

# Pharmacotherapy 2

## Lower Respiratory Tract Infections

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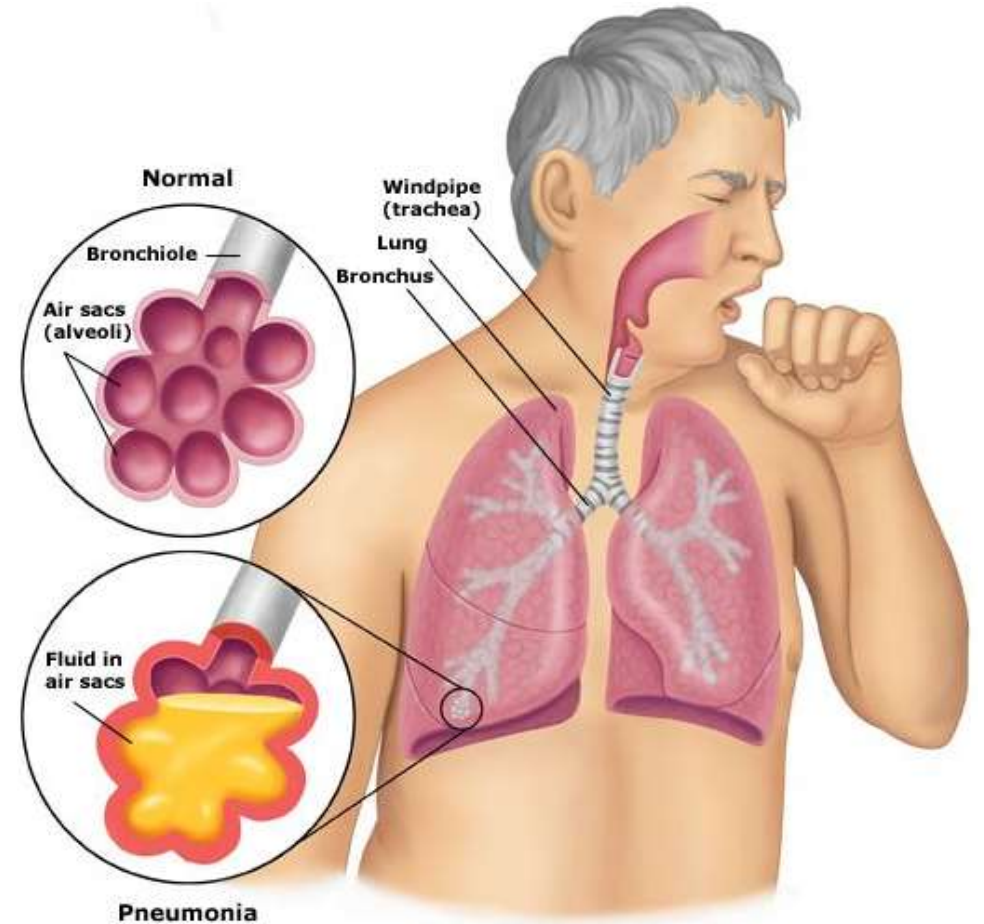
# Community-Acquired Pneumonia (CAP)

## General Principles

- ✓ Predominant organism: *S. pneumoniae*; other bacterial etiologies: *H. influenzae* & *M. catarrhalis*.
- ✓ In Jordan, *S. pneumoniae* and atypical microorganisms are the most common cause of CAP in previously healthy adults; while in those with associated co morbid illness, gram negative organisms are the likely cause. In children, atypical microorganisms are the most common.

*Ref: Al-Ali MK, Batchoun RG, Al-Nour TM. Etiology of community-acquired pneumonia in hospitalized patients in Jordan. Saudi Med J. 2006 Jun;27(6):813-6. PMID: 16758041.*

- ✓ According to the latest WHO data published in 2018 Influenza and Pneumonia Deaths in Jordan reached 1,253 or 3.78% of total deaths.



- ✓ Pneumonia caused by atypical agents, such as *Legionella pneumophila*, *C. pneumoniae*, or *M. pneumoniae*, cannot be reliably distinguished clinically.
- ✓ Community-acquired MRSA is an important cause of severe, necrotizing pneumonia.
- ✓ Patients aged 65 or older, and those with certain medical conditions, should receive the pneumococcal vaccination.
- ✓ Influenza and other respiratory viruses may also cause pneumonia in adults.

**TABLE 125-5   Pneumonia Classifications and Risk Factors**

| Type of Pneumonia                     | Definition                                                                      | Risk Factors                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|---------------------------------------|---------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Community-acquired pneumonia (CAP)    | Pneumonia developing outside the hospital or <48 hours after hospital admission | <ul style="list-style-type: none"><li>• Age &gt;65 years</li><li>• Diabetes mellitus</li><li>• Asplenia</li><li>• Chronic cardiovascular, pulmonary, renal, and/or liver disease</li><li>• Smoking and/or alcohol abuse</li></ul>                                                                                                                                                                                                                                                            |
| Hospital-acquired pneumonia (HAP)     | Pneumonia developing >48 hours after hospital admission                         | <ul style="list-style-type: none"><li>• Witnessed aspiration</li><li>• COPD, ARDS, or coma</li><li>• Administration of antacids, H<sub>2</sub>-antagonists, or proton pump inhibitor</li><li>• Supine position</li><li>• Enteral nutrition, nasogastric tube</li><li>• Reintubation, tracheostomy, or patient transport</li><li>• Head trauma, ICP monitoring</li><li>• Age &gt;60 years</li><li>• MDR risk (eg, MRSA, MDR <i>Pseudomonas</i>) if IV antibiotic use within 90 days</li></ul> |
| Ventilator-associated pneumonia (VAP) | Pneumonia developing >48 hours after endotracheal intubation                    | <ul style="list-style-type: none"><li>• Same as hospital acquired</li><li>• 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</li></ul>                                                                                                                                                                                                                            |

