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Acute Bacterial Sinusitis in Children

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Author Disclosure
Drs DeMuri and Wald have disclosed no financial relationships relevant to this article.
This commentary does contain discussion of unapproved/investigative use of a commercial product/device.

Practice Gaps

1. Acute bacterial sinusitis should be diagnosed in a child who has an acute upper respiratory tract infection with persistent illness (ie, nasal discharge or daytime cough or both) lasting more than 10 days; worsening cough, worsening or new nasal discharge, or daytime cough or fever after initial improvement; or severe onset of fever and purulent nasal discharge for at least 3 consecutive days.

2. The clinician should prescribe antibiotics for acute bacterial sinusitis in children with severe onset or worsening course. Children with persistent illness should be either prescribed antibiotic therapy or offered additional observation for 3 days.

Objectives

After completing this article, readers should be able to:

1. Understand the mechanisms that lead to bacterial sinusitis.
2. Be able to distinguish the child who has bacterial sinusitis from the one who has only a viral upper respiratory infection or allergic congestion.
3. Be aware of the usefulness of nasal cultures, sinus, aspirate cultures, and findings on imaging in diagnosing bacterial sinusitis.
4. Know the current treatment of bacterial sinusitis, taking into consideration changes in the characteristics of infecting organisms.

The viral upper respiratory tract infection (URI) is the most common illness for which children present to the primary care pediatrician. Approximately 5% to 10% of viral URIs are complicated by acute bacterial sinusitis. Sinusitis results in more than $5.8 billion in health care expenditures in the United States annually, of which $1.8 billion is spent on children younger than 13 years. (1) The diagnosis and treatment of acute bacterial sinusitis present unique challenges to the primary care physician in the acute care setting.

Anatomy and Pathogenesis

The ethmoid and maxillary sinuses develop in the third month of gestation and, although small, are present at birth. The frontal sinuses develop from an anterior ethmoidal air cell and are pneumatized by age 5 or 6 years. The sphenoid sinus starts to become aerated at age 5 years and expands in size into the second or third decade of life.

The outflow tract of the maxillary sinus is located at the most superior portion of the medial wall of the sinus (Fig 1). This unfortunate positioning makes gravitational drainage difficult. The clearance of secretions of the sinus is thus dependent on the mucociliary elevator of the mucosa. The maxillary sinus empties via the ostium into the middle meatus of the nasal cavity at a location known as the osteomeatal complex. The maxillary sinus ostia are small, tubular structures with a diameter of only 2.5 mm and a length of 6 mm. The anterior ethmoid and frontal sinuses also empty into the osteomeatal complex in the middle meatus. The posterior ethmoid air cells and the sphenoid sinus drain into the superior meatus.

A key concept in understanding the pathogenesis of acute bacterial sinusitis is that the mucosa of the nose and

Abbreviations

AOM: acute otitis media
PCV-7: 7-valent pneumococcal conjugate vaccine
URI: upper respiratory tract infection
nasopharynx is continuous with the mucosa of the paranasal sinuses. This pseudostratified columnar epithelium clears mucus and other material from the sinus by ciliary action. Any process that affects the nasal mucosa also may affect the sinus mucosa. Unlike the nasal mucosa, which is heavily colonized with bacteria, the paranasal sinuses normally are sterile.

The pathogenesis of sinusitis involves 3 key factors: obstruction of the sinus ostia, dysfunction of the ciliary apparatus, and thickening of sinus secretions. The narrow diameter of the sinus ostia allows for easy obstruction. The factors that predispose the ostia to obstruction may be divided into those that result in mucosal swelling and those that result in a direct mechanical effect (Table 1).

Viral URI is the most common cause of ostial obstruction in children and frequently precedes the development of sinusitis. Obstruction of the ostia results in a transient increase in pressure in the sinus cavity. As oxygen is depleted, the pressure in the sinus becomes negative relative to the atmosphere. This negative pressure allows for the introduction of bacteria from the nose and nasopharynx into the sinus. When the ostia are obstructed, mucous production by the mucosa continues, resulting in the accumulation of fluid in the sinus cavity and the multiplication of bacteria and the initiation of an inflammatory reaction.

