Lecture 20

Therapeutics
Lower Respiratory Tract Infection

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References

• Pharmacotherapy: A Pathophysiologic Approach, 11e. Chapter 125: Lower Respiratory Tract Infections

• Diagnosis and Treatment of Adults with Community-acquired Pneumonia. An Official Clinical Practice Guideline of the American Thoracic Society and Infectious Diseases Society of America. 2019
INTRODUCTION

• The respiratory tract has an elaborate system of host defenses, including **humoral immunity**, **cellular immunity**, and **anatomic mechanisms**.

• Infections in the lower respiratory tract occur only when these defense mechanisms are impaired.

• The majority of pulmonary infections **follow colonization of the upper respiratory tract** with potential pathogens, which, after achieving **sufficiently high concentrations**, gain access to the lung via **aspiration of oropharyngeal secretions**.

• The specific type of pulmonary infection caused by an invading microorganism is determined by a variety of host factors, including **age**, **anatomic features** of the airway, and **specific characteristics** of the **infecting agent**.
PNEUMONIA

• Pneumonia remains one of the most common causes of severe sepsis and the leading infectious cause of death in children and adults, with a mortality rate as high as 50% depending on the severity of illness.

• Pneumonia occurs throughout the year, with the relative incidence of disease resulting from different etiologic entities varying with the seasons.

• It occurs in persons of all ages, although the clinical manifestations are most severe in the very young, the elderly, and the chronically ill.
PATHOGENESIS AND ETIOLOGY

• Respiratory pathogens enter the lower respiratory tract by one of three routes:
  1. direct inhalation of infectious droplets;
  2. aspiration of oropharyngeal contents; or
  3. hematogenous spread from another infection site.

• Respiratory host defenses are preserved in healthy individuals and respiratory pathogens are effectively removed before infection occurs. However, if these mechanism are impaired, this can severely impair pulmonary clearance of aspirated bacteria and evolve to pneumonia requiring antimicrobial treatment.

• Pneumonia is caused by a variety of viral and bacterial pathogens. The causative organism(s) is highly dependent on how and/or where the pneumonia was contacted.
• Pneumonia is often categorized as:

1. Community-acquired pneumonia (CAP): Patients with pneumonia onset outside of the hospital or within 48 hours of hospital admission

2. Hospital-acquired pneumonia (HAP): Patients with pneumonia onset in the hospital after at least 48 hours of hospitalization.

3. Ventilator-associated pneumonia (VAP): Patients with pneumonia onset following 48 hours of endotracheal intubation

• Healthcare associated pneumonia was a classification that had been previously used to distinguish nonhospitalized patients at risk for MDR pathogens from those likely infected with traditional CAP pathogens; however, this has fallen out of use.
## Pneumonia Classifications and Risk Factors

<table>
<thead>
<tr>
<th>Type of Pneumonia</th>
<th>Definition</th>
<th>Risk Factors</th>
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</table>
| Community-acquired pneumonia (CAP)    | Pneumonia developing outside the hospital or ≤48 hours after hospital admission | • Age > 65 years  
• Diabetes mellitus  
• Asplenia  
• Chronic cardiovascular, pulmonary, renal, and/or liver disease  
• Smoking and/or alcohol abuse |
| Hospital-acquired pneumonia (HAP)     | Pneumonia developing >48 hours after hospital admission                     | • Witnessed aspiration  
• COPD, ARDS, or coma  
• Administration of antacids, H₂-antagonists, or proton pump inhibitor  
• Supine position  
• Enteral nutrition, nasogastric tube  
• Reintubation, tracheostomy, or patient transport  
• Head trauma, ICP monitoring  
• Age > 60 years  
• MDR risk (e.g., MRSA, MDR *Pseudomonas*) if IV antibiotic use within 90 days |
| Ventilator-associated pneumonia (VAP) | Pneumonia developing >48 hours after endotracheal intubation                | • Same as hospital acquired  
• MDR risk with IV antibiotics in past 90 days, septic shock, ARDS preceding VAP, acute renal replacement therapy preceding VAP, or 5+ days of hospitalization preceding VAP |
Community-Acquired Pneumonia

• The causative pathogen in CAP in adult patients is **most commonly viral**, with human **rhinovirus and influenza** most common. (up to 80% in those less than 2 years of age)

• The most prominent **bacterial pathogen** causing CAP in otherwise healthy adults is **S. pneumoniae** accounting for up to 35% (12%–68%) of all acute cases.

