C.S. MOTT CHILDREN'S HOSPITAL
MICHIGAN MEDICINE

# ANTIBIOTIC TREATMENT GUIDELINES FOR PNEUMONIA IN PEDIATRIC PATIENTS

This guideline is designed to provide guidance for pneumonia in most children. Management of pneumonia in patients <3 months or in those who have underlying lung disease (e.g., cystic fibrosis; excluding asthma) or febrile neutropenia is beyond the scope of these guidelines. Other types of pneumonia such as Lemierre syndrome and atypical pneumonia in infants (pertussis, *C. trachomatis*) are also beyond the scope of these guidelines.

| Indication | Empiric Therapy | Duration/Comments |
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| **Outpatient Community-Acquired Pneumonia**<br><br>Target pathogen:<br>*S. pneumoniae*<br><br>Underimmunized[1]<br>Above, plus *H. influenzae* type b | 1st line:<br>**Amoxicillin*** 45 mg/kg/DOSE PO BID (max: 2 g/DOSE)<br><br>Penicillin allergy:<br>**Clindamycin** 13 mg/kg/DOSE PO TID (max: 600 mg/DOSE)<br><br>Underimmunized[1]:<br>**Amoxicillin-clavulanate***[2] 30 mg/kg/DOSE PO TID (max: 1 g/DOSE)<br><br>Underimmunized[1] and penicillin allergy:<br>**Levofloxacin***:<br>*<5 years:*<br>10 mg/kg/DOSE IV/PO BID (max: 375 mg/DOSE)<br>*≥5 years:*<br>10 mg/kg/DOSE IV/PO daily (max: 750 mg/DOSE) | • Duration:<br>**5 days**<br>• Suggest **7 days** for infants <6 months (5 days studied for ≥6 mo)<br>• A **3-day** course of amoxicillin can be considered for patients with rapid clinical improvement (CAP-IT Trial, Bielicki 2021, JAMA 2021)<br>• For children <5 years, given predominance of viral pneumonia, consider supportive care only<br>• Oral cephalosporins have inferior *in vitro* activity against *S. pneumoniae* compared to high-dose amoxicillin, clindamycin, and levofloxacin<br>• Azithromycin resistance occurs in up to 40% of *S. pneumoniae* |
| Target pathogens:<br>*M. pneumoniae*<br>*C. pneumoniae* | Children ≥5 years with features of atypical pneumonia[3]:<br>Consider **azithromycin** PO 10 mg/kg once on day 1 (max: 500 mg), followed by 5 mg/kg once daily x4 days (max: 250 mg/day)<br><br>Azithromycin allergy or contraindication:<br>**Doxycycline** 2 mg/kg/dose po BID (max: 100 mg/dose) | • If unable to distinguish atypical from routine bacterial pneumonia, add azithromycin (except to levofloxacin); use azithromycin alone only if clear features of atypical pneumonia[3]<br>• AAP RedBook now permits the use of doxycycline in any age group for courses ≤21 days |