In addition to ostial obstruction, dysfunction of the mucociliary apparatus also contributes to the development of sinusitis. During a viral URI, progressive loss of ciliated cells may be observed in the respiratory mucosa.

Lastly, the quality and character of sinus secretions play an important role in the pathogenesis of acute bacterial sinusitis. Cilia can beat only in a liquid media, and diseases such as cystic fibrosis result in very thick, viscous secretions that diminish ciliary clearance of fluid and debris from the sinus. Infection of the sinus results in thickening of secretions, compounding this process.

The result of a viral URI is that all 3 of these factors are present: ostial obstruction, ciliary dysfunction, and thickening of sinus secretions. The viral URI is the most common predisposing factor to the development of bacterial sinusitis in childhood and accounts for approximately 80% of cases. Allergic inflammation underlies the remaining 20% of cases of acute bacterial sinusitis in children.

Microbiology

Sinus Aspiration Studies

Knowledge of the microbiology of acute sinusitis has been derived from studies of sinus aspiration. The difficulty in obtaining any sample for culture is that the sinuses are a closed space accessible only through a highly contaminated mucous membrane. Maxillary sinus aspiration in children is a time-consuming procedure that should be performed only by a skilled pediatric otolaryngologist. In this procedure, the nasal mucosa is anesthetized and disinfected with a solution of 10% cocaine. A trocar is passed

Figure 1. Coronal (A) and sagittal (B and C) sections of the nose and paranasal sinuses.
just below the inferior nasal turbinate across the lateral nasal wall. Aspirated material is sent for Gram stain and quantitative aerobic and anaerobic bacterial culture. The recovery of bacteria in a density of at least one organism per high-power field correlates with the isolation of bacteria from nasal secretions in a density of $10^4$ CFU/mL or more, and is considered significant growth. A Gram stain finding of at least one organism per high-power field correlates with the isolation of bacteria from nasal secretions in a density of $10^5$ CFU/mL.

Several sinus aspiration studies performed in the 1980s in children with 10 to 30 days of sinus symptoms have provided insight into the microbiology of acute bacterial sinusitis. (2,3) In these studies, *Streptococcus pneumoniae*, *Haemophilus influenzae*, and *Moraxella catarrhalis* were responsible for most episodes of sinusitis. *S pneumoniae* was the most frequently isolated organism, accounting for 40% of isolates, with *H influenzae* and *M catarrhalis* each accounting for approximately 20% of cases. Less commonly isolated organisms include group A *Streptococcus*, group C *Streptococcus*, *Peptostreptococcus* spp, *Eikenella corrodens*, and *Moraxella* spp. Anaerobic bacteria are not isolated commonly in patients with acute sinusitis.

Because of the invasive nature of sinus aspiration, there has been interest in obtaining specimens for culture from a more accessible site that reflects the microbiology of the sinus. Nasopharyngeal swabs have been studied but unfortunately correlate poorly with sinus aspirate cultures. (2) Endoscopically obtained samples of secretions from the middle meatus near the osteomeatal complex also have been studied. In children, these specimens have poor correlation with sinus aspirates, likely because of the narrow caliber of the nasal passages and the potential for contamination with nasal flora. (4)

No sinus puncture studies have been performed since 1984 in children who have acute sinusitis, and yet the microbiology of the nasopharyngeal flora of children has undergone important changes in the past decade. Because the pathogenesis of acute otitis media (AOM) and acute bacterial sinusitis is similar, it is possible to use data derived from studies of tympanocentesis performed in children who have AOM as a surrogate for sinusitis. The middle ear cavity is, in fact, a paranasal sinus.