• It is particularly prevalent and severe for patients with splenic dysfunction, diabetes mellitus, chronic cardiopulmonary or renal disease, or HIV infection.

• Other common pathogens include the atypical pathogens **M. pneumoniae**, Legionella species, and **C.pneumoniae** (about 20%).

• Although generally less common, Staphylococcus aureus in children and adults and is often seen in patients with cystic fibrosis and those recovering from an antecedent viral respiratory infection such as influenza.

• Community-acquired pneumonia caused by enteric gram-negative bacteria, including **E. coli and K. pneumoniae**, is also uncommon but these pathogens are identified most frequently among patients with chronic illness, especially alcoholism and diabetes mellitus.
CLINICAL PRESENTATION AND DIAGNOSIS

• The common signs and symptoms are both constitutional (fever, chills, malaise) and respiratory (cough, increased sputum production, dyspnea).

• These signs and symptoms coupled with physical exam findings suggestive of a pulmonary infiltrate, with or without abnormal white blood cell (WBC) count or oxygen saturation, can form the basis of a presumed clinical diagnosis of pneumonia.

• The diagnosis of pneumonia is preferably further strengthened by radiographic evidence such as pulmonary infiltrate(s) on chest x-ray or other chest imaging.

• Following a pneumonia diagnosis based on clinical and radiographic evidence, further diagnostic testing to confirm the diagnosis and determine the etiology may be warranted.

• Confirmation of etiology is less common in CAP, where a microbiologically confirmed etiology is identified in only 7% of cases in clinical practice. As such, empiric treatment of CAP is often continued for the entire duration of therapy without ever determining the causative pathogen.
Clinical Presentation of Pneumonia

<table>
<thead>
<tr>
<th>Signs and symptoms</th>
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<tbody>
<tr>
<td>Abrupt onset of fever, chills, dyspnea, and productive cough</td>
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<tr>
<td>Rust-colored sputum or hemoptysis</td>
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<tr>
<td>Pleuritic chest pain</td>
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<td>Dyspnea</td>
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<tr>
<th>Physical examination</th>
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<tbody>
<tr>
<td>Tachypnea and tachycardia</td>
</tr>
<tr>
<td>Dullness to percussion</td>
</tr>
<tr>
<td>Increased tactile fremitus, whisper pectoriloquy, and egophony</td>
</tr>
<tr>
<td>Chest wall retractions and grunting respirations</td>
</tr>
<tr>
<td>Diminished breath sounds over affected area</td>
</tr>
<tr>
<td>Inspiratory crackles during lung expansion</td>
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<tr>
<th>Chest radiograph</th>
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<tr>
<td>Dense lobar or segmental infiltrate</td>
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<th>Laboratory tests</th>
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<tr>
<td>Leukocytosis with predominance of polymorphonuclear cells</td>
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<tr>
<td>Low oxygen saturation on arterial blood gas or pulse oximetry</td>
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</table>
TREATMENT

• Treatment Goals

• Eradication of the offending organism through selection of the appropriate antibiotic(s) and subsequent complete clinical cure is the primary goal of therapy of pneumonia.

• Secondary goals include minimization of the unintended consequences of therapy, including toxicities and selection for secondary infections such as *Clostridioides difficile* or antibiotic-resistant pathogens, and minimizing costs through outpatient and oral therapy when the patient's severity of illness and clinical considerations permit.

