Anatomic Alterations of the Lungs

- Pneumonia, or pneumonitis with consolidation, is the result of an inflammatory process
  - primarily affects the gas exchange area of the lung
- In response to the inflammation
  - fluid (serum) and RBCs from adjacent pulmonary capillaries pour into the alveoli
    - this fluid transfer is called effusion

Anatomic Alterations of the Lungs

- Polymorphonuclear leukocytes also move into the infected area
  - engulf and kill invading bacteria on the alveolar walls
  - this process has been termed surface phagocytosis
- Increased numbers of macrophages also appear
  - remove cellular and bacterial debris

Anatomic Alterations of the Lungs

- If the infection is overwhelming alveoli are filled with
  - fluid
  - RBCs
  - polymorphonuclear leukocytes
  - macrophages
- When this occurs, the lungs are said to be consolidated
- Atelectasis is often associated with patients who have aspiration pneumonia

Anatomic Alterations of the Lungs

- Major pathologic or structural changes
  - Inflammation of the alveoli
  - Alveolar consolidation
  - Atelectasis (e.g., aspiration pneumonia)
**Etiology**

- Pneumonia is extremely common
  - sixth leading cause of death in America
  - more than 3 million people in U.S. are affected each year
  - approximately 600,000/yr require hospitalization
  - approximately 40,000 people die each year
  - worldwide, approximately 5 million people die as a result of pneumonia each year

- Causes of pneumonia
  - bacteria
  - viruses
  - fungi
  - tuberculosis
  - anaerobic organisms
  - aspiration
  - inhalation of irritating chemicals

- Terms describing pneumonia
  - lobar pneumonia
  - double pneumonia (bilateral pneumonia)
  - walking pneumonia
    - no clinical significance – often used to describe a mild case of pneumonia
    - for example, patients infected with Mycoplasma pneumoniae, generally have mild symptoms and remain ambulatory

- Initially, pneumonia often mimics a common “cold” or the flu
  - the signs and symptoms develop quickly
    - sudden onset of
      - chills, shivering
      - high fever, sweating
      - chest pain (pleurisy)
      - dry and nonproductive cough

- Pneumonia is often an insidious disease because
  - symptoms of pneumonia vary greatly depending on the patient’s specific underlying condition and the type of organism causing the pneumonia
  - what is initially thought to be a cold or the flu can, in fact, be a much more serious pulmonary infection

- Early recognition and treatment provide the best chance of a full recovery

**Causes and Classifications of Pneumonia**

**Bacterial Causes**
Causes and Classification

• Gram-positive Organisms
  – *Streptococcus pneumoniae*
    • accounts for more than 80% of all the bacterial pneumonias
    • organism is a gram-positive, nonmotile coccus that is found singly, in pairs (called diplococci), and in short chains
    • the coci are enclosed in a smooth, thick polysaccharide capsule essential for virulence

Causes and Classification

• *Streptococcal Pneumonia*
  – Complications
    • empyema
    • effusions

[Image of S. pneumoniae bacteria]

[Image of areas of consolidation in lung tissue]

[Image of chest X-ray showing patches of empyema on lung]

Streptococcus pneumoniae is a gram-positive, encapsulated coccus that is found singly, in pairs (called diplococci), and in short chains.
Causes and Classification

• Gram-positive Organisms
  – *Streptococcus pneumoniae*
    • more than 80 different types of *S. pneumoniae*
      – Serotype 3 organisms are the most virulent
    • streptococci are generally transmitted by aerosol from a cough or sneeze of an infected individual
    • most strains are sensitive to penicillin and its derivatives
    • *S. pneumoniae* is commonly cultured from the sputum of patients having an acute exacerbation of chronic bronchitis

Causes and Classification

• Gram-positive Organisms
  – *Staphylococcus*
    • 2 major groups
      – *Staphylococcus aureus*, which is responsible for most “staph” infections in humans
      – *Staphylococcus albus* and/or *Staphylococcus epidermidis*, which is part of the normal skin flora
    • staphylococci are gram-positive cocci found singly, in pairs (called diplococci), and in irregular clusters

