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# Pneumonia in Adults: the Practical Emergency Department Perspective

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## KEYWORDS

- Pneumonia • Community-acquired • Classification • Treatment
- Adult • Pneumococcus

## INTRODUCTION AND PERSPECTIVE

Pneumonia is an inflammation of the lung most commonly caused by infection with bacteria, viruses, and other organisms. It is both a common and a potentially serious disease. It is estimated that there were more than 500,000 hospital admissions in the United States in 2009 from pneumonia. Whereas pneumonia managed as an outpatient is a less severe disease, pneumonia requiring hospitalization is associated with approximately 15% mortality. Pneumonia is often a complication of a preexisting condition or infection such as influenza. The 2009 national vital statistics identified pneumonia and influenza as the eighth leading cause of death.<sup>1</sup> Pneumonia consistently accounts for most of these deaths. Close to 90% of the deaths attributed to pneumonia occur in the population older than 65 years. In this cohort, pneumonia and influenza combine as the seventh leading cause of death.<sup>2,3</sup>

The Center for Disease Control's Advisory Committee on Immunization Practices recommends annual influenza vaccination for everyone older than 6 months.<sup>4</sup> (The emergence of serious drug-resistant pneumococci also accentuates the urgent need for pneumococcal immunization. Together, pneumonia and influenza represented a cost to the US economy in 2005 of \$40.2 billion. In 2010, the economic costs of all lung diseases were projected to be approximately \$173.4 billion.<sup>5</sup>)

The challenge for emergency department (ED) care is to recognize the diagnosis, initiate early and appropriate empiric antibiotic therapy, risk stratify patients with respect to severity of illness, and recognize indications for admission. This challenge

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must be balanced with an emphasis on cost-effective management, recognizing the changing spectrum of pathogenesis and a cognizance toward variable and less common presentations.

## PATHOGENESIS

Infectious transmission in pneumonia occurs most commonly either by microaspiration or by direct droplet inhalation. However, the development of clinical pneumonia requires either a defect in host defense mechanisms or inoculation with virulent organisms. Several pneumonic pathogens are spread by droplets. This mode of transmission bypasses the upper tract defenses and deposits directly in the lower respiratory tract. **Fig. 1** shows the 2 most common modes of transmission and the infectious organisms most commonly associated with each.

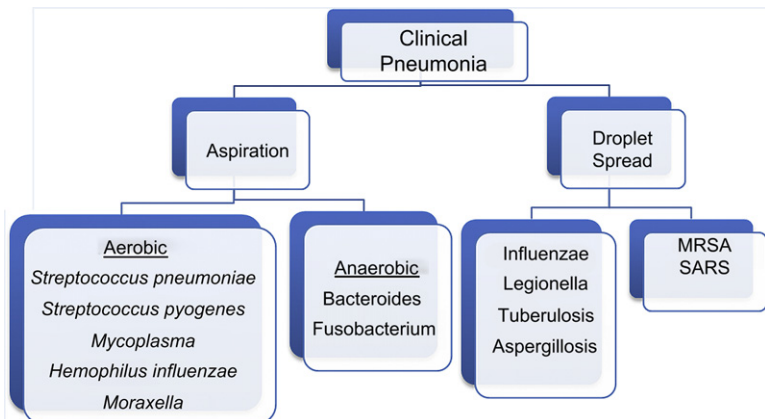
Host defenses can be impaired in many ways. **Fig. 2** shows some common conditions that are associated with an increased risk of the development of pneumonia and the manner in which these conditions impair host defenses.

Pneumonia can also be transmitted through less common mechanisms. These mechanisms may include: hematogenous spread; invasion from infection in contiguous structures (pleura or subdiaphragmatic structures); direct inoculation (as a result of surgery or bronchoscopy); and reactivation, most commonly in immunocompromised hosts. The most common organisms that are implicated in reactivation, even after many years, include *Pneumocystis jiroveci*, *Mycobacterium tuberculosis*, and cytomegalovirus.

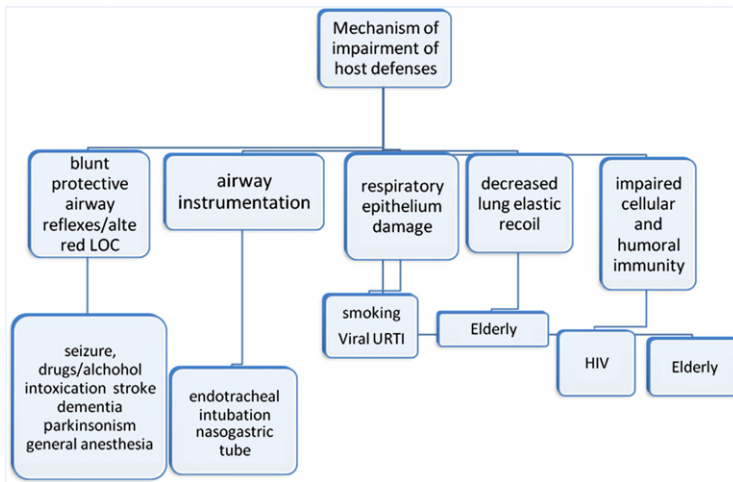
## CAUSE AND CLASSIFICATION

The challenge in the ED is not in making the diagnosis of pneumonia but rather in identifying the cause of the infection such that the appropriate antibiotic treatment can be instituted in a timely manner. This strategy is of particular importance in those patients with higher risk of mortality (ie, hospitalized inpatients). Because microbiological testing results are not available at the time of the ED assessment, the initial therapy with antibiotics is empiric.