• The new guideline focuses on adults who do not have an immunocompromising condition, such as inherited or acquired immune deficiency or drug-induced neutropenia, including patients actively receiving cancer chemotherapy, patients infected with HIV with suppressed CD4 counts, and solid organ or bone marrow transplant recipients.
<table>
<thead>
<tr>
<th>Recommendation</th>
<th>2007 ATS/IDSA Guideline</th>
<th>2019 ATS/IDSA Guideline</th>
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<tbody>
<tr>
<td>Sputum culture</td>
<td>Primarily recommended in patients with severe disease</td>
<td>Now recommended in patients with severe disease as well as in all inpatients empirically treated for MRSA or <em>Pseudomonas aeruginosa</em></td>
</tr>
<tr>
<td>Blood culture</td>
<td>Primarily recommended in patients with severe disease</td>
<td>Now recommended in patients with severe disease as well as in all inpatients empirically treated for MRSA or <em>P. aeruginosa</em></td>
</tr>
<tr>
<td>Macrolide monotherapy</td>
<td>Strong recommendation for outpatients</td>
<td>Conditional recommendation for outpatients based on resistance levels</td>
</tr>
<tr>
<td>Use of procalcitonin</td>
<td>Not covered</td>
<td>Not recommended to determine need for initial antibacterial therapy</td>
</tr>
<tr>
<td>Use of corticosteroids</td>
<td>Not covered</td>
<td>Recommended not to use. May be considered in patients with refractory septic shock</td>
</tr>
<tr>
<td>Use of healthcare-associated pneumonia category</td>
<td>Accepted as introduced in the 2005 ATS/IDSA hospital-acquired and ventilator-associated pneumonia guidelines</td>
<td>Recommend abandoning this categorization. Emphasis on local epidemiology and validated risk factors to determine need for MRSA or <em>P. aeruginosa</em> coverage. Increased emphasis on deescalation of treatment if cultures are negative</td>
</tr>
<tr>
<td>Standard empiric therapy for severe CAP</td>
<td>β-Lactam/macrolide and β-lactam/fluoroquinolone combinations given equal weighting</td>
<td>Both accepted but stronger evidence in favor of β-lactam/macrolide combination</td>
</tr>
<tr>
<td>Routine use of follow-up chest imaging</td>
<td>Not addressed</td>
<td>Recommended not to obtain. Patients may be eligible for lung cancer screening, which should be performed as clinically indicated</td>
</tr>
</tbody>
</table>

*Definition of abbreviations: ATS = American Thoracic Society; CAP = community-acquired pneumonia; IDSA = Infectious Diseases Society of America; MRSA = methicillin-resistant *Staphylococcus aureus*. 
Determine Inpatient versus Outpatient Treatment Location for Adults with CAP

Recommendation. In addition to clinical judgement, we recommend that clinicians use a validated clinical prediction rule for prognosis, preferentially the Pneumonia Severity Index (PSI) over the CURB-65 to determine the need for hospitalization in adults diagnosed with CAP.

- Both the PSI and CURB-65 were developed as prognostic models in immunocompetent patients with pneumonia, using patient demographic and clinical variables from the time of diagnosis to predict 30-day mortality.

- When compared with CURB-65, PSI identifies larger proportions of patients as low risk and has a higher discriminative power in predicting mortality.

- When used as a decision aid, the PSI should be used in conjunction with clinical judgment.
Pneumonia Severity Index (PSI)

Demographics
- Age (1 point per year)
  - Male Yr
  - Female Yr -10
- Nursing home residency +10

Co-morbidities
- Neoplasia +30
- Liver disease +20
- CHF +10
- Cerebrovascular disease +10
- Renal disease +10

Physical exam / vital signs
- Mental confusion +20
- Respiratory rate +20
- SBP +20
- Temperature +15
- Tachycardia +15

Laboratory / imaging
- Arterial pH +30
- BUN +20
- Sodium +20
- Glucose +10
- Hematocrit +10
- Pleural effusion +10
- Oxygenation +10

Recommendation based on clinical judgement too

<table>
<thead>
<tr>
<th>Risk class (Points)</th>
<th>Mortality (%)</th>
<th>Recommended site of care</th>
</tr>
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<tbody>
<tr>
<td>I (&lt;50)</td>
<td>0.1</td>
<td>Outpatient</td>
</tr>
<tr>
<td>II (51–70)</td>
<td>0.6</td>
<td>Outpatient</td>
</tr>
<tr>
<td>III (71–90)</td>
<td>2.8</td>
<td>Outpatient or brief inpatient</td>
</tr>
<tr>
<td>IV (91–130)</td>
<td>8.2</td>
<td>Inpatient</td>
</tr>
<tr>
<td>V (&gt;130)</td>
<td>29.2</td>
<td>Inpatient</td>
</tr>
</tbody>
</table>
Determine Inpatient General Medical versus Higher Levels of Inpatient Treatment Intensity

**Recommendation.** We recommend direct admission to an ICU for patients with hypotension requiring vasopressors or respiratory failure requiring mechanical ventilation.

For patients not requiring vasopressors or mechanical ventilator support, we suggest using the IDSA/ATS 2007 minor severity criteria together with clinical judgment to guide the need for higher levels of treatment intensity.

- The 2007 IDSA/ATS CAP guidelines recommended a set of two major and nine minor criteria to define severe pneumonia requiring ICU admission.
IDSA-ATS Guidelines
Clinical Infectious Diseases 2007; 44:S27–72

Minor criteria
- Respiratory rate ≥ 30 breaths/min
- \( \text{PaO}_2/\text{FiO}_2 \) ratio < 250
- CXR: Multilobar infiltrates
- Confusion/disorientation
- BUN > 20 mg/dL
- Leukopenia (WBC < 4000)
- Thrombocytopenia (platelet < 100,000)
- Hypothermia (core temperature < 36 °C)
- Hypotension (SBP < 90 mmHg) requiring aggressive fluid resuscitation

Major criteria
- Invasive mechanical ventilation
- Septic shock with the need for vasopressors
Empiric Treatment of CAP in Adults (Outpatient)

Recommendation.

