Chapter 170 – Pediatric Respiratory Emergencies: Diseases of the Lungs

Episode Overview:

1. Name 8 non-infectious causes that may present as pneumonia
2. Describe the workup for a child with suspected pneumonia?
3. What are the typical causes of bacterial pneumonia and viral pneumonia in the following age groups:
   a. < 1 month
   b. 1 month – 3 months
   c. 3 months – 5 years
   d. ≥ 5 years
4. What is the empiric treatment of bacterial pneumonia in these age groups for outpatients? For inpatients?
5. List 8 complications of pneumonia
6. List 6 criteria for admission with pneumonia
7. What are three clinical complications of cystic fibrosis?
8. What is the pathophysiology of CF?
9. How is suspected pneumonia in a patient with CF treated?

Wisecracks

1. What is the cause of whooping cough?
2. What are the stages of whooping cough?
3. How is whooping cough managed?
4. How is the flu shot used in the pediatric population?
5. Describe common pneumonia syndromes:
   a. Chlamydia trachomatis
   b. Mycoplasma pneumonia
6. What is the most common bacterial infection in CF?

Key Points:

- Determining the causative agent of pneumonia by clinical presentation and radiographic findings is not reliable; empirical treatment is based on likely pathogens. (you gotta know your bugs!)
- Infants and younger children with pneumonia may have subtle or nonspecific symptoms and signs on presentation
- First-line therapy for the treatment of bacterial pneumonia in children is amoxicillin as an outpatient and ampicillin as an inpatient
- Pertussis should be considered in a young infant with a staccato cough or episodes of cyanosis
- M. pneumoniae and C. pneumoniae may play a role in pneumonia in a younger child
- In patients with CF, defects in chloride transport across the airway epithelium result in reduced ciliary clearance of thickened mucus, which results in an increased likelihood for pneumonia, especially that caused by P. aeruginosa
- CF may respond favorably to bronchodilator therapy and mucolytics, such as inhaled N-acetylcysteine (NAC)
- Patients with BPD have increased airway resistance, decreased lung compliance, and obstructive lung disease; reactive airway disease and pneumonia are common in these patients
Rosen’s in Perspective

- The organism is not definitively identified in most pneumonia cases, so the true incidence of the specific causative agent is unknown.

- Overall, **viral agents cause 60% to 90% of pneumonias and are more common in younger children.**

- **Vaccination is decreasing the incidence of pneumococcal pneumonia and H. influenzae:**
  - Prevnar 13 is recommended for the primary series at 2, 4, and 6 months of age, with a fourth booster dose given at 12 to 15 months of age. Clinical trials have suggested 85% protection against serotype-specific cases of pneumococcal pneumonia.

- **Children with altered protective mechanisms are at increased risk for development of pneumonia;** this includes children with congenital anatomic abnormalities (eg, cleft palate, tracheoesophageal fistulas, pulmonary sequestration, congenital cystic adenomatoid malformation), immune deficiencies, neurologic alterations that predispose to aspiration (eg, coma, seizures, cerebral palsy, general anesthesia), and alterations in quality of secreted mucus (cystic fibrosis [CF]).

- Bacterial pneumonia and mycoplasma infections are usually transmitted person to person by droplet aspiration.

- Sometimes bacteria can cause pneumonia through hematogenous spread; Viruses such as varicella, CMV, herpes simplex, Epstein-Barr, measles, and rubella also may infect the lungs through hematogenous spread.

1) **Name 8 non-infectious causes that may present as pneumonia**

Great list to think through - hopefully it caught you by surprise! (Box 169.1)

- **Bad film / overinterpretation**
  - Underexposed, poor inspiration,
  - Thymus, breast shadow

- **Pulmonary disease**
  - Finding seen with:
    - Bronchopulmonary dysplasia
    - CF
  - Bronchiectasis
  - Atelectasis
  - ARDS

- **Cardiac disease**
  - CHF / Congenital heart disease

- **Blood vessel**
  - AVM
  - Pulmonary embolism
  - Infarcted lung due to sickle cell disease / chest crisis

- **bronchi/oles disease**
  - Foreign body
  - Aspiration
  - Chemical exposure
Rare things:
  - Malignancy
  - Collagen disease / vasculitis / granulomatous disease

2) Describe the workup for a child with suspected pneumonia?

