Community-acquired pneumonia in children: Clinical features and diagnosis

AUTHOR: William J Barson, MD
SECTION EDITOR: Sheldon L Kaplan, MD
DEPUTY EDITOR: Diane Blake, MD

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INTRODUCTION

Community-acquired pneumonia (CAP) is defined as signs and symptoms of an acute infection of the pulmonary parenchyma in an individual who acquired the infection in the community, as distinguished from hospital-acquired (nosocomial) pneumonia (table 1) [1,2]. CAP is a common and potentially serious illness with considerable morbidity.

The clinical features and diagnosis of CAP in children will be reviewed here. The epidemiology, pathogenesis, and treatment of pneumonia in children are discussed separately.

- (See "Pneumonia in children: Epidemiology, pathogenesis, and etiology".)
- (See "Community-acquired pneumonia in children: Outpatient treatment".)
- (See "Pneumonia in children: Inpatient treatment".)

CLINICAL PRESENTATION

The clinical presentation of childhood pneumonia varies depending upon the responsible pathogen, the particular host, and the severity. The presenting signs and symptoms are nonspecific; no single symptom or sign is pathognomonic for pneumonia in children [3].

Symptoms and signs of pneumonia may be subtle, particularly in infants and young children. The combination of fever and cough is suggestive of pneumonia; other respiratory findings

(eg, tachypnea, increased work of breathing) may precede the cough. Cough may not be a feature initially since the alveoli have few cough receptors. Cough begins when the products of infection irritate cough receptors in the airways. The longer fever, cough, and respiratory findings are present, the greater the likelihood of pneumonia [4].

Neonates and young infants may present with difficulty feeding, restlessness, or fussiness rather than with cough and/or abnormal breath sounds [5]. Neonates, young infants, and young children (ie, <5 to 10 years of age) may present only with fever and leukocytosis [4,6].

Older children and adolescents may complain of pleuritic chest pain (pain with respiration), but this is an inconsistent finding [3]. Occasionally, the predominant manifestation may be abdominal pain (because of referred pain from the lower lobes) or nuchal rigidity (because of referred pain from the upper lobes). "Walking pneumonia" is a term that is sometimes used to describe pneumonia in which the respiratory symptoms do not interfere with normal activity.

In a multicenter population-based study that included 2358 children <18 years hospitalized with radiographic evidence of pneumonia, 95 percent had cough, 90 percent had fever, 75 percent had anorexia, 70 percent had dyspnea, and 55 percent had chest wall retractions [7].

CLINICAL EVALUATION

Objectives — The evaluation of the child with cough and potential lower respiratory tract disease has three goals: the identification of the clinical syndrome (eg, pneumonia, bronchiolitis, asthma), consideration of the etiologic agent (eg, bacteria, virus), and an assessment of the severity of the illness [5]. The severity of illness determines the need for additional evaluation.

History and examination — Important aspects of the history for children with possible CAP are listed in the table (table 2) [3,8]. Historical features can be helpful in determining the etiologic agent, the likelihood of infection with an organism that is resistant to antibiotics, and the severity of illness. (See "Pneumonia in children: Epidemiology, pathogenesis, and etiology", section on 'Etiologic agents'.)

Important aspects of the examination are summarized in the table (table 3) and discussed in greater detail below.

- **General appearance** – In the young infant, assessment of general appearance includes the ability to attend to the environment, to feed, to vocalize, and to be consoled. State of awareness and cyanosis should be assessed in all children, although children may be hypoxemic without cyanosis. Most children with radiographically confirmed pneumonia appear ill [9].

- **Fever** – Fever is a common manifestation of pneumonia in children [10]. However, it is nonspecific and variably present. Young infants may have afebrile pneumonia related to *Chlamydia trachomatis* or other pathogens. Fever tends to be lower grade in children with bronchiolitis than in children with pneumonia and typically is absent in children with asthma. (See "Chlamydia trachomatis infections in the newborn", section on 'Pneumonia' and "Pneumonia in children: Epidemiology, pathogenesis, and etiology", section on 'In infants' and "Bronchiolitis in infants and children: Clinical features and diagnosis", section on 'Clinical features'.)

  Fever may be the only sign of occult pneumonia in highly febrile young children. In one report, 26 percent of 146 children (<5 years) with fever ≥39°C (102.2°F), no clinical evidence of pneumonia or other localizing signs, and peripheral white blood cell count ≥20,000/microL had radiographic evidence of pneumonia [6].

- **Tachypnea** – Children with pneumonia often have tachypnea, but tachypnea is less predictive of radiographically confirmed pneumonia than hypoxia or increased work of breathing [3]. Lack of tachypnea is helpful in excluding pneumonia.

  In a systematic review of studies evaluating the correlation between clinical examination findings and radiographic pneumonia, respiratory rate >40 breaths per minute was 1.5 times (95% CI 1.3-1.7) more frequent in children with radiographic pneumonia than without radiographic pneumonia; age-defined tachypnea was not associated with radiographic pneumonia [3].

  Tachypnea in infants with pneumonia (respiratory rate >70 breaths/min) also has been associated with hypoxemia [11]. Tachypnea may be less useful early in the course of illness (eg, less than three days) [12].

  Evaluation of respiratory rate in infants and children is discussed separately. (See "The pediatric physical examination: General principles and standard measurements", section on 'Respiratory rate'.)

- **Respiratory distress** – Signs of respiratory distress include tachypnea, hypoxemia (peripheral arterial oxygen saturation [SpO_2] <90 percent on room air at sea level), increased work of breathing (intercostal, subcostal, or suprasternal retractions; nasal flaring; grunting; use of accessory muscles), apnea, and altered mental status [1].

  Oxygen saturation should be measured in children with increased work of breathing, particularly if they have a decreased level of activity or are agitated [1,2,13]. Infants and children with hypoxemia may not appear cyanotic. Hypoxemia is a sign of severe disease and an indication for admission [1,2].

Signs of respiratory distress are more specific than fever or cough for lower respiratory tract infection, but less sensitive [3]. Signs of respiratory distress that are predictive of pneumonia include hypoxemia (defined differently in different studies, usually oxygen saturation <94 to 96 percent in room air), retractions, head bobbing, and nasal flaring [3,9,14,15]. However, the absence of these findings does not exclude pneumonia.

In a systematic review, retractions, nasal flaring, and grunting were two to three times more frequent in children with radiographically confirmed pneumonia than without [3]. When present, grunting is a sign of severe disease and impending respiratory failure [16].

- **Lung examination** – Examination of the lungs may provide clues to the diagnosis of pneumonia and/or potential complications.

  Auscultation is an important component of the examination of the child who presents with findings suggestive of pneumonia. However, auscultatory findings other than wheezing have less interobserver agreement than observable findings, such as retractions or respiratory rate [17]. Auscultation of all lung fields should be performed.

  Examination findings consistent with radiographically confirmed pneumonia include [18]:

  - Crackles
  - Findings consistent with consolidated lung parenchyma, including:
    - Decreased breath sounds
    - Bronchial breath sounds (louder than normal, with short inspiratory and long expiratory phases, and higher-pitched during expiration), egophony (E to A change)
    - Bronchophony (the distinct transmission of sounds such as the syllables of "ninety-nine")
    - Whispered pectoriloquy (transmission of whispered syllables)
    - Tactile fremitus (eg, when the patient says "ninety-nine")
    - Dullness to percussion
  - Wheezing is more common in pneumonia caused by atypical bacteria and viruses [19,20] than bacteria; it is also a characteristic feature of bronchiolitis and asthma (see 'Clues to etiology' below)

- Findings suggestive of pleural effusion include chest pain with splinting, dullness to percussion, distant breath sounds, and a pleural friction rub (see "Epidemiology, clinical presentation, and evaluation of parapneumonic effusion and empyema in children", section on 'Clinical presentation')

Clues to etiology — Clinical features classically taught to be characteristic of bacterial pneumonia, atypical bacterial pneumonia, or viral pneumonia are summarized in the table (table 4). However, the features frequently overlap and cannot be used reliably to distinguish between the various etiologies [21,22]. In addition, as many as 50 percent of infections may be mixed bacterial/viral infections. (See "Pneumonia in children: Epidemiology, pathogenesis, and etiology", section on 'Community-acquired pneumonia'.)

- **Bacterial** – Classically, bacterial ("typical") pneumonia, usually resulting from *Streptococcus pneumoniae* and less commonly from *Staphylococcus aureus* and group A *Streptococcus*, which may follow days of upper respiratory tract infection symptoms, is considered abrupt in onset, with the febrile patient appearing ill and sometimes toxic. Respiratory distress is moderate to severe; auscultatory findings may be few and focal, limited to the involved anatomic segment. Signs and symptoms of sepsis and localized chest pain (signifying pleural irritation) are more suggestive of bacterial etiology [10], as they are rarely present in nonbacterial pneumonia. Complications, discussed below, also are more suggestive of bacterial etiology (image 1) (see 'Complications' below). On the other hand, typical bacterial pneumonia is unlikely in children older than five years if wheezing is present [23].

  Pneumococcal pneumonia is the most common typical bacterial pneumonia in children of all ages. Fever and cough occur in the majority of children with pneumococcal pneumonia. Other common findings include malaise/lethargy, decreased breath sounds, and crackles. Pneumococcal pneumonia in children is discussed in greater detail separately. (See "Pneumococcal pneumonia in children".)

- **Atypical bacterial** – "Atypical" bacterial pneumonia resulting from *Mycoplasma pneumoniae* or *Chlamydia pneumoniae* usually presents abruptly with constitutional findings of fever, malaise and myalgia; headache; photophobia; sore throat; conjunctivitis; rash; and gradually worsening nonproductive cough despite improvement of other symptoms [19,23]. Although hoarseness may be seen in disease caused by both agents, it is more frequently seen with *C. pneumoniae* infection. Wheezing is a frequent finding in atypical bacterial and viral pneumonias [10]. (See "Pneumonia caused by *Chlamydia pneumoniae* in children" and "*Mycoplasma pneumoniae* infection in children", section on 'Clinical manifestations'.)

  M. pneumoniae may be associated with a variety of extrapulmonary manifestations. Dermatologic manifestations may range from a mild erythematous maculopapular rash

or urticaria to Stevens-Johnson syndrome. Other extrapulmonary manifestations include hemolytic anemia, polyarthritis, pancreatitis, hepatitis, pericarditis, myocarditis, and neurologic complications [24]. (See "*Mycoplasma pneumoniae* infection in children", section on 'Clinical manifestations'.)