To facilitate the decision-making process with regard to the institution of empiric antibiotics, it is helpful to classify pneumonia. The traditional classification was based on the terminology of typical or atypical pneumonia. The traditional clinical



**Fig. 1.** Modes of transmission of pneumonia.

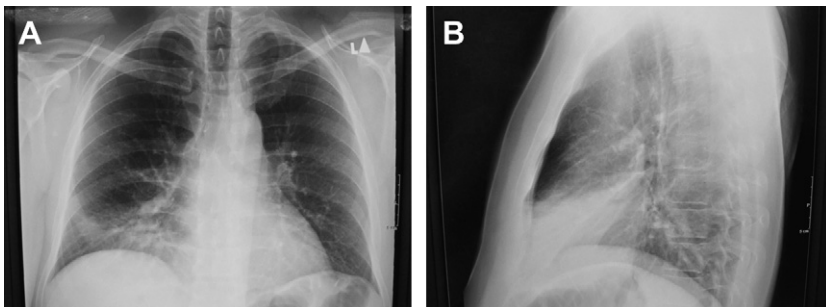


**Fig. 2.** Host conditions that predispose to pneumonia. URTI, upper respiratory tract infection.

presentation of typical pneumonia, most commonly caused by *Streptococcus pneumoniae*, included high fever, rigors, cough with rust-colored sputum, and laboratory findings of leukocytosis. Microbiology revealed gram-positive encapsulated diplococci. The classic chest radiograph (CXR) appearance in this setting was lobar consolidation. *Streptococcus pneumoniae* accounts for approximately 60% of community-acquired pneumonia (CAP). **Fig. 3** shows a CXR with this typical appearance.

The clinical presentation of atypical pneumonia was a more gradual onset, dry cough, in patients who often look well and are ambulatory. Microbiology often did not identify any organisms on Gram stain because most commonly they did not have cell walls. The CXR appearance was more often an interstitial pattern. **Fig. 4** shows a CXR with this atypical interstitial appearance. The most commonly described atypical organisms are *Mycoplasma*, *Legionella*, and *Chlamydia*. The challenge with this traditional classification is that in clinical practice the presentations of these infections have considerable overlap whereby a pneumococcal infection may present with an interstitial pattern on CXR and atypical clinical symptoms and vice versa.

A more practical classification for the ED is to consider the environmental contact combined with host factors, because this can provide guidance with respect to the



**Fig. 3.** (A) CXR, posteroanterior, lobar consolidation. (B) CXR, lateral, lobar consolidation.



**Fig. 4.** CXR, posteroanterior, interstitial pattern.

likely offending agent. This practical classification is important for the ED in guiding treatment. Hence, the history in the ED should focus not only on the pattern of symptoms but also on the setting in which the pneumonia is acquired, any geographic travel or animal exposures in conjunction with any host risk factors that could predispose to certain types of infection and also predict patient outcome. The classification can be broadly divided into 4 categories: CAP; hospital-acquired pneumonia (HAP); health care-associated pneumonia (HCAP); and ventilator-associated pneumonia (VAP).

Community-acquired pneumonia (CAP) is defined as an acute infection of the pulmonary parenchyma, occurring outside the hospital, with clinical symptoms accompanied by the presence of an infiltrate on CXR<sup>6</sup> The diagnosis of CAP requires that a patient has not been hospitalized or in a nursing home in the previous 14 days. The most common pathogens implicated in the development of CAP are *Streptococcus pneumoniae*, *Mycoplasma pneumoniae*, *Hemophilus influenzae*, *Chlamydia pneumoniae* sp, and viruses.

Two classifications of pneumonia are associated with exposure to the health care environment. HAP is a new respiratory infection that presents more than 48 hours after hospital admission. HCAP is infection in patients hospitalized for 2 or more days in the previous 90 days. This group includes patients undergoing dialysis or chemotherapy, chronic wound care, or home intravenous antibiotics care, the immunocompromised patient population, and patients from nursing home facilities.

VAP is pneumonia that is diagnosed more than 48 hours after a patient has been intubated and placed on a ventilator in the intensive care unit (ICU).

**Fig. 5** provides a schematic view of this classification of pneumonia and the pathogenic organisms most commonly associated with infection. The latter 3 classes (HAP, VAP, and HCAP) are predominately associated with gram-negative bacteria. *Acinetobacter* is a pathogen associated with VAP specifically, and the 3 encapsulated bacteria (*Streptococcus pneumoniae*, *Klebsiella*, and *H influenzae*) are all associated with particularly higher morbidity and mortality.<sup>7</sup>

CAP	HAP	VAP	HCAP
<ul style="list-style-type: none"> <li>• <i>Streptococcus pneumoniae</i></li> <li>• <i>Mycoplasma</i></li> <li>• <i>Hemophilus influenzae</i></li> <li>• <i>Chlamydomphila</i></li> <li>• Viral<sup>a</sup></li> </ul>	<ul style="list-style-type: none"> <li>• <i>Pseudomonas aeruginosa</i></li> <li>• MRSA</li> <li>• <i>Legionella</i></li> <li>• <i>Klebsiella pneumoniae</i></li> <li>• <i>Hemophilus influenzae</i></li> <li>• <i>Moraxella catarrhalis</i></li> </ul>	<ul style="list-style-type: none"> <li>• <i>Pseudomonas aeruginosa</i></li> <li>• MRSA</li> <li>• <i>Legionella</i></li> <li>• <i>Klebsiella pneumoniae</i></li> <li>• <i>Hemophilus influenzae</i></li> <li>• <i>Moraxella catarrhalis</i></li> <li>• <i>Acinetobacter baumannii</i></li> </ul>	<ul style="list-style-type: none"> <li>• <i>Pseudomonas aeruginosa</i></li> <li>• MRSA</li> <li>• <i>Legionella</i></li> <li>• <i>Klebsiella pneumoniae</i></li> <li>• <i>Hemophilus influenzae</i></li> <li>• <i>Moraxella catarrhalis</i></li> </ul>

**Fig. 5.** Classification of pneumonia. <sup>a</sup>Viral, includes influenza A and B, adenovirus, respiratory syncytial virus, and parainfluenza.

Mortality from pneumonia varies depending on the causative organism, but *Streptococcus pneumoniae* has the highest mortality. The incidence of *Streptococcus pneumoniae* in 2008 was 100/100,000 adults/y. The mortality statistics for pneumococcal pneumonia in 2005 published by the World Health Organization were 1.6 million deaths worldwide. Even in developed countries the statistics indicate 10% to 20% mortality. The greatest risk of pneumococcal pneumonia is usually among people who have chronic illness such as lung, heart, or kidney disease, sickle cell anemia, or diabetes. But high rates are also noted in patients recovering from severe illness, those residing in nursing homes or chronic care facilities, and those patients older than 65 years.<sup>8</sup> Other high mortality causes include *Klebsiella*, *Legionella*, and methicillin-resistant *Staphylococcus aureus* (MRSA).

