Pediatric Community Acquired Pneumonia

Newborn/Pediatric Critical Care Conference

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Outline

• Review pathophysiology
• Review common organisms
• Review recommended management
• Review common radiographic findings
• Review complications (effusion and abscess)
Pretest

• Which organisms are the most likely causes of pneumonia in a term 3 day old?
• What is the recommended duration of antibiotics for uncomplicated pediatric CAP?
• What organisms typically cause pleural effusions?
Acute Pneumonia

- *Pneumonia* = Greek for “lung inflammation”
- Inflammation of alveoli and interstitial tissue by an infectious organism
- Arises from aspiration, inhalation, or hematogenous seeding of infectious organism
Acute Pneumonia

• Leading infectious cause of mortality in children worldwide\(^1\)
• Estimated to have killed 1.6 million children < 5 yo since 2000\(^1\)
• In U.S. CAP accounts for ~9% outpatient visits in <2 yo and ~5% in 3-6 yo\(^2\)


Pneumonia Pathophysiology

- Physical and physiologic barriers of respiratory tract:
  - Filtration and humidification
  - Mucus production
  - Epiglottis and cough
- B and T cells
- Alveolar phagocytes

- Failure of these barriers or a large inoculum leads to pneumonia
CAP: Difficulty in Diagnosis

• Primarily a clinical diagnosis
  – No single pathognomonic sign (fever, abdominal pain, hypoxia, etc.)
• Bacterial vs. viral etiology
• Can see co-infections (bacterial-viral, viral-viral)¹

Bacterial CAP

- Acute onset
- Usually focal pulmonary findings
- Unvaccinated more at risk
- Alveolar rich blood supply can lead to bacteremia

Viral CAP

- Gradual onset
- Usually diffuse pulmonary findings
- Disrupt alveolar macrophages → secondary infection
- Greater appreciation in age of vaccination and improving molecular diagnostics
CAP: Difficulty in Diagnosis

• Bloodstream infection helps establish diagnosis but only occur in ≤ 10%\textsuperscript{1,2}

• Pathogens vary by age, underlying immune function


Outline

• Review pathophysiology
• **Review common organisms**
• Review recommended management
• Review common radiographic findings
• Review complications (effusion and abscess)
CAP Organisms: 0-3 weeks

- Group B strep
- Gram negative enteric bacilli
- L. monocytogenes
- T. pallidum
- CMV
- HSV
- Genital Mycoplasma and Ureaplasma (LBW)

• Which organisms are the most likely causes of pneumonia in a term 3 day old?
• What is the recommended duration of antibiotics for uncomplicated pediatric CAP?
• What organisms typically cause pleural effusions?

CAP Organisms: 0-3 weeks

• Early vs. late onset
• Consider risk factors: preterm delivery, chorioamnionitis, PROM
• *C. trachomatis* tends to present by 2-3 weeks

CAP Organisms: 3 wk-3mo

- *C. trachomatis*
- RSV
- Rhinovirus
- Parainfluenza viruses
- *S. pneumoniae*
- *B. pertussis*

CAP Organisms: 3mo-5yo

- RSV, parainfluenza, HMPV, influenza, adenovirus, rhinovirus
- *S. pneumoniae*
- *H. influenzae* (non-typeable)
- *S. aureus*
- *M. pneumoniae*
- Other viruses: Enterovirus, parechovirus

CAP Organisms: 5yo-15yo

- *S. pneumoniae*
- *S. aureus*
- Influenza virus
- HMPV*
- *M. pneumoniae*
- *C. pneumoniae*

Pathogens Detected Among Hospitalized Children with CAP Enrolled in EPIC Study--January 1, 2010 to June 30, 2011

- Negative: 18%
- Co-pathogen: 23%
- Bacterial: 10%
- Viral: 77%
### Pathogens Detection in Relation to Age among Hospitalized Children with CAP in EPIC Study--January 1, 2010 to June 30, 2011