Causes and Classification

• Gram-positive Organisms
  – Staphylococcal Pneumonia
    • staphylococcal pneumonia often follows a predisposing virus infection and is seen most often in children and immunosuppressed adults
    • commonly transmitted by aerosol from a cough or by contact with contaminated items
    • common cause of hospital-acquired pneumonia
      – becoming increasingly antibiotic resistant
      – MRSA: multiple drug-resistant *S. aureus*

Causes and Classification

• Staphylococcal Pneumonia
  – Complications
    • empyema
    • spontaneous pneumothorax
    • lung abscess
    • abscesses in brain, kidneys and other organs

Causes and Classification

• Gram-negative Organisms
  – The major gram-negative organisms responsible for pneumonia are rod-shaped microorganisms called *bacilli*
Bacilli are rod-shaped microorganisms and are the major gram-negative organisms responsible for pneumonia.

Causes and Classification

• Gram-negative Organisms
  – *Haemophilus influenzae*
    • pneumonia caused by *H. influenzae B* is seen most often in children 1 month to 6 years old
    • almost always the cause of acute epiglottitis
    • transmitted via aerosol or contact with contaminated objects
    • sensitive to cold and does not survive long after expectoration

•Gram-negative Organisms
  – *Klebsiella pneumoniae* (Friedländer’s Bacillus)
    • gram-negative bacillus found singly, in pairs, and in chains of varying lengths
    • long associated with lobar pneumonia, particularly in men older than 40 years, and in chronic alcoholics of both genders
    • normal inhabitant of the human gastrointestinal tract
    • can be transmitted directly by aerosol or indirectly by contact with freshly contaminated articles

Causes and Classification

• Gram-negative Organisms
  – *Haemophilus influenzae*
    • commonly cultured from the sputum of patients having an acute exacerbation of chronic bronchitis
    • additional risk factors include
      – COPD
      – defects in B cell function
      – functional and anatomic asplenia
      – human immunodeficiency virus (HIV) infection

Causes and Classification

• Gram-negative Organisms
  – *Klebsiella pneumoniae* (Friedländer’s Bacillus)
    • common nosocomial, or hospital-acquired, disease
    • typically transmitted by routes such as clothing, IV solutions, foods, and the hands of health-care workers
    • mortality of patients with *K. pneumoniae* is quite high because septicemia is a frequent complication
Causes and Classification

• **Gram-negative Organisms**
  
  — *Pseudomonas aeruginosa* 
  *Bacillus pyocyaneus* 
  
  • a highly mobile, gram-negative bacillus 
  
  • colonizes the gastrointestinal tract, burns, and catheterized urinary tract 
  
  • contaminant in many aqueous solutions 
  
  • risk factors include 
    
    — neutropenia 
    
    — HIV infection 
    
    — preexisting lung disease 
    
    — endotracheal intubation 
    
    — prior antibiotic use.

Causes and Classification

• **Atypical Organisms**
  
  — *Mycoplasma pneumoniae* 
  
  • most frequently seen in people younger than 40 years of age during the late summer and early fall months 
  
  • pneumonia spreads easily in areas where people congregate, such as child-care centers, schools, and homeless shelters 
  
  • patients often are said to have “walking pneumonia” because the condition is mild (i.e., slight fever, fatigue, and a characteristic dry, hacking cough) and the patient is usually ambulatory

Causes and Classification

• **Atypical Organisms**
  
  — *Legionella pneumophila* 
  
  • in July 1976, a severe pneumonia-like disease outbreak occurred at an American Legion convention in Philadelphia 
  
  • the causative agent eluded identification for many months, despite the concerted efforts of the nation’s top epidemiologic experts 
  
  • the organism was recovered from a patient and found to be an unusual and fastidious gram-negative bacillus 
  
  • the initial isolate was designated as *Legionella pneumophila* — more than 20 Legionella species have now been identified
Causes and Classification