The clinical symptoms that characterize pneumonia caused by various agents often overlap, and the interobserver variability of physical findings has been shown to be high. This finding has led to an approach of antibiotic treatment of pneumonia in the ED, which is mostly empiric. However, to facilitate diagnostic decision making, various epidemiologic conditions have been shown to be related to specific pathogens in patients with pneumonia.<sup>9</sup> These classic associations are shown in **Table 1**.

The typical cardiovascular reaction to fever is tachycardia. However, certain pneumonias may be associated with fever and relative bradycardia (Faget sign). These pneumonias include *Legionella*, *Mycoplasma*, and tularemia. Other infections associated with this clinical sign include yellow fever, typhoid fever, brucellosis, and Colorado tick fever.

It is also often useful to consider the pathogenic organisms in pneumonia with respect to age of the host. **Table 2** shows the most typical organisms based on age classification.

## DIAGNOSTIC TESTS

### Laboratory Tests

#### Complete blood count

The white blood cell count (WBC) is neither sensitive nor specific to identify the likely causative agent of pneumonia (ie, bacterial or viral), but may be correlated with the severity of illness.<sup>10,11</sup> However, the WBC count may be useful in 2 scenarios: first, neutropenia, which may indicate immunosuppression; and second, lymphopenia, which may indicate immunosuppression from AIDS.

**Table 1**  
Epidemiologic conditions, risk factors, and classic presentations of pneumonia associated with specific pathogens

Pathogen	Symptoms	Associated Condition	Radiographic/Laboratory Findings
<i>Streptococcus pneumoniae</i>	Rapid onset, rust sputum, chills, rigors	Alcoholism; COPD/smoking; HIV (early); postinfluenza; IVDU; endobronchial obstruction	Leukocytosis; gram-positive encapsulated diplococci; lobar infiltrate
<i>Staphylococcus aureus</i>	Gradual onset; postviral illness	IVDU; postinfluenza; structural lung disease <sup>a</sup> ; endobronchial obstruction	Gram-positive cocci in clusters; associated with abscess, pleural effusion
<i>Klebsiella</i>	Fever, rigors; current-jelly sputum	Alcoholism; COPD; diabetes; elderly;	Bulging minor fissure; gram-negative encapsulated bacillus
<i>Pseudomonas</i>		HAP; VAP; HCAP; cystic fibrosis; hot tub use; COPD/smoking	Patchy infiltrates; gram-negative bacillus
<i>Hemophilus influenzae</i>	Gradual onset	Elderly; HIV (early); COPD/smoking; postinfluenza; endobronchial obstruction	Patchy infiltrates; pleural effusion; gram-negative encapsulated coccobacillus
<i>Moraxella catarrhalis</i>		COPD/smoking	Gram-negative diplococcus
<i>Chlamydomphila pneumoniae</i>	Gradual onset; dry cough; staccato cough (neonates)	COPD/smoking	Patchy infiltrates; Gram stain negative
<i>Mycoplasma</i>	Insidious onset; young adults		Gram stain negative; CXR, intestinal and perihilar; pleural effusion; extrapulmonary manifestations: bullous myringitis, cold agglutinins, morbilliform rash, hemolytic anemia, Guillain-Barré
<i>Legionella</i>	High mortality; relative bradycardia (Faget sign); GI symptoms; no person-to-person spread	Elderly, COPD/smoking; hotel/cruise ship <sup>b</sup>	Gram stain negative; patchy infiltrates; hyponatremia; nonspecific LFT abnormalities

<i>Anaerobes</i>	Aspiration; oral pathogens or gram-negative enteric pathogens	Alcoholics; edentulous, neuromuscular disease, recent intubation; endobronchial obstruction	CXR: right middle lobe or right upper lobe infiltrates lung abscess
<i>Hantavirus</i>	Acute lung injury and shock; rodent urine/feces	Rodent urine/feces; travel to southwestern United States	
CA-MRSA			CXR: lung abscess
<i>Bordetella pertussis</i>	Cough more than 2 weeks; posttussive vomiting		
<i>Yersinia pestis</i>	Buboes; high person-to-person transmission	Fleas from rodents; hematogenous spread	
<i>Bacillus anthracis</i>	No person-to-person transmission; also GI and skin infection	Inhaled spores	Wide mediastinum
<i>Francisella tularensis</i>	Tularemia; lymphadenopathy; ulcerated skin lesions	Infected rabbits	
<i>Coxiella burnetii</i>	Q fever	Cattle and sheep exposure	Spirochete
<i>Chlamydomphila psittaci</i>	Psittacosis	Infected birds	
<i>Histoplasma capsulatum</i> ; <i>Coccidioides immitis</i> ; <i>Blastomyces dermatitidis</i>	Histoplasmosis (bat/bird droppings); coccidiomycosis (southwestern United States); blastomycosis (erythema nodosum); slow gradual onset	Dirt/construction exposure	Patchy infiltrate
SARS	Coronavirus; acute lung injury; shock; young adults; travelers (Southeast Asia); highly contagious and lethal		
<i>Mycobacterium tuberculosis</i>		Alcoholics; lung abscess; HIV (early); IVDU	

(continued on next page)



<b>Table 1</b> (continued)			
<b>Pathogen</b>	<b>Symptoms</b>	<b>Associated Condition</b>	<b>Radiographic/Laboratory Findings</b>
<i>Acinetobacter</i>		Alcoholics; VAP	
HIV (early) <i>Streptococcus pneumoniae</i> ; <i>H influenzae</i> ; <i>M tuberculosis</i>			
HIV (late) <i>Pneumocystis jiroveci</i> ; <i>Cryptococcus</i> ; <i>Histoplasma</i> ; <i>Aspergillus</i> ; <i>Mycobacterium kansasii</i> ; <i>Pseudomonas aeruginosa</i> ; <i>H influenzae</i>	Opportunistic infection; progressive SOB		CD4 <200; increased LDH; low oxygen saturation

**Abbreviations:** CA-MRSA, community-acquired MRSA; COPD, chronic obstructive pulmonary disease; GI, gastrointestinal; HIV, human immunodeficiency virus; IVDU, intravenous drug use; LDH, lactate dehydrogenase; LFT, liver function test; SARS, severe acute respiratory syndrome; SOB, shortness of breath.

<sup>a</sup> Structural lung disease: bronchiectasis.

<sup>b</sup> Hotel or cruise ship stay within the previous 2 weeks.