Infants younger than one year of age may develop "afebrile pneumonia of infancy." Afebrile pneumonia of infancy is a syndrome generally seen between two weeks and three to four months of age. It is classically caused by *C. trachomatis*, but other agents, such as cytomegalovirus, *Mycoplasma hominis*, and *Ureaplasma urealyticum*, also are implicated. The clinical presentation is one of insidious onset of rhinorrhea and tachypnea followed by a staccato cough pattern (individual coughs separated by inspirations). Physical examination typically reveals diffuse inspiratory crackles. Conjunctivitis may be present, or there may have been a past history of conjunctivitis [25]. (See "Chlamydia trachomatis infections in the newborn", section on 'Pneumonia'.)

- **Viral** – The onset of viral pneumonia is gradual and associated with preceding upper respiratory tract symptoms (eg, rhinorrhea, congestion). The child does not appear toxic. Auscultatory findings are usually diffuse and bilateral. In one study of 98 ambulatory children with pneumonia, wheezing was more frequent in patients with viral than bacterial pneumonia (43 versus 16 percent), but other clinical features often associated with viral illness, such as rhinorrhea, myalgia, and ill contacts, were not [26].

  Some viral causes of pneumonia are associated with characteristic dermatologic findings:

  - Measles (picture 1A-B) (see "Measles: Clinical manifestations, diagnosis, treatment, and prevention")
  - Varicella (picture 2) (see "Clinical features of varicella-zoster virus infection: Chickenpox")

Severity assessment — An assessment of pneumonia severity is necessary in order to determine the need for laboratory and imaging studies and the appropriate therapy. The severity of pneumonia generally is assessed by the child's overall clinical appearance and behavior, including an assessment of their degree of awareness and willingness to eat or drink (table 5) [1,2]. Although a systematic review of studies predicting pneumonia severity in children suggests that hypoxemia, altered mental status, age <3 to 6 months, dyspnea, multilobar infiltrates, and moderate or large pleural effusions are the factors most predictive of pneumonia severity, standardized criteria for mild, moderate, and severe pneumonia in children are lacking [27].

RADIOLOGIC EVALUATION

Radiographs

Indications — Routine chest radiographs are not necessary to confirm the diagnosis of suspected CAP in children with mild, uncomplicated lower respiratory tract infection who are well enough to be treated as outpatients [1,2]. Indications for radiographs in children with clinical evidence of pneumonia include [1,2]:

- Severe disease (table 5) (to confirm the diagnosis and assess for complications) (see 'Severity assessment' above)
- Confirmation/exclusion of the diagnosis when clinical findings are inconclusive
- Hospitalization (to document the presence, size, and character of parenchymal infiltrates and evaluate potential complications)
- History of recurrent pneumonia
- Exclusion of alternate explanations for respiratory distress (eg, foreign body aspiration, heart failure), particularly in patients with underlying cardiopulmonary or medical conditions (see 'Differential diagnosis' below)
- Assessment of complications, particularly in children whose pneumonia is prolonged and unresponsive to antimicrobial therapy (see 'Complications' below and "Community-acquired pneumonia in children: Outpatient treatment", section on 'Treatment failure')
- Exclusion of pneumonia in young children (3 to 36 months) with fever >39°C (102.2°F) and leukocytosis (≥20,000 white blood cell [WBC]/microL) and older children (<10 years) with fever >38°C (100.4°F), cough, and leukocytosis (≥15,000 WBC/microL) [4,6] (see "Fever without a source in children 3 to 36 months of age: Evaluation and management")
- **Important caveats** – There are a number of caveats to consider when deciding whether to obtain radiographs and whether radiographs will alter management. These include:
  - Radiographic findings are poor indicators of the etiologic diagnosis and must be used in conjunction with other clinical features to make therapeutic decisions [2,28-31] (see "Community-acquired pneumonia in children: Outpatient treatment", section on 'Treatment failure')
  - Although radiographic findings may lag behind the clinical findings [32], and patients who are hypovolemic may have normal-appearing chest radiography

before volume repletion, a negative chest radiograph excludes pneumonia in most children ≥3 months of age [33]

- There is variation in intraobserver and interobserver agreement [2,34]
- Radiographic interpretation may be influenced by the clinical information that is provided to the radiologist [35]
- Obtaining outpatient chest radiographs does not affect outcome [36,37]

Views — When radiographs are indicated, the recommended views depend upon the age of the child [38]. In children older than four years, the frontal posteroanterior (PA) upright chest view is usually obtained to minimize the cardiac shadow [39]. In younger children, position does not affect the size of the cardiothoracic shadow, and the anteroposterior (AP) supine view is preferred because immobilization is easier and the likelihood of a better inspiration is improved [39].

There is a lack of consensus regarding the need for lateral radiographs to demonstrate infiltrates behind the dome of the diaphragm or the cardiac shadow that may not be visualized on AP or PA views [1,2,40,41]. In a review of chest radiographs in 201 children with pneumonia, the lateral film was abnormal in 91 percent of 109 children with definite pneumonia [42]. However, it was the sole basis for the diagnosis in only three cases.

It may be reasonable to obtain a lateral view in settings where the radiographs are interpreted by nonradiologists. However, the Pediatric Infectious Diseases Society and Infectious Diseases Society of America suggest PA and lateral views for all children who are hospitalized for management of CAP [1].

A lateral decubitus radiograph (with the affected side down) may be needed to identify pleural effusion. (See "Epidemiology, clinical presentation, and evaluation of parapneumonic effusion and empyema in children", section on 'Radiologic evaluation'.)

Other imaging techniques — High-resolution computed tomography and ultrasonography are available for patients who require more extensive imaging or clarification of radiographic findings [43]. Although the potential utility of bedside lung ultrasonography for detecting lung consolidation in pediatric emergency department and inpatient settings has been reported [44-52], few studies have evaluated the effect on outcomes and management [53]. Diagnostic accuracy appears to be affected by the level of experience of the sonographer [54].

Etiologic clues — Certain radiographic features that are more often associated with bacterial, atypical bacterial, or viral etiologies are listed below. However, none can reliably

differentiate between a bacterial, atypical bacterial, and viral pneumonia (table 4) [21,55-57].

- Segmental consolidation is reasonably specific for bacterial pneumonia but lacks sensitivity [30,58]. Radiologic features of segmental consolidation are not always easy to distinguish from segmental collapse (atelectasis), which is apparent in approximately 25 percent of children with bronchiolitis [59,60].

- In clinical practice, it is common to consider alveolar infiltrates to be caused by bacteria and bilateral diffuse interstitial infiltrates to be caused by atypical bacterial or viral infections. However, this is not supported in the literature. In a study of 254 children with radiographically defined pneumonia, the etiology was determined in 215 [29]. The sensitivity and specificity of alveolar infiltrate for bacterial pneumonia were 72 and 51 percent, respectively; the sensitivity and specificity of interstitial infiltrates for viral pneumonia were 49 and 72 percent, respectively. A lobar infiltrate is reasonably specific for a bacterial pneumonia but lacks sensitivity [61,62].

- Pulmonary consolidation in young children sometimes appears to be spherical (ie, "round pneumonia") [63,64]. Round pneumonias tend to be >3 cm, solitary, and posteriorly located [64,65]. The most common bacterial etiology for round pneumonia is *S. pneumoniae*; additional bacterial causes include other streptococci, *Haemophilus influenzae*, *S. aureus*, and *M. pneumoniae* [30,66].

- Pneumatoceles, cavitations, large pleural effusions (image 2A and image 2B), and necrotizing processes (image 3) are supportive of a bacterial etiology.

- *M. pneumoniae* and viruses are most likely to spread diffusely along the branches of the bronchial tree, resulting in a bronchopneumonic pattern (image 4). However, in a series of 393 children hospitalized with *M. pneumoniae* pneumonia, 37 percent had lobar or segmental consolidation [67]. *S. pneumoniae* has occasionally been associated with a bronchopneumonia pattern in children. (See "Pneumococcal pneumonia in children", section on 'Radiographic features'.)

- In young infants, hyperinflation with an interstitial process is characteristic of afebrile pneumonia of infancy, typically caused by *C. trachomatis*. (See "Chlamydia trachomatis infections in the newborn", section on 'Pneumonia'.)

- Significant mediastinal/hilar adenopathy suggests a mycobacterial or fungal etiology.

LABORATORY EVALUATION

The laboratory evaluation of the child with CAP depends on the clinical scenario, including the age of the child, severity of illness, complications, and whether the child requires hospitalization [1].

Young infants in whom pneumonia is suspected, particularly those who are febrile and toxic appearing, require a full evaluation for sepsis and other serious bacterial infections. (See "The febrile infant (29 to 90 days of age): Outpatient evaluation".)

- **Complete blood count** – CBC usually is not necessary for children with mild lower respiratory tract infection (LRTI) who will be treated as outpatients, unless the CBC will help determine the need for antibiotic therapy. CBC should be obtained in infants and children who require hospital admission. Certain CBC findings, described below, are more characteristic of bacterial, atypical bacterial, or viral pneumonias. However, the findings overlap and cannot reliably differentiate between the etiologic agents.

  - White blood cell (WBC) count <15,000/microL suggests a nonbacterial etiology, except in the severely ill patient, who also may be neutropenic and have a predominance of immature cells.

  - WBC count >15,000/microL is suggestive of pyogenic bacterial disease [68]. However, children with *M. pneumoniae*, influenza, or adenovirus pneumonia also may have WBC count >15,000/microL [69-71].

  - Peripheral eosinophilia may be present in infants with afebrile pneumonia of infancy, typically caused by *C. trachomatis*. (See "Chlamydia trachomatis infections in the newborn", section on 'Pneumonia'.)

- **Acute phase reactants** – Acute phase reactants, such as the erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), and serum procalcitonin (PCT), need not be routinely measured in fully immunized children (table 6) with CAP managed as outpatients [1]. However, for those with more serious disease requiring hospitalization, measurement of acute phase reactants may provide useful information to assist clinical management.

  Acute phase reactants should not be used as the sole determinant to distinguish between viral and bacterial etiologies of CAP but may be helpful in following the disease course, response to therapy, and in determining when therapy can be discontinued [1,72-77]. (See "Pneumonia in children: Inpatient treatment", section on 'Duration of treatment'.)

  Measurement of serum CRP or PCT may be helpful assessing the risk of bacterial, atypical bacterial, and viral pneumonia. In a meta-analysis of observational studies in children, CRP and PCT were better than WBC count in differentiating bacterial from viral

pneumonia, but with sensitivity of approximately 70 percent and specificity of approximately 65 percent, they are insufficiently accurate to be used in isolation [78]. In a multicenter population-based study of 532 children with radiographically confirmed CAP, although overlap in PCT values between bacterial and viral etiologies was found, no child with PCT <0.1 ng/mL had typical bacterial pneumonia, suggesting that low serum PCT may be helpful in identifying children with CAP who are at low risk for bacterial pneumonia [79]. CRP and PCT have not been found to be useful in predicting illness severity in children evaluated for CAP in an emergency department setting [80].

