhinitis medicamentosa:
Decongestants
β-blockers
Birth control pills
Antihypertensives
Rhinitis secondary to:
Pregnancy
Hypothyroidism
Horner syndrome
Wegener granulomatosis–midline granuloma
Anatomic abnormalities causing rhinitis:
Foreign body
Nasal polyps
Nasal septal deviation
Enlarged tonsils and adenoids
Concha bullosa and other middle turbinate abnormalities
Tumors
Cerebral spinal fluid rhinorrhea
Vascular headache (migraine)

Adapted from Kaliner MA. Medical management of sinusitis. Am J Med Sci 1998;16:21-8.
*Many of these conditions also predispose to sinusitis.

TABLE II. Conditions that predispose to sinusitis

Allergic and nonallergic rhinitis
Anatomic abnormality of the ostiomeatal complex
Nasal anatomic variants:
Septal deviation
Concha bullosa
Paradoxical curvature of the middle turbinate
Haller cells
Cystic fibrosis
Common variable immunoglobulin deficiency
Specific antibody deficiency
IgG subclass deficiency
IgA deficiency
Ciliary dyskinesia, Kartagener syndrome, Young syndrome
Aspirin sensitivity
Acquired immunodeficiency syndrome
Churg Strauss syndrome
Rhinitis medicamentosa
Cocaine abuse

Adapted from Kaliner MA. Medical management of sinusitis. Am J Med Sci 1998;316:21-8.

(Table II) should be considered. An accurate history has implications for appropriate initial therapy and long-term management.

Physical examination

Summary Statements

Summary Statement 22: Clinical signs of acute sinusitis include sinus tenderness on palpation, mucosal erythema, purulent nasal secretions, increased pharyngeal secretions, and periorbital edema. **C**

Summary Statement 23: Rhinolaryngoscopy might be a useful adjunct to physical examination, providing direct visualization of abnormalities of the septum, turbinates, mucosa, nasopharynx, adenoids, eustachian tube orifice, tonsils, posterior tongue, epiglottis, glottis, and vocal cords. The origin and extent of nasal polyps might be better identified after the use of topical decongestants, as well as the presence of purulent ostial secretions. **D**

When the clinical history suggests sinusitis, a directed physical examination can help differentiate sinusitis from a simple upper respiratory tract infection or AR.[54-58,61,67] The examination begins with careful inspection of the face. Acute sinusitis can be associated with swelling and tenderness overlying an affected area; rarely, with orbital involvement, diplopia or proptosis can be observed. In contrast, allergic facies demonstrate dark infraorbital swollen semicircles. Allergic children frequently exhibit a transverse nasal crease (caused by constant nose itching) or Morgan-Dennie's lines (accentuated horizontal skin folds on the lower eyelid running parallel to the lower lid margin).

The nasal mucosa and quality of secretions should be assessed. Red, swollen nasal tissue is seen in infectious rhinitis and sinusitis; pale boggy turbinates suggest AR. Secretions are clear and watery at the onset of upper respiratory tract infections but become thicker, colored (yellow-green), and opaque after a few days. Usually, the discharge will remain purulent for several days and then become clearer shortly before resolution. Typical ''colds'' last 5 to 7 days and rarely as long as 10 days. Persistence of purulent secretions beyond 10 days in the middle meatus area are characteristic of sinusitis, and secretions can be yellow-green, green, or gray.[54,55] Allergic nasal secretions are generally clear and watery; with extreme inflammation, a pale yellow color might be observed.

Purulent exudates in the middle meatus are believed to be highly predictive of bacterial sinusitis[54,55] but might be difficult to visualize unless the nasal mucosa is decongested with a vasoconstrictor. Accordingly, the absence of purulent secretions does not exclude the possibility of active sinus infection. Protracted nasal-sinus inflammatory changes in the mucosa might lead to polyps. Again, these could be difficult to see if the turbinates are swollen. In children the presence of polyps should raise concerns about CF. In all ages polyps are frequently seen with aggressive eosinophilic nonallergic sinusitis. Severe persistent asthma and nonsteroidal anti-inflammatory drug intolerance are frequently associated.[68]

The oropharynx should be examined for signs of posterior pharyngeal mucopurulent secretions. On occasion, sinusitis might present with dental pain because the roots of the teeth project into the floor of the maxillary

sinus. In fact, some cases of maxillary sinusitis are secondary to a dental root infection that erodes through the bone into the adjacent sinus. Examination of the ears might reveal otitis media, particularly in children with sinusitis; in fact, unresolved persistent bacterial sinusitis might lead to recurrent otitis media.[61,67] Auscultation of the chest for wheezing might disclose an asthmatic component of a patient's cough. The absence of audible wheezing does not exclude the possibility of asthma; subtle abnormalities might only be apparent on spirometry (see the ''Laboratory tests'' section).

Transillumination of the maxillary sinuses might be reported as opaque (no transmission), dull (reduced transmission), or normal, but the sensitivity and specificity of this technique alone is poor.[69] Unless the clinician has additional knowledge of a patient's sinus anatomy (eg, from a CT scan), it is impossible to differentiate active disease from a congenitally small sinus or bilateral mild involvement of larger sinuses from normal size sinuses.[70-73] In one prospective study, however, abnormal transillumination combined with purulent nasal secretions and a history of maxillary pain, poor response to decongestants, and colored rhinorrhea was the best predictor of acute bacterial sinusitis.[71]

In reassessing patients with recurrent sinusitis, the physical examination should be modified to evaluate for signs of immunodeficiency (associated recurrent otitis media, bronchiectasis, or pneumonia), complications of primary infections (eg, mastoiditis or orbital cellulitis), poor growth in children, unexplained dermatitis, absence of lymphoid tissue, CF (poor growth, nasal polyps, barrel chest, digital clubbing, and diffuse chest abnormalities on auscultation), ciliary dysfunction (nasal polyps, digital clubbing, dextrocardia, and situs inversus), and anatomic abnormalities (eg, septal deviation, nasal polyps, foreign bodies, and tumors).

In selected patients with chronic or recurrent sinusitis, nasal endoscopy should be considered. This procedure provides ideal direct visualization of abnormalities of the septum, turbinates, mucosa, nasopharynx, adenoids, eustachian tube orifice, tonsils, posterior tongue, epiglottis, glottis, and vocal cords. The origin and extent of nasal polyps can be identified, as well as the presence of purulent ostial secretions.[73,74]

Imaging studies

Summary Statements

Summary Statement 24: Imaging techniques can provide confirmatory evidence when symptoms are vague, physical findings are equivocal, or clinical disease persists despite optimal medical therapy. **B**

Summary Statement 25: Ultrasonography has limited utility but might be useful in pregnant women or for determining amounts of retained sinus secretions. **C**

Summary Statement 26: Standard radiographs might be used to detect acute sinusitis, but they are not sensitive, particularly for ethmoid disease. **C**

Summary Statement 27: CT is the optimal technique for evaluating the ethmoid sinuses and for preoperative evaluation of the nose and paranasal sinuses, including assessment of the ostiomeatal complex areas. **C**

Summary Statement 28: MRI is a sensitive technique for evaluating suspected fungal sinusitis and for differentiating between inflammatory disease and malignant tumors. MRI is limited in its ability to define bony anatomy. **C**

The diagnosis of acute sinusitis is generally made on the basis of history and physical examination.[54,55] Occasionally, it might be difficult clinically to distinguish between sinusitis and rhinitis, and it can be a challenge to document the extent of disease. As previously stated, the term *rhinosinusitis* has been suggested in part to reflect this confusion. In this context imaging procedures, particularly CT and MRI, are the generally used imaging techniques for confirmatory evidence in patients with both acute and chronic sinusitis.[75] The clinical utility, relative safety, ease of performance, availability, and cost of these imaging techniques vary considerably, and all have inherent limitations.[58,76-79]

Imaging procedures are often useful when symptoms are vague, physical findings are equivocal, or the response to initial management is poor. The possibility of sinusitis can also be confirmed by imaging patients with atypical presentations (eg, a child with refractory conjunctivitis or a patient with acute severe eye or occipital pain).

Some unusual causes of persistent disease, such as allergic fungal sinusitis and Wegener granulomatosis might be suggested by newer and more sophisticated imaging techniques, such as MRI.[80]

Ultrasonography. A-mode ultrasonography is a safe, rapid, and noninvasive technique for evaluating the maxillary and frontal sinuses. Unfortunately, several studies comparing ultrasonography with radiographic techniques (as the gold standard) suggest that the sensitivity and specificity of ultrasonography is poor, ranging from 39% to 61% and 42% to 53%, respectively.[81-84] Another limitation is that ultrasonography can only be used to evaluate the frontal and maxillary sinuses.[85] Despite these issues, ultrasonography might have some utility as a sinus diagnostic screen in pregnant women to avoid risks of ionizing radiation.

Standard radiography. Caldwell (anterior-posterior) and Waters (occipito-mental) standard radiographs demonstrate the frontal and maxillary sinuses, respectively.[86] Lateral views visualize the sphenoid sinus and adenoids in children. The fine bony anatomy of the ethmoid sinuses is not well seen on any standard radiographs because of problems of normal structural superimposition. Although other sinuses might also be involved, acute sinusitis commonly involves the maxillary sinuses. Accordingly, a single Waters view is a viable diagnostic substitute for a 4-view sinus series in many patients.[87] However, ethmoid involvement without maxillary sinus infection occurs in approximately 20% of patients.

The interpretation of standard radiographs remains controversial. It is generally believed that mild-to-moderate mucosal thickening is a nonspecific finding. In contrast,

sinus opacification, air-fluid level, or severe mucosal thickening in adults is more likely to reflect meaningful pathology.[88] Extrapolating from more recent CT studies, however, the correlation between radiographic extent of disease and likelihood of resolution without medical therapy is poor.[76-78] The decision to treat with antibiotics should therefore be made on clinical grounds alone.

Standard radiographs are of limited value in the evaluation of chronic sinusitis; they are also inadequate for clarifying the need for endoscopic surgery and the precise areas that need surgical attention.[89]

Computed tomography. High-resolution CT scans demonstrate the extent of disease and the degree of ostiomeatal complex obstruction; they might also delineate pathologic variations and anatomic structures that are not apparent on physical examination or rhinoscopy.[89,90] Sinus CT is the imaging technique of choice in preparation for endoscopic surgery.

Coronal scans provide a road map for surgery, best demonstrating the ostiomeatal drainage areas and intricate relationships between the brain, fovea ethmoidalis, and ethmoid sinuses. However, increasingly, surgeons are using computer-assisted surgical navigation, particularly in revision or other cases of complicated anatomy. Computer-assisted surgical navigation requires axial scans with scanning parameters specific for the computer device used, as well as standard coronal views.

