Guidelines for the Evaluation and Management of Pediatric Complicated Pneumonia

This guideline was developed by the following multidisciplinary group:

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I. Basic Principles

a. Complicated pneumonia describes a range of complications developing from community-acquired pneumonia (CAP), including parapneumonic effusion, empyema, lung abscess, and necrotizing pneumonia. Complicated pneumonia typically causes more severe disease and is associated with longer hospitalizations and higher rates of mortality.
b. Complicated pneumonia should be suspected in children who are worsening or not improving within 48-72 hours of appropriate treatment for community acquired pneumonia, or who have evidence of pleural fluid collection on imaging or exam.
c. Treatment consists of antibiotic therapy and supportive care. Surgical drainage is often required in patients with empyemas or large parapneumonic effusions, especially when respiratory function is impacted.
d. The most frequently implicated pathogen in complicated pneumonia is *Streptococcus pneumoniae.* The majority of the remaining disease is caused by *Streptococcus pyogenes* and *Staphylococcus aureus*. Methicillin-resistant *S. aureus* (MRSA) accounts for approximately 30% of all *S. aureus* isolates identified in culture at St. Louis Children's Hospital.

II. Inclusion/Exclusion Criteria

a. This guideline is intended to be applied to patients aged 0-18 years old with complicated pneumonia with the following features:
    i. Pleural effusions identified on chest ultrasound [US] which are moderate (¼ to ½ of the hemithorax on US) to large (>½ of hemithorax on US)
    ii. The presence of complex effusion (loculations, septations), or empyema on imaging
    iii. Mediastinal shift identified on imaging
    iv. Respiratory distress thought to be secondary to pleural effusion
    v. The presence of necrotizing pneumonia or a pulmonary abscess identified on imaging.
b. Patients with simple (free-flowing) effusions which are described as small on chest US (<¼ of hemithorax on US) can generally be managed similarly to patients with uncomplicated CAP. See SLCH Empiric Treatment Recommendations for additional information.

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c. Patients with the following characteristics are **excluded** from this guideline:
    i. Known immunodeficiency
    ii. Diagnosis of cystic fibrosis
    iii. Diagnosis of malignancy
    iv. Complicated pneumonia which develops following traumatic injury

III. **Diagnosis**

a. Imaging
    i. Chest x-ray and chest ultrasound are appropriate initial imaging studies.
    ii. If a chest x-ray for community acquired pneumonia shows signs of pleural effusion, a chest ultrasound should be ordered. Compared to plan radiographs, ultrasound can better demonstrate the size/extent of the fluid collection, characterize the nature of the fluid (simple effusion or purulence), and can identify loculations and consolidations within the pleural space and parenchyma.
    iii. Computed tomography (CT) should not be routinely obtained for initial evaluation. CT chest with contrast may be helpful if ultrasound is inconclusive or does not demonstrate an effusion clearly identified on plain films, for complex surgical planning, or for evaluation for necrotizing pneumonia or bronchopleural fistula when patients are not improving as expected.

