Asthma and Pneumonia

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Data from the 2007 National Hospital Ambulatory Medical Care Survey (NHAMCS) show that chest pain is a presenting complaint in 1.7% of emergency department (ED) visits for children, representing nearly 500,000 annual visits in the United States. Most children with a complaint of chest pain are diagnosed with nonspecific chest pain or pain of musculoskeletal origin (Table 1). Asthma and lower respiratory infections are the most common specific diagnoses, ranging from 4.0% to 26.0% of cases from single-center studies and 8.7% each in the nationally representative NHAMCS survey. Respiratory causes of chest pain appear to be even more common in children younger than 12 years, although in a study of young adults (13–35 years) in an ED, 11% had respiratory infection as the cause. Even among children referred to a cardiologist for evaluation, respiratory causes are among the most common specific diagnoses. In one study, 73% of children seen in a cardiology clinic for chest pain had reversible decreases in pulmonary function after exercise, suggesting a diagnosis of exercise-induced asthma (EIA).

ASTHMA

Pathophysiology

In children with acute asthma, chest pain is a common symptom, occurring in 13% of patients in one study. Acute asthma is a multifactorial process that includes both bronchospasm and airways inflammation, both of which may cause a sensation of pain attributable to stimulation of nociceptors in the bronchi. Bronchoconstriction also causes a feeling of chest tightness, which may be interpreted or reported as pain by children. Frequent or deep cough in a child with an acute asthma exacerbation may lead to soreness of the muscles of the chest wall. Rarely (0.2%–0.3% of cases), children with acute asthma may develop pneumomediastinum (Fig. 1). Those children with asthma and sickle cell disease have an increased incidence of acute chest syndrome owing to local pulmonary hypoxia, sickling, and tissue ischemia or infarction (Box 1).
Asthma is common: although a past history of asthma may be highly suggestive of this as the cause of chest pain, children with asthma can also have any of a number of other conditions causing their chest pain, and a careful evaluation is required in all cases. Conversely, children may have chest pain as their initial presentation of asthma. Indeed, some authors have proposed the existence of a “chest-pain variant asthma” in which this is the only or most prominent symptom. Unfortunately, there is no diagnostic test for asthma that can be readily applied in the ED; therefore, the evaluation is largely clinical. In a child without a known diagnosis of asthma, several historical features may be suggestive of reactive airways disease. These include prior history of wheezing, history of other atopic disease (eg, eczema), family history of asthma or atopic disease, chronic cough (especially nocturnal), and cough or shortness of breath with exercise. Although asthma-associated chest pain may have various characteristics, a description of tightness is also suggestive, as are occurrence or worsening of the pain with exertion and coexisting cough.

The child with chest pain owing to asthma may have overt signs of airway inflammation and bronchospasm, or the examination may be relatively unremarkable. Examine for signs of obstruction to inflow (inspiratory wheezing, accessory muscle use, retractions, nasal flaring), obstruction to outflow (expiratory wheezing, prolonged expiratory phase), atelectasis (diminished aeration, grunting, crackles), or alveolar hypoventilation.