<table>
<thead>
<tr>
<th>Bacterial Pathogen Detected</th>
<th>&lt; 5 yo n=964</th>
<th>5-9 yo n=211</th>
<th>10-17 yo n=145</th>
<th>All ages n=1320</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>S.pneumoniae</em></td>
<td>3%</td>
<td>1%</td>
<td>2%</td>
<td>3%</td>
</tr>
<tr>
<td><em>M.pneumoniae</em></td>
<td>2%</td>
<td>9%</td>
<td>19%</td>
<td>5%</td>
</tr>
<tr>
<td><em>S.pyogenes</em></td>
<td>1%</td>
<td>0%</td>
<td>2%</td>
<td>1%</td>
</tr>
<tr>
<td><em>C.pneumoniae</em></td>
<td>&lt;1%</td>
<td>1%</td>
<td>1%</td>
<td>&lt;1%</td>
</tr>
<tr>
<td><em>S.aureus</em></td>
<td>&lt;1%</td>
<td>&lt;1%</td>
<td>0%</td>
<td>&lt;1%</td>
</tr>
</tbody>
</table>
Outline

• Review pathophysiology
• Review common organisms
• **Review recommended management**
• Review common radiographic findings
• Review complications (effusion and abscess)
Clinical Scenario

You are seeing a previously healthy, fully vaccinated, 4 yo child in clinic. She presents with 2 days of fever and worsening cough.

What are the next steps to work her up for pneumonia?
IDSA Pediatric CAP Guidelines

• Obtain pulse oximetry and examine
  – Exam consistent with pneumonia?
• Decide on inpatient vs. outpatient
• Hospitalization recommended:
  – moderate-to-severe CAP
  – patients 3-6 mo old
  – Concern for virulent pathogen, e.g. MRSA
  – Concern for poor follow-up/compliance
IDSA Pediatric CAP Guidelines

• Recommended inpatient management:
  – Does the child require ICU care?
  – CBC with diff, ESR, CRP, test for influenza and start treatment if high suspicion
  – 2 view CXR (repeat not routinely needed)
  – Blood culture for complicated pneumonia or for moderate-to-severe pneumonia
  – Tracheal aspirate culture (if intubated) and pleural fluid (if significant) for culture and/or PCR testing
  – Reassess in 24-48 hours
IDSA Pediatric CAP Guidelines

• Recommended **outpatient** management:
  – Little evidence to support extensive testing
  – Test for influenza and treat if high suspicion
  – Do not necessarily need CXR or labs
  – Routine blood culture not routinely needed for fully immunized, non-toxic child
  – Consider blood culture for child who does not show clinical improvement or who has worsening symptoms
  – Reassess in 24-48 hours
Bacterial CAP Treatment (IDSA)

• **Inpatient**: Ampicillin or PCN G recommended empiric therapy (target *S.pneumoniae*)
  – PCN allergy: Ceftriaxone, clindamycin, vancomycin
  – If suspect MRSA, add clindamycin or vancomycin
  – Incomplete immunizations, high rate of PCN-resistant *S.pneumoniae*, or empyema: give 3G cephalosporin
  – Discharge: step down to oral therapy preferred over outpatient parenteral therapy
Bacterial CAP Treatment (IDSA)

• **Outpatient**: amoxicillin recommended empiric therapy (target *S. pneumoniae*)
  – PCN allergy or PCN-resistant *S. pneumoniae*: Ceftriaxone, clindamycin, levofloxacin*
  – If suspect atypical organism, use macrolide
• Which organisms are the most likely causes of pneumonia in a term 3 day old?
• What is the recommended duration of antibiotics for uncomplicated pediatric CAP?
• What organisms typically cause pleural effusions?
Bacterial CAP Treatment

• Lack of prospective RCT evaluating duration of therapy in U.S.
  – Various international studies have looked at 3-10 days of treatment

• IDSA recommends **10 days** for uncomplicated pneumonia
  – 2-4 weeks for complicated pneumonia
Viral CAP Treatment (IDSA)

• Antibiotics not routinely required for preschool aged children (viral most likely)
• If suspect influenza, promptly initiate neuraminidase inhibitor (Tamiflu)
• Supportive care
Recommended Tamiflu dosing

- <12 mo old: 3 mg/kg BID
  - Emerging data may change dosing\(^1\)
- >12 mo old: weight-dependent dosing
  - ≤15kg: 30 mg BID
  - 15-23kg: 45 mg BID
  - 23-40kg: 60mg BID
  - > 40 kg: 75 mg BID

Pediatric CAP: *algorithm steps 1-3*

**ALGORITHM: DIAGNOSIS AND DISPOSITION**

Previously healthy child presents to physician office or ED with signs/symptoms suggestive of pneumonia (a)

1. **ASSESS for RESPIRATORY DISTRESS**
   - *starred items have best positive predictive value for CAP*
   - *Tachypnea: RR breaths/minute >50 for age 2-12 months, >40 for age 1-5 years, >20 for age >5 years*
   - *Pulse oximetry <90% on room air*
   - *Nasal flaring*
   - *Grunting*
   - *Dyspnea*
   - *Apnea*
   - *Altered mental status*
   - *Retractions (suprasternal, intercostals, subcostals)*