ARDS, acute respiratory distress syndrome; CAP, community-acquired pneumonia; COPD, chronic obstructive pulmonary disease; HAP, hospital-acquired pneumonia; ICP, intracranial pressure; MDR, multidrug-resistant; MRSA, methicillin-resistant *S. aureus*; VAP, ventilator-associated pneumonia.

## Diagnosis

### ✓ Clinical Presentation:

- The presentation of CAP is extremely variable.
- Fever and respiratory symptoms, including cough with sputum production, dyspnea, and pleuritic chest pain, are common in immunocompetent patients.
- Signs include tachypnea, rales, or evidence of consolidation on auscultation.
- CAP presents acutely, over a matter of hours to days.
- The clinical manifestations are most severe in the very young, the elderly & the chronically ill.



## **TABLE 125-7   Clinical Presentation of Pneumonia**

### **Signs and symptoms**

- Abrupt onset of fever, chills, dyspnea, and productive cough
- Rust-colored sputum or hemoptysis
- Pleuritic chest pain
- Dyspnea

### **Physical examination**

- Tachypnea and tachycardia
- Dullness to percussion
- Increased tactile fremitus, whisper pectoriloquy, and egophony
- Chest wall retractions and grunting respirations
- Diminished breath sounds over affected area
- Inspiratory crackles during lung expansion

### **Chest radiograph**

- Dense lobar or segmental infiltrate

### **Laboratory tests**

- Leukocytosis with predominance of polymorphonuclear cells
- Low oxygen saturation on arterial blood gas or pulse oximetry

## ✓ Diagnostic Testing:

- Sputum Gram stain and culture of an adequate sputum sample and blood cultures before antibiotic therapy should be obtained in all patients who are going to be hospitalized, and, if disease is severe.
- Urinary antigen tests for *S. pneumoniae* and *L. pneumophila*
- Nasopharyngeal swab for influenza or other virus detection by PCR, and respiratory samples for atypical pathogens should be sent in selected cases.
- Chest radiography should be performed.

## Treatment

- ✓ All patients should be assessed for hospitalization & evaluated for comorbid factors, oxygenation & severity of illness using validated severity scales as the Pneumonia Severity Index or CURB-65.
- ✓ For CURB-65, patients receive 1 point for each criterion present: **C**onfusion, **U**remia (BUN > 20 mg/dL [7.1 mmol/L]), **R**espiratory rate  $\geq 30$  breaths/min, **B**lood pressure (systolic < 90 mm Hg, diastolic  $\leq 60$  mm Hg), age  $\geq 65$  years.
- ✓ Patients with CURB-65 or CRB-65 scores < 2 are generally candidates for outpatient treatment.
- ✓ Patients with a score of 2 are typically admitted to the general ward of the hospital with ICU admission considered for patients with scores  $\geq 3$ .
- ✓ Empiric treatment regimens target the most likely pathogens within specific risk groups.
- ✓ Antibiotics should be given as soon as CAP is diagnosed, ideally within 4 hours of arrival to the hospital, as delays lead to higher mortality.



- ✓ Antibiotic therapy should be narrowed once a specific microbiologic etiology has been identified.
- ✓ Immunocompetent outpatients with no recent antibiotic exposure and no comorbidities should receive a macrolide, such as azithromycin 500 mg PO single dose followed by 250 mg PO every day for 4 more days, or doxycycline 100 mg every 12h for at least 5 days.
- ✓ Outpatients with recent antibiotic exposure or comorbidities should receive respiratory fluoroquinolone (e.g., moxifloxacin) monotherapy or a macrolide (azithromycin or clarithromycin) with high-dose amoxicillin 1 g PO every 8h for at least 5 days.
- ✓ Hospitalized patients should be treated with ceftriaxone 1 g IV every day or cefotaxime 1 g IV every 8h PLUS a macrolide (azithromycin or clarithromycin), OR monotherapy with a respiratory fluoroquinolone.
- ✓
- ✓ Duration of therapy should be at least 5 days for low severity pneumonia, provided that the patient has been afebrile for > 48 hours and has demonstrated clinical improvement.
- ✓ For severe pneumonia, duration of therapy is 7 days (longer courses may be indicated)

- ✓ In critically ill patients, the addition of azithromycin or a respiratory fluoroquinolone to a  $\beta$ -lactam (ceftriaxone, cefotaxime, ampicillin-sulbactam) is necessary to provide coverage for *L. pneumophila*.
- ✓ MRSA coverage with vancomycin or linezolid should also be considered.
- ✓ If *P. aeruginosa* is a concern, an antipseudomonal  $\beta$ -lactam (cefepime, piperacillin-tazobactam, meropenem, imipenem) in combination with an antipseudomonal fluoroquinolone (ciprofloxacin, levofloxacin) is recommended.
- ✓ Once *Pseudomonas* has been isolated and antibiotic susceptibilities are available, monotherapy is an option.