### Table 1

<table>
<thead>
<tr>
<th>Study</th>
<th>Setting</th>
<th>Number of Children</th>
<th>Reported Causes of Chest Pain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selbst et al,2 1988</td>
<td>Emergency department (ED)</td>
<td>407</td>
<td>Idiopathic 21%</td>
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<td></td>
<td></td>
<td></td>
<td>Musculoskeletal 24%</td>
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<td></td>
<td></td>
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<td>Respiratory 21%</td>
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<td></td>
<td></td>
<td></td>
<td>Cough 10%</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Asthma 7%</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Pneumonia 4%</td>
</tr>
<tr>
<td>Rowe et al,3 1990</td>
<td>ED</td>
<td>336</td>
<td>Idiopathic 12%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Musculoskeletal 28%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Respiratory 19%</td>
</tr>
<tr>
<td>Massin et al,4 2004</td>
<td>ED, Cardiology clinic</td>
<td>168, 69</td>
<td>Musculoskeletal 64%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Respiratory 13%</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Musculoskeletal 89%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Respiratory (asthma) 4%</td>
</tr>
<tr>
<td>Evangelista et al,5 2008</td>
<td>Cardiology clinic</td>
<td>50</td>
<td>Musculoskeletal 76%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Respiratory (asthma) 12%</td>
</tr>
<tr>
<td>Lin et al,6 2008</td>
<td>ED</td>
<td>103</td>
<td>Idiopathic 59%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Musculoskeletal 7%</td>
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<td></td>
<td></td>
<td></td>
<td>Pulmonary 24%</td>
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<td></td>
<td></td>
<td></td>
<td>Asthma 1%</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Lower respiratory infection 16%</td>
</tr>
<tr>
<td>Danduran et al,7 2008</td>
<td>Cardiology clinic</td>
<td>263</td>
<td>Asthma 26%</td>
</tr>
<tr>
<td>National Hospital Ambulatory Medical Care Survey,1 2007</td>
<td>ED</td>
<td>150</td>
<td>Pulmonary 17.4%</td>
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<td></td>
<td></td>
<td></td>
<td>Asthma 8.7%</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Lower respiratory infection 8.7%</td>
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### Evaluation

Asthma is common: although a past history of asthma may be highly suggestive of this as the cause of chest pain, children with asthma can also have any of a number of other conditions causing their chest pain, and a careful evaluation is required in all cases. Conversely, children may have chest pain as their initial presentation of asthma. Indeed, some authors have proposed the existence of a “chest-pain variant asthma” in which this is the only or most prominent symptom. Unfortunately, there is no diagnostic test for asthma that can be readily applied in the ED; therefore, the evaluation is largely clinical. In a child without a known diagnosis of asthma, several historical features may be suggestive of reactive airways disease. These include prior history of wheezing, history of other atopic disease (eg, eczema), family history of asthma or atopic disease, chronic cough (especially nocturnal), and cough or shortness of breath with exercise. Although asthma-associated chest pain may have various characteristics, a description of tightness is also suggestive, as are occurrence or worsening of the pain with exertion and coexisting cough.

The child with chest pain owing to asthma may have overt signs of airway inflammation and bronchospasm, or the examination may be relatively unremarkable. Examine for signs of obstruction to inflow (inspiratory wheezing, accessory muscle use, retractions, nasal flaring), obstruction to outflow (expiratory wheezing, prolonged expiratory phase), atelectasis (diminished aeration, grunting, crackles), or alveolar hypoventilation.
(tachypnea). Look also for signs of atopic disease such as eczematous changes of the skin, rhinitis, and allergic shiners. Subcutaneous crepitus in the neck and Hamman sign (crunching heart sounds) may indicate the presence of pneumomediastinum.

Pulse oximetry may be useful. Although a normal oxygen saturation does not exclude the presence of asthma, hypoxemia may be seen as a result of ventilation-perfusion mismatch from bronchospasm or atelectasis. Peak expiratory flow rate (PEFR) may be a particularly useful adjunct in a child old enough to be taught the maneuver (typically 8 years or older). PEFR less than 70% of predicted with good effort is strongly suggestive of bronchoconstriction. Having the child perform PEFR before and after exercise may demonstrate a decrease in children with exercise-induced asthma.

Chest radiography is not diagnostic of asthma and is often normal, but may provide helpful clues. In the context of an acute exacerbation, radiographic findings may include hyperinflation, atelectasis, and peribronchial thickening owing to airway inflammation. A chest radiograph is not indicated for all children with chest pain attributable to asthma. If the pain resolves after treatment with bronchodilators, the pain may have been related to overuse of chest wall muscles, and no diagnostic studies are indicated.

**Box 1**

**Etiology of chest pain in children with asthma**

1. Bronchospasm and airways inflammation stimulate nociceptors in the bronchi
2. Bronchoconstriction causes feeling of “chest tightness”
3. Frequent cough leads to soreness/overuse of chest wall muscles (inflammation of nerves, muscles, costochondral junctions)
4. Pneumomediastinum or pneumothorax
5. Acute chest syndrome (children with sickle cell disease)
are needed. Obtain confirmatory radiographs in a child with known asthma and chest pain in whom pneumomediastinum or pneumothorax is suspected based on physical examination, and in a child with coexisting sickle cell disease to evaluate for acute chest syndrome.

