Community Acquired Pneumonia with Complications

Phoenix Children's Clinical Pathway

Disclaimer

This clinical pathway is not intended to replace clinical judgment. It is meant to assist licensed independent practitioners and other health care providers in clinical decision-making by describing a range of generally acceptable approaches to the diagnosis and management of a particular condition. A particular patient's circumstances should always be taken into account when a practitioner is deciding on a course of management.

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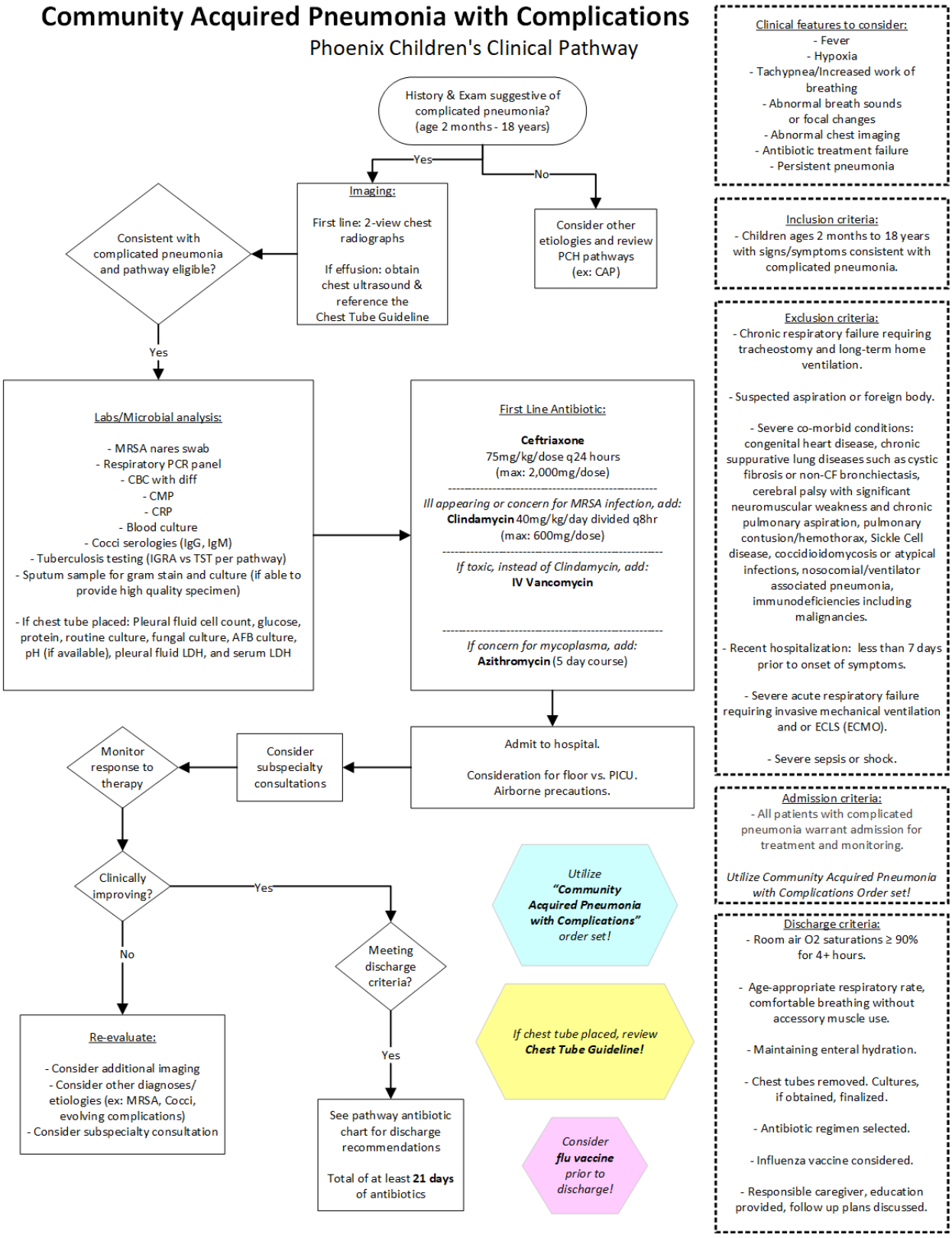
Pathway Flow Diagram



Scope & Definitions

Assist in the evaluation and management of pediatric patients requiring hospitalization for suspected complicated pneumonia.

