

PEDIATRIC EMERGENCY MEDICINE PRACTICE

AN EVIDENCE-BASED APPROACH TO PEDIATRIC EMERGENCY MEDICINE ▲ EB MEDICINE.NET

An Evidence-Based Review Of Pediatric Pneumonia In The ED

A 3-year-old boy presents to the emergency department with a 4-day history of cough and 1-day history of high fever. The mother tells you that he has been having rigors and chills and has vomited once. For the past 12 hours, he has been coughing and complaining of chest pain. His medical history is unremarkable. There is no history of travel, and he has not been with sick contacts. His immunizations are up-to-date. The physical examination reveals a mildly sick-appearing child who is not toxic. His heart rate is 100 beats per minute, his respiratory rate is 30 breaths per minute, and his temperature is 39.6°C (103.3°F). His blood pressure is 90/65 mm Hg. His oxygen saturation is 96%. Chest examination reveals intercostal retractions, decreased air entry on the right side, and crackles. The rest of the physical examination is unremarkable. As you examine this young boy, many questions come to your mind. Do I obtain a chest x-ray to confirm the diagnosis? Does this child require a culture and other blood work? Does he need to be admitted, or can he be treated as an outpatient? What would be the best choice of antibiotic?

Pneumonia occurs more often in early childhood than at any other age and causes significant morbidity and mortality.¹ Over the past decade, a large number of studies have addressed the problems of diagnosis and management of childhood pneumonia. Many of these studies have been conducted in developing countries where acute respiratory infection is now the leading killer of young children. Definitions of pneumonia vary widely. Some require only the presence of infiltration on a chest radiograph,² whereas others require only certain respiratory symptoms or signs.³ The World Health Organization (WHO) defines pneumonia solely on the basis of clinical findings obtained by visual inspection.

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CME Objectives

Upon completion of this article, you should be able to:

1. Recognize children with clinical signs of pneumonia.
2. Describe the major pathogens of childhood pneumonia in different age groups.
3. Identify the antibiotic regimens used to treat pneumonia for both inpatients and outpatients.
4. Identify children who require inpatient management.

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tion and timing of the respiratory rate.⁴ Identifying the cause of pneumonia in children is difficult due to a lack of rapid, accurate, commercially available laboratory tests for most pathogens. Thus, empirical therapy is the common course in most cases. Pneumonia in children has previously been excluded from treatment guidelines because adults and children differ in the frequency and type of underlying illness and causative pathogens.^{5,6} Many guidelines give little direction for diagnosing viral pneumonia, for which antibiotics are not indicated. Antibiotic selection is important, and the emergency clinician should consider prevalent organisms, the child's age, and the presence of risk factors or atypical or resistant organisms when choosing appropriate therapy.⁷

For a close look at a related adult topic, please see the October 2010 issue of our sister publication, *Emergency Medicine Practice*, entitled "Emergency Department Infection In The Era Of Community-Acquired MRSA."

Critical Appraisal Of The Literature

An Ovid MEDLINE® (www.ovid.com) search for relevant articles published from 1960 to 2010 was carried out using the following terms: *pediatric, pneumonia, respiratory tract infection, pneumonitis, etiology, diagnosis, therapy, antibiotics, resistance, radiology, microbiology, biochemistry, and pediatric emergency medicine*. The Cochrane Database of Systematic Reviews and the National Guideline Clearinghouse (www.guideline.gov) were also consulted. A hierarchical evaluation of the strength of evidence modified from the methods of the Canadian Task Force on the Periodic Health Examination was used.

To evaluate studies regarding treatment of pediatric pneumonia, well-conducted, randomized, placebo-controlled trials were deemed level I (strong) evidence; well-designed, controlled studies

without randomization (including cohort and case-control studies) constituted level II (fair) evidence; and expert opinion case studies and before-and-after studies were considered level III (poor) evidence. Level III evidence also included antibiotic choices based on an organism's susceptibility to antimicrobial agents and the generalization of experience gained from treating other clinical conditions involving the same organisms.