**TABLE 125-8 Evidence-Based Empirical Antimicrobial Therapy for Pneumonia in Adults<sup>a</sup>**

| Clinical Setting and/or Patient Characteristics                                                                                                                             | Usual Pathogens                                                                                                                                    | Empirical Therapy                                                                                                                                                                                |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Outpatient/Community-Acquired</b>                                                                                                                                        |                                                                                                                                                    |                                                                                                                                                                                                  |
| No at-risk comorbidity (diabetes, heart/lung/liver/renal disease, alcoholism, malignancy, asplenia) AND no antimicrobial use in past 3 months                               | <i>S. pneumoniae</i> , <i>M. pneumoniae</i> ,<br><i>H. influenzae</i> , <i>C. pneumoniae</i> , <i>M. catarrhalis</i>                               | Macrolide <sup>b</sup> OR doxycycline                                                                                                                                                            |
| At-risk comorbidity (diabetes, heart/lung/liver/renal disease, alcoholism, malignancy, asplenia) OR immunosuppressive condition/drugs OR antimicrobial use in past 3 months | <i>S. pneumoniae</i> (including drug-resistant),<br><i>M. pneumoniae</i> , <i>H. influenzae</i> ,<br><i>C. pneumoniae</i> , <i>M. catarrhalis</i>  | Antipneumococcal fluoroquinolone <sup>c</sup> OR $\beta$ -lactam <sup>d</sup> +<br>EITHER macrolide <sup>b</sup> OR doxycycline                                                                  |
| Regions with more than 25% rate of macrolide-resistant <i>S. pneumoniae</i>                                                                                                 | <i>S. pneumoniae</i> (including drug-resistant),<br><i>M. pneumoniae</i> , <i>H. influenzae</i> ,<br><i>C. pneumoniae</i> , <i>M. catarrhalis</i>  | Antipneumococcal fluoroquinolone <sup>c</sup> OR $\beta$ -lactam <sup>d</sup> +<br>EITHER macrolide <sup>b</sup> OR doxycycline                                                                  |
| <b>Inpatient/Community-Acquired</b>                                                                                                                                         |                                                                                                                                                    |                                                                                                                                                                                                  |
| Non-ICU                                                                                                                                                                     | <i>S. pneumoniae</i> (including drug-resistant),<br><i>H. influenzae</i> , <i>M. pneumoniae</i> ,<br><i>C. pneumoniae</i> , <i>Legionella</i> spp. | Antipneumococcal fluoroquinolone <sup>c</sup> OR $\beta$ -lactam <sup>e</sup> +<br>EITHER macrolide <sup>b</sup> OR doxycycline                                                                  |
| ICU                                                                                                                                                                         | <i>S. pneumoniae</i> (including drug-resistant),<br><i>S. aureus</i> , <i>Legionella</i> spp., gram-negative<br>bacilli, <i>H. influenzae</i>      | $\beta$ -lactam <sup>e</sup> + EITHER azithromycin OR Antipneumococcal<br>fluoroquinolone <sup>c</sup>                                                                                           |
|                                                                                                                                                                             | If MRSA suspected                                                                                                                                  | Add vancomycin or linezolid to above regimen                                                                                                                                                     |
|                                                                                                                                                                             | If <i>P. aeruginosa</i> suspected                                                                                                                  | Antipseudomonal, antipneumococcal $\beta$ -lactam <sup>f</sup><br>+ EITHER (1) ciprofloxacin OR (2) levofloxacin OR<br>(3) aminoglycoside + azithromycin OR<br>(4) aminoglycoside + moxifloxacin |
|                                                                                                                                                                             | If influenza suspected                                                                                                                             | Add oral oseltamivir or intravenous peramivir (when oral<br>medications not possible)                                                                                                            |

## Table 125- 8

**b**: Macrolide: erythromycin, clarithromycin, and azithromycin.

**c**: Antipneumococcal fluoroquinolone: levofloxacin and moxifloxacin.

**d**: Infectious Diseases Society of America recommended outpatient  $\beta$ -lactams: high-dose amoxicillin or amoxicillin/clavulanate preferred, cefpodoxime, cefuroxime, ceftriaxone (IM) alternatives.

**e**: Infectious Diseases Society of America recommended inpatient  $\beta$ -lactams: ceftriaxone (IV), cefotaxime, ampicillin.

**f**: Infectious Diseases Society of America recommended antipneumococcal, antipseudomonal  $\beta$ -lactams: piperacillin/tazobactam, cefepime, meropenem, imipenem..