Complicated pneumonia: Signs and symptoms of pneumonia (such as fever, tachypnea, increased work of breathing, hypoxia, focal changes on lung auscultation) along with complicating features noted on imaging such as moderate-large pleural effusions with or without loculations/septations, hydropneumothorax, or necrotizing pneumonia/pulmonary gangrene or lung abscess.

Consider especially in children with respiratory illness who appear unwell; in the setting of treatment failure; or persistent and/or recurrent pneumonias.

Inclusion Criteria:

1. Hospitalized children ages 2 months-18 years.
2. Signs and symptoms (acquired outside of the hospital) consistent with diagnosis of Complicated Community Acquired Pneumonia (CCAP).

Exclusion Criteria:

1. Chronic respiratory failure requiring tracheostomy and long-term home ventilation.
2. Suspected aspiration or foreign body.
3. Severe co-morbid conditions to include: congenital heart disease, chronic suppurative lung diseases such as cystic fibrosis or non-CF bronchiectasis, cerebral palsy with significant neuromuscular weakness and chronic pulmonary aspiration, pulmonary contusion/hemothorax, Sickle Cell disease, high suspicion for coccidioidomycosis or atypical infections, nosocomial/ventilator associated pneumonia, immunodeficiencies including malignancies.
4. Recent hospitalization – defined as less than 7 days prior to onset of symptoms.
5. Severe acute respiratory failure requiring invasive mechanical ventilation, and/or ECLS (ECMO).
6. Severe sepsis or shock.

Pathway Goals

Provide streamlined, evidence-based management recommendations for community acquired pneumonia with complications. The recommendations include considerations for imaging and laboratory testing, antibiotic therapy selection, involvement of consultations, pleural drainage procedures, and monitoring parameters.

Associated pathways & Guidelines: Community Acquired Pneumonia (CAP) pathway, Chest Tube guideline.

Key Clinical Recommendations with Evidence Based Supporting Material

1. Admission criteria:
    a. All patients with complicated pneumonia warrant admission for treatment and monitoring.
        i. Utilize Community Acquired Pneumonia with Complications order set.

2. Imaging:
    a. First line: Chest radiograph (CXR), anteroposterior and lateral views.
    b. If effusion present: Ultrasound (US), as gold standard to evaluate the extent and nature of a fluid collection.
    c. If concern for parenchymal lung disease/necrotizing pneumonia/lung abscess, or for guidance where CXR/US provide inadequate visualization: Chest computed tomography (CT) with contrast.

3. Routine labs:
    a. CBC with differential
    b. CMP
    c. C-reactive protein (CRP)
    d. Blood culture
    e. If chest tube is placed: serum LDH and take note of protein level on CMP
    f. Microbiological analysis as below

4. Microbial testing:
    a. MRSA nasal swab (ideally before starting MRSA-directed antibiotics):
        i. All inpatients with complicated pneumonia
        ii. In setting of influenza positivity if the patient is not responding to appropriate antibiotic therapy as expected, is clinically decompensating, or concern for MRSA co-infection otherwise arises.

    b. Respiratory PCR panel:
        i. All inpatients with complicated pneumonia.
        ii. Note: Full PCR can be added on to Quad Screen specimen if already obtained in ED.

    c. Coccidioidomycosis/ “Valley Fever” testing with serum antibodies (IgM/IgG):
        i. All inpatients with complicated pneumonia.

    d. Tuberculosis testing:
        i. All patients with complicated pneumonia.
            1. TST/PPD: Preferred in patients who are less than 2 years old. May be less reliable in patients who have received the BGC vaccine, however, if obtained and the result is negative, no further testing is necessary; if the result is positive, an IGRA should be performed.
            2. QuantiFERON gold/IGRA: Preferred in patients who are over 2 years old.

3. Indeterminate/invalid IGRA results are more common in very young children (younger than 2 years) and immunosuppressed patients. When an IGRA result is indeterminate/invalid, either a repeat IGRA test using the same or another IGRA can be performed, ensuring proper technique of specimen collection and processing, or a TST can be performed.
4. Note: A negative result of either the TST or an IGRA should be considered especially unreliable in a child younger than 3 months.
5. Airborne precautions are recommended while test pending and with any positive test; if no airborne rooms available while test pending, consider discussion with ID to risk stratify.

e. Pertussis PCR:
    i. Consider if there is clinical suspicion for pertussis (prolonged coughing spasms, apnea, etc., especially in infants and unvaccinated children). Can be added onto Respiratory PCR if already collected.