b. Laboratory evaluation
    i. CBC – Evaluation for leukocytosis, and hemoglobin level prior to possible procedures. Patients receiving prolonged intravenous antibiotics (>1 week) should have a CBC with differential obtained at least weekly, primarily to assess for antibiotic-induced neutropenia.
    ii. CMP – Baseline electrolytes and hepatic function. Patients receiving prolonged intravenous antibiotics (>1 week) should have renal and hepatic function assessed at least weekly.
    iii. Blood cultures – May be positive in roughly 10-25% of children with complicated pneumonia and may identify a pathogen in patients who do not require pleural fluid drainage or have negative pleural fluid cultures.
    iv. Respiratory pathogen panel (RPP) – Organisms identified on RPP may have predisposed a patient to develop complicated pneumonia, and treatment of co-occurrent pathogens (e.g., influenza, *Mycoplasma pneumoniae*, SARS-CoV-2) may be indicated. Positive results may also have infection prevention implications.
    v. MRSA nasal PCR (or culture, if PCR not available) – This testing is useful at excluding MRSA as a cause of respiratory tract infections (negative predictive value >95%). It should only be ordered in patients in whom anti-MRSA therapy is being ordered empirically (see below).
    vi. BioFire Pneumonia Panel – This test can be considered in patients capable of producing sputum or who have been recently intubated for respiratory failure secondary to pneumonia. See separate Guidance for Use and Interpretation of the BioFire Pneumonia Panel document for additional information.
    vii. PT/PTT/INR – Only indicated prior to procedure if concern for coagulopathy (known hematologic disease, on anti-coagulation, critically ill).
    viii. Inflammatory markers/acute phase reactants including C-reactive protein (CRP), erythrocyte sedimentation rate (ESR), and procalcitonin (PCT) have low clinical utility and should not be routinely ordered or trended in the treatment of complicated pneumonia.

c. Pleural fluid, if obtained, can be sent for the following:
    i. Aerobic/anaerobic pleural fluid culture – May be positive in roughly 10-30% of children with complicated pneumonia. If there is concern for fungal or mycobacterial infection, fungal and acid-fast bacilli (AFB) cultures can be ordered as well in collaboration with ID.
    ii. Cell count and differential.
    iii. Additional studies, such as protein, LDH, pH, and glucose – Can be used (in conjunction with paired serum protein and LDH) to determine whether an effusion is exudative or transudative. Should be considered in patients where alternative, non-infectious, diagnoses are being considered.

IV. Management Considerations

a. Inpatient versus outpatient management
    i. Patients with concern for complicated pneumonia who are at community EDs or in outpatient clinics should have an ultrasound obtained for confirmation of effusion. If unable to obtain an ultrasound, patients should be transferred to SLCH ED for evaluation.
    ii. For patients who have small or trace pleural effusions AND are well-appearing with no other indications for admission, providers may use clinical judgment to determine need for additional workup and admission. ID consultation is not uniformly required for these patients, but can be requested at the discretion of the primary team. Patients who are discharged should have close PCP follow-up.
    iii. For patients with moderate (¼-½ of hemithorax) to large effusions (>½ of hemithorax), with evidence of empyema or loculations on imaging, or who have any additional indications for admission, obtain recommended lab work and plan for admission.
    iv. ID should be consulted on a non-urgent basis for all patients admitted with complicated pneumonia.
b. Antibiotic therapy (see institutional resources for antimicrobial dosing recommendations based on patient clinical status and renal/hepatic function)
    i. A blood culture should be drawn prior to initiating antibiotic therapy. Antibiotics should not be delayed while awaiting pleural fluid cultures. If a blood culture is positive, refer to the ePlex® Blood Culture Identification (BCID) Guidance Document for additional information, in collaboration with the ID consult team.
    ii. Ceftriaxone is recommended as empiric therapy for most patients with complicated pneumonia.
        1. Ampicillin-sulbactam is suggested as preferred alternative therapy for patients with an allergy to ceftriaxone but who tolerate penicillins.
        2. Levofloxacin is suggested as alternative therapy in patients who do not tolerate beta-lactams. Levofloxacin can be administered orally except in patients in whom there is concern about poor PO tolerance or enteral absorption (e.g., shock, short bowel syndrome, etc.).
        3. Consider discussion with ID with questions about alternative therapy.
    iii. The addition of empiric vancomycin should be considered in patients with progressive respiratory failure or hemodynamic instability, as well as those with a recent personal history of MRSA. Clindamycin is not recommended as empiric therapy due to lower rates of susceptibility among *S. pneumoniae*, *S. pyogenes*, and *S. aureus* (both MSSA and MRSA –see SLCH/BJH antibiograms for additional information).
        1. Discussion with ID is recommended for patients with true vancomycin allergies (i.e., reactions other than vancomycin infusion reaction/flushing syndrome) who have a clear indication to receive vancomycin as outlined above. Possible alternative therapies may include linezolid or ceftaroline, both of which require ID/antimicrobial stewardship approval.