The amount of radiation in standard sinus CTs is not negligible. An alternative approach is a low-dose CT with a standard dose in 1 or 2 sections in which more intricate detail is required (eg, in the ostiomeatal complex).[91]

In the past, a series of standard radiographs has been favored in preference to CT because of cost and time considerations. More recently, however, some medical centers offer a limited 4- to 5-cut coronal sinus CT scan at a similar cost to a set of standard radiographs. This typically takes only 15 to 20 minutes and provides much better high-resolution bone and soft tissue detail, including the ethmoids (which are poorly visualized on any standard radiograph).[92] This field is progressing rapidly, and current scanners take only 17 seconds for a complete sinus set.

High-resolution sinus CT is considered a mandatory preoperative study and is important for the planning and safe performance of functional endoscopic sinus surgery. This is particularly crucial when the ostiomeatal complex and ethmoids are involved.[93]

Sinus CT is particularly helpful in the diagnosis of fungal sinusitis. Classic findings for fungal disease are a combination of unilateral lesions of one or more sinuses, nodular mucoperiosteal thickening, focal areas of bone destruction, and/or dense intrasinus concretions.[94]

Magnetic resonance imaging. MRI provides ideal imaging of soft tissues; it is less suited to imaging bony anatomy because bone and air yield similar signal intensities on MRI. The value of MRI is further limited because the signal intensity from normal edematous mucosa is indistinguishable from extensively inflamed and diseased tissue.

TABLE III. Indications and limitations of CT and MRI

Modality	Indications
CT without contrast (coronal views with bone windows)	Images bone, sinus anatomy, ostiomeatal complex, and shows soft tissue–air–bone contrast Indications: Recurrent acute sinusitis Chronic sinusitis Preoperative for sinus surgery Nasal polyposis Persistent nasal congestion-obstruction Immunocompromised patient with fever Dentomaxillary pain Facial pressure–headache unresponsive to medical therapy Anosmia after appropriate workup
CT with contrast (coronal and axial views)	Allows some degree of differentiation of soft tissue opacification Indications: Complications of sinusitis (periorbital edema, subperiosteal abscess) Sinonasal tumor
MRI with contrast (need to specifically request coronal views)	Provides excellent soft tissue differentiation (eg, tumor vs retained fluid) but does not image bone or the bony anatomy required for surgery. Images the nasal cycle and thus might be oversensitive for sinusitis. Indications: Skull base dehiscence with opacification Unilateral sinonasal opacification (on CT) Sinonasal process with cranial extension Expansile sinonasal mass with bony erosion (?remodeling) Sinonasal mass with orbital extension Biopsy -proved tumor Fungal sinusitis

The differential diagnosis between inflammatory diseases and malignant tumor is aided by MRI.[95] MRI assists in clarifying the degree of orbital or intracranial extension in complicated sinusitis. T2-weighted image intensity is useful: high signal with bacterial and viral inflammation, intermediate bright signal with neoplastic processes (eg, squamous cell carcinoma), and very low signal with fungal concretions, similar to that of air.[86]

MRI or CT is more sensitive than standard radiography in defining the extent of disease, particularly with posterior sinus involvement.[96] Table III compares the indications and limitations of CT and MRI.

All imaging should be performed more than 2 weeks after an upper respiratory tract infection and more than

4 weeks after acute bacterial sinusitis and after medical management if the aim is to identify the underlying extent of chronic sinusitis or potential causes of recurrent acute sinusitis.

Laboratory tests

Summary Statements

Summary Statement 29: Laboratory evaluation of acute, chronic, or recurrent sinusitis might include the following: nasal cytology, nasal-sinus biopsy, or tests for immunodeficiency, CF, or ciliary dysfunction. **NR**
Summary Statement 30: Nasal cytology is useful in the evaluation of conditions associated with sinusitis, including AR, eosinophilic NAR, neutrophilic rhinitis, and VMR. **C**
Summary Statement 31: Nasal-sinus biopsy is useful in several clinical situations: determining whether a lesion is neoplastic and, if so, its nature; confirming the presence of fungal disease; confirming the presence of granulomatous disease; and determining the ultrastructure of cilia. **C**

Laboratory tests might provide additional diagnostic information in patients with acute or chronic sinusitis. Nasal cytology can provide data that support or refute the clinical diagnosis of acute infectious sinusitis; results might suggest the presence of underlying disease (eg, eosinophilic rhinitis). Antral puncture and endoscopically obtained culture were discussed in the ''Microbiology'' section. Nasal-sinus biopsy is useful in suspected cases of neoplasia, fungal disease, or granulomatous disease; this technique is also used in patients with ciliary dysmotility to define the ultrastructural nature of the defect. Other tests are used to assess disorders that might be causally associated with recurrent or chronic sinusitis (eg, immunodeficiency, CF, or ciliary dysfunction); these tests are discussed in separate sections (see below).

Nasal cytology. Nasal cytology demonstrates the type of cellular inflammation in patients with acute or chronic sinusitis. This can provide useful adjunctive information to the clinical history and examination with regard to likely infection or associated eosinophilic disease. Samples can be obtained by having the patient blow secretions into transparent plastic wrap or by the use of a cytology brush or Rhinoprobe (Synbiotics Corp, San Diego, Calif). Samples collected by means of the blowing technique often contain less cellular material but are still useful for detecting eosinophils and neutrophils.[1]

Nasal secretions are transferred to a glass slide, fixed, and then treated with Hansel stain, a stain that highlights eosinophil granular contents. Additional stains (eg, Papanicolaou, hematoxylin and eosin, acidified toluidine blue, or May-Grunwald-Giemsa) might be used to identify other elements, including mast cells, basophils, neutrophils, nonciliated epithelial cells, squamous cells, or even pollens or mold spores.

Nasal cytology results can be consistent with a variety of syndromes, including AR, eosinophilic NAR, VMR, bacterial sinusitis, neutrophilic nonbacterial sinusitis, and metaplasia caused by environmental exposures.[97,98] The presence of eosinophils correlates with AR or eosinophilic NAR, a condition often associated with chronic sinusitis, nasal polyposis, asthma, and nonsteroidal anti-inflammatory drug sensitivity.[99]

Unfortunately, the clinical value of nasal cytology in the assessment of sinusitis is limited, with specificity ranging from 40% to 90% and sensitivity from 67% to 80%.[100,101] This occurs because acute viral infections can induce nasal neutrophilia and transient abnormal imaging studies.[101] In addition, patients with AR and acute bacterial sinusitis will demonstrate a mixture of nasal eosinophilia and neutrophilia, potentially creating diagnostic confusion. At the same time, nasal cytology can provide some useful information: the absence of neutrophils (assuming an adequate sample) argues against an infectious component, and the presence of more than 10% eosinophils in a patient with chronic or recurrent disease suggests the potential for underlying AR or NARES.

Nasal-sinus biopsy. Nasal-sinus biopsy should be considered to aid in the diagnosis of nasal or paranasal lesions that obstruct sinus cavities and give rise to chronic or recurrent sinus disease. Clinical reasons to obtain a biopsy are (1) to determine whether a lesion is neoplastic and, if so, to clarify the nature of the neoplasm; (2) to confirm the presence of suspected invasive fungal disease; (3) to confirm the presence of granulomatous disease when the diagnosis is unclear on the basis of clinical or radiographic grounds; and (4) to provide an initial evaluation of the ultrastructure of cilia in patients with known or suspected ciliary dysfunction. In the presence of chronic inflammation, a tracheal biopsy is typically required for confirmation.

Nasal and paranasal sinus neoplasms. Early signs of sinus neoplasia are nonspecific and include nasal obstruction, anosmia, rhinorrhea, and pain. Accordingly, clinical suspicion of tumor is often delayed until epistaxis, proptosis, trismus, facial swelling, or cranial nerve (I/VI) dysfunction develop. Early diagnosis is enhanced by the use of CT or MRI. The most common tumor is an inverted papilloma, which is characterized by a polypoid appearance and unilateral location seen on both physical examination and imaging.

Tumors within the nose or sinuses are histologically diverse and both benign and malignant. Generally, a specific diagnosis is not reliable on the basis of clinical or radiographic findings, making a tissue biopsy invaluable.[102] Juvenile angiofibroma is a notable exception. Diagnosis is made on the basis of finding a vascular posterior nasal or nasopharyngeal mass in an adolescent or preadolescent male. Biopsy should not be performed because of the risk of significant hemorrhage.[103]

Invasive fungal infections. Fungal infection produced by phycomycetes (*Absidia*, *Mucor*, and *Rhizopus* species) can progress from the sinuses to the central nervous system and is potentially fatal. Similar rapidly fulminant infections can be caused by *Aspergillus* species. These fulminant diseases occur essentially only in the immunocompromised (eg, patients with diabetes mellitus, hematologic malignancies, adrenal suppression, chronic renal

failure, hematologic dyscrasia or overt immunodeficiency [eg, patients undergoing chemotherapy, intravenous drug users, and patients with HIV]) However, less fulminant and more indolent invasive disease might occasionally occur in the immunocompetent patient.

Patients with fulminant invasive fungal sinusitis often present with fever, which rapidly progresses to facial pain, proptosis, ophthalmoplegia, and/or facial necrosis. Late radiographic findings can include sinus opacification, mucoperiosteal thickening, bone erosion, and cavernous sinus thrombosis. Endoscopically, early lesions might appear brick red or as black necrotic areas. Suspicious lesions should be biopsied immediately, with the sample sent for fungal staining and culture. Early diagnosis can be critical in determining patient prognosis.[104]

Granulomatous inflammatory disease. Sinusitis can be associated with several granulomatous diseases, both infectious and noninfectious. Sarcoidosis is by far the most common of these disorders identified within the United States. Another noninfectious cause is midline granuloma–Wegener granulomatosis. Infectious causes include *Klebsiella* species–induced rhinoscleroma, tuberculosis, leprosy, syphilis, and fungal infections. Lesions can cause ulceration, necrosis, or hyperplastic mucosa. When such lesions are apparent, biopsy should be obtained to exclude neoplasia, and special staining and cultures should be done for mycobacteria and fungi.[105,106]

Cilia ultrastructure. When ciliary dysfunction is suspected in patients (eg, with recurrent or persistent infectious disease in the absence of underlying rhinitis, anatomic defects, or immunodeficiency), biopsy should be considered for ultrastructural analysis. Reported results include the type of defect (dynein defects are most specific), the percentage of cilia having the defect, the distribution of the defect (bronchial versus nasal if both areas are assessed), and the number of cilia present.[107,108] Because acquired ciliary defects can sometimes mimic primary ciliary dyskinesia in the presence of chronic inflammation, tracheal biopsy is frequently required for confirmation of this diagnosis.

Immunodeficiency tests. See the ''Immunodeficiency'' section.

Cystic fibrosis tests. See the ''Cystic fibrosis'' section.

Ciliary tests. See the ''Ciliary dysfunction'' section.