f. Atypical bacteria (Mycoplasma, Chlamydophila) testing:
    i. Not routinely indicated but can be obtained if clinical suspicion arises, such as in a school-age child with non-focal lung findings.
    ii. If clinical suspicion for atypical pneumonia, consider empiric coverage with Azithromycin.
    iii. Note: Mycoplasma pneumoniae is included with full respiratory PCR swab.

g. Sputum gram stain and culture:
    i. Collect from inpatients with complicated pneumonia as able. Send only high-quality specimens from endotracheal tubes or cooperative children who can produce an adequate specimen, (typically 8 years and older).
    ii. High quality sputum sample is defined by the presence of <10 squamous epithelial cells and > 25 WBCs per low power field.

h. Pleural fluid:
    i. Collect from all inpatients with a chest tube.
    ii. Pleural fluid cell count, glucose, protein, routine culture, fungal culture, AFB culture, pH (if available), LDH.

i. Note: For PCH satellite hospital Arrowhead, most studies can be performed on site yet some will require transport to Thomas campus (MRSA nares, Cocci testing, pertussis PCR, sputum gram stain and culture, pleural fluid testing). Timely processing may require communication with the Arrowhead lab.

5. Antibiotics:
    a. **First line:** IV ceftriaxone 75mg/kg/dose q24 hours (max: 2,000mg/dose).
    b. If concern for **MRSA infection or child is ill appearing,** consider addition of clindamycin.
    c. **If toxic appearing,** add vancomycin pending clinical response and culture data.
        i. Obtain MRSA nares testing prior to starting MRSA-directed antimicrobials!

6. Antibiotic Allergy Considerations:
    a. If penicillin allergic but no anaphylaxis history:
        i. Clindamycin IV/PO 40mg/kg/day divided q8 hours.
    b. If penicillin allergic with severe allergy or known anaphylaxis history, or failed clindamycin treatment:
        i. Levofloxacin IV/PO (see dosing table below).

7. Influenza directed treatment: Oseltamivir is recommended for influenza positive patients who are:
    a. Admitted to the hospital, **even if onset of illness at presentation is >48hr from presentation.**
    b. Experiencing severe, complicated, or progressive influenza illness.
    c. At risk for severe influenza disease/complications, even if an outpatient.
        i. Consideration should be given to potential side effects and shared decision-making with the family/patient.

8. COVID-19/SARS-CoV-2 directed-treatment: Dexamethasone & Remdesivir +/- VTE prophylaxis
    a. Remdesivir: indicated for patients who test positive, who are ≥28 days old and weighing ≥3kg and are hospitalized and requiring supplemental oxygen (or higher supplemental oxygen from home baseline); also consider for those who are not hospitalized yet have mild-moderate disease and are at high risk for progression to severe disease or hospitalization (refer to separate document "Treatment of High Risk Patients with Mild, Acute COVID-19").
        i. For patients ≥ 28 days and between ≥ 3 kg to <40kg:
        5 mg/kg (max dose 200 mg) on Day 1, followed by once-daily maintenance doses of 2.5 mg/kg (max dose 100 mg) from Day 2, administered only via intravenous infusion.
        ii. For adults and pediatric patients weighing ≥40 kg:
        200 mg on Day 1, followed by once-daily maintenance doses of 100 mg from Day 2, administered only via intravenous infusion.
        iii. Remdesivir should be given for 5 days or until hospital discharge, whichever comes first.
    b. Dexamethasone: indicated for patients with hypoxemia <94% requiring oxygen therapy
        i. Dose of 0.15 mg/kg (max 6 mg) PO/IV daily up to 10 days or until discharge from the hospital/resolution of acute COVID-19 illness, whichever is shorter.

9. Venous thromboembolism (VTE) prophylaxis: Refer to the VTE Prophylaxis in COVID-19 Patients document on InDEx under Patient Management.

10. Airway Clearance Therapy (ACT): Current evidence does not support the universal, routine use of ACT in otherwise healthy children with complicated pneumonia, unless there is diminished function of the mucociliary escalator and/or cough mechanics are altered, and ability to mobilize and/or expectorate airways secretions is compromised.

