Cook Children's Medical Center
Clinical Excellence Committee

Evidence based pathway for the diagnosis and management of community acquired pneumonia

Inclusion Criteria:

-Children and adolescents, from 3 months – 18 years of age, with community-acquired pneumonia

Exclusion Criteria:

-Children younger than 3 months or older than 18 years
-Concern for non-infectious etiology
-Patients with immunodeficiency
-Patients with Empyema (refer to empyema guideline by clicking here)
-Patients with underlying lung disease besides asthma or bronchiolitis, such as CF
-Patients who are trach or vent dependent
-Patients with neuromuscular disease
-Patients with Sickle Cell disease
-Oncology patients
-Patients with concern for aspiration
-Patients with recent hospitalization

Background:

Pneumonia accounts for approximately 2.8 million ambulatory visits and 124,000 hospitalizations among US children each year.[1, 2] This guideline is based largely on the 2011 IDSA Guidelines and subsequent research.

This guideline will address community acquired pneumonia in the outpatient and inpatient setting. Treatment is largely based on severity. For guidelines related to management of empyema, please refer to that guideline.

Below are some characteristics that can differentiate mild pneumonia from severe pneumonia: [3]

Clinical Features of Mild Pneumonia	**Clinical Features of Severe Pneumonia**
Temperature ≤ 38.5 °C	Temperature > 38.5 °C
Mild or Absent Respiratory Distress -Increased RR, but less than Mod/Severe -Mild or absent retractions -No grunting -No nasal flaring -No apnea -Mild shortness of breath	Moderate to Severe Respiratory Distress -RR > 70 in infants, RR > 40 in older children -Moderate/Severe retractions -Grunting -Nasal flaring -Apnea -Moderate/Severe shortness of breath

Clinical Features of Mild Pneumonia (Continued)	Clinical Features of Severe Pneumonia (Continued)
Normal Color	Cyanosis
Normal Mental Status	Altered Mental Status
Oxygen Saturations ≥ 90% on Room Air	Oxygen Saturations < 90% on Room Air
Normal Feeding and Hydration	Poor Feeding and Signs of Dehydration
Normal Heart Rate	Elevated Heart Rate
Capillary Refill ≤ 2 sec	Capillary Refill > 2 sec

Complicated pneumonia:

Involves pneumonia with parapneumonic effusion, necrotizing process, or lung abscess.

Immunization Status:

For the purposes of treating pediatric community-acquired pneumonia, a child with up-do-date vaccinations is defined as one whose *Haemophilus influenzae* Type b and *Streptococcus pneumoniae* vaccines are up-do-date.

Allergy to Penicillin:

To select the most appropriate antimicrobial option, accurately identifying the type of reaction to penicillin is important:

- Non allergic reactions (eg: diarrhea, vomiting, family history)
  - In this case, the patient could likely receive penicillin safely.

- Mild non-IgE reaction (eg: maculopapular rash with or without itching)
  - The patient could be a candidate for **penicillin delabeling** **. If not, a third generation cephalosporin could be used.**

- Serious forms of delayed reactions (eg: Steven Johnson syndrome (SJS), toxic epidermal necrolysis (TEN), drug reaction with eosinophilia and systemic symptoms (DRESS), serum sickness like reactions)
  - **AVOID penicillin, cephalosporins and carbapenems**

- Reaction with features of immediate IgE-mediated allergy (eg: anaphylaxis, hives, urticaria, angioedema, bronchospasm, hypotension)
  - **AVOID penicillin or amoxicillin**. A **cross-reactivity chart** for a penicillin allergy with an immediate reaction could be used to guide the safe administration of alternative β-lactam antibiotics, such as cephalosporins, in patients with documented IgE-mediated hypersensitivity to penicillins. This chart helps clinicians identify which cephalosporins are less likely to cross-react with penicillins based on structural similarities, particularly the R1 side chain [4].

- See table 1 and figure 1

Diagnostic Testing:

1. Chest X-ray
    a. Consider Chest X-ray as an option, though it is not essential for the initial diagnosis of community acquired pneumonia in patients with mild disease who are able to be managed as an outpatient. Chest X-rays should be obtained, in patients who do not show clinical improvement after 48-72 hours with empiric antibiotics to evaluate for complications, such as parapneumonic effusion, that may explain the failure of empiric treatment [5].

    b. Chest X-rays should be obtained in children with significant respiratory distress, hypoxemia or those who are being admitted to the hospital [5].
        This allows for evaluation of the presence of parapneumonic effusions or other complications that may require additional interventions.

    c. Follow-up chest x-rays should be obtained in those patients with progressive worsening, clinical instability or persistent fevers.

    d. For uncomplicated community acquired pneumonia, follow-up chest x-ray is not necessary.

    e. Follow up CXR is recommended for patients with recurrent pneumonia involving the same anatomical location that could lead to a suspicion for lobar collapse, foreign body aspiration, pulmonary sequestration, etc.