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| Indication | Empiric Therapy | Step-Down Therapy | Duration/Comments |
|---|---|---|---|
| **Non-severe / Uncomplicated Inpatient Community-Acquired Pneumonia**<br><br>**Excludes pneumonia with:** Loculated or moderate-large effusion, abscess, necrosis, bacteremia, septic shock requiring vasopressors, need for invasive mechanical ventilation<br><br>Target pathogen:<br>*S. pneumoniae*<br><br>Underimmunized[1]<br>Above, plus *H. influenzae* type b<br><br>**Risk factors that require expanded antibacterial coverage:** Respiratory infection/colonization with MRSA, *P. aeruginosa*, or other organism resistant to non-severe CAP therapy in the past 12 months (see **Patients at Risk for Drug-Resistant Pneumonia**) | 1st line:<br>**Ampicillin*** 50 mg/kg/DOSE IV q6h<br>(max: 2 g/DOSE)<br><br>Low/medium-risk penicillin allergy[4], underimmunized[1], OR failed high-dose amoxicillin[7]:<br>**Ceftriaxone** 100 mg/kg once, then 50 mg/kg/DOSE IV q24h<br>(max: 2 g/DOSE)<br><br>High-risk allergy[5]/ contraindication[6] to beta-lactams:<br>**Levofloxacin***:<br>*<5 years:*<br>10 mg/kg/DOSE IV/PO BID<br>(max: 375 mg/DOSE)<br>*≥5 years:*<br>10 mg/kg/DOSE IV/PO daily<br>(max: 750 mg/DOSE) | 1st line:<br>**Amoxicillin*** 30 mg/kg/DOSE PO TID<br>(max: 1 g/DOSE)<br><br>Penicillin allergy:<br>**Clindamycin** 13 mg/kg/DOSE PO TID<br>(max: 600 mg/DOSE)<br><br>Underimmunized[1]:<br>**Amoxicillin-clavulanate***[2] 30 mg/kg/DOSE PO TID (max: 1 g/DOSE)<br><br>Failed high-dose amoxicillin[7] OR underimmunized[1] with penicillin allergy:<br>**Levofloxacin***:<br>*<5 years:*<br>10 mg/kg/DOSE IV/PO BID<br>(max: 375 mg/DOSE)<br>*≥5 years:*<br>10 mg/kg/DOSE IV/PO daily<br>(max: 750 mg/DOSE) | • Duration:<br>**5 days** (IV + oral) for patients who defervesce within 72 hours and have resolution of vital sign abnormalities by the time of antibiotic discontinuation<br>• Patients with delayed response should discontinue therapy 48-72 hours after defervescence and when vital sign abnormalities have resolved<br>• If vital signs remain abnormal >5 days but likely due to another etiology (e.g., bronchiolitis, asthma exacerbation), antibiotics may be discontinued at 5 days per clinical judgment<br>• Suggest 7 days for infants <6 months (5 days studied for ≥6 mo)<br><br>• Ceftriaxone should not be transitioned to oral cephalosporins due to inferior *in vitro* activity against *S. pneumoniae*<br>• Consider consultation to Beta-lactam Allergy Services while inpatient to assess whether amoxicillin can be trialed<br><br>• Aspiration pneumonia<br>• Empiric antibiotics are not indicated after an aspiration event or for aspiration pneumonitis. Aspiration pneumonitis typically resolves within 24-48 hours<br>• For patients who develop pneumonia following an aspiration event, anaerobic coverage is not necessary, unless lung abscess or necrosis are present. Prescribe routine pneumonia antibiotics<br><br>• Consider ID consult for significant prior antibiotics, no improvement with >48 hrs guideline therapy, or anticipated prolonged antibiotics |
| Target pathogens:<br>*M. pneumoniae*<br>*C. pneumoniae* | Children ≥5 years with features of atypical pneumonia[3]:<br>Add **azithromycin** PO 10 mg/kg once on day 1 (max: 500 mg), followed by 5 mg/kg once daily x 4 days (max: 250 mg/day)<br><br>Azithromycin allergy or contraindication:<br>**Doxycycline** 2 mg/kg/dose po BID (max: 100 mg/dose) | | • Discontinue if RPAN negative for atypical pathogens<br><br>• No additional atypical coverage needed if using levofloxacin<br><br>• AAP RedBook now permits the use of doxycycline in any age group for courses ≤21 days |

