

## Summary

The information in this article does not apply to infants < 2 months old. In young infants that present with signs of pneumonia (e.g., apnea, hypotonia, poor feeding), a full workup for sepsis is indicated (see “Fever in infants ≤ 60 days”).

## FEEDBACK

- **Pneumonia** : infection of the lower respiratory tract that involves the airways and parenchyma with consolidation of the alveolar spaces.
- **Lower respiratory tract infection** : bronchitis, bronchiolitis or pneumonia or any combination of the three, which may be difficult to distinguish clinically.
- **Pneumonitis** : lung inflammation  $\pm$  consolidation.
- **Lobar pneumonia** : "typical" pneumonia localized to one or more lobes of the lung in which the affected lobe or lobes are completely consolidated.
- **Atypical pneumonia** : patterns other than lobar pneumonia.
- **Bronchopneumonia** : inflammation of the lung that is centered in the bronchioles and leads to the production of a mucopurulent exudate that obstructs some of these small airways and causes patchy consolidation of the adjacent lobules.
- **Interstitial pneumonitis** : inflammation of the interstitium, which is composed of the walls of the alveoli, the alveolar sacs and ducts, and the bronchioles. characteristic of acute viral infections, but also may be a chronic process.

What is consolidation in medical terms?

n. 1. the state of the lung in which the alveoli (air sacs) are filled with fluid produced by inflamed tissue, as in pneumonia. It is diagnosed from its dullness to percussion, bronchial breathing (see breath sounds) in the patient, and from the distribution of shadows on the chest X-ray. 2.

pneumonia according to X-Ray :

- ① Lobar pneumonia = any opacity lobe distense
- ② bronchopneumonia = patchy inflammation
- ③ Interstitial pneumonia = reticular "

pneumonia according to cause :

- ① Infectious
- ② Non-infectious : chemical pneumonitis

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graph TD
    A[Aspiration] --> B[Hydrocarbon]
    B --> C["Suppurative pneumonia  
(abscess formation)"]
    C --> D["Chemical pneumonia  
(allergic reaction)"]
    D --> E[Viral pneumonia]
    E --> F[Meningitis]
    F --> G[Septicemia]
    
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The diagram illustrates the progression of infectious pneumonia from aspiration to various complications like meningitis and septicemia.

mcc. of Infectious pneumonia :

- viral
- bacterial
- fungal
- parasitic

- Respiratory syncytial virus (RSV): most common overall pathogen, particularly in those < 2 years old
- Coronaviruses (including COVID-19)
- Human metapneumovirus
- Rhinovirus
- Influenza
- Parainfluenza

- *Streptococcus pneumoniae*
- *Streptococcus pyogenes*
- *Staphylococcus aureus*
- *Haemophilus influenzae*
- *Chlamydia trachomatis* (in infants) [3][4]
- *Chlamydia pneumoniae* (in young children and adolescents) [5]
- *Mycoplasma pneumoniae*

- ◆ *Legionella pneumophila* (legionnaires' disease) is a rare cause of pneumonia in children.
- ◆ Infants 1 to 3 months of age: *Chlamydia trachomatis* and *Mycoplasma hominis*, *Ureaplasma urealyticum*, and CMV → similar respiratory syndrome (subacute onset of an **afebrile pneumonia** with **cough** and **hyperinflation** as the **predominant signs**)
- ◆ Causes of pneumonia in immunocompromised persons: gram-negative enteric bacteria, mycobacteria (*M. avium* complex), fungi (aspergillosis, histoplasmosis), viruses (CMV), and *Pneumocystis jirovecii* (carinii).
- ◆ Pneumonia in patients with cystic fibrosis: *S. aureus* in infancy and *P. aeruginosa* or *Burkholderia cepacia* in older patients.

