Chapter 23
Microbial Diseases of the Cardiovascular and Lymphatic Systems

The Cardiovascular System and Lymphatics System

- Blood, heart, vessels = cardiovascular system
- Lymph, lymph vessels, lymph nodes and lymphoid organs = lymphatic system
- Blood—Transports nutrients to and wastes from cells
- WBCs—Defend against infection
- Lymphatics—Transport interstitial fluid to blood
- Lymph nodes—Contain fixed macrophages

The Cardiovascular System

- Blood = mixture of plasma and cells
- Plasma transports dissolved substances; RBC carry oxygen; WBC mediate body’s defenses against infection
- Interstitial fluid – fluid that filters out of capillaries into spaces between tissue cells; enters lymph capillaries as lymph
- Lymph nodes contain fixed macrophages, B and T cells

Relationship between Cardiovascular and Lymphatic System

Identify the role of the cardiovascular and lymphatic systems in spreading and eliminating infections.

Sepsis and Septic Shock

List the signs and symptoms of septicemia, and explain the importance of infections that develop into septicemia.

- Sepsis
  - Bacteria growing in the blood
  - Results from focus of infection
  - Severe sepsis
  - Decrease in blood pressure
  - Septic shock
  - Low blood pressure cannot be controlled

Sepsis – growth of organisms in blood

Differentiate gram-negative sepsis, gram-positive sepsis, and puerperal sepsis.

- Gram-negative Sepsis – septic shock by endotoxins
  - Endotoxins cause blood pressure decrease
  - Antibiotics can worsen condition by killing bacteria
- Gram-Positive Sepsis (enterococci and group B streptococci are antibiotic resistant)
  - Nosocomial infections
    - Staphylococcus aureus
    - Streptococcus pyogenes
    - Group B streptococcus
    - Enterococcus faecium and E. faecalis
Sepsis

- Puerperal Sepsis (Childbirth fever) – infection of uterus following childbirth or abortion, leading to peritonitis or septicemia
  - *Streptococcus pyogenes* most frequent cause
  - Transmitted to mother during childbirth by attending physicians & midwives (demonstrated by Oliver Wendell Holmes and Ignaz Semmerweiss)
  - Uncommon today due to aseptic procedures

Bacterial Infections of the Heart

*Endocarditis*
- Inflammation of the endocardium, inner layer of heart, aggravated by preexisting heart conditions
- Fever, anemia, heart murmurs
- Subacute bacterial endocarditis from alpha-hemolytic streptococci from mouth, staphylococci, enterococci
- Arises from focus of infection like tooth extraction
- Acute bacterial endocarditis (rapid destruction of heart valves)
  - *Staphylococcus aureus* from mouth
  - Pericarditis
  - *Streptococci*

Rheumatic Fever

- Inflammation of heart valves and arthritis symptoms
- Autoimmune complication of *Streptococcus pyogenes* infections, indicating prompt treatment of infections
- Penicillin as preventative measure against subsequent infections
- Antibodies against group A beta-hemolytic streptococci react with antigens deposited in joints or heart valves

Tularemia

*Francisella tularensis*, gram-negative rod
- Reservoir - transmitted from rabbits and deer by deer flies
- Ulceration at the site of entry followed by septicemia and pneumonia
- Bacteria reproduce in phagocytes
Brucellosis (Undulant Fever)

*Discuss the epidemiology of brucellosis.*

- *Brucella*, gram-negative rods that grow in phagocytes
- *B. abortus* (elk, bison, cows)
- *B. suis* (swine)
- *B. melitensis* (goats, sheep, camels)
- Undulating fever that spikes to 40°C each evening
- Transmitted via milk from infected animals or contact with infected animals, entering minute breaks in mucosa or skin
- Spread via lymphatics to liver, spleen, bone marrow
- Diagnosis based upon serological tests

