TREATMENT GUIDELINES FOR THE COMPLICATED PNEUMONIA:
PARAPNEUMONIC EFFUSIONS, EMPYEMA, NECROTIZING PNEUMONIA, AND PULMONARY ABSCESS

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PREFACE

Children’s National Medical Center (CNMC) is a tertiary pediatric hospital consisting of, but not limited to, the following specialties: Pediatric Infectious Disease, Pediatric Pulmonary Medicine, Pediatric Radiology, Pediatric Surgery, Pediatric Emergency Medicine, and a Pediatric Hospitalist Team. A committee was formed consisting of representatives from these departments. The guidelines found within this document are a reflection of the combined efforts of these departments as represented in this committee. These guidelines will be reviewed and revised at future meetings based on the input from all committee members to further improve the care of children treated at CNMC.

Many of the recommendations found within this document have been adopted from the 2005 British Thoracic Society’s Guidelines for the Management of Pleural Infection in Children [1]. These BTS guidelines were used as a foundation upon which the CNMC algorithm was built, and their recommendation levels [A, B, C, D] have been included within this document to illustrate the strength of the literature reviewed when compiling the BTS guidelines. Please refer to this article (as referenced above) for recommendation details. Wherever possible, current literature was reviewed, and if applicable to our institution, was implemented in the CNMC guidelines in addition to the references detailed in the BTS guidelines. These added references have been annotated accordingly within the CNMC algorithm. It should be noted that not all BTS guidelines are being accepted by CNMC as standard of care, but have been reviewed while compiling guidelines specific to Children’s National Medical Center.

The goals of the document are geared towards children diagnosed with complicated pneumonias and include the following:

1. Improve communication between the above stated departments while treating these patients.
2. Minimize morbidity and mortality.
3. Maximize patient care in the acute and chronic setting.
4. Decrease radiation exposure when possible.
5. Limit the amount of unnecessary antibiotic use within our institution.
6. Decrease hospital length of stay.
7. Provide adequate follow up with our Infectious Disease and Pulmonary Medicine Divisions.

The contents of this document are detailed recommendations, and are by no means mandatory for the care of children diagnosed with pneumonia and the varying complications associated with this diagnosis.
### 2005 BTS Management of Pleural Infection in Children: Grading System (Revised SIGN System)

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A</strong></td>
<td>At least one meta-analysis, systematic review, or randomised controlled trial (RCT) rated as I++ and directly applicable to the target population; or a systematic review of RCTs or a body of evidence consisting principally of studies rated as I+ directly applicable to the target population and demonstrating overall consistency of results.</td>
</tr>
<tr>
<td><strong>B</strong></td>
<td>A body of evidence including studies rated as II++ directly applicable to the target population and demonstrating overall consistency of results; or extrapolated evidence from studies rated as I++ or I+.</td>
</tr>
<tr>
<td><strong>C</strong></td>
<td>A body of evidence including studies rated as II+ directly applicable to the target population and demonstrating overall consistency of results; or extrapolated evidence from studies rated as II++.</td>
</tr>
<tr>
<td><strong>D</strong></td>
<td>Evidence level III or IV; or extrapolated evidence from studies rated as II++.</td>
</tr>
</tbody>
</table>

### Levels of Evidence (Revised SIGN Grading System)

<table>
<thead>
<tr>
<th>Evidence</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>I++</strong></td>
<td>High quality meta-analyses, systematic reviews of randomised controlled trials (RCTs), or RCTs with a very low risk of bias.</td>
</tr>
<tr>
<td><strong>I+</strong></td>
<td>Well conducted meta-analyses, systematic reviews of RCTs, or RCTs with a low risk of bias.</td>
</tr>
<tr>
<td><strong>I-</strong></td>
<td>Meta-analyses, systematic reviews of RCTs, or RCTs with a high risk of bias.</td>
</tr>
<tr>
<td><strong>II++</strong></td>
<td>High quality systematic reviews of case-control or cohort studies. High quality case-control or cohort studies with a very low risk of confounding, bias, or chance and a high probability that the relationship is causal.</td>
</tr>
<tr>
<td><strong>II+</strong></td>
<td>Well conducted case-control or cohort studies with a low risk of confounding, bias, or chance and a moderate probability that the relationship is causal.</td>
</tr>
<tr>
<td><strong>II-</strong></td>
<td>Case-control or cohort studies with a high risk of confounding, bias, or chance and a significant risk that the relationship is not causal.</td>
</tr>
<tr>
<td><strong>III</strong></td>
<td>Non-analytical studies, e.g. case reports, case series.</td>
</tr>
<tr>
<td><strong>IV</strong></td>
<td>Expert opinion.</td>
</tr>
</tbody>
</table>

Taken directly from 2005 BTS Guidelines for the Management of Pleural Infection in Children [1]
**Epidemiology**

**Parapneumonic Effusion/Pneumonia**
- 3.3/100,000 children [2]
- Boys>Girls
- More frequent in young children/infants [3]
- More common in winter/spring [3]

**Lung Abscess/Necrotizing Pneumonia**
- Predisposing risk factors include:
  - Aspiration and airway obstruction
  - Change in oropharyngeal flora (repeat administration of antibiotics, poor oral hygiene)
  - Impaired immunological and other defenses (i.e. impaired airway clearance, abnormal cilia, cystic fibrosis)