- **Serum electrolytes** – Measurement of serum electrolytes may be helpful in assessing the degree of dehydration in children with limited fluid intake and whether hyponatremia is present (as hyponatremia often accompanies CAP). (See 'Complications' below.)

DIAGNOSIS

Clinical diagnosis — The diagnosis of pneumonia should be considered in infants and children with respiratory complaints, particularly cough, tachypnea, retractions, and abnormal lung examination [2,4].

The diagnosis of pneumonia can be made clinically in children with fever and historical or physical examination evidence of an infectious process with symptoms or signs of respiratory distress [24]. Radiographs are not necessary in children with mild pneumonia (table 5). Tachypnea, nasal flaring, grunting, retractions, and hypoxia increase the likelihood of pneumonia [3]. The absence of tachypnea is helpful in excluding pneumonia; the absence of the other signs is not. (See 'History and examination' above.)

In resource-limited countries where there is a high prevalence of pneumonia, a single positive respiratory sign increases the certainty of pneumonia [5]. The World Health Organization uses tachypnea (>60 breaths/min in infants <2 months; >50 breaths/min in infants 2 to 12 months; >40 breaths/min in children 1 to 5 years; and >20 breaths/min in children ≥5 years) as the sole criterion to define pneumonia in children with cough or difficulty breathing [81]. In developed countries with a lower prevalence of pneumonia, multiple respiratory signs (eg, hypoxia, grunting, nasal flaring, retractions) are necessary to increase the certainty of pneumonia [3,82].

Radiographic confirmation — An infiltrate on chest radiograph confirms the diagnosis of pneumonia in children with compatible clinical findings, although chest radiographs must be interpreted with caution in children with asthma and comorbid viral infection. (See 'Differential diagnosis' below.)

Radiographs should be obtained in children who require hospitalization, those in whom the diagnosis is uncertain, and in those with severe, complicated, or recurrent pneumonia [1,2].

Radiographic confirmation is not necessary in children with mild, uncomplicated lower respiratory tract infection who will be treated as outpatients. (See 'Indications' above.)

Radiographic findings cannot reliably distinguish between bacterial, atypical bacterial, and viral etiologies of pneumonia. Radiographic findings should be used in conjunction with clinical and microbiologic data to make therapeutic decisions [2]. (See "Pneumonia in children: Inpatient treatment", section on 'Empiric therapy' and "Community-acquired pneumonia in children: Outpatient treatment".)

Etiologic diagnosis

Indications for microbiologic testing — Although the etiologic agent is suggested by host characteristics, clinical presentation, epidemiologic considerations, and the results of nonspecific laboratory tests and chest radiographic patterns (table 4), neither clinical nor radiologic features reliably distinguish between bacterial, atypical bacterial, and viral pneumonia. (See 'Clues to etiology' above and 'Etiologic clues' above and "Pneumonia in children: Epidemiology, pathogenesis, and etiology", section on 'Etiologic agents'.)

Accurate and rapid diagnosis of the responsible pathogen can be helpful in making treatment or cohorting decisions for infants and children who are admitted to the hospital with CAP [1,83]. (See "Pneumonia in children: Inpatient treatment".)

If possible, a microbiologic diagnosis should be established in children:

- With severe disease (table 5)
- With potential complications
- Who require hospitalization
- In whom an unusual pathogen is suspected, particularly if it requires treatment that differs from standard empiric regimens (eg, S*. aureus* including methicillin-resistant strains, *Mycobacterium tuberculosis*) (see 'Critical microbes' below)
- Who fail to respond to initial therapy (see "Community-acquired pneumonia in children: Outpatient treatment", section on 'Monitoring response' and "Pneumonia in children: Inpatient treatment", section on 'Response to therapy')

Microbiologic diagnosis should also be established if there appears to be a community outbreak [84].

Children with mild disease (table 5) who are treated as outpatients usually can be treated empirically, based on age and other epidemiologic features, without establishing a microbiologic etiology [2,85]. (See "Community-acquired pneumonia in children: Outpatient treatment" and "Community-acquired pneumonia in children: Outpatient treatment", section on 'Indications for hospitalization' and "Community-acquired pneumonia in children: Outpatient treatment", section on 'Monitoring response'.)

Approach to microbiologic testing — Microbiologic diagnosis can be established with culture or rapid diagnostic testing (enzyme immunoassay [EIA], immunofluorescence, or polymerase chain reaction [PCR]).

Among children who are hospitalized with CAP, we usually obtain:

- Blood cultures, particularly in children with complications
- Sputum Gram stain and culture in children who are able to produce sputum
- Pleural fluid Gram stain and culture in children with more than minimal pleural effusion
- Rapid diagnostic tests (eg, PCR-based assays)

Our approach to microbiologic testing is generally consistent with that of the Pediatric Infectious Diseases Society and the Infectious Diseases Society of America clinical practice guidelines [1]. (See 'Society guideline links' below.)

- **Cultures**

  - **Blood cultures** – We suggest that blood cultures be performed in children with CAP who require hospital admission, particularly those with complications. (See "Detection of bacteremia: Blood cultures and other diagnostic tests".)

    In observational studies in the post-pneumococcal conjugate vaccine era, the prevalence of bacteremic pneumonia in hospitalized children who had blood cultures obtained ranges from 2.2 to 7 percent [86-88]. In the only prospective study, blood cultures were obtained in 91 percent of 2358 children who were hospitalized with radiographically confirmed pneumonia and were positive in 2.2 percent (95% CI 1.6-2.9 percent) [88]. The majority of isolates were susceptible to penicillin; the most frequently isolated pathogens were *S. pneumoniae* (46 percent), *S. aureus* (6 percent), and *Streptococcus pyogenes* (9 percent). In this and other observational studies, the prevalence of bacteremia was increased in patients with complicated pneumonia or pneumonia-related metastatic complications (eg, osteomyelitis) [86-92].

    Although targeting blood cultures to children at increased risk for bacteremia (ie, those with pleural effusion/empyema, admission to the intensive care unit, or immunosuppression) may be clinically effective and reduce costs [92,93], it can be difficult to determine which children are at risk for bacteremia at the time of

admission. In one multicenter study, 6 of the 26 patients with bacteremia were initially thought to have uncomplicated pneumonia [86].

- **Sputum cultures** – We suggest that sputum samples for Gram stain and culture be obtained in children who require hospital admission if they are able to produce sputum [1]. Children younger than five years usually swallow sputum, so it is rarely available for examination.

  Although good-quality sputum samples can be obtained by sputum induction [94,95], sputum induction is unpleasant. In addition, in a prospective study of the etiology of pneumonia in hospitalized children <18 years of age, bacterial pathogens were isolated from most induced sputum cultures whether or not the sample was good quality or the child had radiographically confirmed pneumonia [95]. Among children with radiographically confirmed pneumonia, induced sputum cultures infrequently matched cultures from sterile sites.

- **Pleural fluid cultures** – Diagnostic (and possibly therapeutic) thoracentesis generally is warranted for children with more than minimal pleural effusion. Specimens for culture of pleural fluid ideally should be obtained before administration of antibiotics. For patients who received oral antibiotics before identification of pleural effusion, molecular testing for detection of *S. pneumoniae*, *S. pyogenes*, and *S. aureus* using PCR techniques (when available) may be warranted. The evaluation of pleural fluid is discussed separately. (See "Epidemiology, clinical presentation, and evaluation of parapneumonic effusion and empyema in children", section on 'Pleural fluid analysis'.)

- **Nasopharyngeal cultures** – We do not obtain nasopharyngeal (NP) cultures for etiologic diagnosis in children with pneumonia. Bacterial organisms that cause pneumonia also may be normal upper respiratory flora. Although the results of NP cultures for viruses and atypical bacterial may be helpful, they may not be available soon enough to assist with management decisions.

- **Rapid diagnostic tests** – Rapid diagnostic tests include molecular tests that use PCR techniques (including multiplex PCR panels) and immunofluorescence. They can be performed on samples from the NP, pleural fluid, or throat (for *M. pneumoniae* [96]).

  When available, we suggest rapid diagnostic tests for hospitalized patients. Results of rapid diagnostic tests can be helpful in making treatment or cohorting decisions for infants and children who are admitted to the hospital with probable bacterial, mixed bacterial/viral, viral, or atypical bacterial CAP [1,83]. In prospective studies, PCR of blood and respiratory samples had a higher yield than culture for *S. pneumoniae* [7,97-99]. However, the latter may merely represent respiratory tract colonization. Rapid viral

testing cannot be used in isolation to exclude bacterial infection given the possibility of concomitant bacterial-viral infection, particularly in children who are severely ill [53].

Results of multiplex panels must be interpreted with caution because they do not differentiate colonization from infection. In a meta-analysis of case-control studies, respiratory syncytial virus, influenza virus, parainfluenza virus, and human metapneumovirus were associated with LRTI symptoms; rhinovirus was only weakly associated with LRTI symptoms; and adenovirus, bocavirus, and coronaviruses were not associated with LRTI symptoms. Quantitative *S. pneumoniae* PCR testing may help to differentiate colonization from infection [100-102].

The rapid diagnostic tests that are available for the following viral pathogens are discussed separately:

- Respiratory syncytial virus (see "Respiratory syncytial virus infection: Clinical features and diagnosis in infants and children", section on 'Diagnosis')
- Influenza viruses (see "Seasonal influenza in children: Clinical features and diagnosis", section on 'Diagnosis')
- Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (see "COVID-19: Clinical manifestations and diagnosis in children", section on 'Approach to diagnosis')
- Parainfluenza viruses (see "Parainfluenza viruses in children", section on 'Diagnosis')
- Adenovirus (see "Diagnosis, treatment, and prevention of adenovirus infection", section on 'Pneumonia')
- *M. pneumoniae* (see "*Mycoplasma pneumoniae* infection in children", section on 'Diagnosis')
- *Chlamydia* spp (see "Pneumonia caused by *Chlamydia pneumoniae* in children", section on 'Diagnosis')
- Human metapneumovirus (see "Human metapneumovirus infections", section on 'Diagnosis')

The use of rapid diagnostic tests for identification of pathogens in children with parapneumonic effusion is discussed separately. (See "Epidemiology, clinical presentation, and evaluation of parapneumonic effusion and empyema in children", section on 'Pleural fluid analysis'.)

