Therapy of Pneumonia

Pneumonias

- **Pneumonia is one of the most common causes of severe sepsis, and infectious cause of death in children and adults.**
- **It affects all ages, although the clinical manifestations are most severe in the very young, the elderly, and the chronically ill.**
- **Mortality rate is high.**

Pneumonias Causative Agents

- **The most prominent pathogen causing community-acquired pneumonia (CAP) in otherwise healthy adults is *Streptococcus pneumoniae* and accounts for up to 35% (12%-68%) of all acute cases.**
- **Other common pathogens include:**

1. ***H. influenza* (2.5%-45%).**
2. **Atypical pathogens *Mycoplasma. pneumoniae*, *Legionella* species, and *Chlamydia. pneumoniae* (~20%).**
3. **A variety of viruses including influenza.**

Pneumonia Causative Agents

- **The leading causative agents in hospital-acquired pneumonia (HAP) are Gram-negative aerobic bacilli, *S. aureus*, and multidrug-resistant (MDR) pathogens.**
- **In pneumonia that follows the aspiration of gastric or oropharyngeal contents, anaerobic bacteria are the most common etiologic agents.**
- **Ventilator-associated pneumonia (VAP) is also associated with MDR pathogens.**

Pneumonia Causative Agents

- **Pneumonia in infants and children is caused by a wider range of microorganisms, and, unlike adults, nonbacterial pathogens predominate.**
- **Most pneumonias occurring in the pediatric age group are caused by viruses, especially RSV, parainfluenza, and adenovirus.**
- ***M. pneumoniae* is an important pathogen in older children.**

Pneumonia Causative Agents

- **Beyond the neonatal period, *S. pneumoniae* is the major bacterial pathogen in childhood pneumonia, followed by group A *Streptococcus* and *S. aureus*.**
- ***H. influenzae* type b, once a major childhood pathogen, has become an infrequent cause of pneumonia since the introduction of active vaccination against this organism in the late 1980s.**

Pneumonia Causative Agents

- **Pneumonia in non-ambulatory residents of nursing homes and other long-term care facilities epidemiologically mirrors hospital-acquired pneumonia and should be treated according to the HAP guidelines.**
- **However, certain other patients are better served by management in accordance with CAP guidelines with concern for specific pathogens.**

Therapy of Pneumonia

Treatment:

The goals of therapy are:

1. **Eradication of the offending organism through selection of the appropriate antibiotic**
2. **Subsequent complete clinical cure.**
3. **Therapy should minimize associated drug-induced toxicity.**

Therapy of Pneumonia

General Approach to Treatment:

Supportive care:

a) **humidified oxygen for hypoxemia.**
b) **administration of bronchodilators (albuterol) when bronchospasm is present.**
c) **chest physiotherapy with postural drainage with evidence of retained secretions.**
d) **adequate hydration (IV if necessary).**
e) **optimal nutritional support.**
f) **control of fever.**

Therapy of Pneumonia

- **Appropriate sputum samples should be obtained to determine the microbiologic etiology.**
- **Selection of an appropriate antimicrobial must be made based on the patient's probable or documented microbiology.**

Pharmacologic Therapy:

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

Therapy of Pneumonia

Selection of Antimicrobial Agents:

- **Treatment, initially involves the empirical use of a relatively broad-spectrum antibiotic that is effective against probable pathogens after appropriate cultures and specimens for laboratory evaluation have been obtained.**
- **Therapy should be narrowed to cover specific pathogens after the results of cultures are known.**

Management of CAP in Adults

- **This discussion is in accordance of the "Infectious Diseases Society of America / American Thoracic Society" Consensus Guidelines on the Management of Community-Acquired Pneumonia in Adults (2016).**

Antibiotic Treatment:

- **Recommendations are generally for a class of antibiotics rather than for a specific drug, unless outcome data clearly favor one drug.**

Table 6. Most common etiologies of community-acquired pneumonia.