| Setting | Empiric Therapy | Step-Down Therapy | Duration/Comments |
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| **Severe / Complicated Community-Acquired Pneumonia**<br>Severe Pneumonia is defined by septic shock requiring vasopressors or severe respiratory failure requiring invasive mechanical ventilation primarily attributed to bacterial pneumonia.<br>Complicated Pneumonia includes loculated or moderate-large effusion, abscess, necrosis, and secondary bacteremia.<br><br>Target pathogens:<br>*S. pneumoniae*<br>*S. aureus*<br>*S. pyogenes*<br>*H. influenzae*<br>*M. catarrhalis*<br>Anaerobes (abscess, necrosis)<br><br>Underimmunized[1]<br>Above, plus *H. influenzae* type b<br><br>**Risk factors that require expanded antibacterial coverage:**<br>• Infection/colonization with *P. aeruginosa* or other organism resistant to severe CAP therapy in the past 12 months<br>• Severe pneumonia AND hospitalization >72 hrs in the past 90 days (including current admission) with receipt of intravenous antibiotics<br>**If present, see Patients at Risk for Drug-Resistant Pneumonia** | 1st line:<br>**Ceftriaxone** 100 mg/kg once, then 50 mg/kg/DOSE IV q12h (max: 2 g/DOSE)<br>+ **Vancomycin***<br><br>High-risk allergy[5]/ contraindication[6] to beta-lactams or low/medium-risk allergy[4] to ceftriaxone/cefotaxime/cefepime/cefpodoxime:<br>**Levofloxacin***:<br>*<5 years:*<br>10 mg/kg/DOSE IV/PO BID (max: 375 mg/DOSE)<br>*≥5 years:*<br>10 mg/kg/DOSE IV/PO daily (max: 750 mg/DOSE)<br>+ **Vancomycin*** (link to dosing)<br><br>Abscess or necrotizing pneumonia:<br>Substitute **ampicillin-sulbactam** 50 mg ampicillin/kg/DOSE IV q6h (max: 2 g ampicillin/DOSE) for ceftriaxone<br>-OR-<br>Add **metronidazole*** 10 mg/kg/DOSE IV/PO q8h (max: 500 mg/DOSE) to levofloxacin | 1st line:<br>**Amoxicillin-clavulanate***[2] 30 mg/kg/DOSE PO TID (max: 1 g/DOSE)<br><br>If ongoing need for empiric MRSA coverage:<br>Add **TMP-SMX***[8] 5 mg TMP/kg/DOSE PO BID (max: 320 mg/DOSE)<br><br>Penicillin allergy:<br>**Levofloxacin***:<br>*<5 years:*<br>10 mg/kg/DOSE IV/PO BID (max: 375 mg/DOSE)<br>*≥5 years:*<br>10 mg/kg/DOSE IV/PO daily (max: 750 mg/DOSE)<br>**+ TMP-SMX***[6] 5 mg TMP/kg/DOSE PO BID (max: 320 mg/DOSE)<br><br>Penicillin allergy with abscess or necrotizing pneumonia:<br>Add **metronidazole*** 10 mg/kg/DOSE IV/PO q8h (max: 500 mg/DOSE) to levofloxacin | • Duration:<br>**5 days** (IV + oral) for patients who defervesce within 72 hours and have resolution of vital sign abnormalities by the time of antibiotic discontinuation<br>• Patients with delayed response should discontinue therapy 48-72 hours after defervescence and when vital sign abnormalities have resolved<br>• **7 days** (IV + oral) for patients with *S. aureus*, *P. aeruginosa* or other NLFGNR[7] infection or for infants <6 months<br>• Consult ID for complicated pneumonia as longer duration is typically required for empyema, abscess, and bacteremia.<br><br>• Obtain MRSA nasal culture when starting vancomycin and discontinue vancomycin if negative and no concurrent bacteremia. TMP-SMX is not needed for step-down if vancomycin is discontinued.<br><br>• Tailor therapy to culture results; if cultures negative, de-escalate to ceftriaxone, ampicillin-sulbactam, or amoxicillin-clavulanate<br><br>• Empiric ceftriaxone should be transitioned to amoxicillin-clavulanate, not oral cephalosporins (inferior *in vitro* activity against *S. pneumoniae*) |
| See below for atypical pneumonia | | | |

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| Severe / Complicated Atypical Pneumonia<br><br>Target pathogens:<br>*M. pneumoniae*<br>*C. pneumoniae*<br>*Legionella* spp. | Empiric coverage for children ≥5 years with features of atypical pneumonia[3]:<br>Add **azithromycin** IV/PO 10 mg/kg once on day 1 (max: 500 mg), followed by 5 mg/kg once daily x 4 days (max: 250 mg/day)<br><br>Azithromycin allergy/contraindication and no concern for *Legionella*:<br>**Doxycycline** 2mg/kg/dose po BID (max: 100 mg/dose)<br><br>Documented or high clinical suspicion for *Legionella* infection:<br>**Azithromycin** 10 mg/kg q24 h (max: 500 mg)<br><br>Azithromycin allergy/contraindication and *Legionella* infection:<br>**Levofloxacin***:<br>*<5 years:* 10 mg/kg/DOSE IV/PO BID (max: 375 mg/DOSE)<br>*≥5 years:* 10 mg/kg/DOSE IV/PO daily (max: 750 mg/DOSE)<br><br>Severe documented *Mycoplasma* infection:<br>**Doxycycline** 2 mg/kg/dose po BID (max: 100 mg/dose) | • Consider discontinuing empiric coverage if RPAN is negative for atypical pathogens<br><br>• No additional atypical coverage needed if already using levofloxacin<br><br>• If suspicion for *Legionella* infection, send urine *Legionella* antigen and, if possible, respiratory *Legionella* PCR<br><br>• In patients with severe documented *Mycoplasma*, doxycycline is preferred for treatment due to rising macrolide resistance<br><br>• AAP RedBook now permits the use of doxycycline in any age group for courses ≤21 days |

