How to use this guideline
This document provides guidance in management, including diagnostic evaluation, antimicrobial therapy, procedural management, and disposition, of children with community-acquired pneumonia (CAP). It is not intended to replace clinician judgment in individual cases. However, it should apply to the vast majority of patients diagnosed with CAP. This guideline does not address other pulmonary infections such as COVID-19, bronchiolitis, or tuberculosis.

SARS-CoV-2 Pandemic
During the SARS-CoV-2 pandemic, testing protocols to identify respiratory viruses have changed and are updated frequently to account for testing supply. Please refer to your hospital’s testing guidelines for updated guidance.

Population
Inclusion criteria: children ≥60 days and ≤18 years of age with concern for community-acquired pneumonia (CAP) and treated at UNC Children’s Hospital or affiliated clinics.

Exclusion criteria:
- Immunocompromised status (malignancy, autoimmune disease, primary immunodeficiency, HIV infection, bone-marrow or organ transplant recipient)
- Sickle-cell disease
- End-stage renal disease
- Severe underlying pulmonary disease (such as cystic fibrosis or oxygen requirement at home)
- Cyanotic congenital heart disease
- Neurologic or neuromuscular disease that affects respiratory function (such as cerebral palsy, cervical spinal cord injury, or muscular dystrophy)
- Presence of artificial airway, with or without need for supplemental oxygen or ventilator support
- Any condition that, in the view of the care team, significantly increases the risk of adverse outcomes of CAP

Important Distinctions
Sepsis: Sepsis is defined according to UNC Children’s Sepsis Pathways. When a patient is identified as having sepsis, Sepsis Pathways take precedence over this document.

Severity of pneumonia: Definitions can be found on Page 2. Pneumonia is divided into “Mild,” “Moderate,” and “Severe.” Most patients with mild pneumonia do not require admission to the hospital. Most patients with moderate or severe pneumonia are hospitalized.

Complications of pneumonia: These generally refer to intrathoracic complications, including significant parapneumonic pleural effusion, pleural empyema (infection within the pleural space), and intraparenchymal lung abscess.
Inclusion Criteria
- Age ≥60 days to 18 years
- Healthy without major underlying conditions

Exclusion Criteria
- Aspiration risk
- Immune-compromised
- Sickle-cell disease
- Recent hospitalization (<30 days)
- Underlying neuromuscular disease or lung disease other than asthma
- Tracheostomy

START
Initial Clinical Findings Concerning for CAP?

YES
Concern for Sepsis?

YES
Proceed with evaluation per Code Sepsis. If pneumonia considered, evaluate as recommended below under "Severe"

NO
OFF Algorithm

NO
Determine Severity of Pneumonia (see below)

Admit to pediatric floor
- Recommended respiratory testing: RPP with COVID-19
- Start IV antibiotics (see Page 5: Antibiotic Selection)
- Obtain CXR
- Obtain blood culture only if patient progressing to severe or complicated pneumonia

Admit to PICU**
- Recommended respiratory testing: RPP with COVID-19
- Start IV antibiotics (see treatment guideline)
- Diagnostic Tests:
  - Obtain CXR, CBC diff, BMP, blood culture
  - Respiratory culture if intubated
- **Note: May go to intermediate bed if ONLY severe feature is requiring HFNC. Requires approval of admitting attending.

MILD
Discharge home
- Recommended respiratory testing: Rapid PCR for flu/RSV/COVID-19
- Start PO antibiotics (see Page 5: Antibiotic Selection)
- Arrange follow up

Moderate
Severe features develop?

Proceed to Page 3: Complicated pneumonia

NO
Concer for significant pleural effusion or lung abscess?

YES
COVID-19?

NO
Influenza?

YES
RPP positive for Pertussis, Mycoplasma pneumoniae, or Chlamydia pneumoniae?

NO
Assess continuously. Patient improving?

YES (Floor)
Discharge Criteria:
- Stable on room air
- Tolerating PO

YES (PICU)

Considerations for patients who fail to improve
- Alternative diagnosis, such as a separate infection with pulmonary manifestations
- Antibiotic resistance
- Development of lung abscess or empyema
- Uncommon pathogen (e.g., Legionella, mycobacteria including TB, fungal infection such as histoplasmosis)
- Immunocompromised state (e.g., HIV)