Epidemiology

According to the WHO, about 150 million cases of pneumonia occur worldwide each year in children younger than 5 years of age, with up to 20 million cases classified as sufficiently severe to require hospital admission.⁸ In North America, the annual incidence of pneumonia ranges from 30 to 45 per 1000 children under age 5, from 16 to 20 per 1000 children ages 5 to 9, and from 6 to 12 per 1000 older children and adolescents.⁹⁻¹¹ Mortality is low among children living in developed countries (less than 1 per 1000 per year), but it is substantial in the developing world (4 million cases per year), making it the number one killer of children.¹²⁻¹⁵

Several risk factors are known to increase the incidence or severity of pneumonia in children: prematurity, malnutrition, low socioeconomic status, passive exposure to smoke, and attendance at daycare centers.¹⁵ Underlying disease, especially one affecting the cardiopulmonary, immune, or nervous system, also increases the risk of severe pneumonia.

Etiology

A very large number of microorganisms can cause pediatric pneumonia, and the best predictor of the cause of a child's pneumonia is age. (See Table 1.) During the first 2 years of a child's life, viruses are most frequently implicated.⁹⁻¹¹ As the child grows older and the incidence of pneumonia decreases, bacterial pathogens become more prevalent, including *Streptococcus pneumoniae* and *Mycoplasma pneumoniae*.

Multiple investigations of pediatric pneumonia during the 1970s and 1980s failed to identify the cause in 40% to 60% of cases,^{9-11,15-25} mainly because of the difficulty in differentiating between viral and bacterial infections. Early studies required a positive result on blood culture to confirm bacterial pneumonia.⁹⁻¹¹ In a recent prospective multi-center study of 154 children hospitalized for acute community-acquired pneumonia, a pathogen was identified in 79% of children despite a comprehensive search for the etiology. Bacteria were identified and accounted for in 60% of the cases, of which 73% were due to *S pneumoniae*; *M pneumoniae* and *Chlamydia pneumoniae* were

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detected in 14% and 9% of cases, respectively. Viruses were documented in 45% of children. Notably, 23% of the children had concurrent acute viral and bacterial disease.²⁶

Newborns (Birth–3 weeks)

Newborns infrequently contract pneumonia; however, in this demographic, pneumonia is often diffuse and severe. As listed in **Table 1**, etiologies of newborn pneumonia are similar to those associated with early onset sepsis. Therefore, newborns with pneumonia require a full sepsis evaluation including blood, urine, and cerebrospinal fluid (CSF) cultures in addition to a chest x-ray.⁸³

In addition, consideration should be given to newborns who are respiratory syncytial virus (RSV) positive. Premature newborns and those with other co-morbidities are at a higher risk for apnea and should be admitted to a monitored setting.⁸⁰

Infants And Toddlers (Ages 1–24 Months)

Pneumonitis Syndrome

Infants (1–3 months of age) may present with a characteristic syndrome of cough, tachypnea, progressive respiratory distress, and radiologic evidence of bilateral diffuse pulmonary infiltrates with air trapping. Most are afebrile. Stagno and associates¹⁶ found a single responsible pathogen in 75% of 104 patients and multiple pathogens in the remaining 25%. The presence of more than 1 pathogen in these patients was significantly associated with the need for more frequent oxygen administration and mechanical ventilation. The most common pathogens included *Chlamydia trachomatis* and respiratory viruses. Infection with *Bordetella pertussis* may also be considered in the differential diagnosis of this syndrome. Because of the recent decrease in immunizations as well as the cyclic recurrence of *Bordetella pertussis*, there has been a dramatic increase in reported cases of bordetella, particularly in California. According to the CDC, there has been a 418% increase in reported cases of bordetella from 2009 with the most severe

cases in infants under 1 year of age.^{83,84} Infants with pertussis present less often with a “whooping cough” and more frequently with apnea and autonomic instability.⁸⁵

Mild And Moderate Pneumonia

Respiratory syncytial virus, parainfluenza, influenza, adenovirus, and metapneumovirus account for most lower respiratory tract infections, including pneumonia, in infants and toddlers (level II evidence).^{10,11,17–19} In most cases, the illness begins as an upper respiratory tract infection and progresses gradually over several days, with increasing cough and respiratory distress. Scandinavian investigators have implicated *S pneumoniae* and nontypeable *Haemophilus influenzae* (NTHi).^{18,21–22}