**TABLE 125-9 Empirical Antimicrobial Therapy for Pneumonia in Pediatric Patients<sup>a</sup>**

| Clinical Setting and/or Patient Characteristics                                                                      | Usual Pathogen(s)                                                                                                                                                   | Empirical Therapy                                                                                                                                 |
|----------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Outpatient/Community-Acquired</b>                                                                                 |                                                                                                                                                                     |                                                                                                                                                   |
| <1 month                                                                                                             | Group B <i>Streptococcus</i> , <i>H. influenzae</i> (nontypable),<br><i>E. coli</i> , <i>S. aureus</i> , <i>Listeria</i> CMV, RSV, adenovirus                       | Ampicillin-sulbactam, cephalosporin, <sup>b</sup><br>carbapenem <sup>c</sup><br>Ribavirin for RSV <sup>d</sup>                                    |
| 1–3 months                                                                                                           | <i>C. pneumoniae</i> , possibly <i>Ureaplasma</i> , CMV,<br><i>Pneumocystis carinii</i> (afebrile pneumonia<br>syndrome)<br><i>S. pneumoniae</i> , <i>S. aureus</i> | Macrolide/azalide, <sup>e</sup><br>trimethoprim-sulfamethoxazole<br>Semisynthetic penicillin <sup>f</sup> OR cephalosporin <sup>g</sup>           |
| Preschool-aged children                                                                                              | Viral (rhinovirus, RSV, influenza A and B,<br>parainfluenzae, adenovirus, human<br>metapneumovirus, coronavirus)                                                    | Antimicrobial therapy not routinely required                                                                                                      |
| Previously healthy, fully immunized infants and<br>preschool children with suspected mild–<br>moderate bacterial CAP | <i>S. pneumoniae</i><br><i>M. pneumoniae</i> , other atypical                                                                                                       | Amoxicillin, cephalosporin <sup>b,g</sup><br>Macrolide/azalide or fluoroquinolone                                                                 |
| Previously healthy, fully immunized school-aged<br>children and adolescents with mild–moderate<br>CAP                | <i>S. pneumoniae</i><br><i>M. pneumoniae</i> , other atypical                                                                                                       | Amoxicillin, cephalosporin, <sup>b,g</sup> or fluoroquinolone<br>Macrolide/azalide, fluoroquinolone, or<br>tetracycline                           |
| Moderate–severe CAP during influenza virus<br>outbreak                                                               | Influenza A and B, other viruses                                                                                                                                    | Oseltamivir or zanamivir                                                                                                                          |
| <b>Inpatient/Community-Acquired</b>                                                                                  |                                                                                                                                                                     |                                                                                                                                                   |
| Fully immunized infants and school-aged children                                                                     | <i>S. pneumoniae</i><br>CA-MRSA<br><i>M. pneumoniae</i> , <i>C. pneumoniae</i>                                                                                      | Ampicillin, penicillin G, cephalosporin <sup>b</sup><br>β-Lactam + vancomycin/clindamycin<br>β-Lactam + macrolide/fluoroquinolone/<br>doxycycline |

Table 125-9 continued

|                                                                                                                                                      |                                                                                                 |                                                                                                                                              |
|------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|
| Not fully immunized infants and children; regions with invasive penicillin-resistant pneumococcal strains; patients with life-threatening infections | <i>S. pneumoniae</i> , PCN-resistant<br>MRSA<br><i>M. pneumoniae</i> , other atypical pathogens | Cephalosporin <sup>b</sup><br>Add vancomycin/clindamycin<br>Macrolide/azalide <sup>e</sup> + $\beta$ -lactam/doxycycline/<br>fluoroquinolone |
|------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|

**a** See the section Selection of Antimicrobial Agents.

**b** Third-generation cephalosporin: ceftriaxone and cefotaxime. Note that cephalosporins are not active against *Listeria*.

**c** Carbapenem: imipenem–cilastatin and meropenem.

**d** See text for details regarding possible ribavirin treatment for RSV infection.

**e** Macrolide/azalide: erythromycin and clarithromycin/azithromycin.

**f** Semisynthetic penicillin: nafcillin and oxacillin.

**g** Second-generation cephalosporin: cefuroxime and cefprozil.

CAP, community-acquired pneumonia; CMV, cytomegalovirus; MRSA, methicillin resistant *Staphylococcus aureus*; RSV, respiratory syncytial virus.