**Management**

Not surprisingly, management of chest pain associated with asthma is best approached by treating the underlying exacerbation. In cases where asthma is suspected as the cause, a therapeutic trial of an inhaled bronchodilator may provide a diagnostic clue as well as symptomatic relief. Although most children with asthma and chest pain will respond to bronchodilator therapy, in some cases the pain is more related to inflammation; in those children, systemic corticosteroids will produce more pain relief.11

If the chest pain in an asthmatic child is a result of thoracic muscle overuse or strain from coughing, administer analgesics such as acetaminophen or ibuprofen. Pneumomediastinum does not typically require specific treatment (see another article elsewhere in this issue for further exploration of this topic). The subcutaneous air will resorb spontaneously, although resolution may be hastened by providing supplemental oxygen. Similarly, a small nontension pneumothorax may be treated expectantly, whereas larger (>20%) pneumothoraces should generally be evacuated by placing a chest tube. Tension pneumothorax in asthma is rare, but if it occurs it must be evacuated emergently. Similarly, place a chest tube in any patient with pneumothorax if the asthma exacerbation is severe enough that positive-pressure ventilation is required.

For children with sickle cell disease and asthma, administer supplemental oxygen even if oxygen saturation by pulse oximetry is normal, as this may help prevent sickling caused by localized pulmonary hypoxia.

Admission to the hospital for treatment and observation is not generally needed for the child with asthma solely on the basis of chest pain. Admission is recommended for those children with asthma and chest pain with inadequate response to standard ED asthma therapy, as indicated by persistent moderately severe symptoms, peak expiratory flow rate less than 50% of predicted, or hypoxia.

**PNEUMONIA**

**Pathophysiology**

Pneumonia is an infection of the lower respiratory tract defined by fever, acute respiratory symptoms, and tachypnea or radiologic evidence of parenchymal infiltrates. It is the leading cause of morbidity among children worldwide, accounting for an estimated 1.9 million deaths in children younger than 5 annually.13,14 Although the mortality is reduced outside of underdeveloped nations, at an approximate rate of 36 cases per 1000 per year, pneumonia causes significant morbidity in developed countries.15–17 Pneumonia frequently begins as colonization of the nasopharynx with subsequent infection of the lower respiratory tract and can be caused by bacteria, viruses, atypical organisms, or fungi.

Chest pain associated with acute respiratory infections can be produced through several mechanisms. Direct tracheobronchial irritation and pain travels from the lungs through vagal afferent nerve fibers to the cervical spinal column and can be manifested as a dull, aching, or sharp pain usually felt in the anterior chest or neck.18 In addition, prolonged and severe coughing causes stress and strain to the chest wall, producing inflammation of the associated nerves, muscles, and costochondral junctions.18–21 Pain associated with coughing travels through intercostal nerves and
can be a constant ache or a sharp pain worse with coughing or deep inspiration. It is typically localized to the lateral chest wall, but may also cause diffuse chest discomfort. Pleuritis, or painful inflammation of the pleura, may also be associated with pneumonia. Pleuritic chest pain typically occurs during inspiration when inflamed areas of the pleura rub against one another and is typically sharp, severe, and well localized. Finally, parapneumonic effusions can complicate bacterial pneumonia and can contribute to the causes of chest pain. This pain is characteristically sharp and dramatically worse with deep inspiration. As the pathophysiology of chest pain in pneumonia is largely associated with symptoms of infection, the pain generally recedes with improvement of cough, tachypnea, and respiratory distress (Box 2).

