Pediatric Pneumonia in the ED:
How to Diagnose and Treat?

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Conflict of Interest

- Nil
Learning Objectives

At the end of this session participants:

1.) will have reviewed an evidence-based approach to the diagnosis and management of pediatric pneumonia

2.) will have reviewed new clinical practice guidelines for the diagnosis and management of pediatric pneumonia

3.) will have reviewed atypical presentations and complications that may pose a challenge to the clinician
Burden of Disease

- Pneumonia is the single greatest cause of death in children worldwide.
- Each year >2 million children younger than 5 years die of pneumonia, representing ~20% of all deaths in children within this age group.
- World Pneumonia Day – November 12, 2012.
Objectives

• Introduction
• Epidemiology
• Diagnosis – evidence-based
• New Guidelines
• Complications
• Treatment – evidence-based
• Take Home Message
Population

- Management of:
  - neonates and infants less than 3 months,
  - Immunocompromised,
  - those receiving home mechanical ventilation,
  - And those with chronic conditions or underlying lung disease - cystic fibrosis
Introduction

- Common clinical entity
- Overall incidence:
  - 4% per year < 5 years
  - 2% 5-9 years
  - 1% > 9 years
Introduction

- Inflammation of the lung tissue post noninfectious or infectious insult
- Acute infection of the lower respiratory tract parenchyma
  - Viral – increased risk of secondary bacterial
  - Bacterial
  - Atypical
Introduction

• Community acquired pneumonia (CAP) can be defined clinically as:

  • the presence of signs and symptoms of pneumonia in a previously healthy child due to an infection which has been acquired outside hospital.
Etiology

- Viral
  - RSV, influenza – seasonal
  - Parainfluenza 1 and 3
  - Adenovirus
  - Metapneumovirus
Etiology

- Bacterial and Atypical:
  - 3 months to 5 years – S.pneumoniae, S.aureus
  - 5 years to 18 years – S.pneumoniae, M.pneumoniae
Accurate Etiologies

• Extrapolate from hospitalized patients
Aspiration disclosed the etiology in:
- 20 of 34 cases overall (59%)

Pneumothorax developed in:
- 6 patients (18%)
Epidemiology and Clinical Characteristics of Community-Acquired Pneumonia in Hospitalized Children
Michelow, I et al Pediatrics 2004;113:701-707

- 154 children (2 mo – 17 y) with lower respiratory tract infections:
  - 80 % had pathogen identified
    - 60 % bacterial – 75 % pneumococcus
    - 45 % viral
    - 15 % Mycoplasma pneumoniae
    - 10 % Chlamydia pneumoniae
    - 23 % Mixed bacterial/viral
Epidemiology and Clinical Characteristics of Community-Acquired Pneumonia in Hospitalized Children
Michelow, I et al Pediatrics 2004;113:701-707

- Those with **bacterial** and mixed LRI’s had the greatest degree of inflammation and severity
  - High temperatures
  - Pleural effusions
  - Elevated procalcitonin, bands
  - Assisted ventilation
  - Prolonged hospitalization
Epidemiology and Clinical Characteristics of Community-Acquired Pneumonia in Hospitalized Children
Michelow, I et al Pediatrics 2004;113:701-707

- Those with M and C pneumoniae:
  - As common in pre-schoolers as older children
Diagnosis of Pneumonia

- What is your gold standard?
Clinical Symptoms

- Fever, cough, poor feeding, difficulty breathing, vomiting
- Chest, abdominal pain
- Persistent cough
Clinical Signs

- Tachypnea
- Dullness, tactile fremitus, reduced vesicular, increased bronchial
- Wheeze
Tachypnea

Tachypnea is a nonspecific clinical sign

- may be a marker for respiratory distress and/or hypoxemia.
- fever, dehydration, or a metabolic acidosis
WHO Diagnosis

- Tachypnea and retractions are the most accurate signs for identifying pneumonia
  - > 50 breaths/min in infants 2 to 12 months of age,
  - > 40 breaths/min in children aged 1 to 5 years, and
  - > 20 breaths/min in children aged 5 years and older
Investigations