Patient type	Etiology
Outpatient	*Streptococcus pneumoniae* *Mycoplasma pneumoniae* *Haemophilus influenzae* *Chlamydophila pneumoniae* Respiratory viruses[a]
Inpatient (non-ICU)	*S. pneumoniae* *M. pneumoniae* *C. pneumoniae* *H. influenzae* *Legionella* species Aspiration Respiratory viruses[a]
Inpatient (ICU)	*S. pneumoniae* *Staphylococcus aureus* *Legionella* species Gram-negative bacilli *H. influenzae*

NOTE. Based on collective data from recent studies [171]. ICU, intensive care unit.

[a] Influenza A and B, adenovirus, respiratory syncytial virus, and parainfluenza.

Management of CAP in Adults

Outpatient treatment:

1. **Previously healthy and no risk factors for drug-resistant *S. pneumoniae* (DRSP) infection:**

A. **A macrolide (azithromycin, clarithromycin, or erythromycin).**

B. **Doxycycline is an alternative.**

Management of CAP in Adults

2. Presence of comorbidities (chronic heart, lung, liver, or renal disease; diabetes mellitus; alcoholism; malignancies; asplenia; immunosuppressing conditions or use of immunosuppressing drugs; use of antimicrobials within the previous 3 months, etc):

A. A respiratory fluoroquinolone (moxifloxacin, gemifloxacin, or levofloxacin).

B. A β-lactam plus a macrolide (High-dose amoxicillin [1g x3] or amoxicillin-clavulanate [2g x2] is preferred. Alternatives include ceftriaxone, and cefuroxime.

Management of CAP in Adults

3. In regions with a high rate (> 25%) of infection with high-level (MIC, ≥16 mg/mL) macrolide-resistant *S. pneumoniae,* consider the use of alternative agents listed above in recommendation 2 for any patient, including those without comorbidities.

Management of CAP in Adults

Inpatient, non-ICU treatment:

1. **A respiratory fluoroquinolone (moxifloxacin, gemifloxacin, or levofloxacin.**
2. **A β-lactam plus a macrolide.**

- **(Preferred β-lactam agents include cefotaxime, ceftriaxone, and ampicillin; ertapenem for selected patients; with doxycycline as an alternative to the macrolide).**
- **A respiratory fluoroquinolone should be used for penicillin-allergic patients.**

Management of CAP in Adults

Inpatient, ICU treatment:

1. **A β-lactam (cefotaxime, ceftriaxone, or ampicillin-sulbactam) + either azithromycin, or a fluoroquinolone.**

- **(for penicillin-allergic patients, a respiratory fluoroquinolone and aztreonam may be used).**

2. **For *Pseudomonas* infection, use an antipseudomonal β-lactam (piperacillin-tazobactam, cefepime, imipenem, or meropenem) + either ciprofloxacin or levofloxacin.**

Management of CAP in Adults

- **or the above β-lactam plus an aminoglycoside and azithromycin**
- **or the above β-lactam plus an aminoglycoside and an antipneumococcal fluoroquinolone**
- **(for penicillin-allergic patients, substitute aztreonam for the above β-lactam).**

3. **For community-acquired methicillin-resistant *Staphylococcus aureus* infection, add vancomycin or linezolid.**

Management of CAP in Adults

Pathogen-directed therapy:

- **Once the etiology of CAP has been identified on the basis of reliable microbiological methods, antimicrobial therapy should be directed at the specific pathogen.**

Table 9. Recommended antimicrobial therapy for specific pathogens.

Organism	Preferred antimicrobial(s)	Alternative antimicrobial(s)
Streptococcus pneumoniae		
Penicillin nonresistant; MIC <2 μg/mL	Penicillin G, amoxicillin	Macrolide, cephalosporins (oral [cefpodoxime, cefprozil, cefuroxime, cefdinir, cefditoren] or parenteral [cefuroxime, ceftriaxone, cefotaxime]), clindamycin, doxycyline, respiratory fluoroquinolone[a]
Penicillin resistant; MIC ⩾2 μg/mL	Agents chosen on the basis of susceptibility, including cefotaxime, ceftriaxone, fluoroquinolone	Vancomycin, linezolid, high-dose amoxicillin (3 g/day with penicillin MIC ⩽4 μg/mL)
Haemophilus influenzae		
Non–β-lactamase producing	Amoxicillin	Fluoroquinolone, doxycycline, azithromycin, clarithromycin[b]
β-Lactamase producing	Second- or third-generation cephalosporin, amoxicillin-clavulanate	Fluoroquinolone, doxycycline, azithromycin, clarithromycin[b]
Mycoplasma pneumoniae/Chlamydophila pneumoniae	Macrolide, a tetracycline	Fluoroquinolone
Legionella species	Fluoroquinolone, azithromycin	Doxycyline