• Atypical Organisms
  – *Legionella pneumophila*
    • most species are free-living in soil and water, where they act as decomposer organisms
    • the organism also multiplies in standing water such as contaminated mud puddles, large air-conditioning systems, and water tanks
  – *Chlamydia pneumoniae*
    • recently identified as a cause of pneumonia in adults
    • has been detected in schools, military institutions, and families
    • associated with meningocerebralitis, myocarditis, endocarditis, coronary artery disease, and Guillain-Barré syndrome

Causes and Classification

• Atypical Organisms
  – *Legionella pneumophila*
    • organism is transmitted when it becomes airborne and enters the patient’s lungs as an aerosol
    • no convincing evidence suggests that the organism is transmitted from person to person
    • organism can be detected in pleural fluid, sputum, or lung tissue by direct fluorescent antibody microscopy
    • rarely found outside the lungs, but may be found in other tissues
    • most commonly seen in middle-aged males who smoke

Causes and Classification

• Atypical Organisms
  – *Chlamydia psittaci* (Psittacosis)
    • small gram-negative bacterium in the respiratory tract and feces in a variety of birds (e.g., parrots, parakeets, lorikeets, cockatoos, chickens, pigeons, ducks, pheasants, turkeys)
    • transmitted from birds to humans by aerosol or direct contact
    • clinical manifestations of closely resemble those caused by *M. pneumoniae*

Causes and Classifications of Pneumonia

Viral Causes

Etiology

• Viruses
  – minute organisms not visible by ordinary light microscopy
  – parasitic and depend on nutrients inside cells for their metabolic and reproductive needs
  – 90% of acute upper respiratory tract infections and 50% of lower respiratory tract infections are viral
  – respiratory viruses are the most common cause of pneumonia in young children, peaking between the ages of 2 and 3
Viral Pneumonias

- Influenza virus
  - several subtypes but A and B are commonly associated with outbreaks (epidemics) and pandemics
  - survives well in conditions of low temperature and low humidity
  - transmitted by aerosol droplets
  - also found in:
    - horses
    - swine
    - birds
  - incubation period of 1 to 3 days – causes URI's
  - children, young adults and elderly are particularly susceptible

- Respiratory Syncytial Virus
  - Member of paramyxovirus group along with parainfluenza, mumps and rubella
  - seen primarily in children under 6 months and elderly with underlying pulmonary disease
  - accounts for about 25% of respiratory illnesses in children less than 1 year of age (rarely fatal)
  - may set the stage for secondary bacterial infections
  - transmitted by aerosol and direct contact
  - seen primarily in winter and spring but cases are diagnosed year around
  - pathology of RSV pneumonia shows multinucleated giant cells

- Parainfluenza Viruses
  - members of the paramyxovirus group
  - five types of parainfluenza viruses: types 1, 2, 3, 4A, and 4B
  - types 1, 2, and 3 are the major causes of infections in humans
  - type 1 is considered a “croup” type of virus
  - types 2 and 3 are associated with severe infections
  - transmitted by aerosol droplets and by direct person-to-person contact
  - often spread rapidly among members of the same family

- Adenovirus
  - more than 30 subgroups
  - serotypes 4, 7, 14, and 21 cause viral infections and pneumonia in all age groups
  - serotype 7 has been related to fatal cases of pneumonia in children
  - transmitted by aerosol
  - cause seasonal pneumonias
Causes and Classifications of Pneumonia

Other Causes

Other Pneumonias

• Rickettsiae
  - small, pleomorphic coccobacilli
  - most rickettsiae are intracellular parasites possessing RNA and DNA
  - pathogenic Rickettsia include
    • R. rickettsii (Rocky Mountain spotted fever)
    • R. prowazekii (typhus)
    • R. burnetii (Q fever)
  - all species are unstable outside of cells except for R. burnetii
  - Q fever can cause pneumonia as well as a prolonged febrile illness, an influenza-like illness, and endocarditis
  - transmitted by arthropods (lice, fleas, ticks, mites), cattle, sheep, and goats and possibly in raw milk

