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AHC Media

Community-acquired Pneumonia in Pediatric Populations

This article is adapted from one that originally appeared in the April 2012 issue of Pediatric Emergency Medicine Reports.

Epidemiology

According to the World Health Organization (WHO), pneumonia is the leading cause of death in children worldwide, with an estimated mortality of 1.4 million children per year younger than the age of 5 years.[1] This is more than AIDS, malaria, and tuberculosis combined. There are an estimated 150 million cases of pneumonia in children younger than 5 years of age, with up to 20 million requiring hospitalization. Only 30% of the children diagnosed with pneumonia receive antibiotic treatment.[2] In the United States, the incidence of disease is estimated at 35-40 cases per 1000 for those younger than 5 years old, and seven cases per 1000 in adolescents aged 12 to 15 years.[3] Prior to the regular use of pneumococcal conjugate vaccine PCV7, disease estimates were significantly higher.

Pneumonia spreads via respiratory droplets from person to person, or via fomite transmission. In general, hosts with compromised mucociliary clearance are more susceptible to pneumonia. It is presumed that dry heat used during the winter season can impede mucociliary clearance in healthy individuals. Children from families with smokers, wood-burning stoves, and lower socioeconomic status are at an increased risk, as well as adolescents who smoke or consume alcohol. Overall, boys are affected more commonly than girls.[4]

Etiology

Pneumonia is caused by bacteria, viruses, atypical organisms, and fungus, with etiology varying by age group. The etiology is often inferred by history, clinical exam, or detection of microorganisms in the upper respiratory tract by polymerase chain reactions (PCR) or serologic assay. Even in those exhaustively sampled, up to 50% of patients with pneumonia show no specific microbial cause. Further, simultaneous infection with multiple agents (viral and bacterial) is common. Table 1 provides a summary of common causes of pneumonia by age group with key clinical features.[5]

Neonates

Most cases of pneumonia seen within the first seven days of life are a result of vertical transmission from the maternal genital tract, either by aspiration or contact with infected secretions or amniotic fluid. The most common cause is group B streptococcus. Risk factors for neonatal pneumonia include prolonged rupture of membranes, maternal chorioamnionitis, and premature birth. Although much less common, hematogenous spread from an infected mother may also occur. Severe disease, including acute respiratory distress syndrome (ARDS) and/or systemic infection, can be caused by group B streptococcus, *Listeria monocytogenes*, *Escherichia coli*, *Haemophilus influenzae*, group D

Executive Summary

- Neonates are more likely to have bacterial pneumonia. After that stage, viral pneumonias are most common.
- Children older than the age of 5 years are most likely to have mycoplasma pneumonia.
- Most children can be treated as outpatients, but those who are immunosuppressed, in respiratory distress, or fail outpatient treatment should be considered for hospitalization.
- Complications of pneumonia include pleural effusion and empyema.

Table 1: Microbial Causes of Community-Acquired Pneumonia in Children

Age	Etiologic Agents	Clinical Features
Birth to 3 weeks	Group B streptococcus	Part of early-onset septicemia and/or meningitis
	Gram (-) enteric bacteria	Nosocomial, occurs within 1 week of birth
	Listeria monocytogenes	Part of early-onset septicemia
	Mycoplasma or *Ureaplasma*	Maternal infection, afebrile
	Treponema pallidum	Part of congenital syndrome
	Cytomegalovirus	Part of systemic infection
	Herpes simplex virus	Part of disseminated infection
3 weeks to 3 months	Group B streptococcus	Part of late-onset septicemia and/or meningitis
	Chlamydia trachomatis	Maternal infection, afebrile, subacute, interstitial infiltrates on CXR
	Bordetella pertussis	Risk of secondary pneumonia from cough and aspiration
	Streptococcus pneumoniae	Acute onset, high fever, focal findings
	Respiratory syncytial virus	Peaks at 2-7 months, wheezing and crackles predominate
	Parainfluenza virus	Similar to RSV, common in fall to spring season
3 months to 5 years	RSV, parainfluenza, influenza, hMPV, adenovirus, rhinovirus	Most common cause, low-grade fever, diffuse findings, insidious onset
	Streptococcus pneumonia	Most likely cause of lobar pneumonia, acute onset, high fever, focal findings
	Haemophilus influenzae	Non-typeable strains in immune-compromised hosts, type b in non-vaccinated
	Staphylococcus aureus	CA-MRSA becoming more common
	Mycoplasma pneumoniae	Usually in children > 4 years, similar to viral syndrome
	Mycoplasma tuberculosis	HIV and endemic areas
5 to 15 years	*Streptococcus pneumoniae*	Most likely cause of lobar pneumonia, acute onset, high fever, focal findings, complications
	Mycoplasma pneumoniae	Very common cause, clinically similar to viral syndrome
	Chlamydia pneumoniae	Unsure incidence, probably common in older children

Modified from: *Principles and Practice of Pediatric Infectious Disease*, 3rd ed. 2008.

streptococcus, *Ureaplasma urealyticum*, and gram-negative bacilli (anaerobes).