iv. Antibiotics are generally continued intravenously while monitoring for clinical improvement and while any chest tubes are in place. Transition to oral therapy is generally appropriate following clinical improvement, assuming an oral agent to which any implicated microorganisms are susceptible is available, but antibiotics should be individualized to each patient.
    1. As discussed above, levofloxacin can be administered enterally for the entire duration of therapy provided there are no concerns about PO tolerance or enteral absorption (e.g., shock, short bowel syndrome, etc.).
v. Most patients with complicated pneumonia benefit from a prolonged course of antibiotics. One common approach is continuing antibiotics for seven additional days following chest tube removal, to complete a minimum of fourteen days of total antibiotic therapy. ID will make a decision regarding the final duration of therapy based on patient-specific factors such as disease severity (e.g., pulmonary abscesses, necrotizing pneumonia), the identification of specific microorganisms, duration of bacteremia (if present), and any potential complications. Final duration may ultimately be determined after hospital discharge at follow-up with ID.

c. Drainage
    i. Patients who are well-appearing with small (less than ¼ of hemithorax), simple, free-flowing effusions likely do not need drainage of fluid and can be observed clinically.
    ii. Patients who are well-appearing with larger effusions may not need drainage if those effusions are simple (no loculations, septations, or signs of empyema).
    iii. Patients who have complex effusions larger than ¼ of the hemithorax with loculations, septations, or empyema, or who are ill-appearing will likely benefit from drainage of fluid and should be evaluated for drainage.
    iv. Surgery should be consulted on all patients being evaluated for drainage. Interventional radiology can be consulted if image-guided drainage is needed.

V. Procedures

a. Drainage
    i. Thoracentesis – Needle drainage of pleural effusion. Less common than chest tube placement due to possibility of repeat procedure requiring repeat sedation.
    ii. Thoracostomy – Placement of chest tube for continued fluid drainage.
    iii. Video-assisted thoracoscopic surgery (VATS).
    iv. Open thoracotomy and decortication.
b. Fibrinolytics
    i. Medication used to dissolve clots caused by fibrin formation.
    ii. At SLCH, alteplase (tissue plasminogen activator) alone or in combination with dornase alpha (DNase) are the options for fibrinolysis.
    iii. Indications – Empyema, evidence of septated or loculated fluid collections on imaging.
    iv. Fibrinolytics should be instilled by provider into chest tube and chest tube should be clamped for 1 hour after instillation.
    v. Can be painful, consider providing analgesia prior to instillation.

VI. Additional Considerations

a. Pulmonary toilet – EzPAP is recommended for all patients as tolerated.
b. Physical/occupational therapy – Early mobility with chest tubes helps with pain control and recovery.
c. Pain control – Recommend all patients with chest tubes have orders for multimodal pain control. Consult pain team for additional recommendations if needed.

d. Pulmonology – Consultation should be considered in cases where there is worsening or lack of improvement despite initial medical and surgical management, or when there is evidence of necrotizing pneumonia or bronchopleural fistula. Patients with residual pleural disease in need of follow-up should be referred to pulmonology at discharge.
e. Steroids – Several studies have suggested that steroids may provide a possible decreased recovery time for children with complicated pneumonia. However, at this time there is insufficient evidence to recommend steroid use as an adjunctive therapy.
f. Follow-up – ID consult service will arrange ID clinic follow-up, if necessary.
g. Vaccines – Update seasonal and non-seasonal vaccines prior to hospital discharge, as appropriate. Intercurrent illness may result in clinical worsening.