Other Pneumonias

• Mycoplasma Pneumoniae
  - described as primary atypical pneumonia
  - mild disease – “walking pneumonia”
  - produces slight fever, fatigue, and dry hacking cough
  - not easily identified by standard bacteriological tests
  - not highly communicable – may require weeks to spread

• Varicella (Chickenpox)
  - can spread to the lungs and cause a serious secondary pneumonitis

• Rubella (Measles)
  - spreads from person to person by the respiratory route

• Cytomegalovirus
  - member of herpes virus family
  - most common complication of AIDS
  - often coexists with Pneumocystis jiroveci infection

Other Pneumonias

• Pneumocystis jiroveci (carinii)
  - opportunistic, often fatal, seen in immunosuppressed patients
  - identified as protozoa, but is probably fungi
  - seen in patients with AIDS (80 to 90% of cases)
  - in immunosuppressed hosts the disease spreads rapidly

Causes and Classifications of Pneumonia

Acquired Pneumonia Classifications
Acquired Pneumonia Classifications

- **Community-Acquired Pneumonias (CAPs)**
  - acquired outside the hospital
  - American Thoracic Society categorizes CAP as follows
    - patients 60 years of age or younger, with no co-morbidity, who can be treated as outpatients
    - patients older than 60 years of age, with co-morbidity, who can be treated as outpatients
    - patients requiring hospitalization but not in an intensive care unit
    - severely ill patients requiring admission to an intensive care unit

- **Hospital-Acquired Pneumonia**
  - also called nosocomial pneumonia – a pneumonia that develops 48 hours or more after admission to the hospital
  - estimated to account for more than 15% of all respiratory infections
  - include *P. aeruginosa*, *S. aureus*, *K. pneumoniae*, *E. coli*, *Serratia* species, and oral anaerobes (aspiration)

- **Nursing Home–Acquired Pneumonia**
  - defined as a respiratory tract infection that develops in a long-term care facility
  - common nursing home–acquired infections include mixed aerobic and anaerobic mouth flora, *S. aureus*, enteric gram-negative bacilli, influenza, and *M. tuberculosis*.

- **Ventilator-Acquired Pneumonia (VAP)**
  - also called ventilator-associated pneumonia
  - occurs in up to 25% of all people who require mechanical ventilation
  - can develop at any time during ventilation, but occurs during the first 48 hours of ventilation
  - especially common in patients with ARDS
  - common ventilator-associated infections include *P. aeruginosa*, *Acinetobacter*, *Enterobacter*, *Klebsiella*, *Stenotrophomonas maltophilia*, and *S. aureus*.

**Treatment**
- Treatment should be matched to known causative bacteria
- when VAP is first suspected, broad-spectrum antibiotics are given (empiric therapy) until the particular bacterium and its sensitivities are determined

**Risk factors** for infection with an MDR strain include ventilation for more than five days, recent hospitalization (last 90 days), residence in a nursing home, treatment in a hemodialysis clinic, and prior antibiotic use (last 90 days).
Ventilator-Acquired Pneumonia

**Treatment**
- Possible empirical therapy combinations include (but are not limited to):
  - vancomycin/linezolid and ciprofloxacin,
  - cefepime and gentamicin/amikacin/tobramycin
  - vancomycin/linezolid and ceftazidime
  - ureidopenicillin plus β-lactamase inhibitor such as piperacillin/tazobactam or ticarcillin/clavulanate
  - a carbapenem (e.g., imipenem or meropenem)

**Prevention**
- limit exposure to resistant bacteria
- discontinue mechanical ventilation as soon as possible
- various strategies to limit infection while intubated
  - hand washing
  - isolation of those with resistant organisms
  - aggressive weaning
  - limiting sedation