Data from Reference 5



**TABLE 125-10 Antibiotic Doses for Treatment of Bacterial Pneumonia**

| Antibiotic Class                 | Antibiotic                             | Antibiotic Dose <sup>a</sup>                                                      |                                                                                |
|----------------------------------|----------------------------------------|-----------------------------------------------------------------------------------|--------------------------------------------------------------------------------|
|                                  |                                        | Pediatric                                                                         | Usual Adult Dose                                                               |
| Penicillin                       | Ampicillin ± sulbactam                 | 150–200 mg/kg/day IV                                                              | 2 g IV every 4–6 h (6 h if ampicillin/sulbactam)                               |
|                                  | Amoxicillin ± clavulanate <sup>b</sup> | 45–100 mg/kg/day orally                                                           | 875–2,000 mg orally twice daily                                                |
|                                  | Piperacillin-tazobactam                | 200–300 mg/kg/day IV                                                              | 3.375–4.5 g IV every 6–8 h                                                     |
|                                  | Penicillin                             | 100,000–250,000 units/kg/day IV                                                   | 12–24 million units/day in divided doses IV every 4–6 h                        |
| Extended-spectrum cephalosporins | Ceftriaxone                            | 50–75 mg/kg/day IV                                                                | 1–2 g IV daily                                                                 |
|                                  | Cefotaxime                             | 150 mg/kg/day IV                                                                  | 1–2 g IV every 8 h                                                             |
|                                  | Ceftazidime                            | 90–150 mg/kg/day IV                                                               | 1–2 g IV every 8 h                                                             |
|                                  | Cefepime                               | 100–150 mg/kg/day IV                                                              | 1–2 g IV every 6–8 h                                                           |
|                                  | Ceftolozane-tazobactam                 | –                                                                                 | 3 g IV every 8 h                                                               |
|                                  | Ceftazidime-avibactam                  | –                                                                                 | 2.5 g IV every 8 h                                                             |
| Monobactam                       | Aztreonam                              | 90–120 mg/kg/day IV                                                               | 1–2 g IV every 8 h                                                             |
| Macrolide/azalide                | Clarithromycin                         | 15 orally mg/kg/day                                                               | 0.5–1 g orally once or twice daily                                             |
|                                  | Erythromycin                           | 30–50 IV or orally mg/kg/day                                                      | 500 mg IV or orally every 6 to 8 h                                             |
|                                  | Azithromycin                           | 10 mg/kg × 1 day (× 2 days if parenteral), and then 5 mg/kg days 2–5 IV or orally | 500 mg × 1 day (× 2 days if parenteral), and then 250 mg days 2–5 IV or orally |
|                                  |                                        |                                                                                   |                                                                                |
| Fluoroquinolones <sup>c</sup>    | Moxifloxacin                           | –                                                                                 | 400 mg IV or orally daily                                                      |
|                                  | Levofloxacin                           | 8–20 mg/kg/day IV or orally                                                       | 750 mg IV or orally daily                                                      |
|                                  | Ciprofloxacin                          | 30 mg/kg/day IV or orally                                                         | 400 mg IV every 8 h / 750 mg orally twice daily                                |
| Tetracycline <sup>d</sup>        | Doxycycline                            | 2–5 mg/kg/day IV or orally                                                        | 100 mg IV or orally twice daily                                                |
|                                  | Tetracycline HCl                       | 25–50 mg/kg/day orally                                                            | –                                                                              |
| Aminoglycosides                  | Gentamicin                             | 7.5–10 mg/kg/day IV                                                               | 7.5 mg/kg IV daily                                                             |
|                                  | Tobramycin                             | 7.5–10 mg/kg/day IV                                                               | 7.5 mg/kg IV daily                                                             |
|                                  | Amikacin                               | 15–20 mg/kg/day IV                                                                | 15–20 mg/kg IV daily                                                           |

Table 125-10 continued

|             |                       |                               |                                                             |
|-------------|-----------------------|-------------------------------|-------------------------------------------------------------|
| Carbapenems | Imipenem              | 60–100 mg/kg/day IV           | 500–1000 mg IV every 6 to 8 h                               |
|             | Meropenem             | 30–60 mg/kg/day IV            | 500–2000 mg IV every 6 to 8 h                               |
|             | Meropenem-vaborbactam |                               | 2 g/2 g IV every 8 h                                        |
| Polymyxins  | Colistin              | 2.5–5 mg/kg/day IV            | IV: 300 mg × 1, then 150 mg daily/<br>Neb: 150 mg every 8 h |
|             | Polymyxin B           | 15,000–30,000 units/kg/day IV | IV: 2–2.5 mg/kg × 1, then 1.25–1.5 mg/kg<br>every 12 h      |
| Other       | Vancomycin            | 45–60 mg/kg/day IV            | 15–20 mg/kg IV every 8–12 h                                 |
|             | Linezolid             | 20–30 mg/kg/day IV or orally  | 600 mg IV or orally every 12 h                              |
|             | Clindamycin           | 30–40 mg/kg/day IV or orally  | 600 mg IV or orally every 8 h or 450 mg orally<br>every 6 h |

**a** Doses can be increased for more severe disease and may require modification for patients with organ dysfunction.

**b** Higher-dose amoxicillin and amoxicillin/clavulanate (eg, 90 mg/kg/day) are used for penicillin-resistant *S. pneumoniae*.

**c** Fluoroquinolones have been avoided for pediatric patients because of the potential for cartilage damage; however, they have been used for MDR bacterial infection safely and effectively in infants and children.

**d** Tetracyclines are rarely used in pediatric patients, particularly in those younger than 8 years because of tetracycline-induced permanent tooth discoloration.



