Chapter 24
Microbial Diseases of the Respiratory System

Microbial Diseases of the Upper Respiratory System

- Most common type of infection and can infect other parts of the body
- Consists of nose, pharynx, associated structures (middle ear, auditory tubes)
- Coarse hairs in nose filter large particles; ciliated mucous membranes of nose and throat trap airborne particles and remove them
- Specific areas become infected (self-limiting/healing) to produce:
  - Laryngitis: *S. pneumoniae*, *S. pyogenes*, viruses
  - Tonsillitis: *S. pneumoniae*, *S. pyogenes*, viruses
  - Sinusitis: Bacteria
  - Epiglottitis: *H. influenzae*

Characterize the normal microbiota of the upper and lower respiratory systems.

Upper Respiratory System

- Upper respiratory normal microbiota may include pathogens

Lower Respiratory System

- Consists of larynx, trachea, bronchial tubes, and alveoli
- Ciliary escalator helps prevent microorganisms from reaching lungs
- Microbes in lungs phagocytized by alveolar macrophages
- Respiratory mucus contains IgA antibodies
- Lower respiratory system usually sterile due to ciliary escalator

Streptococcal pharyngitis (Strep throat)

- *Streptococcus pyogenes* (group A beta-hemolytic)
- Inflammation of mucous membrane and fever, tonsillitis and otitis media
- Diagnosis by indirect agglutination
- Resistant to phagocytosis
- Penicillin treatment
- Streptokinases lyse clots
- Streptolysins are cytotoxic

Differentiate among pharyngitis, laryngitis, tonsillitis, sinusitis, and epiglottitis. Simply dependent upon which structure is attacked by bacteria.
Streptococcus pyogenes – strep throat can result in scarlet fever
- Red rash, high fever, strawberry tongue
- Pharyngitis also
- Erythrogenic toxin produced by lysogenized S. pyogenes

Scarlet Fever – strawberry tongue

Corynebacterium diphtheriae: Gram-positive rod
- Diphtheria membrane of fibrin, dead tissue, and bacteria forms in throat, sometimes blocking air
- Diphtheria exotoxin produced by lysogenized C. diphtheriae – inhibits protein synthesis, heart/kidney/nerve damage can result
- Antitoxin necessary to neutralize toxin; antibiotics too
- Prevented by DTaP and Td vaccine (Diphtheria toxoid)
- Cutaneous diphtheria - Infected skin wound leads to slow healing ulcer

Diphtheria

Otitis Media - earache
- Often a complication of nose and throat infections
- Pus accumulation can cause pressure on eardrum
- Streptococcus pneumoniae (35%)
- Haemophilus influenzae (20-30%)
- Moraxella catarrhalis (10-15%)
- Streptococcus pyogenes (8-10%)
- Staphylococcus aureus (1-2%)
- Treated with broad-spectrum antibiotics
- Incidence of S. pneumoniae reduced by vaccine

Acute Otitis Media – bulging eardrum
Common cold

List the causative agents and treatments for the common cold.

- Can be caused by nearly 200 different viruses
- Rhinoviruses (50%) – grow best slightly below body temperature
- Coronaviruses (15-20%)
- Rhinoviruses attached to ICAN-1 on nasal mucosa
- Antibodies produced against specific viruses
- Complications can include infections in sinuses, larynx, ear, lower respiratory
- Most often transmitted by indirect contact, therefore more colds in cold weather due to greater indoor contact and physiological changes

Microbial Diseases of the Lower Respiratory System

- Similar organisms attack both upper and lower respiratory systems
- Bacteria, viruses, & fungi cause:
  - Bronchitis
  - Bronchiolitis
  - Pneumonia

Lower Respiratory System

- The ciliary escalator keeps the lower respiratory system sterile.

Pertussis (Whooping Cough)

List the causative agent, symptoms, prevention, preferred treatment, and laboratory identification tests for pertussis and tuberculosis.