Chlamydophila psittaci	A tetracycline	Macrolide
Coxiella burnetii	A tetracycline	Macrolide
Francisella tularensis	Doxycycline	Gentamicin, streptomycin
Yersinisa pestis	Streptomycin, gentamicin	Doxycyline, fluoroquinolone
Bacillus anthracis (inhalation)	Ciprofloxacin, levofloxacin, doxycycline (usually with second agent)	Other fluoroquinolones; β-lactam, if susceptible; rifampin; clindamycin; chloramphenicol
Enterobacteriaceae	Third-generation cephalosporin, carbapenem[c] (drug of choice if extended-spectrum β-lactamase producer)	β-Lactam/β-lactamase inhibitor,[d] fluoroquinolone
Pseudomonas aeruginosa	Antipseudomonal β-lactam[e] **plus** (ciprofloxacin or levofloxacin[f] or aminoglycoside)	Aminoglycoside **plus** (ciprofloxacin or levofloxacin[f])
Burkholderia pseudomallei	Carbapenem, ceftazadime	Fluoroquinolone, TMP-SMX
Acinetobacter species	Carbapenem	Cephalosporin-aminoglycoside, ampicillin-sulbactam, colistin
Staphylococcus aureus		
Methicillin susceptible	Antistaphylococcal penicillin[g]	Cefazolin, clindamycin
Methicillin resistant	Vancomycin or linezolid	TMP-SMX

Bordetella pertussis	Macrolide	TMP-SMX
Anaerobe (aspiration)	β-Lactam/β-lactamase inhibitor,[d] clindamycin	Carbapenem
Influenza virus	Oseltamivir or zanamivir	
Mycobacterium tuberculosis	Isoniazid plus rifampin plus ethambutol plus pyrazinamide	Refer to [243] for specific recommendations
Coccidioides species	For uncomplicated infection in a normal host, no therapy generally recommended; for therapy, itraconazole, fluconazole	Amphotericin B
Histoplasmosis	Itraconazole	Amphotericin B
Blastomycosis	Itraconazole	Amphotericin B

NOTE. Choices should be modified on the basis of susceptibility test results and advice from local specialists. Refer to local references for appropriate doses. ATS, American Thoracic Society; CDC, Centers for Disease Control and Prevention; IDSA, Infectious Diseases Society of America; TMP-SMX, trimethoprim-sulfamethoxazole.

[a] Levofloxacin, moxifloxacin, gemifloxacin (not a first-line choice for penicillin susceptible strains); ciprofloxacin is appropriate for *Legionella* and most gram-negative bacilli (including *H. influenza*).

[b] Azithromycin is more active in vitro than clarithromycin for *H. influenza*.

[c] Imipenem-cilastatin, meropenem, ertapenem.

[d] Piperacillin-tazobactam for gram-negative bacilli, ticarcillin-clavulanate, ampicillin-sulbactam or amoxicillin-clavulanate.

[e] Ticarcillin, piperacillin, ceftazidime, cefepime, aztreonam, imipenem, meropenem.

[f] 750 mg daily.

[g] Nafcillin, oxacillin flucloxacillin.

Management of CAP in Adults

Time to first antibiotic dose:

- **For patients admitted through the emergency department (ED), the first antibiotic dose should be administered while still in the ED.**

Management of CAP in Adults

Switch from intravenous to oral therapy:

1. **Patients should be switched from intravenous to oral therapy when they are hemodynamically stable and improving clinically, are able to ingest medications, and have a normally functioning gastrointestinal tract.**
2. **Patients should be discharged as soon as they are clinically stable, have no other active medical problems, and have a safe environment for continued care. Inpatient observation while receiving oral therapy is not necessary.**

Management of CAP in Adults

Duration of antibiotic therapy:

1. **Patients with CAP should be treated for a minimum of 5 days, and should be afebrile for 48-72 hours.**
2. **A longer duration of therapy may be needed if initial therapy was not active against the identified pathogen, or if it was complicated by extrapulmonary infection such as meningitis or endocarditis.**

Management of CAP in Adults

Remember the importance of:

1. **The local pattern of causative pathogens.**
2. **The local pattern of antibiotic sensitivity and/or resistance.**

Management of HAP- and VAP-associated Pneumonia in Adults

- **Each hospital should generate an antibiograms as a guide for the optimal choice of antibiotics.**
- **Patients with suspected HAP (non-VAP) may be treated according to the results of microbiologic studies performed on respiratory samples obtained noninvasively, rather than being treated empirically (weak recommendation).**
- **VAP may be treated empirically according to the local distribution of pathogens associated with it and their antimicrobial susceptibilities.**

Empiric Treatment of Clinically Suspected VAP

- **Cover for S. aureus, Pseudomonas aeruginosa, and other gram-negative bacilli in all empiric regimens.**
- **A regimen including piperacillin-tazobactam, cefepime, levofloxacin, imipenem, or meropenem is acceptable (This regimen for coverage of MSSA (not MRSA).**
- **Oxacillin, nafcillin, or cefazolin are preferred for treatment of proven MSSA, but are not necessary if one of the above agents is used.**

Empiric Treatment of Clinically Suspected VAP

- **For MRSA, either vancomycin or linezolid is indicated.**
- **If resistance is suspected, 2 antipseudomonal antibiotics from different classes are indicated.**
- **If risk of resistance is low, one antibiotic active against *P. aeruginosa* is indicated.**
- **Avoid aminoglycosides and colistin if alternative agents with adequate gram-negative activity are available.**

Empiric Treatment of Clinically Suspected VAP

- **If patient has structural lung disease increasing the risk of gram-negative infection (cystic fibrosis or bronchiectasis), 2 antipseudomonal agents are recommended.**

Table 3. Suggested Empiric Treatment Options for Clinically Suspected Ventilator-Associated Pneumonia in Units Where Empiric Methicillin-Resistant *Staphylococcus aureus* Coverage and Double Antipseudomonal/Gram-Negative Coverage Are Appropriate

A. Gram-Positive Antibiotics With MRSA Activity	B. Gram-Negative Antibiotics With Antipseudomonal Activity: β-Lactam–Based Agents	C. Gram-Negative Antibiotics With Antipseudomonal Activity: Non-β-Lactam–Based Agents
Glycopeptides[a] Vancomycin 15 mg/kg IV q8–12h (consider a loading dose of 25–30 mg/kg × 1 for severe illness)	Antipseudomonal penicillins[b] Piperacillin-tazobactam 4.5 g IV q6h[b]	Fluoroquinolones Ciprofloxacin 400 mg IV q8h Levofloxacin 750 mg IV q24h
OR	OR	OR
Oxazolidinones Linezolid 600 mg IV q12h	Cephalosporins[b] Cefepime 2 g IV q8h Ceftazidime 2 g IV q8h	Aminoglycosides[a,c] Amikacin 15–20 mg/kg IV q24h Gentamicin 5–7 mg/kg IV q24h Tobramycin 5–7 mg/kg IV q24h
	OR	OR
	Carbapenems[b] Imipenem 500 mg IV q6h[d] Meropenem 1 g IV q8h	Polymyxins[a,e] Colistin 5 mg/kg IV × 1 (loading dose) followed by 2.5 mg × (1.5 × CrCl + 30) IV q12h (maintenance dose) [135] Polymyxin B 2.5–3.0 mg/kg/d divided in 2 daily IV doses
	OR	
	Monobactams[f] Aztreonam 2 g IV q8h	

Choose one gram-positive option from column A, one gram-negative option from column B, and one gram-negative option from column C. Note that the initial doses suggested in this table may need to be modified for patients with hepatic or renal dysfunction.

Abbreviations: CrCl, creatinine clearance; IV, intravenous; MRSA, methicillin-resistant *Staphylococcus aureus*.

[a] Drug levels and adjustment of doses and/or intervals required.