**TABLE 125-11 Directed Antimicrobial Therapy for Common Pneumonia Pathogens in Adult Patients**

| Pathogen                                                             | Preferred Antibiotic Therapy                                                                                                                                                                                                | Alternative Antibiotic Therapy                                                                       |
|----------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|
| Penicillin-susceptible<br><i>S. pneumoniae</i> (MIC $\leq$ 2 mg/L)   | Ampicillin, amoxicillin, penicillin G                                                                                                                                                                                       | Ceftriaxone, cefotaxime, macrolide, levofloxacin, moxifloxacin, doxycycline, clindamycin, vancomycin |
| Penicillin-resistant <i>S. pneumoniae</i><br>(MIC > 2 mg/L)          | Ceftriaxone, cefotaxime, levofloxacin, moxifloxacin                                                                                                                                                                         | High-dose amoxicillin (3 g/day), linezolid, clindamycin, vancomycin                                  |
| Non- $\beta$ -lactamase-producing<br><i>H. influenzae</i>            | Ampicillin (IV), amoxicillin                                                                                                                                                                                                | Fluoroquinolone, doxycycline, azithromycin, clarithromycin                                           |
| $\beta$ -Lactamase-producing<br><i>H. influenzae</i>                 | Ceftriaxone, cefotaxime, ampicillin-sulbactam, amoxicillin-clavulanate                                                                                                                                                      | Fluoroquinolone, doxycycline, azithromycin, clarithromycin                                           |
| <i>Mycoplasma pneumoniae</i>                                         | Macrolide, doxycycline                                                                                                                                                                                                      | Fluoroquinolone                                                                                      |
| <i>Chlamydophila pneumoniae</i>                                      | Macrolide, doxycycline                                                                                                                                                                                                      | Fluoroquinolone                                                                                      |
| <i>Legionella pneumophila</i>                                        | Fluoroquinolone or azithromycin                                                                                                                                                                                             | Doxycycline                                                                                          |
| MSSA                                                                 | Cefazolin, antistaphylococcal penicillin                                                                                                                                                                                    | Clindamycin, vancomycin                                                                              |
| MRSA                                                                 | Vancomycin, linezolid                                                                                                                                                                                                       | Telavancin, ceftaroline, quinupristin/dalfopristin, clindamycin, sulfamethoxazole/trimethoprim       |
| <i>P. aeruginosa</i>                                                 | Antipseudomonal $\beta$ -lactam <sup>a</sup> or fluoroquinolone <sup>b</sup> based on antimicrobial susceptibility testing results. Can consider adding aminoglycoside if patient in septic shock or at high mortality risk | IV colistin or polymyxin B + inhaled colistin for isolates resistant to all preferred therapies      |
| <i>Acinetobacter</i> spp.                                            | Carbapenem OR ampicillin-sulbactam based on antimicrobial susceptibility testing results                                                                                                                                    | IV colistin or polymyxin B + inhaled colistin for isolates resistant to all preferred therapies      |
| Extended-spectrum $\beta$ -lactamase-producing gram-negative bacilli | Carbapenem                                                                                                                                                                                                                  | Piperacillin-tazobactam or cefepime potential options depending on susceptibility/adequate dosing    |

## Table 125-11 continued

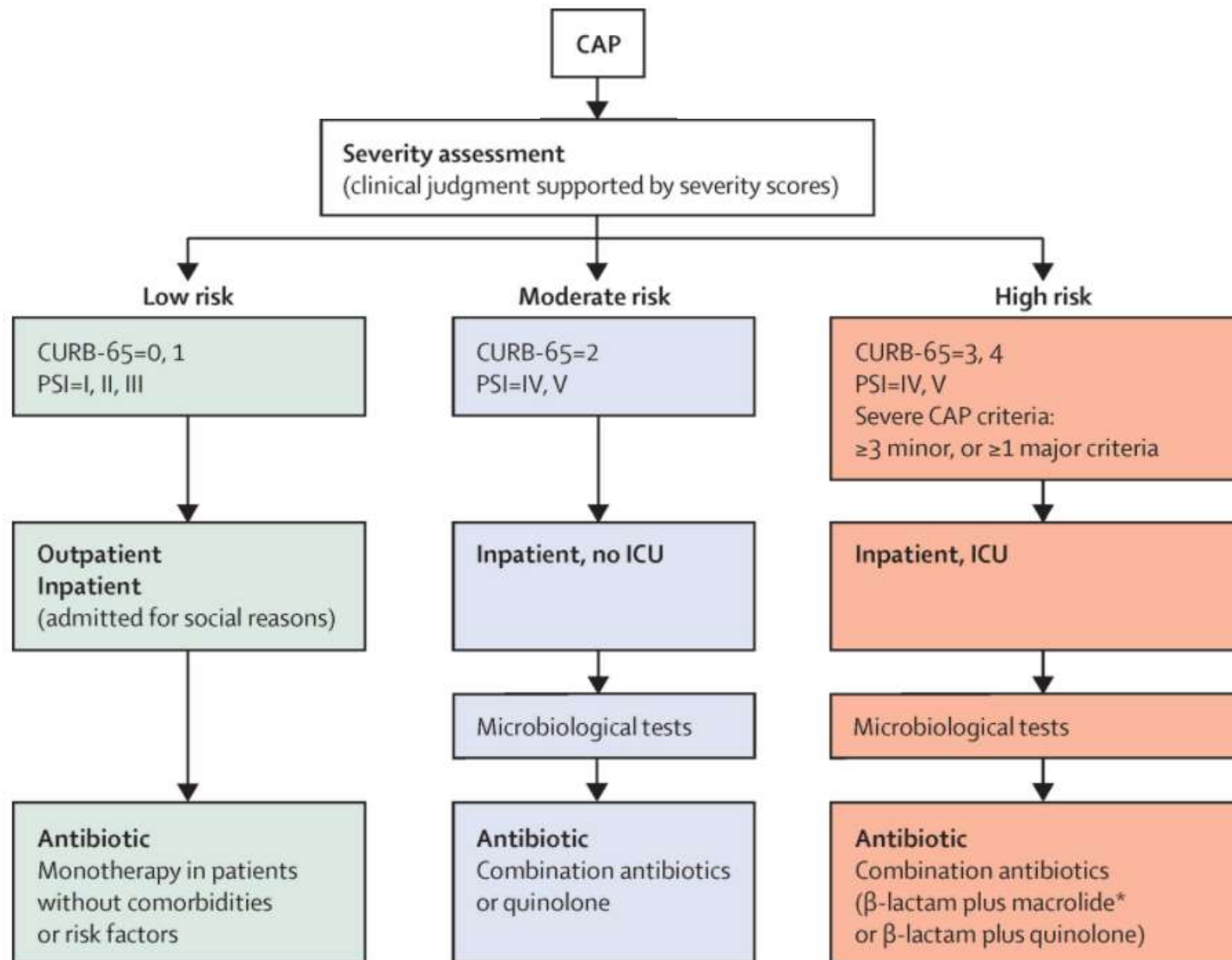
| Carbapenem-resistant organisms | New $\beta$ -lactam/ $\beta$ -lactamase inhibitors <sup>c</sup> based on antimicrobial susceptibility testing OR IV colistin or polymyxin B + inhaled colistin |
|--------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|
|--------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|