11. Chest tubes & Fibrinolytic Instillation:
    a. Consult with Interventional Radiology (IR) to place chest tube and assist with management. Typically, IR will discuss case directly with Pediatric Surgery if escalation to surgical chest tube is necessary.
    b. If the patient is in the PICU, the Intensivist may choose to place and manage the chest tube.
        i. If the tube was placed by an outside hospital or the PCH ED, and patient transferred to the floor, determine which team will manage the tube (see "Drain Ownership Overview" in Chest Tube Guideline).
    c. If chest tube is placed, collect: Pleural fluid cell count, glucose, protein, routine culture, fungal culture, AFB culture, pH (if available), pleural LDH.
        i. Serum LDH and protein levels should also be obtained to calculate pleural fluid/serum LDH and protein ratios with Light's criteria.
        ii. pH <7.2 is a strong predictor of pleural infection.
    d. Intrapleural fibrinolytic therapy using tPA (tissue plasminogen activator) +/- DNase should be individualized and plan developed in consultation with the managing proceduralist (IR, Pediatric Surgery or PICU Intensivist).

12. Infectious Diseases (ID) subspecialty consult should be considered if:
    a. Complicated pneumonia (with moderate-large or complex effusion, severe pleuropulmonary infections, necrotizing pneumonia, lung abscess, clinical concerns, etc).
    b. Pulmonary coccidioidomycosis or concern for atypical infection.
    c. Treatment failure secondary to antibiotic resistance or suspicion for atypical infections.
    d. Persistent pneumonia in an unwell child with persistent symptoms despite 48 hours of appropriate antibiotic therapy.
    e. Complicated pneumonia as the first presentation of an underlying immunodeficiency.
    f. Severe COVID-19/SARS CoV-2 pneumonia.
    g. Need for pleural drainage/chest tube.

13. Interventional Radiology (IR) consult should be considered if:
    a. Complicated pneumonia with imaging characteristics which may require chest tube placement.
    b. See Chest Tube Guideline.

14. Pediatric Surgery consult should be considered if:
    a. Complicated pneumonia with imaging characteristics or persistent disease which may require surgical chest tube placement or other surgical intervention. Typically, IR will discuss case directly with Pediatric Surgery if escalation to surgical chest tube is necessary.

15. Pediatric Pulmonology consult should be considered if:
    a. Complex, severe pleuropulmonary infection requiring pleural drainage.
    b. Necrotizing pneumonia.
    c. Lung abscess.
    d. Recurrent lower respiratory tract infections.
    e. Concern that complicated pneumonia as the first presentation of an underlying condition such as cystic fibrosis, immunodeficiency, or congenital thoracic malformation (particularly in infants).

16. Monitoring and Determining Response to Therapy:
    a. See Chest Tube Guideline.
    b. Daily chest radiograph (CXR) while tube is in place.
    c. Monitoring of chest tube output.
    d. Consider chest tube removal when there is clinical response to therapy, no air leak, and drainage is less than 1-1.5ml/kg/day over the previous 24 hours, in consultation with proceduralist.

17. Treatment failure:
    a. If no improvement in fever curve, respiratory exam or systemic oxygenation after 48-72 hours of appropriate antibiotic therapy and/or pleural drainage, a repeat CRP and ultrasound (or CT scan depending on clinical scenario) should be obtained. Additional laboratory evaluations, imaging, adjustments in the antibiotic therapy and consultation should be considered.
    b. If a patient with a chest tube experiences clinical deterioration despite appropriate intrapleural fibrinolytic therapy, consideration should be made with multidisciplinary team for primary surgical management (for example, surgical chest tube, a mini-thoracotomy, or VATS).

18. Duration of antibiotic therapy:
    a. Minimum of 21 days (from initiation of appropriate therapy, or from time of chest tube drainage), or longer depending on clinical scenario. Discuss route, monitoring, and length of therapy with ID.

19. Discharge planning:

    a. Patients may be eligible for discharge when they demonstrate a decreasing fever curve, improving PO intake and activity, maintained adequate oxygenation with SpO2>90% for 12-24 hours on room air, have had chest tube removed without decompensation for 12-24 hours, cultures finalized (if obtained), influenza vaccine considered, and outpatient follow up with the PCP/necessary subspecialists has been arranged.

20. Discharge antibiotics:
    a. Ceftriaxone step-down therapy at discharge:
        i. Amoxicillin-Clavulanate 90mg/kg/day divided TID is first line step-down therapy (if no penicillin allergy) unless cultures are available to direct/narrow therapy.
        ii. Clindamycin PO: if penicillin allergic but no anaphylaxis history.
        iii. Levofloxacin IV: if penicillin allergic with severe allergy or known anaphylaxis history, or failed clindamycin treatment.