11 Common bacteria cause pneumonia

1. Strept. pneumoniae → most common bacterial cause of pneumonia

2. Group B strep (GBS) → m.c. of bacterial pneumonia in newborn

Causes of pneumonia in neonates

- < 1 month (1-3)
  - GPS
  - Lactose
- > 3 months
  - Strept. pneumoniae

3. hemophilus influenzae

4. Staph pneumoniae

5. Chlamydia trachomatis

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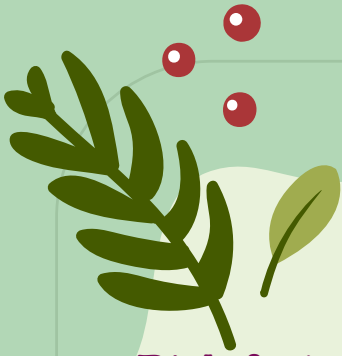
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## Risk factor:

### EPIDEMIOLOGY

- Risk factors for lower respiratory tract infections include:
  - gastroesophageal reflux
  - neurologic impairment (aspiration)
  - immunocompromised states
  - anatomic abnormalities of the respiratory tract
  - residence in residential care facilities for handicapped children, and hospitalization, especially in an ICU or requiring invasive procedures.
- Recurrent pneumonia: >2times/year (investigate)

## Clinical findings:

#### - Viral:

- Usually several days of URI symptoms; low-grade fever
- Most consistent manifestation is tachypnea
- If severe—cyanosis, respiratory fatigue

#### - Examination—scattered crackles and wheezing

- Difficult to localize source in young children with hyper-resonant chests; difficult to clinically distinguish viral versus nonviral

#### - Bacterial pneumonia:

- Sudden shaking chills with high fever, acute onset
- Significant cough and chest pain
- Tachypnea; productive cough
- Spitting on affected side—minimize pleuritic pain
- Examination—diminished breath sounds, localized crackles, rhonchi early; with increasing consolidation, markedly diminished breath sounds and dullness to percussion

#### - Chlamydia trachomatis pneumonia:

- No fever or wheezing (serves to distinguish from RSV)
- 1-3 months of age with insidious onset
- May or may not have conjunctivitis at birth
- Mild interstitial chest x-ray findings

#### - Staccato cough

#### - Peripheral eosinophilia

#### - Chlamydia pneumoniae and mycoplasma pneumoniae

- Cannot clinically distinguish
- Atypical, insidious pneumonia; constitutional symptoms
- Bronchopneumonia; gradual onset of constitutional symptoms with persistence of cough and hoarseness; coryza is unusual (usually viral)
- Cough worsens with dyspnea over 2 weeks, then gradual improvement over next 2 weeks; becomes more productive; rales are most consistent finding (basilar)

#### ⑥ Clinical manifestation of pneumonia:

1. Fever (febrile)
  2. Cough
  3. Resp. distress symptoms
  4. Cyanosis
- ⑦ How compensatory mechanism done?
1. By increase the Rate
  2. Flaring of ala nasi = dilatation of upper airway
  3. retraction

⑧ Clinical manifestation of pneumonia:

1. Fever (febrile)
2. Cough
3. Resp. distress symptoms
4. Cyanosis

⑨ How compensatory mechanism done?

1. By increase the Rate
2. Flaring of ala nasi = dilatation of upper airway
3. retraction

⑩ Lung pressure = Negative (-3 mmHg)

⑪ Clinical manifestation of pneumonia:

1. Fever (febrile)
2. Cough
3. Resp. distress symptoms
4. Cyanosis

⑫ How compensatory mechanism done?

1. By increase the Rate
2. Flaring of ala nasi = dilatation of upper airway
3. retraction

4. grunting = expiratory sound caused by sudden closure of glottis

5. functional residual volume

6. cyanosis

7. tachypnea

8. retractions

9. hyperinflation

10. crackles

11. wheezing

12. decreased breath sounds

13. dullness to percussion

14. hyperresonance

15. staccato cough

16. peripheral eosinophilia

17. chlamydia pneumoniae

18. mycoplasma pneumoniae

19. atypical pneumonia

20. constitutional symptoms

21. bronchopneumonia

22. gradual onset

23. persistence of cough

24. hoarseness

25. coryza

26. unusual

27. usually viral

28. cough worsens

29. dyspnea over 2 weeks

30. gradual improvement over next 2 weeks

31. becomes more productive

32. rales are most consistent finding

33. basilar

clinical manifestation of pneumonia:

1. poor appetite
2. irritability
3. easy fatigability
4. arthralgia / myalgia
5. auscultation
6. decreased entry
7. crepitation
8. wheezy
9. decreased breath sounds
10. dullness to percussion
11. hyperresonance
12. staccato cough
13. peripheral eosinophilia
14. chlamydia pneumoniae
15. mycoplasma pneumoniae
16. atypical pneumonia
17. constitutional symptoms
18. bronchopneumonia
19. gradual onset
20. persistence of cough
21. hoarseness
22. coryza
23. unusual
24. usually viral
25. cough worsens
26. dyspnea over 2 weeks
27. gradual improvement over next 2 weeks
28. becomes more productive
29. rales are most consistent finding
30. basilar

## So in general:

- Age is a determinant in the clinical manifestations of pneumonia.
  - Neonates may have fever only with subtle or no physical findings of pneumonia.
  - older infants and children have **Fever, chills, tachypnea, cough, malaise, pleuritic chest pain, retractions, and apprehension**, because of difficulty breathing or SOB
- tachypnea is the most common constant clinical manifestations in infant
- Viral pneumonias:** cough, wheezing, or stridor; fever is less prominent than bacterial.
  - The chest x-ray: diffuse, streaky infiltrates of bronchopneumonia
  - the WBC count: normal or mildly elevated, with a predominance of lymphocytes.
- Bacterial pneumonias:** higher fever, chills, cough, dyspnea, and auscultatory findings of lung consolidation.
  - The chest x-ray: lobar consolidation (or round pneumonia) & pleural effusion (10%- 30%).
  - The WBC count is elevated (>20,000/mm<sup>3</sup>) with a predominance of neutrophils.
- Afebrile pneumonia** in young infants is characterized by tachypnea, cough, crackles on auscultation, and often concomitant chlamydial conjunctivitis.
  - WBC count typically shows mild eosinophilia
  - Chest X-ray: hyperinflation
- All significant pneumonias have localized crackles and decreased breath sounds
- pleural effusion has dullness to percussion.

# Investigation:

## LABORATORY AND IMAGING STUDIES

- The upper respiratory tract bacterial flora is not an accurate reflection of the causes of lower respiratory tract infection, and good quality sputum is rarely obtainable from children.
- In healthy children without life-threatening disease, invasive procedures to obtain lower respiratory tissue or secretions usually are not indicated.
- Serologic tests** are not useful for the most common causes of bacterial pneumonia.
- The WBC count:**
  - viral pneumonias: normal or mildly elevated, with a predominance of lymphocytes.
  - bacterial pneumonias the WBC count ( $>20,000/\text{mm}^3$ ) with a predominance of neutrophils.
  - C. trachomatis* pneumonia of infant: Mild eosinophilia is characteristic.
- Blood cultures** positive in 10% to 20% of bacterial pneumonia and are considered to be confirmatory of the cause of pneumonia if positive.
- Urinary antigen tests** for *L. pneumophila* (legionnaires' disease).
- viral and mycoplasmal lower respiratory disease: **Cultures of upper respiratory secretions or serologic tests** with paired sera are relatively accurate for the diagnosis.
- pneumolysin-based PCR** test: aid in diagnosis of pneumococcal pneumonia.
- CMV and enterovirus:** culture from nasopharynx, urine, or bronchoalveolar lavage fluid.
- M. pneumoniae*: if cold agglutinins are present in peripheral blood samples; this may be confirmed by *Mycoplasma* IgM or more specifically PCR.
- The diagnosis of *M. tuberculosis* is established by **TSTs** and analysis of sputum or gastric aspirates by culture, antigen detection, or PCR.

- The need to establish an etiologic diagnosis of pneumonia is greater for patients who are:

1. ill enough to require hospitalization
2. immunocompromised
3. recurrent pneumonia,
4. pneumonia unresponsive to empirical therapy.

- methods of obtaining material for microbiologic diagnosis:

1. bronchoscopy with bronchoalveolar lavage and brush mucosal biopsy,
2. needle aspiration of the lung
3. open lung biopsy

- When there is effusion or empyema  $\rightarrow$  **thoracentesis** (diagnostic and therapeutic).

### Gram stain and culture

- The pleural fluid should be cultured for bacteria, mycobacteria, fungi, and viruses.
- If the fluid is grossly purulent, removal reduces the patient's toxicity and associated discomfort and may facilitate more rapid recovery.
- If accumulation is large, removal improves pulmonary mechanics & gas exchange.