Miscellaneous tests. The role of nasopharyngeal culture in the diagnosis of acute sinusitis remains controversial. In the past, studies have suggested a poor correlation between the presence of nasal bacteria and the likelihood of active bacterial sinusitis; even in patients with culture-proved sinusitis, the bacteria present in the sinus was different from bacteria in the nasophayrnx. More recently, it has been suggested that the presence of pathogenic organisms (*S pneumoniae*, *H influenzae*, or *M catarrhalis*) in the nasopharynx of patients presenting with upper respiratory tract infection symptoms might define patients more likely to have bacterial disease.[109]

The value of routine hematologic tests (eg, erythrocyte sedimentation rate, white blood cell count, and C-reactive protein) was recently evaluated in 176 patients with acute maxillary sinusitis. In general, these tests were not sensitive indicators of disease or specific cause (82% of test results were normal). Increased C-reactive protein (>40 mg/L) was associated with likely infection with *Streptococcus pyogenes* or *S pneumoniae*, a fact that could influence choice and duration of therapy.[110]

In suspected Wegener granulomatosis, an antineutrophil cytoplasmic antibody test might be a useful adjunct to tissue biopsy.[111] Similarly, increases of angiotensin-converting enzyme and soluble IL-2 receptor levels might be of help in clarifying a suspected tissue diagnosis of sarcoidosis.[112]

Predisposing factors

Viral infections

Summary Statements

Summary Statement 32: Acute viral upper respiratory tract infections often precede acute bacterial sinusitis. **B**
Summary Statement 33: Viral upper respiratory tract infections are often (40% to 90% of the time) associated with CT evidence of sinusitis. Viral sinusitis appears to resolve within 21 days without the need for antibiotics. **B**
Summary Statement 34: There is minimal evidence that viruses play a role in chronic sinusitis. **B**

The average child in the United States has 3 to 8 viral upper respiratory tract infections per year; the average adult has 2 to 3 such infections. Up to 90% of these upper respiratory tract infections are associated with CT changes consistent with mucosal involvement within the sinuses.[113-115] Thus these subjects have acute viral sinusitis. Acute bacterial sinusitis is thought to follow 0.5% to 13% of these acute upper respiratory tract infections,[113,116,117] resulting in approximately 20 million bacterial infections.[118] The symptoms of patients with a viral upper respiratory tract infection and radiologic evidence of sinusitis are no different than those of subjects experiencing a cold uncomplicated by CT abnormalities.[119] In one study of CT abnormalities in patients with colds, 39% of patients with a cold had CT evidence of viral sinusitis, and all resolved within 21 days without the need for antibiotics.[119] This observation has been confirmed.[115]

Because many acute sinus infections resolve without the need for antibiotics, it has always been thought (but not proved) that viruses might be responsible for the symptoms in such patients. The technique of PCR allows amplification of small quantities of viral genomes to the level of detection. PCR analysis of the sinus mucosa obtained at surgery for chronic sinusitis in 20 patients revealed that 20% had positive results for respiratory syncytial virus and none for adenovirus. Thus a number of patients with chronic sinusitis might have had a predisposing viral infection.[120] By contrast, biopsy of the maxillary sinus mucosa in patients with acute sinusitis revealed that 50% had RNA evidence of rhinovirus.[121] The weight of the evidence supports the clinical observations that a sizeable number of acute sinusitis infections are caused by viruses but that viruses play a more limited

role in chronic sinusitis, except to predispose to possible superimposed acute bacterial sinusitis.

Allergic rhinitis

Summary Statements

Summary Statement 35: AR commonly precedes the development of recurrent or chronic sinusitis. The nasal obstruction and inflammation associated with AR interrupts normal mucociliary clearance and leads to retention of secretions within the sinus cavities. **B**
Summary Statement 36: Patients with recurrent or chronic sinusitis should be evaluated for the presence of underlying allergy. **B**

AR is one of the most common chronic diseases, accounting for approximately 2.5% of all physician visits. The incidence is estimated at 10% to 14% of the population at any time, with a cumulative prevalence ranging up to 20%. AR usually develops during childhood at the average age of 10 years, although 30% of patients have their onset of symptoms after age 30 years.[122-124]

Allergic inflammation leads to nasal congestion and swelling of the mucous membrane, which can obstruct or impede normal sinus drainage. Obstructed sinuses partially fill with secretions, use trapped oxygen, and become acidotic, leading to even more impaired mucociliary function and impaction of secretions. Bacteria, either already in the sinuses or gaining access because of abnormal ciliary flow, multiply, infecting the mucosal lining. Subsequent inflammatory responses in the epithelium lead to an influx of granulocytes, with swelling and pain from the mucosa and thickened secretions.

A number of observations support the association of AR and sinusitis both in adults and children. In children evidence of AR has been found in 36% to 60% of patients with chronic sinusitis.[125-127] Young adults with acute maxillary sinusitis had a 25% to 31% incidence of AR,[128,129] whereas chronic sinusitis was associated with AR in 40% to 84% of adult patients.[130-132] Newman et al[133] found an association between extensive sinus disease, quantified by means of CT, and allergy in 78% of patients and asthma in 71% of patients. Moreover, sinusitis in patients with AR is associated with more extensive abnormalities on CT scans.[134] About twice as many patients with AR, compared with normal subjects, have abnormal CT scans (67% versus 33%).[135] Although these studies would suggest a uniform association between allergy and sinusitis, other studies have failed to confirm differences between allergic and nonallergic subjects with sinusitis by means of CT scan.[136,137]

In a careful retrospective study of 200 patients with chronic sinusitis, McNally et al[138] found that more than half the patients had AR, and this diagnosis was considered the most important underlying cause of sinusitis. In one additional study, 43% of acute sinusitis was noted to be seasonal, the cause of which was thought to be allergic.[139]

A suggestive experimental link is derived from a study in which rhinomanometry was performed and maxillary sinus x-ray films were taken before and after nasal provocation tests.[140] Of 73 separate provocation tests, 41 led to early-phase responses only, 18 led to late-phase responses alone, and 10 yielded both early and late responses. Thirty-two of these patients experienced increased sinus mucosal edema and opacification of the paranasal sinuses, as revealed on sinus x-ray films. Concomitantly, increased pressure in the maxillary sinus, acute headaches, and associated otalgia were reported by patients. In addition, 3 of the patients who did not have an obvious clinical response had thickened mucosa and subjective symptoms. In view of the difficulty in performing direct paranasal sinus challenges, these nasal challenges provide an experimental link between AR and sinusitis. However, in contrast to this study involving experimental provocations, examination of ragweed-sensitive subjects in the midst of their allergy season demonstrated no consistent abnormalities on sinus CT.[141]

Does allergen enter the sinus through the nasal ostia and initiate an allergic response within the sinus cavity? As noted above,[140] experimentally instilled allergen in the nose can cause sinus edema and changes on CT scans, whereas other studies using radiolabeled pollen could show no evidence that pollen enters the sinus cavity.[142] Collection of fluid from patients with chronic sinusitis reveals the presence of allergic mediators, including histamine and leukotrienes,[143] inflammatory cells (including eosinophils),[143,144] and cytokines,[145,146] suggesting that allergic responses, inflammatory responses, or both participate in sinusitis.

In one recent study higher levels of eosinophil-derived neurotoxin and decreased levels of lysozyme were found in nasal fluids from patients with perennial AR with recurrent sinusitis compared with patients with either perennial AR alone or control subjects.[147]

Management of AR is focused on environmental control, pharmacologic management, and immunotherapy as an immunomodulating approach. The effective treatment of AR might decrease the frequency of sinusitis by reducing the inflammation and swelling in the nasal mucosa that compromises the sinus outflow tract, although at this time there are few or no studies that have focused on this end point. Patients with sinusitis, especially of a chronic or recurrent nature, should have an allergy evaluation.

Nonallergic rhinitis

Summary Statements

Summary Statement 37: NAR has a much higher prevalence than usually suspected. **B**
Summary Statement 38: The primary symptoms associated with NAR, congestion and increased secretions, are often found in patients with sinusitis. **B**
Summary Statement 39: NAR is one of the most frequent diseases occurring in patients with chronic sinusitis and might predispose toward the development of sinusitis. **B**

NAR, by itself or in combination with AR, occurs more frequently than commonly recognized. Recent data

suggest that about 40 million Americans have either pure NAR or mixed rhinitis, in which both NAR and AR contribute to the symptoms.[148] In one study 52% of 142 patients with rhinitis seen in an allergy clinic had NAR,[149] whereas in another study 17% of patients with rhinitis in an academic setting had NAR.[150] The European Community Respiratory Health Survey of 1412 subjects found 25% with NAR.[151] A recent retrospective survey conducted by the National Rhinitis Classification Task Force of 975 patients with rhinitis found 43% to have AR, 23% to have NAR, and 34% to have both diseases (mixed rhinitis).[148] The few studies that have reported incidence by sex suggest that women are disproportionately affected by NAR or mixed rhinitis.[152] Diagnosing NAR can be confusing because the primary symptoms (ie, rhinorrhea, nasal congestion, and postnatal drip) can be indistinguishable from those of AR. Diagnosis of NAR is made by a combination of careful history taking and exclusion: negative or irrelevant skin test responses rule out IgE-mediated rhinitis, and a history of symptoms triggered by environmental irritants suggests a diagnosis of NAR. Positive skin test responses do not, however, rule out NAR.[152,153] Patients with NAR often have normal nasal examination results, and epithelial scrapings are usually normal as well.

There are limited data on the incidence or frequency of distinct subtypes of NAR. A 1985 study of 78 patients with NAR showed that VMR was the major type of NAR, affecting about two thirds of the patients.[154] In another study VMR was present in 37% of 142 patients with rhinitis followed prospectively. Fifty-two percent of these patients were given diagnoses of NAR.[148] Some have estimated that more than 65% of all NAR is vasomotor in nature.[155]

VMR deserves special attention because of its high incidence in clinical practice. It is estimated that the prevalence of VMR in all patients is 5% to 10%, whereas the prevalence of AR is 15% to 17%.[155,156] VMR should be suspected in patients presenting with symptoms of chronic nasal congestion, rhinorrhea, or postnasal drip. These classic symptoms are sometimes accompanied by lack of taste or smell, sinus headache, chronic cough, and throat clearing.[152,153,156] A patient describing nasal symptoms in response to cold air; strong smells (eg, perfumes, tobacco, paint, or cleaning solutions); ingestion of alcohol; changes in temperature, humidity, and/or barometric pressure; or emotional stress has vasomotor symptoms. It should be emphasized that patients with AR or NAR might also respond to these triggers. Some have suggested that VMR be reserved for subjects in whom the nasal symptoms are more chronic in nature.[155,156] In recent years, the use of CT has revealed that many patients given diagnoses of VMR in fact have chronic sinusitis or other disorders. Thus the diagnosis of VMR has come under question.

NAR can be associated with sinusitis. In the only study of chronic sinusitis in which NAR was evaluated, 26% of patients had NAR. In the same study, more than half the patients had AR.[138] There have been no other studies in which NAR was estimated with respect to its relationship with sinusitis.