- Stage 1: Catarrhal stage, like common cold
- Stage 2: Paroxysmal stage: Violent coughing sieges due to accumulation of mucus in trachea and bronchi
- Stage 3: Convalescence stage can last for months
- Lab diagnosis based on isolation and selective media, followed by serological tests
- Regular immunization has decreased incidence

Tuberculosis

- Mycobacterium tuberculosis: Acid-fast rod. Transmitted from human to human
- Lipids in cell wall are acid-fast and resistant to drying and disinfectants
- M. bovis: <1% U.S. cases, not transmitted from human to human (unpasteurized milk)
- M. avium-intracellulare complex infects people with late stage HIV infection
Tuberculosis

- "Military" tuberculosis develops when caseous lesion ruptures and releases bacteria into blood or lymph vessels
- Characterized by weight loss, coughing, low vigor
- Treatment of Tuberculosis: Prolonged treatment with multiple antibiotics – two drugs taken for 1-2 years due to multidrug-resistant M. tuberculosis
- Vaccines: BCG - live, avirulent M. bovis. Not widely used in U.S.

Diagnosis: Tuberculin skin testing
- + = current or previous infection
- Followed by X-ray or CT, acid-fast staining of sputum, culturing bacteria (up to 8 weeks incubation)

(c) Reported tuberculosis cases, 1948-2002
Streptococcus pneumoniae: Gram-positive encapsulated diplococci
- Fever, breathing difficulty, chest pain, rust-colored sputum
- Most common cause of pneumococcal pneumonia
- Diagnosis by culturing bacteria
- Penicillin is drug of choice

Pneumococcal Pneumonia

Haemophilus influenzae Pneumonia
- Gram-negative coccobacillus
- Alcoholism, poor nutrition, cancer, or diabetes are predisposing factors
- Second-generation cephalosporins for treatment

Mycoplasmal Pneumonia – endemic disease
- Mycoplasma pneumoniae: pleomorphic, wall-less bacteria
- Also called primary atypical pneumonia and walking pneumonia
- Common in children and young adults
- Diagnosis by PCR or by IgM antibodies

Mycoplasmal Pneumonia

Arrowheads indicate terminal structures that probably aid in attachment to eukaryotic cells (left); filamentous growth (right)
### Legionellosis
- **Legionella pneumophila**: Gram-negative rod
- *L. pneumophila* is found in water (air-conditioning units)
- Transmitted by inhaling aerosols, not transmitted from human to human
- Diagnosis: culturing bacteria and DNA probes
- Treatment: Erythromycin

### Psittacosis (Ornithosis)
- **Chlamydia psittaci**: gram-negative intracellular bacterium
- Transmitted by elementary bodies (allow bacteria to survive outside host) from bird dropping to humans
- Reorganizes into reticulate body after being phagocytized
- Diagnosis: culturing bacteria in eggs or cell culture
- Treatment: Tetracycline

### Chlamydial Pneumonia
- **Chlamydia pneumoniae**
- Transmitted from human to human
- Diagnosis by FA (fluorescent antibody) test
- Treatment: Tetracycline

### Q fever
- **Mycoplasma pneumoniae**: obligately parasitic, intracellular, pleomorphic, wall-less bacteria
- Transmitted to humans from unpasteurized milk or inhalation of dairy barn aerosols
- Inhaling a single pathogen is enough to cause infection
- Diagnosis by isolation and growth in eggs or cell cultures, serological tests

### Viral Pneumonia
- Viral pneumonia as a complication of influenza, measles, chickenpox
- Viral etiology suspected if no cause determined
- Respiratory Syncytial Virus (RSV)
  - Common in infants; 4500 deaths annually
  - Causes cell fusion (syncytium) in cell culture
  - Symptoms: coughing
  - Diagnosis by serologic test for viruses and antibodies
  - Treatment: Ribavirin

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List the causative agent, symptoms, prevention, and preferred treatment for viral pneumonia, RSV, and influenza.
Influenza

- Chills, fever, headache, muscle aches (no intestinal symptoms)
- Viral strains identified by antigenic differences in the H and N spikes that project from outer lipid bilayer of virus
- Hemagglutinin (H) spikes used for attachment to host cells
- Neuaminidase (N) spikes used to release virus from cell
- Antigenic shifts make natural immunity and vaccination ineffective
- 1% mortality due to secondary bacterial infections
- Treatment: Amantadine and rimantadine
- Vaccine for high-risk individuals

Influenza

- Antigenic shift
  - Changes in H and N spikes
  - Probably due to genetic recombination between different strains infecting the same cell
- Antigenic drift
  - Mutations in genes encoding H or N spikes
  - May involve only 1 amino acid
  - Allows virus to avoid mucosal IgA antibodies