<b>Age Range</b>	<b>Suspected Organism</b>
0–3 weeks	Group B streptococcus, <i>Listeria</i> , <i>E coli</i>
3 weeks–3 months	<i>Streptococcus pneumoniae</i> , <i>Chlamydia</i> , <i>Bordetella pertussis</i> , viral (respiratory syncytial virus, parainfluenzae)
4 months–4 years	Viral, <i>Streptococcus pneumoniae</i> , <i>Mycoplasma</i>
4 years–15 years	<i>Mycoplasma</i> , <i>Streptococcus pneumoniae</i>
Adults: CAP, HAP, VAP, HCAP	See <a href="#">Table 1</a>

### **Blood cultures and sputum cultures**

The laboratory detection of pneumonia can be difficult because of problems in obtaining an optimal specimen for diagnosis.<sup>12</sup> Blood cultures from pneumococcal pneumonia cases are often negative, and respiratory specimens such as sputum or nasopharyngeal samples can be confounded by the presence of normal flora.

The 2003 guidelines from the Infectious Diseases Society of America (IDSA) and the American Thoracic Society (ATS) recommend 2 blood cultures for patients hospitalized with pneumonia.<sup>6,13</sup> However, low rates of secondary bacteremia have led many to question the usefulness and cost-effectiveness of routine blood cultures. Studies have repeatedly shown sensitivity of blood cultures in patients admitted to the hospital with CAP to be between 7% and 10%. Patients with CAP who had blood cultures performed had a less than 2% chance of having a change in therapy directed by blood culture results. Severity of pneumonia, as measured by the Pneumonia Severity Index (PSI), also poorly correlates with the yield of blood cultures.<sup>14</sup> Blood cultures should be considered in patients who have a host defect in the ability to clear bacteremia. These patient groups include those with asplenia, complement deficiencies, chronic liver disease, and leucopenia.<sup>15,16</sup>

The Agency for Healthcare Research and Quality (AHRQ) has made recommendations regarding the use of blood cultures in adult patients with CAP.<sup>17</sup> The AHRQ states that routine blood cultures are not recommended in patients admitted with CAP. Consideration should be given to obtaining blood cultures in higher-risk patients admitted with CAP (ie, those with severe disease, immunocompromise, significant comorbidities, or other risk factors for infection with resistant organisms).

The benefits of sputum culture are also controversial. A meta-analysis has shown the use of sputum Gram stain to have low yield.<sup>18</sup> The initial limitation is that less than 50% of patients do not produce an adequate sample. Despite this finding, when a sputum sample has more than 25 polymorphonuclear cells per low-power field and there is a predominant organism, the causative organism is identified in more than 80% of cases. The interpretation of the sputum culture is also problematic. For properly handled samples the sensitivity is approximately 75%. This sensitivity is lower if antibiotics therapy has been started before the sample is taken. In addition, because of the possibility of culturing bacteria that colonize the oropharynx, false-positive results may occur. This finding is especially true for debilitated patients, who are more likely to be colonized with pathogens. However, certain organisms are always pathogenic and can be assumed to be causing disease if they are identified. These organisms include *Legionella* species, *Mycobacterium tuberculosis*, and the endemic fungi.<sup>19</sup>

The current IDSA/ATS guidelines for CAP in adults published in 2007<sup>7</sup> state that sputum cultures should be considered in patients when it is expected that the findings

will result in a change in antibiotic management or that the test is likely to have high yield. The specific guidelines recommend therefore the use of sputum cultures in the following 8 circumstances: ICU admission; failure of outpatient antibiotic management; cavitary infiltrates; active alcohol abuse; severe obstructive or structural lung disease; positive *Legionella* urinary antigen test (UAT); positive pneumococcal UAT; or pleural effusion.

### **Serologic testing**

Serologic testing is available for *Chlamydia* sp, *Legionella*, and some fungi. In the ED these investigations are useful only from a retrospective perspective because they usually require both acute and convalescent serum titers. Rapid antigen tests are also available for influenza and respiratory syncytial virus (RSV). These tests may be useful as an adjunctive ED test for infection control purposes for hospital inpatients and as an aid in decision making regarding family and contact prophylaxis.

UATs are commercially available for *Streptococcus pneumoniae* and *Legionella pneumophila*. These tests have the highest diagnostic yield in patients with more severe illness. These antigen tests are rapid, simple to use, have high specificity in adults (<90%), and, most importantly, have the ability to detect the organism after antibiotics have been started.<sup>20,21</sup>

Serologic testing can be useful as an aid to tailoring antibiotic management. This finding is of particular importance for the identification of *Mycobacterium* or the identification of antibiotic-resistant strains. The latter have been implicated in increased mortality<sup>22</sup> and in increased risk of clinical failure.<sup>23</sup> The identification of certain pathogens may have important epidemiologic implications. These implications include severe acute respiratory syndrome (SARS), influenza, legionnaire disease, and agents of bioterrorism. Cost is the greatest impedance to testing in all patients. The cost/benefit ratio must be considered.<sup>24</sup>

Microbiological testing in severe CAP in patients admitted to the ICU has been shown to both identify the causative agent and lead to changes in antibiotic therapy, both of which, in this setting, have had a positive impact on patient outcome.<sup>25</sup>

### **Imaging Modalities**

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#### **CXR**

The diagnosis of CAP is based on the presence of select clinical features (cough, fever, sputum production, or pleuritic chest pain) and is supported by imaging of the lung. The CXR remains the reference standard for the diagnosis of pneumonia. It has been shown to have greater sensitivity and specificity than the physical examination of the chest for diagnosis of pneumonia.<sup>26</sup> The CXR is not only useful in making the diagnosis of pneumonia but also in aiding in differentiating pneumonia from other common causes of cough and fever, or in identifying an alternative diagnosis.

There is considerable overlap in the classic CXR appearances associated with specific pathogens. However, CXR has low sensitivity for the diagnosis of pneumonia in the very elderly population and in the neutropenic population.

#### **Computed tomography scan/magnetic resonance imaging**

Computed tomography (CT) of the chest has been shown to have greater sensitivity than CXR for the diagnosis of pneumonia. However, the clinical significance of these findings when the CXR is negative is unclear.<sup>27</sup> For patients who are hospitalized with suspected pneumonia but have a negative CXR, it is recommended to treat the condition empirically and repeat the CXR in 24 to 48 hours.