Ventilator-Acquired Pneumonia

**Treatment**
- therapy is typically changed once the causative bacteria are known and continued until symptoms resolve (often 7 to 14 days)
  - For patients with VAP not caused by nonfermenting Gram-negative bacilli (Acinetobacter, Pseudomonas aeruginosa) the available evidence seems to support the use of short-course antimicrobial treatments (< or =10 days)

**Prevention**
- Other recommendations include
  - raising the head of the bed to at least 30 degrees
  - placement of feedings tubes beyond the pylorus of the stomach
  - antiseptic mouth washes such as chlorhexidine
  - using heated humidifiers instead of HMEs
  - American and Canadian guidelines strongly recommend the use of supraglottic and subglottic secretion drainage
  - EVAC tubes

Overview of the Cardiopulmonary Clinical Manifestations Associated with Pneumonia

The following clinical manifestations result from the pathophysiologic mechanisms caused (or activated) by
- Alveolar Consolidation
- Increased Alveolar-Capillary Membrane Thickness
- Atelectasis
- Excessive Bronchial Secretions
  - During the resolution stage of pneumonia
The Physical Examination

- Vital Signs
  - Increased
    - Respiratory rate
    - Heart rate
    - Blood pressure

Clinical Data Obtained at the Patient’s Bedside

The Physical Examination (Cont’d)

- Chest pain/decreased chest expansion
- Cyanosis
- Cough, sputum production, and hemoptysis
The Physical Examination (Cont’d)

- **Chest Assessment Findings**
  - Increased tactile and vocal fremitus
  - Dull percussion note
  - Bronchial breath sounds
  - Crackles and rhonchi
  - Pleural friction rub
    - if process extends to pleural surface
  - Whispered pectoriloquy

Clinical Data Obtained from Laboratory Tests and Special Procedures

---

Pulmonary Function Test Findings

<table>
<thead>
<tr>
<th>Moderate to Severe</th>
<th>(Restrictive Lung Pathophysiology)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Forced Expiratory Flow Rate Findings</strong></td>
<td></td>
</tr>
<tr>
<td>FVC</td>
<td>FEV₁</td>
</tr>
<tr>
<td>↓ N or ↓</td>
<td>N or ↑</td>
</tr>
<tr>
<td>FEF₅₀%</td>
<td>FEF₂₀₀⁻₁₂₀₀</td>
</tr>
<tr>
<td>N or ↓</td>
<td>N or ↓</td>
</tr>
</tbody>
</table>

| **Lung Volume & Capacity Findings** | |
| VT | IRV | ERV | RV | VC |
| N or ↓ | ↓ | ↓ | ↓ | ↓ |
| IC | FRC | TLC | RV/TLC ratio |
| ↓ | ↓ | ↓ | N |

Arterial Blood Gases

Pneumonia

**Mild to Moderate Stages**
Acute Alveolar Hyperventilation with Hypoxemia
(Acute Respiratory Alkalosis)

<table>
<thead>
<tr>
<th>pH</th>
<th>PaCO₂</th>
<th>HCO₃⁻</th>
<th>PaO₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>↑</td>
<td>↓</td>
<td>↓ (slightly)</td>
<td>↓</td>
</tr>
</tbody>
</table>
### Arterial Blood Gases

**Pneumonia**

**Severe Stage**

*Acute Ventilatory Failure with Hypoxemia*  
*(Acute Respiratory Acidosis)*

<table>
<thead>
<tr>
<th>pH</th>
<th>PaCO₂</th>
<th>HCO₃⁻</th>
<th>PaO₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>↓</td>
<td>↑</td>
<td>↑</td>
<td>↓</td>
</tr>
<tr>
<td></td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
</tbody>
</table>

(Slightly)

### Oxygenation Indices

<table>
<thead>
<tr>
<th>Qs/Qt</th>
<th>DO₂</th>
<th>VO₂</th>
<th>C(a-v)O₂</th>
<th>O₂ER</th>
<th>SvO₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>↑</td>
<td>↓</td>
<td>N</td>
<td>N</td>
<td>↑</td>
<td>↓</td>
</tr>
</tbody>
</table>