**TABLE 24.1 Human Influenza Viruses**

<table>
<thead>
<tr>
<th>Type</th>
<th>Antigenic Subtype</th>
<th>Year</th>
<th>Disease Severity</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>H1N1 (1918)</td>
<td>1918</td>
<td>Severe</td>
</tr>
<tr>
<td></td>
<td>H1N2 (1957)</td>
<td>1957</td>
<td>Severe</td>
</tr>
<tr>
<td></td>
<td>H1N3 (Hong Kong)</td>
<td>1968</td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td>H3N2 (Hong Kong)</td>
<td>1968</td>
<td>Low</td>
</tr>
<tr>
<td>B</td>
<td>None</td>
<td>1940</td>
<td>Moderate</td>
</tr>
<tr>
<td>C</td>
<td>None</td>
<td>1967</td>
<td>Very mild</td>
</tr>
</tbody>
</table>

Influenza serotypes

- A: causes most epidemics, H3N2, H1N1, H2N2
- B: moderate, local outbreaks
- C: mild disease

**Histoplasmosis**

- Fungal diseases increasing in recent years
- *Histoplasma capsulatum*, dimorphic fungus
- Droppings of birds and bats (airborne conidia)

List the causative agent, mode of transmission, preferred treatment, and laboratory identification tests for four fungal diseases of the respiratory system.
**Histoplasmosis**
- Transmitted by airborne conidia from soil
- Diagnosis by culturing fungus
- Treatment: amphotericin B

**Coccidioidomycosis**
- *Coccidioides immitis*
- Transmitted by airborne arthrospores
- Diagnosis by serological tests or DNA probe
- Treatment: amphotericin B

**Pneumocystis Pneumonia**
- *Pneumocystis jiroveci* (formerly *P. carinii*) found in healthy human lungs
- Pneumonia occurs in newly infected infants & immunosuppressed individuals
- Treatment: Trimethoprim-sulfamethoxazole

**Blastomycosis**
- *Blastomyces dermatitidis*, dimorphic fungus
- Found in soil
- Can cause extensive tissue destruction (abscesses)
- Treatment: amphotericin B
Opportunistic fungi involved in respiratory disease:

- Aspergillus
- Rhizopus
- Mucor

TABLE 34.2

<table>
<thead>
<tr>
<th>Disease</th>
<th>Pathogen</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pneumonia</td>
<td>Pneumococci</td>
<td>Causes lobar or bronchopneumonia.</td>
</tr>
<tr>
<td>Lobar pneumonia</td>
<td>Staphylococcus pneumoniae</td>
<td>Causes severe illness.</td>
</tr>
<tr>
<td>Acute bronchitis</td>
<td>Haemophilus influenzae</td>
<td>Causes a cough and fever.</td>
</tr>
<tr>
<td>Acute lobar pneumonia</td>
<td>Streptococcus pneumoniae</td>
<td>Causes severe illness.</td>
</tr>
<tr>
<td>Acute bronchiolitis</td>
<td>Rhinovirus</td>
<td>Causes a cough and fever.</td>
</tr>
</tbody>
</table>

Viral Diseases of the Upper Respiratory System:

- Common cold
- Common cold, rhinitis

<table>
<thead>
<tr>
<th>Disease</th>
<th>Pathogen</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common cold</td>
<td>Rhinoviruses, Coronaviruses</td>
<td>Familiar symptoms of coughing, sneezing, runny nose.</td>
</tr>
</tbody>
</table>

TABLE 34.1 (continued)

<table>
<thead>
<tr>
<th>Disease</th>
<th>Pathogen</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bacterial Diseases of the Upper Respiratory System</td>
<td>Hemolytic streptococci</td>
<td>Causes streptococcal pharyngitis.</td>
</tr>
<tr>
<td>Bacterial Diseases of the Lower Respiratory System</td>
<td>Hemophilus influenzae</td>
<td>Causes lobar pneumonia.</td>
</tr>
<tr>
<td>Bacterial Diseases of the Lower Respiratory System</td>
<td>Staphylococcus aureus</td>
<td>Causes necrotizing pneumonia.</td>
</tr>
<tr>
<td>Bacterial Diseases of the Lower Respiratory System</td>
<td>Streptococcus pneumoniae</td>
<td>Causes streptococcal pneumonia.</td>
</tr>
</tbody>
</table>

Figures 12.2b, 12.4