One study[157] described a series of patients with sneezing, watery rhinorrhea, nasal pruritus, and negative skin test and RAST results. Smears of secretions revealed eosinophilia, and this syndrome was identified as NARES. It is estimated that 15% to 20% of patients with NAR have NARES. NARES is found as an isolated syndrome or in conjunction with aspirin sensitivity. In general, patients with NARES have rather profound nasal symptoms and respond well to treatment with nasal corticosteroids. Some observers think that NARES can be associated with an increased risk of nasal polyps, and polyps are often found in patients with NARES with aspirin sensitivity.

GERD

Summary Statements

Summary Statement 40: GERD has been suggested as a cause of sinusitis. **D**
Summary Statement 41: pH probe monitoring of both children and adults with chronic sinusitis shows a high incidence of both esophageal and nasopharyngeal reflux. **B**
Summary Statement 42: Medical treatment of GERD in children and adults has been shown to result in significant improvement in sinusitis symptoms. **B**
Summary Statement 43: In patients with sinusitis refractory to medical therapy, treatment of associated GERD should be considered before surgical intervention. **B**

GERD has been suggested as a cause of sinusitis. The mechanism is thought to be direct reflux of gastric acid into the pharynx and subsequently to the nasopharynx, causing inflammation of the sinus ostium and leading to sinusitis.[158]

A study in 30 children with chronic sinusitis was done using 24-hour monitoring with dual-pH probes, one in the nasopharynx and one in the distal esophagus. Nineteen (63%) showed gastroesophageal reflux, well above the expected prevalence of 5% in the healthy general population. Of these 19, 6 (32%) demonstrated nasopharyngeal reflux. Seventy-nine percent improved their sinusitis symptoms after treatment of GERD. The recommendation of the authors was that children with chronic sinus disease refractory to medical therapy be evaluated for GERD and treated before sinus surgery is considered.[159]

A study in adults evaluated the prevalence of gastroesophagopharyngeal reflux in 11 patients with CT scan–confirmed chronic sinusitis who had not responded to conventional therapy and 11 healthy control subjects. A 3-site ambulatory esophagopharyngeal pH monitoring technique was used. Ambulatory pH monitoring documented gastroesophagopharyngeal reflux in 7 of 11 patients and 2 of 11 healthy volunteers.[160]

Another uncontrolled study involved 19 adult patients with chronic sinusitis, 18 of whom had undergone sinus surgery. Sixty-eight percent had classic GERD symptoms, and 78% had abnormal results on an esophageal pH probe.

Twelve were treated with proton-pump inhibitors, 4 were treated with proton-pump inhibitors and pyrokinetics, and 2 had repeat surgery. Six months later, 12 (67%) had improvement in sinus symptoms, with 4 having dramatic improvement. The authors suggest that medical therapy as a treatment for adults with chronic sinusitis be confined to patients with abnormal pH results.[161] Although an association between GERD and sinusitis has been suggested, a definitive causal relationship has not been proved in a well-performed controlled study. However, in patients with sinusitis refractory to medical therapy, treatment of associated GERD should be considered before surgical intervention.

Immunodeficiency

Summary Statements

Summary Statement 44: Immune deficiency should be considered in cases of sinusitis resistant to usual medical therapy. **B**

Summary Statement 45: The majority of immunodeficient patients with recurrent sinusitis have defects in humoral immunity. However, other types of immunodeficiencies might present with recurrent sinusitis as one of their clinical features, including AIDS. **B**

Summary Statement 46: The most common primary immunodeficiency disorders with recurrent sinusitis as a clinical feature are humoral immunodeficiencies, such as selective IgA deficiency and common variable immunodeficiency. Other primary immunodeficiencies that might present with recurrent sinusitis among other features include Wiskott-Aldrich syndrome, ataxia telangiectasia, warts, hypogammaglobulinemia, infections, myelokathexis syndrome, and caspase-8 deficiency. **C**

Summary Statement 47: Appropriate laboratory studies in patients with recurrent or chronic sinusitis might include quantitative immunoglobulin measurement (IgG, IgA, and IgM), specific antibody responses (tetanus toxoid and pneumococcal vaccine), and measurement of T-cell number and function (delayed hypersensitivity skin tests and flow cytometric enumeration of T cells). **B**

Immunodeficiency should be considered in any patient with recurrent or chronic sinusitis, particularly in patients in whom aggressive prior medical and surgical management has failed.[162] One study of medically diagnosed patients with therapy-refractory recurrent sinusitis found only 8 (3%) of 245 patients to have hypogammablobulinemia, impaired pneumococcal vaccine responses, or both.[163] However, a more rigorous study of 79 patients with sinusitis diagnosed radiographically and refractory to medical and surgical therapy revealed 10% of patients to have common variable immunodeficiency and 6% to have IgA deficiency.[162] Suspicion is heightened when the patient also has a history of recurrent otitis media, bronchitis, and/or bronchiectasis. When congenital immunodeficiency is suspected, the physical examination should focus on findings associated with specific diseases: absence of tonsillar tissue, ocular telangiectasia, skin and mucous membrane infections, eczema, clubbing, rales, rhonchi, petechiae, and purpura.[164] The majority of immunodeficient patients with recurrent sinusitis have defects in humoral immunity; however, patients with other types of immune defects might present with recurrent sinusitis, such as patients with AIDS who have combined humoral and cellular impairments.[165-168]

The indications for pursuing an immunodeficiency evaluation depend on the age, medical history, physical examination, and lifestyle of the patient. For example, in an infant of less than 2 years of age with recurrent and life-threatening infections of the sinuses and other organs, one should pursue this evaluation in an expeditious manner. In addition, infections with organisms of low pathogenicity should alert the physician to the probability of a congenital immune deficiency. Similar indications for evaluation of immune deficiency exist for AIDS in both children and adults.

Appropriate screening laboratory studies for immunodeficiencies might include quantitative immunoglobulin measurement (IgG, IgA, and IgM), specific antibody responses, and measurement of T-cell number and function (delayed hypersensitivity skin tests and flow cytometric enumeration of T cells). Although the post-immunization response to any protein antigen can be measured, assessment of response to tetanus immunization is particularly advantageous because most patients have been immunized, and 90% to 100% of children should have protective antibody titers after completing primary immunization.[168] The response to polysaccharide antigens can be determined by measuring preimmunization and postimmunization titers to unconjugated pneumococcal vaccine. The diagnosis of IgG subclass deficiency is controversial, and the clinical significance of abnormal IgG subclass levels in patients with recurrent infections is unclear (see ''Practice parameters for the diagnosis and management of primary immunodeficiency'').

The most common primary immunodeficiency disorders with recurrent sinusitis as a clinical feature are humoral immunodeficiencies, such as selective IgA deficiency[169] and common variable immunodeficiency.[166] Other primary immunodeficiencies that might present with recurrent sinusitis among other features include Wiskott-Aldrich syndrome,[170] ataxia telangiectasia,[171] warts, hypogammaglobulinemia, infections, myelokathexis syndrome,[172] and caspase-8 deficiency.[173] When these syndromes are clinically suspected, referral to a board-certified allergist-immunologist for evaluation and therapy is indicated.

Sinusitis is a recurrent or chronic problem in 30% to 68% of patients with HIV infection.[174,175] There might be a direct correlation between CD4 deficiency and increased likelihood of sinus disease. Specific antibody responses are abnormal in these patients, even though total serum immunoglobulin levels are often increased. Although there are case reports of infections with atypical organisms, most sinus infections in patients with HIV are caused by the same organisms involved in immunocompetent patients.[176] Accordingly, successful

treatment of these patients involves a much longer duration of aggressive standard therapy.

Cystic fibrosis

Summary Statements

Summary Statement 48: Virtually all patients with CF have sinusitis as a consequence of dehydration of mucosal fluids and sulfation of mucous glycoproteins, a combination resulting in retention of viscous tenacious sinus secretions that predispose to bacterial infection. **B**
Summary Statement 49: CF should be considered in any patient with chronic sinusitis at an early age or in children with nasal polyps. **B**
Summary Statement 50: The sinus pathogens in patients with CF are similar to those that cause recurrent bronchial infection in these patients: *P aeruginosa*, *H influenzae*, streptococci, *Burkholderia cepacia*, *S aureus*, diphtheroids, and anaerobes. Fungi are also cultured frequently. This might result in an allergic fungal sinusitis similar pathologically to allergic bronchopulmonary aspergillosis. **B**
Summary Statement 51: Younger children with CF with sinusitis not yet colonized with *Pseudomonas* species should be treated with a high dose and prolonged course (3-6 weeks) of antibiotics (eg, amoxicillin-clavulanate, cefdinir, cefuroxime, or cefpodoxime). Older children typically need coverage for *P aeruginosa* with an oral quinolone (eg, ciprofloxacin, levofloxacin, gatifloxacin, or moxifloxacin). Treatment failures are common, and intravenous tobramycin, ceftazidime, or both or imipenem-meropenem are often required. **A**

CF is a disorder caused by mutations in the CF transmembrane conductance regulator gene (CFTR) on the long arm of chromosome 7.[177] The heterozygous carrier rate for such mutations is about 3% to 4%, with clinical disease occurring in about 1:2000.[178] Disease occurs when the *CFTR* defect is severe enough to decrease chloride ion transport and associated transport of water: the end result is increased viscosity of all exocrine secretions, particularly in the airway (nose, sinuses, and lungs) and gastrointestinal tract.[179]

The gold standard for diagnosis is the Gibson-Cooke sweat test or quantitative pilocarpine iontophoresis. Assuming that at least 75 mg of sweat is obtained, chloride levels greater than 60 mEq/L are considered diagnostic in children; adults can have values 10 to 15 mEq/L higher than this.[180] A sweat test should be performed in any child with nasal polyps or any patient with chronic colonization of the nose-sinuses with *Pseudomonas* species/*B capacia*.[181,182] When results are equivocal, the diagnosis can be clarified by means of DNA analysis for known genetic mutations. To date, more than 230 alleles have been described.[178,183] The most common mutation, ΔF508, accounts for greater than 70% of cases. This defect involves a 3-bp deletion that creates a *CFTR* product missing a phenylalanine residue. The ΔF508 product is unable to traffic out of the cytoplasm and remains nonfunctional. Recent studies suggest that abnormal *CFTR*s are a common occurrence in patients with chronic infectious sinusitis, affecting as many as 12% of patients. Most have milder mutations and accordingly do not demonstrate the full clinical spectrum of CF.[174-186]

Virtually all patients with CF have sinusitis as a consequence of dehydration of mucosal fluids and sulfation of mucous glycoproteins, a combination resulting in retention of viscous and tenacious sinus secretions that predisposes to bacterial infection.[179] Infection subsequently stimulates even more thick mucus production, which induces a vicious chronic cycle of sinus disease. In fact, secretions are typically so thick that antibiotics do not perfuse well, and surgical lavage is generally needed.[187] CF is an important consideration in all patients who experience chronic sinusitis in early age, particularly if they had their first operation before the age of 20 years.