| Setting | Empiric Therapy | Step-Down Therapy | Duration/Comments |
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| **Patients at Risk for Drug-Resistant Pneumonia**<br><br>Includes:<br>Ventilator-Associated Pneumonia<br><br>Ventilator-Associated Tracheobronchitis<br><br>Patients with non-severe pneumonia and respiratory infection/colonization with MRSA, *P. aeruginosa*, or other organism resistant to non-severe CAP therapy in the past 12 months<br><br>Patients with severe pneumonia and infection/colonization with *P. aeruginosa*, or other organism resistant to severe CAP therapy in the past 12 months<br><br>Patients with severe pneumonia and hospitalization >72 hrs in the past 90 days (including current admission) with receipt of intravenous antibiotics<br><br>Target pathogens:<br>*S. pneumoniae*<br>*S. aureus*<br>*P. aeruginosa*<br>*H. influenzae*<br>*M. catarrhalis* | *Empiric therapy should be guided by previous culture data. Patients with non-severe CAP do not require cefepime or vancomycin unless dictated by cultures.*<br><br>1st line:<br>**Cefepime** 50 mg/kg/DOSE IV extended infusion q8h (max: 2 g/DOSE)<br>+ **Vancomycin***<br><br>Severe[1] PCN or cephalosporin allergy:<br>**Levofloxacin***:<br>*<5 years:*<br>10 mg/kg/DOSE IV/PO BID (max: 375 mg/DOSE)<br>*≥5 years:*<br>10 mg/kg/DOSE IV/PO daily (max: 750 mg/DOSE)<br>+ **Vancomycin***<br><br>Abscess or necrotizing pneumonia:<br>Add **metronidazole*** 10 mg/kg/DOSE IV/PO q8h (max: 500 mg/DOSE) | Negative culture results:<br>Use step-down therapy for non-severe or severe CAP as appropriate<br><br>Positive culture results:<br>Tailor therapy to culture results | • Duration:<br>**7 days** for ventilator-associated pneumonia (VAP)<br><br>**5 days** for ventilator-associated tracheobronchitis (VAT), if patient has new purulent endotracheal secretions without chest x-ray infiltrate plus 1) fever/hypothermia and 2) leukocytosis/leukopenia or elevated/rising inflammatory markers. Consider not treating with systemic antibiotics for patients with less severe signs/symptoms<br><br>Non-VAP: see applicable sections for non-severe or severe pneumonia<br><br>• Obtain MRSA nasal culture when starting vancomycin and discontinue vancomycin if negative and no concurrent bacteremia<br><br>• Patients with mild-moderate VAP/VAT may be started on alternative regimens to better target known organisms, or if tolerating PO and suitable oral alternatives exist |

| Setting | Empiric Therapy | Duration/Comments |
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| **Emergency Department** | Anticipated discharge to home:<br>• Prescribe antibiotics per Outpatient recommendations<br>• If failed high-dose amoxicillin[5] for typical bacterial pneumonia, use levofloxacin<br><br>Hypoxemic and/or not tolerating PO but not progressing toward fluid-refractory septic shock or intubation; no loculated or moderate-large effusion, abscess, or necrosis:<br>• Begin empiric therapy per Non-severe/Uncomplicated recommendations<br>• Transition to Outpatient empiric therapy if able to discharge<br><br>Progressing toward fluid-refractory septic shock/intubation, or pneumonia with loculated or moderate-large effusion, abscess, or necrosis:<br>• Begin empiric therapy per Complicated / Severe recommendations<br>• If signs/symptoms of sepsis resolve and patient does not have empyema, abscess or necrosis, transition to non-severe recommendations | • Duration for outpatient therapy: 5 days (IV + oral) |

*Renal adjustment may be necessary. See Pediatric Antimicrobial Dosing Guidelines.

[1]Children who are not up-to-date for age with conjugate vaccines for S. pneumoniae or H. influenza type b

[2]Use amoxicillin-clavulanate ES (600 mg/42.9 mg/5 mL) to limit the risk of diarrhea associated with high doses of clavulanate

[3]Atypical pneumonia is characterized by slow progression of symptoms (over 3-5 days); typical signs/symptoms include, but are not limited to: malaise, sore throat, headache, cough, low-grade fever, and non-focal auscultatory and chest x-ray findings

[4]Low-risk allergies include: pruritus without rash, remote (>10 years) unknown reaction, patient denies allergy but is on record, mild rash with no other symptoms (mild rash: non-urticarial rash that resolves without medical intervention). Medium-risk allergies include: urticaria/hives with no other symptoms, severe rash with no other symptoms (severe rash: requires medical intervention [corticosteroids, anti-histamines] and/or ER visit or hospitalization). See β-lactam allergy evaluation and empiric guidance for further information.