- Chest Radiograph
- Pathogen Detection
- Blood Tests
# Estimates of radiation dosage delivered from common diagnostic images

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Average Effective Dose (mSv)</th>
<th>Equivalent natural background radiation (months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plain Film</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chest PA</td>
<td>0.02-0.05</td>
<td>0.14</td>
</tr>
<tr>
<td>Chest PA and Lateral</td>
<td>0.1</td>
<td>0.3</td>
</tr>
<tr>
<td>Extremity</td>
<td>0.1</td>
<td>0.3</td>
</tr>
<tr>
<td>Abdomen</td>
<td>1.0</td>
<td>2.9</td>
</tr>
<tr>
<td>Pelvis</td>
<td>1.6</td>
<td>4.6</td>
</tr>
<tr>
<td>Computed Tomography Head</td>
<td>2.0</td>
<td>5.7</td>
</tr>
<tr>
<td>Computed Tomography Chest</td>
<td>7.0</td>
<td>20</td>
</tr>
<tr>
<td>Computed Tomography Abdomen</td>
<td>9.0</td>
<td>25.7</td>
</tr>
</tbody>
</table>
Chest Radiograph

– Otherwise overdiagnosed
– Helps if deterioration

– Viral – peribronchial wall thickening, hyperinflation
– Bacterial - lobar, segmental infiltrates, effusion
– Atypical – interstitial infiltrates
Characteristics of Streptococcus pneumoniae and atypical bacterial infections in children 2-5 years of age with community-acquired pneumonia.

- S. pneumoniae infections were diagnosed in 48 patients (24.5%)
- Atypical bacterial infections in 46 (23.5%)
- Mixed infections in 16 (8.2%)
Comparison of **radiographic** findings for 196 children who were evaluated in a study of pediatric community-acquired pneumonia:

<table>
<thead>
<tr>
<th>Findings</th>
<th>Streptococcus pneumoniae (48)</th>
<th>Atypical bacteria (46)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hyperinflation</td>
<td>5 (10.4)</td>
<td>6 (13)</td>
</tr>
<tr>
<td>Peribronchial wall thickening</td>
<td>3 (6.3)</td>
<td>4 (8.7)</td>
</tr>
<tr>
<td>Perihilar linear opacities</td>
<td>15 (31.3)</td>
<td>20 (43.5))</td>
</tr>
<tr>
<td>Reticulonodular infiltrate</td>
<td>13 (27.1)</td>
<td>21 (45.7)</td>
</tr>
<tr>
<td>Segmental or lobar consolidation</td>
<td>18 (37.5)</td>
<td>12 (26.1)</td>
</tr>
<tr>
<td>Bilateral consolidations</td>
<td>7(14.6)</td>
<td>4(8.7)</td>
</tr>
<tr>
<td>Pleural effusion</td>
<td>3 (6.3)</td>
<td>3 (6.5)</td>
</tr>
</tbody>
</table>
Chest Radiographs

• Should they be done?
• How many views?
• Whose interpretation?
Randomised controlled trial of clinical outcome after chest radiograph in ambulatory acute lower-respiratory infection in children.
Swingler G et al Lancet 1998 7;351:404-8

• **Objective** - to assess the impact of chest radiography on clinical outcome

• **Methods** - 522 children aged 2 to 59 mo randomly allocated to have CXR or not
  • main outcome was time to recovery
Randomised controlled trial of clinical outcome after chest radiograph in ambulatory acute lower-respiratory infection in children
Swingler G et al Lancet 1998 7;351:404-8

• Results:
  
  – median time to recovery was 7 days in both groups

  – antibiotic use was higher in the CXR group
    
    (60.8% vs 52.2%, p=0.05)

• Routine use of chest radiography was not beneficial
• 99.0% of all emergency department radiographs were read correctly on initial review by ED attending physicians.