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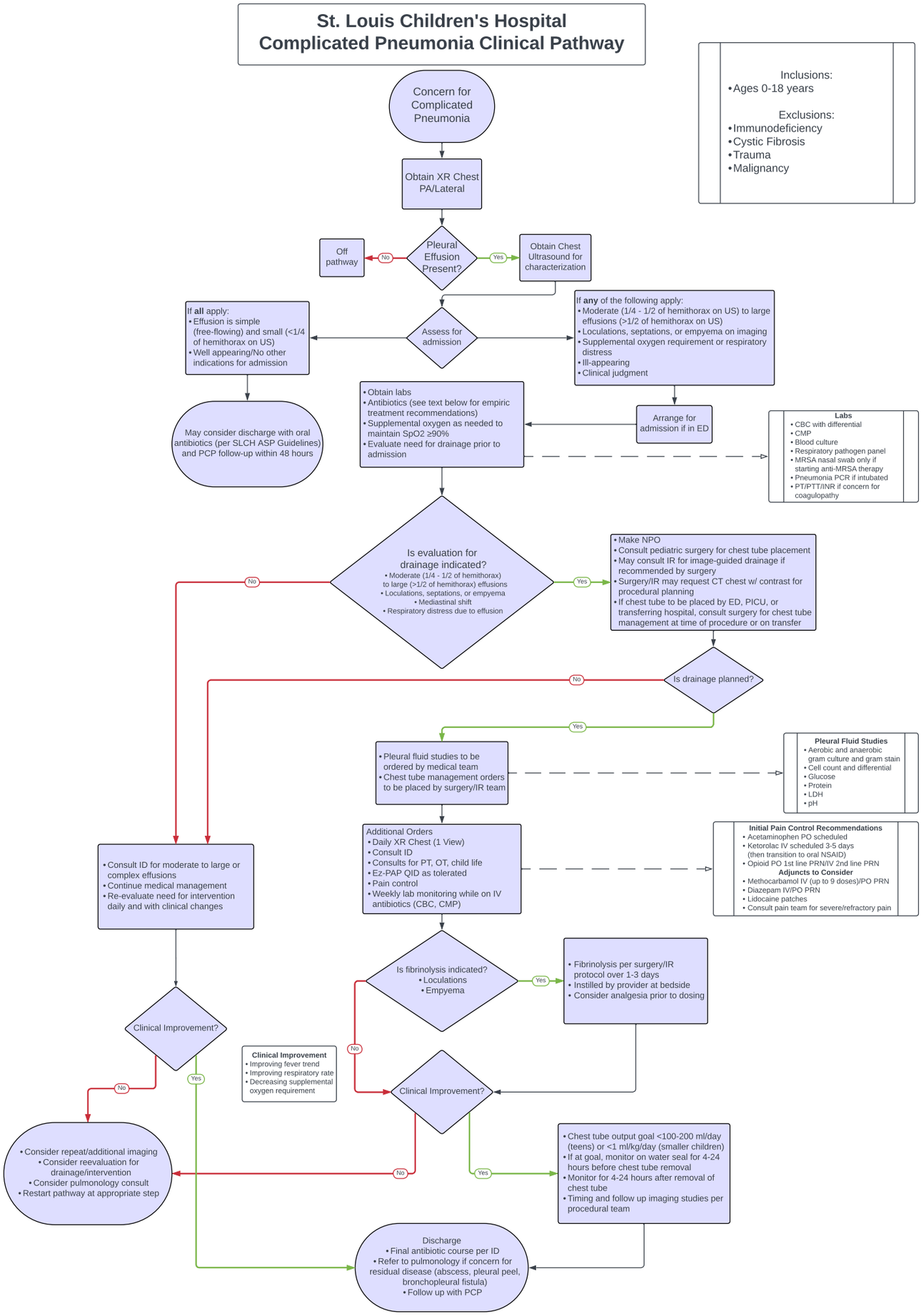
St. Louis Children's Hospital
Complicated Pneumonia Clinical Pathway
Inclusions:
• Ages 0-18 years
Exclusions:
• Immunodeficiency
• Cystic Fibrosis
• Trauma
• Malignancy
Concern for Complicated Pneumonia
Obtain XR Chest PA/Lateral
Pleural Effusion Present?
No
Off pathway
Yes
Obtain Chest Ultrasound for characterization
Assess for admission
If all apply:
• Effusion is simple (free-flowing) and small (<1/4 of hemithorax on US)
• Well appearing/No other indications for admission
If any of the following apply:
• Moderate (1/4 - 1/2 of hemithorax on US) to large effusions (>1/2 of hemithorax on US)
• Loculations, septations, or empyema on imaging
• Supplemental oxygen requirement or respiratory distress
• Ill-appearing
• Clinical judgment
May consider discharge with oral antibiotics (per SLCH ASP Guidelines) and PCP follow-up within 48 hours
• Obtain labs
• Antibiotics (see text below for empiric treatment recommendations)
• Supplemental oxygen as needed to maintain SpO2 ≥90%
• Evaluate need for drainage prior to admission
Arrange for admission if in ED
Labs
• CBC with differential
• CMP
• Blood culture
• Respiratory pathogen panel
• MRSA nasal swab only if starting anti-MRSA therapy
• Pneumonia PCR if intubated
• PT/PTT/INR if concern for coagulopathy
Is evaluation for drainage indicated?
• Moderate (1/4 - 1/2 of hemithorax) to large (>1/2 of hemithorax) effusions
• Loculations, septations, or empyema
• Mediastinal shift
• Respiratory distress due to effusion
No
Yes
• Make NPO
• Consult pediatric surgery for chest tube placement
• May consult IR for image-guided drainage if recommended by surgery
• Surgery/IR may request CT chest w/ contrast for procedural planning
• If chest tube to be placed by ED, PICU, or transferring hospital, consult surgery for chest tube management at time of procedure or on transfer