   If bronchiolitis, follow appropriate guidelines.
   Clinical diagnosis of CAP? (b)

   - Yes → pneumococcus
   - Yes → Hib
   - No → influenza (this season)

2. **ASSESS IMMUNIZATION STATUS**
   - To guide decision-making re: labs and therapy
   - yes / no

3. **ASSESS NEED FOR INPATIENT CARE**
   - Moderate to severe CAP as determined by several factors, including respiratory distress and sustained hypoxemia
   - Age <6 months with suspected bacterial CAP (RSV negative)
   - Persistent respiratory distress

   - Suspicion/confirmation of CA-MRSA, other highly virulent CAP cause
   - Dehydration or inability to feed
   - Concern about observation at home or ability to follow up

   Plan OUTPATIENT care

   - none of above

   or

   Plan INPATIENT care

   - any one of above

...*with notes*

a) **SIGNS AND SYMPTOMS** suggestive of pneumonitis: Clinical presentation varies depending upon the responsible pathogen and the severity. Symptoms may be subtle, especially in young children.
   - Fever
   - Cough
   - Chest pain
   - Abdominal pain
   - Breath sounds: striking focal findings of bronchial breath sounds or crackles
   - In infants and young children: difficulty feeding, restlessness, or fussiness

For guidance in ruling out bronchiolitis, see the Discussion on page 4 of this CPM.

(b) **CLINICAL DIAGNOSIS OF CAP**: Best positive predictive value: tachypnea, O₂ saturation <90%, and nasal flaring (for age <12 months); best negative predictive value is absence of tachypnea or other signs and symptoms of respiratory distress.
Pediatric CAP: *algorithm* step 4

**4. PERFORM LIMITED TESTING AS NEEDED**

- If child is *NOT* fully immunized, obtain:
  - CBC
  - Blood culture

*Consider:*

- Influenza testing as seasonally appropriate.
  - (see [www.GemWatch.org](http://www.GemWatch.org)) when the child’s symptoms are compatible with influenza and the results may influence decision to treat with antiviral medication.
- Testing for other viruses, if results will influence clinical decisions such as need for treatment with antibiotics.
- Chest x-ray (c); note that chest radiographs are generally *NOT* needed to confirm CAP in patients well enough to be treated in an outpatient setting.

**OUTPATIENT care**

**Plan OUTPATIENT care**

4. **PERFORM FULL TESTING**

- Obtain:
  - Chest x-ray (c)
  - CBC
  - Blood culture
  - Viral testing as available per facies on seasonality, see [www.GemWatch.org](http://www.GemWatch.org)

*Consider CRP testing*

**Plan INPATIENT care**

**Effusion requiring intervention? (e)**

- *No*
  - **NON-ICU care**
- *Yes*
  - **Manage per IDSA algorithm (e)**
  - **Need ICU? (d)**
    - *No*
      - **NON-ICU care**
    - *Yes*
      - **ICU** (discuss w/ICU staff)

**ICU Admit:** Consider ICU admit if:

- Requires non-rebreather to maintain $O_2$ saturation $>90$
- Requires $>8$ liters $O_2$ by simple mask
- Impending respiratory failure, sustained tachycardia, inadequate BP, or need for pharmacologic support of BP or perfusion
- Need for invasive ventilation via a nonpermanent artificial airway (e.g., endotracheal tube)
- Need for noninvasive positive pressure ventilation (e.g., CPAP or BPAP)
- Altered mental status, whether due to hypercarbia or hypoxemia due to CAP

**ASSESS & MANAGE PARAPNEUMONIC EFFUSION:** Size of effusion and proportion of thorax opacity determine management; intervention is recommended when effusion $\geq 10$ mm rim or $\geq 1/4$ of thorax is opacified.

For guidance on managing effusion, refer to the IDSA guidelines.

...with notes
5. SELECT TREATMENT OPTION(S)

- **NO TREATMENT.** Most children well enough to be treated as outpatients do not require antibiotics, as viral pathogens are responsible for the majority of clinical disease.

- **ANTIBIOTICS.** If you choose to give antibiotics, follow these recommendations (see (f) for first-line choices, doses):
  - GIVE **PO antibiotics**.
  - ADD azithromycin if suspected or confirmed atypical pathogen (may be used alone if high suspicion of single atypical pathogen).