[5]High-risk allergies include: respiratory symptoms (chest tightness, bronchospasm, wheezing, cough), angioedema (swelling, throat tightness), cardiovascular symptoms (hypotension, dizzy/lightheadedness, syncope/passing out, arrhythmia), anaphylaxis. If a patient has a high-risk allergy to penicillins, cephalosporins, or carbapenems, the only beta-lactam antibiotic that can be safely used without Allergy consult is aztreonam (if the allergy is to ceftazidime or aztreonam, aztreonam should be avoided as well). See β-lactam allergy evaluation and empiric guidance for further information.

[6]Previous reactions that are contraindications to further beta-lactam use (except aztreonam, which can be used unless the reaction was to ceftazidime or aztreonam) unless approved by Allergy: organ damage (kidney, liver), drug-induced immune-mediated anemia/thrombocytopenia/leukopenia, rash with mucosal lesions (Stevens Johnson

Syndrome/Toxic Epidermal Necrosis), rash with pustules (acute generalized exanthematous pustulosis), rash with eosinophils and organ injury (DRESS – drug rash eosinophilia and systemic symptoms), rash with joint pain, fever, and myalgia (Serum Sickness). See β-lactam allergy evaluation and empiric guidance for further information.
[7]Refers to patients who were compliant with, and tolerated oral high-dose amoxicillin for >48 hours
[8]TMP-SMX: trimethoprim-sulfamethoxazole
[9]NLFGNR: non-lactose-fermenting gram-negative rods, which include *Pseudomonas aeruginosa*, *Stenotrophomonas maltophilia*, *Acinetobacter* spp., and *Achromobacter* spp.

**References:**

1. Bradley JS et al. The Management of Community-Acquired Pneumonia in Infants and Children Older Than 3 Months of Age: Clinical Practice Guidelines by the Pediatric Infectious Diseases Society and the Infectious Diseases Society of America. Clin Infect Dis. 2011 Oct;53(7):617-30.
2. Kalil AC et al. Management of Adults With Hospital-acquired and Ventilator-associated Pneumonia: 2016 Clinical Practice Guidelines by the Infectious Diseases Society of America and the American Thoracic Society. Clin Infect Dis. 2016 Sep 1;63(5):e61-e111. doi: 10.1093/cid/ciw353.
3. Metlay JP et al. 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. Am J Respir Crit Care Med. 2019 Oct 1;200(7):e45-e67.
4. Pernica JM et al. Short-Course Antimicrobial Therapy for Pediatric Community-Acquired Pneumonia: The SAFER Randomized Clinical Trial. JAMA Pediatr. 2021 May 1;175(5):475-482.
5. Williams D et al. 175. Randomized Double-blind Controlled Trial of Short vs. Standard Course Outpatient Therapy of Community Acquird Pneumoina in Children (SCOUT-CAP). Open Forum Infectious Diseases, Volume 7, Issue Supplement_1, October 2020, Page S216, https://doi-org.proxy.lib.umich.edu/10.1093/ofid/ofaa439.485
6. Bielicki JA et al. Effect of Amoxicillin Dose and Treatment Duration on the Need for Antibiotic Re-treatment in Children With Community-Acquired Pneumonia: The CAP-IT Randomized Clinical Trial. JAMA. 2021 Nov 2;326(17):1713-1724.
7. Same RG et al. The Association of Antibiotic Duration With Successful Treamtent of Community-Acquired Pneumonia in Children. J Pediatric Infect Dis Soc. 2021 Apr 3;10(3):267-273.
8. Waites KB et al. Macrolide-Resistant Mycoplasma pneumoniae in the United States as Determined from a National Surveillance Program. J Clin Microbiol. 2019 Oct 23;57(11):e00968-19. doi: 10.1128/JCM.00968-19.
9. Tamma PD et al. Ventilator-associated tracheitis in children: does antibiotic duration matter? Clin Infect Dis. 2011 Jun;52(11):1324-31. doi: 10.1093/cid/cir203.

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Revision History:

03/21: Updated vancomycin goals

12/21: Major revision: decreased treatment duration, substituted ceftriaxone for clindamycin inpatient, defined severe/complicated pneumonia, added section on drug-resistant pneumonia