**Pathophysiology of Pleural Effusion/Empyema**
- 0.3ml/kg body wt = pleural fluid [4]
- Continuous circulation
- Lymphatics can handle excess of several hundred mL of extra fluids/24 hours [5]
- Normal Pleural Fluid: small # of cells: low [protein] (0.1 g/L), low LDH
- ↑HCO3⁻, ↓Na⁺, ~glucose compared to serum [6]
- Pleural Effusion: Imbalance of pleural fluid formation and drainage
- Disease State: Immune Response → Pleural Inflammation → ↑ vascular permeability → Migration of Inflammatory Mediators (neutrophils, lymphocytes, eosinophils) into Pleural Space => Exudative Pleural Effusion (~2-5 days after initial infection)
- ↑ Fluid Accumulation + Bacterial Invasion across Damaged Epithelium => Fibropurulent Stage [6] (~10 days after initial infection)
- Neutrophil Migration + Coagulation Cascade Activation = Decreased Fibrinolysis + Procoagulant Activity [7] (10-21 days after initial infection)
- Fibrin Deposition → Septation or Loculation; ↓pH, ↓glucose, ↑LDH [8] (~21 days)

**Pathophysiology of Necrotizing Pneumonia/Lung Abscess**
- Inoculum from the gingival crevice reaches lower airways
- Infection is initiated either because the bacteria are not cleared due to suppressed consciousness or because the inoculum size is large due to dysphagia.
- Pneumonitis arises first but based upon the usual mixture of organisms develops into a necrotizing pneumonia (significant parenchymal damage and necrosis)
- Progression over 7 to 14 days: results in lung abscess, pneumatocele, and/or an empyema (due to a bronchopleural fistula/direct extension of infection into pleural space).

**Etiology**
- Lung abscess and chronic conditions (bronchiectasis) [3]
- Immunodeficiency
- Post-Surgery
• Trauma
• Aspiration
• Malignancy
• Congenital Heart Disease
• Renal Disease
• Connective Tissue Disorders
• Bilateral effusion may indicate tuberculosis or parasitic infection [9]

**Clinical Presentation**

- *All children with parapneumonic effusion or empyema should be admitted to the hospital.* [D]
- *If a child remains febrile or unwell 48 hours after admission for pneumonia, parapneumonic effusion/empyema must be excluded.* [D]
- Classic symptoms of pneumonia: cough, dyspnea, fever, malaise, loss of appetite +:
  - More unwell than usual
  - May have pleuritic chest pain
  - Abdominal Pain: Infection in the lower lobes
- Previous pneumonia diagnosis: spiking fever and lack of improvement after 48 hours of antibiotics
- Antibiotic history is important
- Consider underlying rare conditions (tuberculosis, immunodeficiency, FB, and malignancy)
- Physical Exam
  - Unilateral signs of decreased chest expansion
  - Dullness to percussion
  - Reduced or absent breath sounds.
  - The assessment of severity is the same as that for any childhood pneumonia
  - $\text{SpaO}_2 < 92\%$ = severe disease [10]
  - Assess state of hydration, height, weight, presence of scoliosis, and any underlying disorders.

### Committee Recommendations

<table>
<thead>
<tr>
<th>Admission Criteria</th>
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<tbody>
<tr>
<td>Oxygen Requirement</td>
</tr>
<tr>
<td>↓ PO (not taking liquids)</td>
</tr>
<tr>
<td>Need for IV Rehydration</td>
</tr>
<tr>
<td>No reliable follow-up</td>
</tr>
<tr>
<td>Ill appearing</td>
</tr>
<tr>
<td>Concern for effusion, empyema, abscess, or necrotizing pneumonia on chest x-ray</td>
</tr>
</tbody>
</table>

**Microbiology**

- Bacteria:
  - Report rate of identifying organism 8% - 76% [3, 11, 12]
Many cultures are negative despite bacterial cause of infection [13]

Introduction of penicillinase stable penicillins and other anti-staphylococcal agents → ↑ of *S. pneumoniae* as predominant pathogen in childhood empyema; not always reflected in culture results as many are culture negative [13-16]

- Shown via molecular techniques, PCR, and latex agglutination for pneumococcal antigen. [17]

Other bacteria: *S. pyogenes, H. influenzae type b, Mycoplasma pneumoniae, P. aeruginosa,* and other streptococcal species (i.e. *viridans* and Lancefield group F39).

Rare bacterial organisms: *Klebsiella, Enterobacter, Proteus, Salmonella, Yersinia.*

Anaerobic organisms: *Bacteroides, Peptostreptococcus,* and *Streptococcus milleri* are rarely isolated (associated with aspiration pneumonia or foreign bodies)

- Consider in children with delayed neurodevelopment.

Disseminated *Fusobacterium necrophorum* infection (Lemierre syndrome)

- Potentially fatal

- Follows a severe pharyngitis and may be seen in older children (and young adults).

*Mycoplasma:* associated with pleural effusion; empyema is rare [18]

- Mycoplasma serology, suggests involvement in some cases [14, 19] but most series do not report serology results and paired samples may not have been taken

*Legionella pneumophila* [20] and primary viral pneumonia [21] may also be associated with pleural effusion; role in pleural empyema is not accurately known

Viral infection may simply precede a secondary bacterial infection leading to empyema.