[b] Extended infusions may be appropriate. Please see section XIII on pharmacokinetic/pharmacodynamic optimization of antibiotic therapy.

[c] On meta-analysis, aminoglycoside regimens were associated with lower clinical response rates with no differences in mortality.

[d] The dose may need to be lowered in patients weighing <70 kg to prevent seizures.

[e] Polymyxins should be reserved for settings where there is a high prevalence of multidrug resistance and local expertise in using this medication. Dosing is based on colistin-base activity (CBA); for example, One million IU of colistin is equivalent to about 30 mg of CBA, which corresponds to about 80 mg of the prodrug colistimethate. Polymyxin B (1 mg = 10 000 units) [136].

[f] In the absence of other options, it is acceptable to use aztreonam as an adjunctive agent with another β-lactam–based agent because it has different targets within the bacterial cell wall [137].

Empiric Treatment of Clinically Suspected VAP

Role Of Inhaled Antibiotic Therapy:

- **For patients with VAP due to gram-negative bacilli that are susceptible to only aminoglycosides or polymyxins (colistin or polymyxin B), It is suggested to use both inhaled and systemic antibiotics, rather than systemic antibiotics alone.**
- **Adjunctive inhaled antibiotic therapy is a last resort for patients who are not responding to intravenous antibiotics alone, whether the infecting organism is or is not multidrug resistant (MDR).**

Empiric Treatment of Clinically Suspected HAP (Non-VAP)

- **When there is high risk for MRSA infection, use an antibiotic with activity against MRSA (vancomycin or linezolid).**
- **For patients with no risk factors for MRSA infection, use an antibiotic with activity against MSSA.**
- **When empiric treatment may include coverage for MSSA (and not MRSA) use a regimen containing piperacillin-tazobactam, cefepime, levofloxacin, imipenem, or meropenem.**

Empiric Treatment of Clinically Suspected HAP (Non-VAP)

- **Oxacillin, nafcillin, or cefazolin are indicated for the treatment of proven MSSA, but are not necessary if one of the above agents is used.**
- **Also use antibiotics with activity against P. aeruginosa and other gram-negative bacilli.**
- **In patients who have factors increasing the likelihood for *Pseudomonas* or other gram-negative infection, use antibiotics from 2 different classes with activity against *P. aeruginosa*.**

Empiric Treatment of Clinically Suspected HAP (Non-VAP)

- **All other patients with HAP who are being treated empirically may be prescribed a single antibiotic with activity against *P. aeruginosa*.**
- **Do not use an aminoglycoside as the sole antipseudomonal.**
- **These recommendations are a compromise between providing early appropriate antibiotic coverage and avoiding adverse drug effects, *C. difficile* infections, antibiotic resistance, and increased cost.**

Table 4. Recommended Initial Empiric Antibiotic Therapy for Hospital-Acquired Pneumonia (Non-Ventilator-Associated Pneumonia)

Not at High Risk of Mortality[a] and no Factors Increasing the Likelihood of MRSA[b,c]	Not at High Risk of Mortality[a] but With Factors Increasing the Likelihood of MRSA[b,c]	High Risk of Mortality or Receipt of Intravenous Antibiotics During the Prior 90 d[a,c]
One of the following:	One of the following:	Two of the following, avoid 2 β-lactams:
Piperacillin-tazobactam[d] 4.5 g IV q6h	Piperacillin-tazobactam[d] 4.5 g IV q6h	Piperacillin-tazobactam[d] 4.5 g IV q6h
OR	OR	OR
Cefepime[d] 2 g IV q8h	Cefepime[d] or ceftazidime[d] 2 g IV q8h	Cefepime[d] or ceftazidime[d] 2 g IV q8h
OR	OR	OR
Levofloxacin 750 mg IV daily	Levofloxacin 750 mg IV daily	Levofloxacin 750 mg IV daily
	Ciprofloxacin 400 mg IV q8h	Ciprofloxacin 400 mg IV q8h
	OR	OR
Imipenem[d] 500 mg IV q6h	Imipenem[d] 500 mg IV q6h	Imipenem[d] 500 mg IV q6h
Meropenem[d] 1 g IV q8h	Meropenem[d] 1 g IV q8h	Meropenem[d] 1 g IV q8h
	OR	OR
	Aztreonam 2 g IV q8h	Amikacin 15–20 mg/kg IV daily
		Gentamicin 5–7 mg/kg IV daily
		Tobramycin 5–7 mg/kg IV daily
		OR
		Aztreonam[e] 2 g IV q8h
	Plus: Vancomycin 15 mg/kg IV q8–12h with goal to target 15–20 mg/mL trough level (consider a loading dose of 25–30 mg/kg × 1 for severe illness)	Plus: Vancomycin 15 mg/kg IV q8–12h with goal to target 15–20 mg/mL trough level (consider a loading dose of 25–30 mg/kg IV × 1 for severe illness)
	OR	OR
	Linezolid 600 mg IV q12h	Linezolid 600 mg IV q12h
		If MRSA coverage is not going to be used, include coverage for MSSA. Options include: Piperacillin-tazobactam, cefepime, levofloxacin, imipenem, meropenem. Oxacillin, nafcillin, and cefazolin are preferred for the treatment of proven MSSA, but would ordinarily not be used in an empiric regimen for HAP.
	If patient has severe penicillin allergy and aztreonam is going to be used instead of any β-lactam–based antibiotic, include coverage for MSSA.	