Medication Dosing Table

Medication & Route	Dosing & Frequency	Indications
Amoxicillin-Clavulanate (PO)	*Suspension:* *Amoxicillin-clavulanate ES 600-42.9mg/5mL:* **30mg/kg/dose TID** (max: 1,000mg/dose for suspension) or *Tablets:* *[if >30kg and able to swallow tabs]* **875mg-125mg/dose BID** (max: 875mg-125mg BID)	Step-down therapy from ceftriaxone (if no penicillin allergy). Recommend keeping clavulanate component <10mg/kg/day to mitigate potential GI side effects.
Azithromycin (IV or PO)	10mg/kg once for day 1 dose (max: 500 mg/dose) followed by 5mg/kg/day (max: 250mg/dose for days 2-5 (max day 1: 500mg/day, max days 2-5: 250mg/day)	For symptomatic patients with suspected atypical organisms such as Mycoplasma or Chlamydophila. Duration of therapy is 5 days.
Ceftriaxone (IV)	75mg/kg q24hr (max 2,000mg/dose)	First line treatment. If no history of B-lactam allergy.
Clindamycin (IV or PO)	13mg/kg/dose q8hr (max:600mg/dose)	For MRSA coverage. IV clindamycin and PO clindamycin are equivalent; prefer PO as appropriate.
Levofloxacin (IV or PO)	Infants ≥ 6mo and Children <5yrs: 10mg/kg/dose q12hr (max: 750mg/dose) --- Children ≥5yrs: 10mg/kg/dose q24hr (max: 750mg/dose)	Recommended if penicillin allergic with severe allergy or known anaphylaxis history, or failed Clindamycin treatment. PO step down therapy from ceftriaxone only if penicillin allergic with severe allergy or known anaphylaxis history.
Oseltamivir (PO)	Infants: ≤ 8mo: 3mg/kg/dose BID ≥ 9mo: 3.5mg/kg/dose BID Children: ≤15kg: 30mg BID >15-23kg: 45mg BID >23-40kg: 60mg BID >40kg: 75mg BID	Administer to patients with influenza, ideally within the first 48hr of symptom onset but is recommended for **any hospitalized patient with influenza** regardless of time frame. Discuss potential side effects with family/ patient, use shared decision-making. Duration of therapy is 5 days.
Vancomycin (IV)	Children <13 years: 15mg/kg/dose q6hr Children ≥ 13 years: 15mg/kg/dose q8hr	First Vancomycin trough typically before 4th dose due. Discuss monitoring with Pharmacist.

Admission Criteria

1. All patients with complicated pneumonia warrant admission for treatment and monitoring.
2. Hypoxemia, defined as room air oxyhemoglobin saturations consistently less than 90%, and subsequent need for supplemental oxygen.
3. Marked and/or persistent respiratory distress.
4. Dehydration with inability to take adequate volumes of fluids enterally.
5. Failed outpatient treatment (with confirmed appropriate antibiotic and duration).
6. Ill or toxic appearing.
7. Altered mental status.
8. Concern regarding the ability of the child to be cared for and followed-up appropriately as an outpatient.

Discharge Criteria

1. Room air saturations >90% for at least 4 hours.
2. Age-appropriate respiratory rate without accessory muscle use.
3. Chest tubes removed. Cultures, if obtained, finalized.
4. Maintaining adequate enteral hydration.
5. Influenza vaccine discussed with family and administered prior to discharge, if clinically appropriate and consent is provided.
6. Responsible and capable caregiver(s) to care for the child as an outpatient.
7. Follow up plans in place.
8. Discharge education including medication administration and specific return precautions completed.

Patient and Family Education/Discharge Planning

1. Begin discharge education upon presentation.
2. Identify family's preferred outpatient pharmacy.
3. Plan to send outpatient prescriptions 24 hours prior to discharge.
4. Involve case management and social work upon admission if special needs exist that may be expected to delay discharge.
5. Review antibiotic administration including dosage, frequency, length of therapy, taste, and potential side effects.
6. Review education material with caregiver(s) and teach signs of worsening respiratory distress, signs of inadequate oral intake and signs of allergic reaction.
    a. Emily Center patient education hand out for Pneumonia is available and families should be encouraged to review.
7. Discuss with family the benefits of influenza vaccine, offer vaccination while inpatient if not yet received.
8. Review whom to contact for questions or problems and reasons to call a physician or return to the Emergency Department.