Late-onset pneumonia presents after day 7 of life to 3 months of age. The most common causes include group B streptococcus, *Chlamydia trachomatis*, *Bordetella pertussis*, and several organisms associated with

congenital syndromes. Ten percent of all infants born to mothers colonized with *C. trachomatis* during birth will become symptomatic in the first two to three weeks of life. *B. pertussis* should be considered in any neonate greater than 7 days old presenting with pulmonary hypertension and pneumonia symptoms. Other congenital infections or perinatal infections such as cytomegalovirus (CMV), herpes simplex virus (HSV), and *Treponema pallidum* can cause severe pneumonia. Infants with these organisms present with a combination of respiratory distress and systemic toxicity.

Viruses

Viruses cause 80% of community-acquired pneumonia in children younger than 2 years of age, and 49% in those 2-5 years old.[6] Respiratory syncytial virus (RSV) is most common, although human metapneumovirus (hMPV), parainfluenza virus types, influenza viruses A and B, adenovirus, rhinovirus, enteroviruses, and coronavirus also occur. Bocaviruses and human parechovirus 1 are associated with lower respiratory tract illness. RSV is most common during the first 6 months of life, and illness varies in presentation from bronchiolitis-like symptoms to focal findings without wheezing. While adenovirus infections occur throughout the year, RSV, hMPV, and influenza viruses occur most commonly during the late fall and winter. Parainfluenza and rhinoviruses are more common during the spring and early fall seasons.

Bacteria

The most common cause of bacterial pneumonia in the United States in individuals older than 30 days old is *Streptococcus pneumoniae*. School-aged children are more likely to have bacterial pneumonia than younger children. Other common causes of CAP include *Moraxella catarrhalis* and *Staphylococcus aureus*. *Haemophilus influenzae* type b pneumonia has decreased with the use of Hib vaccine. Uncommon causes of CAP in the United States include non-typeable *H. influenzae*, gram-negative organisms, methicillin-resistant *Staphylococcus aureus* (MRSA), and *Streptococcus pyogenes*. Both MRSA and *S. pyogenes* can cause necrotizing pneumonia with rapidly progressive hypoxemia and formation of pleural effusion within hours of symptom onset.

Table 2: Diagnostic Clues: Community-acquired Pneumonia in Children

Diagnostic Clue	Description
Age	< 30 days, toddler, school-age
Season	Late fall, winter, early spring
Fever	Height, duration, onset
Associated symptoms	Headache, congestion, rash, myalgia, malaise, diarrhea, vomiting, sore throat
Associated pain	Abdominal, stomach, chest, ear
Nature of cough	Productive, dry, staccato, worsening
Risk for foreign body	Developmental age
Underlying disorders	Reactive airway disease, immunodeficiency, malignancy, sickle cell disease, cystic fibrosis, seizure disorder, substance abuse
Exposure risk	Sick contacts, recent immigration from endemic areas
Travel history	Asia, Africa, Middle East, Latin America, geographic regions of the United States
Immunization status	Pneumococcal conjugate, *Haemophilus influenzae* type b, DTaP, TDaP, annual influenza
Animal exposure/insect bites	Birds, cattle, sheep, bats, chickens, soil-dwelling animals

Adapted from *Pediatrics in Review* 2008;29:151.[3]

Atypical Organisms

Mycoplasma pneumoniae is more common in children older than 5 years of age. *Chlamydophila pneumoniae* (formerly *Chlamydia pneumoniae*) accounts for about 20% of CAP cases in all children.[6] Co-infections of *M. pneumoniae* with *C. pneumoniae* or *S. pneumoniae* are common. Both *M. pneumoniae* and *C. pneumoniae* are common causes of CAP in adolescents.

Special Populations

Children with sickle cell disease, chronic lung disease, gastroesophageal reflux disease (GERD), asthma, cystic fibrosis, congenital heart disease, and immunodeficiencies are at higher risk for CAP. *Pneumocystis jirovecii* (formerly *Pneumocystis carinii*), non-typeable *H. influenzae*, and *Legionella pneumophila* should be considered in all immune-compromised patients. In the United States, most cases of primary *Mycobacterium tuberculosis* occur in children born to recent immigrants from TB-endemic countries or HIV-infected individuals. Children with white blood cell defects have an increased risk of gram-negative bacilli, *Legionella pneumophila*, *S. aureus*, *Aspergillosis* species, *Fusarium* species, *Pneumocystis jirovecii*, and potentially serious viral pathogens such as rubeola, VZV, CMV, and EBV.