2. Pulse oximetry
    a. Pulse oximetry should be performed on all children diagnosed with pneumonia. Sustained saturations of <90% on room air should prompt hospitalization [5].

3. Blood cultures
    a. **Blood cultures are not necessary in a child with uncomplicated community acquired pneumonia**. Obtain blood cultures in less common situations, such as in patients without clinical improvement, those who worsen after starting empiric antibiotics, those with moderate or severe disease, those admitted to an Intensive Care Unit, those with parapneumonic fluid collections or those with features that put them at higher risk for invasive disease [5]. Studies have indicated that blood cultures obtained in these situations are higher yield [6].
        While a blood culture is recommended in the 2011 IDSA guidelines as a potential way of tailoring antibiotic therapy [5], subsequent studies question the value of this recommendation when applied to all admitted patients [7-12]. Based on one study of over 7,500 children, if routine blood cultures were obtained for all children hospitalized with CAP, it would take 667 blood cultures to identify one child who needed their antibiotic coverage expanded beyond the recommended empiric ampicillin [12].
    b. Repeating blood cultures in children with clear clinical improvement is not necessary to document resolution of pneumococcal bacteremia, however repeat blood culture to document resolution of bacteremia should be obtained in

children with *Staphylococcus aureus* bacteremia, regardless of the patient's clinical status [5].

4. Testing for *Mycoplasma pneumoniae*
    a. Molecular testing for *Mycoplasma pneumoniae* should be done on a case-by-case basis. *M. pneumoniae* polymerase chain reaction (PCR), including respiratory PCR panel from nasopharynx or just *M. pneumoniae* PCR from throat swab. PCR testing on throat swabs are superior to nasopharyngeal swabs in *detecting M. pneumoniae[13]*.

        i. *Mycoplasma pneumoniae* should be considered in children older than 5 years with insidious onset of symptoms or/and that failed therapy for typical pneumonia [5]. Younger children have also been infected in the recent national outbreak in 2024. Mycoplasma pneumoniae infection surveillance and trends

        ii. Important to consider the *Mycoplasma pneumoniae* activity in the community, Micro/Viro report.

        iii. The IDSA guidelines recommend testing for *Mycoplasma pneumoniae* in children with signs and symptoms suspicious for it. Two recent systematic reviews found insufficient evidence to recommend or refute treatment of *Mycoplasma pneumoniae* [14, 15]. One recent study found that those patients who were treated with a beta-lactam alone had similar outcomes as those treated with a beta-lactam and a macrolide, even in those patients who tested positive for an atypical pathogen [16]. Given the conflicting studies and lack of clear evidence for or against**; it is recommended that macrolides not be routinely used for treatment of community acquired pneumonia unless a patient tests positive for an atypical pathogen or has lack of improvement with monotherapy using beta-lactams.**

5. Viral Testing
    a. Molecular testing for Influenza +/- RSV +/- other viral testing (ie, SARS-CoV-2) is recommended during influenza and RSV season or at other times when respiratory illnesses are prevalent for children with CAP, as antibiotic therapy is not necessary for those with positive viral testing, unless there is specific clinical, laboratory or radiologic evidence concerning for bacterial coinfection [5], Micro/Viro report.

6. Tuberculosis Testing
    a. Consider tuberculosis testing if history of travel to tuberculosis prevalent areas or concerns for a recent tuberculosis exposure. Tuberculosis risks.
    b. Tuberculin skin test (TST) or blood based testing with IGRAs
        i. IGRA is preferred for children who have received BCG as a vaccine or who are unlikely to return for the TST reading [17].