Severe Pneumonia

Bacterial pneumonia due to *S pneumoniae*, *Streptococcus pyogenes* (group A beta-hemolytic streptococcus [GABHS]), or *Staphylococcus aureus* must be considered in severely ill infants and toddlers who have one of the following signs or symptoms: a rapid onset and progression of symptoms, radiographic evidence of lobar or diffuse infiltrates, a large pleural effusion, or a lung abscess (level II evidence).^{11,21,22}

Preschool Children (Ages 2–5 Years)

Viral pneumonia occurs less frequently among children in this age group. The predominant bacterial pathogen is *S pneumoniae*. Others include NTHi, group A streptococci, and *S aureus*.^{3,10,17,18,20,26} In recent studies, *M pneumoniae* has been found more frequently.^{26–30}

School-Aged Children And Adolescents (Ages 6–18 Years)

In this age group, the most common causes of community-acquired pneumonia in otherwise healthy children are *M pneumoniae* and *S pneumoniae*.^{3,8,9,26,29,30} Respiratory viruses, primarily influenza A and B, and adenovirus are found in less than 15% of cases.

Table 1. Age-Specific Causes Of Pneumonia In Otherwise Healthy Children

Age Group	Pathogen (in order of frequency)
Neonates (0–3 weeks)	Group B streptococci, <i>Escherichia coli</i> , <i>Listeria monocytogenes</i> , <i>Staphylococcus aureus</i>
3 weeks–3 months — pneumonitis syndrome	<i>Chlamydia trachomatis</i> , respiratory syncytial virus, parainfluenza virus, <i>Bordetella pertussis</i>
1 month–2 years	Respiratory syncytial virus, parainfluenza virus, metapneumovirus, influenza virus, adenovirus, <i>Streptococcus pneumoniae</i> , parainfluenza virus
2–5 years	Respiratory syncytial viruses, <i>Streptococcus pneumoniae</i> , NTHi, GAS, <i>Mycoplasma pneumoniae</i> , <i>Chlamydophila pneumoniae</i>
6–18 years	<i>Mycoplasma pneumoniae</i> , <i>Chlamydophila pneumoniae</i> , <i>Streptococcus pneumoniae</i> , NTHi, influenza virus A, other respiratory viruses

Abbreviations: GAS, group A *Streptococcus pyogenes*; NTHi, nontypeable *Haemophilus influenzae*.

Impact Of Recent Trends

Universal *Haemophilus influenzae* Type B (Hib) And Heptavalent Pneumococcal Vaccine For Infants

In the past, Hib was responsible for 5% to 18% of cases of bacterial pneumonia.^{3,11,16-18,20} Since the introduction of the Hib conjugate vaccine, however, the number of cases of invasive disease has markedly decreased, and Hib is now considered an unlikely cause of bacterial pneumonia in children who have completed a primary series of Hib vaccinations.

Pneumococcal conjugate vaccine, or PCV7, (Prevnar™) has had a significant impact on the incidence of pneumococcal pneumonia. In a randomized double-blind trial, the heptavalent pneumococcal vaccine reduced the incidence of clinically diagnosed and radiographically diagnosed pneumonia among children younger than 5 years of age by 4% and 20%, respectively.³¹

Human Immunodeficiency Virus (HIV) Infection

Although this article's focus is primarily on otherwise healthy children, the first overt sign of HIV infection may be an opportunistic infection such as *Pneumocystis jiroveci* (formerly *P carinii*) pneumonia in a previously healthy child. In this era of acquired immunodeficiency syndrome (AIDS), the possibility of unusual pathogens must always be considered.

Resurgence Of Tuberculosis

Children with pulmonary tuberculosis may not differ clinically from those with bacterial or viral pneumonia.³³ However, they are more likely to have a history of contact with a person with pulmonary tuberculosis.

Increased Prevalence Of Empyema

Secondary to the introduction of the pneumococcal vaccine, overall pneumococcal hospitalizations have decreased;⁸⁶ however, the prevalence of pneumonia complicated by empyema has increased.^{86,87} The incidence of staphylococcal empyema increased from 0.6 per 100,000 cases in 1996-1998 to 2.5 cases per 100,000 in 2007.⁸⁷ The percentage of pneumococcal empyema has decreased slightly during this time period from 47% to 39%.⁸⁷ In children presenting to the emergency department (ED) with empyema, strong consideration should be given to treating with vancomycin, given the high association with staphylococcal infections and the recent increase in methicillin-resistant *Staphylococcus aureus* (MRSA).