Is drainage planned?
No
Yes
• Pleural fluid studies to be ordered by medical team
• Chest tube management orders to be placed by surgery/IR team
Pleural Fluid Studies
• Aerobic and anaerobic gram culture and gram stain
• Cell count and differential
• Glucose
• Protein
• LDH
• pH
Additional Orders
• Daily XR Chest (1 View)
• Consult ID
• Consults for PT, OT, child life
• Ez-PAP QID as tolerated
• Pain control
• Weekly lab monitoring while on IV antibiotics (CBC, CMP)
Initial Pain Control Recommendations
• Acetaminophen PO scheduled
• Ketorolac IV scheduled 3-5 days (then transition to oral NSAID)
• Opioid PO 1st line PRN/IV 2nd line PRN
Adjuncts to Consider
• Methocarbamol IV (up to 9 doses)/PO PRN
• Diazepam IV/PO PRN
• Lidocaine patches
• Consult pain team for severe/refractory pain
• Consult ID for moderate to large or complex effusions
• Continue medical management
• Re-evaluate need for intervention daily and with clinical changes
Is fibrinolysis indicated?
• Loculations
• Empyema
Yes
• Fibrinolysis per surgery/IR protocol over 1-3 days
• Instilled by provider at bedside
• Consider analgesia prior to dosing
Clinical Improvement?
No
Yes
Clinical Improvement
• Improving fever trend
• Improving respiratory rate
• Decreasing supplemental oxygen requirement
Clinical Improvement?
No
Yes
• Consider repeat/additional imaging
• Consider reevaluation for drainage/intervention
• Consider pulmonology consult
• Restart pathway at appropriate step
• Chest tube output goal <100-200 ml/day (teens) or <1 ml/kg/day (smaller children)
• If at goal, monitor on water seal for 4-24 hours before chest tube removal
• Monitor for 4-24 hours after removal of chest tube
• Timing and follow up imaging studies per procedural team
Discharge
• Final antibiotic course per ID
• Refer to pulmonology if concern for residual disease (abscess, pleural peel, bronchopleural fistula)
• Follow up with PCP