- **Serology** – We do not suggest routine serologic testing for specific pathogens (eg, *S. pneumoniae*, *M. pneumoniae*, *C. pneumoniae*) because the results usually do not influence management [103,104]. Serologic diagnosis of viral pathogens is not practical because acute and convalescent specimens are needed. *S. pneumoniae* has too many potential infecting serotypes to make antibody determinations practical. Immunoglobulin (Ig)M antibody testing for *M. pneumoniae* may give false positive results. Serologic tests for *Chlamydia* spp are not readily available.

  Although most older children with atypical pneumonia can be treated empirically for *M. pneumoniae*, PCR testing can be helpful in evaluating the younger child [105]. PCR also may be helpful in establishing the diagnosis of *M. pneumoniae* in patients with extrapulmonary manifestations, particularly central nervous system manifestations [105]. (See "*Mycoplasma pneumoniae* infection in children", section on 'Clinical manifestations'.)

- **Other tests** – Other tests that may be helpful in establishing less common microbiologic etiologies of CAP in children with appropriate clinical indications include:

  - Tuberculin skin test and interferon gamma release assay if pulmonary tuberculosis is a consideration (eg, exposure to an individual with active tuberculosis (table 7), being foreign born, having a foreign-born caregiver, history of foreign travel, exposure to foreign traveler); additional diagnostic testing for tuberculosis in children is discussed separately (see "Tuberculosis disease in children: Epidemiology, clinical manifestations, and diagnosis")

  - Urine antigen testing for legionellosis due to serogroup 1 (see "Clinical manifestations and diagnosis of *Legionella* infection", section on 'Approach to testing' and "Microbiology, epidemiology, and pathogenesis of *Legionella* infection", section on 'Pathogen')

  - Serum and urine antigen and antibody (complement fixation, immunodiffusion, and EIA IgM/IgG) testing for histoplasmosis (exposure to bird droppings or bat guano in endemic area) [106] (see "Pathogenesis and clinical features of pulmonary histoplasmosis" and "Diagnosis and treatment of pulmonary histoplasmosis", section on 'Antigen detection')

  - At this time, urine antigen testing for *S. pneumoniae* in children should **not be** performed, because of the concern for false-positive reactions, some of which may merely indicate colonization with *S. pneumoniae* [1,2]; additional studies are needed to evaluate the potential usefulness of this diagnostic technique in children with and without CAP [107].

The addition of cell-free plasma sequencing and transcriptional profile analysis to diagnostic capabilities awaits the results of further studies in children with CAP and more widespread availability [108,109]. These laboratory approaches may be found to be most useful in immunocompromised hosts with CAP for whom the risks of invasive procedures may outweigh the benefits.

Invasive studies — Invasive procedures may be necessary to obtain lower respiratory tract specimens for culture and other studies in children in whom an etiologic diagnosis is necessary and has not been established by other means [1,110-113]. These procedures are typically reserved for seriously ill patients whose condition is worsening despite empiric therapy or individuals with significant comorbidities (eg, immune compromise). They include [1,110-112,114]:

- **Bronchoscopy with bronchoalveolar lavage (BAL)** – For samples obtained via bronchoscopy, quantitative culture techniques are suggested to differentiate true infection from upper airway contamination [115-117].

- **Percutaneous needle aspiration of the affected lung tissue guided by ultrasonography or computed tomography** – Microbiologic specimens may be obtained by ultrasonography or computed tomography-guided needle aspiration. Ultrasonography is preferred because of the lack of radiation exposure. In an observational study, a pathogen was identified in 20 of 34 children who underwent needle aspiration [110]. Six patients developed a pneumothorax, which resolved over two to three days without intervention.

- **Lung biopsy either by a thoracoscopic or thoracotomy approach** – Samples obtained by lung biopsy often yield diagnostic information in children who had nondiagnostic BAL [111,112,118].

Critical microbes — Some microbes are critical to detect because they require treatment that differs from standard empiric regimens or have public health implications. Diagnostic testing for these pathogens is discussed separately.

- Influenza A and B (see "Seasonal influenza in children: Clinical features and diagnosis", section on 'Diagnosis')

- SARS-CoV-2 (see "COVID-19: Clinical manifestations and diagnosis in children", section on 'Approach to diagnosis')

- Community-associated methicillin-resistant *S. aureus* (see "Methicillin-resistant *Staphylococcus aureus* infections in children: Epidemiology and clinical spectrum", section on 'Epidemiology and risk factors')

- Measles (picture 1A-B) (see "Measles: Clinical manifestations, diagnosis, treatment, and prevention")
- Varicella (picture 2) (see "Clinical features of varicella-zoster virus infection: Chickenpox" and "Diagnosis of varicella-zoster virus infection")
- Adenovirus (see "Pathogenesis, epidemiology, and clinical manifestations of adenovirus infection" and "Diagnosis, treatment, and prevention of adenovirus infection")
- *M. tuberculosis* (see "Tuberculosis disease in children: Epidemiology, clinical manifestations, and diagnosis")
- Fungal etiologies (*Coccidioides immitis*, *Blastomyces dermatitidis*, *Histoplasma capsulatum*) (see "Primary pulmonary coccidioidal infection" and "Mycology, pathogenesis, and epidemiology of blastomycosis" and "Treatment of blastomycosis" and "Diagnosis and treatment of pulmonary histoplasmosis")
- *Legionella* species (see "Clinical manifestations and diagnosis of *Legionella* infection")
- Avian influenza (see "Avian influenza: Clinical manifestations and diagnosis")
- Hantavirus (see "Hantavirus cardiopulmonary syndrome")
- Agents of bioterrorism (see "Identifying and managing casualties of biological terrorism")

DIFFERENTIAL DIAGNOSIS

Although pneumonia is highly probable in a child with fever, tachypnea, cough, and infiltrate(s) on chest radiograph, alternate diagnoses and coincident conditions must be considered in children who fail to respond to therapy or have an unusual presentation/course.

- **Noninfectious mimics of pneumonia** – The table lists a number of other conditions that can mimic an infectious pneumonia (table 8). History and/or associated clinical features usually help to distinguish the conditions in the table from infectious pneumonia. In some cases, laboratory studies or additional imaging may be necessary.

  Foreign body aspiration must be considered in young children. The aspiration event may not have been witnessed. (See "Airway foreign bodies in children", section on 'Presentation'.)

- **Other causes of tachypnea** – Other causes of tachypnea, with or without fever and cough, in infants and young children include [119]:

- Bronchiolitis (see "Bronchiolitis in infants and children: Clinical features and diagnosis", section on 'Clinical features')
- Heart failure (see "Heart failure in children: Etiology, clinical manifestations, and diagnosis", section on 'Clinical manifestations')
- Sepsis (see "Children with early and life-threatening sepsis: Definitions, clinical manifestations, and diagnosis" and "Clinical features, evaluation, and diagnosis of sepsis in term and late preterm neonates")
- Metabolic acidosis (see "Approach to the child with metabolic acidosis", section on 'Acute metabolic acidosis')

These conditions usually can be distinguished from pneumonia by history, examination, and laboratory tests.

- **Other considerations**
  - **Lemierre syndrome** – Lemierre syndrome (jugular vein suppurative thrombophlebitis) is an important consideration in adolescents and young adults whose illness began with pharyngitis. In Lemierre syndrome, the vessels of the carotid sheath become infected (typically with *Fusobacterium* spp), leading to bacteremia and metastatic spread of infection to the lungs and mediastinum. (See "Lemierre syndrome: Septic thrombophlebitis of the internal jugular vein".)
  - **Vaping-associated pulmonary illness** – In adolescents and young adults, use of electronic cigarette devices to inhale aerosolized substances (ie, "vaping") has been associated with a severe pulmonary illness that shares symptoms with pneumonia (eg, shortness of breath, fever, chest pain) [120,121]. Vaping-associated pulmonary illness is discussed separately. (See "Vaping and e-cigarettes", section on 'Aerosol (also known as vapor) exposure'.)
  - **Comorbid asthma and viral respiratory infection** – CAP can be misdiagnosed in young children with asthma who have viral respiratory infections [122]. Many such children have respiratory distress and may have hypoxemia. The diagnosis of CAP and treatment with antibiotics must be carefully considered in young children who have a prodrome compatible with a viral respiratory infection and wheezing, even if there are pulmonary infiltrates (versus atelectasis) on chest radiograph. (See "Asthma in children younger than 12 years: Initial evaluation and diagnosis", section on 'Respiratory tract infections'.)
  - **Comorbid noninfectious lung disease** – Rare, noninfectious lung diseases may present with an intercurrent infectious illness. These conditions should be

considered, especially if the acute illness is atypical or the radiographic and clinical findings do not resolve as expected with uncomplicated CAP.

- Pulmonary alveolar proteinosis (see "Pulmonary alveolar proteinosis in children")
- Eosinophilic pneumonia (see "Idiopathic acute eosinophilic pneumonia")
- Acute interstitial pneumonitis (see "Acute interstitial pneumonia (Hamman-Rich syndrome)")
- Cryptogenic organizing pneumonia (see "Cryptogenic organizing pneumonia")

COMPLICATIONS

Bacterial pneumonias are more likely than atypical bacterial or viral pneumonias to be associated with complications involving the respiratory tract.

Pleural effusion and empyema — The clinical features, evaluation, and management of parapneumonic effusion (image 2A-B) and empyema in children are discussed separately. Hypoalbuminemia is common in children with parapneumonic effusions, and hypogammaglobulinemia may be encountered. (See 'Laboratory evaluation' above and "Epidemiology, clinical presentation, and evaluation of parapneumonic effusion and empyema in children" and "Management and prognosis of parapneumonic effusion and empyema in children".)

Necrotizing pneumonia — Necrotizing pneumonia, necrosis, and liquefaction of lung parenchyma is a serious complication of CAP. Necrotizing pneumonia usually follows pneumonia caused by particularly virulent bacteria [123]. *S. pneumoniae* (especially serotype 3 and serogroup 19) is the most common cause of necrotizing pneumonia (image 3) [124-127]. Necrotizing pneumonia also may occur with *S. aureus* and group A *Streptococcus* and has been reported due to *M. pneumoniae*, *Legionella*, and *Aspergillus* [126,128-132].

Clinical manifestations of necrotizing pneumonia are similar to those of uncomplicated pneumonia, but they are more severe [132-134]. Necrotizing pneumonia should be considered in a child with prolonged fever or septic appearance [123]. The diagnosis can be confirmed by Doppler ultrasonography, chest radiograph (which demonstrates a radiolucent lesion) (image 1), or contrast-enhanced computed tomography (CT) (image 3) if the diagnosis remains uncertain [135,136]. The findings on chest radiograph may lag behind those of CT and Doppler ultrasonography may detect necrotic changes earlier than CT [130,137].