- Frontal and lateral radiographs** are required to localize the diseased segments and to visualize adequately infiltrates behind the heart or the diaphragmatic leaflets.

- Characteristic radiographic findings of pneumonia:

- May be normal in early pneumonia, with appearance of an infiltrate during the treatment phase of the disease when edema fluid is greater.
- Bacterial pneumonia** characteristically shows lobar consolidation, or a round pneumonia, with pleural effusion in 10% to 30% of cases.
- Viral pneumonia** characteristically shows diffuse, streaky infiltrates of bronchopneumonia.
- Atypical pneumonia**, such as with *M. pneumoniae* and *C. pneumoniae*, shows increased interstitial markings or bronchopneumonia.
- Hilar lymphadenopathy is uncommon with bacterial pneumonia, but may be a sign of tuberculosis, histoplasmosis, or malignant neoplasm.
- S. aureus**  $\rightarrow$  unilateral bronchopneumonia  $\rightarrow$  area of necrosis  $\rightarrow$  Lung abscesses, pneumatoceles, and empyema (common in: boys,  $<1\text{yr}$  and GI manifestations)

- Decubitus views or ultrasound assess size of pleural effusions and whether they are freely mobile.

- CT evaluates serious disease, pleural abscesses, bronchiectasis, and delineating effusions.



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## NOTE:

Indications for admission:

1. age  $<6$  months
2. multiple lobar pneumonia
3. vomiting & dehydration
4. severe RD/Need O2
5. not tolerate PO ATB
6. immunocompromised
7. Sickle cell anemia
8. toxic appearance

Criteria of admission:

1.  $<6$  months
2. Signs of distress
3. Complicated pneumonia [effusion, empyema, abscess, pneumothorax]
4. multilobar infiltration
5. Risky pt [cyanotic heart, immune deficiency, CF, severe hypotonia, floppy, CP, ...]
6. Toxic look
7. persistent vomiting
8. Not responded to oral antibiotic
9. Social (unstable family, etc.)

## DDx:

### DIFFERENTIAL DIAGNOSIS

#### INSPECTION:

- Mucosal congestion and inflammation** of the upper airway suggest a viral infection.
- signs of respiratory distress** include Tachypnea, flaring of the alae of the nose, intercostal and subcostal retractions, and grunting.
- Generalized or peripheral **cyanosis** indicates hypoxia with severe diffuse or multilobar pneumonia or a large pleural effusion.
- With a young infant, **apneic spells** may be the first sign of pneumonia.
- Asymmetry or shallow breathing may be due to splinting from pain.

#### PERCUSSION:

- Low diaphragms by percussion** indicate air trapping, which is common in asthma, but also frequently accompanies viral lower respiratory infections.
- Poor diaphragmatic excursion** may indicate hyperexpanded lungs or an inability for expansion because a large consolidation is causing poor lung compliance.
- Hyperexpansion** may push the diaphragm and liver downward.
- Dullness** to percussion may be due to lobar or segmental infiltrates or pleural fluid.

#### AUSCULTATION:

- the presence of localized **crackles**, **rhonchi**, and **wheezes** may help one to detect and locate pneumonia.
- Distant breath sounds** may indicate a large, poorly ventilated area of consolidation or pleural fluid.
- Pneumonia must be differentiated from **other acute lung diseases**, including:
  1. lung edema caused by heart failure,
  2. allergic pneumonitis, and aspiration,
  3. autoimmune diseases, such as rheumatoid disease and SLE.
- Radiographically, pneumonia must be differentiated from:
  1. lung trauma
  2. contusion
  3. hemorrhage
  4. foreign body obstruction
  5. irritation from subdiaphragmatic inflammation



## Management:

→ to diagnose: Biopsy from mucous membrane.  
 rare but can be seen in cilia dyskinesia.