Adenovirus [19, 21] and influenza virus [22] can cause effusions (rarely large)

Tuberculous empyema: may result from progressive pulmonary tuberculosis

- Account for up to 6% of all empyema cases worldwide [6]

Fungal: Usually nosocomial [23, 24] or, in the case of the rare *Histoplasma,* following exposure. [25, 26]

Entamoeba histolytica: Case report noted

### Diagnostic Testing

Data on Sputum samples: *When available, sputum should be sent for bacterial culture.* [D]

- *S. pneumoniae* nasopharyngeal culture positive in 15% (19/128) of subjects; RQ-PCR in 27% cases (34/127) (P < 0.001) [27]

- Of all RQ-PCR positive samples (n=34), 17 were negative by sputum culture (50%) [27]

- 14/32 RQ-PCR-positive nasopharyngeal samples were from patients treated with antibiotics prior to sampling – all were negative by culture. [27]

  - *S. pneumoniae* may be rapidly diagnosed by analyzing induced sputum samples by RQ-PCR and may be particularly valuable in patients in whom antibiotic therapy has been initiated. [27]

- The following studies have been described in the literature on expectorated sputum, but their practical use in management of patients with complicated pneumonia is not clear and these are not routinely recommended

  - Culture and Sensitivities
  - Quantitative Real-time (RQ) PCR for *S. pneumoniae* [27-29]
  - Respiratory Viral Antigen Panel
• Quantitative Real-Time PCR for Mycoplasma, S. aureus, M. catarrhalis, H. influenza
• Antigen latex agglutination for S. pneumoniae, S. aureus, M. catarrhalis, H. influenza, and Mycoplasma
• If unable to give expectorated sputum, consider induced sputum via nebulized hypertonic saline (if not contraindicated).

• Blood Culture: Blood cultures should be performed in all patients with parapneumonic effusion. [D]
  - Blood cultures positive in 15/153 (10%) with empyema and 25/387 (6.4%) of those with pneumonia alone. [30]
  - 76 children with complicated parapneumonic effusions found positive blood cultures in 22% compared with pleural fluid which was positive in 33% of cases. [31]
  - In another series, blood culture was positive in 10/56 cases (18%) of empyema in children, all with S. pneumoniae, and in 7/10 positive blood cultures the pleural fluid was sterile. [2]
  - Rarely positive in abscess from anaerobic bacteria

• Pleural Fluid Analysis:
  - Pleural fluid should be sent for microbiological analysis including Gram stain and bacterial culture. [C]
  - Aspirated pleural fluid should be sent for differential cell count. [D]
  - Tuberculosis and malignancy must be excluded in the presence of pleural lymphocytosis. [C]
  - If there is any indication the effusion is not secondary to infection, consider an initial small volume diagnostic tap for cytological analysis, avoiding general anesthesia/sedation whenever possible. [D]
  - Biochemical analysis of pleural fluid is unnecessary in the management of uncomplicated parapneumonic effusions/empyema. [D]
  - Although pleural fluid is often sterile due to prior administration of antibiotics [32], it should still be sent for Gram stain and culture.
    - Gram positive cocci with 90% polymorphonuclear leucocytes on Gram stain differential is enough to make full cytological analysis unnecessary.
    - Other pleural fluid studies to strongly consider that may aid treatment include:
      - Direct and enrichment culture for aerobic and anaerobic organisms (in addition send some pleural fluid in anaerobic blood culture bottle. [33]
      - Stain for acid-fast bacilli, culture for mycobacteria, and mycobacteria tuberculosis polymerase chain reaction [34]
        - May have low sensitivity but is more rapid than standard culture.
      - Specific (i.e. S. pneumoniae) or broad range PCR techniques. [17, 35]
      - If possible, antigen agglutination tests (i.e. S pneumoniae) may aid in identifying causative bacteria (may consider other bacteria and viruses as well). [17]
    - Pleural fluid solely for the purposes of cytological analysis is rarely necessary in children; however pH, glucose, protein, WBC and LDH have been shown to correlate with ultrasound staging of parapneumonic effusion/empyema. [36]
      - If infection is not immediately apparent (on Gram stain), a sample should be sent for cytological analysis.
Aspiration of pleural fluid should be of small volume (e.g. 5 ml) for diagnostic purposes only.
- Large volume aspiration and general anaesthesia pose a significant risk of sudden death in children with superior mediastinal obstruction related to malignancy.
- Protein levels or Light’s criteria differentiate exudates from transudates. [33]
- Infection is indicated by pleural acidosis associated with raised LDH and low glucose levels.[6]
- pH may guide the need for tube drainage (pH <7.2) in an infected effusion. [33]
  - Absolute protein values do not correlate with likelihood of spontaneous resolution or chest drain requirements. [6]
- Parapneumonic pleural effusions are dominated by polymorphonuclear leucocytes.
- Predominance of lymphocytes in an exudate should raise the possibility of tuberculosis or malignancy. [33]
  - Mantoux test should be considered when lymphocytes predominate, particularly if the history is suggestive of tuberculosis.
  - As many as 10% of tuberculous pleural effusions are predominantly neutrophilic. [37]
  - Most malignant effusions in children will be blood stained but, as in adults, cytological examination may not reveal malignant cells. [33]
- The utility of biochemical analysis, on its own, is still questionable, and many physicians may treat regardless of these values.
  - Reflects the fact that the majority of effusions are parapneumonic and may resolve spontaneously with appropriate antibiotic therapy.