1. For healthy outpatient adults without comorbidities (chronic heart, lung, liver, or renal disease; diabetes mellitus; alcoholism; malignancy; or asplenia) or risk factors for antibiotic resistant pathogens, we recommend:

   • amoxicillin 1 g three times daily, or
   • doxycycline 100 mg twice daily, or
   • a macrolide (azithromycin 500 mg on first day then 250 mg daily or clarithromycin 500 mg twice daily or clarithromycin extended release 1,000 mg daily) only in areas with pneumococcal resistance to macrolides <25%
Empiric Treatment of CAP in Adults (outpatient)

Recommendation.

2. For outpatient adults with comorbidities such as chronic heart, lung, liver, or renal disease; diabetes mellitus; alcoholism; malignancy; or asplenia we recommend:
   - Combination therapy:
     - amoxicillin/clavulanate 500 mg/125 mg TID, or
     - amoxicillin/clavulanate 875 mg/125 mg BID, or
     - amoxicillin/clavulanate 2,000 mg/125 mg BID, or
     - cefpodoxime 200 mg twice daily, or
     - cefuroxime 500 mg twice daily

   • or

   • Monotherapy: respiratory fluoroquinolone (levofloxacin 750 mg daily, moxifloxacin 400 mg daily, or gemifloxacin 320 mg daily)

   +

   • azithromycin 500 mg on first day then 250 mg daily,
   • clarithromycin 500 mg twice daily or extended release 1,000 mg once daily,
   • doxycycline 100 mg twice daily;
| No comorbidities or risk factors for MRSA or *Pseudomonas aeruginosa* | Amoxicillin or doxycycline or macrolide (if local pneumococcal resistance is $<25\%$)† |
| With comorbidities‡ | Combination therapy with amoxicillin/clavulanate or cephalosporin AND macrolide or doxycycline§ OR monotherapy with respiratory fluoroquinolone‖ |

*Definition of abbreviations: ER = extended release; MRSA = methicillin-resistant *Staphylococcus aureus*.  
*Risk factors include prior respiratory isolation of MRSA or *P. aeruginosa* or recent hospitalization AND receipt of parenteral antibiotics (in the last 90 d).  
†Amoxicillin 1 g three times daily, doxycycline 100 mg twice daily, azithromycin 500 mg on first day then 250 mg daily, clarithromycin 500 mg twice daily, or clarithromycin ER 1,000 mg daily.  
‡Comorbidities include chronic heart, lung, liver, or renal disease; diabetes mellitus; alcoholism; malignancy; or asplenia.  
§Amoxicillin/clavulanate 500 mg/125 mg three times daily, amoxicillin/clavulanate 875 mg/125 mg twice daily, 2,000 mg/125 mg twice daily, cefpodoxime 200 mg twice daily, or cefuroxime 500 mg twice daily; AND azithromycin 500 mg on first day then 250 mg daily, clarithromycin 500 mg twice daily, clarithromycin ER 1,000 mg daily, or doxycycline 100 mg twice daily.  
‖Levofoxacin 750 mg daily, moxifloxacin 400 mg daily, or gemifloxacin 320 mg daily.
Empiric Treatment of CAP in Adults (Inpatient)

Recommendation.

1. In inpatient adults with nonsevere CAP without risk factors for MRSA or P. aeruginosa we recommend the following empiric treatment regimens:

   • Combination therapy with a b-lactam and a macrolide (or doxycycline)
   
     | Ampicillin/sulbactam 1.5–3 g QID, | azithromycin 500 mg daily |
     | cefotaxime 1–2 g every 8 h,     | clarithromycin 500 mg twice daily |
     | ceftriaxone 1–2 g daily,        | doxycycline 100 mg twice daily   |
     | ceftaroline 600 mg every 12 h   | (for adults with CAP who have contraindications to both macrolides and fluoroquinolones) |

   • Or

   • Monotherapy with a respiratory fluoroquinolone (levofloxacin 750 mg daily, moxifloxacin 400 mg daily)
Empiric Treatment of CAP in Adults (Inpatient)

Recommendation.