CT scanning has been shown to be beneficial for the diagnosis of pneumonia in the neutropenic patient.<sup>27,28</sup> CT scanning can be useful in those patients who do not

respond to initial therapy. In addition to ruling out other diagnoses such as pulmonary emboli, a CT scan can disclose other reasons for antibiotic failure, including pleural effusions, lung abscess, or central airway obstruction. Magnetic resonance imaging has been shown to have similar sensitivity compared with CT and has been recommended for follow-up examinations in this patient population to minimize repeated radiograph exposure.<sup>29</sup>

### **Ultrasonography**

Recently the use of bedside ultrasonography has been studied in the ED diagnosis of pulmonary conditions including pneumonia. Bedside lung ultrasonography has been shown to be 96% sensitive and 96% specific in the diagnosis of radio-occult (negative CXR) pleural-pulmonary lesions.<sup>30</sup> A recent systematic review<sup>31</sup> has also shown bedside lung ultrasonography to be an ideal tool for the diagnosis of emergency pulmonary conditions, with the benefit of the absence of radiation.

## **HOSPITAL ADMISSION DECISIONS**

Diagnostic and treatment decisions for pneumonia are based on assessing the severity of illness. These assessments also affect the decision between inpatient and outpatient treatment and ICU admission versus admission to a general ward.

### **Scoring Systems**

Two scoring systems have been developed that can assist in the identification of patients who may be candidates for outpatient treatment: CURB-65 is a severity of illness score,<sup>32</sup> and the PSI<sup>33</sup> is a prognostic model (**Table 3**).

The use of these objective criteria must be supplemented by physician judgment. Factors such as patient compliance to oral medication and outpatient social support

<b>Table 3 Comparison of CURB-65 and PSI scores</b>	
<b>CURB - 65</b>	<b>PSI</b>
Confusion +1	Age
Blood urea nitrogen >7 mmol/L +1	Female –10
Respiratory rate >30 +1	Nursing home resident +10
Systolic blood pressure <90 mm Hg or diastolic blood pressure <60 mm Hg +1	Neoplastic disease history +30
Age >65 y +1	Liver disease +20
	Congestive heart failure +10
	Cerebrovascular disease +10
	Renal disease +10
	Altered mental status +20
	Respiratory rate >29 +20
	Systolic blood pressure <90 +20
	Temperature <35°C or >39.9°C +15
	Pulse >124 +10
	pH <7.35 +30
	Blood urea nitrogen <29 +20
	Sodium <130 +20
	Glucose >13.8 +10
	Hematocrit <30% +10
	Partial pressure oxygen <60 +10
	Pleural effusion on radiograph +10

systems should be taken into account. The ATS has also developed criteria to assist in the decision making regarding which patients require higher-level monitoring or an ICU admission directly from the ED.<sup>7</sup>

The PSI uses a 2-step approach to risk assessment. Patients are first identified as low-risk and recommended for outpatient management. The low-risk patients are those less than 50 years, who do not have significant comorbid conditions, and who have no concerning features on physical examination. Patients who do not meet these low-risk criteria are then classified into categories based on age, comorbid illness, abnormal physical examination findings, and laboratory abnormalities. Scoring is divided into 5 classes and each class is associated with a predicted mortality: class 1, points 0, mortality 0.1%; class 2, points less than 70, mortality 0.6%; class 3, points 71–90, mortality 2.8%; class 4, points 91–130, mortality 8.2%; class 5, points greater than 130, mortality 29.2%. Classes 1, 2, and 3 are considered low-risk patients, class 4, moderate-risk, and class 5, high-risk. Hospital admission is recommended for those patients who score more than 91 (class 4). This score has been shown to decrease overall admission rates and decrease health care costs.<sup>34</sup> However, the scoring system does not consider dynamic observation of patients over time, the ability to take oral medications, home supports, and access to follow-up.

CURB-65 is a more simplified tool that uses 5 criteria to determine patients at lower risk for adverse events. These criteria are confusion; uremia (blood urea nitrogen [BUN] >7 mmol/L); respiratory rate (>30); blood pressure (<90 systolic, or >60 diastolic); age 65 years or greater. Each criterion is rated equally for a total score of 5. The risk of 30-day mortality increases with increasing score. A score of 1 point is the lowest-risk group, with an estimated 2.7% 30-day mortality; outpatient treatment is recommended. Two points is the moderate-risk group, with a 6.8% 30-day mortality; either outpatient treatment with close follow-up or inpatient treatment is recommended in this group. Three points is the severe group, with an estimated 14% mortality; inpatient treatment is recommended in this group with consideration for an ICU admission. Four and 5 points are the highest-risk groups. There is an estimated 27.8% mortality in these groups and an ICU admission is recommended.

Comparison of the PSI and CURB-65 scores reveals that they are equivalent in predicting mortality.<sup>35</sup> Both the 28-day mortality and the inhospital mortality for PSI level V and CURB >/- 3 were equivalent.<sup>36</sup> Both scoring indices have also been shown to accurately predict outcomes in patients with HCAP.<sup>37</sup> However, there are no randomized trials of hospital admission strategies that directly compare the 2 scoring systems. In addition, no prospective criteria have been validated for the decision-making process for an ICU admission.<sup>38</sup> PSI also underperforms in the elderly population.<sup>39</sup> This finding is suspected secondary to the inappropriate weight given to the age variable in the scoring system. This situation is of concern because elderly patients often have atypical presentations and worse outcomes.

The ATS has developed criteria to assist with in-hospital disposition decision making. These criteria are divided into major and minor criteria. Direct admission to an ICU or high-level monitoring unit is recommended for patients with either of the major criteria or with 3 of the minor criteria. Major criteria are invasive mechanical ventilation or septic shock with the need for vasopressors. **Table 4** shows the minor criteria for severe CAP.

## MANAGEMENT

The goal of therapy is eradication of the infecting microorganism, with resultant resolution of clinical disease. Antimicrobials are the mainstay of treatment. The ATS

**Table 4**  
Minor criteria for severe CAP

Physical Examination	CXR	Laboratory
Respiratory rate >30/min	Multilobar infiltrates	Leukopenia: WBC <4000 cells/mm <sup>3</sup>
Blood pressure: requires aggressive intravenous fluids		Thrombocytopenia: platelet count <100,000 cells/mm <sup>3</sup>
Hypoxemia: Pao <sub>2</sub> /Fio <sub>2</sub> ratio <250		
Mental status: confusion		
Hypothermia: temperature <36°C		

advocates an empiric approach to treatment based on clinical presentation. This approach also incorporates the presence of risk factors for *Pseudomonas* species, gram-negative organisms, and drug-resistant *Streptococcus pneumoniae* (DRSP).<sup>7</sup>

**Table 5** provides a schematic view of the current recommended treatments for various patient populations with pneumonia.