Anthrax

*Discuss the epidemiology of anthrax.*

- *Bacillus anthracis*, gram-positive, endospore-forming aerobic rod
- Diagnosis based upon isolation and identification
- Found in soil, lasting up to 60 years
- Grazing animals ingest endospores
- Cattle are routinely vaccinated
- Treated with ciprofloxacin or doxycycline
- Cutaneous anthrax (handling hides)
  - Endospores enter through minor cut (pustule), respiratory tract (septic shock), mouth
  - 20% mortality

Gangrene

*Discuss the epidemiology of gas gangrene.*

- Ischemia
  - Loss of blood supply to tissue
- Necrosis
  - Death of tissue
- Gangrene (complication of diabetes often)
  - Death of soft tissue, microbes grow on nutrients released by gangrenous cells
- Gas gangrene
  - *Clostridium perfringens*, gram-positive, endospore-forming anaerobic rod, grows in necrotic tissue
  - Treatment includes surgical removal of necrotic tissue and/or hyperbaric chamber, amputation as last resort

Potential Biological Weapons

*Potential Biological Weapons*

<table>
<thead>
<tr>
<th>Bacteria</th>
<th>Viruses</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Bacillus anthracis</em></td>
<td>“Eradicated” polo and measles</td>
</tr>
<tr>
<td><em>Brucella</em></td>
<td>E. coli</td>
</tr>
<tr>
<td><em>Chlamydia</em></td>
<td><em>Ehrlichia</em></td>
</tr>
<tr>
<td><em>Clostridium</em></td>
<td>B. anthracis</td>
</tr>
<tr>
<td><em>Francisella</em></td>
<td>H. influenzae</td>
</tr>
<tr>
<td><em>Rickettsia</em></td>
<td><em>Rickettsia</em></td>
</tr>
<tr>
<td><em>Shigella</em></td>
<td><em>Shigella</em></td>
</tr>
<tr>
<td><em>Vibrio</em></td>
<td>V. cholerae</td>
</tr>
<tr>
<td><em>Yersinia</em></td>
<td>Y. pestis</td>
</tr>
</tbody>
</table>

Biological Weapons

*Biological Weapons*

- 1346 Plague-ridden bodies used by Tartar army against Kaffa
- 1925 Plague-carrying flea bombs used in the Sino-Japanese War
- 1950s U.S. Army spraying of *S. marcescens* to test weapons dispersal (one died)
- 1972 International agreement to not possess biological weapons
- 1979 *B. anthracis* weapons plant explosion in the Soviet Union (100 deaths)
- 1984 *S. enterica* used against the people of The Dalles, Oregon, by cult
- 2001 *B. anthracis* distributed in the U.S.
Gangrene – Clostridium perfringens spp.

Hyperbaric chambers for treating gangrene, carbon monoxide poisoning

Animal bites and scratches

List three pathogens that are transmitted by animal bites and scratches.

- Pasteurella multocida – can cause septicemia (from bite of cat or dog)
- Anaerobic bacteria infect deep animal bites:
  - Clostridium
  - Bacteroides
  - Fusobacterium
  - Bartonella henselae
- Cat-scratch disease

Plague

Yersinia pestis, gram-negative rod
- Bruises on skin or buboes (enlarged lymph nodes)
- Reservoir
  - Rats, ground squirrels, prairie dogs
- Vector – rat flea
  - Xenopsylla cheopsis
- Bubonic plague
  - Bacterial growth in blood and lymph
  - Septicemia plague
  - Septic shock
  - Pneumonic plague
  - Bacteria in the lungs

Compare and contrast the causative agents, vectors, reservoirs, symptoms, treatments, and preventive measures for plague, relapsing fever, and Lyme disease.

Plague

Bubonic plague (above) by Yersinia pestis
- Bubo – swollen lymph node (systemic infection)
- Antibiotics effective, but must be given promptly after exposure

Identify the vector, etiology, and symptoms of five diseases transmitted by ticks.