Coccidioides immitis is a frequent cause of CAP in several southwestern states and is endemic to many South American vacation spots. Risk factors for coccidioidomycosis include exposure to ground dust, such as construction, archaeological excavation, military maneuvers, dirt biking, and natural events such as earthquakes. In the southeastern and central states, and

Table 3: Clinical Manifestations of Community-acquired Pneumonia in Children

Pediatric Signs of Respiratory Distress	
Tachypnea	Breaths/minute, consider cardiac or metabolic causes
0-2 months	> 60
2-12 months	> 50
1-5 years	> 40
> 5 years	> 20
Dyspnea	
Accessory muscle use	Sign of inspiration requiring extra effort
Retractions	Sign of partially blocked airflow
Suprasternal	May be seen alone with mild disease
Subcostal	May be seen in mild, moderate, or severe disease
Intercostal	Generally seen in moderate to severe disease
Nasal flaring	
Grunting	Indicates SBI in previously healthy children > 3 months[a]
Apnea	
Crackles	Indicates distal airway narrowing by fluid, mucus, or pus
Altered mental status	
Pulse oximetry	< 90% on room air

SBI = serious bacterial infection

[a] Bilavsky E, Shouval DS, Yarden-Bilavsky H, et al. Are grunting respirations a sign of serious bacterial infection in children? *Acta Paediatr* 2008;97:1086-1089.

Adapted from: World Health Organization's Criteria for Community-acquired Pneumonia in Children.

those bordering the Great Lakes, *Blastomyces dermatitidis* causes distinct lung and skin pathology. *Histoplasma capsulatum* is endemic in the Mississippi and Ohio River valleys and is commonly found in poultry house litter, areas harboring bats, and in bird roosts. Bacterial pathogens such as *Brucella abortus*, *Chlamydophila psittaci*, *Coxiella burnetii,* and *Francisella tularensis* are transmitted from infected birds, animals, or humans. (*See Table 2.*)

Clinical Manifestations

Classic symptoms, including abrupt onset fever, cough, and tachypnea, are not pathognomonic. Nonspecific signs of lower respiratory tract infections include tachypnea, nasal flaring, decreased breath sounds, grunting, and crackles or rales. (*See Table 3.*) Further, 5-10% of children will have radiographic evidence of pneumonia without any respiratory symptomatology.[7] According to the WHO guidelines, the best indicators of pneumonia are tachypnea and retractions, with tachypnea as defined in Table 3.[8] Crackles in the lungs have been reported to have a sensitivity of 75% and specificity of 57% for pneumonia, while wheezing and a prolonged expiratory phase were more commonly associated with bronchiolitis or a viral etiology.[9] In a large, prospective study, hypoxia, lack of wheeze, and focal lung findings placed children at an increased risk of radiologic pneumonia.[10]

Neonates

In general, infants younger than 2 months of age with pneumonia will present with respiratory distress, increased work of breathing, and systemic toxicity. When present during the first days of life, neonatal pneumonia can resemble acute respiratory distress syndrome (ARDS) or transient tachypnea of the newborn. Young infants with *Chlamydia trachomatis*, *Bordetella pertussis,* and *Ureaplasma* are often afebrile. Premature infants who have been discharged from the neonatal intensive care unit (NICU) may not mount fever, but instead display episodes of apnea or cyanosis as their only clinical indicator of pneumonia. Any afebrile infant aged 3 weeks to 3 months who presents with tachypnea, short, sudden bursts of cough (staccato), and crackles should be evaluated for *C. trachomatis* infection. Indicators of an acute infection include eosinophilia on a complete blood count.

Viral Pneumonia

Viral pneumonia is more gradual in onset than bacterial pneumonia and is usually preceded by an upper respiratory tract infection with low-grade fever and rhinorrhea. Any significant increase in congestion, fever, fussiness, cough, post-tussive emesis, or irritability can indicate pneumonia. Some viruses, such as adenovirus and influenza, can cause an associated viral syndrome with malaise, abdominal pain, and diarrhea. Auscultatory findings typically include diffuse wheezing, rhonchi, and crackles. Hypoxia is variable but can be severe in young infants, immune-compromised patients, or those with underlying lung disease.

Bacterial Pneumonia

A classic presentation of bacterial pneumonia includes an abrupt onset of fever, with or without a preceding upper respiratory tract infection. Variable degrees of hypoxemia and respiratory distress are seen, dependent upon the presence of pyogenic bacteria, pleural effusion, and/or systemic disease. Children

Table 4: Common Clinical Pneumonia Syndromes of Childhood

Syndrome	Typical Cause	Age Group	Clinical Features	Radiographic Findings
Bacterial	*Streptococcus pneumoniae*	All ages, MC* 1 mo to 6 yrs	Abrupt onset, high fever, focal findings, chest and/or abdominal pain	Focal infiltrate
Atypical infancy	*Chlamydia trachomatis*	3 wks to 3 mos	Tachypnea, no fever, staccato cough, crackles	Interstitial infiltrate
Atypical	*Mycoplasma pneumoniae*	> 5 yrs	Insidious onset, low-grade fever, systemic symptoms (headache, malaise, etc.)	Diffuse, bilateral infiltrates, often "patchy"
Viral	Multiple viruses	All ages, MC* 3 mos to 5 yrs	URI symptoms, wheezing, +/- low-grade fever, diffuse exam findings	Variable, diffuse interstitial infiltrates common

* MC = Most common

Adapted from: *Pediatrics in Review* 2008;29:152.[3]

with pyogenic infections will appear toxic, with high fevers, rigors, and tachypnea. Cough is variable and may not manifest until day 3-4 of illness. Physical exam findings include decreased air movement, decreased tactile fremitus, dullness to percussion, and rales/rhonchi in affected lung regions. Classically, the absence of wheezing is a positive predictor of pneumonia.