- **INFLUENZA ANTIVIRAL THERAPY.** Start if symptoms <48 hours and flu is suspected or confirmed in a child <2 years or at high risk (see back page for discussion, sidebar (g) for dosing):
  - PROVIDE oseltamivir for moderate disease or to high-risk patients UNLESS OR UNTIL negative PCR result is obtained, and
  - CONTINUE antiviral therapy if flu result is positive

### OUTPATIENT care for mild-moderate CAP

If not already done, obtain blood cultures BEFORE starting antibiotic. Do not wait for culture results before giving antibiotics.

### INPATIENT care (non-ICU) for moderate-severe CAP

(f) **ANTIBIOTIC DOSING.** The first-line therapy choices listed below provide appropriate coverage for *Streptococcus pneumoniae*, the most prominent invasive bacterial pathogen. For more medication options, see IDSA guidelines.

<table>
<thead>
<tr>
<th>Antibiotic and dose</th>
<th>PO if appropriateimmunization* (outpatient and hospital)</th>
<th>PO if NOT appropriately immunized* (outpatient and hospital)</th>
<th>IV if appropriateimmunization* (hospital)</th>
<th>IV if NOT appropriately immunized* (hospital)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amoxicillin, PO</td>
<td>30 mg/kg/dose (max 1 g) 3 times daily x 10 days</td>
<td>30 mg/kg/dose (max 1 g) 3 times daily x 10 days</td>
<td>30 mg/kg/dose (max 2 g) every 8 hours</td>
<td>10 mg/kg/dose (max 500 mg) on day one, followed by 5 mg/kg/dose (max 250 mg) once daily on days 2-5</td>
</tr>
<tr>
<td>Clindamycin, PO</td>
<td>10-13 mg/kg/dose (max 300 mg) 3 times daily x 10 days</td>
<td>10-13 mg/kg/dose (max 300 mg) 3 times daily x 10 days</td>
<td>10 mg/kg/dose (max 500 mg) on day one, followed by 5 mg/kg/dose (max 250 mg) once daily on days 2-5</td>
<td></td>
</tr>
<tr>
<td>Clavulanate, PO</td>
<td>30 mg/kg/dose (max 1 g) 3 times daily x 10 days</td>
<td>30 mg/kg/dose (max 1 g) 3 times daily x 10 days</td>
<td>30 mg/kg/dose (max 2 g) every 8 hours</td>
<td>10 mg/kg/dose (max 500 mg) on day one, followed by 5 mg/kg/dose (max 250 mg) once daily on days 2-5</td>
</tr>
</tbody>
</table>

*appropriately immunized for pneumococcus, flu

5. SELECT TREATMENT OPTION(S)

- **NO TREATMENT.** If testing suggests pneumonia is caused by a viral process, antibiotics may not be needed.

- **ANTIBIOTICS.** If you choose to give antibiotics, follow these recommendations (see (f) for first-line choices, doses):
  - BEGIN trial of **PO antibiotics** if:
    - patient is tolerating PO fluids, able to absorb PO medication, and
    - patient’s RRT allows for PO medications, and
    - patient has NOT failed a trial of high-dose amoxicillin (no improvement within 48-72 hours) prior to admission; OTHERWISE...
  - BEGIN **IV antibiotics** and @ 24 hours convert to PO antibiotics if patient can tolerate oral therapy
  - ADD azithromycin if suspected or confirmed atypical pathogen

- **INFLUENZA ANTIVIRAL THERAPY.** Choose during flu season (see (g) for dosing):
  - PROVIDE oseltamivir UNLESS OR UNTIL negative PCR result is obtained, and
  - CONTINUE both antibiotic and antiviral if flu result is positive

Modify antiviral treatment as test results become available or with ability to tolerate PO meds.
Pediatric CAP: algorithm steps 6 and 7

6. PROVIDE OTHER OUTPATIENT CARE

- IMMUNIZATIONS: Give influenza and pneumococcal immunizations if appropriate (h).
- Patient education. Use Intermountain fact sheet Pneumonia: Prevention and Care at Home or Let’s Talk About...Pneumonia (pediatric), available in English and Spanish at i-printstore.com.

7. FOLLOW-UP WITH OUTPATIENTS

- Follow-up visit or phone call in 48-72 hours.
- Modify anti-infective treatment as test results become available.
- As needed for parents: Provide smoking cessation advice/counseling; can use Intermountain’s Quitting Tobacco — your journey to freedom booklet available at i-printstore.com.