Pathogen-Specific Therapy

- **Treatment for MRSA HAP/VAP: Vancomycin or linezolid.**
- **HAP/VAP Due to *P. aeruginosa*: Definitive (not empiric) therapy based upon the results of antimicrobial susceptibility testing.**
- **No aminoglycoside monotherapy.**

Pathogen-Specific Therapy

- **For patients with HAP/VAP due to *P. aeruginosa* who are not in septic shock or at a high risk for death, and for whom the results of antibiotic susceptibility testing are known, use monotherapy with an antibiotic to which the isolate is susceptible.**
- **For patients with HAP/VAP due to *P. aeruginosa* who remain in septic shock or at a high risk for death when the results of antibiotic susceptibility testing are known, use combination therapy with 2 antibiotics to which the isolate is susceptible.**

Pathogen-Specific Therapy

- **Treatment of patients with HAP/VAP due to extended-spectrum β-lactamase (ESBL)–producing gram-negative bacilli:**
- **For patients with HAP/VAP due to ESBL-producing gram negative bacilli, the choice of an antibiotic for definitive (not empiric) therapy should be based upon the results of antimicrobial susceptibility testing and patient-specific factors (allergies and comorbidities that may confer an increased risk of side effects).**

Pathogen-Specific Therapy

- **Treatment of patients with HAP/VAP due to *Acinetobacter* species: use either a carbapenem or ampicillin/sulbactam if the isolate is susceptible to these agents.**
- **In patients with HAP/VAP caused by *Acinetobacter* species that is sensitive only to polymyxins, use intravenous polymyxin (colistin or polymyxin B), with adjunctive inhaled colistin.**
- **Do not use tigecycline.**

Pathogen-Specific Therapy

- **Treatment of patients with HAP/VAP due to carbapenem-resistant pathogens: If the pathogen is sensitive only to polymyxins, use intravenous polymyxins (colistin or polymyxin B), with adjunctive inhaled colistin.**

Length of therapy

- **For patients with VAP or HAP, a 7-day course of antimicrobial therapy rather than a longer duration is recommended.**
- **A shorter or longer duration of antibiotics may be indicated, depending upon the rate of improvement of clinical, radiologic, and laboratory parameters.**

Should Antibiotic Therapy Be De-escalated or Fixed in Patients With HAP/VAP?

- **For patients with HAP/VAP, antibiotic therapy be de-escalated rather than fixed.**
- **De-escalation therapy means changing an empiric broad-spectrum antibiotic regimen to a narrower antibiotic regimen by changing the antimicrobial agent or changing from combination therapy to monotherapy.**
- **Fixed antibiotic therapy refers to maintaining a broad-spectrum antibiotic regimen until therapy is completed.**

Neonatal Pneumonia

Onset:

1) **may be within hours of birth and part of a generalized sepsis syndrome.**
2) **or after 7 days (most commonly in neonatal ICUs among infants who require prolonged endotracheal intubation because of lung Disease).**