The most common pathogens in this mild (ambulatory) group are all adequately covered by macrolide antibiotics (see **Fig. 5**). Macrolide antibiotics are recommended as monotherapy in this patient population. The use of fluoroquinolones to treat

**Table 5**  
Recommended antibiotic treatment

Outpatient	Inpatient Hospital Ward <sup>a</sup>	Inpatient ICU
Healthy/no risk factors for DRSP	Respiratory fluoroquinolone	Minimum treatment β-lactam plus macrolide
Macrolide <sup>b</sup> or Doxycycline	or β-lactam plus macrolide	
Comorbidity <sup>c</sup> Respiratory fluoroquinolone <sup>d</sup> or β-lactam <sup>e</sup> plus macrolide		Antipseudomonal coverage Imipenem; meropenem plus ciprofloxacin or levofloxacin or β-lactam plus aminoglycoside plus azithromycin or β-lactam plus aminoglycoside plus antipseudomonal fluoroquinolone
		CA-MRSA Vancomycin or linezolid

<sup>a</sup> Increasing resistance rates suggest that empiric therapy with a macrolide alone is not recommended in this population.

<sup>b</sup> Macrolide antibiotics include azithromycin, clarithromycin, and erythromycin; doxycycline can be used as a macrolide alternative.

<sup>c</sup> Cardiovascular: coronary artery disease or congestive heart failure, valvular heart disease; Pulmonary: asthma, chronic obstructive pulmonary, interstitial lung disorders; Renal: preexisting renal disease with a documented abnormal serum creatinine level outside the period of the pneumonia episode; Hepatic: preexisting viral or toxic hepatopathy; Central nervous system: vascular or nonvascular encephalopathy, diabetes mellitus and treatment with oral anti-diabetics or insulin; Neoplastic illness: any solid tumor active at the time of presentation or requiring antineoplastic treatment within the preceding year.

<sup>d</sup> Respiratory fluoroquinolones included moxifloxacin and levofloxacin.

<sup>e</sup> β-Lactams include high-dose amoxicillin (1 g 3 times a day) or amoxicillin clavulanate (750 mg twice a day) or ceftriaxone or cefuroxime.

ambulatory patients with pneumonia without comorbid conditions, risk factors for DRSP, or recent antibiotic use is not recommended because of the concern for the development of fluoroquinolone resistance.<sup>40</sup> Comorbidity or recent antimicrobial therapy increased the likelihood of infection with DRSP, and enteric gram-negative bacteria. In these patients, therapeutic options include either a respiratory fluoroquinolone or a combination therapy with a  $\beta$ -lactam antibiotic effective against *Streptococcus pneumoniae* plus a macrolide. Recommended  $\beta$ -lactams include: high-dose amoxicillin or amoxicillin clavulanate. Oral cephalosporins can also be used as alternatives. Agents in the same class as the patient has been receiving previously should not be used to treat patients with recent antibiotic exposure.

For patients who are admitted to a hospital ward, the combination treatment of a  $\beta$ -lactam plus a macrolide or monotherapy with a fluoroquinolone has been shown to be associated with a significant reduction in mortality compared with that of the administration of a cephalosporin alone.<sup>41</sup> The choice between dual or monotherapy should be based on the patient's previous 3-month antibiotic exposure. Initial therapy for admitted patients is usually intravenous, but oral therapy can be considered for patients without risk factors for severe pneumonia, especially with highly bioavailable agents such as fluoroquinolones.<sup>42</sup>

Patients admitted to the ICU with pneumonia are those who are usually diagnosed with severe pneumonia initially from the ED. The antimicrobial treatment in this patient population must be broader. The minimum recommended treatment of these patients is a  $\beta$ -lactam plus either azithromycin or a fluoroquinolone. For all patients admitted to the ICU, antimicrobial coverage should include that for *Streptococcus pneumoniae* and *Legionella*. This combination therapy is recommended for at least 48 hours or until results of diagnostic tests are known. In the mechanically ventilated ICU patient, treatment with a fluoroquinolone alone has been associated with inferior outcome.<sup>43</sup>

In the critically ill ICU patient with severe pneumonia, many microorganisms other than *Streptococcus pneumoniae* and *Legionella* sp must be considered. Of particular importance is *Pseudomonas* sp and gram-negative bacteria.<sup>44</sup> Therefore, standard empiric treatment regimens in this population should include coverage for *Streptococcus pneumoniae*, *Legionella* sp, and *H influenzae*, all of the atypical organisms, Enterobacteriaceae sp, and Pseudomonadaceae sp (see **Table 5**). Penicillin-allergic patients should have the  $\beta$ -lactam substituted with aztreonam, a synthetic monocyclic  $\beta$ -lactam antibiotic. The excess mortality associated with MRSA indicates empiric coverage for this organism in this patient population. For suspected MRSA (end-stage renal disease, injection drug abuse, previous influenza, and previous recent antibiotic use) vancomycin or linezolid should be added.

## SPECIAL TREATMENT CONSIDERATIONS

### *Timing of Antibiotics*

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There seems to be a causal relationship between antibiotic timing and improved outcomes, especially in the elderly population.<sup>45</sup> Early antibiotic treatment does not seem to shorten the time to clinical stability but has been shown to decrease length of hospital stay.<sup>46</sup> However, there is insufficient evidence to establish an overall benefit in mortality or morbidity from antibiotics administered in less than 8 hours from ED arrival in patients with CAP without severe sepsis. For patients admitted through the ED, the first antibiotic dose should be administered while the patient is still in the ED.

### *Transition from Parenteral Antibiotics to Oral Antibiotics*

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Most hospitalized patients are initially treated with parenteral antibiotics. The transition to oral antibiotics can occur when the patient has become clinically stable and has

shown clinical improvement. Criteria for clinical stability include temperature less than 37.8°C, heart rate less than 100/min, respiratory rate less than 24/min, systolic blood pressure greater than 90 mm Hg; room air oxygen saturation of greater than 90%; and normal mental status.<sup>47</sup> This transition should be balanced with an assessment of the ability to ingest oral medications in patients with normal functioning gastrointestinal tracts.