<table>
<thead>
<tr>
<th>Pleural Fluid Characteristic</th>
<th>Uncomplicated Parapneumonic Effusion</th>
<th>Complicated Parapneumonic Effusion</th>
<th>Empyema</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance</td>
<td>Slightly turbid</td>
<td>Cloudy</td>
<td>Pus</td>
</tr>
<tr>
<td>pH</td>
<td>&gt;7.30</td>
<td>&lt;7.20</td>
<td>NA</td>
</tr>
<tr>
<td>Glucose Level (mg/dL)</td>
<td>&gt;60</td>
<td>&lt;40</td>
<td></td>
</tr>
<tr>
<td>Pleural Fluid to Serum Glucose Ratio</td>
<td>&gt;0.5</td>
<td>&lt;0.5</td>
<td>NA</td>
</tr>
<tr>
<td>Lactate Dehydrogenase Level (LDH) (U/L)</td>
<td>&lt;700</td>
<td>&gt;1000</td>
<td>NA</td>
</tr>
<tr>
<td>Polymorphonuclear Leukocyte Count (cells/mL)</td>
<td>&lt;15,000</td>
<td>&gt;25,000</td>
<td>NA</td>
</tr>
<tr>
<td>Culture/Microbiology</td>
<td>Negative</td>
<td>May be positive</td>
<td>May be positive</td>
</tr>
</tbody>
</table>

Table 2. Pleural Fluid Analysis Table: [38] NA=Not Applicable
• Serum Studies:
  - Complete Blood Count (CBC):
    • WBC has been correlated with disease progression and ultrasound staging of parapneumonic effusions. [36]
    • Thrombocytopenia may be a sign of sepsis, and may affect invasive management (i.e. chest tube placement, VATS)
    • Thrombocytosis and elevated WBC may be a sign of inflammation (acute phase reactants). [39]
  - If possible, serum antigen agglutination tests (i.e. *S. pneumoniae*) may aid in identifying causative bacteria (may consider other bacteria and viruses as well). [17]
  - Acute Phase Reactants [WBC, total neutrophil count, C-reactive protein (CRP), erythrocyte sedimentation rate (ESR)]:
    • A number of prospective studies have examined the usefulness of acute reactants in distinguishing bacterial from viral pneumonia and showed them to be unhelpful. [40-43]
    • A prospective study showed a significant correlation between ESR and CRP elevation and the diagnosis of necrotizing pneumonia, parapneumonic effusion, and uncomplicated pneumonia. [44]
      - This study also showed a significant difference in number of days for CRP normalization between patients diagnosed with necrotizing pneumonia (14 +/- 4 d) and those with parapneumonic effusion (11 +/- 4 d) after medical intervention.
    • A prospective study on ventilator-associated pneumonia showed that CRP may be a biochemical marker for bacterial burden in a selected population. [45]
    • Clinical practice has shown that serial measurements of CRP and the white cell count can be helpful.
    • If no other markers are available to dictate antibiotic therapy/response to medical intervention, follow CRP or ESR trend may be used by Infectious Disease Team as treatment aid.
  - Other Studies:
    • If deemed necessary and possible, urine latex agglutination (for detection of *S. pneumoniae* antigen) [17] may aid in establishing etiology.
    • Transtracheal Aspiration (TTA) and Transthoracic Needle Aspiration (TTNA) for lung abscess are rarely performed and place patient at high risk for complications.

<table>
<thead>
<tr>
<th>COMMITTEE RECOMMENDATIONS</th>
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<tbody>
<tr>
<td>Laboratory Studies</td>
</tr>
</tbody>
</table>

| Initial Presentation       | Blood Culture
|                           | CBC with Differential
|                           | Consider ESR and/or CRP |
| Pleural Fluid (within 24 hours of admission) | Culture, Gram stain, Cell Count w/ diff, pH, protein, LDH, glucose |
| Pleural Fluid              | AFB stain, Mycobacterial culture, PCR |
### Table 3. Laboratory Studies Recommendations

<table>
<thead>
<tr>
<th>(Other tests to consider)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Other Studies</strong> (not routinely recommended)</td>
<td>Pleural Fluid, Serum and Urine latex agglutination (for <em>S. pneumoniae</em> antigen)</td>
</tr>
<tr>
<td><strong>Repeat Testing</strong> (if on IV antibiotics &gt; two weeks)</td>
<td>Weekly (outpatient): CBC w/ differential, ESR/CRP, ALT, AST, Creatinine</td>
</tr>
<tr>
<td><strong>Placed on Vancomycin</strong></td>
<td>Weekly: Vancomycin Trough</td>
</tr>
</tbody>
</table>

### Diagnostic Imaging

- **Chest Radiograph:**
  - *PA or AP radiographs should be taken; there is no role for a routine lateral radiograph.* [D]
  - Obliteration of the costophrenic angle is the earliest sign of a pleural effusion
    - A rim of fluid may be seen ascending the lateral chest wall (meniscus sign) on a postero-anterior (PA) or antero-posterior (AP) radiograph.
    - If the film is taken when a (younger) child is supine, the appearance can be of a fluid. [46]
  - Lateral radiographs should be taken when concerned for routine, uncomplicated community acquired pneumonias, and may aid in discerning location of uncomplicated pneumonia as well as verifying cardiac borders, heart size, and possibility of cardiac disease (i.e., pericardial effusion).
  - Lateral decubitus radiograph may be useful in identifying smaller effusions in cases with high index of suspicion for effusion that may not be noted in upright/supine AP/PA films, but should not be done if it will cause a delay in treatment. [47]
  - Repeat CXR without deterioration in clinical status is not recommended
    - Radiograph changes lag behind clinical findings
    - Original size does not correlate with resolution rate
    - May take one month to many years before complete resolution is seen on radiograph
    - Not all patients that are clinically asymptomatic are completely free of radiograph findings related to previous pneumonia complications
    - Use repeat radiographs only as an aid after assessing clinical status

