Lecture 35: Microbial Diseases of the Digestive System - Infections of the mouth, bacterial gastroenteritis

Most infectious diseases of the gastrointestinal tract are acquired through ingestion of contaminated food or water that contains pathogenic microorganisms or their toxins.

- The digestive system (Tortora et al., Figure 25.1) may be divided into two groups of organs.
  - The gastrointestinal (GI) tract (which is, in a topological sense, an external surface!) consists of the mouth, esophagus, stomach, small intestine and large intestine.
  - Various accessory structures, including salivary glands, liver, gallbladder and pancreas, lie outside of the GI tract and produce secretions that are conveyed into the GI tract.

- The function of the GI tract is to provide conditions for digestion of nutrients and their transfer to the cardiovascular and lymphoid systems for use by cells.
  - The combined action of enzymes produced in the GI tract and accessory structures serves to catalyze hydrolysis of polymers (polysaccharides, lipids, proteins) to their soluble monomers (simple carbohydrates, fatty acids, amino acids).
  - The small intestine serves the process of absorption of these monomers into the bloodstream.
  - The processes of digestion and absorption require that large amounts of water and electrolytes (salts) be secreted into the GI tract.
    - The large intestine serves the process of resorption of the water and electrolytes secreted during digestion.
      - Dehydration and hypovolemia (low blood volume) resulting from inadequate resorption are the leading pathogenic effects of bacterial and viral gastroenteritis.

- The gastrointestinal tract contains an abundant bacterial flora.
  - Various streptococci, including Streptococcus salivarius, inhabit the mouth, along with numerous spirochaetes and some strict anaerobes.
  - The stomach and small intestine have relatively few bacteria, as the conditions that favor digestion (low pH, hydrolytic enzymes) do not favor growth of most microorganisms.
  - The large intestine possesses an enormous native flora.
    - Most of these are anaerobes, including species of Bacteroides, and are not readily isolated in the laboratory.
    - The most common facultative anaerobe is Escherichia coli.

Dental caries (tooth decay) involve breakdown of enamel and dentin from teeth (Tortora et al., Figure 25.2).

- Eventually, decay allows for bacterial invasion and necrosis of the pulp, and abscess of the bone surrounding the tooth (Tortora et al. Figure 25.4).

- Interestingly (and just like everybody always told you), development of dental caries is closely associated with the presence of sucrose in the diet.

- Streptococcus mutans may be the most important bacterial species in development of dental caries.
  - When provided with sucrose, S. mutans is able to produce dextran, a glucose polymer (Tortora et al., Figure 25.3); plaque consists of accumulated dextran and bacterial cells.
  - Dextran aids in attachment of bacteria to tooth surfaces, but also prevents dilution of acids produced during bacterial metabolism; these concentrated acids are what cause dissolution of enamel.

- Periodontal disease refers to inflammation and degeneration of gum tissue (Tortora et al. Figure 25.5); some periodontal disease may result from invasion of the gums by bacteria associated with plaque, hence the emphasis on removal of plaque that has accumulated in the gingival crevice.
The term *gastroenteritis* refers to diseases causing inflammation of the gastrointestinal tract.
- Although gastroenteritis in healthy adults is usually self-limiting, it remains a major cause of infant mortality in developing countries
  - This is due to interference with absorption and, especially, with resorption, leading to rapid dehydration
  - The World Health Organization's promotion of *oral rehydration therapy* is intended to address the major health problem associated with gastroenteritis
- As an infectious disease, gastroenteritis may be due to either infection or intoxication
  - *Infection* results from multiplication of a pathogen in the GI tract
  - *Intoxication* is due to ingestion of a preformed bacterial toxin that affects GI tract function
  - Infection and intoxication can be distinguished by the rapid onset of intoxication versus the incubation time required for an infection to develop

*Staphylococcal food poisoning* is a very common intoxication-type gastroenteritis (Tortora et al., Figure 25.6)
- The symptoms are due to an *enterotoxin* produced by *Staphylococcus aureus*
- *S. aureus* exhibits characteristics that sometimes favor its growth in foods
  - It is a common member of the human native microbiota, so food is readily contaminated with *S. aureus* by handling
  - *S. aureus* is tolerant of high osmotic pressures, allowing it to grow in foods (cured hams, custards) where it has few competitors
- Since it is an intoxication, staphylococcal food poisoning is characterized by rapid onset of symptoms