### ***Duration of Treatment***

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It is recommended that the duration of treatment be a minimum of 5 days and that the patient be afebrile for 48 to 72 hours before discontinuation of treatment. The patient should not possess any signs of clinical instability at the time of discontinuation of treatment.<sup>47</sup> Few controlled trials have evaluated the optimum duration of antibiotic therapy in either inpatients or outpatients. However, most patients with CAP are treated for 7 to 10 days or longer.

### ***Noninvasive Positive Pressure Ventilation***

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In patients with pneumonia, noninvasive positive pressure ventilation (NPPV) has been shown to be well tolerated, safe, and associated with a significant reduction in respiratory rate, need for endotracheal intubation, and duration of ICU stay. NPPV does not decrease overall duration of overall hospitalization or inhospital mortality, except in the subgroup of patients with pneumonia and underlying chronic obstructive pulmonary disease (COPD).<sup>48</sup> However, other studies of patients with hypoxic respiratory failure have failed to show a benefit of NPPV, with many patients eventually requiring intubation.<sup>49</sup> Hence, these conflicting data do not support the routine use of NPPV in patients with severe pneumonia, with the exception of patients with underlying COPD. The ATS and the IDSA currently recommend a cautious trial of NPPV for refractory hypoxemia in patients with severe pneumonia.<sup>7</sup>

### ***Hypotensive, Fluid-resuscitated Patients with Severe Pneumonia***

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Corticosteroids have been studied in patients with septic shock and have yielded no benefit. A recent 2010 Cochrane review of 20 randomized trials revealed that corticosteroids did not change 28-day mortality. Furthermore, corticosteroids did show a statistically significant increase in adverse events such as hyperglycemia and hypernatremia.<sup>50,51</sup>

Recombinant human activated protein C (APC) has also been studied in patients with severe sepsis. A Cochrane Review of 4434 adult patients yielded no benefit. There was no difference in mortality between the control group and those who received APC, regardless of the severity of the sepsis. However, use of APC was associated with a higher risk of serious bleeding.<sup>52</sup>

### ***Diffuse Bilateral Pneumonia and Acute Respiratory Distress Syndrome***

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Mortality for patients with severe diffuse bilateral pneumonia or acute respiratory distress syndrome (ARDS) is extremely high. The ARDSnet trial revealed a significant reduction in mortality with the use of low tidal volume ventilation (6 mL/kg ideal body weight) or what has become known as a lung protective ventilation strategy. With this intervention, the number needed to treat (NNT) to avoid 1 death is 9 (NNT = 9).<sup>53,54</sup> The ATS therefore has made a level 1 recommendation that patients with diffuse bilateral pneumonia or ARDS should be mechanically ventilated with low tidal volumes.

### ***DRSP***

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Antibiotic resistance patterns vary considerable among countries/regions and evolve over time. Globally, 1.6 million people die of invasive pneumococcal disease annually.



This incidence is highest in extremes of age, in patients with comorbidity, and in those with defects in immunity. The development of drug-resistant strains of microorganisms has placed a challenge on effective treatment options.<sup>55,56</sup>

Emergency physicians should be aware that the patients at the highest risk of infection with DRSP include those who take antibiotics frequently, patients who are exposed to others who commonly receive antibiotics, children younger than 6 years (especially those in daycare facilities and their immediate family members), adults older than 70 years, and those with underlying immunosuppression.

Penicillin resistance occurs in a stepwise fashion with irreversible mutations of the penicillin binding proteins. In the United States, penicillin resistance decreased from 1999 to 2005. This decrease was reported in both the pediatric and the adult population. This decline is a reflection of the introduction of the 7-valent pneumococcal conjugate vaccine.<sup>57,58</sup>

During this same period, resistance rates to macrolides did not change, but resistance to fluoroquinolones increased, likely reflecting an increase in use. The resistance of fluoroquinolone is highest in adults older than 64 years and in patients with underlying COPD.

The impact of antimicrobial resistance on clinical outcome remains controversial. Host factors such as extremes of age, immunosuppression, and comorbidity likely also influence mortality.<sup>59</sup>

Prescribing antibiotics for respiratory infection contributes to the development of resistance to that antibiotic. The effect seems to be greatest in the month immediately after treatment but may persist for up to 12 months. Reduction in antibiotic use may reduce the potential for antimicrobial resistance.<sup>60</sup>

Antibiotic resistance is a problem that can be combated at the ED level through a combination of appropriate antibiotic selection, prescribing patterns, use of antibiotic resistance profiles, surveillance protocols, and an understanding of new antibiotic treatment options.

### ***Nonresponding Pneumonia***

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Nonresolving pneumonia is a clinical syndrome in which clinical symptoms of pneumonia do not improve or worsen despite an initial 10 days of antibiotic therapy or in which radiographic opacities fail to resolve within 12 weeks. Mortality among nonresponding patients is greatly increased compared with patients who initially respond to treatment. Overall mortality as high as 49% has been reported for nonresponding hospitalized patients with pneumonia.<sup>61</sup> Nonresponse mandates either a transfer to a higher level of care, further diagnostic testing, or a change in treatment. Inadequate host response is the most common cause of apparent treatment failure. Patients older than 65 years, those with COPD, diabetes, alcoholism, or those who are undergoing immunosuppressive therapy are the most likely to be nonresponders.