- **Chest Ultrasound (U/S):**
  - *Ultrasound must be used to confirm the presence of a pleural fluid collection.* [D]
  - *Ultrasound should be used to guide thoracentesis or drain placement.* [C]
  - U/S may be more sensitive than chest radiograph in quantifying pleural effusion. [48]
  - Chest U/S can detect the presence of fluid in the pleural space; particularly useful with “whiteout” on the chest radiograph. [6]
  - Based on previously published literature, it was thought that U/S cannot reliably establish the stage of pleural infection [49]
  - A recent study [36] demonstrated that chest U/S can discriminate the progressive stages of bacterial parapneumonic effusion, possibly excluding the need for chest CT.
• Based on their classification of effusions, children with a parapneumonic effusion that showed fibrin formation receiving early aggressive tube drainage may avoid a subsequent surgical intervention.
  
  • In children with a fibrin septated parapneumonic effusion, an initial VATS is recommended to shorten the duration of fever and hospital stay.
    
      - U/S can estimate the size of the effusion, differentiate free from loculated pleural fluid, and determine the echogenicity of the fluid. [46]
      - Ultrasound may demonstrate pleural thickening and assist in diagnosis of effusion secondary to tuberculosis (for example, the presence of diffuse small nodules on the pleural surface). [50]
      - U/S can be used to guide chest drain insertion or thoracentesis. [48, 51-53]
      - It enables the exact location of any fluid collection to be determined and allows guided diagnostic aspiration if required. [48, 53]
      - Ultrasound scanning is readily available and is the preferred investigation in children, especially as no sedation is necessary and it involves no radiation.

• Chest CT:
  
    - Chest CT scans should not be performed routinely. [D]
    - Ultrasound can confirm the presence of pleural fluid (differentiating it from pulmonary infiltrates).
    - A study of 320 adults and some children showed that U/S might sometimes help to distinguish exudative pleural effusions from transudates. [54]
    - Fibrinous septations are better visualized using ultrasound than CT scans.
    - Ultrasound has also been shown to be good at distinguishing fluid from solid material in the pleural space. [55]
    - U/S may not predict those patients who will fail with chest drain and fibrinolytics alone and subsequently require surgery. [49]
    - A study of 30 children demonstrated that CT scan was not helpful in differentiating empyema from parapneumonic effusion. [56]
    - In a review of ultrasound and CT scanning in a group of 50 adults with parapneumonic effusion requiring drainage, neither technique reliably identified the stage of the pleural effusion, although pleural thickness on the CT scan was greater in those with frankly purulent effusions. [49]
    - CT scanning of the chest with contrast enhancement assists in delineating loculated pleural fluid and can also detect airway or parenchymal lung abnormalities such as endobronchial obstruction or a lung abscess, as well as helping with mediastinal pathology. [57, 58]
    - In the evaluation of children with complicated pneumonia, CT often reveals clinically significant findings not apparent on radiography. [59]
    - While unnecessary for most cases of pediatric empyema, chest CT has a role in complicated cases:
      - Initial failure to aspirate pleural fluid
      - Failing medical management
      - In immunocompromised children (may reveal other clinical problems).
      - Malignancy (i.e. lymphoma)
    - CT may be useful in differentiating between complicated empyema and formation of lung abscess. [57, 60]
Chest CT will help identify impending cavitation that may not be identified on basic chest radiograph. [57, 60]
Many surgeons may require a CT scan before surgery to delineate the anatomy further and to look for an intrapulmonary abscess.

### COMMITTEE RECOMMENDATIONS

<table>
<thead>
<tr>
<th>Diagnostic Imaging Studies</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Initial Presentation</strong></td>
</tr>
<tr>
<td><strong>Suspect Community Acquired Pneumonia</strong></td>
</tr>
<tr>
<td><strong>Suspect Pleural Effusion or Empyema</strong></td>
</tr>
<tr>
<td><strong>Unable to Differentiate between Effusion/Empyema</strong></td>
</tr>
<tr>
<td><strong>Surgical vs. Non-Surgical Intervention</strong></td>
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<tr>
<td><strong>Follow up Studies</strong></td>
</tr>
</tbody>
</table>

Table 4. Diagnostic Imaging Recommendations

### DIAGNOSTIC BRONCHOSCOPY

- There is no indication for flexible bronchoscopy and it is not routinely recommended. [D]
- No formal studies have been done to validate the routine use of bronchoscopy in the treatment of a complicated pneumonia. [6]
- Bronchoalveolar lavage (BAL) may aid in diagnosing the infecting organism, but is unnecessary when pleural fluid is available.
- In abscess, may help with drainage but places patient at risk for spillage of abscess contents into the airways [61]
- Indications for bronchoscopy may include:
  - The possibility of foreign body aspiration.
  - Immunocompromised patient not responding to formal treatment plan, and having had an induced sputum sample in the past, obviating the need for BAL specimen.