- Not all pneumonias present with classic symptoms:
  - With increasing age, signs and symptoms in children become more specific, although pneumonia in any child may have only subtle manifestations.
  - Pleural irritation may cause chest, abdominal, or neck pain or result in neck stiffness. Vomiting (often posttussive) or poor oral intake is common.

Radiography:

A chest radiograph is unnecessary in children without comorbid conditions who have no fever, unilateral wheezing, or tachypnea because they are unlikely to have pneumonia.

A well-appearing child with cough and rales may be diagnosed clinically and treated with antibiotics as an outpatient.

A child who appears ill or in whom the diagnosis is unclear requires radiographic evaluation.

Labs:

- A complete blood count (CBC) has a very limited role and is often not useful in differentiating between viral and bacterial pneumonia.
  - A CBC should not be obtained unless the results will change management.
- A venous or arterial blood gas study is not needed in most patients, but may be considered in a child with severe respiratory distress to monitor the effectiveness of respiratory status or ventilation with therapy.
- In a well-appearing child with an uncomplicated pneumonia, a blood culture is unlikely to be helpful and should not be obtained. Blood cultures should only be considered in ill-appearing hospitalized patients.
- The health care provider should strongly consider a bacterial cause in a child with a temperature higher than 39°C (102.2°F), clinical toxicity, lobar infiltrate, or pleural effusions. Consider the host factors, epidemiology, and the clinical picture, with judicious use of laboratory tests.

3) What are the typical causes of bacterial pneumonia and viral pneumonia in the following age groups:

  a. < 1 month

<table>
<thead>
<tr>
<th>Viral</th>
<th>Bacterial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viruses that may be responsible for neonatal pneumonia include <strong>rubella</strong>, <strong>cytomegalovirus (CMV)</strong>, and <strong>herpes simplex virus</strong>. Other viral agents include influenza, adenovirus, rhinovirus, enterovirus, measles, varicella, and Epstein-Barr virus.</td>
<td>(RARE!!) Group B. strep. Gram -ve bacilli Listeria C. trachomatis or B. pertussis</td>
</tr>
</tbody>
</table>
b. 1 month – 3 months

<table>
<thead>
<tr>
<th>Viral</th>
<th>Bacterial</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>RSV, influenza</em></td>
<td><em>Strep. pneumoniae</em></td>
</tr>
<tr>
<td>*Other viral agents include influenza,</td>
<td><em>C. trachomatis or B. pertussis</em></td>
</tr>
<tr>
<td>adenovirus, rhinovirus, enterovirus,</td>
<td></td>
</tr>
<tr>
<td>measles, varicella, and Epstein-Barr</td>
<td></td>
</tr>
<tr>
<td>virus.</td>
<td></td>
</tr>
</tbody>
</table>


c. 3 months – 5 years

<table>
<thead>
<tr>
<th>Viral</th>
<th>Bacterial</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Respiratory syncytial virus (RSV) and</em></td>
<td><em>Strep. Pneumoniae</em></td>
</tr>
<tr>
<td><em>parainfluenza are the</em></td>
<td><em>Staph. Aureus</em></td>
</tr>
<tr>
<td><em>most frequent viral agents in infants</em></td>
<td><em>Haemophilus influenzae</em></td>
</tr>
<tr>
<td><em>younger than 1 year.</em></td>
<td></td>
</tr>
<tr>
<td><em>Other viral</em></td>
<td><em>Mycoplasma pneumoniae</em></td>
</tr>
<tr>
<td>*agents include influenza, adenovirus,</td>
<td><em>Chlamydophila (formerly</em></td>
</tr>
<tr>
<td>rhinovirus, enterovirus, measles,</td>
<td><em>Chlamydia) pneumoniae</em></td>
</tr>
<tr>
<td>varicella, and Epstein-Barr virus.*</td>
<td><em>C. trachomatis or B. pertussis</em></td>
</tr>
</tbody>
</table>


d. ≥ 5 years

<table>
<thead>
<tr>
<th>Viral</th>
<th>Bacterial</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Other viral</em></td>
<td><em>Mycoplasma pneumoniae</em></td>
</tr>
<tr>
<td>*agents include influenza, adenovirus,</td>
<td><em>Chlamydophila (formerly</em></td>
</tr>
<tr>
<td>rhinovirus, enterovirus, measles,</td>
<td><em>Chlamydia) pneumoniae</em></td>
</tr>
<tr>
<td>varicella, and Epstein-Barr virus.*</td>
<td><em>Strep. Pneumoniae</em></td>
</tr>
<tr>
<td></td>
<td><em>Staph. Aureus</em></td>
</tr>
<tr>
<td></td>
<td><em>Haemophilus influenzae</em></td>
</tr>
<tr>
<td></td>
<td><em>C. trachomatis or B. pertussis</em></td>
</tr>
</tbody>
</table>