Since the introduction of the 7-valent pneumococcal conjugate vaccine (PCV-7), there has been a significant shift in the pathogens responsible for AOM. In a rural Kentucky clinic, Block et al performed tympanocentesis and culture of middle ear fluid on 381 children ages 7 to 24 months who had AOM in the period before and after the introduction of PCV-7. (5) The proportion of cases of AOM caused by *S pneumoniae* had decreased significantly from 56% to 41%, whereas that caused by *H influenzae* had increased from 38% to 57%. The rate of isolation of *M catarrhalis* remained constant at approximately 10%. Studies performed since the introduction of the 13-valent pneumococcal conjugate vaccine have suggested an even greater decrease in the proportion of AOM cases due to *S pneumoniae*. (6)

In addition to the increase in the rate of isolation of *H influenzae* in children with AOM, there has been a shift in the susceptibility patterns of this organism. The mechanism by which isolates of *H influenzae* are resistant to penicillins such as amoxicillin is by the production of β-lactamases. Historically, approximately 20% to 30% of isolates of *H influenzae* causing sinusitis and AOM in children have produced β-lactamase. Recently, middle ear and nasopharyngeal cultures taken from children in Rochester, New York, have demonstrated β-lactamase rates as high as 50%. (7) This increase in the rate of resistance has important implications for antibiotic selection because empirical choices will need to include a β-lactamase stable drug.

There has been recent controversy in the medical literature over the role of *Staphylococcus aureus* (including methicillin-resistant strains) in acute sinusitis. Some authors have stated that this pathogen should be considered an important cause of acute bacterial sinusitis. (8) However, these studies have serious methodologic flaws. (9) Most were performed by obtaining cultures from the middle meatus via an endoscope. The middle meatus in healthy children is colonized with *S aureus* as frequently as 65% of the time. Those authors who performed direct sinus aspirate did not verify decontamination of the puncture site. The isolation

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**Table 1. Factors Predisposing Patients to Obstruction of the Sinus Ostia**

<table>
<thead>
<tr>
<th>Mucosal Swelling</th>
<th>Mechanical Obstruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systemic factors</td>
<td>Tumor</td>
</tr>
<tr>
<td>Viral upper respiratory tract infection</td>
<td>Foreign body</td>
</tr>
<tr>
<td>Allergic rhinitis</td>
<td>Nasal polyps</td>
</tr>
<tr>
<td>Tobacco smoke</td>
<td>Choanal atresia</td>
</tr>
<tr>
<td>Immotile cilia syndromes</td>
<td>Ethmoid bullae</td>
</tr>
<tr>
<td>Immune disorders</td>
<td>Deviated septum</td>
</tr>
<tr>
<td>Cystic fibrosis</td>
<td></td>
</tr>
<tr>
<td>Local insults</td>
<td></td>
</tr>
<tr>
<td>Trauma</td>
<td></td>
</tr>
<tr>
<td>Nasal intubation</td>
<td></td>
</tr>
<tr>
<td>Swimming/diving</td>
<td></td>
</tr>
<tr>
<td>Nasal decongestant overuse</td>
<td></td>
</tr>
</tbody>
</table>

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(4) Overuse
(5) Nasal decongestant
(6) Swimming/diving
(7) Nasal intubation
(8) Mucosal Swelling
(9) Cystic fibrosis
(10) Immune disorders
(11) Immotile cilia syndromes
(12) Tobacco smoke
(13) Allergic rhinitis
(14) Viral upper respiratory tract infection
(15) Systemic factors
(16) Tumor
(17) Foreign body
(18) Nasal polyps
(19) Choanal atresia
(20) Ethmoid bullae
(21) Deviated septum
(22) Cystic fibrosis
(23) Local insults
(24) Trauma
(25) Nasal intubation
(26) Swimming/diving
(27) Nasal decongestant overuse

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of *S. aureus* in these studies likely represents contamination from a colonized nasal mucosa. It is notable also that in the original sinus aspirate studies performed in children, *S. aureus* was not isolated in any of the 50 children enrolled in the study. It is doubtful then that this agent is a significant pathogen in acute bacterial sinusitis. However, *S. aureus* plays an important role in some of the complications of sinusitis.

### Acute Bacterial Sinusitis

The presentation of acute bacterial sinusitis conforms to 1 of 3 predictable patterns (Table 2). The first and most common presentation in children is that of persistent respiratory symptoms. These patients have nasal congestion or nasal discharge, with or without cough, for more than 10 but fewer than 30 days without improvement. The key in distinguishing this presentation from an uncomplicated URI is the lack of improvement of their respiratory symptoms after 10 days. Although patients with uncomplicated viral URI may have residual respiratory symptoms at 10 days, almost always these symptoms are improving.