Pneumonia Severity Assessment
Note: if overlapping, assign more severe category

<table>
<thead>
<tr>
<th></th>
<th>MILD</th>
<th>MODERATE</th>
<th>SEVERE</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Appearance</td>
<td>Well-appearing or mildly ill</td>
<td>Ill-appearing</td>
<td>Toxic or lethargic</td>
</tr>
<tr>
<td>Oxygen Requirement</td>
<td>None</td>
<td>Standard nasal cannula</td>
<td>HFNC or non-invasive or invasive ventilation</td>
</tr>
<tr>
<td>Signs of respiratory distress</td>
<td>None or minimal</td>
<td>Moderate retractions, head bobbing, and/or nasal flaring</td>
<td>Severe retractions, head bobbing, and/or nasal flaring</td>
</tr>
<tr>
<td>Signs of sepsis?</td>
<td>Absent</td>
<td>Absent</td>
<td>Present</td>
</tr>
<tr>
<td>Hydration status</td>
<td>Able to maintain adequate hydration</td>
<td>Unable to maintain adequate hydration</td>
<td>Unable to maintain adequate hydration</td>
</tr>
</tbody>
</table>

Please refer to institutional COVID-19 testing recommendations for the most updated testing guidance. Manage as symptomatic patients.
**Initial Management of Empyema**

<table>
<thead>
<tr>
<th>Labs</th>
<th>CBC/diff, CMP, CRP, blood culture.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consults</td>
<td>Pediatric Surgery, Pulmonology, ID</td>
</tr>
<tr>
<td>Antibiotics</td>
<td>See page 5 for details. Use oseltamivir or remdesivir for patients with influenza or COVID-19, respectively.</td>
</tr>
<tr>
<td>Imaging</td>
<td>Following initial US, additional imaging not routinely required. Chest CT with contrast in selected cases (e.g., to rule out lung abscess), in consultation with Pediatric Surgery.</td>
</tr>
</tbody>
</table>

**Procedural Management of Empyema**

- Preferred option: chest tube to be placed by Pediatric Surgery, with or without video-assisted thoracoscopic surgery (VATS) depending on duration of symptoms.
- IPA instillation Q24 hours x 3 doses should be given after chest tube placement.
- Send pleural fluid for Gram stain and culture, cell counts (AFB and fungal cultures if suspected). Optional: pH, glucose, LDH.

If worsening or not improving by 72 hours, consider the following:
- Recheck CBC/diff, CRP, imaging
- Progress to VATS procedure if not done previously

**Initial Management of Necrotizing Pneumonia / Lung Abscess**

- Labs: CBC/diff, CMP, CRP, blood culture. If intubated, send ETT aspirate for culture.
- Imaging: CT chest with contrast
- Consults: Pediatric Surgery, Pulmonology, ID
- Antibiotics: See page 5 for details. Use oseltamivir or remdesivir for patients with influenza or COVID-19, respectively.

**Ongoing Management of Necrotizing Pneumonia / Lung Abscess**

- Supportive Care: Admit to ICU or floor as indicated.
- Differential Diagnosis: Consider atypical causes, such as TB, infected CPAM, FB aspiration, vasculitis
- Labs: As indicated; suggest monitoring every 2-3 days or more as needed.
- Imaging: As indicated; repeat CT rarely indicated
- Procedures: Rarely indicated due to risk of bronchopleural fistula
- Antibiotics: See Page 5 for details. In most cases, prolonged antibiotic duration of 4-6 weeks, generally IV for most of the inpatient course. Antivirals per protocol.

Note: Improvement is usually gradual, and some initial worsening can occur.

**Assess Discharge Criteria**
- Clinically improved
- Pain well-controlled
- Off oxygen x 12+ hours
- Fever curve downtrending
- CRP downtrending
- Tolerating home antibiotics

**Consider**
- Re-evaluate differential diagnosis and antibiotics
- Repeat inflammatory markers
- Repeat imaging
- Consultants and primary team huddle

**Discharge Planning**
- Set antibiotic duration; recommend having meds in hand at discharge
- Follow-ups: Pulm, Surg, ID (ID will generally be for abscess only)
- Flu shot at discharge if indicated
START
Diagnosis of CAP

Yes

Requires Admission? (Moderate or Severe, p2)

No

Yes

Septic?

Influenza?

No

Complicated?

ICU?

Yes

Start oseltamivir (see Page 4)

IF

Follow Code Sepsis protocols (in most cases, vancomycin plus ceftriaxone)

ICU?

NO

If concerned for bacterial infection, consider amp-sulbactam

YES

Linezolid plus ceftriaxone

YES

Reported Penicillin Reactions
Patients reporting penicillin reactions can receive cephalosporins if the reaction was NOT IgE-mediated (anaphylaxis, urticaria, etc) or a severe/delayed reaction such as Stevens-Johnson Syndrome.