• Of all misread radiographs, less than half (46%) were deemed clinically significant and required a follow-up intervention.
Pediatric Emergency Physician Interpretation of Plain Radiographs: Is routine Review by a Radiologist Necessary and Cost Effective?

- **Objective** - to determine the concordance rate of plain radiograph interpretations by PEP and pediatric radiologists

- **Methods** - a prospective series of patients undergoing radiography had PEP interpretation compared with radiology interpretation within 24 h
Pediatric Emergency Physician Interpretation


• **Results** - concordance rate of 90.2% (638 of 707)

  – 19 of 69 discordant interpretations required changes in management:

    » 9 false-negatives - 5 fractures,
      2 pneumonia, 1 sinusitis, 1 cardiomegaly

    » 10 false-positives - 5 fractures,
      4 pneumonia, 1 sinusitis

• no adverse outcomes resulted

- To compare the accuracy of diagnostic interpretation of radiographs by pediatric emergency physicians:
  - before (2001) and after (2002) the introduction of PACS

- Diagnostic performance for the two time periods was as follows:
  - Conventional = 98.1%
  - PACS = 98.5%
Should a lateral chest radiograph be routine in suspected pneumonia?

• **Objective** - to determine if a lateral view provides additional diagnostic information to the frontal

• **Methods** - retrospective review of 414 chest films of children aged 1 to 12

  – frontal film interpreted and then lateral film interpreted by a pediatric radiologist
Should a lateral chest radiograph be routine in suspected pneumonia?

- **Results** - 215 of 414 (52%) pneumonia positive
  - 206 frontal films positive
  - 9 (2.2%) lateral films additionally positive

- Frontal film should be the initial film projection
Occult Infections

- Bacteremia
  - Before pneumococcal conjugate vaccines, ~1% with pneumococcal bacteremia had bacterial meningitis.

- Pneumonia
  - Occult pneumonia is defined as radiographic pneumonia patients without signs of pneumonia.
Clinical predictors of occult pneumonia in the febrile child.
Murphy C et al Acad Emerg Med 2007;14:243-9

• Clinical features associated with a higher likelihood of occult pneumonia included:
  – presence of cough and duration > 10 days,
  – fever for >5 days,
  – fever >39°C, and
  – leukocytosis (WBC count >20 000/μL)
Right-lower-lobe pneumonia and acute appendicitis in childhood: A therapeutic disorder

- Two children with simultaneous right-lower-lobe pneumonia and acute appendicitis had uneventful recoveries after early diagnosis and appendectomy.

- The presence of right-lower-lobe pneumonia does not exclude the possibility of simultaneous acute acute appendicitis.
Pathogen Detection

- Aspiration
- Sputum
- Serology
- Molecular Studies - PCR
Blood Tests

- Complete blood count
- Blood culture
- Inflammatory Markers
Guidelines

• Practice guidelines are:

  • “systematically developed statements to assist practitioners and patients in making decisions about appropriate health care for specific clinical circumstances”
Guidelines

• Guidelines for the management of community-acquired pneumonia in adults:
  • decrease morbidity and mortality rates
What has changed?

• PCV
  – Pneumococcal conjugate vaccines have reduced pneumonia admissions by 25%

• Penicillin-resistant streptococcus, CA-MRSA

• Influenza
The Management of Community-Acquired Pneumonia in Infants and Children Older Than 3 Months of Age: Clinical Practice Guidelines by the Pediatric Infectious Diseases Society and the Infectious Diseases Society of America

• Evidence-based guidelines prepared by expert panel:

  • community pediatrics,
  • public health, and
  • the pediatric specialties of
    – critical care,
    – emergency medicine,
    – hospital medicine,
    – infectious diseases,
    – pulmonology, and
    – surgery.
What Imaging Tests Should Be Used in a Child With Suspected CAP in an Outpatient Setting?

- Routine chest radiographs are not necessary for the confirmation of suspected CAP in patients well enough to be treated in the outpatient setting.
  - Cannot reliably distinguish viral from bacterial CAP.
When Does a Child or Infant With CAP Require Hospitalization?