Evaluation

Pneumonia should be suspected as an etiology of chest pain in children presenting with respiratory symptoms. Associated fever and cough are hallmark symptoms of typical bacterial pneumonia. Chills, abdominal pain, and mucous production are also commonly seen with pneumonia. The combination of fever, cyanosis, and at least one other sign of respiratory distress is highly predictive of pyogenic pneumonia. Atypical pneumonias, such as those caused by Mycoplasma pneumoniae or Chlamydia pneumoniae, are often accompanied by less severe symptoms of a more gradual onset. These symptoms may include headache, malaise, and low-grade fever. Clinical presentation of children with pneumonia can vary considerably from those who are acutely ill to those who look reasonably well, partly because of the etiologic organism and the age of the child.

The physical evaluation of a patient with suspected pneumonia should include the patient’s temperature, pulse and respiratory rate, and pulse oximetry reading. The child’s overall demeanor, degree of hydration, color, and the presence of cyanosis should also be assessed. Tachypnea, nasal flaring, chest wall retractions, grunting, and other signs of respiratory distress are suggestive of lower respiratory tract infection. Tachypnea is the most sensitive and the most specific of all physical findings associated with pneumonia. An increased respiratory rate is found twice as often in children with radiographically proven pneumonia than in those children without positive radiographs. Lung examination will often reveal crackles, focal decreased breath sounds, bronchial breath sounds, or dullness to percussion. Observed hypoxemia in a child with complaints of chest pain is concerning for lower respiratory tract etiology. New-onset wheezing may be heard with viral or atypical infections, but are not commonly associated with pyogenic bacterial pneumonia. Similarly, rhonchi, or coarse airway sounds associated with secretions in the large airways, are not necessarily indicative of pneumonia.

There is little role for ancillary testing in the well-appearing child with auscultatory findings consistent with pneumonia who is eligible for ambulatory pharmacotherapy.

<table>
<thead>
<tr>
<th>Box 2</th>
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<tbody>
<tr>
<td><strong>Etiology of chest pain in children with pneumonia</strong></td>
</tr>
<tr>
<td>1. Direct tracheobronchial irritation (pain travels from lungs through vagal afferent nerve fibers to cervical spinal column)</td>
</tr>
<tr>
<td>2. Severe cough leads to soreness/overuse of chest wall muscles (inflammation of nerves, muscles, costochondral junctions)</td>
</tr>
<tr>
<td>3. Inflammation of the pleura is possible (causes pain with inspiration)</td>
</tr>
<tr>
<td>4. Parapneumonic effusions are possible (cause pain with inspiration)</td>
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</table>
Although white blood cell counts and C-reactive protein levels have been shown to be higher in children with bacterial pneumonia, these results showed such significant variability that clinical application is unreliable and have shown little value in differentiating bacterial pneumonia from pneumonia caused by other agents. Blood cultures are positive in children with pneumonia no more than 10% of the time and their use is not recommended in outpatient management. In children hospitalized with more severe, resistant, or unusual forms of pneumonia, blood cultures may be helpful and may provide a possible opportunity for identification of a causative organism. Other methods of identifying etiologic organisms are available and include sputum examination, antigen detection testing, and polymerase chain reaction (PCR)-based respiratory infection testing. These ancillary tests are associated with difficulty obtaining an adequate sample, poor testing performance, and high cost, respectively, limiting their use in pediatrics.

Ancillary radiographs in the diagnosis of uncomplicated, ambulatory pneumonia do not appear to modify outcomes and the British Thoracic Society guidelines for pneumonia do not recommend its use in children older than 2 months. In daily practice, however, chest radiographs are commonly used to confirm the clinical diagnosis of pneumonia, characterize the severity of the disease, and assess for complications such as effusion or empyema (Figs. 2 and 3). Chest radiographs can be beneficial and are recommended in children who are in respiratory distress, ill-appearing, requiring hospitalization, or with physical findings concerning for pleural effusion. This final use of chest radiographs may be especially important in febrile
children presenting with chest pain and clinical concern for bacterial pneumonia. Although radiograph findings can guide management in the ill child and may provide clues to the causative organism, they lack sufficient specificity to be considered diagnostic for specific etiologic agents.