7. Acute Phase Reactants
    a. Acute-phase reactants, such as C-reactive protein and procalcitonin cannot be used in isolation as the sole determinant in distinguishing viral from bacterial causes of community-acquired pneumonia.

    b. **Consider not starting antibiotics in a child with relatively mild disease who has a procalcitonin value < 0.1 ng/ml**. Procalcitonin value < 0.1 ng/ml has a negative predictive value of 100% (95% CI, 94-100) for bacterial respiratory infections and could be used to reduce administration of antibiotics [18, 19].

    c. For those patients who remain hospitalized with community acquired pneumonia, we recommend discontinuation of antibiotic therapy for their community acquired pneumonia once procalcitonin levels fall below 0.25 ng/ml, as this was shown to be an effective way of reducing antibiotic therapy without increased rate of treatment failure [20, 21].

8. Nares MRSA Screening
    a. Multiple observational studies among adults suggest that MRSA nares PCR testing can be used for antibiotic de-escalation given its high negative predictive value (NPV). Recent pediatric studies have also demonstrated high NPV (99%) in critically ill children with suspected respiratory infection. Negative MRSA nasal PCR testing during the same admission may help to facilitate anti-MRSA de-escalation and prevent adverse effects [22-24].
    b. Nares PCR should be obtained upon the first 24-48 hours of admission in children with severe lobar pneumonia or complicated pneumonia.

9. Tracheal Samples
    a. Lower respiratory tract samples, such as endotracheal aspirates, should be obtained soon after intubation and sent for gram stain and culture in those patients who are high risk for MRSA infection and those with severe disease that require mechanical ventilation [25].

Admission Criteria

1. Children with moderate to severe respiratory distress [5]
2. Children with sustained oxygen saturation < 90% on room air [5]
3. Infants less than 3-6 months of age who are suspected of having bacterial CAP [5]
4. Children with pleural effusion > ¼ of hemithorax on upright chest x-ray [26]
5. Children with suspected or documented CAP with *S. aureus*, as they have a high incidence of necrotizing pneumonia [5]
6. Children who have failed to respond to optimal outpatient therapy for 48-72 hours

Inpatient discharge criteria

1. Improving respiratory rate and work of breathing
2. Feeding well
3. No supplemental oxygen requirement

4. Improving fever curve
5. Able to take oral antibiotics
6. Chest tube removal if applicable

Empiric Antibiotic Therapy

See table 2. Empiric antibiotic therapy in the ambulatory setting, uncomplicated pneumonia
See table 3. Empiric antibiotic therapy in the inpatient setting, uncomplicated pneumonia
See table 4. Empiric antibiotic therapy in the inpatient setting, complicated pneumonia
See table 5. Atypical pneumonia inpatient and outpatient setting.

Detailed Treatment Recommendations

1. **Empiric Ambulatory Therapy**
    a. **Children with up-to-date immunizations against *H. influenzae* type b and *S. pneumoniae*** [5]
        i. Antibiotics are not routinely required for preschool-aged children with community acquired pneumonia well enough to be treated in the ambulatory setting because viral pathogens are responsible for the vast majority of disease in this age group.

        ii. Amoxicillin 45 mg/kg/dose twice daily (max 4 g/DAY) is considered first-line treatment.

        iii. Alternatives include amoxicillin-clavulanate 45 mg/kg/dose twice daily based on amoxicillin component (max 4 g Amoxicillin/DAY). Avoid oral cephalosporins such as cefdinir, which are considered inferior to high dose amoxicillin.

        iv. Given the conflicting studies and lack of clear evidence for or against the treatment of *Mycoplasma pneumoniae*, it is recommended that macrolides not be routinely used for the treatment of CAP, unless patients test positive for *Mycoplasma pneumoniae* or have a lack of improvement with monotherapy using beta-lactams.

        v. Recommended duration of therapy is 5 days for uncomplicated pneumonia [27, 28].

    b. Children with delayed immunizations against *H. influenzae* type b and *S. pneumoniae*
        i. Amoxicillin-clavulanate 45 mg/kg/dose twice daily based on amoxicillin component (max 4 g amoxicillin/DAY) is considered first-line therapy.

ii. Avoid oral cephalosporins such as cefdinir or cefpodoxime, which are considered inferior to high dose amoxicillin.

iii. Recommended duration of therapy is 5 days for uncomplicated pneumonia [27, 28].

c. Children with β-lactam allergies

i. Allergic to pencillins
   1. Cefpodoxime 5 mg/kg/dose PO two times a day. **It is considered inferior choice to alternatives such as amoxicillin for susceptible organisms like *Streptococcus pneumoniae*.** Alternative when need to cover gram negative organisms such as *Hemophilus influezae* or *Moraxella catarrhalis* in patients with penicillin allergy.

ii. Allergic to penicillins and or cephalosporins
   1. Clindamycin 10 mg/kg/dose PO three times daily (max 1,800 mg/DAY). Local *S. pneumoniae* susceptibility to Clindamycin is >90% based on 2023 Cook Children's antibiogram data.