Prolonged Course of Illness

The typical presentation of *Mycoplasma pneumoniae* infection includes malaise, headache with photophobia, myalgias, fever, sore throat, gastrointestinal symptoms, and a nonproductive progressive cough that worsens as other symptoms improve. Rhinorrhea is not usually seen. Physical findings are usually restricted to fine crackles at the bilateral bases of the lungs. Chest radiography (CXR) may show bilateral patchy infiltrates. *M. pneumoniae* infection may be associated with bullous myringitis, urticaria, arthritis, hemolytic anemia, or Stevens-Johnson syndrome.

Q fever may present with a prolonged illness course and is generally associated with fever, cough, and intractable headache. Round opacities may be seen on CXR.

History of Reactive Airway Disease

Children with fever of 39.0°C or greater were five times more likely to have pneumonia, while those with hypoxia (pO_2 < 92%) were three times more likely.[11] A similar study in children younger than 18 months of age with wheezing found that while grunting and oxygen saturation less than or equal to 93% were associated with infiltrates on CXR, first-time wheezing, fever, and tachypnea were not.[12]

Table 5: Indications for Radiographs by Setting

Emergency Department	Inpatient
Suspected or documented hypoxemia with or without significant respiratory distress	**All patients admitted**, to document presence, size, and character of parenchymal infiltrations and to identify complications
Failure of initial antibiotic therapy (to identify complications of pneumonia)	Follow-up CXR **if** no clinical improvement or deterioration within 48-72 hours of antibiotic initiation
Suspected foreign body aspiration or cardiac disease	Follow-up CXR in 4-6 weeks in patients with recurrent pneumonia involving same lobe or lobar collapse at initial CXR to identify anatomic abnormality

Aspiration Pneumonia

Aspiration pneumonia can occur in children of all ages. While this is most common in children and adolescents with musculoskeletal disorders, it must also be considered in any patient with anatomic abnormalities of the proximal airway or digestive tract, history of substance abuse, intoxicated patients, history of seizure disorder, foreign body aspiration, and any patient who has recently undergone procedural sedation. Secondary infections may occur in up to 50% of patients with acute aspiration syndrome and may include a variety of mixed flora (*S. aureus*, *Klebsiella*, *Proteus*, *Pseudomonas*, *E. coli*, and anaerobes such as *Bacteroides*, *Fusobacterium*, *Peptostreptococcus*, and *Prevotella melaninogenica*).[13] (*See Table 4.*)

Differential Diagnosis

Alternative diagnoses, especially in the setting of a child without fever or with chronic symptoms, include foreign body aspiration, asthma, gastroesophageal reflux disease (GERD), cystic fibrosis, and congestive cardiac failure. Causes of recurrent pneumonia include anatomic lesions, such as

Table 6: Inpatient vs. Outpatient Management of Children with CAP

Indication	Outpatient	Inpatient	Intensive Care
Respiratory distress/oxygen saturation	SpO_2 > 92%	SpO_2 < 92%	Endotracheal intubation, CPAP, BiPAP
Tachycardia	Resolved with fever defervescence		Sustained tachycardia
Blood pressure	Stable	Unstable on presentation, positive response to resuscitation	Pharmacological support required
Mental status			Altered mental status, sleepiness in infant, etc.
Oral tolerance	Stable	Variable; IV antibiotics required	Variable; IV antibiotics required
Age		< 3-6 months, unless *C. trachomatis* proven and relatively nonsymptomatic	If symptoms present within day of life 0-3, NICU admission likely
Complicating factors		CA-MRSA, virulence Parapneumonic effusion Empyema Lung abscess	
Social concerns	Reliable family	Concerns for compliance with medication, judgment of illness, and follow-up	

vascular rings, cysts, pulmonary sequestration, and immunologic disorders such as human immunodeficiency virus (HIV) infection, chronic granulomatous disease, and hypogammaglobulinemia.

Evaluation

Routine imaging and/or measurement of laboratory values is unnecessary in mildly ill patients who may be managed as outpatients. Patients who are moderately ill or fail to show improvement in symptoms on empiric treatment, who are immunocompromised or have an underlying chronic disease, or who require hospitalization for pneumonia warrant further testing.

Laboratory Studies

Blood Tests. Complete blood count with differential and acute phase reactants (erythrocyte sedimentation rate [ESR], C-reactive protein [CRP] concentration, serum procalcitonin concentration) may aid in the diagnosis of CAP, but do not reliably predict pneumonia.