The rhinorrhea may be of any color or character: clear and watery, mucoid, or purulent (thick, colored, and opaque). The cough may be wet or dry in character. When cough is a symptom of acute bacterial sinusitis, it must be present during the day but often is reported to be worse at night. Face pain and headache are rare, although painless morning eye swelling occurs on occasion. Parents of preschool children often will report malodorous breath. The child who has this presentation usually appears only mildly ill, and fever, if it is present, is low grade.

The second presentation of acute bacterial sinusitis is that of the onset of severe illness. These patients present with temperatures of at least 38.5°C accompanied by a particular type of nasal discharge, a purulent nasal discharge, for a period of 3 to 4 days. Older children and adults may experience focal face pain, tooth pain, fever, and purulent nasal discharge. The presence of fever for longer than 48 hours distinguishes this presentation from that of an uncomplicated viral URI.

The third presentation is one of biphasic or worsening symptoms. In the Scandinavian literature, this is referred to as “double sickening.” These patients have initial symptoms of an uncomplicated viral URI that begins

### Table 2. Clinical Presentation and Criteria for the Diagnosis of Acute Bacterial Sinusitis

<table>
<thead>
<tr>
<th>Persistent symptoms</th>
<th>Severe symptoms</th>
<th>Worsening symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nasal discharge/congestion and/or cough for ≥10 days without improvement</td>
<td>Temperature ≥38.5°C with purulent rhinorrhea for at least 3 days</td>
<td>Worsening of nasal congestion or rhinorrhea, cough, and fever after a 3- to 4-day period of improved symptoms</td>
</tr>
</tbody>
</table>

![Figure 2. Schematic representation of an uncomplicated viral upper respiratory infection.](http://pedsinreview.aappublications.org/)
to improve. Then after several days there is a substantial worsening of symptoms with exacerbation of cough or nasal discharge or congestion. A new fever may be present, or fever may recur if it was present at the onset.

The physical findings in children who have sinusitis may demonstrate mucopurulent material on the nasal mucosa or in the posterior pharynx. The nasal mucosa itself may be erythematous or boggy and pale, and the oropharynx may be injected. Malodorous breath may be present with sinusitis in the absence of a nasal foreign body or dental disease. Examination of the tympanic membranes may reveal evidence of concomitant AOM or otitis media with effusion. Swelling and discoloration of the eyelids are observed sometimes, and occasionally facial tenderness over the maxillary or frontal sinuses is present. Overall, the physical examination is of limited use in making a specific diagnosis because none of these physical findings distinguishes a viral URI from acute bacterial sinusitis.

**Diagnosis**

### Clinical Criteria

The diagnosis of acute bacterial sinusitis is almost always a clinical one. Strict application of the clinical criteria (Table 2) that define persistent, severe, and worsening symptoms will distinguish those children with sinusitis from those with viral URI and thus identify a cohort of patients most likely to benefit from an antimicrobial agent. The use of these clinical criteria results in a diagnosis of acute bacterial sinusitis in 6% to 7% of children presenting in a primary care setting with upper respiratory tract symptoms. (10)

### Imaging

Although various imaging modalities have been used to assess the paranasal sinuses, imaging is not necessary to confirm the diagnosis of uncomplicated acute bacterial sinusitis. Abnormal findings on imaging studies include complete sinus opacification, mucosal thickening of at least 4 mm, or an air-fluid level. The continuity of the nasal mucosa with the sinus mucosa limits the usefulness of imaging in the diagnosis of sinusitis. It has been demonstrated that both adults and children have significant abnormalities on imaging studies that are performed during an uncomplicated URI.

A classic study by Gwaltney et al reported on an experience in adults who had uncomplicated colds. (11) Computed tomographic scans performed within 48 to 96 hours of the onset of symptoms demonstrated abnormalities of the sinuses in more than 80% of patients. In children with viral URI, more than half will have abnormal sinuses on plain radiograph. (12) Accordingly, no imaging study is able to distinguish the inflammation of the sinus mucosa caused by viruses from that due to bacteria.