Emergency Department Management

Three challenges arise in the management of pediatric pneumonia: (1) making the diagnosis of pneumonia, (2) distinguishing patients with bacterial pneumonia, who would benefit from antibiot-

ics, from those with nonbacterial pneumonia, who would not, and (3) determining which child requires inpatient management and which child can be safely discharged home on oral antibiotics.

Clinical Evaluation

Pneumonia in children presents differently depending on the age of the child. For example, neonates usually present with nonspecific symptoms such as poor feeding, irritability, and temperature instability. Cough may be absent in the newborn period. They usually have an increased respiratory rate, with grunting, flaring, and chest retractions. In infants, cough is the most common presenting symptom. Usually, these children have a history of antecedent upper respiratory tract symptoms. The majority of them will have fever and an increased respiratory rate with grunting. Vomiting and poor feeding are also common. Preschool children with pneumonia will present with fever and cough. Abdominal and chest pain are not uncommon presenting features. Older children with pneumonia due to atypical pathogens such as mycoplasma usually present with symptoms that have appeared gradually over several days such as headache, malaise, a nonproductive cough, and a low-grade fever.

Emergency clinicians must question the parents about a possible underlying immune deficiency in children who present with pneumonia, since the responsible microorganisms will be different in this group. Also, the clinical presentation of children with pulmonary tuberculosis may not differ from that of children with bacterial or viral pneumonia;¹⁹ however, the former are more likely to have a history of contact with a person with pulmonary tuberculosis or of travel to an endemic area.

Clinical Assessment

Pneumonia can be defined clinically as the presence of lower respiratory tract dysfunction in association with radiographic opacity. The World Health Organization (WHO) has promoted an algorithm to assess children who present with cough and fever. This algorithm defines tachypnea as a respiratory rate (RR) > 60 breaths/minute in infants under 2 months, an RR > 50 breaths/minute in infants 2 to 12 months, and an RR > 40 breaths/minute in children over 1 year of age.³⁷ The presence of suprasternal, subcostal, or intercostal retractions indicates disease of greater severity.

The estimation of respiratory rate can vary depending on the method of measurement.^{39,40} Rates are lower when measured by observation than when measured by electronic monitoring, which in turn yields lower rates than does auscultation. The duration of measurement also affects rate estimation; rates are lowest when counted for 60 seconds and highest when count-

ed for 15 seconds. Another factor is the child's level of alertness. A sleeping child's respiratory rate is lower than that of a child who is awake and crying. Ideally, the respiratory rate should be measured by observation for 60 seconds when the child is awake and not crying.

Table 2 lists the sensitivity and specificity of certain clinical findings. The reproducibility of tachypnea measurement is superior to that of observation of retractions, auscultatory findings, or crackles or wheezes (level II evidence).⁴¹⁻⁴³ However, no finding in itself can be used to diagnose or exclude pneumonia. Recent data from a prospective observational study of 1622 children under 5 years of age undergoing chest x-ray for suspicion of pneumonia show that WHO guidelines can be a useful discriminator for radiographic pneumonia in children. This was more notable in children over 2 months of age.⁸⁷ Findings of fever and crackles as well as findings of fever plus tachypnea or decreased breath sounds had high sensitivity (93%-97%) but low specificity.⁸⁸ Combinations of physical findings increase the likelihood of radiographic diagnosis of pneumonia. For example, fever plus tachypnea, fever plus hypoxia, and fever plus decreased breath sounds are associated with an increased likelihood of diagnosis of pneumonia.⁸⁹ A recent survey queried physicians about indications for obtaining chest x-rays in the pediatric ED. The most common reasons were prolonged duration of cough, prolonged duration of fever, height of fever, and auscultatory findings.⁹⁰ The rate of pneumonia defined on chest x-ray was 8.3%, 10.4%, 7.4%, and 8.1%, respectively.⁹⁰

Of note, multiple studies have examined whether wheezing is a clinical predictor of pneumonia. In afebrile children with wheezing, clinical pneumonia has been found to be very uncommon. Even in febrile children with wheezing, the diagnosis of radiographic pneumonia was very low.^{90,91} The WHO

guidelines recommend that a trial of a bronchodilator be given to a tachypneic wheezing child before considering the diagnosis of pneumonia.