2. In inpatient adults with severe CAP without risk factors for MRSA or P. aeruginosa, we recommend:

- a b-lactam plus a macrolide
- Or
- a b-lactam plus a respiratory fluoroquinolone
# Empiric Treatment of CAP in Adults (Inpatient)

<table>
<thead>
<tr>
<th>Standard Regimen</th>
<th>Prior Respiratory Isolation of MRSA</th>
<th>Prior Respiratory Isolation of <em>Pseudomonas aeruginosa</em></th>
<th>Recent Hospitalization and Parenteral Antibiotics and Locally Validated Risk Factors for MRSA</th>
<th>Recent Hospitalization and Parenteral Antibiotics and Locally Validated Risk Factors for <em>P. aeruginosa</em></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nonsevere inpatient pneumonia</strong>&lt;sup&gt;†&lt;/sup&gt;&lt;br&gt;β-Lactam + macrolide&lt;sup&gt;‡&lt;/sup&gt; or respiratory fluoroquinolone&lt;sup&gt;‡&lt;/sup&gt;</td>
<td>Add MRSA coverage&lt;sup&gt;§&lt;/sup&gt; and obtain cultures/nasal PCR to allow deescalation or confirmation of need for continued therapy</td>
<td>Add coverage for <em>P. aeruginosa</em>&lt;sup&gt;†&lt;/sup&gt; and obtain cultures to allow deescalation or confirmation of need for continued therapy</td>
<td>Obtain cultures but withhold MRSA coverage unless culture results are positive. If rapid nasal PCR is available, withhold additional empiric therapy against MRSA if rapid testing is negative or add coverage if PCR is positive and obtain cultures</td>
<td>Obtain cultures but initiate coverage for <em>P. aeruginosa</em> only if culture results are positive</td>
</tr>
<tr>
<td><strong>Severe inpatient pneumonia</strong>&lt;sup&gt;†&lt;/sup&gt;&lt;br&gt;β-Lactam + macrolide† or β-lactam + fluoroquinolone&lt;sup&gt;‡&lt;/sup&gt;</td>
<td>Add MRSA coverage&lt;sup&gt;§&lt;/sup&gt; and obtain cultures/nasal PCR to allow deescalation or confirmation of need for continued therapy</td>
<td>Add coverage for <em>P. aeruginosa</em>&lt;sup&gt;†&lt;/sup&gt; and obtain cultures to allow deescalation or confirmation of need for continued therapy</td>
<td>Add MRSA coverage&lt;sup&gt;§&lt;/sup&gt; and obtain nasal PCR and cultures to allow deescalation or confirmation of need for continued therapy</td>
<td>Add coverage for <em>P. aeruginosa</em>&lt;sup&gt;‖&lt;/sup&gt; and obtain cultures to allow deescalation or confirmation of need for continued therapy</td>
</tr>
</tbody>
</table>

**Definition of abbreviations:** ATS = American Thoracic Society; CAP = community-acquired pneumonia; HAP = hospital-acquired pneumonia; IDSA = Infectious Diseases Society of America; MRSA = methicillin-resistant *Staphylococcus aureus*; VAP = ventilator-associated pneumonia.

<sup><sup>†</sup></sup>As defined by 2007 ATS/IDSA CAP severity criteria guidelines (see Table 1).

<sup><sup>‡</sup></sup>Amoxicillin + sulbactam 1.5–3 g every 6 hours, cefotaxime 1–2 g every 8 hours, ceftriaxone 1–2 g daily, or ceftazidime 600 mg every 12 hours AND azithromycin 500 mg daily or clarithromycin 500 mg twice daily.

<sup><sup>§</sup></sup>Levofoxacin 750 mg daily or moxifloxacin 400 mg daily.

<sup><sup>‖</sup></sup>Per the 2016 ATS/IDSA HAP/VAP guidelines: vancomycin (15 mg/kg every 12 h, adjust based on levels) or linezolid (600 mg every 12 h).

<sup><sup>‖</sup></sup>Per the 2016 ATS/IDSA HAP/VAP guidelines: piperacillin-tazobactam (4.5 g every 6 h), cefepime (2 g every 8 h), ceftazidime (2 g every 8 h), imipenem (500 mg every 6 h), meropenem (1 g every 8 h), or aztreonam (2 g every 8 h). Does not include coverage for extended-spectrum β-lactamase–producing Enterobacteriaceae, which should be considered only on the basis of patient or local microbiological data.
Use of Corticosteroids

Recommendation.

1. **We recommend not** routinely using corticosteroids in adults with nonsevere CAP.