**Rare causes of bacterial pneumonia:**

- *Pseudomonas aeruginosa, Legionella pneumophila, Pneumocystis jiroveci*
- rickettsial infections.
- Mycobacterium tuberculosis
4) What is the empiric treatment of bacterial pneumonia in these age groups for outpatients? For inpatients?

Groups A and B should also be getting a full septic workup!

a. < 1 month
   i. All should be admitted!
   ii. Ampicillin + cefotaxime / gentamicin
   iii. Add azithromycin or TMP-Sulfa if suspecting C. trachomatis or B. pertussis

b. 1 month – 3 months
   i. Probably all should be admitted!
   ii. Ampicillin + 3rd generation cephalosporin
   iii. Add azithromycin or TMP-Sulfa if suspecting C. trachomatis or B. pertussis

c. 3 months – 5 years

**older child, pneumonia should be categorized into likely bacterial, viral, or mycoplasmal**.

i. Outpatient (well appearing, normal Sp02, good supports/followup)
   1. If suspected typical PNA:
      a. High dose amoxicillin
         i. high-dose amoxicillin (90 mg/kg/day, divided tid) is the first-line agent and will treat intermediate susceptible S. pneumonia.
         ii. Oral cephalosporins are relatively poorly absorbed and are highly protein-bound, resulting in inferior pharmacokinetics as compared to amoxicillin; these should be reserved for penicillin allergic patients only.

      b. Amox-clav
         i. Amoxicillin–clavulanic acid (90 mg/kg/day of the amoxicillin component, divided tid) is the second-line agent and includes some gram-negative and methicillin-sensitive S. aureus coverage.

   2. If suspected atypical PNA:
      a. Azithromycin (10 mg/kg on day 1, followed by 5 mg/kg once daily on days 2–5) is the antibiotic of choice in a school-age child or adolescent, in whom M. pneumoniae and C. pneumoniae are more common.
ii. Inpatient (IV)

1. First-line parenteral therapy is ampicillin (150–200 mg/kg/day, q 6 hours).
2. Ceftriaxone (100 mg/kg/day, every 12–24 hours) or cefotaxime (150 mg/kg/day q 8 hours) are second-line agents.
3. Addition of azithromycin (10 mg/kg on day 1, followed by 5 mg/kg once daily on days 2–5) should be considered if M. pneumoniae is a possible causative agent.
4. Vancomycin (40–60 mg/kg/day, divided every 6–8 hours) or clindamycin (40 mg/kg/day, divided every 6–8 hours) should be added if methicillin-resistant S. aureus is suspected.

Consider a penicillin and clindamycin for children who are prone to aspiration.

Consider local resistance patterns - penicillin resistant S. pneumoniae exist!

d. ≥ 5 years

i. Outpatient (PO)
   1. Amox-clav
   2. Cefuroxime
   3. Consider azithromycin for atypical pneumonia or pertussis

ii. Inpatient (IV)
   1. Ceftriaxone
   2. Consider adding azithromycin if thought to be atypical
   3. Consider adding Vanco / clinda if suspicious for MRSA
   4. Consider antipseudomonal

5) List 8 complications of pneumonia

- Hypoxia
- Respiratory failure
- Dehydration
- Apnea
  - Apnea without other symptoms is usually seen in viral, chlamydial, and pertussis infections in infants younger than 3 months.
- Empyema
- Pleural effusion
- Lung abscess
- Pneumothorax
- Pneumatocele
- Secondary sepsis/bacteremia
- Rhabdomyolysis
- HUS
6) List 6 criteria for admission with pneumonia

1. Toxic appearance
2. Vomiting or dehydration
3. Respiratory compromise (eg, distress, hypoxia, inadequate ventilation)
4. Multilobar disease,
5. Pleural effusions,
6. Impaired immune function,
7. Unstable social environments
8. Unable to ensure good follow-up
9. Multiple comorbidities
10. Age < 6 months

7) What are three clinical complications of cystic fibrosis?