- Relapsing fever – Borrelia transmitted by soft ticks, reservoir is rodents, fever/jaundice/rose-colored spots
- Lyme disease – Borrelia burgdorferi, field mice reservoir
- Ehrlichiosis – Ehrlichia transmitted by Ixodes ticks
- Typhus – rickettsias, obligate intracellular parasites (epidemic typhus by body louse, murine typhus by rat flea)
- Spotted fevers (Rocky Mountain spotted fever)

Five diseases transmitted by ticks
Relapsing Fever

- *Borrelia* spp., spirochete
- Reservoir
  - Rodents
  - Vector
  - Ticks
- Successive relapses are less severe

Lyme Disease

- *Borrelia burgdorferi*
- Reservoir
  - Deer
  - Vector
  - Ticks

Lyme Disease

- First symptom
  - bull's eye rash
- Second phase
  - Irregular heartbeat, encephalitis
- Third phase
  - Arthritis
Ehrlichiosis

- *Ehrlichia*, gram-negative, obligately intracellular (in white blood cells)
- Reservoir
  - Deer, rodents
- Vector
  - Ticks

Typhus

- Epidemic murine typhus
  - *Rickettsia typhi*
  - Reservoir
    - Rodents
  - Vector
    - *Xenopsylla cheopis*

Typhus

- Epidemic typhus
  - *Rickettsia prowazekii*
  - Reservoir
    - Rodents
  - Vector
    - *Pediculus humanus corporis*
  - Transmitted when louse feces rubbed into bite wound

Spotted Fevers (Rocky Mountain spotted fever)

- *Rickettsia rickettsii*
- Measles-like rash except that the rash appears on palms and soles too
CMV and Burkitt’s Lymphoma

Describe the epidemiologies of CMV inclusion disease, Burkitt’s lymphoma, and infectious mononucleosis.

- CMV (cytomegalic inclusion disease):
  - Almost all infected during lifetime
  - Very large herpesvirus latent in white blood cells
  - Mild or no symptoms in healthy individuals
  - Several disease symptoms in developing world
- Burkitt’s Lymphoma
  - Nasopharyngeal carcinoma
  - Epstein-Barr virus (EBV) (Human herpesvirus 4)
  - Cancer in immunosuppressed individuals, and malaria and AIDS patients

Infectious Mononucleosis

- Epstein-Barr virus (Human herpesvirus 4)
- Multiplies in parotid glands, in saliva
- Childhood infections are asymptomatic
- Transmitted via saliva
- Characterized by proliferation of atypical monocytes
- Diagnosis by fluorescent-antibody technique

U.S. Prevalence of antibodies

- EB virus
- CMV
- TOXO – Toxoplasma gondii
Cytomegalic Inclusion Disease

- Cytomegalovirus (CMV) (Human herpesvirus 5)
- Infected cells swell due to intranuclear inclusion bodies
- Latent in white blood cells
- May be asymptomatic, mild, progressive, or fatal
- Transmitted by saliva and other body fluids
- Transmitted across the placenta, may cause mental retardation, neurological damage, stillbirth
- Transmitted sexually, by blood, or by transplanted tissue

Viral Hemorrhagic Fevers

<table>
<thead>
<tr>
<th>Classic</th>
<th>Emergent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yellow fever</td>
<td>Filovirus</td>
</tr>
<tr>
<td>Dengue &amp; DHF</td>
<td>Arenavirus</td>
</tr>
</tbody>
</table>

Ebola Virus – filoform virus on a macrophage

American Trypanosomiasis (Chagas’ Disease)

- Trypanosoma cruzi
- Reservoir
  - Rodents, opossums, armadillos
- Red blood cells in picture
- Vector
  - Reduviid bug

Toxoplasmosis – Toxoplasma gondii

- Toxoplasma gondii

Malaria

- Plasmodium vivax, P. ovale, P malariae, P. falciparum
- Reproduce in liver, release merozoites into bloodstream to affect RBC
- Chills, fever, vomiting, headache
- Anopheles mosquito vector
**Malaria**

Figure 23.25

(a) Merozoites being released from lysed RBC.

(b) Malarial blood smear; note the ring forms.

**Malaria**

Figure 23.24

(a) Areas where malaria was endemic as recently as 1972.

(b) Graph showing reported cases of malaria in the U.S. 1940–2002.