Although imaging studies are not recommended routinely in the diagnosis of sinusitis, a negative radiograph effectively eliminates the diagnosis. Computed tomography and magnetic resonance imaging of the sinuses may be useful when complications of sinusitis are suspected. In this situation, fluid collections that may require surgical drainage may be identified.

### Sinus Aspiration

A skilled pediatric otolaryngologist may perform maxillary sinus aspiration in an outpatient setting. Indications for this procedure include sinusitis unresponsive to multiple courses of antibiotics, orbital or intracranial complications, severe facial pain, and suspected sinusitis in an immunocompromised host in whom unusual pathogens such as fungi may be present.

### Complications

Complications of sinusitis may be divided into those involving the orbit, the central nervous system, or the bone (Table 3). The frontal and ethmoid sinuses are the most common sinuses from which complications arise. The delicate and thin walls of the ethmoid sinuses, called *lamina papyracea*, allow for spread of infection into the orbit. Orbital complications are the most common and include subperiosteal abscess, orbital cellulitis, and orbital abscess. Signs of orbital infection include eyelid swelling, proptosis, and impairment of extraocular muscle movement. This complication may result from spread of infection through the

<table>
<thead>
<tr>
<th>Table 3. Major Complications of Sinusitis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Intracranial</strong></td>
</tr>
<tr>
<td>Meningitis</td>
</tr>
<tr>
<td>Subdural empyema</td>
</tr>
<tr>
<td>Epidural empyema</td>
</tr>
<tr>
<td>Brain abscess</td>
</tr>
<tr>
<td>Venous sinus thrombosis</td>
</tr>
<tr>
<td><strong>Orbital</strong></td>
</tr>
<tr>
<td>Optic neuritis</td>
</tr>
<tr>
<td>Orbital cellulitis</td>
</tr>
<tr>
<td>Orbital abscess</td>
</tr>
<tr>
<td>Subperiosteal abscess</td>
</tr>
<tr>
<td>Inflammatory edema (peri-orbital cellulitis)</td>
</tr>
<tr>
<td><strong>Osteitis</strong></td>
</tr>
<tr>
<td>Maxillary</td>
</tr>
<tr>
<td>Frontal (Pott puffy tumor)</td>
</tr>
</tbody>
</table>
natural dehiscences between the bones that comprise the medial wall of the orbit (which is also the lateral wall of the ethmoid sinus) or from the development of a subperiosteal abscess of the ethmoid bone.

The frontal sinuses share venous drainage with intracranial structures, allowing for infection to develop within the brain and surrounding structures. Intracranial infection may present with headache, seizures, focal neurologic signs, or meningeal signs and can include subdural and epidural empyema and brain abscess. Parenteral antibiotics are necessary for treatment, and surgery is indicated when a drainable fluid collection is present. The bony complication of acute frontal sinusitis is Pott puffy tumor, which is a subperiosteal abscess of the frontal bone.

**Treatment**

**Controlled Trials**

The necessity of treating sinusitis with antibiotics has been controversial. There have been several randomized trials of placebo vs antimicrobial therapy in the treatment of sinusitis in children that have produced conflicting results. Lack of efficacy in 2 of these studies may be explained by underdosing of antibiotics and lack of clear definition of the population of patients included in the studies. (13,14) Two other trials have found consistent benefit to antibiotic treatment when strict clinical criteria are used to select patients with sinusitis. (10,15)

In the most recent trial, high-dose amoxicillin-clavulanate was compared with placebo. (10) This study included 58 children ages 1 to 10 years who met stringent criteria for sinusitis based on persistent, worsening, or severe symptoms. A standardized symptom score was used to evaluate treatment effect. Of those children who received antibiotic, 64% were cured or improved vs 32% in the placebo arm. In addition, treatment failure was noted in 68% of those receiving placebo vs 14% in the antibiotic arm of the study \((P<.01)\). This study demonstrates that antibiotic treatment is beneficial when children in an office setting are diagnosed as having sinusitis using stringent clinical criteria.

**Antimicrobial Recommendations**

The antibiotics used to treat acute bacterial sinusitis in children are listed in Tables 4 and 5.