   2. If patient is unable to tolerate clindamycin or is failing therapy, linezolid or levofloxacin could be considered, see below.
      a. Patients on linezolid should receive weekly monitoring of CBCs if therapy duration is 2 weeks or longer.
      b. Children < 12 years old: Linezolid 10mg/kg/dose IV or PO q8hrs (max 1,800 mg/DAY)
      c. Children ≥ 12 years old: Linezolid 600 mg IV or PO q12hrs

   3. Levofloxacin could be considered as alternative, however it has an increased risk of promoting antibiotic resistance, increased risk of *Clostridioides difficile,* and comes with a black box warning.

   4. Avoid macrolides, as local *S. pneumoniae* susceptibility to this group is below 50 % based on 2024 Cook Children's antibiogram data. CCMC Fort Worth Antibiogram 2024

iii. Recommended duration of therapy is 5 days for uncomplicated pneumonia [27, 28].

d. Children who also test positive for influenza

i. For patients with uncomplicated pneumonia who are being treated outpatient, it is not necessary to initially provide empiric treatment against *Staphylococcus aureus*. In those situations, treatment can follow the above recommendations in addition to influenza management.

2. **Empiric Inpatient Therapy for Simple, Uncomplicated Pneumonia**
    a. **Children with up-to-date immunizations against *H. influenzae* type b and *S. pneumoniae***
        i. Ampicillin 50 mg/kg/dose q6hrs (max 8 g/DAY) is considered first-line treatment.
            Based on Cook Children's 2024 Antibiogram, 97% of local *S. pneumoniae* isolates are susceptible to penicillin making the above dose adequate for treatment.

        ii. Alternatives include ceftriaxone 50 mg/kg/dose every 24 hours (max 2 g/DAY), though this should not routinely be used as first-line treatment.

        iii. Recommended duration of therapy is 5 days for uncomplicated pneumonia [27, 28].

    b. **Children with delayed immunizations against *H. influenzae* Type b and *S. pneumoniae***
        i. Ceftriaxone 50 mg/kg/dose every 24 hours (max 2 g/DAY)

        ii. Recommended duration of therapy is 5-7 days [29].

    c. **Children with β-lactam allergies**
        i. If allergic to only Penicillin
            1. Ceftriaxone 50 mg/kg/dose every 24 hours (max 2 g/DAY)

        ii. If allergic to penicillin and cephalosporin
            1. Clindamycin 13mg/kg/dose IV q8hrs (max 2,700 mg/DAY)

            2. If patient is unable to tolerate clindamycin or is failing therapy, linezolid could be considered.
                a. Patients on linezolid should receive weekly monitoring of CBCs if therapy duration is 2 weeks or longer
                b. Children < 12 years old: Linezolid 10mg/kg/dose IV or PO q8hrs (max 1,800 mg/DAY)
                c. Children ≥ 12 years old: Linezolid 600 mg IV or PO q12hrs

            3. Levofloxacin could be considered as alternative, however it has an increased risk of promoting antibiotic resistance, increased risk of *Clostridioides difficile,* and comes with a black box warning.

        vi. Recommended duration of therapy is 5-7 days [29]

    d. Children who also test positive for influenza
        i. For those patients with uncomplicated pneumonia who are being admitted to the medical floor, but are relatively well-appearing, it is not necessary to initially provide empiric treatment against *Staphylococcal*

aureus. In those situations, treatment can follow the above recommendations in addition to influenza management.

3. **Empiric Inpatient Therapy for Complicated or Severe Pneumonia**
    a. Ceftriaxone 50 mg/kg/dose daily (max 2 g/DAY)

        AND

    b. Clindamycin 13mg/kg IV q8hrs (max 2,700 mg/DAY) OR Vancomycin (refer to Vancomycin dosing pathway) OR Linezolid.
        i. Patients on linezolid should receive weekly monitoring of CBCs if therapy duration is 2 weeks or longer.
        ii. Children < 12 years old: Linezolid 10mg/kg/dose IV or PO q8hrs (max 1,800 mg/DAY)
        iii. Children ≥ 12 years old: Linezolid 600 mg IV or PO q12hrs

    c. If positive Flu testing during influenza season:
        i. Oseltamivir (dosing is according to weight and age)

        ii. When initiating empiric antibiotic therapy, vancomycin level will be low, so consider double coverage with linezolid or clindamycin while establishing therapeutic vancomycin levels when treating children with influenza-related critical illness [30].

        iii. Consider Infectious Disease consultation in this situation.

    d. Recommended duration of therapy is 1-4 weeks after discharge from the hospital [5, 31].