**Leishmaniasis**

Discuss the worldwide effects of these diseases on health.

<table>
<thead>
<tr>
<th>Disease</th>
<th>Visceral leishmaniasis</th>
<th>Cutaneous leishmaniasis</th>
<th>Mucocutaneous leishmaniasis</th>
<th>Babesiosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatal if untreated</td>
<td>Patches that ulcerate and scar</td>
<td>Disfiguring</td>
<td>Neutropenia</td>
<td></td>
</tr>
<tr>
<td>Causative agent</td>
<td>Leishmania donovani</td>
<td>L. Tropica</td>
<td>L. braziliensis</td>
<td>Babesia microti</td>
</tr>
<tr>
<td>Vector</td>
<td>Sandflies</td>
<td>Sandflies</td>
<td>Sandflies</td>
<td>Sandflies</td>
</tr>
<tr>
<td>Reservoir</td>
<td>Small mammals</td>
<td>Small mammals</td>
<td>Small mammals</td>
<td>Rodents</td>
</tr>
<tr>
<td>Treatment</td>
<td>Amphotericin B or miltefosine</td>
<td>Amphotericin B or miltefosine</td>
<td>Amphotericin B or miltefosine</td>
<td>Atovaquone + azithromycin</td>
</tr>
<tr>
<td>Geographic distribution</td>
<td>Asia, Africa</td>
<td>Southeast Asia</td>
<td>Asia, Africa, Mediterranean, Central America, South America</td>
<td>U.S.</td>
</tr>
</tbody>
</table>

**Schistosomiasis**

- Blood fluke *Schistosoma*
- Snail is intermediate host, free-swimming cercariae penetrate human skin
- Live in veins of liver or urinary bladder
- Tissue damage (granulomas) in response to eggs lodging in tissues

<table>
<thead>
<tr>
<th>Species</th>
<th>Location</th>
<th>Disease</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>S. haematobium</em></td>
<td>Granulomas in urinary bladder wall</td>
<td>Africa, Middle East</td>
</tr>
<tr>
<td><em>S. japonicum</em></td>
<td>Granulomas in intestinal wall</td>
<td>East Asia</td>
</tr>
<tr>
<td><em>S. mansoni</em></td>
<td>Granulomas in intestinal wall</td>
<td>African, Middle East, South American, Caribbean</td>
</tr>
<tr>
<td><em>Swimmer's itch</em></td>
<td>Cutaneous allergic reaction to cercariae</td>
<td>U.S. parasite of wildfowl</td>
</tr>
</tbody>
</table>
Diagram the life cycle of Schistosoma, and show where the cycle can be interrupted to prevent human disease.

- Sanitation and snail eradication help prevent it
- Chemotherapy treats disease

Schistosomiasis – granuloma (scar-like tissue)
<table>
<thead>
<tr>
<th>Disease</th>
<th>Pathogen</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>American trypanosomiasis</td>
<td>Trypanosoma cruzi</td>
<td>Common in Central and South America, transmitted by bite of reduviid bug, damages heart muscle or perivascular movement in endothelial cells.</td>
</tr>
<tr>
<td>Taenia solium</td>
<td>Taenia solium</td>
<td>Adult life cycle is in the intestine and the eggs are passed in the feces.</td>
</tr>
<tr>
<td>Leishmaniasis</td>
<td>Leishmania spp.</td>
<td>As many as 20 species of Leishmania, primarily L. donovani, L. major, and L. tropica.</td>
</tr>
<tr>
<td>Babesiosis</td>
<td>Babesia microti</td>
<td>An arthropod-borne disease that causes fever, chills, and fatigue.</td>
</tr>
<tr>
<td>Helminth Disease</td>
<td>Schistosoma spp.</td>
<td>Eggs produced by schistosomes lodge in tissue and induce immune response.</td>
</tr>
<tr>
<td>Scabies</td>
<td>Sarcoptes scabiei</td>
<td>An allergic reaction to parasites in skin.</td>
</tr>
</tbody>
</table>