Finally, consideration should be given to the child who presents to the ED with possible occult pneumonia. Occult pneumonia is defined as radiographic pneumonia in a child with high fever and the absence of focal respiratory findings or tachypnea.⁹² Prior to the advent of the PCV7 vaccine, the prevalence rate of occult pneumonia was estimated at 26% in a febrile child with a white blood cell count (WBC) of greater than 20,000/mm³.^{92,93} Recent studies have attempted to define the new prevalence rate after the introduction of PCV7 in a setting where physicians no longer routinely obtain blood work on immunized children. In 2 studies examining the prevalence of occult pneumonia, prevalence rates varied between 5.3% and 6.8%. Factors associated with positive radiographs included duration of fever > 5 days, prolonged duration of cough at home, and a WBC > 15,000/mm³.^{92,93} Conversely, patients with fever for less than 1 day and the absence of cough are at very low risk for pneumonia and do not require radiographic evaluation.⁹³ Absence of the symptom cluster of respiratory distress, tachypnea, crackles, and decreased breath sounds will accurately exclude the presence of pneumonia (with 100% specificity) (level II evidence).⁴⁴⁻⁴⁷

In summary, consideration of pneumonia should be given to any child presenting with prolonged fever, prolonged cough, high fever, as well as focal respiratory findings not including wheezing, especially with the presence of multiple symptoms.

Diagnostic Studies

Chest Radiography

Traditionally, chest x-rays have been the gold standard diagnostic test of pneumonia; however,

Table 2. Sensitivity And Specificity Of Clinical Findings In Patients With Radiographic Evidence Of Streptococcal Pneumonia

Study	Number of Patients	Age Range	Number of Patients With Pneumonia	Clinical Appearance		Tachypnea		Chest Retractions		Crackles	
				Sens	Spec	Sens	Spec	Sens	Spec	Sens	Spec
Berman et al ³⁹	90	< 4 months	63			62	63				
Leventhal ⁴³	133	3 months–15 years	26	92	15	81	60	35	82	44	80
Zukin et al ⁴⁴	125	< 17 years	18			50	68	17	84	57	75
Grossman and Caplan ⁴⁵	155	< 19 years	51	67	40	64	54			43	77
Taylor et al ⁴⁶	576	< 2 years	42			75	70				

Abbreviations: Sens, sensitivity (%); Spec, specificity (%).

multiple studies have questioned the utility of radiographs as a defining standard. Chest x-ray patterns do not accurately distinguish bacterial from viral pneumonia or give a bacterial etiology. Nonetheless, in the absence of better, more easily available bedside testing, chest radiographs will continue to be used as the standard for diagnosis.⁹⁴ Two main patterns of pneumonia are recognized — interstitial and alveolar. Peribronchial thickening, diffuse interstitial infiltrates, and hyperinflation tend to be seen with viral pneumonia (level III evidence),⁵³⁻⁵⁶ whereas lobar infiltrates, particularly with pneumatoceles and pulmonary abscesses, strongly suggest bacterial pneumonia.⁵³⁻⁵⁶ Bronchiolitis and asthma may also cause hyperinflation and atelectasis and must be distinguished from pneumonia.

Half of patients with bacterial pneumonia will present with a lobar infiltrate. Alveolar infiltrates, however, can be seen in pneumonia of either bacterial or viral origin and in *M pneumoniae* infections.⁵³⁻⁵⁶ Round infiltrates are seen in the early stages of pneumococcal pneumonia.^{53,56} *Mycoplasma pneumoniae* infection is typically associated with radiologic evidence of diffuse infiltration out of proportion with the clinical findings. Lobar consolidation, platelike atelectasis, nodular infiltration, and hilar adenopathy have also been described with *M pneumoniae* (level III evidence).⁵⁴ *Chlamydia pneumoniae* pneumonia may be indistinguishable from that due to *M pneumoniae*. *Pneumocystis jiroveci* pneumonia is typically associated with a reticulonodular infiltrate that progresses to alveolar infiltrates. Hilar adenopathy strongly suggests tuberculosis, especially if the patient has epidemiologic risk factors.