Patients with CF also have a high incidence of nasal-sinus polyps, although the ostiomeatal complex is often patent in individuals with CF (in contrast to patients with non-CF polyps, in whom obstruction is nearly universal). Studies have shown the incidence of nasal polyps in patients with CF to range from 10% to 50%, with frequencies increasing in older populations.[188-191]

As a consequence of thick, inspissated respiratory secretions and the presence of nasal polyps, radiographic evidence of sinus disease is invariably present in patients with CF, occurring in 92% to 100% of patients older than 2 years.[192,193] As is the case in patients without CF with asthma, it is now appreciated that sinusitis in patients with CF can be an important exacerbating factor of lower airway disease.[193]

Clinical signs and symptoms of sinusitis in patients with CF are similar to those in patients without CF, although often more subtle because patients become accustomed to having sinus symptoms. Physical examination findings are also similar, except for the higher incidence of polyps.[187,194]

The sinus pathogens in patients with CF are similar to those that cause recurrent bronchial infection in these patients: *P aeruginosa*, *H influenzae*, streptococci, *Escherichia coli*, *S aureus*, *B cepacia* diphtheroids, and anaerobes. Fungi are also cultured frequently, causing an allergic fungal sinusitis similar pathologically to allergic bronchopulmonary aspergillosis. Although *Aspergillus fumigatus* accounts for most cases, *Pseudallescheria boydii* has also been observed.[195]

Younger children with CF with sinusitis, who have not yet been colonized with *Pseudomonas* species, often are successfully treated with a high dose and prolonged course (3-6 weeks) of antibiotics (eg, amoxicillin-clavulanate, cefdinir, cefuroxime, or cefpodoxime). Older children and adults typically need coverage for *P aeruginosa* with an oral quinolone (eg, ciprofloxacin, levofloxacin, gatifloxacin, or moxifloxacin). Treatment failures are common, and intravenous tobramycin, ceftazidime, or both are often required to obtain clinical control. Even with improvement, oral or intravenous antibiotics rarely

sterilize the sinuses of patients with CF, and intermittent antipseudomonal antibiotic lavage of the sinuses might be required.[196]

Ciliary dysfunction

Summary Statements

Summary Statement 52: Primary ciliary dyskinesia is a rare autosomal recessive group of disorders occurring in 1 in 20,000 live births. The majority of patients with ciliary dyskinesia have recurrent otitis media, sinusitis, and pneumonia with bronchiectasis. Nearly half of the patients have situs inversus with or without dextrocardia. **B**

Summary Statement 53: Functional cilia tests include visual and videoscopic measurement of tissue and mucociliary transport; examples include the saccharin or disc movement tests. **B**

Summary Statement 54: The saccharin test for mucociliary transport is useful for screening. In this test a small amount of saccharin is placed at the bottom of the inferior meatus. Normally, the patient should detect the saccharin within 6 to 10 minutes. Abnormal or equivocal results could be confirmed by means of nasal biopsy and electron microscopy. **B**

Summary Statement 55: In cases of resistant bacterial sinusitis in which other underlying causes, such as immune deficiency, have been eliminated, consideration should be given to ciliary dysfunction. **B**

Primary ciliary dyskinesia is a rare autosomal recessive group of disorders occurring in 1 in 20,000 live births. It can be observed in as many as 5% of children with chronic respiratory infections arising in the first weeks of life.[197-200] The majority of these patients have recurrent otitis media, sinusitis, and pneumonia with bronchiectasis.[200,201] Affected patients are generally sterile because defects are associated with sperm and fallopian tube dysfunction. Nearly half of the patients have situs inversus with or without dextrocardia, a constellation of clinical findings first described in 4 patients by Kartagener in 1933.[202] In these defects loss of normal mucociliary transport increases susceptibility to bacterial infection. Some defects are also associated with abnormal neutrophil chemotaxis.[200]

Functional cilia tests include visual and videoscopic measurement of tissue and mucociliary transport. Examples include the saccharin or disc movement tests. Visual assessment can be done by collecting ciliated cells, which are then suspended on a glass slide.[203] Ciliary motion is observed by means of light or phase microscopy and is considered abnormal if the beat frequency is less than 10 per second.

The saccharin test is useful for screening.[204] A small amount of saccharin is placed at the bottom of the inferior meatus. After 3 minutes, the patient swallows every 30 seconds until a sweet taste is detected. Normally, the patient should detect the saccharin within 6 to 10 minutes.[205] Abnormal or equivocal results could be confirmed by means of electron microscopic ultrastructural analysis.[206] In the presence of chronic inflammation (eg, because of infection or smoking), ciliary function might be compromised. In fact, improvement in saccharin clearance has been demonstrated after successful endoscopic sinus surgery.[207] In the setting of chronic sinusitis, a tracheal biopsy (noninflamed area) might be required for confirmation of suspected primary cilia defects. Defective cilia might be missing any of the following components: outer dynein arms, inner dynein arms, entire dynein arms, central pair, central sheath, radial spokes, or nexin links.[197]

Associated conditions

Otitis media

Summary Statements

Summary Statement 56: Many similarities exist between otitis media and sinusitis, including histology, pathogenesis, and risk factors. **A**

Summary Statement 57: Otitis media and sinusitis frequently coexist. **A**

Summary Statement 58: In patients with acute bacterial sinusitis, one should look for the presence of otitis media. The converse is also true. **A**

There are many clinical similarities between otitis media and sinusitis, and as has been suggested by at least one investigator, the middle ear might be considered a paranasal sinus, with the eustachian tube serving as the sinus ostium.[208] The lining of the middle ear and the sinus cavities is comprised of ciliated, pseudostratified columnar cells. The 3 major pathogens that cause acute otitis media and acute bacterial sinusitis, *S pneumoniae*, *H influenzae*, and *M catarrhalis*, are the same. The important risk factors for both acute bacterial otitis media and acute bacterial sinusitis are viral upper respiratory tract infections and AR or NAR. The peak age incidence of acute otitis media is between 6 and 18 months. Bacterial sinusitis is most common between 2 and 6 years of age.

In many children acute otitis media begins soon after the onset of a viral upper respiratory tract infection, which leads to the initiation of antibiotic therapy before the development of acute bacterial sinusitis. When children with acute bacterial sinusitis are evaluated, acute otitis media is a variable finding. In one study acute otitis media and sinusitis were concurrent 40% of the time.[209] However, in another report it was rarely necessary to exclude children from a placebo-controlled trial of antibiotic therapy for acute sinusitis because of acute otitis media.[210] When children with either persistent middle ear effusion or chronic rhinitis-sinusitis are evaluated, it is common to find evidence of persistent inflammation at the other site.[211-213] Another common feature in children with recurrent acute or persistent sinusitis is a history of recurrent acute otitis media. This association is not seen as frequently in adults.

Asthma

Summary Statements

Summary Statement 59: The association between sinusitis and asthma is extremely high. **B**
Summary Statement 60: Although a number of theories have been proposed to explain this relationship, no direct causal factor has yet been found. **D**
Summary Statement 61: Studies in both adults and children suggest that medical and surgical management of sinusitis results in objective and subjective improvement of asthma. **C**

The association between sinusitis and asthma has long been appreciated. In one study 100% of subjects with steroid-dependent asthma had abnormal CT scans of the sinuses compared with 88% of subjects with mild-to-moderate asthma.[214] In another group of patients with severe asthma, 84% showed CT abnormalities. There was a significant correlation between CT scores, eosinophils in peripheral blood and induced sputum, and level of exhaled nitric oxide.[215] The sinusitis typically associated with asthma has been termed *chronic hyperplastic eosinophilic sinusitis*, which is often associated with nasal polyps.

Although these studies suggest that sinusitis triggers or worsens asthma, it could be argued that they merely coexist and represent different end products of the same inflammatory process occurring in different organ systems.[216]

Mechanisms relating sinusitis and asthma. Various mechanisms have been proposed to explain the relationship between sinusitis and asthma. They include nasopharyngeal bronchial reflex,[217] pulmonary aspiration of inflammatory cells and mediators,[218] inhalation of dry cold air,[219] and local upper respiratory tract inflammation leading to pulmonary inflammation.[220]

In one intriguing study of 106 patients with acute exacerbations of chronic sinusitis, histamine challenges to the lower airway before and after medical treatment of sinusitis were performed. FEV_1 was measured as an index of bronchial narrowing, and midinspiratory flow was measured as an index of extrabronchial airway narrowing.[221] Both intrabronchial and extrabronchial hyperreactivity decreased, with the reduction in extrabronchial hyperreactivity being more pronounced and preceding the decrease in intrabronchial hyperreactivity. The changes in intrabronchial and extrabronchial reactivity were strongly associated with pharyngitis, as determined by history, physical examination, and nasal lavage. The authors propose that airway hyperresponsiveness in sinusitis might depend on pharyngobronchial reflexes triggered by the postnasal drip of inflammatory mediators and infected material from infected sinuses into the pharynx.

In a later study, these same authors demonstrated actual damage of pharyngeal mucosa in patients with chronic sinusitis marked by epithelial thinning and a striking increase in pharyngeal nerve fiber density.[222] This would favor increased access of irritants to submucosal nerve endings, inducing the release of sensory neuropeptides through axon reflexes with activation of a neural arch, resulting in reflex airway constriction.

The linkage previously described between asthma and severity of sinusitis, including eosinophils in peripheral blood and sputum and nitric oxide levels in exhaled air, would support the concept that the influence of upper respiratory disease on asthma is mediated through the circulation. It has been hypothesized that inflamed sinus tissue not only releases mediators and cytokines into the circulation, thereby directly inducing inflammation of the upper airway, but also releases chemotactic factors that recruit eosinophils from the bone marrow and from the circulation into the upper and lower airways.[220]

Effects of medical and surgical treatment of sinusitis on asthma. Perhaps the most direct evidence of a cause-and-effect relationship of sinusitis to asthma is provided by studies that show significant improvement in asthma symptoms when sinusitis is appropriately treated. Two uncontrolled observational studies in children with combined infectious sinusitis and asthma have demonstrated significant improvement in the asthmatic state, including pulmonary function when sinusitis was medically treated.[223,224] Comparable studies have not been done in adults.

Sinus surgery has also been shown to result in improvement in lower airway disease. In one study 15 adult patients with chronic sinusitis who required inhaled corticosteroids and at least intermittent oral prednisone to control asthma showed an improvement in symptoms and a decrease in both total dosage and number of days of systemic corticosteroid use in the postoperative year.[225] More objective findings were reported in an uncontrolled study on adult patients who not only showed improvement in symptoms but also had a significant increase in peak expiratory flow after endoscopic sinus surgery.[226]

Although these reports are encouraging, it is evident that randomized, blind, controlled trials are needed in both children and adults to assess therapies of chronic sinusitis and the response of asthma. Further research is required to establish the relationships between the upper and lower airways.