- Infants less than 3–6 months of age with suspected bacterial CAP
- Moderate to severe CAP
  - respiratory distress and hypoxemia (saturation of oxygen <90% at sea level)
When Does a Child or Infant With CAP Require Hospitalization?

- Suspected or documented community-associated methicillin-resistant Staphylococcus aureus (CA-MRSA)
- Children and infants for whom
  - there is concern about careful observation at home or
  - who are unable to comply with therapy
Treatment

- Congruent with CPS Guidelines
New Guidelines

Canadian Paediatric Society

Pediatric Infectious Diseases Society and Infectious Disease Society of America
Pneumonia in healthy Canadian children and youth: Practice points for management
CPS Infectious Diseases and Immunization Committee
Le Saux N and Robinson J Paediatr Child Health 2011;16(7):417-20

- Role of chest radiographs
- Empirical therapy
  - Severity
  - Pleural Effusion
  - Risk of co-infection
Chest Radiographs

- “unless it is totally impractical, a chest radiograph should be performed to confirm the diagnosis of pneumonia”
- If the clinical picture and CXR are compatible with bacterial pneumonia then treat
CPS Guidelines

- Empirical antimicrobial therapy for previously healthy children 3 months to 17 years of age with community-acquired, radiologically proven pneumonia of suspected bacterial etiology

- Four step treatment guideline
Step 1

Assess severity and features of pneumonia?
Treatment

A.) Most cases of nonsevere pneumonia

- does not require hospital admission or
- requires admission and minimal supplemental oxygen (fraction of inspired oxygen less than 0.30) and
- is in minimal respiratory distress

- high-dose amoxicillin or ampicillin for 7 to 10 days
Treatment

• B.) Nonsevere pneumonia with primary features of atypical
  
  • subacute onset, prominent cough, minimal leukocytosis, nonlobar infiltrate, school-aged
  
  – clarithromycin or azithromycin
Treatment

• C.) **Severe** pneumonia

  • requires significant supplemental oxygen,
  • patient is in moderate respiratory distress, and
  • may require intensive care

  • ceftriaxone or cefotaxime plus clarithromycin or azithromycin
Step 2

Assess whether the child has proven or clinically suspected influenza plus evidence of secondary bacterial infection?
Treatment

• Consider adding an antiviral for influenza

• **Nonsevere** pneumonia – amoxicillin/clavulanate po or cefuroxime iv

• **Severe** pneumonia – ceftriaxone or cefotaxime plus clarithromycin po or azithromycin po/iv +/- cloxacillin
Step 3

Assess whether the child also has a pleural effusion?
Treatment

- Small – follow closely for clinical deterioration and antibiotics in step 1 and 2
- Moderate to large – consider pleural tap, ceftriaxone or cefotaxime, +/- clindamycin
Pediatric Complicated Pneumonia Position Statement
Hospital Paediatrics Section

• Empyema
• Abscess
• Necrotizing Lung
Empyema

- Intrapleural pus
- Exudative parapneumonic effusion (stage 1)
- Fibrinopurulent stage with loculations (stage 2)
- Organized with a thick fibrinous peel (stage 3)
Empyema

- Small parapneumonic effusions are common
- Increasing incidence
- Etiology
  - *Streptococcus pneumonia*, *Staphylococcus aureus*, *Streptococcus pyogenes* (Group A streptococcus)
  - Methicillin-resistant *S aureus* (MRSA)
  - Emerging non-vaccine serotypes of pneumococcus
Empyema: Diagnosis

- Ultrasound
  - can estimate the size
  - can differentiate free-flowing from loculated

- CT
Empyema Management

- Antibiotics
  - Cefotaxime or ceftriaxone
    - Clindamycin
    - Vancomycin
- Procedural interventions
  - If in moderate to severe respiratory distress
Empyema Treatment

- Procedural Interventions
  - Thoracentesis
  - Chest tube placement with or without fibrinolytics
  - Video-assisted thorascopic surgery (VATS)
  - Open thoracotomy with decortication
Step Four