Emergency physicians should be aware that as many as 10% of patients with CAP and up to 60% of patients with HAP have inadequate responses to initial empiric therapy. As many as 20% of these patients are diagnosed with diseases other than pneumonia.<sup>62</sup>

## **SPECIAL PATIENT POPULATIONS**

### ***MRSA***

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There are 2 patterns of MRSA: the hospital-acquired strain (HA-MRSA) and those more recently identified strains that are phenotypically distinct and have become known as community-acquired MRSA (CA-MRSA).<sup>63</sup> The latter are resistant to fewer

antimicrobials than are the hospital-acquired MRSA strains. However, most of these strains do contain a toxin associated with the clinical features of necrotizing pneumonia, shock, respiratory failure, and the formation of abscesses and empyema. This strain should be suspected in patients with cavitory infiltrates on CXR. It is estimated that 2% of CA-MRSA infections result in pneumonia.<sup>64</sup>

CA-MRSA pneumonia is associated with an influenzalike illness, occurs most commonly in young healthy individuals, and has high mortality. The recommended parenteral antibiotic treatment is vancomycin or linezolid. The addition of rifampicin may also be considered. The management of CA-MRSA should also include culture of blood, sputum, and pleural specimens in the case of pleural effusion. Empyema is an associated complication and should be drained. It is recommended that patients with this diagnosis be admitted to an ICU. Respiratory infection control measures are important for the prevention of nosocomial spread of MRSA.<sup>65</sup>

## **VIRAL PNEUMONIAS**

### ***Influenza***

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In the ambulatory setting, in uncomplicated cases of viral pneumonia caused by influenza, treatment within 48 hours of symptoms with oseltamivir or zanamivir is recommended. These neuraminidase inhibitors have been shown to reduce median time to resolution of symptoms by 0.5 to 2.5 days. In this patient population, both oral oseltamivir and inhaled zanamivir reduce the likelihood of complications of the lower respiratory tract.<sup>66</sup>

In the hospitalized patient population, it is postulated that oseltamivir may reduce viral shedding and therefore treatment even greater than 48 hours of symptom onset may confer some benefit. Oseltamivir has been shown to have a broad influenza spectrum (both influenza A and B) and a low risk of resistance.

Amantadine is effective against influenza A only. Recent circulating influenza viruses in North America have been resistant to amantadine. Hence, treatment or chemoprophylaxis with amantadine is not currently recommended.<sup>67</sup>

### ***Pandemic Influenza***

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Influenza A from H5N1 (Avian) and H1N1 (pandemic influenza A) have a greater severity of infection than routine seasonal influenza. Both strains possess pandemic potential. These strains have been associated with acute respiratory failure and mortality greater than 70%. The usual clinical presentation is fever, cough, and respiratory distress progressive over 3 to 5 days. Exposure to dead or dying poultry in an area with known or suspected H5N1 activity has been reported by most patients with avian influenza A.<sup>68</sup>

Rapid bedside tests to detect influenza A have been used as screening tools. It is recommended that confirmed cases be treated with oseltamivir. The current recommendation is for a 5-day course of treatment at the standard dosage of 75 mg 2 times daily. Oseltamivir has been shown to have a significant mortality reduction, especially when started within 6 to 8 days after symptom onset. The mortality benefit seems to affect all age groups.<sup>69</sup> All such patients should also be placed in respiratory isolation and droplet precautions used.

The cause of viral pneumonia is most likely unknown to the emergency physician at initial presentation. No universal empiric therapy for viral pneumonia can be recommended. Causes of viral pneumonia other than influenza A and B include RSV, adenovirus, rhinovirus, enteroviruses, human metapneumovirus, hantavirus, and varicella

zoster virus. Evidence for antiviral treatment of CAP caused by viruses other than influenza comes mainly from case reports and treatment of immunocompromised patients. Ribavirin has been shown to be efficacious against RSV, human metapneumovirus, and parainfluenza. It can be used in intravenous form for the treatment of severe pneumonia caused by these viruses, from experience with immunocompromised patients.<sup>70</sup> Ribavirin aerosol treatment has been shown to be less efficacious.

### ***Human Immunodeficiency Virus and Tuberculosis***

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The use of HAART (highly active antiretroviral therapy) has decreased the incidence of opportunistic infection in patients infected with the human immunodeficiency virus (HIV). Respiratory infections are the most common type of opportunistic infection in the population with HIV. Pneumonia is associated with high mortality in the immunocompromised patient population. *Pneumocystis jiroveci* is the most common opportunistic infection in the HIV population. Traditionally, such infection in a patient with HIV is believed to represent reactivation of latent colonization. Those with CD4 counts less than 200 cells/mm<sup>3</sup> are at the greatest risk. Among patients with HIV and Pneumocystis pneumonia (PCP), mortality is 10% to 20%. This mortality increases substantially with the need for mechanical ventilation. The addition of corticosteroids to the standard treatment of PCP has been shown to decrease both mortality and the need for mechanical ventilation. Corticosteroids are indicated in patients with PCP and substantial hypoxemia (PaO<sub>2</sub> <70 mm Hg; A-a gradient >35 mm Hg on room air).<sup>71-73</sup>

However, the most common cause of bacterial pneumonia in the population with HIV remains *Streptococcus pneumoniae*. Patients infected with this microorganism develop pneumonia more frequently than do patients who do not have HIV and they have a more severe clinical course when infected.<sup>74</sup> Pneumococcal infections occur in patients with HIV with CD4 counts less than 500 cells/mm<sup>3</sup>.

In 2010, 11,181 tuberculosis (TB) cases were reported in the United States for a rate of 3.6 cases per 100,000 population.<sup>75</sup> HIV is considered the greatest risk factor for TB infection. TB can occur in the early stage of HIV with CD4 cell counts less than 300 cells/mm<sup>3</sup>. Patients with HIV are more likely to develop active TB once infected and they have a higher risk of death. It is estimated that in 2009, there were 1.1 million HIV-positive patients with TB worldwide and 380,000 deaths from TB in the population with HIV. HIV is also the most important risk factor for progression from latent to active TB. Early diagnosis of TB can be difficult because of a lack of specific clinical findings, such as abnormal CXR or positive skin test result. In patients with more advanced HIV disease, extrapulmonary disease is more common.<sup>76</sup> Treatment of latent TB infection has been shown to reduce the risk of active TB in HIV-positive patients, especially those with a positive skin test.<sup>77</sup>

### **SUMMARY**

Pneumonia is a common disease presentation to the ED. The challenge for the emergency physician is to recognize the diagnosis, initiate early and appropriate empiric antibiotic therapy, risk stratify patients with respect to severity of illness, and recognize indications for admission. Treatment should consider not only empiric therapy guidelines but also the environment in which the pneumonia was contracted and the host factors that may implicate risk for a particular microorganism.

The emergency physician should initiate antibiotic treatment in the ED for all patients who are diagnosed with pneumonia and should be vigilant regarding respiratory isolation and droplet precautions. Disposition should be based not only on the

severity of the presenting symptoms, but the underlying comorbidities of the patient, the clinical likelihood of deterioration, and the access to outpatient follow-up.

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