Cultures. Blood culture is found to be positive in, at most, 10-12% of children with pneumonia and 30-40% in patients with a parapneumonic effusion and empyema. Moderate-quality evidence suggests obtaining blood cultures when children fail to respond to traditional therapy, have prolonged or progressive symptoms, or have clinical deterioration.[14] Nasopharyngeal culture is unreliable. Sputum cultures can be obtained from older children.

Rapid Diagnostic Tests. Polymerase chain reaction (PCR) techniques and immunofluorescence on nasopharyngeal secretions may be helpful in guiding the clinical decision process in patients suspected of having CAP. However, the presence of a viral agent in the upper respiratory tract does not exclude the presence of secondary bacterial pneumonia. Common rapid diagnostic tests that are available include tests for RSV, influenza, adenovirus, parainfluenza, and *M. pneumoniae*.

Imaging

Indications for chest radiography in children with clinical evidence of pneumonia are in Table 5.[14] When radiographs are indicated, posteroanterior (PA) and lateral views should be obtained. Radiologic findings may lag behind clinical findings. Patients who are dehydrated may have a normal-appearing chest radiograph prior to volume repletion.

Ultrasonography often can determine the location, quantity, and quality of fluid (e.g., thickness, fibrinous streaking, and presence of loculations). Chest CT is used to better visualize the extent of parenchymal involvement in selected patients.

Management

Inpatient vs. Outpatient. The majority of CAP may be treated by clinical suspicion, limited diagnostic tests, and outpatient management. Current evidence shows that children admitted for CAP may be treated with oral medication and supportive care, as intravenous line placement and invasive testing show no cost or outcome benefit.

Table 7: Empiric Therapy for Pediatric Community-acquired Pneumonia (CAP)

Site of Care	Patient	Causative Agent	Therapeutic Agent	Length of Therapy (days)
Outpatient	< 5 years old	Bacteria	Oral amoxicillin Alternative: amoxicillin-clavulanate	10
		Atypical	Oral azithromycin Alternatives: clarithromycin, erythromycin	5
	≥ 5 years old	Bacteria	Oral amoxicillin Alternative: amoxicillin-clavulanate	10
		Atypical	Oral azithromycin Alternatives: clarithromycin, erythromycin, doxycycline, levofloxacin	5
Inpatient	Fully immunized with conjugate vaccines for *H. influenzae* type b and *S. pneumoniae* Local penicillin resistance in invasive strains of pneumococcus is minimal.	Bacteria	IV ampicillin IV penicillin G Alternatives: IV ceftriaxone	10
		Atypical	IV azithromycin, then transition to oral therapy if possible on days 2 or 3 Alternatives: IV erythromycin, levofloxacin, clarithromycin, doxycycline	5
		CA-MRSA	Vancomycin Clindamycin	Possibly > 10
	Not fully immunized for *H. influenzae* type b and *S. pneumoniae* Local penicillin resistance in invasive strains of pneumococcus is significant.	Bacteria	IV ceftriaxone IV cefotaxime Alternative: levofloxacin	10
		CA-MRSA	Vancomycin Clindamycin	Possibly > 10
The above recommendations represent general guidelines for the treatment of pneumonia. Practitioners should tailor the selection of antimicrobials in children with pneumonia based on the individual patient circumstances, geography, and community drug sensitivities.				

Indications for hospitalization of pediatric patients with CAP are reviewed in Table 6.

Supportive Therapy. Supplemental oxygen therapy is indicated in any patient whose oxygen saturation is persistently 92% or less. Chest physiotherapy is not recommended for routine treatment of CAP in any population despite its consistent use in 15% of cases.[14] Finally, pain and fever should be adequately controlled with age-appropriate antipyretics or analgesics.

Antimicrobial Therapy. At this time, there is no reliable technique to distinguish viral and bacterial causes of CAP, and, therefore, all older children with pneumonia should receive antibiotic therapy. Typical antimicrobial regimens are reviewed in Table 7.

Viruses. Infants and young children who are mildly ill with diffuse findings on chest examination will generally not require antimicrobials. Effective antivirals are not available for most viral pneumonias except for influenza. In children with moderate to severe CAP consistent with influenza virus infection (high fever, malaise, myalgia, diarrhea), as well as during widespread local circulation of influenza viruses, treatment with oseltamivir (Tamiflu) or zanamivir (Relenza) should be started immediately. As early antiviral treatment has been shown to provide significant benefit, treatment should not be delayed until confirmation of a positive influenza test.