**a** Antipseudomonal  $\beta$ -lactam: piperacillin/tazobactam, cefepime, ceftazidime, meropenem, imipenem/cilastatin, doripenem, aztreonam.

**b** Antipseudomonal fluoroquinolone: ciprofloxacin and levofloxacin

**c** New  $\beta$ -lactam/  $\beta$ -lactamase inhibitors: ceftazidime/avibactam, meropenem/vaborbactam, ceftolozane/tazobactam.

MIC, minimum inhibitory concentration; MRSA, methicillin-resistant *Staphylococcus aureus* ; MSSA, methicillin-sensitive *Staphylococcus aureus* ; PCN, penicillin.





# Severe pneumonia = one major criterion or 3+ minor criteria

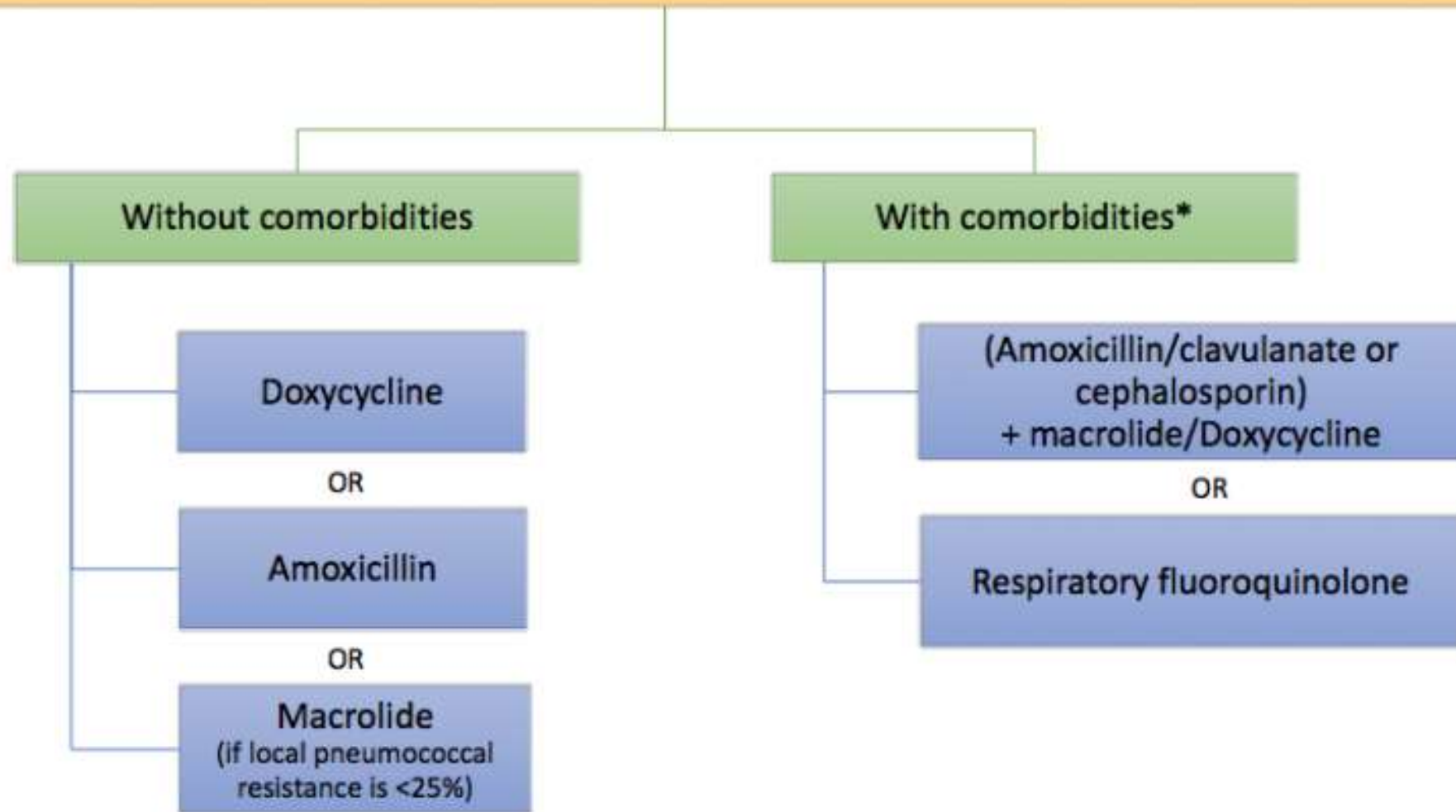
## Major criteria

- Septic shock, with need for vasopressors
- Respiratory failure requiring mechanical ventilation