### Kartagener's Syndrome

50% of cilia dyskinesia associated with Kart. & pure

### Triad of Kartagener's S:

1. Situs inversus + Dextrocardia
2. cilia dyskinesia
3. Chronic Sinusitis

1. & 2. cystic fibrosis associated with cilia dyskinesia  
 - otitis media common in C. dyskinesia  
 Rare C. Fibrosis

### congenital malformation of the lung

recurrent chest infection + recurrent wheeze

1. bronchogenic cyst [by C.T. & I.S.]
2. cystic adenomatoid malformation [by C.T.]

abnormal change of bronchial

recurrent infection

### 3. Lung sequestration

abnormal blood supply to part of lung

lobule or segments

[by MRI or C.T. angio]

ttt: surgical removal

### Immune deficiency:

نقص في جهاز المناعة

قد يكون خلل في إنتاج الأجسام المضادة أو خلل في الخلايا الليمفاوية

غالباً ما يصاحبه خلل في الجهاز الهضمي

### ⇒ recurrent pneumonia:

during 6 months 2 pneumonias

during his life 3 pneumonias

in between cleared X-ray

slowly p. is re-evaluation

## Complications::

### Complications

- Pulmonary complications<sup>[7]</sup>
  - Parapneumonic effusion
  - Empyema
  - Lung abscess
  - Multilobar disease
  - Pneumothorax
  - Bronchopleural fistula
- Dissemination of infection, causing:<sup>[7]</sup>
  - Sepsis
  - Septic arthritis
  - Osteomyelitis
  - Meningitis
  - Cardiac involvement (endocarditis or pericarditis)
  - CNS abscess

### ⑥ complicated pneumonia:

→ effusion → mild (antibiotic + follow up)

→ empyema → surgery with antibiotic

→ effusion → moderate to severe

|                                               | transudate | exudate    | empyema   |
|-----------------------------------------------|------------|------------|-----------|
| → wall                                        | clear      | turbid     | pus       |
| → cells                                       | <1000      | >1000      | >5000     |
| → types of cells                              | lympho     | Neutrophil |           |
| → Protein                                     | <3g/dL     | >3g/dL     |           |
| → protein / protein in fluid / in blood ratio | <0.5       | >0.5       |           |
| → LDH                                         | <200       | >200       |           |
| → LDH ratio                                   | <0.6       | >0.6       |           |
| → LDH                                         | >7.4       | 7.2-7.4    | <7.2      |
| → LDH                                         | normal     | 40-60      | <40 mg/dL |
| → culture                                     | (-)        | (+)        | (+)       |

### ⑥ High criteria for exudate:

① Protein ratio

② LDH ratio

③ LDH > 2/3 upper limit of the lab

### ⑥ empyema → chest tube

fibrin tissue due to inflammation

pus form multilobulated abscess → septation

fibrinolytic agent → tissue plasminogen activator

1. streptokinase

2. tissue plasminogen activator

3. Neurokinase

fibrin → pus → cavities

Decortication surgery

x. Fever

x. distress

✓ oral intake

ceftriaxone IV

ceftriaxone IV

chest examination

## In genral:

### COMPLICATIONS

- Bacterial pneumonias frequently cause **parapneumonic effusion** or, if grossly purulent, an **empyema**. Large effusions usually restrict breathing and require drainage.
- **pneumatocele**, or air pocket.
- **bronchiectasis** and increased risk for recurrent infection.
- **lung abscess**.
  - uncommon in children, caused by aspiration or infection behind an obstructed bronchus.
  - The most commonly involved sites: **posterior segments of the upper lobes** and the **superior segments of the lower lobes**, drain in recumbent position.
  - Anaerobic bacteria predominate, along with various streptococci, *E. coli*, *Klebsiella pneumoniae*, *P. aeruginosa*, and *S. aureus*.
- Chest X-ray or CT scan: cavity lesion, with an air-fluid level, surrounded by parenchymal inflammation.
- If the cavity communicates with the bronchi, organisms may be isolated from sputum.
- bronchoscopy indicated to exclude a foreign body and obtain microbiologic specimens.
- Lung abscesses antimicrobial ttt: clindamycin<sup>®</sup>, penicillin G, or ampicillin-sulbactam.