Pleural effusion/empyema generally accompanies necrotizing pneumonia whereas bronchopleural fistula, pneumatocele, or abscess formation (which typically is insidious) is

much less common. Drainage of the pleural fluid collection is frequently required, but pneumonectomy is rarely needed. (See 'Pneumatocele' below and 'Lung abscess' below.)

Treatment of necrotizing pneumonia is discussed separately. (See "Pneumonia in children: Inpatient treatment", section on 'Complicated CAP'.)

Lung abscess — A lung abscess is an accumulation of inflammatory cells, accompanied by tissue destruction or necrosis that produces one or more cavities in the lung [40]. Abscess formation may result from inadequate or delayed treatment of lobar pneumonia or more commonly develops one to two weeks following an aspiration event. Other predisposing factors include airway obstruction and congenitally abnormal lung [40]. Anaerobic flora of the upper respiratory tract and *S. aureus* are the organisms most frequently involved [119].

Clinical manifestations of lung abscess are nonspecific and similar to those of pneumonia [40]. They include fever, cough, dyspnea, chest pain, anorexia, hemoptysis, and putrid breath [123,138-140]. The course may be indolent.

The diagnosis is suggested by a chest radiograph demonstrating a thick-walled cavity with an air-fluid level (image 1) [40] and confirmed by contrast-enhanced CT in questionable clinical situations or if necessary before invasive interventions (eg, percutaneous aspiration, placement of a drainage catheter) [135]. Lung abscess is often accompanied by parapneumonic effusion [141,142]. Lung abscess should be suspected when consolidation is unusually persistent, when pneumonia remains persistently round or mass-like, and when the volume of the involved lobe is increased (as suggested by a bulging fissure) [40,143].

Interventional radiology may be helpful in obtaining a specimen from the abscess cavity for diagnostic studies. Treatment of lung abscess is discussed separately. (See "Pneumonia in children: Inpatient treatment", section on 'Complicated CAP'.)

The most common complication of lung abscess is intracavitary hemorrhage. This can cause hemoptysis or spillage of the abscess contents with spread of infection to other areas of the lung [133]. Other complications of lung abscess include empyema, bronchopleural fistula, septicemia, cerebral abscess, and inappropriate secretion of antidiuretic hormone [133].

Pneumatocele — Pneumatoceles are thin-walled, air-containing cysts of the lungs. They are classically associated with *S. aureus* but may occur with a variety of organisms [144,145]. Pneumatoceles frequently occur in association with empyema [144]. In most cases, pneumatoceles involute spontaneously, and long-term lung function is normal [144,146,147]. However, on occasion, pneumatoceles result in pneumothorax [145].

Hyponatremia — Hyponatremia (serum sodium concentration ≤135 mEq/L) occurs in approximately 45 percent of children with CAP and one-third of children hospitalized with CAP, but is usually mild (ie, serum sodium concentration >130 and ≤135 mEq/L) [148-152].

Hyponatremia is associated with increased length of hospital stay, complications, and mortality and may be associated with inappropriate secretion of antidiuretic hormone [148,149,151,152]. (See "Pathophysiology and etiology of the syndrome of inappropriate antidiuretic hormone secretion (SIADH)", section on 'Pulmonary disease'.)

INDICATIONS FOR HOSPITALIZATION

Indications for hospitalization are discussed separately. (See "Pneumonia in children: Inpatient treatment", section on 'Indications'.)

SOCIETY GUIDELINE LINKS

Links to society and government-sponsored guidelines from selected countries and regions around the world are provided separately. (See "Society guideline links: Pediatric pneumonia".)

INFORMATION FOR PATIENTS

UpToDate offers two types of patient education materials, "The Basics" and "Beyond the Basics." The Basics patient education pieces are written in plain language, at the 5th to 6th grade reading level, and they answer the four or five key questions a patient might have about a given condition. These articles are best for patients who want a general overview and who prefer short, easy-to-read materials. Beyond the Basics patient education pieces are longer, more sophisticated, and more detailed. These articles are written at the 10th to 12th grade reading level and are best for patients who want in-depth information and are comfortable with some medical jargon.

Here are the patient education articles that are relevant to this topic. We encourage you to print or email these topics to your patients. (You can also locate patient education articles on a variety of subjects by searching on "patient education" and the keyword[s] of interest.)

- Basics topic (see "Patient education: Pneumonia in children (The Basics)")

SUMMARY AND RECOMMENDATIONS

- **Clinical presentation** – The presenting signs and symptoms of community-acquired pneumonia (CAP) are nonspecific; no single symptom or sign is pathognomonic for pneumonia in children. The combination of fever and cough is suggestive of

pneumonia, but the presentation may be subtle or misleading (eg, abdominal pain or nuchal rigidity). (See 'Clinical presentation' above.)

- **Clinical evaluation**
  - The history should focus on features that can help to define the clinical syndrome (eg, pneumonia, bronchiolitis) and narrow the list of potential pathogens (table 2 and table 4). (See 'History and examination' above and "Pneumonia in children: Epidemiology, pathogenesis, and etiology", section on 'Etiologic agents'.)
  - Physical examination findings that have been correlated with radiographic pneumonia include tachypnea, increased work of breathing (retractions, nasal flaring, grunting, use of accessory muscles), hypoxemia, and adventitious lung sounds. Combinations of findings (eg, fever, cough, tachypnea) are more predictive than single findings. The absence of tachypnea is useful in excluding pneumonia. (See 'History and examination' above.)
  - The history and physical examination are used to determine the severity of illness (table 5), which determines, in part, the need for radiologic and laboratory evaluation. (See 'Severity assessment' above.)
- **Radiologic evaluation** – Radiographs are not necessary for children with pneumonia who are well enough to be treated as outpatients. We suggest that chest radiographs be obtained for the following indications:
  - Severe disease (table 5) (see 'Severity assessment' above)
  - Confirmation of the diagnosis when clinical findings are inconclusive
  - Exclusion of alternate explanations for respiratory distress (see 'Differential diagnosis' above)
  - History of recurrent pneumonia
  - Evaluation for complications (see 'Complications' above)
  - Exclusion of occult pneumonia in young children (3 to 36 months) with fever >39°C (102.2°F), leukocytosis (white blood cell count >20,000/microL), and no obvious focus of infection (see 'Radiologic evaluation' above)
- **Laboratory evaluation** – Routine laboratory evaluation is not necessary for children with mild uncomplicated lower respiratory tract infection who will be treated as outpatients unless the findings will help in deciding whether antimicrobial therapy is necessary. Complete blood count with differential and acute phase reactants may

provide supportive evidence for bacterial or viral pneumonia but should not be used as the only criteria in determining the need for antimicrobial therapy. (See 'Laboratory evaluation' above.)

- **Clinical diagnosis** – The diagnosis of pneumonia should be considered in infants and children with respiratory complaints, particularly cough, tachypnea, retractions, and abnormal lung examination. It can be made clinically in children with fever and clinical findings of an infectious process with respiratory distress. (See 'Clinical diagnosis' above and 'Radiographic confirmation' above.)

- **Etiologic diagnosis** – Neither clinical, laboratory, nor radiographic features reliably distinguish between bacterial, atypical bacterial, and viral pneumonia (table 4). (See 'Clues to etiology' above and 'Etiologic clues' above.)

  - Attempts to establish an etiologic diagnosis should be made in children with severe disease or potential complications, children who require hospitalization, children in whom an unusual pathogen is suspected, and children who fail to respond to initial therapy. Attempts to establish an etiologic diagnosis should also be made if there appears to be a community outbreak. (See 'Indications for microbiologic testing' above and 'Critical microbes' above.)

  - Among children who are hospitalized with CAP, we generally obtain blood culture and rapid diagnostic tests (eg, polymerase chain reaction-based assays, immunofluorescence).

    We obtain sputum for Gram stain and culture in children who are able to produce sputum and pleural fluid for Gram stain, culture, and other microbiologic tests in children with more than minimal pleural effusion. Other specimens for microbiologic testing should be obtained as indicated by the clinical scenario. (See 'Approach to microbiologic testing' above and 'Critical microbes' above.)

- **Differential diagnosis** – Alternate diagnoses and coincident conditions must be considered in children who fail to respond to therapy or who have an unusual presentation or course (table 8). (See 'Differential diagnosis' above and "Community-acquired pneumonia in children: Outpatient treatment", section on 'Treatment failure' and "Pneumonia in children: Inpatient treatment".)

- **Complications** – Complications of CAP in children include pleural effusion and empyema, necrotizing pneumonia, lung abscess, pneumatocele, and hyponatremia. (See 'Complications' above.)

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Topic 5986 Version 61.0

GRAPHICS

Pneumonia terminology

Term	Definition
Classification by site of acquisition	
Community-acquired pneumonia (CAP)	An acute infection of the pulmonary parenchyma acquired outside of health care settings
Nosocomial pneumonia	An acute infection of the pulmonary parenchyma acquired in hospital settings, which encompasses hospital-acquired pneumonia and ventilator-associated pneumonia
Hospital-acquired pneumonia (HAP)	Pneumonia acquired ≥48 hours after hospital admission; includes both HAP and VAP
Ventilator-associated pneumonia (VAP)	Pneumonia acquired ≥48 hours after endotracheal intubation
Health care-associated pneumonia (HCAP)	Retired term, which referred to pneumonia acquired in health care facilities (eg, nursing homes, hemodialysis centers) or after recent hospitalization*
Classification by etiology	
Atypical pneumonia	Pneumonia caused by "atypical"¶ bacterial pathogens including *Legionella* spp, *Mycoplasma pneumoniae*, *Chlamydia pneumoniae*, *Chlamydia psittaci*, and *Coxiella burnetii*
Aspiration pneumonia	Pneumonia resulting from entry of gastric or oropharyngeal fluid, which may contain bacteria and/or exogenous substances (eg, ingested food particles or liquids, mineral oil, salt or fresh water) or be of low pH into the lower airways
Chemical pneumonitis	Aspiration of substances (eg, acidic gastric fluid) that cause an inflammatory reaction in the lower airways, independent of bacterial infection
Bacterial aspiration pneumonia	An active infection caused by inoculation of large amounts of bacteria into the lungs via orogastric contents

* The term HCAP was used to identify patients at risk for infection with multidrug-resistant pathogens. This categorization may have been overly sensitive, leading to increased, inappropriately broad antibiotic use.

¶ The origin of the term "atypical" is a matter of debate. The term may refer to the fact that these organisms are not "typical" bacteria, which cannot be identified by standard microbiologic techniques. Others suggest that atypical refers to the mild nature of the pneumonia caused by some of these organisms compared with pneumonia caused by *Streptococcus pneumoniae*.