Monitoring Response

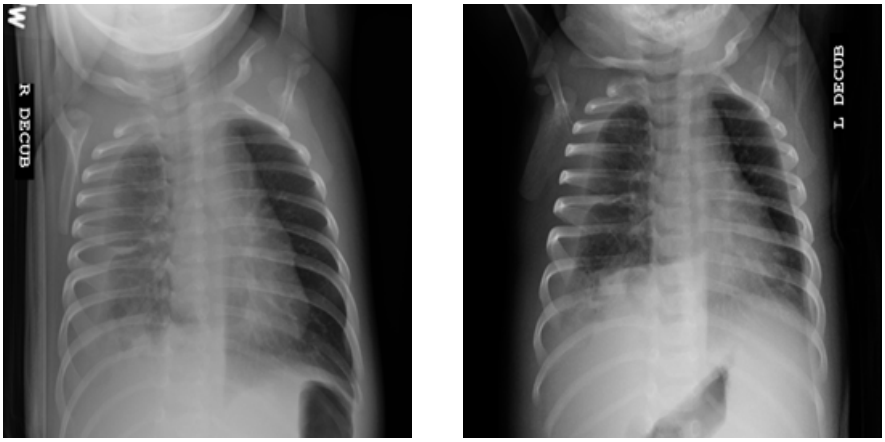
Children with pneumonia who are treated as outpatients (including those who were not initially treated with antibiotics) should be followed up within 24 to 48 hours.

Table 8: Complications Associated with Community-acquired Pneumonia

Pulmonary
• Pleural effusion or empyema
• Pneumothorax
• Lung abscess
• Bronchopleural fistula
• Necrotizing pneumonia
• Acute respiratory failure
Metastatic
• Meningitis
• Central nervous system abscess
• Pericarditis
• Endocarditis
• Osteomyelitis
• Septic arthritis
Systemic
• Systemic inflammatory response syndrome or sepsis
• Hemolytic uremic syndrome

Adapted from: Clinical Practice Guidelines by the Pediatric Infectious Diseases Society and the IDSA, 2011.

Figure 1: Parapneumonic Effusion



Right and left decubitus films showing evidence of complex, loculated right parapneumonic effusion that is not free-flowing. There is also a right lower lobe airspace consolidation.
Images courtesy of P. Kochan, MD, of St. Christopher's Hospital for Children Radiology Department, Philadelphia, PA.

Appropriately treated children generally show signs of improvement within 48 to 72 hours. Children with a worsening condition should have a chest radiograph and may need hospitalization. Patients with suspected atypical pneumonia who were initially treated with macrolides may require pneumococcal coverage if they fail to improve clinically.

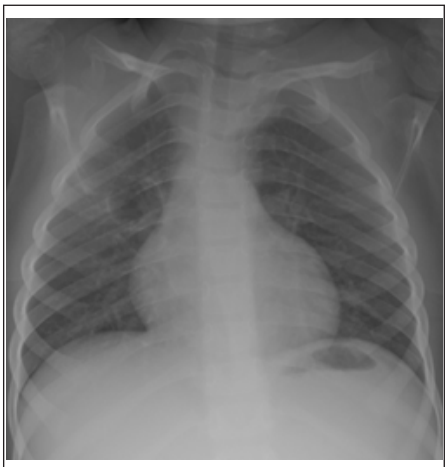
Complications

Bacterial pneumonias are more likely to be associated with complications compared to atypical and viral etiologies. Major pulmonary complications associated with bacterial pneumonias include parapneumonic effusion, empyema, necrotizing pneumonia, lung abscess, and pneumatoceles. See Table 8 for a complete list of complications associated with CAP.

Parapneumonic Effusions. Parapneumonic effusions (PPE) are inflammatory fluid collections adjacent to a pneumonic process seen in about 40% of cases of bacterial pneumonia. Affected children are usually ill-appearing and typically present with respiratory distress, persistent fever, tachypnea, chest pain, and splinting. On physical exam, there will be decreased breath sounds on the affected side. Plain radiographs can establish the diagnosis of an effusion, while a decubitus view will assist with the differentiation of free-flowing vs. loculated fluid. (*See Figure 1.*) Ultrasonography may be used to localize and estimate the size of an effusion, in addition to identifying an optimal position for chest tube placement. CT may be used to better visualize the extent of parenchymal involvement, although it is usually not necessary.[18]

Small free-flowing effusions may

Figure 2: Pneumatocele



Note pneumatocele in the right upper lobe, commonly seen as a complication of necrotizing pneumonia.
Image courtesy of P. Kochan, MD, of St. Christopher's Hospital for Children Radiology Department, Philadelphia, PA.

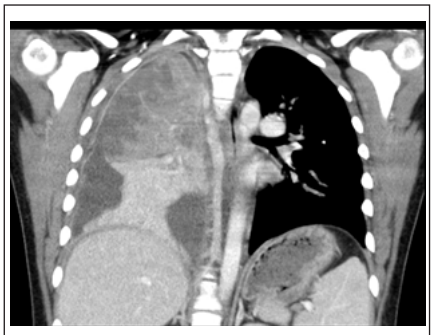
be treated with antibiotics alone, while moderate to large effusions will need to be drained.