- Progressive lung tissue disease - scarring, etc.
- Recurrent infections
  - By age 18 - 80% of patients with CF are colonized with pseudomonas
- Pancreatic insufficiency / recurrent pancreatitis
- Cystic fibrosis-related diabetes (CFRD)
- Infertility
- Vitamin deficiencies, osteoporosis

8) What is the pathophysiology of CF?

Autosomal recessive disease:

Defects in chloride transport across the airway epithelium result in reduced ciliary clearance of thickened mucus, decreased antimicrobial effect of the airway surface, increased bacterial adherence, and innate secretion of inflammatory cytokines.

Cystic fibrosis (CF) is caused by mutations in the cystic fibrosis transmembrane conductance regulator (CFTR) protein. Deranged chloride transport leads to thick, viscous secretions in the lungs, pancreas, liver, intestine, and reproductive tract.

9) How is suspected pneumonia in a patient with CF treated?

Aggressively and based on previous patient-specific culture/resistance patterns.

Acute infective exacerbations generally are managed by oral and intravenous antimicrobial drugs, typically a penicillin (eg, ticarcillin, piperacillin) or ceftazidime combined with an aminoglycoside for purposes of synergy. Imipenem or meropenem may also be added.

Adjuncts:

- Careful isolation from other patients
- Chest physiotherapy to help with mucous clearance
- Bronchodilator therapy
- Mucolytics, such as inhaled N-acetylcysteine
- Short-term control of inflammation may be obtained by inhaled corticosteroids
Wisecracks

1) What is the cause of whooping cough?

Bordetella pertussis: a fastidious organism, making culture difficult.

2) What are the stages of whooping cough?

**the classic whoop-cough is RARE!**

Catarrhal stage, paroxysmal stage, and convalescent stage.

1. Catarrhal stage
   a. mild upper respiratory tract symptoms and cough 1-2 weeks

2. Paroxysmal stage
   a. severe paroxysms of a staccato cough, followed by posttussive emesis
      i. may be accompanied by periods of cyanosis and apnea in infants younger than 6 months.
      ii. The classic whoop is rare, occurring in only 6% of patients and generally seen in children older than 2 to 3 years.
   b. Fever is often absent, and the examination findings are remarkably normal between paroxysms.
   c. The paroxysmal stage lasts 2 to 4 weeks

3. Convalescent stage
   a. Gradually resolving symptoms; 2-4 weeks

3) How is whooping cough managed?

Ideally infectious spread from mildly symptomatic/asymptomatic adults to children is prevented through vaccination!

Treatment:

Erythromycin, azithromycin, or trimethoprim-sulfamethoxazole.

Given the association of erythromycin with infantile hypertrophic pyloric stenosis, azithromycin may be the most appropriate choice.

Antimicrobials have no effect on disease progression after the beginning of the paroxysmal stage but limit the spread of organisms.

Vaccination of health care workers and the adult population with Tdap (tetanus, diphtheria, pertussis) has been shown to decrease rates of pertussis in infants.
4) How is the flu shot used in the pediatric population?

The Canadian Paediatric Society continues to encourage annual influenza vaccination for ALL children and youth ≥ 6 months of age.

Check out: https://www.cps.ca/en/documents/position/influenza-vaccine-recommendations#box1

For particularly high risk groups see the link above.

5) Describe common pneumonia syndromes:

a. Chlamydia trachomatis
   i. <4 months
   ii. Gradual illness, Low or no fever
   iii. Staccato cough
   iv. Follows bout of conjunctivitis; diffuse rales
   v. Diffuse, interstitial infiltrate with hyperinflation
   vi. Normal labs with eosinophilia

b. Mycoplasma pneumonia
   i. 5-18 yr old
   ii. Gradual illness, low fever, hacking cough, h/a, sore throat, rash
   iii. Unilateral lobar or diffuse infiltrate

6) What is the most common bacterial infection in CF?

*Staphylococcus aureus* and *Pseudomonas aeruginosa*.

But, *Burkholderia cepacia*, a significant pathogen in CF patients, has been associated with an accelerated decline in clinical status and increased mortality. In general, antimicrobial coverage is similar to that for Pseudomonas.