Do features suggest pneumonia could be due to MRSA?
Treatment

- If MRSA – add vancomycin or linezolid
  - Severe and MRSA accounts for more than 5% of all S. Aureus in the community
  - Colonized with MRSA and severe pneumonia
  - Rapidly progressive disease
  - Pneumatocele
  - Septic shock or purpura fulminans
Treatment

- Randomized, clinical trials looking at clinical outcomes of high-dose vs. regular dose amoxicillin are lacking
Comparison of standard versus double dose of amoxicillin in the treatment of non-severe pneumonia in children aged 2–59 months: a multi-centre, double blind, randomised controlled trial in Pakistan
Hazir T et al Arch Dis Child 2007;92:291-297

• A double blind randomised controlled trial

• Children aged 2–59 months with non-severe pneumonia were randomised to receive:
  – either standard (45 mg/kg/day) for 3 days or
  – double dose (90 mg/kg/day) oral amoxicillin

• Final outcome was treatment failure by day 5.
Comparison of standard versus double dose of amoxicillin in the treatment of non-severe pneumonia in children aged 2–59 months: a multi-centre, double blind, randomised controlled trial in Pakistan

Hazir T et al Arch Dis Child 2007;92:291-297

- 876 children completed the study.
  - 437 were randomised to standard and
  - 439 to double dose oral amoxicillin

- Therapy failure by day 5:
  - 20 (4.5%) children in the standard group
  - 25 (5.7%) in the double dose group
Comparison of standard versus double dose of amoxicillin in the treatment of non-severe pneumonia in children aged 2–59 months: a multi-centre, double blind, randomised controlled trial in Pakistan
Hazir T et al Arch Dis Child 2007;92:291-297

• **Conclusion:**

  – Clinical outcome in children aged 2–59 months with non-severe pneumonia is the same with standard and double dose oral amoxicillin.
Antibiotics for community-acquired lower respiratory tract infections secondary to Mycoplasma pneumoniae in children (Review)
Mulholland S et al Cochrane Library 2010, Issue 7

- To determine whether antibiotics are effective in the treatment of LRTI secondary to M. pneumoniae infections
- Insufficient evidence to draw any specific conclusions about efficacy
Take Home Message

• Respect pneumonia
• Measure the respiratory rate accurately
• Order a chest radiograph
• Prescribe high dose amoxicillin
Future of Pneumonia

• Viruses and Streptococcus pneumoniae may synergistically contribute to clinical illness.

• Do sequential or concurrent viral and bacterial infections have a synergistic impact on disease evolution?

• Areas of the world without access to pneumococcal vaccine continue to see high rates of death caused by childhood pneumonia. A recent analysis suggested that pneumococcal vaccination in 72 developing countries could prevent 262,000 deaths per
Conclusion

- Given the high probability that CAP is caused by at least 1 of these infections, therapy should cover all of the possibilities.
- Macrolides are not always active in vitro against S. pneumoniae, and resistance of up to 50% has been reported.
- The combination of a b-lactam plus a macrolide could be suggested in the first-line treatment of CAP in immunocompetent children aged 2–5 years.
Take Home Message

- Treatment should be directed toward likely pathogens based on the patient’s age.
- Because mixed infections are common, positive viral testing may not preclude a bacterial cause.
- “Atypical” organisms such as Mycoplasma pneumoniae may occur in children younger than 5 years, despite historical dogma.
- Nothing has really changed!
Table 4

Dosing table for amoxicillin-clavulanate plus amoxicillin to achieve 90 mg/kg/day of the amoxicillin component and 6.4 mg/kg/day of the clavulanate component for acute otitis media that failed initial antimicrobial therapy*

Drug Dose of amoxicillin from amoxicillin-clavulanate

Dose of amoxicillin to add
CPS Admission Requirements

- Unable to eat or drink - dehydration
- Oral therapy compliance, Social situation
- Hypotension, Sepsis
- Sats less than 92%
- Vomiting, tachypnea, retractions
- Empyema, abscess Less than 6 months – difficult for caregivers to recognize pneumonia
What Diagnostic Laboratory and Imaging Tests Should Be Used in a Child With Suspected CAP in an Outpatient Setting?

