Chapter 38 Pt. II

Human Diseases Caused by Bacteria
Arthropod-Borne Diseases

- generally rare
- some are of historical interest
- some newly emerged
Yersinia pestis

- nonenteric
- tiny, gram-negative rod, unusual bipolar staining & capsules
- virulence factors – capsular & envelope proteins protect against phagocytosis & foster intracellular growth
  - coagulase, endotoxin, murine toxin
Yersinia pestis

White blood cell  Y. pestis
**Yersinia pestis**

- humans develop plague through contact with wild animals (sylvatic plague) or domestic or semidomestic animals (urban plague) or infected humans
- found in 200 species of mammals – rodents without causing disease
- flea vectors – bacteria replicates in gut, coagulase causes blood clotting that blocks the esophagus; flea becomes ravenous
Plague...

- clinical manifestations
  - subcutaneous hemorrhages, fever, and buboes (hence name **bubonic plague**)
  - high mortality if untreated
  - **pneumonic plague** arises from:
    - primary exposure to infectious respiratory droplets of infected persons or cats
    - secondary to hematogenous spread in a patient with bubonic plague
Plague

Yersinia pestis – proliferates inside phagocytic cells

Figure 38.9 (a)
Plague

Yersinia pestis causative agent

Figure 38.9 (b) and (c)
Plague…

• diagnosis made in reference labs which use direct microscopic examination, culture and serological tests, and PCR

• treatment, prevention, and control
  – antibiotic therapy
  – ectoparasite and rodent control, isolation of human patients, prophylaxis of exposed persons, immunization of persons at high risk
Food-Borne and Water-Borne Diseases

- gastroenteritis is most common
- food poisoning
  - food source of pathogen
- food-borne infection
  - pathogen must colonize host
- food-intoxication
  - ingestion of toxin
    - enterotoxins — disrupt functioning of intestinal mucosa causing nausea, vomiting, and/or diarrhea
- generally prevented and controlled by sanitation measures
**Campylobacter jejuni**

**Gastroenteritis**

- *Campylobacter jejuni* is a gram-negative curved rod found in intestinal tract of animals (e.g., chickens, turkey, and cattle)
- causes campylobacteriosis
- transmitted to humans by contaminated food or water, contact with infected animals or anal-oral sexual activity
- C. jejuni invades epithelium of small intestine, causes inflammation and secretes an endotoxin
Campylobacter jejuni
Gastroenteritis

• diagnosis
  – culture in low oxygen, high CO₂ atmosphere
• treatment, prevention, and control
  – symptomatic/supportive therapy and antibiotic therapy in severe cases
  – good personal hygiene, safe food handling practices
Cholera

- caused by Vibrio cholerae, a comma-shaped, gram-negative bacterium
- acquired by ingesting food or water contaminated by fecal matter from patients or carriers
- shellfish are natural reservoirs
- organisms adhere to intestinal mucosa of small intestine and secrete the toxin cholera
  gen
Cholera...

- presence of toxin results in massive loss of water and electrolytes
  - production of “rice-water stools”
- diagnosis
  - culture from feces with subsequent identification by agglutination reactions
- treatment, control and prevention
  - oral rehydration
  - antibiotic therapy
(a) The specific action of cholera toxin (CT) upon the intestinal epithelial cells heightens the activity of an enzyme called adenyl cyclase (AC).

(b) This enzyme stimulates abnormally high levels of cAMP (cyclic adenosine monophosphate), a chemical messenger that normally mediates the action of hormones on cells, but in higher concentrations promotes removal of anions (chloride and carbonate) by the cell membrane.