### TREATMENT OF COMPLICATED PNEUMONIA

**Antibiotics:** Drug regimen should be discussed with Infectious Disease (ID) team when concerned about complicated pneumonia

- Uncomplicated community acquired pneumonias (CAP) should be treated with broad spectrum antibiotics covering *S. pneumoniae, S. aureus, M. catarrhalis, H. influenza*, and possibly *Mycoplasma*.
  - If there are any questions about antibiotic treatment for CAP, please discuss with ID team.
• All cases should be treated initially with intravenous antibiotics and must include coverage for *Streptococcus pneumoniae*. [D]
• Must consider treatment for *S. pyogenes*, *S. aureus*, *M. catarrhalis*, *H. influenza* and possibly *Mycoplasma* as well.
  – As per our ID team, start with third generation cephalosporin (Cefotaxime or Ceftriaxone) and Clindamycin (for coverage of potential MRSA)
• *Broader spectrum cover is required for hospital acquired infections, as well as those secondary to surgery, trauma, and aspiration.* [D]
  – Include coverage of multidrug resistant aerobic gram negative rods
• Lung Abscess/Necrotizing Pneumonia:
  – Need coverage for anaerobic organisms as well
    • Clindamycin is considered standard therapy for anaerobic lung infections [62, 63] and also provides coverage for most MRSA
    • Metronidazole provides extended anaerobic therapy (including beta-lactamase producing *Bacteroides fragilis*), but does not provide coverage for MRSA.
      – Should be combined with penicillin or cephalosporin for broad coverage
• Avoid use of Vancomycin for all patients unless known MRSA diagnosis (without susceptibility pattern available, or know resistance to clindamycin) or patient has signs of sepsis/significant clinical deterioration (consider metronidazole as well)
• *Mycobacterium tuberculosis*
  – Treatment for *M. tuberculosis* should not be started immediately, unless clinical presentation suggests otherwise
• *Where possible, antibiotic choice should be guided by microbiology results.* [B]
  – If pleural fluid, sputum, nasopharyngeal, or blood cultures are positive (and appear to not be contaminated), continued treatment should be based on these identification and antibiotic sensitivities. [6]
• *Antibiotic regimen may last for 2–4 weeks, but may be extended longer if there is residual disease.* [D]
  – No consensus on length of therapy for complicated pneumonias
    • Pleural Effusion/Empyema: Minimum 2 weeks of IV treatment
    • Necrotizing Pneumonia: Minimum 2 weeks of IV treatment
    • Drained Abscess: Minimum 2 weeks IV treatment, usually ≥ 3 weeks total course.
    • Undrained Abscess: Minimum 4 weeks of IV treatment (consider 2 more weeks of IV/PO Abx)
  – ID team will dictate length of treatment course, length of IV antibiotics and additive oral antibiotic therapy based on clinical course, interval resolution on radiographs, and serum markers (i.e. CRP).
  – ID team will follow as outpatient to monitor response to antibiotics
  – If there are any complications, ID team will refer to/consult pulmonary medicine.
<table>
<thead>
<tr>
<th>Type</th>
<th>Treatment Course (per ID Team)</th>
<th>Antibiotic Choice</th>
</tr>
</thead>
</table>
| Uncomplicated Community Acquired Pneumonia | May switch to PO Abx as soon as tolerated  
Treat for 10-14 Days total                                  | 3rd Generation Cephalosporin,  
With/without clindamycin*  
With/without macrolide* |

*Clindamycin adds coverage for possible MSSA, most MRSA, anaerobes.  
Consider adding if recurrent symptoms despite outpatient amoxicillin or cephalosporin treatment  
In setting of influenza - possible *S. aureus* super-infection; consider in possible aspiration event  
*Macrolide adds coverage for possible atypical agents: *Mycoplasma, Pertussis, Chlamydia* |

<table>
<thead>
<tr>
<th>Empyema s/p VATS</th>
<th>2 weeks IV antibiotics (Followed by 1-2 weeks IV/PO)</th>
<th>Start on 3rd Generation Cephalosporin + Clindamycin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Necrotizing Pneumonia</td>
<td>2 weeks IV antibiotics (Followed by 1-2 weeks IV/PO)</td>
<td><strong>If Septic:</strong> 3rd Generation Cephalosporin + Vancomycin + Metronidazole</td>
</tr>
<tr>
<td>Abscess (Drained)</td>
<td>2 weeks IV antibiotics (Followed by 1-2 weeks IV/PO)</td>
<td></td>
</tr>
<tr>
<td>Abscess (Undrained)</td>
<td>4-6 weeks abx (At least 4 wks IV, consider 2 more weeks PO/IV )</td>
<td></td>
</tr>
</tbody>
</table>

Consult Infectious Disease Team for complicated pneumonias and failed outpatient therapy  