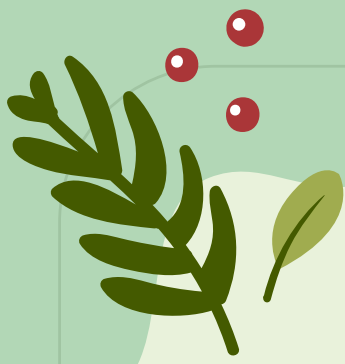


Table 8-3. Pneumonia

| Feature                                                | Bacterial                                                                                                                                                                                                                                                                 | Viral                                                                                                                                                                                | <i>C. trachomatis</i>                                                                                                                                         | <i>M. pneumoniae</i> or <i>C. pneumonia</i>                                                                                                                                                                    |
|--------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Etiology</b>                                        | <ul style="list-style-type: none"> <li>• <i>S. pneumoniae</i></li> <li>• <i>HIB</i></li> <li>• <i>S. aureus</i></li> </ul>                                                                                                                                                | <ul style="list-style-type: none"> <li>• RSV</li> <li>• Parainfluenza</li> <li>• Influenza</li> <li>• Adenovirus</li> </ul>                                                          | <i>C. Trachomatis</i>                                                                                                                                         | <ul style="list-style-type: none"> <li>• <i>M. Pneumoniae</i></li> <li>• <i>C. Pneumonia</i></li> </ul>                                                                                                        |
| <b>Age</b>                                             | <ul style="list-style-type: none"> <li>• Any age</li> <li>• Most common reason for lobar is <i>S. pneumoniae</i></li> </ul>                                                                                                                                               | Most common form <5 years                                                                                                                                                            | Age 1–3 months                                                                                                                                                | Most common form age >5 years                                                                                                                                                                                  |
| <b>Timing</b>                                          | More in cold months                                                                                                                                                                                                                                                       | Cold months                                                                                                                                                                          | All year                                                                                                                                                      | All year; more in winter                                                                                                                                                                                       |
| <b>Diagnosis Key Words</b>                             | <ul style="list-style-type: none"> <li>• Acute</li> <li>• Severe</li> <li>• Productive cough</li> <li>• Dyspnea</li> <li>• High fever</li> <li>• Chest pain</li> <li>• Rhonchi</li> <li>• Rales</li> <li>• Decreased breath sounds</li> <li>• May have empyema</li> </ul> | <ul style="list-style-type: none"> <li>• Insidious</li> <li>• Often worsening URI</li> <li>• Lower temperature</li> <li>• Wheeze</li> <li>• Cough</li> <li>• Mild dyspnea</li> </ul> | <ul style="list-style-type: none"> <li>• May have had conjunctivitis as newborn</li> <li>• Afebrile</li> <li>• No wheeze</li> <li>• Staccato cough</li> </ul> | <ul style="list-style-type: none"> <li>• Insidious</li> <li>• URI symptoms with persistence of cough worsening over 2 weeks</li> <li>• Rales most consistent finding (lower lobe uni- or bilateral)</li> </ul> |
| <b>Best Initial Test</b>                               | <ul style="list-style-type: none"> <li>• CXR = lobar consolidation</li> </ul>                                                                                                                                                                                             | <ul style="list-style-type: none"> <li>• CXR = bronchopneumonia, interstitial</li> <li>• Hyperinflation with increased peribronchial markings</li> </ul>                             | <ul style="list-style-type: none"> <li>• CXR = mild interstitial</li> </ul>                                                                                   | <ul style="list-style-type: none"> <li>• CXR most unilateral lower lobe interstitial</li> <li>• Classically looks worse than symptoms</li> </ul>                                                               |
| <b>Most Accurate Test</b>                              | <ul style="list-style-type: none"> <li>• Sputum C and S (cannot rely on in child)</li> <li>• Blood culture</li> <li>• Pleural fluid culture</li> </ul>                                                                                                                    | Respiratory secretions for viral or antigen isolation (would not do routinely)                                                                                                       | Sputum PCR (but not needed = classic clinical diagnosis)                                                                                                      | PCR of NP or throat swab (but not usually needed)                                                                                                                                                              |
| <b>Best Initial Treatment and Definitive Treatment</b> | <ul style="list-style-type: none"> <li>• Admit for IV cefuroxime</li> <li>• Then change if needed based on C and S</li> </ul>                                                                                                                                             | <ul style="list-style-type: none"> <li>• No treatment of viral pneumonia</li> <li>• If uncertain, give oral amoxicillin</li> </ul>                                                   | Oral macrolide                                                                                                                                                | Oral macrolide                                                                                                                                                                                                 |