Graphic 130821 Version 4.0

Important aspects of the history in a child with pneumonia

Historical feature	Possible significance
Age of the child	Viral etiologies are most common in infants and preschool children Atypical bacterial pathogens are more common in school-age children
Recent viral upper respiratory tract infection	May predispose to bacterial superinfection with *Streptococcus pneumoniae* or *Staphylococcus aureus*
Associated symptoms	*Mycoplasma pneumoniae* is often associated with extrapulmonary manifestations (eg, headache, sore throat, conjunctivitis, photophobia, rash)
Cough, chest pain, shortness of breath, difficulty breathing	"Classic" features of pneumonia, but nonspecific
Increased work of breathing in the absence of stridor or wheezing	Suggestive of severe pneumonia
Fluid and nutrition intake	Difficulty or inability to feed suggests severe illness
Choking episode	May indicate foreign body aspiration
Duration of symptoms	Chronic cough (>4 weeks) suggests etiology other than acute pneumonia (refer to UpToDate topic on causes of chronic cough in children)
Previous episodes	Recurrent episodes may indicate aspiration, congenital or acquired anatomic abnormality, cystic fibrosis, immunodeficiency, asthma, missed foreign body
Immunization status	Completion of the primary series of immunizations for *Haemophilus influenzae* type b, *S. pneumoniae*, *Bordetella pertussis*, and seasonal influenza decreases, but does not eliminate, the risk of infection with these organisms
Previous antibiotic therapy	Increases the likelihood of antibiotic-resistant bacteria
Maternal history of chlamydia during pregnancy (for infants <4 months of age)	May indicate *Chlamydia trachomatis* infection
Foreign travel or known exposure to tuberculosis	May indicate *Mycobacterium tuberculosis* infection
Ill contacts	More common with viral etiologies
Travel to or residence in certain areas that suggest endemic pathogens	▪ Measles: Resource-limited countries ▪ Coccidioidomycosis: Southwestern United States, northern Mexico, Central and South America ▪ Blastomycosis: Southeastern and Central United States; states bordering the Great Lakes

	▪ Histoplasmosis: Ohio, Missouri, and Mississippi River valleys in the United States; Canada; Central America; eastern and southern Europe; parts of Africa; eastern Asia; and Australia ▪ Hantavirus: West of the Mississippi River; four corners region of United States (where borders of Colorado, New Mexico, Arizona, and Utah meet) ▪ Middle East respiratory syndrome (MERS): Countries in or near Arabian Peninsula
Animal exposure	May indicate histoplasmosis, psittacosis, Q fever
Day care center attendance	Exposure to viruses and antibiotic-resistant bacteria

Graphic 52510 Version 14.0

Important aspects of the physical examination in a child with suspected pneumonia

Physical examination feature	Possible significance
General appearance (state of awareness, cyanosis)*	Most children with radiographically confirmed pneumonia appear ill
Vital signs	
Temperature	Fever may be the only sign of pneumonia in highly febrile young children; however, it is variably present and nonspecific
Respiratory rate	Tachypnea¶ less predictive of radiographically confirmed pneumonia than hypoxemia or increased work of breathing Tachypnea correlates with hypoxemia Absence of tachypnea helps to exclude pneumonia
Degree of respiratory distress	Respiratory distress is more specific than fever or cough for lower respiratory infection
Tachypnea	Described in section on "Vital signs"
Hypoxemia	Predictive of pneumonia
Increased work of breathing:	
Retractions	More common in children with pneumonia than without; absence does not exclude pneumonia
Nasal flaring	More common in children with pneumonia than without; absence does not exclude pneumonia
Grunting	Sign of severe disease and impending respiratory failure
Accessory muscle use	Sign of severe disease
Head bobbing	Sign of severe disease
Lung examination	
Cough	Nonspecific finding of pneumonia
Auscultation	Findings suggestive of pneumonia include: crackles (rales, crepitations), decreased breath sounds, bronchial breath sounds, egophony, bronchophony, and whispered pectoriloquy Wheezing more common in viral and atypical pneumonias
Tactile fremitus	Suggestive of parenchymal consolidation
Dullness to percussion	Suggestive of parenchymal consolidation or pleural effusion
Mental status	Altered mental status may be a sign of hypoxia

* For young infants: Ability to attend to the environment, feed, vocalize, and be consoled.

¶ World Health Organization definitions of tachypnea according to age are as follows: <2 months: >60 breaths/min; 2 to 12 months: >50 breaths/min; 1 to 5 years: >40 breaths/min; ≥5 years: >20 breaths/min.

Graphic 65313 Version 6.0

Clinical and radiographic clues to the etiology of pneumonia in children*

Etiology	Clinical features	Radiographic features
Bacteria (most commonly *Streptococcus pneumoniae*)	▪ Children of all ages ▪ Abrupt onset ▪ Ill-appearance ▪ Chills ▪ Moderate to severe respiratory distress ▪ Focal auscultatory findings ▪ Localized chest pain ▪ WBC count >15,000/microL (if obtained) ▪ Elevated acute phase reactants (if obtained)	▪ Alveolar infiltrates ▪ Segmental consolidation ▪ Lobar consolidation ▪ "Round" pneumonia Complications: ▪ Pleural effusion/empyema ▪ Lung abscess ▪ Necrotizing pneumonia ▪ Pneumatocele
Atypical bacterial (*Mycoplasma pneumoniae*, *Chlamydia pneumoniae*)	▪ Children of all ages (most common in children >5 years) ▪ Abrupt onset with constitutional findings (malaise, myalgia, headache, rash, conjunctivitis, photophobia, sore throat) ▪ Gradually worsening nonproductive cough ▪ Wheezing ▪ Extrapulmonary manifestations or complications (eg, polymorphous mucocutaneous eruptions, hemolytic anemia, hepatitis, pancreatitis, myopericarditis, aseptic meningitis)	▪ *M. pneumoniae:* • Lobar or segmental consolidation (37%) • Parahilar or peribronchial infiltrates (27%) • Localized reticulonodular infiltrates (21%) • Patchy infiltrates (15%)
Viral	▪ Usually children <5 years ▪ Gradual onset ▪ Preceding upper airway symptoms ▪ Nontoxic appearing ▪ Diffuse, bilateral auscultatory findings ▪ Wheezing ▪ May have associated rash (eg, measles, varicella)	▪ Interstitial infiltrates ▪ Associated bronchiolitis: • Patchy atelectasis • Peribronchial infiltrations with air bronchograms • Hyperinflation with flattening of the diaphragms
Afebrile pneumonia of infancy (most commonly	▪ Usually in infants 2 weeks to 4 months ▪ Insidious onset ▪ Tachypnea, diffuse crackles	▪ Hyperinflation with interstitial infiltrates

Chlamydia trachomatis)	▪ Rhinorrhea ▪ Staccato cough pattern ▪ Peripheral eosinophilia (if CBC obtained)	
Fungal	▪ Appropriate geographic or environmental exposure	▪ Mediastinal or hilar adenopathy
Mycobacterium tuberculosis	▪ Children of any age ▪ Chronic cough ▪ Constitutional symptoms ▪ Exposure history	▪ Mediastinal or hilar adenopathy

WBC: white blood cell; CBC: complete blood count.

* The clinical features frequently overlap and cannot reliably distinguish between bacterial, atypical bacterial, and viral etiologies; up to one-half of community-acquired pneumonias in children may be mixed bacterial/viral infections. Chest radiography generally is not helpful in determining the potential causative agent of pneumonia. Nonetheless, these features may facilitate decisions regarding empiric therapy.

Data from:

1. *Bartlett JG, Mundy LM. Community-acquired pneumonia. N Engl J Med 1995; 333:1618.*
2. *Boyer KM. Nonbacterial pneumonia. In: Textbook of Pediatric Infectious Diseases, 6th ed, Feigin RD, Cherry JD, Demmler-Harrison GJ, Kaplan SL (Eds), Saunders, Philadelphia 2009. p.289.*
3. *Broughton RA. Infections due to Mycoplasma pneumoniae in childhood. Pediatr Infect Dis 1986; 5:71.*
4. *McIntosh K. Community-acquired pneumonia in children. N Engl J Med 2002; 346:429.*
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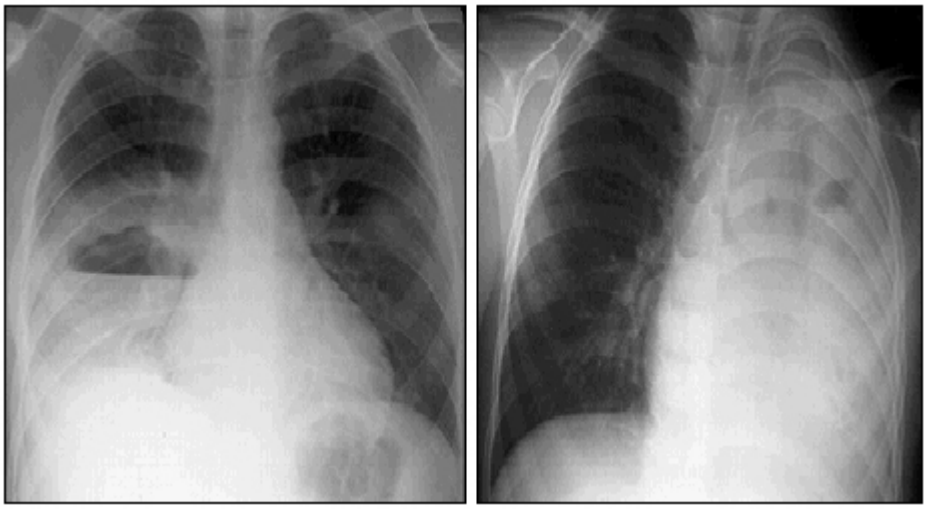
Graphic 52021 Version 14.0

Pneumococcal pneumonia: Complications



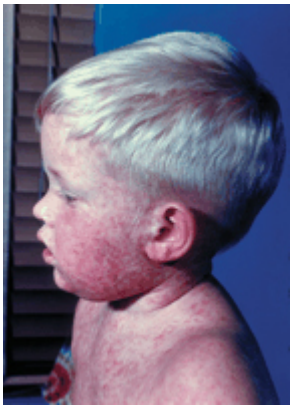
Radiographic images of the complications of pneumococcal pneumonia.

(Left panel) Lung abscess with an air-fluid level in the right lung. Abscess cavity material is nearly always culture positive, and patients commonly defervesce within 48 hours of interventional drainage.

(Right panel) Radiograph of necrotizing pneumonia in the left lung.