High-dose amoxicillin-clavulanate (90 mg/kg/d) should be considered as a first-line agent for the treatment of sinusitis because it has the most comprehensive in vitro activity against sinus pathogens. Because the proportion of cases caused by \(H\) *influenzae* is likely increasing and the rate of \(\beta\)-lactamase production by this organism is also increasing, the addition of clavulanic acid to amoxicillin provides an advantage over amoxicillin alone. Using 90 mg/kg/d of the amoxicillin component provides better coverage for penicillin nonsusceptible *S pneumoniae*. Although gastrointestinal adverse events are more common with amoxicillin-clavulanate than placebo, most are mild and self-limiting. Amoxicillin alone is an acceptable second-line agent but should be used at a high dose (90 mg/kg) in those children at risk for resistant pneumococci, for example, those younger than 2 years, attending child care, or having recently (<30 days) received antibiotics.

The choice of a second-line agent for treating sinusitis in children is problematic. Cephalosporins, such as cefpodoxime, cefuroxime axetil, or cefdinir, are alternative antibiotics that may be used to treat sinusitis in children, although they are less active against *S pneumoniae* than amoxicillin-clavulanate. As discussed, the microbiology of respiratory tract infections in children is dynamic and has demonstrated significant shifts since the introduction of the pneumococcal conjugate vaccine. If *S pneumoniae*, particularly penicillin-nonsusceptible strains, continues to decrease in prevalence, the cephalosporins may be more effective in the treatment of sinusitis.

### Table 4. Antimicrobial Agents for the Treatment of Sinusitis in Children

<table>
<thead>
<tr>
<th>Drug</th>
<th>Dosage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Oral</strong></td>
<td></td>
</tr>
<tr>
<td>Amoxicillin</td>
<td>40–90 mg/kg/d divided twice daily</td>
</tr>
<tr>
<td>Amoxicillin–clavulanate</td>
<td>90 mg/kg/d (amoxicillin) divided twice daily</td>
</tr>
<tr>
<td>Cefdinir</td>
<td>14 mg/kg/d divided once or twice daily</td>
</tr>
<tr>
<td>Cefixime</td>
<td>8 mg/kg/d once a day</td>
</tr>
<tr>
<td>Cefpodoxime</td>
<td>10 mg/kg/d divided twice daily</td>
</tr>
<tr>
<td>Cefuroxime axetil</td>
<td>30 mg/kg/d divided twice daily</td>
</tr>
<tr>
<td>Linezolid (with cefixime)</td>
<td>20–30 mg/kg/d divided</td>
</tr>
<tr>
<td>Levofloxacin</td>
<td>16 mg/kg/d divided every 12 hours</td>
</tr>
<tr>
<td><strong>Parenteral</strong></td>
<td></td>
</tr>
<tr>
<td>Cefotaxime</td>
<td>150–200 mg/kg/d divided every 6–8 hours</td>
</tr>
<tr>
<td>Ceftriaxone</td>
<td>50–100 mg/kg/d divided every 12–24 hours</td>
</tr>
<tr>
<td>Clindamycin</td>
<td>20–40 mg/kg/d divided every 8 hours</td>
</tr>
<tr>
<td>Vancomycin</td>
<td>40–60 mg/kg/d divided every 6–8 hours</td>
</tr>
</tbody>
</table>
For those children in whom amoxicillin-clavulanate or second- or third-generation cephalosporins fail, a combination of cefixime (or cefdinir) and linezolid may be used. Despite the increased complexity and expense of this regimen, it is an alternative to the use of parenteral antimicrobial agents in these children.

Levofloxacin, a quinolone antimicrobial, is also an effective agent for children in whom amoxicillin-clavulanate therapy fails or in the severely (type 1 hypersensitivity) penicillin allergic patient. It is not approved by the Food and Drug Administration for this indication, however. The rate of musculoskeletal adverse events, such as tendinopathy, arthritis, or arthralgia, is slightly higher in patients receiving levofloxacin than other antibiotics. However, the drug usually is well tolerated in children, and the American Academy of Pediatrics has issued a policy statement on the use of fluoroquinolones in children. It was concluded that their use may be justified where there is no safe and effective alternative. (16)

Patients with evidence of systemic toxic effects, complications of sinusitis, or an inability to take antibiotics orally should be hospitalized for parenteral therapy. For uncomplicated sinusitis, ceftriaxone or cefotaxime should be used as single agents. If complications are suspected, the cephalosporin should be combined with vancomycin until the results of culture and susceptibilities are known.