(c) Under the constant action of cAMP, the cells begin to secrete large quantities of chloride (Cl\textsuperscript{−}) and bicarbonate (CO\textsubscript{3}\textsuperscript{2−}) ions into the intestinal lumen. Electrolyte loss is followed by water loss from epithelial cells, which is what causes the major symptoms.
**Clostridium**

- gram-positive, spore-forming rods
- **anaerobic** & catalase negative
- 120 species
- oval or spherical spores produced only under anaerobic conditions
- synthesize organic acids & alcohols & exotoxins
- cause wound & tissue infections & food intoxications
**Clostridium perfringens**

- causes *gas gangrene* in damaged or dead tissues
- 2\textsuperscript{nd} most common cause of food poisoning, worldwide
- **virulence factors**
  - toxins – alpha toxin – causes RBC rupture, edema & tissue destruction
  - collagenase
  - hyaluronidase
  - DNase
Gas Gangrene or Clostridial Myonecrosis

- most commonly caused by *Clostridium perfringens*
  - gram-positive, spore-forming rod
  - produce *gas gangrene*, a necrotizing infection of skeletal muscle or *clostridial myonecrosis*
  - secretes toxin and tissue damaging enzymes
- transmitted by contamination of injured tissue by spores from soil or bowel microbiota
Gas gangrene...

- **Clinical manifestations**
  - severe pain, edema, drainage, and muscle necrosis

- **Diagnosis**
  - recovery of appropriate clostridial species and characteristic disease symptoms

- **Treatment, prevention, and control**
  - surgical debridement, administration of antitoxin, antibiotic therapy, and hyperbaric oxygen therapy
  - prompt treatment of all wound infections and amputation of limbs
Figure 38.11
Clostridium perfringens

- treatment of gangrene – debridement of diseased tissue
  - large doses of cephalosporin or penicillin
  - hyperbaric oxygen
**Clostridium botulinum**

Causes 3 diseases

1. **food poisoning** - spores are in soil, may contaminate vegetables; improper canning does not kill spores & they germinate in the can producing botulinum toxin
   - toxin causes paralysis by preventing release of acetylcholine
2. **infant botulism** – caused by ingested spores that germinate & release toxin
3. **wound botulism** – spores enter wound & cause food poisoning symptoms
Botulism

- caused by *Clostridium botulinum*, an obligately anerobic, endospore-forming, gram-positive rod
  - on Select Agent List
- most common source of infection is insufficiently heated home-canned food
  - endospores not killed, then germinate and produce toxin
  - if food inadequately cooked, toxin remains and causes disease
Botulism...

• infant botulism
  – endospores ingested, germinate, reproduce, and produce exotoxin
  – constipation, listlessness, general weakness, and poor appetite; death may result from respiratory failure

• treatment, prevention and control
  – symptomatic/supportive therapy and administration of antitoxin
  – safe food processing practices and not feeding honey to babies under one year of age
Clostridium tetani

- common resident of soil & GI tracts of animals
- causes tetanus or lockjaw, a neuromuscular disease
- spores usually enter through accidental puncture wounds, burns, umbilical stumps, frostbite, & crushed body parts
- tetanospasmin – neurotoxin causes paralysis
- vaccine booster needed every 10 years
**Clostridium difficile**

- normal resident of colon, in low numbers
- causes antibiotic-associated colitis
  - treatment with broad-spectrum antibiotics kills the other bacteria, allowing *C. difficile* to overgrow
- produces enterotoxins that damage intestine
- major cause of diarrhea in hospitals
Salmonella

- motile; ferments glucose
- resistant to chemicals – bile & dyes
- *S. typhi* – typhoid fever – ingested bacilli adhere to small intestine, cause invasive diarrhea that leads to septicemia
  - 2 new vaccines
- *S. cholerae-suis* - pigs
- *S. enteritidis* – 1,700 serotypes - salmonellosis – zoonotic
  - gastroenteritis 2-5 days
Sepsis and Septic Shock

• sepsis
  – systemic response to a microbial infection
  – e.g., changes in heart rate, respiratory rate, and blood cell counts

• septic shock
  – sepsis associated with severe hypotension
  – can be caused by gram-positive bacteria, fungi and endotoxin-containing gram-negative bacteria
Salmonellosis

- caused by >2,000 Salmonella serovars, gram-negative non-spore forming rods
- transmitted to humans by contaminated foods such as beef products, poultry, egg products, and water
- disease results from food-borne infection
  - bacteria in intestinal mucosa produce enterotoxin and cytotoxin
Salmonellosis