No

ICU status: vancomycin plus ceftriaxone

Floor status: amp-sulbactam

YES

Empyema

Lung abscess

ICU status: vancomycin plus amp-sulbactam

Floor status: amp-sulbactam

Yes

Ceftriaxone

No

Vaccinated appropriately for age against Hib and S. pneumoniae?

Yes: Ampicillin
No: Ceftriaxone

Note: for patients who would receive IV ampicillin with limited IV access, PO amoxicillin is acceptable.
### Table 1: Overview of Antibiotic Selection for Children (1 month to 18 years) with CAP

<table>
<thead>
<tr>
<th>Patient Characteristics</th>
<th>Preferred Antimicrobial Therapy</th>
<th>Alternative Antimicrobial Therapy Options</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild (Outpatient)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fully immunized – at least 3 doses of Hib and PCV13, usually at 6-month visit</td>
<td>Amoxicillin</td>
<td>Recent exposure to amoxicillin (last 30 days): Amoxicillin/clavulanic acid</td>
<td>Viruses and pneumococcus are most common causes. Oral cephalosporins are inferior to penicillins for pneumococci. Consider atypical infection in children ≥5 years of age (rare below 5 years)</td>
</tr>
<tr>
<td>Incompletely immunized, including &lt;6 months of age</td>
<td>Amoxicillin-clavulanate</td>
<td>Penicillin allergy: Clindamycin</td>
<td></td>
</tr>
<tr>
<td>Influenza positive, meets criteria for treatment</td>
<td>Oseltamivir</td>
<td>NA</td>
<td>Highest efficacy if oseltamivir started within 48 hours of symptom onset</td>
</tr>
<tr>
<td>Moderate (Inpatient, Floor)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fully immunized (as above)</td>
<td>Ampicillin</td>
<td>Ceftriaxone</td>
<td>Underimmunization increases the patient’s risk of infection caused by <em>Haemophilus influenzae</em> type b and <em>Streptococcus pneumoniae</em>.</td>
</tr>
<tr>
<td>Not fully immunized, not meeting “Severe CAP” criteria (Table 1), ≥ 1 month old</td>
<td>Ceftriaxone</td>
<td>Cephalosporin allergy: Levofloxacin</td>
<td>Most patients with influenza do not require antibiotics.</td>
</tr>
<tr>
<td>Influenza positive</td>
<td>Oseltamivir</td>
<td>If antibiotics indicated, ampicillin-sulbactam preferred</td>
<td></td>
</tr>
<tr>
<td>Complications: empyema or lung abscess</td>
<td>Ampicillin-sulbactam</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥ 1 month old and admitted to PICU without influenza or complications</td>
<td>Ceftriaxone</td>
<td>May add clindamycin or vancomycin if empiric MRSA coverage indicated (e.g., recent MRSA infection, known MRSA colonization, recent hospitalization [60 days]).</td>
<td>Send ETT aspirate cultures from all patients at intubation (or ASAP)</td>
</tr>
<tr>
<td>≥ 1 month old and admitted to PICU with influenza</td>
<td>Linezolid PLUS ceftriaxone PLUS oseltamiv</td>
<td></td>
<td>Consider de-escalating anti-MRSA agents if MRSA is not identified in cultures.</td>
</tr>
<tr>
<td>Admitted to PICU with complications (empyema or lung abscess)</td>
<td><strong>Empyema:</strong> Vancomycin plus ceftriaxone PLUS oseltamiv</td>
<td>Clindamycin OR vancomycin may be used in place of linezolid if patient is unable to tolerate linezolid (e.g., thrombocytopenia, multiple serotonergic drugs)</td>
<td></td>
</tr>
</tbody>
</table>

Updated: 2/15/2021

Developed by: UNC Children’s & Carolina Antimicrobial Stewardship Program
## Table 2: IV to PO conversion/de-escalation

<table>
<thead>
<tr>
<th>IV Antibiotic</th>
<th>Recommended PO Antibiotic</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ampicillin</td>
<td>High-dose amoxicillin</td>
<td>High-dose = 90 mg/kg/day of amoxicillin</td>
</tr>
<tr>
<td>Ampicillin-sulbactam</td>
<td>High-dose amoxicillin/clav</td>
<td></td>
</tr>
<tr>
<td>Ceftriaxone</td>
<td>High-dose amox/clav</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cefuroxime (preferred cephalosporin)</td>
<td>Amox/clav preferred if no penicillin allergy. Cefuroxime or cefdinir may be used in patients with penicillin allergy</td>
</tr>
<tr>
<td>Linezolid</td>
<td>Linezolid</td>
<td>In absence of positive cultures for <em>Staphylococcus aureus</em>, consider discontinuation of linezolid</td>
</tr>
</tbody>
</table>