6. IMPLEMENT INPATIENT BEST PRACTICES

- Pulse oximetry.
- Early ambulation — sitting in chair and/or ambulating for at least 20 minutes during the first 24 hours of hospitalization.

7. EVALUATE CLINICAL STATUS AT 48-72 HOURS

- ATTEMPT TRANSITION to oral medication if not already done (f)
- IMMUNIZE as needed (h)
- DISCHARGE per criteria (i)

Further Investigation
Chest x-ray (c)
Additional or repeat tests? ID consult?

...with notes

(h) IMMUNIZATIONS.
- Screen all patients for influenza, pneumococcal, and/or pertussis immunizations at the clinic or before hospital discharge.
- Promote immunizations for influenza virus and pertussis for all parents and caretakers of infants age <6 months.

(i) DISCHARGE CRITERIA.
- Documented overall clinical improvement (↓ fever, ↑ appetite and activity) for at least 12 hours
- Consistent pulse oximetry measurements demonstrating adequate oxygenation
- Normal and/or baseline mental status
- NO substantially increased work of breathing or sustained tachypnea or tachycardia
- NO barriers to follow-up or at-home care
Outline

• Review pathophysiology
• Review common organisms
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• Review common radiographic findings
• Review complications (effusion and abscess)
Classic Radiographic Findings

• Can be falsely normal and lag behind clinical exam

http://fitsweb.uchc.edu/ctanatomy/chest/review/lobes-anterior.html
Viral Pneumonia
S. pneumoniae Focal Infiltrate
S. pneumoniae Focal Infiltrate
S. pneumoniae Focal Infiltrate
Nodular infiltrates
Nodular Infiltrates
Nodular Infiltrates
Outline

• Review pathophysiology
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PPE and Empyema

- **Pleural effusion**: any fluid between visceral and parietal pleurae (exudate vs. transudate)
- **Parapneumonic effusion (PPE)**: inflammatory fluid around a pneumonic process
- **Empyema**: purulent PPE
• Which organisms are the most likely causes of pneumonia in a term 3 day old?
• What is the recommended duration of antibiotics for uncomplicated pediatric CAP?
• What organisms typically cause pleural effusions?
PPE and Empyema

• Culture is often negative
• Common bacteria include: *S.pneumoniae*, *S.aureus*, *S.pyogenes*, *M.pneumoniae*¹
• Rare complications include **bronchopleural fistula**

PPE and Empyema

• Radiographs are relatively sensitive and better predictors than physical exam
• Consider US or CT chest to distinguish fluid from parenchymal disease

PPE and Empyema Treatment

- Small-to-moderate rarely require drainage\(^1\)
- Large (>1/2 thorax) usually require continuous drainage\(^1\)
- PPE with loculations benefits from chest tube placement, fibrinolysis, or VATS\(^2,3\)
- Consider VATS for persistent moderate-to-large effusions causing ongoing respiratory compromise

PPE and Empyema Treatment

• Empiric antibiotics target most likely organisms (ceftriaxone, vancomycin, clindamycin, azithromycin)

• Treat for 2-4 weeks
Necrotizing Pneumonia/Pulmonary Abscess

- Necrotizing pneumonia: insidious necrosis of lung parenchyma
- Suspect when no improvement despite appropriate antibiotics
- Often complicated by PPE
- Can lead to pulmonary abscess, pneumatocele, bronchopleural fistula

- Usually due to virulent, toxin-producing bacteria (S.pneumoniae, S.aureus, S.pyogenes)
Necrotizing Pneumonia/Pulmonary Abscess Treatment

• Percutaneous drainage of abscess can create bronchopulmonary fistula
  – Consider drainage if no improvement after 5-7 days, abscess > 4 cm, causes mediastinal shift, or results in mechanical ventilation\(^1\)

Necrotizing Pneumonia/Pulmonary Abscess Treatment

• Most cases respond to antibiotics without surgery
  – Empiric choices depend on suspected source (clindamycin, zosyn)

• Treat for 4 weeks
Preventing CAP

- Immunize, immunize, immunize!
Summary

• Etiology of CAP varies with age
• Extensive testing and CXRs not routinely needed for outpatient
• Be wary of co-infections
• Recommended duration of treatment for uncomplicated CAP is 10 days
• PPE, empyema, necrotic lung, lung abscess require longer duration of antibiotics
Questions?