Graphic 53664 Version 9.0

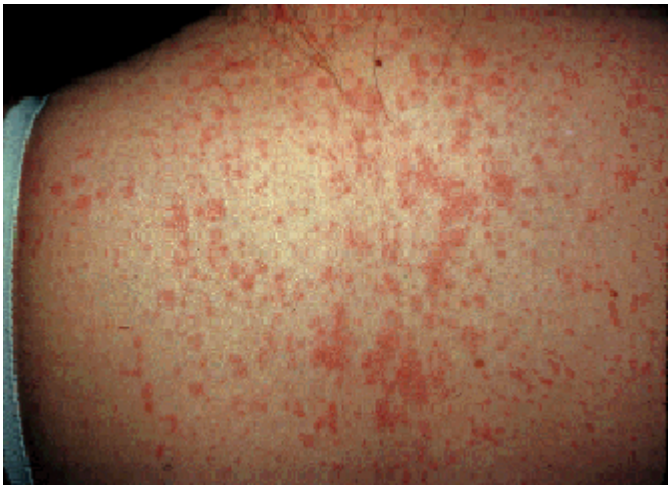
Boy with measles



Source: Centers for Disease Control and Prevention.

Graphic 57803 Version 3.0

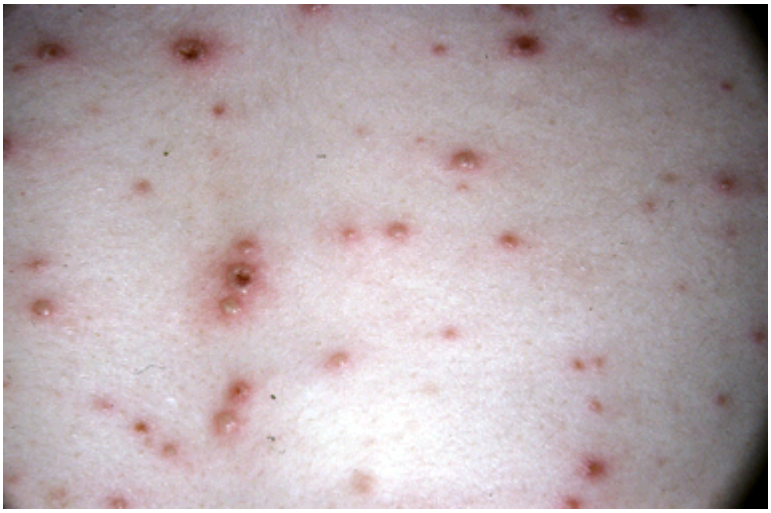
Measles exanthem



Blanching erythematous macules with some confluent areas on the trunk in a patient with measles.

Graphic 57093 Version 4.0

Primary varicella lesions



Vesicular lesions on an erythematous base are characteristic of chickenpox. The lesions occur in crops and are present in a variety of stages from maculopapular to vesicular or even pustular. Central necrosis and early crusting is also visible.

Courtesy of Lee T Nesbitt, Jr. The Skin and Infection: A Color Atlas and Text, Sanders CV, Nesbitt LT Jr (Eds), Williams & Wilkins, Baltimore 1995.

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http://www.lww.com

Graphic 55533 Version 5.0

Severity of community-acquired pneumonia in infants and children

Clinical features of mild pneumonia	Clinical features of severe pneumonia
Temperature <38.5°C (101.3°F)	Temperature ≥38.5°C (101.3°F)
Mild or absent respiratory distress: ▪ Increased RR, but less than the age-specific RR that defines moderate to severe respiratory distress ▪ Mild or absent retractions ▪ No grunting ▪ No nasal flaring ▪ No apnea ▪ Mild shortness of breath	Moderate to severe respiratory distress: ▪ RR >70 breaths/minute for infants; RR >50 breaths/minute for older children ▪ Moderate/severe suprasternal, intercostal, or subcostal retractions (<12 months) ▪ Severe difficulty breathing (≥12 months) ▪ Grunting ▪ Nasal flaring ▪ Apnea ▪ Significant shortness of breath
Normal color	Cyanosis
Normal mental status	Altered mental status
Normoxemia (oxygen saturation ≥92 percent in room air)	Hypoxemia (sustained oxygen saturation <90 percent in room air at sea level)
Normal feeding (infants); no vomiting	Not feeding (infants) or signs of dehydration (older children)
Normal heart rate	Tachycardia
Capillary refill <2 seconds	Capillary refill ≥2 seconds

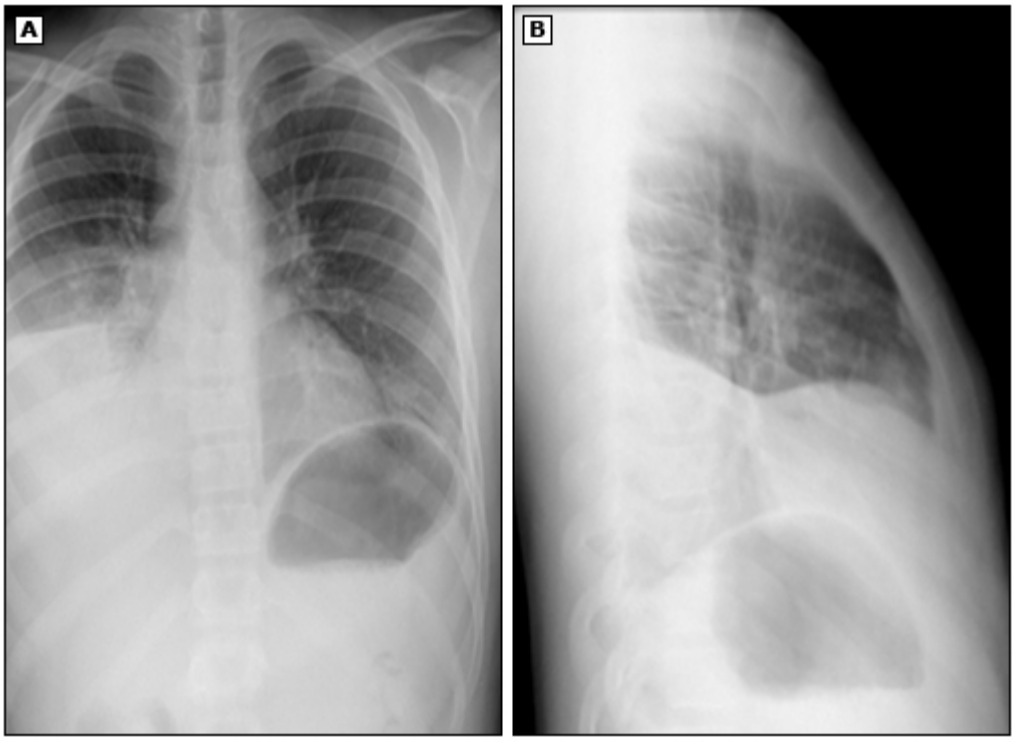
RR: respiratory rate.

Data from:

1. *Bradley JS, Byington CL, Shah SS, et al. The management of community-acquired pneumonia in infants and children older than 3 months of age: Clinical practice guidelines by the Pediatric Infectious Diseases Society and the Infectious Diseases Society of America. Clin Infect Dis 2011; 53:e25.*
2. *Harris M, Clark J, Coote N, et al. British Thoracic Society guidelines for the management of community acquired pneumonia in children: Update 2011. Thorax 2011; 66:ii1.*

Graphic 72015 Version 4.0

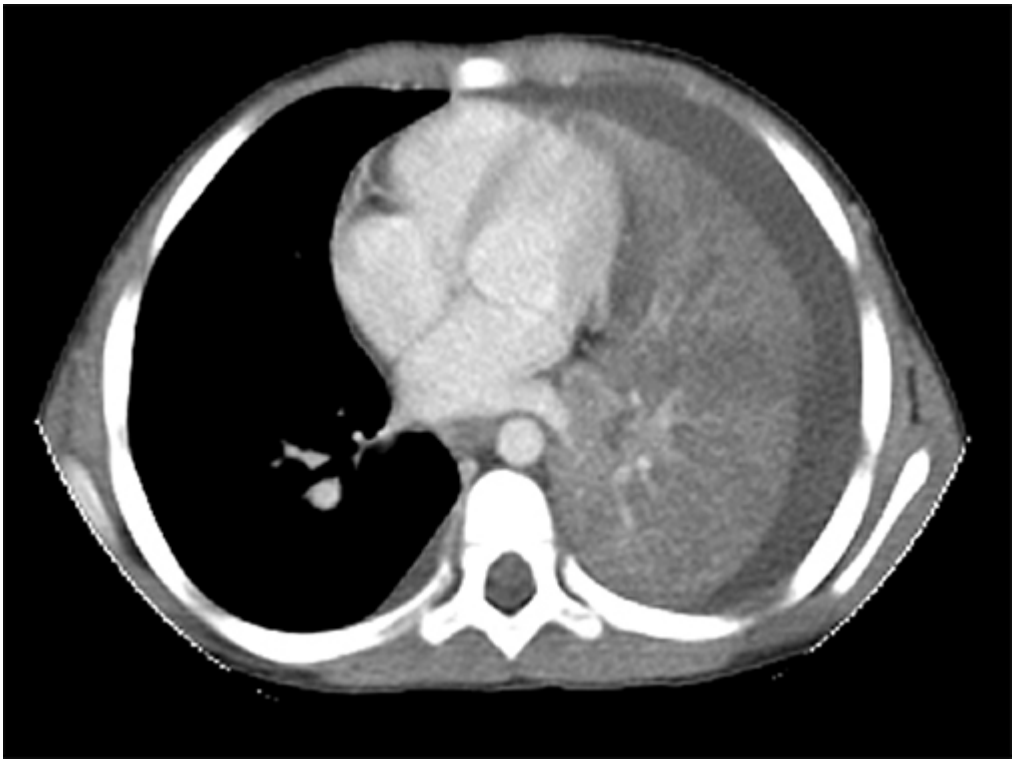
Right-sided pneumonia with pleural effusion



Courtesy of Dwight A Powell, MD.