## Minor criteria

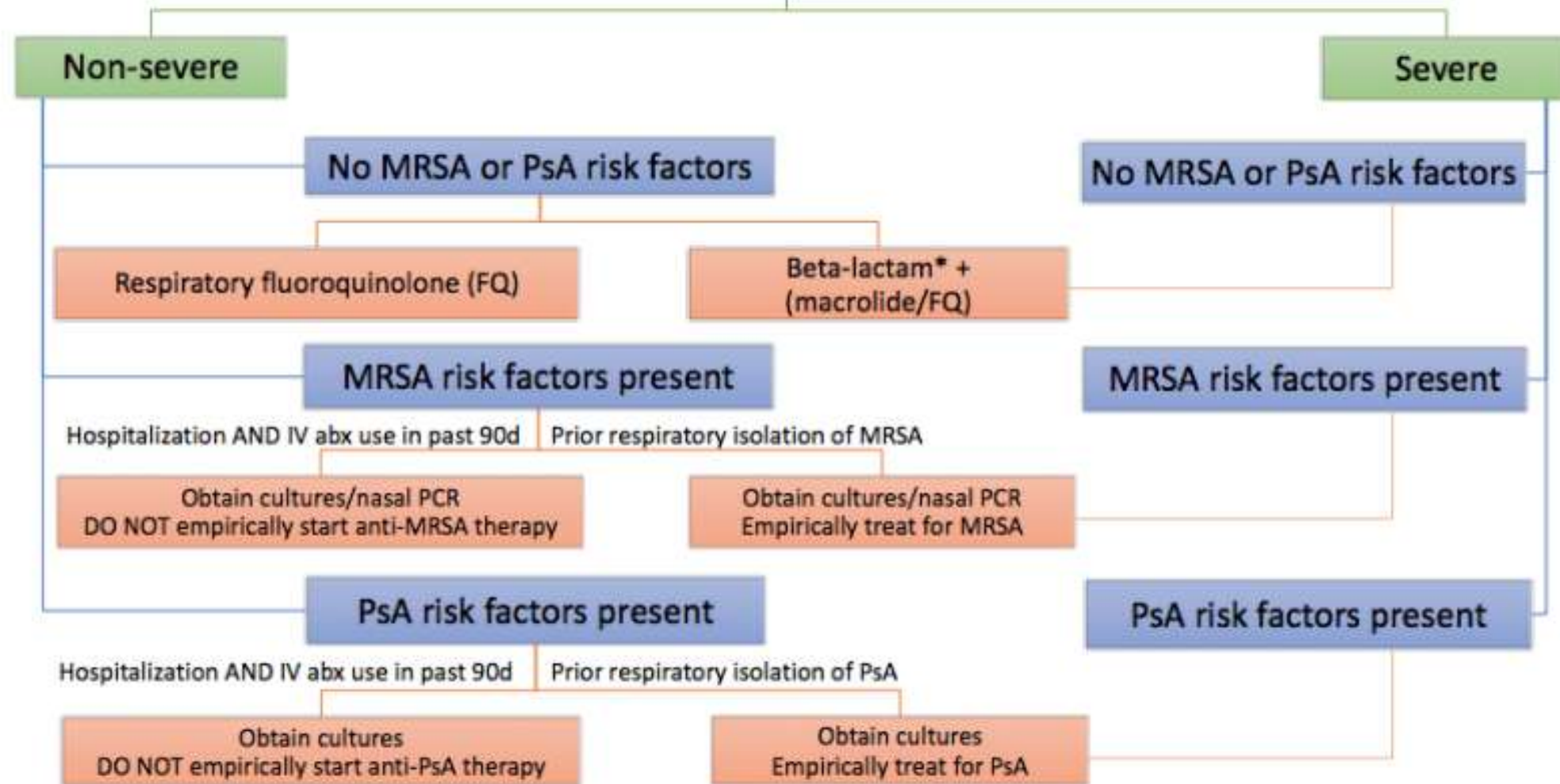
- Respiratory rate  $\geq 30$  breaths/min
- PaO<sub>2</sub>/FiO<sub>2</sub> ratio  $\leq 250$
- Multilobar infiltrates
- Confusion/disorientation
- Uremia (BUN  $\geq 20$ mg/dL)
- Leukopenia (WBC  $< 4,000$  cells/microL)
- Thrombocytopenia (platelet  $< 100,000$ /microL)
- Hypothermia (T  $< 36^\circ\text{C}$ )
- Hypotension that requires aggressive fluid resuscitation

## Community-acquired pneumonia treatment algorithm (outpatient)



\*Comorbidities: chronic heart, lung, liver, or kidney disease; diabetes mellitus; alcoholism; malignancy; or asplenia

# Community-acquired pneumonia treatment algorithm (inpatient)



\*Beta-lactam: ampicillin-sulbactam, cefotaxime, ceftriaxone, or ceftaroline