### Abnormal Laboratory Tests and Procedures

- **Sputum Examination**
  - Gram Positive Organisms
    - Streptococcus
    - Staphylococcus
  - Gram Negative Organisms
    - Klebsiella
    - Pseudomonas aeruginosa
    - Haemophilus influenzae
    - Legionella pneumophila

### Radiologic Findings

- **Chest Radiograph**
  - Increased density (from consolidation and atelectasis)
  - Air bronchograms
  - Pleural effusions

---

**Figure 15-5. Chest X-ray film of a 20-year-old woman with severe pneumonia of the left lung and patchy pneumonia in the right middle and lower lobes.**
Figure 15-6. Air bronchogram. The branching linear lucencies within the consolidation in the right lower lobe are particularly well demonstrated in this example of staphylococcal pneumonia.

Radiologic Findings
- CT Scan
  - Alveolar consolidation
  - Air bronchograms

General Management of Pneumonia
- The treatment of pneumonia is based on:
  - the specific etiology of the pneumonia
  - the severity of symptoms demonstrated by the patient

Figure 15-7. Air bronchogram shown by CT in a patient with pneumonia.

Commonly Encountered Organisms Responsible for Pneumonia and the Therapeutic Agents Used to Treat Them

<table>
<thead>
<tr>
<th>Organism Responsible for Pneumonia</th>
<th>Common Treatment Choices</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gram-Positive Organisms</strong></td>
<td></td>
</tr>
<tr>
<td>Staphylococcus aureus</td>
<td>Methicillin-susceptible strains: nafcillin or oxacillin with or without rifampin</td>
</tr>
<tr>
<td></td>
<td>Methicillin-resistant strains: vancomycin with or without rifampin</td>
</tr>
<tr>
<td></td>
<td>Alternative choice: cephalosporins, clindamycin,</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Organism Responsible for Pneumonia</th>
<th>Common Treatment Choices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Streptococcus</td>
<td>Penicillins: procaine penicillin-G or aqueous penicillin G, amoxicillin</td>
</tr>
<tr>
<td></td>
<td>Alternative choice: macrolides, cephalosporins, doxycycline, quinolones oxacitaine or ceftarline; antipseudomonal fluoroquinolones (levofloxacin, gatifloxacin, moxifloxacin).</td>
</tr>
</tbody>
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<tr>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Gram-Negative Organisms</strong></td>
<td></td>
</tr>
<tr>
<td>Haemophilus influenzae</td>
<td>Ampicillin, third-or fourth-generation cephalosporin, macrolides (azithromycin, clarithromycin), fluoroquinolones</td>
</tr>
<tr>
<td>Klebsiella pneumoniae</td>
<td>Third-and/or fourth-generation cephalosporins (cefotaxime, ceftriaxone) plus aminoglycoside, antipseudomonal penicillin, monobactam (aztreonam), or quinolone</td>
</tr>
<tr>
<td>Pseudomonas aeruginosa</td>
<td>Tobramycin (TOBI), Aminoglycoside and antipseudomonal agents (ticarcillin, piperacillin, mezlocillin, cefazidine)</td>
</tr>
<tr>
<td><strong>Atypical Organisms</strong></td>
<td></td>
</tr>
<tr>
<td>Mycoplasma pneumoniae</td>
<td>Doxycycline, macrolides or fluoroquinolones</td>
</tr>
<tr>
<td>Legionella pneumophila</td>
<td>Erythromycin + rifampin (in severely compromised patient) or clarithromycin, or a macrolide (azithromycin), or a fluoroquinolone (ofloxacin, levofloxacin, sparfloxacin)</td>
</tr>
<tr>
<td>Chlamydia pneumoniae</td>
<td>Tetracycline, erythromycin, macrolide, quinolone</td>
</tr>
<tr>
<td><strong>Anaerobic bacterial infections</strong></td>
<td></td>
</tr>
<tr>
<td>Peptostreptococcus species</td>
<td>Most of these organisms are oral contaminants. For anaerobic coverage use metronidazole (Flagyl) or clindamycin, or Metronidazole + ceftriaxone, or penicillin + amoxicillin. Infections respond slowly. 4-6 weeks of therapy is generally recommended. Most of the problem with aspiration pneumonia is secondary to the acid present in stomach contents, causing a chemical pneumonia. Quinolones, penicillins are also useful</td>
</tr>
<tr>
<td>Bacteroides melaninogenicum</td>
<td></td>
</tr>
<tr>
<td>Bacteroides distasonis</td>
<td></td>
</tr>
<tr>
<td>Bacteroides thetaiotaomicron</td>
<td></td>
</tr>
<tr>
<td>Peptostreptococcus anaerobius</td>
<td></td>
</tr>
<tr>
<td>Peptostreptococcus microaerogenes</td>
<td></td>
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<tr>
<td>Peptostreptococcus palustris</td>
<td></td>
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<tr>
<td>Peptostreptococcus loeschei</td>
<td></td>
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<tr>
<td>Peptostreptococcus magnus</td>
<td></td>
</tr>
<tr>
<td>Peptostreptococcus asaccharolyticus</td>
<td></td>
</tr>
<tr>
<td>Porphyromonas endodontalis</td>
<td></td>
</tr>
<tr>
<td>Porphyromonas gingivalis</td>
<td></td>
</tr>
<tr>
<td>Porphyromonas asaccharolyticus</td>
<td></td>
</tr>
<tr>
<td>Porphyromonas salisiproducens</td>
<td></td>
</tr>
<tr>
<td>Aspiration fluid should be cultured immediately (even with bronchoscopy and special culture) then patient started on coverage medication while awaiting culture results. If the culture is negative, stop the antibiotics. Then reculture if CXR, or patient, gets worse. Monitor closely for superinfections such as candida, other yeasts. May add vancomycin and Diflucan to cover nosocomial suprainfections.</td>
<td></td>
</tr>
</tbody>
</table>