Necrotizing Pneumonia. Necrotizing pneumonia usually occurs as a result of localized lung infection by highly virulent, pyogenic bacteria. As a result, the affected lung tissue undergoes liquefaction and necrosis. Complications include formation of a lung abscess, pneumatocele (thin-walled, air-containing cysts in the lung parenchyma, *see Figure 2*), or a bronchopleural fistula. The most common causative pathogen is *S. pneumoniae* or, less commonly, *S. aureus* (especially CA-MRSA) or *S. pyogenes*. Clinical manifestations are similar but usually more severe than non-necrotizing pneumonia. The presentation with necrotizing pneumonia may be variable and include hemoptysis, prolonged fever, toxic appearance, and persistent hypoxia despite appropriate antimicrobial therapy. A CT scan may be used to further delineate the extent of parenchymal involvement. (*See Figure 3.*) Initial broad-spectrum antimicrobial coverage is indicated with signs or radiographic evidence of a necrotizing pneumonia.

Lung Abscess and Empyema. Lung abscess is caused by necrotizing pneumonia, aspiration, bacteremia, and septic emboli. (*See Figure 4.*) Further, lung abscesses may develop as a consequence of subacute or chronic airway infection (cystic fibrosis, prolonged intubation). Clinical manifestations include fever, cough, dyspnea, sputum production, chest pain, hemoptysis, and putrid breath. On chest radiograph, the diagnosis can be made based on the finding of an air-fluid level in a cavity at least 2 cm in diameter, with a well-defined wall. Anaerobic bacteria are the typical causative organisms, with *Peptostreptococcus* spp., *Bacteroides* spp., *Prevotella* spp., and *Veillonella* spp. being most common. *S. aureus* and gram-negative rods may also be involved. Tuberculosis should be considered in a child with a lung abscess. Clindamycin is commonly used empirically to treat lung abscesses. However, culture specimens obtained via bronchoscopy or direct aspiration of the abscess may be necessary in complex cases or when there is a lack of response to initial empiric therapy.

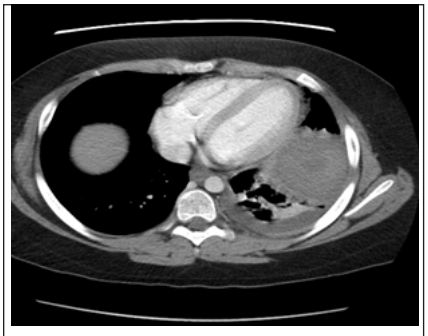
Empyema is a collection of pus in the pleural space. Symptoms consistent with empyema include dry cough, night sweats, fever and chills, shortness of breath, malaise, and unintentional weight loss. Risk factors for empyema include bacterial pneumonia, lung abscess, recent chest surgery, and trauma or injury to the chest wall. Ultrasound and chest CT are typically utilized to characterize the collection. (*See*

Figure 3: Necrotizing Pneumonia



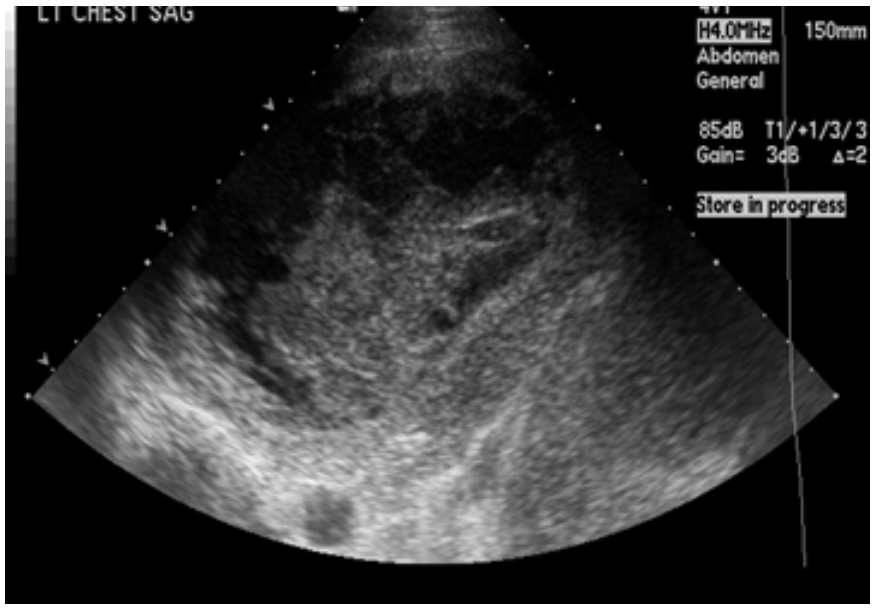
Chest CT showing a complex and mottled appearance of the right upper lobe consistent with necrotizing pneumonia.
Image courtesy of P. Kochan, MD, of St. Christopher's Hospital for Children Radiology Department, Philadelphia, PA.