Table 5. Antibiotic Recommendations

**Surgical Intervention vs. Non-Surgical Intervention**
- **Effusions which are enlarging and/or compromising respiratory function should not be managed by antibiotics alone.** [D]  
- **Give consideration to early active treatment as conservative treatment results in prolonged duration of illness and hospital stay.** [D]  
- **Pleural Effusion/Empyema: multiple non-surgical, non-antibiotic treatment modalities exist:**  
  - Thoracentesis  
  - Chest tube drainage (CTD)  
  - Instillation of fibrinolytic therapy into the pleural cavity  
  - Decortication  
- **VATS (Video-assisted thoracic surgery) should be performed, if possible, within 48 hours of hospitalization, if intervention is necessary.**  
  - The decision for surgical vs. non-surgical intervention remains solely with they surgery and/or interventional radiology teams.  
  - VATS performed within 48 hours of hospitalization has been shown to significantly decrease hospital length of stay. [36, 64-66]  
- **Pleural fluid obtained during VATS should be sent for appropriate fluid studies (see pleural fluid analysis above).**  
- **VATS has become recognized as a less invasive surgical option that has led to the recommendation of VATS as an early surgical approach to drain the pleural space (rather than thoracentesis, CTD, or antibiotics alone).** [36, 66-69]
Primary operative therapy (i.e. VATS) is associated with a lower in hospital mortality rate, re-intervention rate, length of stay, time with tube thoracostomy, and time of antibiotic therapy, compared with non-operative treatment. This study demonstrated a significantly reduced relative risk of failure among patients treated with VATS. [64]

- Repeated Thoracentesis: *If a child has significant pleural infection, a drain should be inserted at the outset and repeated taps are not recommended.* [D]
  - Thoracentesis as a treatment option may not be most beneficial at CNMC due to the availability of our Pediatric Surgery Team and Interventional Radiology
    - Decisions on thoracentesis should be made solely by Interventional Radiology and/or Surgery Team
    - Cost/Benefit Ratio of non-surgical vs. surgical intervention (i.e. VATS) should be considered.

- Chest Drains: Placement should be based on similar recommendations as those outlined in the 2005 BTS Guidelines for the Management of Pleural Infection in Children. [1]
  - As stated above for thoracentesis, chest drain/tube placement as a treatment option may not be most beneficial at CNMC due to the availability of our Pediatric Surgery Team and Interventional Radiology
  - Decisions on thoracentesis should be made after consulting with Interventional Radiology and/or Surgery Team
  - Cost/Benefit Ratio of non-surgical vs. surgical intervention (i.e. VATS) should be considered
  - 2005 BTS Guideline Recommendations for chest tube drainage [1]:
    - Chest drains should be inserted by adequately trained personnel to reduce the risk of complications. [C]
    - A suitable assistant and trained nurse must be available. [D]
    - Routine measurement of the platelet count and clotting studies are only recommended in patients with known risk factors. [D]
    - Where possible, any coagulopathy or platelet defect should be corrected before chest drain insertion. [D]
    - Ultrasound should be used to guide thoracentesis or drain placement. [C]
    - If general anaesthesia is not being used, intravenous sedation should only be given by those trained in the use of conscious sedation, airway management and resuscitation of children, using full monitoring equipment. [D]
    - Small bore percutaneous drains should be inserted at the optimum site suggested by chest ultrasound. [C]
    - Large bore surgical drains should also be inserted at the optimum site suggested by ultrasound, but preferentially placed in the mid axillary line through the ‘safe triangle’. [D]
    - Since there is no evidence that large bore chest drains confer any advantage, small drains (including pigtail catheters) should be used whenever possible to minimize patient discomfort. [C]

- Lung Abscess/Necrotizing Pneumonia:
  - Surgery is rarely required for uncomplicated lung abscess.
  - Indications:
    - Failure to respond to medical management
    - Suspected neoplasm
    - Hemorrhage
- Predictors of abscess with slow/no response:
  - Abscesses associated with an obstructed bronchus,
  - Extremely large abscess (>6 cm in diameter), and
  - Abscesses involving relatively resistant organisms, (i.e. *P. aeruginosa*).
- Procedure:
  - Usually lobectomy or pneumonectomy.
  - Alternative approaches (poor operative risk patients)
    - Percutaneous and endoscopic drainage.
    - Require special care (prevent contamination of pleural space).

<table>
<thead>
<tr>
<th>COMMITTEE RECOMMENDATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Surgical vs. Non-Surgical Intervention</strong></td>
</tr>
<tr>
<td>Decision on intervention to be made by Surgical Team/Interventional Radiology</td>
</tr>
<tr>
<td>VATS should be performed within 48 hours of admission (consult Surgery within 24 hours of admission, preferable in ED)</td>
</tr>
<tr>
<td>Chest tube placement and drainage should be monitored closely</td>
</tr>
<tr>
<td>Recurrent small effusions may require intervention</td>
</tr>
<tr>
<td>Any fluid sample removed should be sent for fluid analysis (see laboratory study recommendations)</td>
</tr>
</tbody>
</table>

Table 6. Surgical vs. Non-Surgical Intervention Recommendations

**INPATIENT PLANNING**

- IV antibiotics
  - Start treatment immediately; there should be no reason to delay antibiotic treatment
  - For complicated pneumonias, PICC line should be placed for convenience and planning for long term IV antibiotics (>10 days of IV treatment)
  - Uncomplicated, community acquired pneumonias do not require PICC placement
- Follow clinical symptoms closely
  - Oxygen requirement, PO intake, hydration status, fever trend, etc.
- Consultation:
  - Infectious Disease: will aid in antibiotic selection
  - Surgery: Discuss options for intervention; When possible, VATS should be performed within 48 hours of admission (see above)
  - Pulmonary: If recurrent effusion, abscess, history of asthma, or other complicated past medical history regarding lung disease, consult pulmonary fellow early in treatment course
    - If no significant pulmonary history, may give pulmonary team a courtesy call regarding patient.
- Supportive treatment:
  - Antipyretics
  - Analgesia (may have pleuritic chest pain)
  - Encourage PO
- Wean oxygen as tolerated (keep O₂ saturation > 93%)
- If history of asthma, may require beta agonist therapy
- Monitor for SIADH
- Early mobilization