Treatment

Medical

Antibiotics

Summary Statements

Summary Statement 62: Antibiotics are the primary therapy for bacterial sinusitis. **A**
Summary Statement 63: The most common bacteria observed in acute sinusitis, recurrent acute sinusitis, and acute exacerbations of chronic sinusitis are *S pneumoniae*, *H influenzae*, and *M catarrhalis*. **A**
Summary Statement 64: The appropriate duration of antibiotic therapy for acute sinusitis is not well defined. **D**

TABLE IV. Commonly used antibiotics for sinusitis

Antibiotic	Pediatric dosage	Adult dosage
Amoxicillin	45 mg/kg BID	500 mg BID
Amoxicillin/potassium Clavulanate	22.5-45 mg/kg BID*	500-875 mg BID†
Erythromycin/sulfisoxazole	12.5/37.5 mg/kg QID	—
Sulfamethoxazole/ trimethoprim	200/40 mg/kg BID‡	800/160 mg/kg BID
Cefuroxime	7.5 mg/kg BID	250-500 mg BID
Cefpodoxime	5 mg/kg BID	200-400 mg BID
Cefprozil	15 mg/kg BID	250-500 mg BID
Cefixime	8 mg/kg QD	400 mg QD
Ceftibuten	9 mg/kg QD	400 mg QD
Azithromycin	5 mg/kg QD§	250 mg QD§
Clarithromycin	7.5 mg/kg BID	500 mg BID
Ciprofloxacin	—	500-700 mg BID
Levofloxacin	—	500 mg QD
Grepafloxacin	—	400 mg QD
Trovafloxacin	—	200 mg QD
Gatifloxacin	—	400 mg QD
Clindamycin	15 mg/kg TID	150-450 mg TID, QID
Metronidazole	7.5 mg/kg TID	250-500 mg TID, QID
Telithromycin	—	800 mg QD‖

BID, Twice daily; *QID*, 4 times daily; *QD*, every day; *TID*, 3 times a day.
*Based on amoxicillin component.
†Maximum adult dose, 4.0 g twice daily.
‡Based on trimethoprim.
§Typically 5-day course after 10 mg/kg (pediatric) or 500 mg (adult) load equals 10 days total therapy.
‖Typically a 5-day course.

Summary Statement 65: Choice of antibiotic should be based on predicted effectiveness, cost, and side effects. **D**
Summary Statement 66: Antibiotic treatment of uncomplicated viral upper respiratory tract infection is inappropriate and discouraged strongly. **D**

Antibiotics are the primary form of medical treatment for acute bacterial sinusitis (Table IV). This has been the consensus of the guidelines published by several national organizations.[227-231] Because direct antral puncture is rarely performed in clinical practice, the appropriate choice of an antimicrobial agent should be based on likely bacterial pathogens consistent with the clinical history. In patients with acute sinusitis, recurrent acute sinusitis, and acute exacerbations of chronic sinusitis, the most common bacteria observed are *S pneumoniae*, *M catarrhalis*, and *H influenzae*. Penicillin resistance among *S pneumoniae*, mediated by alteration in penicillin-binding proteins, has been increasing over the last several years, and at present, 25% to 50% of strains are relatively or highly resistant.[232,233] In most, but not all, cases, the resistance of *S pneumoniae* to penicillin or ampicillin can be overcome by increasing the prescribed dose to 90 mg/kg/d in 2 divided doses (maximum dose of amoxicillin is 1.0 g every 12 hours). In most geographic areas nearly 50% of *H influenzae* and 90% to 100% of *M catarrhalis* are β-lactamase positive.[233] Studies of patients with more protracted or refractory disease suggest that anaerobic bacteria and staphylococci are increasingly being identified as pathogens. However, the role, if any, of bacteria in many patients with chronic sinusitis is controversial.[8,21]

Amoxicillin is a reasonable initial antibiotic choice in both children and adults with uncomplicated disease. It is generally effective, it is relatively inexpensive, and side effects are rare. A substantial drawback of amoxicillin is lack of effectiveness against β-lactamase–producing strains. There is a wide geographic variation in β-lactam–resistant organisms.[234] This negative aspect can be overcome by the addition of a β-lactam salt, potassium clavulanate, which can inhibit the β-lactamase enzymes. Such a combination of amoxicillin–potassium clavulanate is typically effective against most β-lactamase–producing *H influenzae*, *M catarrhalis*, *S aureus*, and anaerobic bacteria. Gastrointestinal symptoms, including cramping and diarrhea, might occur. These side effects usually reverse quickly when the agent is discontinued.

Whether laboratory-demonstrated resistance is necessarily equated with clinical resistance has not yet been established. However, in general, there is good correlation between antibiotic resistance and clinical failure. Although some patients do recover spontaneously, most clinical failures will be among patients with resistant organisms.

Sulfamethoxazole-trimethoprim and erythromycin-sulfisoxazole are combination agents that were popular for the treatment of acute sinusitis in the past, the latter primarily in children. Although a meta-analysis conducted by the New England Medical Center for the Agency for Health Care Policy and Research concluded that therapy of uncomplicated acute bacterial sinusitis with folate inhibitors was as effective as newer and more expensive antibiotics, they acknowledged that data were sparse and of low quality.[234] Currently, *in vitro* evidence indicates that in certain areas there are high rates of resistance to sulfamethoxazole-trimethoprim present in *S pneumoniae*, *H influenzae*, and *M catarrhalis*.[235] Erythromycin-sulfisoxazole is accompanied by frequent side effects and is not particularly potent.

Cephalosporins are commonly prescribed for both acute and chronic sinusitis. First-generation agents, such as cephalexin and cefadroxil, have the disadvantage of poor coverage for *H influenzae* and are therefore inappropriate. Cefaclor, an early second-generation cephalosporin has inadequate activity against all β-lactamase–producing *M catarrhalis* and some, but not all, *H influenzae*. In addition, the high prevalence of serum sickness–like reactions makes it an unattractive candidate for treatment.

Other second-generation cephalosporins are cefuroxime axetil and cefprozil. These drugs have the advantage of twice-daily administration and significantly enhanced activity against β-lactamase–producing *H influenzae*, *M catarrhalis*, and *S aureus*.[236] These agents are available as suspensions and therefore can be easily used in young children, but cefuroxime axetil is unpalatable in suspension.

Cefixime, ceftibuten, cefpodoxime axetil, and cefdinir are third-generation cephalosporins, which can be given orally once or twice daily. Both cefixime and ceftibuten have poor activity against *S pneumoniae* and are especially ineffective against penicillin-resistant strains. Neither of these drugs should be used for acute bacterial sinusitis. Cefpodoxime and cefdinir are suitable agents.[237]

There is theoretic concern regarding the 2 erythromycin analogues azithromycin and clarithromycin. Because both are relatively weak against penicillin-resistant *H influenzae* and *S pneumoniae*, this might lead to increasing resistance to macrolides.[235]

The new ketolide telithromycin provides a targeted spectrum of activity against common respiratory pathogens, such as *S pneumoniae*, including macrolide and penicillin-resistant strains, *H influenzae*, *M catarrhalis*, and atypicals.[238]

In adults ciprofloxacin, levofloxacin, gemifloxacin, moxifloxacin, and grepafloxacin presently have specific indications for the treatment of sinusitis.[239] Sparfloxacin might show enhanced gram-positive coverage but lacks the specific indication for sinusitis and has a significant risk for phototoxicity. There has been concern about adverse effects on developmental joint formation with all quinolones. In one report involving more than 6000 fluoroquinolone-treated children, the incidence of tendon or joint disorders was less than 1% and was comparable with that of the reference group, children treated with azithromycin.[240]

In protracted or severe cases of sinusitis, the possibility of anaerobic pathogens should be considered. Generally, these organisms are sensitive to penicillin, but those that are resistant, including *Prevotella* species, respond to amoxicillin-clavulanate. If the clinical course suggests that an anaerobe is a likely pathogen, clindamycin or metronidazole might be considered in combination therapy with a broad-spectrum drug. Although clindamycin is generally well tolerated, patients should be alerted to the possibility of pseudomembranous enterocolitis and told to contact their physician for any sign of diarrhea or bloody stools.

The appropriate duration of antibiotic therapy for sinusitis is not well defined.[228] A 10- to 14-day course of antibiotic might be adequate for most patients with acute disease. Some experts suggest that patients should be treated until they are free of symptoms plus 7 days.[228] It has been recommended that if there is no clinical improvement in children within 3 days of initiating antimicrobial therapy, an alternative antibiotic should be considered.[228]

The role of antibiotics in patients with chronic sinusitis is controversial.[8,21] These patients might require antibiotics for acute exacerbations of chronic sinusitis, and then amoxicillin potassium clavulanate is a good selection. The underlying symptoms, often attributable to AR or NAR will benefit most from therapy directed at the specific problem.

Regrettably, there are no published studies on antibiotic prophylaxis in patients with recurrent sinusitis. However, the prophylactic use of antibiotics in patients with recurrent sinusitis can be considered in carefully selected patients, such as those with immunodeficiency disorders.[228] Recurrent sinusitis is frequently defined as 3 episodes in 6 months or 4 episodes in 12 months. An initial approach with antibiotic prophylaxis might include initiating antibiotic therapy at the first sign of a new respiratory illness. If this fails, the next step would include once-daily administration of an antibiotic during the fall and winter, when viral upper respiratory tract infections are more likely to compromise ostiomeatal clearance. The potential value of this approach is suggested from studies of children with recurrent otitis media.[241,242]

There has been interest in administering topical antibiotics through the inhalation route as a compounded formulation delivered by means of aerosol or nebulizer. Antibiotics used for this purpose include tobramycin, gentamicin, ciprofloxacin, levofloxacin, and some cephalosporins. Several uncontrolled studies have claimed improvement.[243,244] In the absence of adequate randomized controlled studies demonstrating the clear effectiveness of aerosolized antibiotics for acute or chronic sinusitis, no definite conclusions can be drawn regarding the effectiveness of this form of therapy.

Because of a lack of convincing evidence, the role of antifungal agents in chronic sinusitis has not yet been established.

Several agencies have published guidelines concerning the diagnosis and management of acute bacterial sinusitis, in part to promote the judicious use of antibiotics.[227-230] These guidelines, which have been endorsed by the Centers for Disease Control and Prevention, the American College of Physicians–American Society of Internal Medicine, the American Academy of Family Practice, the American Academy of Pediatrics, and the Infectious Diseases Society of America, conclude that most cases of acute sinusitis are caused by uncomplicated viral infections. Antibiotic treatment of uncomplicated viral upper respiratory tract infections is inappropriate and should be discouraged. In these uncomplicated cases, a 7- to 10-day course of watchful waiting for spontaneous resolution of symptoms before prescribing antibiotics is recommended. Antibiotics should be considered in those patients with severe signs and symptoms of sinusitis, regardless of duration of illness. These would include worsening symptoms after 3 to 5 days, temperature of greater than 39°C, maxillary tooth or facial pain (especially when unilateral), unilateral sinus tenderness, and periorbital swelling.