Management

The initial management of a child with pneumonia must include rapid cardiopulmonary stabilization. Cardiorespiratory support is essential in the toxic or distressed child and may include the administration of supplemental oxygen, intubation or other advanced airway techniques, intravenous fluid administration, or the use of vasopressor medications. Additional therapies may be instituted concurrently, but should not supplant stabilizing interventions.

Acute pneumonia-associated chest pain can typically be alleviated with over-the-counter analgesia medication such as acetaminophen or ibuprofen. In the acutely ill or distressed child, intravenous narcotic pain medication can be used to treat severe pain; however, an anti-inflammatory medication such as ketorolac is generally favored because of its lack of respiratory depression. Anti-inflammatory medication is especially
effective in relieving pleuritic chest pain or musculoskeletal pain associated with coughing. The underlying strategy for treatment of pneumonia-associated chest pain, however, is effective treatment of the causative infection and its associated painful complications (i.e., effusion or empyema). The mainstay of therapy for bacterial pneumonia is the administration of antimicrobials. Over-the-counter cough medications are not indicated. The specifics of pneumonia management should be based on the age and overall state of the child and the suspected causative organism. Children with clinical concern for bacterial pneumonia who do not appear ill, are without signs of respiratory distress or hypoxemia, and who are maintaining adequate hydration may be treated successfully with outpatient, oral antibiotics. Hospital admission for treatment and observation is appropriate for children who are younger than 3 months old, toxic in appearance, have signs of significant respiratory distress or hypoxemia, are incapable of maintaining adequate fluid intake, or who have serious concomitant chronic conditions.

Antibacterial selection is ideally based on an identified organism, but identification of the organism in children is unlikely and empiric therapy is often mandatory. As viral infections are the most common cause of pneumonia in children between the ages of 3 months and 5 years, antibacterials are not needed in the only mildly ill infant or young child who has diffuse findings on lung examination. For children in this age group who are suspected of having bacterial pneumonia, however, empiric treatment for *Streptococcus pneumoniae* is indicated. *S pneumoniae* is the predominant bacterial cause of pneumonia across all pediatric age groups causing approximately 73% of bacterial infections. Oral beta-lactam penicillin antibiotics such as amoxicillin or amoxicillin/clavulanic acid have a low failure rate and are the recommended first-line medications for outpatient therapy. *S pneumoniae* resistance to first-line antibacterials is a growing concern. In vitro penicillin and ceftriaxone resistance rates have been shown to be approximately 6% and 2%, respectively. Despite this, in vivo resistance is uncommon and clinical amoxicillin treatment failures are seen in fewer than 3% of children.

The high prevalence of pneumonia caused by atypical organisms such as *Mycoplasma pneumoniae* and *Chlamydia pneumoniae* in preschool- and school-age children has recently been noted. When an atypical pneumonia is suspected, a macrolide antibiotic such as azithromycin becomes the drug of choice. Because of the poor response of *S pneumoniae* to macrolide antibiotics and to the significant complications associated with undertreating *S pneumoniae* infection, combination therapy with a beta-lactam and a macrolide antibiotic may be the most prudent course in children where the exact etiology remains unclear.

Patients requiring hospitalization should be treated with an intravenous penicillin antibiotic or a third-generation cephalosporin. Vancomycin is active against *S pneumoniae*, but should be reserved for those who fail to improve on standard antibacterial therapy. In children admitted to the hospital, an intravenous macrolide antibiotic may be added in cases where atypical organisms are suspected.

**SUMMARY**

Chest pain remains a common complaint among children seeking care in the United States. Asthma and lower respiratory tract infections such as pneumonia can be significant causes of chest pain. Children with chest pain caused by either of these pulmonary etiologies generally present with associated respiratory symptoms, including cough, wheezing, tachypnea, respiratory distress, and/or fever. Although analgesic medications can improve chest pain associated with pulmonary pathologies, the mainstay of
therapy is to treat the underlying etiology; this includes bronchodilator and/or steroid medications in children with asthma and appropriate antibacterial administration in children with suspicions of bacterial pneumonia. The chest pain generally resolves along with the resolution of other respiratory symptoms.

REFERENCES