### COMMITTEE RECOMMENDATIONS

#### Inpatient Planning for Pneumonia with Complication

| Start IV Antibiotics immediately  
| (see recommendations above) |
| Place PICC Line  
| (NOT necessary for Community Acquired Pneumonia) |
| Follow Clinical Symptoms  
| (See admission criteria) |

#### Consults
- ID: Aid in Antibiotic Selection
- Surgery: Discuss Intervention Options
- Pulmonary: If recurrent abscess, asthma, other significant history

#### Supportive Treatment:
- Antipyretics (invariably febrile)
- Analgesia (pleuritic pain)
- Early Mobilization
- Monitor for SIADH
- Encourage PO

Table 7. Inpatient Planning Recommendations

### DISCHARGE PLANNING

- **Clinical Criteria for Discharge**
  - At baseline Oxygen requirement
  - Fever trending down
  - No signs of respiratory distress
  - Chest tubes (if placed) have been removed and patient cleared by surgical team

- **Chest CT**: repeat chest CT, if performed earlier, should not be repeated
  - CT changes may take many months to years to show complete resolution
  - Clinical improvement is more sensitive indicator of clinical status
  - May cause unnecessary radiation exposure without assisting in treatment plan

- **Home Antibiotics**
  - See *Treatment Course* (above)

- **Outpatient Appointments**
  - Primary Medical Doctor (PMD): within 1 week of discharge
    - Reassurance, monitor overall health
    - For details, see *Committee Recommendations: Outpatient Follow Up* below
  - Infectious Disease (ID): weekly beginning 1 week after discharge
    - Monitor response to antibiotic therapy
    - Weekly history/exam to screen for complications

Complicated Pneumonia Guidelines 18
• For details, see Committee Recommendations: Outpatient Follow Up below
  - Pulmonary Medicine: 6-8 weeks post discharge
  • Monitor for long term pulmonary complications
  • For details, see Committee Recommendations: Outpatient Follow Up below

### COMMITTEE RECOMMENDATIONS

#### Discharge Planning

<table>
<thead>
<tr>
<th>Clinical Symptoms:</th>
<th>Chest tubes out</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>At baseline oxygen requirement</td>
</tr>
<tr>
<td></td>
<td>Fever trending down</td>
</tr>
<tr>
<td></td>
<td>No respiratory distress</td>
</tr>
<tr>
<td></td>
<td>No need for CT chest unless change in clinical status</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Home antibiotics:</th>
<th>Initially order 2 weeks IV Antibiotics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Final course decided by ID as outpatient</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Outpatient Follow-Up Appointments:</th>
<th>PMD: Within 1 week of discharge</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ID: Weekly starting 1 week after discharge</td>
</tr>
<tr>
<td></td>
<td>Pulmonary: 6-8 weeks after discharge</td>
</tr>
</tbody>
</table>

Table 9. Discharge Planning Recommendations

#### COMMITTEE RECOMMENDATIONS

#### Outpatient Follow Up

<table>
<thead>
<tr>
<th>ID Clinic:</th>
<th>Weekly for 4 weeks post discharge to monitor exam and antibiotics:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Necrotizing pneumonia: 2-3 weeks antibiotics (At least 2 weeks IV)</td>
</tr>
<tr>
<td></td>
<td>Empyema s/p VATS: 2-3 weeks antibiotics (At least 2 weeks IV)</td>
</tr>
<tr>
<td></td>
<td>Drained Abscess: 3-4 weeks antibiotics (At least 2 weeks IV)</td>
</tr>
<tr>
<td></td>
<td>Undrained Abscess: 4-6 weeks antibiotics (At least 4 wks IV, consider 2 more weeks PO/IV)</td>
</tr>
<tr>
<td><strong>Weekly/biweekly Labs:</strong></td>
<td>CBC w/diff, CRP, ESR, AST, ALT, Creatinine, (trough if on Vancomycin) Fax to 202-476-3850 (ID) for review</td>
</tr>
<tr>
<td>--------------------------</td>
<td>--------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Chest X-Ray (AP/Lateral)</strong></td>
<td>Not recommended until 4 weeks unless clinical deterioration (most patients will be switching from IV to PO except undrained abscess) Repeat at 4 wk appointment to monitor resolution: May not fully resolve radiographically, but look for improvement</td>
</tr>
<tr>
<td><strong>Repeat Studies</strong></td>
<td>Repeat CXR, ESR, CRP earlier if no signs of improvement or: 1. fever spike &gt; post 14 days abx 2. ↓ PO/weight loss 3. ↓ Activity/tired Consider CT if complications noted on repeat CXR or based on history</td>
</tr>
<tr>
<td><strong>Pulm Clinic:</strong></td>
<td>6-8 wks post d/c based on history and complications ID can refer earlier if complications Page Pulmonary Consult Fellow Obtain Full Pulmonary History Consider PFTs: Monitor lung function long term May need interval CXR (based on illness course)</td>
</tr>
</tbody>
</table>

If acute decompensation at any time, may require admission, surgical referral/consultation, and possible resection based on presentation and history

**Table 10. Outpatient Follow Up Recommendations**
REFERENCES