## Table 3: Antibiotic dosing recommendations

<table>
<thead>
<tr>
<th>Antimicrobial</th>
<th>Dose</th>
<th>Max Dose</th>
<th>Route</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amoxicillin</td>
<td>90 mg/kg/day divided BID</td>
<td>2000 mg</td>
<td>PO</td>
<td>Dosing based on amoxicillin component. Recommended formulations: amoxicillin 600 mg / 42.9 mg clavulanate (14:1) (Not on inpatient formulary) amoxicillin 400 mg / 57 mg clavulanate suspension (7:1) amoxicillin 875 mg / 125 mg clavulanate tablet (7:1)</td>
</tr>
<tr>
<td>Amoxicillin / clavulanic acid</td>
<td>90 mg/kg/day divided BID</td>
<td>2000 mg amoxicillin</td>
<td>PO</td>
<td></td>
</tr>
<tr>
<td>Ampicillin</td>
<td>200 mg/kg/day divided q6h</td>
<td>2000 mg</td>
<td>IV</td>
<td>Dosing based on ampicillin component</td>
</tr>
<tr>
<td>Ampicillin / sulbactam</td>
<td>200 mg/kg/day divided q6h</td>
<td>2000 mg ampicillin</td>
<td>IV</td>
<td></td>
</tr>
<tr>
<td>Azithromycin</td>
<td>10 mg/kg on day 1, followed by 5 mg/kg once daily for days 2 through 5</td>
<td>500 mg (day 1) 250 mg (days 2-5)</td>
<td>IV / PO</td>
<td>May be used in patients with severe penicillin allergy. Not preferred due to low activity against Pneumococcus</td>
</tr>
<tr>
<td>Cefdinir</td>
<td>14 mg/kg/day BID</td>
<td>300 mg</td>
<td>PO</td>
<td>May be used in patients with severe penicillin allergy. Not preferred due to low activity against Pneumococcus</td>
</tr>
<tr>
<td>Ceftriaxone</td>
<td>50 mg/kg once daily</td>
<td>2000 mg</td>
<td>IV</td>
<td>Preferred cephalosporin for Pneumococcus; Suspension not on inpatient formulary, has unpleasant taste</td>
</tr>
<tr>
<td>Cefuroxime</td>
<td>30 mg/kg/day BID</td>
<td>500 mg</td>
<td>PO</td>
<td>Preferred cephalosporin for Pneumococcus; Suspension not on inpatient formulary, has unpleasant taste</td>
</tr>
<tr>
<td>Clindamycin</td>
<td>40 mg/kg/day divided TID</td>
<td>600 mg (IV) 450 mg (PO)</td>
<td>IV / PO</td>
<td>Doses &gt; 450 mg may be given orally; however, GI distress may occur.</td>
</tr>
<tr>
<td>Doxycycline</td>
<td>2 mg/kg/dose BID</td>
<td>100 mg</td>
<td>IV / PO</td>
<td></td>
</tr>
<tr>
<td>Levofoxacin</td>
<td>&lt; 5 yo: 10 mg/kg BID</td>
<td>750 mg</td>
<td>IV / PO</td>
<td>May be used in patients with severe beta-lactam allergy (e.g., IgE-mediated reaction, anaphylaxis)</td>
</tr>
<tr>
<td></td>
<td>≥ 5 yo: 10 mg/kg daily</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Linezolid</td>
<td>&lt; 12 yo: 10 mg/kg TID</td>
<td>600 mg</td>
<td>IV / PO</td>
<td>Only use if influenza PCR test positive or if patient admitted to PICU with high concern for influenza</td>
</tr>
<tr>
<td></td>
<td>≥ 12 yo: 10 mg/kg BID</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oseltamivir</td>
<td>3 mg/kg/dose BID</td>
<td>75 mg</td>
<td>PO</td>
<td>Place inpatient consult to pharmacy for vancomycin dosing &amp; monitoring. Target troughs 15-20 mg/L.</td>
</tr>
<tr>
<td>Vancomycin</td>
<td>15-20 mg/kg/dose q6-8h</td>
<td>2000 mg</td>
<td>IV</td>
<td>Place inpatient consult to pharmacy for vancomycin dosing &amp; monitoring. Target troughs 15-20 mg/L.</td>
</tr>
</tbody>
</table>