Graphic 86360 Version 1.0

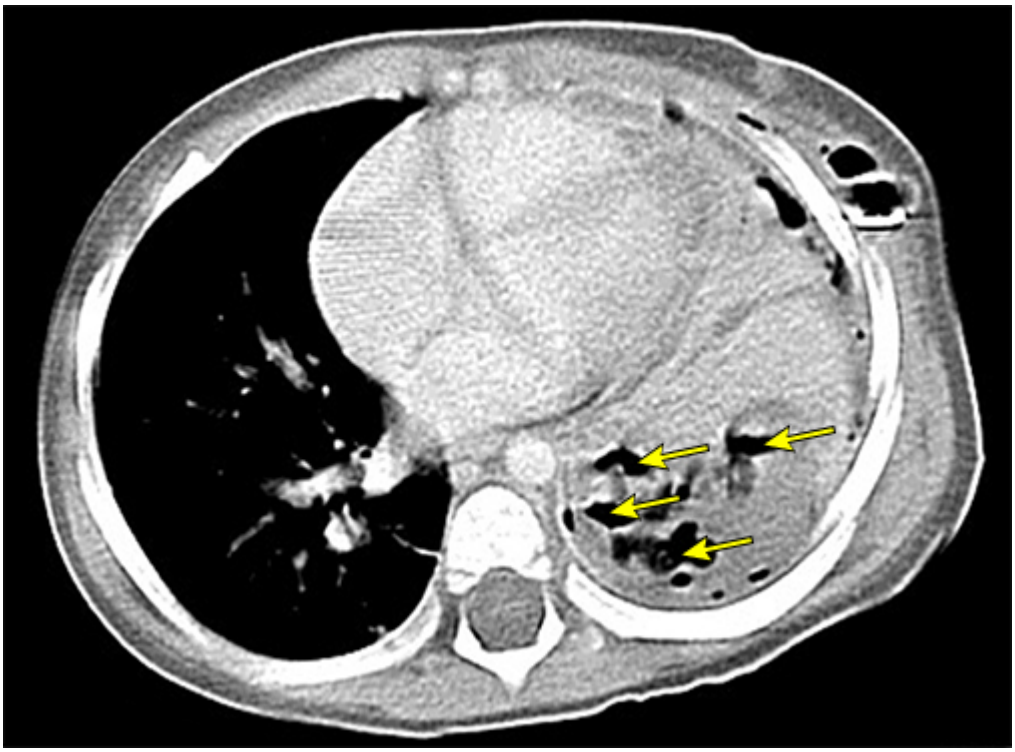
Computed tomography: Left-sided pneumonia with pleural effusion



Courtesy of Dwight A Powell, MD.

Graphic 86361 Version 1.0

Computed tomography: Left-sided *Streptococcus pneumoniae* necrotizing pneumonia

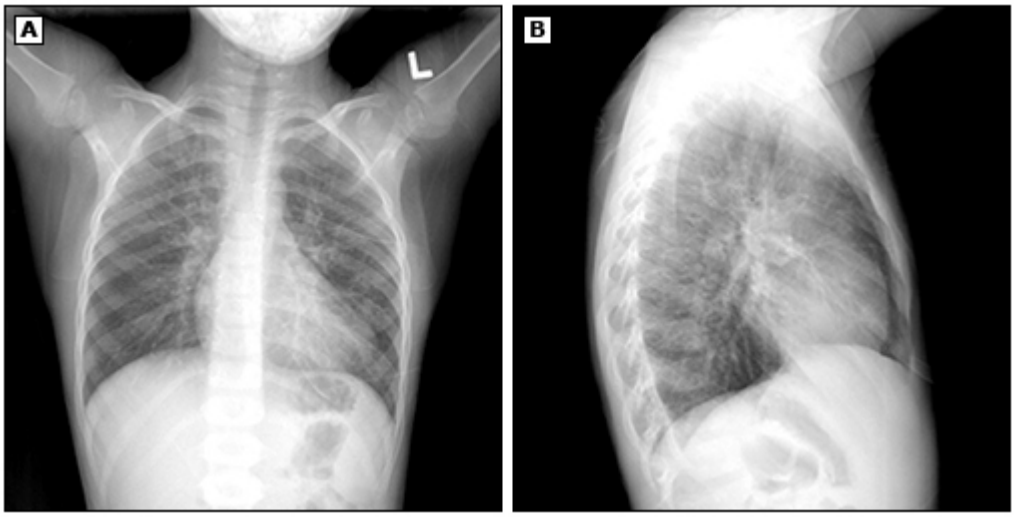


Computed tomography of the chest demonstrating left-sided necrotizing pneumonia. Note the consolidation of the left lung parenchyma with focal areas of liquefaction (arrows).

Courtesy William J Barson, MD.

Graphic 86362 Version 3.0

Mycoplasma pneumoniae pneumonia: Chest radiograph



Diffuse bilateral interstitial infiltrates with *M. pneumoniae* infection.

Courtesy of Dwight A Powell, MD.

Graphic 86363 Version 4.0

Suggested criteria for full *Haemophilus influenza* type b and *Streptococcus pneumoniae* immunization status when considering empiric antibiotics for community-acquired pneumonia in children

Current age*	Criteria for full immunization¶
***Haemophilus influenzae* type b**	
12 to 15 months	≥2 doses of Hib conjugate vaccine, with at least one dose at ≥12 months of age
15 months to 5 years	≥2 doses of Hib conjugate vaccine, with at least one dose at ≥12 months of age, **or**
	≥1 dose of Hib conjugate vaccine at ≥15 months of age
≥5 years, not high risk[Δ]	Hib immunization not necessary
Streptococcus pneumoniae	
12 to 24 months	≥3 doses of PCV at <16 months, with ≥1 dose at ≥12 months, **or**
	2 doses of PCV, both at ≥12 months
24 months through 5 years	≥3 doses of PCV at <16 months, with ≥1 dose at ≥12 months, **or**
	2 doses of PCV, both at ≥12 months, **or**
	≥1 dose of PCV at ≥24 months
>5 years, not high risk[◇]	PCV immunization not necessary

Hib: *H. influenzae* type b; PCV: pneumococcal conjugate vaccine.

* Children younger than 12 months are incompletely immunized against Hib and *S. pneumoniae*.

¶ Immunizations must be completed at least two weeks before pneumonia diagnosis.

Δ Children at high risk for invasive Hib disease include chemotherapy recipients and those with anatomic or functional asplenia (including sickle cell disease), HIV infection, immunoglobulin deficiency, or early component complement deficiency. Please refer to the UpToDate topic on prevention of *H. influenzae* infection for a discussion of full Hib immunization in children at high risk for invasive Hib disease.

◇ Children at high risk for invasive *S. pneumoniae* disease include those with chronic heart disease (particularly cyanotic congenital heart disease and cardiac failure); chronic lung disease (including asthma if treated with high-dose oral corticosteroid therapy); diabetes mellitus; cerebrospinal fluid leak; cochlear implrant; sickle cell disease and other hemoglobinopathies; anatomic or functional asplenia; HIV infection; chronic kidney failure; nephrotic syndrome; diseases associated with treatment with immunosuppressive drugs or radiation therapy, including malignant neoplasms, leukemias, lymphomas, and Hodgkin disease; solid organ transplantation; or congenital immunodeficiency. Please refer to the UpToDate topics on PCVs and pneumococcal polysaccharide

vaccines for a discussion of full *S. pneumoniae* immunization in children at high risk for invasive *S. pneumoniae* disease.

Graphic 95852 Version 7.0

Tuberculosis terminology

Tuberculosis terminology is inconsistent in the literature[1].
The following terms refer to the clinical state in which there is evidence of specific cell-mediated immunologic response following exposure to *Mycobacterium tuberculosis*-derived protein antigens in solution (eg, positive TST and/or IGRA), in the absence of signs or symptoms of illness: ▪ Tuberculosis infection (newer term) ▪ Latent tuberculosis infection (older term)
The following terms refer to presence of signs or symptoms reflecting illness due to *M. tuberculosis*: ▪ Tuberculosis disease (newer term) ▪ Active tuberculosis (older term) ▪ Active tuberculosis disease (older term) ▪ Active tuberculosis infection (older term)

TST: tuberculin skin test; IGRA: interferon-gamma release assay.

Reference:

1. *Behr MA, Kaufmann E, Duffin J, et al. Latent Tuberculosis: Two Centuries of Confusion. Am J Respir Crit Care Med 2021; 204:142.*

Graphic 132526 Version 3.0

Noninfectious conditions that can mimic pneumonia in children

Anatomical considerations
Prominent thymus
Breast shadows
Bronchogenic cyst
Vascular ring
Pulmonary sequestration
Congenital lobar emphysema
Atelectasis (due to a foreign body or mucus plug)
Aspiration of gastric contents
Gastroesophageal reflux
Tracheoesophageal fistula
Cleft palate
Neuromuscular disorders
Chronic pulmonary disorders
Asthma
Bronchiectasis
Bronchopulmonary dysplasia
Cystic fibrosis
Pulmonary fibrosis
Alpha-1 antitrypsin deficiency
Pulmonary hemosiderosis
Alveolar proteinosis
Desquamative interstitial pneumonitis
Sarcoidosis
Histiocytosis X

Drugs and chemical exposures
Nitrofurantoin
Bleomycin
Cytotoxic drugs
Opiates
Radiation therapy
Smoke inhalation
"Vaping" (ie, use of electronic cigarette devices to inhale aerosolized substances)
Lipoid pneumonia
Vasculitic disorders
Systemic lupus erythematosus
Granulomatosis with polyangiitis (Wegener)
Juvenile idiopathic arthritis
Others
Hypersensitivity pneumonitis
Neoplasm
Pulmonary edema due to heart failure
Pulmonary infarction
Acute respiratory distress syndrome
Graft-versus-host disease
Poor inspiratory film
Near drowning event
Underpenetrated film

Data from:

1. *Klein JO. Bacterial pneumonias. In: Textbook of Pediatric Infectious Diseases, 5th ed, Feigin RD, Cherry JD, Demmler GJ, Kaplan SL (Eds), WB Saunders, Philadelphia 2004. p.299.*
2. *McIntosh K. Community-acquired pneumonia in children. N Engl J Med 2002; 346:429.*
3. *Gaston B. Pneumonia. Pediatr Rev 2002; 23:132.*
4. *Boyer KM. Nonbacterial pneumonia. In: Textbook of Pediatric Infectious Disease, 5th ed, Feigin RD, Cherry JD, Demmler GJ, Kaplan SL (Eds), WB Saunders, Philadelphia 2004. p.286.*

5. *Layden JE, Ghinai I, Pray I, et al. Pulmonary illness related to e-cigarette use in Illinois and Wisconsin - Preliminary report. N Engl J Med 2019.*

Graphic 65148 Version 9.0

Contributor Disclosures

William J Barson, MD Grant/Research/Clinical Trial Support: Pfizer [Pneumonia]. All of the relevant financial relationships listed have been mitigated. **Sheldon L Kaplan, MD** Grant/Research/Clinical Trial Support: Pfizer [Streptococcus pneumoniae]. Other Financial Interest: Elsevier [Textbook honoraria – Pediatric infectious diseases]. All of the relevant financial relationships listed have been mitigated. **Diane Blake, MD** No relevant financial relationship(s) with ineligible companies to disclose.

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Conflict of interest policy

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