Neonatal Pneumonia

- **Organisms are acquired from the maternal genital tract or the nursery.**

These organisms include:

a) **gram-positive cocci (groups A and B streptococci, both methicillin-sensitive and methicillin-resistant *Staphylococcus aureus*)**

b) **gram-negative bacilli (*Escherichia coli, Klebsiella* sp, *Proteus* sp).**

c) ***Pseudomonas, Citrobacter, Bacillus,* and *Serratia* in infants who have received broad-spectrum antibiotics.**

Neonatal Pneumonia

Treatment:

- **Antimicrobial therapy in early-onset disease is similar to that for neonatal sepsis.**
- **Vancomycin and a broad-spectrum β-lactam drug such as meropenem, piperacillin/tazobactam, or cefepime are the initial treatment of choice.**
- **This regimen treats sepsis as well as pneumonia with typical hospital-acquired pathogens including *P. aeruginosa*.**

Neonatal Pneumonia

- **Local patterns of infection and bacterial resistance should always be used to help guide empiric choices of antimicrobials.**
- **More specific antibiotics are substituted after sensitivity results are available.**

Neonatal Pneumonia

Chlamydial pneumonia:

- **Exposure to chlamydial organisms (*Chlamydia trachomatis*) occur during delivery.**
- **May result in development of chlamydial pneumonia at 2 to 18 wk.**

Neonatal Pneumonia

Treatment:

- **Erythromycin or azithromycin lead to rapid resolution.**
- **Erythromycin may cause hypertrophic pyloric stenosis in neonates.**
- **The mother and father should also be treated for chlamydia.**

Community-Acquired Pneumonia in Children

- **The most likely etiology depends on the age of the child.**
- **Viral and *Streptococcus pneumoniae* infections are most common in preschool-aged children, whereas *Mycoplasma pneumoniae* is common in older children.**

Community-Acquired Pneumonia in Children

- **Preschool-aged children with uncomplicated bacterial pneumonia should be treated with amoxicillin.**
- **Macrolides are first-line agents in older children.**
- **Immunization with the 13-valent pneumococcal conjugate vaccine is important in reducing the severity of childhood pneumococcal infections.**

CAP Etiologies in Children

Age	*Common etiologies*	*Less common etiologies*
2 to 24 months	Respiratory syncytial virus Human metapneumovirus Parainfluenza viruses Influenza A and B Rhinovirus Adenovirus Enterovirus *Streptococcus pneumoniae* *Chlamydia trachomatis*	*Mycoplasma pneumoniae* *Haemophilus influenzae* (type B and nontypable) *Chlamydophila pneumoniae*

CAP Etiologies in Children

2 to 5 years	Respiratory syncytial virus Human metapneumovirus Parainfluenza viruses Influenza A and B Rhinovirus Adenovirus Enterovirus *S. pneumoniae* *M. pneumoniae* *H. influenzae* (B and nontypable) *C. pneumoniae*	*Staphylococcus aureus* (including methicillin-resistant *S. aureus*) Group A streptococcus

CAP Etiologies in Children

Older than 5 years	*M. pneumoniae* *C. pneumoniae* *S. pneumoniae* Rhinovirus Adenovirus Influenza A and B	*H. influenzae* (B and nontypable) *S. aureus* (including methicillin-resistant *S. aureus*) Group A streptococcus Respiratory syncytial virus Parainfluenza viruses Human metapneumovirus Enterovirus

Recommended Empiric Outpatient Treatment of Childhood CAP

60 days to 5 years of age:

- **Preferred regimens: Amoxicillin for 7-10 days.**
- **Alternative regimens for patients allergic to penicillin or beta-lactam antibiotics: Azithromycin (5 days), clarithromycin (7-10 days), or erythromycin (7-10 days).**

5 to 16 years of age: Azithromycin (5 days).

Recommended Empiric Inpatient Treatment of Childhood CAP

60 days to 5 years of age:

- **Cefuroxime for 10-14 days.**
- **In critically ill patients: Cefuroxime + erythromycin 10-14 days, or cefotaxime + cloxacillin for 10-14 days**

5 to 16 years of age: Cefuroxime + erythromycin 10-14 days, or azithromycin for 5 days.