- Symptoms include abdominal pain, cramps, diarrhea, nausea, vomiting, and fever.
- Diagnosis: isolation of organism from food or patients' stools.
- Treatment, control, and prevention: fluid and electrolyte replacement, good food handling practices, proper refrigeration, adequate cooking.
Typhoid Fever

- caused by *Salmonella enterica* subspecies *enterica* serovar *typhi*, a gram-negative rod
- acquired by ingestion of food or water contaminated by feces in infected humans or person-to-person contact
- paratyphoid fever
  - milder form of disease
Typhoid Fever

- bacteria spread from small intestine to lymphoid tissue, blood, liver and gallbladder
- symptoms include fever, headache, abdominal pain, anorexia and malaise
- in carriers (e.g., Typhoid Mary) bacteria grow in gallbladder and reach intestine through bile duct
Typhoid Fever

• diagnosis
  – demonstration of typhoid bacilli in blood, urine, or stools
  – serology (Widal test)
• treatment, prevention and control
  – antibiotic therapy
  – vaccine for high risk individuals
  – purification of drinking water, prevention of food handling by carriers, and isolation of patients
Shigellosis

- **bacillary dysentery**
- caused by four species of genus *Shigella*
  - gram-negative, non-spore forming rods
- organisms cause inflammatory reaction in mucosa
- humans are the only host
Shigella

- shigellosis – incapacitating dysentery
- *S. dysenteriae, S. sonnei, S. flexneri* & *S. boydii*
- produce H$_2$S or urease
- invades villus of large intestine, can perforate intestine or invade blood
- enters Peyer’s patches instigates inflammatory response; endotoxin & exotoxins
- treatment – fluid replacement & ciprofloxacin & sulfa-trimethoprim
Shigellosis...

- Endotoxins and exotoxins may play role in disease progression
- Watery stools often contain blood, mucus and pus
- Diagnosis
  - Biochemical characteristics
  - Serology
- Treatment, prevention and control
  - Antibiotic therapy
  - Prevention by use of good personal hygiene and a clean water supply
Traveler’s Diarrhea and *Escherichia coli* infections

- traveler’s diarrhea
  - caused by certain viruses, bacteria, or protozoa normally absent from traveler’s environment
  - *E. coli* is one of major causative agents
- six categories or strains are recognized
Traveler’s disease…

• diagnosis
  – past travel history and symptoms, isolation and identification of causative agents using DNA probes, tests for virulence factors, and PCR

• treatment, prevention, and control
  – symptomatic/supportive therapy and antibiotic therapy
  – avoiding contaminated food and water
a. enterotoxigenic  b. enteroinvasive  c. enteropathogenic or attaching-effacing
 d. enterohemorrhagic  e. enteroaggregative  f. diffusely adhering

Figure 38.25
Pathogenic *E. coli* Strains

- **enterotoxigenic** *E. coli* (ETEC)
  - produces one or both enterotoxins responsible for diarrhea
  - distinguished by their heat stability
- **enteroinvasive** *E. coli* (EIEC)
  - multiplies within intestinal epithelial cells
  - may produce a cytotoxin and an enterotoxin
- **enteropathogenic** *E. coli* (EPEC)
  - causes effacing lesions
  - caused by destruction of brush border microvilli on intestinal epithelial cells
from Supramolecular structure of the enteropathogenic Escherichia coli type III secretion system and its direct interaction with the EspA-sheath-like structure PNAS September 25, 2001, vol. 98, no. 20 11638–11643
More diarrheagenic strains

- enterohemorrhagic *E. coli* (EHEC)
  - produces effacing lesions, leading to hemorrhagic colitis
  - releases *shiga-like* toxins
    - implicated in *hemolytic uremic syndrome* and thrombotic thrombocytopenic purpura
      - e.g., *E. coli* 0157:H7
More strains

- **enteroaggregative *E. coli* (EAggEC)**
  - forms clumps adhering to epithelial cells
  - toxins have not been identified

- **diffusely adhering *E. coli* (DAEC)**
  - adheres in a uniform pattern to epithelial cells
  - particular problem in immunologically naïve or malnourished children