Figure 4: Lung Abscess



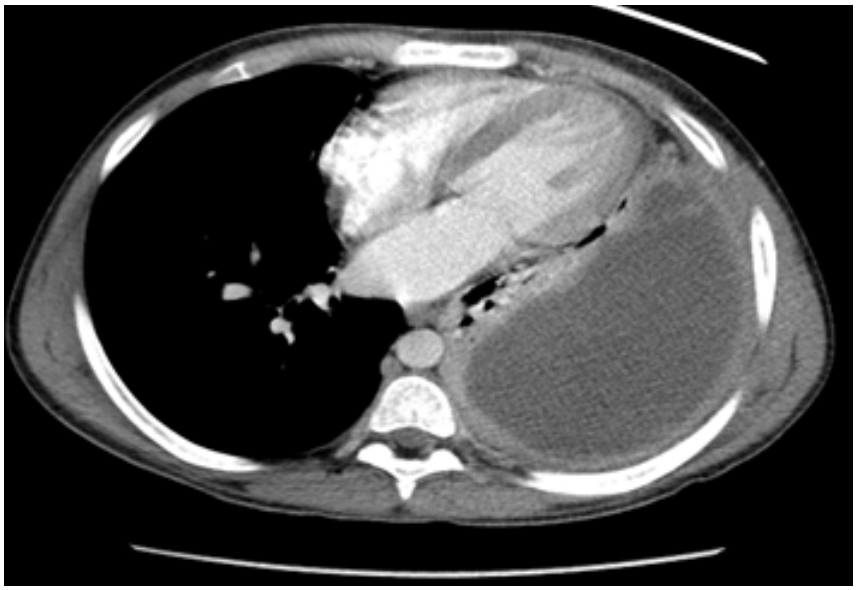
Chest CT showing evidence of a left lung abscess.
Image courtesy of P. Kochan, MD, of St. Christopher's Hospital for Children Radiology Department, Philadelphia, PA.

Figure 5: Empyema



Ultrasound image showing complex collection in the left pleural space (note the septations), likely representing a nonmobile empyema.
Image courtesy of P. Kochan, MD, of St. Christopher's Hospital for Children Radiology Department, Philadelphia, PA.

Figure 6: Empyema



Chest CT showing evidence of empyema in the left lung. Image courtesy of P. Kochan, MD, of St. Christopher's Hospital for Children Radiology Department, Philadelphia, PA.

Figures 5 and 6.) Surgical intervention is frequently required.

Prognosis

Mortality due to CAP is uncommon beyond infancy in the United States, secondary to access to health care, availability of antimicrobial therapy, and enhanced immunization rates. Few studies have examined the long-term outcome of children with pneumonia. However, there is evidence of decreased lung function in adults with a history of pneumonia before the age of 7 years.[19] In regard to children, there is sparse information about the long-term outcome after pneumonia.

Summary

CAP is a commonly encountered disease process in the emergency department. Early recognition and appropriate management can minimize morbidity and mortality. In addition, the early recognition of complications may facilitate timely intervention.

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Physician CME Questions

1. Risk factors for pneumonia in children include all of the following *except*:
   A. lower socioeconomic status
   B. passive smoking
   C. wood-burning stoves
   D. pets in the house

2. Which of the following is the most common cause of neonatal pneumonia (first 7 days of life)?
   A. *E. coli*
   B. *L. monocytogenes*
   C. group B streptococcus
   D. virus

3. Which of the following is the most common etiology of community-acquired pneumonia in children younger than 2 years of age?
   A. *E. coli*
   B. *S. aureus*
   C. *L. monocytogenes*
   D. *S. pneumoniae*
   E. virus

4. Mycoplasma pneumonia is most common in children of which age?
   A. < 7 days old
   B. 7 days to 3 months old
   C. 1-2 years old
   D. > 5 years old

5. Which of the following special population: organism pairs is *incorrect*?
   A. *Pneumocystis jirovecii*: immunocompromised patients
   B. *Coccidioides immitis*: southwestern U.S. states
   C. *Histoplasma capsulatum*: Alaska
   D. gram-negative bacilli: WBC defects

6. The classic pattern associated with bacterial pneumonia includes which of the following?
   A. chronically ill child, prolonged fever, dehydration
   B. acute onset of fever and cough
   C. malaise, headache, photophobia, and bullous myringitis
   D. gastrointestinal symptoms

7. All of the following should be considered in the differential diagnosis of a child presenting with pneumonia-like symptoms (cough, respiratory distress, and ill appearance) *except*:
   A. Kawasaki disease
   B. congenital heart disease with heart failure
   C. foreign body aspiration
   D. reactive airway disease

8. Parapneumonic effusions are seen in approximately what percentage of cases of pediatric bacterial pneumonia?
   A. 10%
   B. 70%
   C. 40%
   D. 100%

9. The most common etiology of necrotizing pneumonia is which of the following?
   A. virus
   B. *S. pneumoniae*
   C. *Mycoplasma*
   D. *E. coli*

10. All of the following are complications associated with community-acquired pneumonia *except*:
    A. empyema
    B. acute respiratory failure
    C. appendicitis
    D. pleural effusion

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- apply state-of-the-art diagnostic and therapeutic techniques to patients with the particular medical problems discussed in the publication;
- discuss the differential diagnosis of the particular medical problems discussed in the publication;
- explain both the likely and rare complications that may be associated with the particular medical problems discussed in the publication.

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