Response to therapy is prompt in children who have sinusitis and are adherent to therapy with an appropriate antimicrobial agent. Fever, if present at onset, resolves, and a rapid decrease in cough and nasal symptoms occurs within 48 hours. If symptoms are not improved within this time frame, then clinical reevaluation is warranted. If the diagnosis is unchanged, a second-line antimicrobial should be prescribed. Alternatively, sinus aspiration may be considered for precise identification of the causative organism.

The appropriate duration of antimicrobial therapy has not been studied systematically. For patients who have a rapid response to the initiation of antimicrobial, 10 days of therapy usually is adequate. For those who respond at a slower rate, treating until the patient is symptom free plus an additional 7 days is reasonable.

### Adjunctive Therapies

Adjunctive therapies, such as antihistamines and decongestants, have not been found consistently to provide benefit in children with sinusitis and may be associated with toxic effects. Intranasal corticosteroids have too modest a benefit to be recommended routinely.

### Recurrent Sinusitis

Some children experience frequent recurrences of sinus symptoms. The most common cause of such symptoms is recurrent viral URI, especially in those children attending child care. Other conditions, such as allergic rhinitis, exposure to tobacco smoke, gastroesophageal reflux, anatomical abnormalities, cystic fibrosis, an immunodeficiency disorder, or ciliary dyskinesia, may predispose patients to recurrent symptoms. The evaluation of a child with recurrent sinusitis should include

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**Table 5. Formulations and Dosing of Amoxicillin–Clavulanate**

<table>
<thead>
<tr>
<th>Strength/concentration (amoxicillin–clavulanate), mg</th>
<th>Ratio (amoxicillin: clavulanate)</th>
<th>Dosage per dose (mg/kg of amoxicillin)</th>
<th>Dosing frequency (h)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Liquid per 5 mL</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>125–31</td>
<td>4:1</td>
<td>13.3</td>
<td>8</td>
</tr>
<tr>
<td>250–62.5</td>
<td>4:1</td>
<td>13.3</td>
<td>8</td>
</tr>
<tr>
<td>200–28.5</td>
<td>7:1</td>
<td>22.5</td>
<td>12</td>
</tr>
<tr>
<td>400–57</td>
<td>7:1</td>
<td>22.5</td>
<td>12</td>
</tr>
<tr>
<td>600–42.9</td>
<td>14:1</td>
<td>45</td>
<td>12</td>
</tr>
<tr>
<td><strong>Chewable tablets, mg</strong></td>
<td>4:1</td>
<td>13.3</td>
<td>8</td>
</tr>
<tr>
<td>250–62.5</td>
<td>7:1</td>
<td>22.5</td>
<td>12</td>
</tr>
<tr>
<td>200–28.5</td>
<td>7:1</td>
<td>22.5</td>
<td>12</td>
</tr>
<tr>
<td><strong>Tablets, mg</strong></td>
<td>2:1</td>
<td>250</td>
<td>8</td>
</tr>
<tr>
<td>250–125</td>
<td>4:1</td>
<td>500</td>
<td>8 or 12</td>
</tr>
<tr>
<td>500–125</td>
<td>4:1</td>
<td>875</td>
<td>12</td>
</tr>
<tr>
<td>1000–62.5</td>
<td>16:1</td>
<td>1000–2000</td>
<td>12</td>
</tr>
</tbody>
</table>

*Note: Maximum daily dose of amoxicillin is 4 g.*

*Food and Drug Administration approved for children and adults 16 years and older.*
consultation with an allergist, measurement of serum quantitative immunoglobulins and CH₅₀, a test for cystic fibrosis, and a biopsy of nasal mucosa to assess ciliary structure and function. If sinusitis does not respond to medical therapy, surgical intervention may be indicated.