Antihistamines

Summary Statements

Summary Statement 67: There are no data presently to recommend the use of H_1 antihistamines in acute bacterial sinusitis. **D**

Summary Statement 68: There might be a role for antihistamines in chronic sinusitis if the underlying risk factor is AR. **D**

Both first- and second-generation H_1 antihistamines have a major role in the treatment of AR, allergic conjunctivitis, cutaneous allergic disorders, and anaphylaxis. In addition, 2 recent studies have shown a modest beneficial effect of first-generation antihistamines on sneezing and rhinorrhea in the common cold.[245,246] However, a role for the use of these agents in the treatment of sinusitis has not been demonstrated, and they were not recommended in the recent guidelines for the diagnosis and management of sinusitis in children.[117]

α-Adrenergic decongestants

Summary Statements

Summary Statement 69: Topical and oral decongestants are often used in the therapy of acute or chronic sinusitis because they decrease nasal resistance and theoretically increase ostial patency. **D**
Summary Statement 70: Prospective studies are lacking and are needed to assess the value of α-adrenergic agents in the prevention or treatment of sinusitis. **D**

There has been relatively little systematic study of decongestant therapy in adults with the common cold and no study in either children with the common cold or patients of any age with sinusitis.[247] Decongestants have a modest effect in decreasing nasal airway resistance and improving symptom scores in adults with a cold. Theoretically, both topical and oral decongestants used in the therapy of acute or chronic sinusitis might widen the ostia and reduce turbinate swelling, thus promoting sinus and nasal ventilation.

Pharmacology. Decongestants can produce their effects through 2 broad mechanisms. First, direct-acting sympathomimetic drugs activate α-adrenergic receptors, resulting in vasoconstriction.[248] Second, indirect-acting sympathomimetic agents function by being taken up into the prejunctional nerve terminal, where they displace norepinephrine from storage vesicles. The displaced norepinephrine is then released from the sympathetic nerve terminal to postjunctional α-adrenergic receptors, producing vasoconstriction.

Side effects of decongestants. Topical agents used as nasal sprays act rapidly, usually within minutes, and therapeutic doses have no systemic side effects. Rebound hyperemia or rhinitis medicamentosa, however, is a frequent side effect in patients who use the drugs over an extended period of time.

Oral decongestants cause generalized constriction of blood vessels, and increased arterial pressure is always of concern. Most available oral agents, however, cause blood pressure increases in healthy persons only at doses that significantly exceed those that are recommended. Other possible adverse effects are reflex bradycardia, central nervous system stimulation and insomnia, urinary retention, mydriasis (with effects on glaucoma), and effects on endocrine and other regulators of metabolic function. Only 2 drugs are commonly used as oral decongestants: pseudoephedrine and phenylephrine. Direct-acting sympathomimetics, such as phenylephrine and oxymetazoline, activate α_1- and α_2-adrenergic receptors, respectively, and both cause vasoconstriction and a decrease in nasal congestion.

The US Food and Drug Administration has mandated the withdrawal of all over-the-counter products that contain phenylpropanolamine because of the risk of hemorrhagic stroke in women.[249,250]

Glucocorticosteroids

Summary Statements

Summary Statement 71: The use of systemic corticosteroid therapy for sinus disease has not been studied systematically in a well-controlled or blinded manner. **D**
Summary Statement 72: A few recent studies suggest that the addition of intranasal corticosteroids as an adjunct to antibiotic therapy might be modestly beneficial in the treatment of patients with recurrent acute or chronic sinusitis. **C**

Researchers and clinicians agree on the potential usefulness of corticosteroids as potent anti-inflammatory agents and the fact that sinusitis is an inflammatory disease. The leap from this logical association to clinical proof of the effectiveness of corticosteroids in managing sinus disease has been difficult.

The anti-inflammatory activities of corticosteroids include decreased vascular permeability, inhibition of release, and/or formation of mucous secretagogues, including histamine, leukotrienes, platelet-activating factor, and prostanoids, as well as inhibition of inflammatory cell infiltration, especially eosinophils.

Topical corticosteroids have a clear effect on inflammatory cell influx into the nasal mucosa after nasal antigen challenge.[251] Pretreatment of nasal mucosa with inhaled steroid has been shown to modify both the immediate- and late-phase response after antigen challenge.[252] Glucocorticosteroids also inhibit antigen-induced nasal hyperresponsiveness to histamine.[253] Numerous clinical trials attest to the efficacy of topical corticosteroids in controlling symptoms of AR.[254,255]

Although intranasal corticosteroids are unlikely to reach the interior of the paranasal sinuses, their relative safety, their recognized anti-inflammatory effect, and their documented efficacy in relieving nasal congestion make intranasal corticosteroids a reasonable adjunctive therapy for the treatment of sinusitis. Most studies evaluating the effectiveness of intranasal corticosteroids, even randomized controlled studies, use study designs that make it difficult to conclude that the use of intranasal corticosteroids is effective in the treatment of sinusitis.[256-261] It is, in particular, difficult to separate improvement in manifestations of sinusitis from improvement in nasal congestion, which is a significant component of sinusitis and for which intranasal corticosteroids have been shown to be effective. The effectiveness of intranasal corticosteroids in the treatment of sinusitis will need to be conclusively demonstrated in carefully designed studies in the future.

Nasal polyps are a common accompaniment of chronic sinusitis, and there is good evidence that they are favorably affected by intranasal and systemic corticosteroids.[262,263]

Adjunctive therapies: Saline, mucolytics, and expectorants

Summary Statements

Summary Statement 73: There are several scientific studies that imply but do not directly confirm a role for these agents in sinusitis. **D**
Summary Statement 74: Use of all these agents as prophylaxis for exacerbations of chronic sinusitis is empiric and not supported by clinical data. **D**
Summary Statement 75: These agents are commonly used and in some instances might be beneficial in some patients. **D**

Medical management of sinusitis is based on empiric goals. Adjunctive agents are frequently prescribed in addition to antibiotics in the hope of facilitating drainage of retained secretions through the sinus ostia into the nasal cavity. Use is based on clinical experience.[264-266]
Pharmacologic agents: Guaifenesin. Guaifenesin (glyceryl guaicolate; 3-(2 methoxyphonoxy)-1, 2-propanediol) is a water- and alcohol-soluble substance that has been used as an expectorant to loosen phlegm and bronchial secretions in the symptomatic management of cough associated with the upper and lower respiratory tract infections that occur when these conditions are complicated by tenacious mucus, mucus plugs, or both and congestion. There is clinical evidence that guaifenesin is an effective expectorant in that it increases expectorated sputum volume over the first 4 to 6 days of a productive cough, decreases sputum viscosity and difficulty in expectoration, and improves associated symptoms. However, there is currently insufficient evidence to support efficacy of the drug as an adjunct in sinusitis because no clinical trials have been reported in sinusitis to demonstrate its efficacy.[267]
Pharmacologic agents: Iodine. Iodine-containing compounds, such as potassium iodide or iodinated glycerol, might be expected to have similar effects as guaifenesin. However, they are of limited clinical use, and no studies in sinusitis have been reported.
Nonpharmacologic adjuncts. Many nonpharmacologic measures are advocated for symptomatic relief of acute sinusitis. Because scientific data on efficacy are lacking, physicians might dismiss some of these measures as folk medicine. For many patients, however, one or more of these treatments could provide effective relief of distressing symptoms while the infection is resolving. Unfortunately, most of these measures are short lived in effectiveness, and they must be repeated as symptoms recur.
Saline. Saline prevents crusting of secretions in the nasal cavity, especially in the region of the ostiomeatal complex. This facilitates mechanical removal of mucus through either nose blowing or suction. Theoretically, hypertonic saline might reduce mucosal edema and enhance mucociliary clearance and secondarily improve the patency of the sinus ostia.[268] In a cross-over study 21 healthy volunteers underwent nasal irrigation with either buffered normal saline or buffered hypertonic saline, followed by assessment of their mucociliary clearance with the saccharin clearance method. The outcome showed hypertonic saline nasal irrigation to improve mucociliary transit times, whereas normal saline had no effect. This study should be repeated in patients with acute and also chronic sinusitis.

In a study of 30 patients aged 3 to 16 years with chronic sinusitis,[269] subjects were stratified by age and severity and randomized to receive either normal saline or hypertonic saline nose drops 3 times daily for 4 weeks. Outcome was evaluated by a comparison of a nasal, cough, and radiology score. The hypertonic saline group improved significantly in all scores in comparison with the normal saline group, in which improvement was observed in only the nasal score.

Two other studies have claimed a benefit from hypertonic saline nasal washes.[270,271] However, the absence of a comparator group in one and possible placebo effect in the other weaken their conclusions. The optimal delivery system for the hypertonic saline (water pick, ultrasonic Rhinoflo nasal spray, or nose drops) has not been clarified.
Steam. The traditional method of steam inhalation is to instruct the patient to do the following:

1. Pour boiling water in a pan or basin on a low table.
2. Sit at the table with a towel draped over the head to make a tent over the pan of water.
3. Hold the face a few inches above the water and breathe through the nose for approximately 10 minutes.

This procedure liquefies and softens crusts while moisturizing the dry inflamed mucosa.
Astringents. Adding pine oil or mentholated preparations, such as Vicks VapoRub (Proctor & Gamble, Cincinnati, Ohio), oil of eucalyptus, or similar aromatics, might add to the beneficial effect of the steam treatment. Such additions could help relieve stuffiness or at least produce a subjective sensation of increased air flow. Again, there are no scientific data to support these therapies, but patients often believe that they help.
Spicy foods. Garlic has an active ingredient (n-allythiosulphinate) that provides short-lived decongestant effects. Eating foods highly seasoned with garlic has been considered therapeutic. There has been no systemic study of the effect of garlic on patients with sinusitis.

IVIG

Summary Statements

Summary Statement 76: Immunodeficiency might be an underlying risk factor for the development of recurrent acute or chronic sinusitis. **B**
Summary Statement 77: IVIG is approved as a replacement therapy for antibody deficiency disorders, including

X-linked agammaglobulinemia, common variable immunodeficiency, Wiskott-Aldrich syndrome, and hyper-IgM syndrome. **A**
Summary Statement 78: Appropriate use of IVIG can prevent complications from chronic sinusitis, including subperiosteal and intracranial abscesses, meningitis, sepsis, and death. **B**

Immunodeficiency might be an underlying risk factor for the development of recurrent acute or chronic sinusitis. IVIG is approved as a replacement therapy for antibody deficiency disorders, including X-linked agammaglobulinemia, common variable immunodeficiency, Wiskott-Aldrich syndrome, and hyper-IgM syndrome.[272] The use of IVIG in other immune disorders (eg, selective antibody deficiency or IgG subclass deficiencies) remains controversial.