4. **Empiric Antibiotics *Mycoplasma pneumoniae***
Mycoplasma pneumoniae should be considered in children older than 5 years with insidious onset of symptoms or that failed therapy for typical pneumonia [32]. Also consider the *Mycoplasma pneumoniae* activity in the community, Micro/Viro report

    a. *Mycoplasmas* lack a cell wall, making them inherently resistant to beta-lactams.

    b. Macrolides are the preferred choice. While resistance has been observed, most strains remain susceptible, and the clinical implications of resistance are not well-defined [32]. If there are concerns about resistance or a lack of improvement with prolonged fever, cough, and/or hospital stay, consider levofloxacin or doxycycline as an alternative. Note the potential adverse effects of these options in children [33, 34].

        i. Azithromycin 10 mg/kg/dose IV or PO x1 on day 1 (max 500 mg/DAY), followed by 5 mg/kg/dose IV or PO once daily for days 2-5 (max 250 mg/DAY)

ii. Levofloxacin has activity against *S. pneumoniae* as well as atypical pathogens, so no additional agents targeting atypicals are needed when levofloxacin is otherwise indicated.
    1. Children ≥6 months to < 5 years old: Levofloxacin 10 mg/kg IV or PO every 12 hours (max 750 mg/DAY) for 7 days
    2. Children ≥5 years old: Levofloxacin 10 mg/kg IV or PO every 24 hours (max 750 mg/DAY) for 7 days

iii. Doxycycline can be considered in rare cases where there is a macrolide allergy, the patient failed macrolide therapy, or there is a contraindication to macrolides (eg, prolonged QT syndrome). Doxycyline has activity against *S. pneumoniae* as well as atypical pathogens, so no additional agents targeting atypicals are needed when doxycycline is otherwise indicated
    1. Doxycycline 1-2 mg/kg/dose (max 100mg/dose) IV or PO twice daily x 7 days

5. Empiric Antibiotics for Suspected Community Acquired MRSA

Consider empiric coverage for MRSA in situations where the patient has a history of MRSA colonization, has history of previous MRSA infection, has a moderate to large pleural effusion on chest x-ray, sepsis, life threatening infection, or has failed to respond after 48-72 hours of optimal antibiotic coverage for community acquired pneumonia.

In addition to antibiotics for pneumonia, add:

i. Clindamycin 13.3 mg/kg/dose IV q8hrs (Max 2,700 mg/DAY) OR Vancomycin (refer to vancomycin dosing pathway) OR Linezolid

ii. Patients on Linezolid should receive weekly monitoring CBCs if therapy duration is 2 weeks or longer
    1. Children < 12 years old: Linezolid 10mg/kg/dose IV or PO q8hrs (max 1,800 mg/DAY)
    2. Children ≥ 12 years old: Linezolid 600 mg IV or PO q12hrs

iii. Longer courses than 5-7 days may be needed for MRSA CAP

6. **Aspiration pneumonia**

Most aspiration events cause a chemical pneumonitis that does not warrant antibiotic therapy. In such cases, no antimicrobials are suggested for mild or moderately ill children.

Duration of antibiotic therapy

a. **The recommended duration for uncomplicated pneumonia is 5 days providing that there is resolution of fever, tachypnea, and supplemental oxygen requirement.**
b. May need to extend duration when complicated by empyema, necrotizing pneumonia, or pulmonary abscess.
c. Early switch to oral antibiotic is encouraged when tolerated.
d. Transient bacteremia with *Streptococcus pneumoniae* in otherwise uncomplicated pneumonia does not warrant prolonged or IV antibiotic therapy [28]
e. Using procalcitonin at presentation and during follow-up ***in conjunction*** with clinical assessment, can help to support the need to start antibiotics and support shorter courses when procalcitonin levels decrease.

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This guideline is intended to assist providers in decision making by providing the current state of evidence and recommendations for the management. This guideline is not meant to replace clinical judgement and will not be appropriate for all cases.

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