In patients with uncomplicated pneumonia, repeat chest radiographs are unwarranted. However, in patients with pleural effusion, pneumatoceles, or pulmonary abscess, a repeat chest radiograph should be considered after treatment to ensure resolution of the infection. Patients with a complicated course or persistent clinical abnormalities should undergo repeat chest radiography after 4 weeks (level III evidence).

The presence of a foreign body, congenital malformation, or asthma should be considered in patients with recurrent pneumonia or atelectasis in the same area of the lung. Recurrences in different areas may suggest aspiration, immunodeficiency, or cystic fibrosis.

Laboratory Tests

The laboratory evaluation of the child with pneumonia should be guided by the results of the history and physical examination, the severity of the illness, and the presence of complications. Unfortunately, there are no gold standards in assessing these factors. Establishing a microbiologic diagnosis, despite its limitations, may be important in children with severe or complicated pneumonia and

in those with unusual but treatable causes. In most instances, blood tests (such as a complete blood count [CBC]), differential, chemistries, serology, and measurements of acute-phase reactants (such as erythrocyte sedimentation rates [ESR], C-reactive protein [CRP], and procalcitonin) will not help to identify the cause or aid in management.^{57,58} In cases of bacterial pneumonia, the white blood cell count is usually increased, with a predominance of polymorphonuclear cells.^{56,59} Leukocytosis can occur with infections due to adenovirus and influenza virus or to mycoplasma infections. Leukopenia may also be seen in viral infections; however, in bacterial infections, leukopenia suggests severe or overwhelming infection.^{60,61}

Blood cultures are positive in only 10% to 30% of patients with bacterial pneumonia and only in those where bacteremia occurs. Blood cultures are not recommended in patients as part of outpatient management and are infrequently recommended for inpatient management in cases where severe or unusual forms of pneumonia are present.⁹⁵ *Mycoplasma pneumoniae* and *C pneumoniae* infection can be detected most effectively by polymerase chain reaction (PCR) assay, but the test may not be available in all hospital or commercial laboratories.⁶¹ The enzyme-linked immunosorbent assay (ELISA) is a sensitive technique for the detection of mycoplasma (immunoglobulin M) and can be considered for children 5 years of age or older; however, these tests may not be readily available in many EDs.^{55,58}

Treatment

Initial Approach

Initial treatment must be directed toward determining whether the child needs to be admitted to the hospital or can be treated as an outpatient with oral antibiotics.

The vast majority of children diagnosed with pneumonia in the ED may be treated on an outpatient basis with oral antibiotics. There is a paucity of randomized controlled trials to guide clinicians in choosing the appropriate antibiotic. Most guidelines are based on observations of the organism—its in vitro susceptibility to the antibiotic—rather than on proof of benefit of one antibiotic over another. When stronger evidence is available, it is provided in this article; however, most randomized trials of pediatric pneumonia have significant flaws or have such limited power that they are not informative.⁶²⁻⁷²

Some factors to consider when contemplating hospitalization include age (ie, infants less than 6 months of age are prone to deteriorate rapidly), the need for supplemental oxygen for hypoxemia, a toxic appearance, the presence of severe respiratory distress, dehydration, vomiting, immunocompromise, evidence of complications, and noncompliant

parents. These children will need immediate attention in the ED, including prompt respiratory support, rehydration, and intravenous antibiotics. The British Thoracic Society Guidelines include oxygen saturation less than 92%, RR > 70 in infants and > 50 in older children, intermittent apnea or grunting, difficulty breathing, signs of not feeding and dehydration, and the family's inability to provide support or appropriate observation.⁹⁶

Empiric Antibiotic Therapy

Given the rise in incidence of organisms resistant to antimicrobial agents,⁷² the practice of prescribing antibiotics for nonbacterial infections should be actively discouraged. The choice of empiric antimicrobial therapy is based on several factors, including age of the patient, clinical presentation, and local resistance patterns of predominant bacterial pathogens.⁷³⁻⁷⁷ Although penicillin-resistant pneumococcal strains are present in most communities, high-level resistance to the beta-lactam antibiotics is still relatively rare, and penicillins and cephalosporins administered in the appropriate doses are usually sufficient to eradicate such organisms.^{63,64,78}

Table 3 summarizes the empiric antimicrobial agents recommended for patients admitted to the hospital, those admitted to the intensive care unit (ICU), and those treated as outpatients (level III evidence).^{55,58,78}

In neonates, the pneumonia-causing pathogens are similar to those causing sepsis; broad-spectrum

antibiotics such as ampicillin and gentamicin are appropriate for this age group.