The appropriate use of IVIG in patients with immunoglobulin deficiency can prevent complications from chronic sinusitis, including subperiosteal abscess, intracranial abscess, meningitis, sepsis, or even death.

There is considerable controversy regarding gammaglobulin prescribing for therapy of patients with specific antibody deficiency and normal immunoglobulin levels (see ''Practice parameters for the diagnosis and management of primary immunodeficiency''). Most experts in this area consider demonstration of impaired antibody production essential. It must be demonstrated that (1) the patient has significant and clearly documented infectious morbidity (eg, recurrent pneumonias and frequent episodes of documented bacterial sinusitis and not just isolated chronic sinusitis), (2) other disorders (eg, allergy and anatomic defects) have been sought and treated aggressively if present, and (3) other modes of therapy (antimicrobial, anti-inflammatory, and surgical) are inadequate or poorly tolerated. If administered to children with milder antibody deficiencies, gammaglobulin therapy should be discontinued if there has been an extended period of significant improvement because the susceptibility to infection might decrease over time.[273] Humoral immune function should be reassessed but no sooner than 3 months (preferably 4-6 months) after the last infusion. Patients must be followed closely, and therapy should be discontinued, generally after no more than 3 to 6 months, if there is lack of clinical efficacy.

Aspirin desensitization therapy

Summary Statement

Summary Statement 79: Beneficial effects of aspirin desensitization on patients with aspirin-exacerbated respiratory disease (AERD) have been reported. **A**

The clinical efficacy in patients with AERD of aspirin desensitization followed by daily aspirin treatment has been reported. In one study 65 patients with AERD were treated with aspirin, 650 mg twice daily, after aspirin desensitization. While the patients were under treatment with aspirin, objective clinical criteria demonstrated significant improvement in their clinical courses, particularly a reduction in sinusitis. Simultaneous requirement for systemic corticosteroids decreased significantly.[274]

In another study[275] 172 patients with AERD were desensitized to and treated with aspirin. By the first 6 months of aspirin treatment, there were significant reductions in sinus infections and frequency of short courses of prednisone and improvements in sense of smell and general assessment of nasal-sinus and asthma symptoms. Of the patients who completed a year or more of aspirin treatment, 87% experienced improvement. Results persisted for 1 to 5 years.

Treatment of nasal polyposis with daily nasal application of aspirin-lysine solution has been reported with decreased swelling, reduction of polyp formation, and return of smell.[276]

Zileuton, a 5-lipoxygenase inhibitor was given as add-on therapy to 40 patients with AERD. This resulted not only in improvement in asthma but also in return of smell, less rhinorrhea, and a trend toward less stuffiness and higher nasal inspiratory flow.[277]

Surgical

Summary Statements

Summary Statement 80: Antral puncture and irrigation is an office procedure that has a place in the management of acute ethmomaxillary sinusitis refractory to medical therapy or in acute sinusitis in an immunosuppressed patient in whom early identification of pathogenic organisms is paramount. **D**
Summary Statement 81: Surgical intervention might be required in acute sinusitis to provide drainage when there is a significant risk of intracranial complication or in a patient with periorbital or intraorbital abscess or visual compromise. **D**
Summary Statement 82: Functional endoscopic sinus surgery, in combination with appropriate medical therapy, has been shown in uncontrolled studies to have long-term efficacy in reducing disease-specific symptoms and in improving overall quality of life. **C**

The surgical approach to sinus disease has undergone a significant transition, resulting from renewed insights into sinus physiology and the widespread use of nasal endoscopy. In the latter part of the 20th century, several authors noted the importance of the middle meatus and of the ethmoid sinuses in the cause of frontal and maxillary sinusitis.[278] This region was termed the *ostiomeatal complex* in recognition of the importance of this area to disease in the dependent sinuses.[279,280]

Our current knowledge continues to indicate that limited and localized inflammation within this region might cause or exacerbate disease within the dependent sinuses.[281] Thus surgical therapy is typically directed toward removing mucosal disease and the involved bone within the ethmoid sinuses and sinus ostia under endoscopic visualization (functional endoscopic sinus surgery) rather than stripping inflamed mucosa from the larger dependent sinuses. Indeed, more recently, increased

attention has been paid to mucoperiosteal preservation and the necessity of avoiding bone exposure, even within the region of the ostiomeatal complex.[282]

After surgical intervention, most patients with infectious sinusitis have a significant improvement in disease-specific symptoms. However, in a significant number of patients, endoscopic and radiologic evidence of asymptomatic disease might persist after surgical intervention, requiring continued medical therapy or local debridement.[283] It appears that eventually, with proper ventilation and appropriate systemic and local therapy, residual evidence of chronic inflammation slowly resolves in many patients.[284]

Evaluation for surgery. In acute sinusitis the necessity for surgery is usually predicated either by a threatened complication or by severe symptoms unresponsive to medical therapy. In chronic sinusitis, patient evaluation should include a careful history and evaluation for environmental and general host factors that might predispose to sinusitis in addition to evaluation of the local host factors within the ostiomeatal complex. It has been demonstrated that patients who continue to smoke after surgery have a significantly worse long-term outcome.[285] Thus the advantages and disadvantages of elective surgical intervention should be carefully considered in patients who continue to smoke or have other ongoing marked environmental exposures.

Surgery is typically required for fungal sinusitis. Fungus balls within the maxillary sinus, allergic fungal sinusitis, and invasive fungal sinusitis generally require surgical intervention. Because the radiographic and endoscopic appearance of unilateral polypoid disease might frequently be the result of either fungal disease or tumor (eg, inverted papilloma), biopsy should be considered in these patients.

Surgical approaches. Endoscopic approaches have generally become the surgical standard of care for chronic infectious sinusitis, especially if there is evidence of mechanical blockage of the ostiomeatal complex. However, open surgical procedures are still required, depending on the extent and the location of the sinuses involved (ie, frontal or sphenoid). Frontal sinus trephine and postoperative irrigation is a valid consideration in patients with acute or chronic frontal sinusitis. Additionally, when endoscopic surgical techniques fail to resolve chronic frontal sinusitis, even with revised surgical intervention, the frontal sinus obliteration with fat remains a viable consideration.

Operative intervention. Endoscopic sinus surgery can be performed under local anesthesia.[286] However, as the importance of carefully removing disease and meticulously preserving the mucoperiosteum and normal structures has increasingly been recognized, surgical cases have tended to become longer. Thus there has been a trend toward performing the surgery under general anesthesia. In many cases the surgery can still be performed on an outpatient basis. Patients with significant asthma or other underlying medical conditions are usually kept overnight for observation. The surgical procedure is carried out under endoscopic visualization through the nostril and involves no external incisions. The extent of the surgical dissection is dictated by the amount and location of disease identified by means of preoperative CT, as well as by the findings during the surgical procedure. The standard teaching for the functional endoscopic approach is that the surgical procedure should extend beyond the margins of the ostiomeatal disease. Postoperative pain is typically minimal, and early symptom improvement is generally the rule. The incidence of severe surgical complications is approximately 0.5%. However, the meticulous surgical techniques used require considerable experience.[287,288]

Conclusions. The surgical treatment of sinusitis has been significantly enhanced by the routine use of nasal endoscopy and by the use of CT imaging. The nasal telescope has significantly improved our ability to visualize the ostiomeatal complex, a critical region in the pathogenesis of chronic sinusitis and a region that is very poorly visualized on both anterior rhinoscopy and on standard radiographic films. Although chronic sinusitis is typically a multifactorial disease with environmental and general host factors, localized persistent disease within the ostiomeatal complex plays a significant part in continuation of the disease process. Functional endoscopic sinus surgery results in significant improvement in the majority of patients. However, significant improvement often requires a combination of appropriate surgical intervention with intensive postoperative local management to the region and appropriate medical therapy.

Indications for referral

1. Indications for referral to a specialist:
   - When the condition or its treatment is interfering with a patient's performance or causing significant loss of school or work on a chronic or recurrent basis or when the patient's quality of life is significantly affected.
   - When there are complications of sinusitis, such as otitis, asthma, bronchiectasis, nasal polyps, or bronchitis.
   - When there is consideration for an allergic or immunologic basis for the sinusitis or when immunocompetence needs to be assessed.
   - When the condition becomes chronic, persists for several months, or recurs 2 to 3 times per year, despite treatment by the primary care physician.
   - When there is the need for complex pharmacology to treat recalcitrant infections caused by underlying allergies, allergic fungal sinusitis, resistant pathogens, or aspirin desensitization.
2. What the specialist should provide to the referring physician:
   - Clarification of allergic, immunologic, or nonallergic causative basis for the patient's condition.
   - Assessment of nasal and sinus outflow tract anatomy and any contribution these anatomic factors have in the causation of the sinus problems.
   - Identification of specific allergens or other triggers for the patient's condition, and education in ways to avoid exposure to these triggers.

- Assistance in developing an effective treatment plan, including patient education, allergy avoidance, pharmacotherapy, anti-infectious therapy, and immunotherapy, if appropriate.
- Provision of specialized services, such as preparation of extracts and provision of immunotherapy.
- Evaluation for associated conditions, such as asthma.

3. Indications for surgical intervention:
   - When nasal polyps obstruct sinus drainage and persist despite appropriate medical treatment.
   - When there is recurrent or persistent infectious sinusitis despite adequate trials of medical management: adequate medical management minimally involves multiple courses of antibiotics chosen to cover the spectrum of pathogens anticipated to be causing the disease.
   - For biopsy of the nasal mucosa to rule out granulomatous disease, neoplasms, ciliary dyskinesia, or fungal infections.
   - When maxillary antral puncture is required.
   - When anatomic defects exist that obstruct the sinus outflow tract, particularly including the ostiomeatal complex (and adenoidal tissues in children), and are thought to be contributing to recurrent or chronic infectious sinusitis.
   - For sinusitis with threatened complications (eg, threat of brain abscess, meningitis, cavernous sinus thrombosis, or Pott's tumor).
4. What the surgical consultant should provide the referring physician:
   - An evaluation of the likely pathologic factors involved in the disease process and the chances of improvement with surgical intervention: this could include puncture and quantitative cultures.
   - Determination of whether an adequate trial of medical, allergic, or immunologic treatment has been provided before recommending surgery.
   - Recommendation of a specific procedure or procedures for the specific patient and discussion of the merits of alternative approaches.
   - Assessment of the need for surgical revision of abnormal anatomy through rhinolaryngoscopy and CT imaging and the likelihood that such revision will reduce the recurrent or chronic sinus disease.
   - Assessment of nasal and sinus outflow tract anatomy through rhinolaryngoscopy and CT imaging and any contribution these anatomic factors have in the causation of the sinus problems.

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