2. **We suggest not** routinely using corticosteroids in adults with severe CAP.

3. **We suggest not** routinely using corticosteroids in adults with severe influenza pneumonia.

4. **We endorse the Surviving Sepsis Campaign recommendations on the use of corticosteroids in patients with CAP and refractory septic shock.**
Viral CAP (Test Positive for Influenza)

Recommendation.

1. We **recommend** that antiinfluenza treatment, such as oseltamivir, be prescribed for adults with CAP who test positive for influenza in the **inpatient** setting, independent of duration of illness before diagnosis.

2. We **suggest** that antiinfluenza treatment be prescribed for adults with CAP who test positive for influenza in the **outpatient** setting, independent of duration of illness before diagnosis.

3. We **recommend** that standard antibacterial treatment be initially prescribed for adults with clinical and radiographic evidence of CAP who test positive for influenza in the inpatient and outpatient settings.
Duration of treatment in CAP (Outpatient)

Recommendation.

We recommend that the duration of antibiotic therapy should be guided by a validated measure of clinical stability (resolution of vital sign abnormalities [heart rate, respiratory rate, blood pressure, oxygen saturation, and temperature], ability to eat, and normal mentation), and antibiotic therapy should be continued until the patient achieves stability and for no less than a total of 5 days.

- A small number of randomized trials address the appropriate duration of antibiotic therapy in CAP, and randomized placebo-controlled trials of high quality are mostly limited to the inpatient setting.

- Failure to achieve clinical stability within 5 days is associated with higher mortality and worse clinical outcomes. Such failure should prompt assessment for a pathogen resistant to the current therapy and/or complications of pneumonia (e.g., empyema or lung abscess) or for an alternative source of infection and/or inflammatory response.
Antimicrobial Pharmacokinetic/Pharmacodynamic Considerations

• Antimicrobial pharmacokinetics/pharmacodynamics (PK/PD) is an important aspect of optimal antimicrobial therapy for pneumonia.

• Antibiotic concentrations in respiratory secretions in excess of the pathogen MIC are necessary for successful treatment of pulmonary infections.

• Thus, ability of an antimicrobial to penetrate into pulmonary secretions is important and must be factored into antimicrobial selection and dosing for pneumonia.

• The ability of a drug to penetrate respiratory secretions depends on multiple physicochemical factors, including molecular size, lipid solubility, and degree of ionization at serum and biologic fluid pH and the extent of protein binding.

• Studies evaluating antibiotic concentrations in the pulmonary epithelial lining fluid (ELF) indicate that β-lactams, glycopeptide, and aminoglycosides tend to have ELF to plasma antibiotic concentration ratios less than 1.

• In contrast, macrolides, fluoroquinolones, and linezolid tend to have ELF to plasma antibiotic concentration ratios much greater than 1. Thus, the latter agents penetrate and concentrate into the ELF to a greater extent.
PATIENT MONITORING

• After therapy has been instituted, appropriate clinical parameters should be monitored to ensure the efficacy and safety of the therapeutic regimen.

• For patients with pneumonia of mild to moderate clinical severity, the time to resolution of cough, decreasing sputum production, and fever, as well as other constitutional symptoms of malaise, nausea, vomiting, and lethargy, should be noted.

• If the patient requires supplemental oxygen therapy, the amount and need should be assessed regularly.

• A gradual and persistent improvement in the resolution of these symptoms and therapies should be observed. Initial resolution of infection should be observed within the first 2 days of therapy and progression to complete resolution within 5 to 7 days (usually no more than 10 days).

• The majority of hospitalized patients with CAP should be switched from IV to oral therapy when hemodynamically stable, improving clinically as described above, have normal gastrointestinal tract function, and be able to ingest oral medications.
**Prevention of Pneumonia**

- Prevention of some cases of pneumonia is possible through the use of vaccines and medications against selected infectious agents.

- Polyvalent polysaccharide vaccines are available for two of the leading causes of bacterial pneumonia, *S. pneumoniae* and *H. influenzae type b*.

- Children should be vaccinated against *S. pneumoniae*, *H. influenzae type b*, pertussis, and influenza while caregivers for infants less than 6 months should also be vaccinated against influenza and pertussis.

- Immune prophylaxis for RSV is only recommended for high-risk infants during RSV season.

- To minimize the risk of developing VAP, healthcare providers should seek to minimize colonization of the aerodigestive tract, prevent aspiration (head raised 45 degrees), and limit the length of mechanical ventilation.
Thank you