Chronic sinusitis in children is less common in adults and occurs often in children who have the above predisposing conditions. Children with chronic sinusitis have more of an inflammatory disease, although bacteria may cause acute exacerbations.

Summary

• On the basis of strong research evidence, the pathogenesis of sinusitis involves 3 key factors: sinus ostia obstruction, ciliary dysfunction, and thickening of sinus secretions.
• On the basis of studies of the microbiology of otitis media, *H influenzae* is playing an increasingly important role in the etiology of sinusitis, exceeding that of *S pneumoniae* in some areas, and β-lactamase production by *H influenzae* is increasing in respiratory isolates in the United States.
• On the basis of some research evidence and consensus, the presentation of acute bacterial sinusitis conforms to 1 of 3 predictable patterns; persistent, severe, and worsening symptoms.
• On the basis of some research evidence and consensus, the diagnosis of sinusitis should be made by applying strict clinical criteria. This approach will select children with upper respiratory infection symptoms who are most likely to benefit from an antibiotic.
• On the basis of some research evidence and consensus, imaging is not indicated routinely in the diagnosis of sinusitis. Computed tomography or magnetic resonance imaging provides useful information when complications of sinusitis are suspected.
• On the basis of some research evidence and consensus, amoxicillin–clavulanate should be considered as a first-line agent for the treatment of sinusitis.

References


PIR Quiz

This quiz is available online at http://www.pedsinreview.aappublications.org. NOTE: Learners can take Pediatrics in Review quizzes and claim credit online only. No paper answer form will be printed in the journal.

New Minimum Performance Level Requirements

Per the 2010 revision of the American Medical Association (AMA) Physician’s Recognition Award (PRA) and credit system, a minimum performance level must be established on enduring material and journal-based CME activities that are certified for AMA PRA Category 1 Credit™. In order to successfully complete 2013 Pediatrics in Review articles for AMA PRA Category 1 Credit™, learners must demonstrate a minimum performance level of 60% or higher on this assessment, which measures achievement of the educational purpose and/or objectives of this activity.

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1. Which of the following mechanisms can potentially lead to bacterial sinusitis?
   A. Dysfunction of mucociliary apparatus.
   B. Increase in bacterial load in the nasal mucosa.
   C. Increase in positive sinus pressure relative to the atmosphere.
   D. Prolonged fever during upper respiratory tract infection.
   E. Thinning of sinus secretions.

2. A 5-year-old boy comes to the office with 3 days of a low-grade fever (maximum temperature, 38.3˚C), a cough that is described as wet, clear rhinorrhea, and decreased oral intake. The child has not had a headache or facial pain, and his urine output has been adequate. The next step in management is:
   A. Amoxicillin-clavulanate (50 mg/kg/d).
   B. Close observation and follow-up.
   C. Maxillary sinus aspiration by an otolaryngologist.
   D. Obtain a nasopharyngeal swab for bacterial culture.
   E. Plain radiographs of the sinuses.

3. Since the introduction of the 7-valent pneumococcal conjugate vaccine, the most common organism isolated in bacterial sinusitis is:
   A. Anaerobic bacteria.
   B. Haemophilus influenzae.
   C. Moraxella catarrhalis.
   D. Streptococcus pneumoniae.
   E. Streptococcus pyogenes.

4. A 15-year-old girl comes to see you with acute onset of fever, facial pain, headache, and purulent nasal discharge. You diagnose her with bacterial sinusitis. Which of the following antibiotics should be prescribed at this time?
   A. Amoxicillin (40–50 mg/kg/d).
   B. Amoxicillin-clavulanate (90 mg/kg/d).
   C. Clindamycin (30–40 mg/kg/d).
   D. Cephalexin (40 mg/kg/d).
   E. Ciprofloxacin (30 mg/kg/d).

5. The most common complication seen in children who have bacterial sinusitis is:
   A. Brain abscess.
   B. Meningitis.
   C. Orbital cellulitis.
   D. Osteomyelitis of maxillary bone.
   E. Venous sinus thrombosis.
Acute Bacterial Sinusitis in Children
Gregory DeMuri and Ellen R. Wald
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