**Note:** Most of these organisms are oral contaminants. For anaerobic coverage use metronidazole (Flagyl) or clindamycin, or Metronidazole + ceftriaxone, or penicillin + amoxicillin. Infections respond slowly. 4-6 weeks of therapy is generally recommended. Most of the problem with aspiration pneumonia is secondary to the acid present in stomach contents, causing a chemical pneumonia. Quinolones, penicillins are also useful.
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</thead>
<tbody>
<tr>
<td>Viral Causes</td>
<td></td>
</tr>
<tr>
<td>Influenza virus</td>
<td>Type A: amantadine and rimantadine</td>
</tr>
<tr>
<td>Respiratory syncytial virus</td>
<td>Type A/B: zanamivir, oseltamivir phosphate</td>
</tr>
<tr>
<td></td>
<td>Ribavirin (Virazole), palivizumab (Synagis)</td>
</tr>
</tbody>
</table>

Commonly Encountered Organisms Responsible for Pneumonia and the Therapeutic Agents Used to Treat Them

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Other Common Causes</td>
<td></td>
</tr>
<tr>
<td>Pneumocystis carinii</td>
<td>Pentamidine (NebuPent), Trimethoprim-sulfamethoxazole (TMP-SMZ), dapsone-tetracycline, trimethoprim, primaquine plus clindamycin</td>
</tr>
<tr>
<td>Fungal infections</td>
<td>Amphotericin B, itraconazole, fluconazole, ketoconazole</td>
</tr>
<tr>
<td>Tuberculosis (Mycobacterium tuberculosis)</td>
<td>Isoniazid (INH), rifampicin, pyrazinamide, ethambutol, streptomycin</td>
</tr>
</tbody>
</table>

RC Treatment Protocols

- Oxygen Therapy Protocol
- Bronchopulmonary Hygiene Therapy Protocol
- Lung Expansion Therapy Protocol
- Mechanical Ventilation Protocol