Infants younger than 3 months of age whose illness is suggestive of the atypical pneumonia syndrome of infancy (ie, tachypnea, mild hypoxemia, absence of fever, and interstitial infiltrates on the chest film) should be treated with a macrolide antibiotic. Azithromycin is generally recommended because of its lower rate of side effects and once-daily dosing schedule.

Most cases of bacterial pneumonia in infants over 3 months of age and in older children (up to 5 years of age) are caused by *S pneumoniae* and occasionally NTHi, or *S pyogenes* or group A *streptococcus* (GAS). Therefore, treatment that is directed toward eradicating *S pneumoniae* is warranted. The first-line agent is amoxicillin in a dose of 80 to 100 mg/kg/day orally divided every 12 hours to provide effective coverage for penicillin-resistant organisms. For children who have type I reactions to penicillin, the clinician should consider macrolides such as azithromycin; however, because pneumococcal resistance to macrolides is increasing, these children will need to be monitored closely. For those who are not allergic to penicillin, a cephalosporin such as cefprozil or cefuroxime may be used. For patients admitted to the hospital, antimicrobial therapy can be initiated with ampicillin or ceftriaxone (level III evidence).⁷⁹ Children in this age group who require admission to the ICU should receive ceftriaxone, with

Table 3. Empiric Antimicrobial Therapy For Children With Pneumonia By Age Group

Age Group	Outpatient	Patients in Hospital	Patients in Intensive Care Unit
0–30 days	Initial outpatient treatment not recommended	Ampicillin, 200 mg/kg/day IV divided, every 6 hours plus gentamicin, 7.5 mg/kg/day IV divided, every 8 hours OR cefotaxime, 150 mg/kg/day IV divided, every 8 hours Consider cloxacillin and nafcillin for patients with <i>S aureus</i> infection or vancomycin for MRSA	Ampicillin, 200 mg/kg/day IV divided, every 6 hours plus gentamicin, 7.5 mg/kg/day IV divided, every 8 hours Consider cloxacillin or nafcillin for patients with <i>S aureus</i> infection
3 weeks–3 months (pneumonitis syndrome)	Initial outpatient treatment not recommended	Azithromycin, 10 mg/kg IV for first dose, then 5 mg/kg daily for 4 days	Azithromycin, 10 mg/kg for first dose, then 5 mg/kg daily for 4 days
3 months–5 years	Amoxicillin, 80–100 mg/kg/day in 2 divided doses	Ampicillin, 200 mg/kg/day divided, every 6 hours OR ceftriaxone, 50 mg/kg every 24 hours Consider azithromycin, 10 mg/kg for first dose, then 5 mg/kg daily for 4 days Consider vancomycin for seriously ill patients	Ceftriaxone, 50 mg/kg Q24H + azithromycin 10 mg/kg first dose, then 5 mg/kg daily for 4 days Consider vancomycin for seriously ill patients
6–18 years	Azithromycin, 10 mg/kg for first dose, then 5 mg/kg daily for 4 days	Azithromycin, 10 mg/kg for first dose, then 5 mg/kg daily for 4 days, plus ceftriaxone, 50 mg/kg every 24 hours Consider vancomycin for seriously ill patients	Azithromycin, 10 mg/kg for first dose, then 5 mg/kg daily for 4 days, plus ceftriaxone, 50 mg/kg every 24 hours

the possible addition of azithromycin (level III evidence).^{64,66} Children who have more fulminant or extensive disease (characterized by the rapid onset of large pleural fluid collections or pneumatoceles) and those for whom anti-pneumococcal therapy has been ineffective should generally be treated with vancomycin added to ceftriaxone to provide coverage for *Staphylococcus aureus* (including MRSA).