Evidence Based Supporting Material

a) Chest radiographs should be considered when: patient has hypoxemia or significant respiratory distress, clinical findings are ambiguous such as children less than 5 years old and febrile without a source, concern for moderate-to-severe pneumonia, suspected complicated pneumonia, or persistent pneumonia with no clinical improvement despite appropriate antibiotic therapy (concern for treatment failure).

b) Procalcitonin and CBC may be helpful to support a diagnosis of bacterial pneumonia. The likelihood of a bacterial cause does increase with WBC counts above 15,000. CRP and ESR are useful for evaluation and to trend response to therapy.

c) Mixed etiologies with multiple organisms account for 30-50% of CAP but *Streptococcus pneumoniae* is the most common cause of bacterial pneumonia.

d) Streptococcus pneumoniae is the most common cause of bacterial pneumonia. When stratifying PCH's pneumococcal culture results from blood and CSF isolates, the susceptibility rate of Penicillin G was 97% from May 2022 - April 2024.

e) Streptococcus pneumoniae has a susceptibility rate of 89% to clindamycin as evidenced by isolates from May 2022 – April 2024.

f) Methicillin resistant *Staphylococcus aureus* (MRSA) is responsible for an increasing number of CAPs, particularly complicated pneumonia. Consider treatment against MRSA when significant risk factors are present (past MRSA infection in patient and/or family) or if the patient fails to respond to conventional therapy, especially in the setting of influenza co-infection.

g) Institutionally, MRSA is 84% susceptible to clindamycin in 2023, thus, is the preferred oral step-down treatment for penicillin allergic children with pneumonia.

h) In a multicenter study, cefdinir had a reported susceptibility rate of 59.1% in pediatric blood culture-positive patients with pneumonia. Ceftriaxone susceptibility rates were reported as 88.9% which provides evidence that we are not able to infer cefdinir susceptibility rates from ceftriaxone, despite both being 3rd generation cephalosporins. Thus, is not ideal for treating penicillin-class allergic patients and **is not** the preferred choice for Ceftriaxone step-down therapy.

i) Per the AAP, "Antiviral treatment of influenza is recommended for children with suspected (eg, influenza-like illness [fever with either cough or sore throat]) or confirmed influenza who are hospitalized, have severe or progressive disease, or have underlying conditions that increase their risk of complications of influenza, regardless of duration of illness. Antiviral treatment should be initiated as soon as possible. Antiviral treatment may be considered in the outpatient setting for symptomatic children with suspected or confirmed influenza disease who are not at high risk for influenza complications if treatment can be initiated within 48 hours of illness onset. Antiviral treatment may also be considered for children with suspected or confirmed influenza disease whose siblings or household contacts either are younger than 6 months or have a high-risk condition that predisposes them to complications of influenza. Antiviral chemoprophylaxis is recommended for the prevention of influenza virus infection as an adjunct to vaccination in certain

individuals, especially exposed children who are at high risk for influenza complications but have not yet been immunized or those who are not expected to mount an effective immune response."

j) Measuring pleural fluid pH has been shown to be one of the best predictors of pleural infections in children and adults when obtained correctly (if <7.2). Additionally, blood LDH and protein level can be used to calculate ratios based on Light's criteria.

k) Simple, small, pleural effusions in CAP may respond to antibiotics alone and resolve with conservative management. Complicated pneumonia with complex effusions, moderate-large effusions or empyema or other complicating features will necessitate additional evaluation.

l) Airway Clearance Therapy (ACT) such as chest physiotherapy (CPT), EzPAP, inhaled bronchodilators, etc., may be indicated for individuals whose function of the mucociliary escalator and/or cough mechanics are altered and whose ability to mobilize and expectorate airways secretions is compromised. These include children with suppurative lung diseases such as CF and non-CF bronchiectasis, and neuromuscular weakness with ineffective airway clearance. For all other instances, including pleural infections/lung abscess and/or necrotizing pneumonia, in individuals who do not meet the above criteria, the current evidence does not support the universal, routine, use of ACT. Bronchodilators may be considered in patients with signs of lower airway obstruction with wheezing and/or in combination with mucolytic therapy (however, the current evidence only supports the use of mucolytics in chronic suppurative lung diseases). Thus, ACT should be assessed on an individual basis utilizing clinical/radiological response to therapy and professional judgement.

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