• Routine chest radiographs are not necessary for the confirmation of suspected CAP in patients well enough to be treated in the outpatient setting.

• Chest radiographs, posteroanterior and lateral, should be obtained in patients with suspected or documented:
  • hypoxemia or significant respiratory distress and
  • in those with failed initial antibiotic therapy to verify the presence or absence of complications of pneumonia, including parapneumonic effusions, necrotizing pneumonia, and pneumothorax.
Which Anti-Infective Therapy Should Be Provided to a Child With Suspected CAP in Inpatient Setting?

- Ampicillin or penicillin G should be administered to the fully immunized infant or school-aged child admitted to a hospital ward with CAP when local epidemiologic data document lack of substantial high-level penicillin resistance for invasive S. pneumoniae.

- Empiric therapy with a third-generation parenteral cephalosporin (ceftriaxone or cefotaxime) should be prescribed for hospitalized infants and children:
  - in regions where local epidemiology of invasive pneumococcal strains documents high-level penicillin resistance, or
  - for infants and children with life-threatening infection, including those with empyema.

- Non–β-lactam agents, such as vancomycin, have not been shown to be more effective than third-generation cephalosporins in the treatment of pneumococcal pneumonia for the degree of resistance noted currently in North America. (weak recommendation; moderate-quality evidence)
Which Anti-Infective Therapy Should Be Provided to a Child With Suspected CAP in Inpatient Setting?

• Empiric combination therapy with a macrolide (oral or parenteral), in addition to a β-lactam antibiotic, should be prescribed for the hospitalized child for whom M. pneumoniae and C. pneumoniae are significant considerations; diagnostic testing should be performed if available in a clinically relevant time frame.

• Vancomycin or clindamycin (based on local susceptibility data) should be provided in addition to β-lactam therapy if clinical, laboratory, or imaging characteristics are consistent with infection caused by S. aureus.
Which Anti-Infective Therapy Should Be Provided to a Child With Suspected CAP in Both Outpatient and Inpatient Settings?

- Empiric combination therapy with a macrolide (oral or parenteral), in addition to a β-lactam antibiotic, should be prescribed for the hospitalized child for whom M. pneumoniae and C. pneumoniae are significant considerations; diagnostic testing should be performed if available in a clinically relevant time frame.

- Vancomycin or clindamycin (based on local susceptibility data) should be provided in addition to β-lactam therapy if clinical, laboratory, or imaging characteristics are consistent with infection caused by S. aureus (Table 7).
Which Anti-Infective Therapy Should Be Provided to a Child With Suspected CAP in Outpatient Setting?

- Amoxicillin should be used as first-line therapy for previously healthy, appropriately immunized infants and preschool children with mild to moderate CAP suspected to be of bacterial origin.
Which Anti-Infective Therapy Should Be Provided to a Child With Suspected CAP in Outpatient Setting?

- Amoxicillin should be used as first-line therapy for previously healthy appropriately immunized school-aged children and adolescents with mild to moderate CAP for S. pneumoniae.

- Atypical bacterial pathogens (eg, M. pneumoniae), and less common lower respiratory tract bacterial pathogens should also be considered.
Which Anti-Infective Therapy Should Be Provided to a Child With Suspected CAP in Outpatient Setting?

- **Macrolide antibiotics** should be prescribed for treatment of children (primarily school-aged children and adolescents) evaluated in an outpatient setting with findings compatible with CAP caused by atypical pathogens.

  – Laboratory testing for *M. pneumoniae* should be performed if available in a clinically relevant time frame.
Which Anti-Infective Therapy Should Be Provided to a Child With Suspected CAP in Both Outpatient and Inpatient Settings?

- **Influenza antiviral therapy** should be administered as soon as possible to children with **moderate to severe CAP** consistent with influenza virus infection during widespread local circulation of influenza viruses, particularly for those with clinically worsening disease documented at the time of an outpatient visit.