The likely organisms responsible for community-acquired pneumonia in children 6 to 18 years of age are the atypical pathogens *M pneumoniae* and *C pneumoniae*.^{29,30} Macrolides are the preferred drug of choice. Since these drugs have similar efficacy (according to the results of comparative trials), the choice of a macrolide can be based on availability, cost, tolerability, and convenience.^{79,80} For children in this age group who are severely ill and require admission to the ICU, ceftriaxone plus azithromycin is recommended (level III evidence).⁷⁴

Special Circumstances

The first overt sign of HIV infection in a previously healthy child may be an opportunistic infection such as *P jiroveci* pneumonia. In this era of AIDS, the possibility of unusual pathogens must always be considered. In immunocompromised children with pneumonia, the clinical findings are diverse, the potential for extended morbidity and mortality is great, and the range of causative microorganisms is broad.⁸² All these children will need to be hospitalized, with appropriate investigations carried out. Empiric treatment should be guided by the radiologic, clinical, and epidemiologic circumstances.

Disposition

The majority of children diagnosed with community-acquired pneumonia can be discharged home on appropriate antibiotic therapy. Most children treated with oral antibiotics will be much improved within 48 to 72 hours after treatment is begun. If there is no improvement, medical attention should be sought.

Children diagnosed with bacterial pneumonia who are younger than 6 months of age and have respiratory distress, dehydration, and vomiting must be stabilized in the ED and then admitted to the hospital for IV antibiotic administration and close monitoring. Other children with pneumonia who warrant hospitalization are neonates and those who are immunocompromised.

Summary

Bacterial pneumonia is a substantial cause of childhood morbidity and mortality worldwide, yet determining the pathogen-specific burden remains a challenge. The child's age is the best predictor of the causative organ-

ism in pediatric pneumonia. In selecting the appropriate antibiotic, the clinician should consider prevalent organisms, the child's age, and the presence of risk factors for atypical or resistant organisms. Although most children with uncomplicated bacterial pneumonia can be treated with oral antibiotics, some are at high risk and will need to be hospitalized.

Case Conclusion

The initial chest x-ray showed right middle-lobe consolidation with pleural effusion. These findings and the boy's ill appearance met the criteria for hospitalization and IV antibiotic therapy. You chose to start him on ceftriaxone 50 mg/kg IV every 24 hours. Since he was hypoxic in the ED, 4 L of oxygen was delivered by nasal prongs. Additional laboratory results showed an elevated WBC (29,500/mm³) with 65% polymorphonuclear leukocytes and 5% bands. On reassessing the patient, you noted that his oxygen saturation was 100%, and he was not in acute respiratory distress. The following day, the lab faxed over the blood culture results, which showed gram-positive cocci resembling streptococcus. The patient was admitted and remained stable on IV ceftriaxone. He became afebrile on the second day of hospitalization. Blood culture results confirmed the presence of Streptococcus pneumoniae with an intermediate susceptibility to penicillin. On day 4 of his hospital stay, the patient's medication was changed to oral cefuroxime, and he was discharged home.

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Evidence-based medicine requires a critical appraisal of the literature based upon study methodology and number of subjects. Not all references are equally robust. The findings of a large, prospective, randomized, and blinded trial should carry more weight than a case report.

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1. **Pneumonia in children has previously been excluded from treatment guidelines because:**
 - a. Adults and children differ in the frequency and type of underlying illness and causative pathogens.
 - b. Treatment is exactly the same as for adults.
 - c. Children rarely get pneumonia.
 - d. Few studies have been done on pediatric pneumonia.
2. **The most likely organism from the list below causing community-acquired pneumonia in an 8-year-old, previously healthy boy is:**
 - a. *Mycobacterium tuberculosis*
 - b. Nontypeable *Haemophilus influenzae*
 - c. Respiratory syncytial virus
 - d. *Mycoplasma pneumoniae*
3. **The treatment of choice in treating community-acquired pneumonia in a 3-year-old boy is:**
 - a. Cefprozil
 - b. Clindamycin
 - c. Amoxicillin
 - d. Azithromycin
 - e. Cefixime
4. **Chest radiograph can predict the cause of pneumonia.**
 - a. True
 - b. False
5. **Empiric antimicrobial therapy for a 10-year-old child with pneumonia who requires hospitalization is:**
 - a. Amoxicillin
 - b. Amoxicillin plus vancomycin
 - c. Azithromycin plus ceftriaxone
 - d. Clindamycin
 - e. Amoxicillin plus clarithromycin

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