*Shigellosis*, or *bacillary dysentary*, is a relatively severe form of gastroenteritis caused by bacteria belonging to the genus *Shigella*
- Invasion of the large intestine by *Shigella* cells can cause extensive tissue destruction and profound interference with resorption, leading to severe diarrhea and dehydration
- *Shigella* produces *Shiga toxin*, which is also produced by *Escherichia coli O157*
- *Shigella* invades intestinal epithelia and can spread directly between cells (Tortora et al. Figure 25.7)

*Salmonellosis* is the most common form of bacterial infection-type gastroenteritis
- Taxonomy of the genus *Salmonella* is complex, based on reactions of an isolate with antisera
- *Salmonella* gastroenteritis is caused by multiplication of the bacteria in the intestinal mucosa
- Occasionally, the bacteria may invade the bloodstream, leading to potentially fatal septicemia
  - Fortunately this is a strain characteristic, and the invasive strains are relatively rare
  - The most virulent are *Salmonella typhi*, the agent of *typhoid fever*
- *Salmonella* are frequent contaminants of meat products, especially poultry
- Salmonellosis is usually mild, and is probably underreported
- Typhoid fever results from *Salmonella* crossing the intestinal epithelium and entering the bloodstream (Tortora et al. Figure 25.8)

*Cholera*, perhaps the most infamous form of bacterial gastroenteritis, is caused by the Gram-negative, rod-shaped *Vibrio cholerae* (Tortora et al., Figure 25.11)
- Cholera is endemic in western Asia, and continues to cause epidemics where war or natural disasters disrupt normal water treatment and other precautions to prevent fecal-oral transmission
- *V. cholerae* grows in the small intestine and secretes an enterotoxin, *choleragen*, that causes secretion of water and electrolytes into the GI tract
  - This massive fluid loss (up to 20 liters per day) can lead to shock, and often death
  - Constant fluid replacement through oral rehydration therapy may be necessary until the bacterial infection is cleared
Like other bacterial species causing gastroenteritis, strains of *V. cholerae* vary in virulence and pathogenicity.

Another *Vibrio* species, *V. parahaemolyticus*, is a common cause of bacterial gastroenteritis in eastern Asia.

Although *Escherichia coli* is best known as a commensal in the lower intestine, certain strains are capable of causing gastroenteritis:

- It is estimated that over half the cases of "traveler's diarrhea" are due to pathogenic *E. coli*.  
  - Most of these are *enterotoxigenic* strains, in which pathogenesis is due to a enterotoxin produced by the bacteria.
  - Some *E. coli* strains are *enteroinvasive* and can invade the intestinal epithelium.
- Of greatest current concern in the U.S. are *enterohemorrhagic E. coli (EHEC)*, including the well-covered “O157” strains
  - EHEC have been associated with *hemolytic uremic syndrome (HUS)*, leading to kidney failure.
  - Concern with EHEC has heightened awareness of safe food handling practices.

- Diagnosis of *E. coli* gastroenteritis is hindered by the difficulty in distinguishing between pathogenic and nonpathogenic strains.

A few forms of bacterial gastroenteritis have received increased attention because their incidence is probably greater than had been realized previously:

- In most cases of acute gastroenteritis, with limited diarrhea and abdominal cramping, the pathogen is never identified (and, in fact, the disease is never treated by a physician).
- *Campylobacter*, found as part of the GI flora in a number of animals, is now known to be the second-most important bacterial cause of diarrhea in the United States (behind *Salmonella*).
- *Yersinia enterocolitica* and *Y. pseudotuberculosis* are likewise transmitted from animal hosts.
- *Clostridium perfringens* and *Bacillus cereus* are common soil organisms that have been implicated in cases of gastroenteritis acquired from contaminated foods.

*Helicobacter pylori* is now recognized as responsible for *peptic ulcer disease* (Tortora et al. Figure 25.12).

- *H. pylori* is able to survive in the acidic environment of the stomach due to strong urease activity.
- Peptic ulcer disease results from an inflammatory response, probably initiated by leucocytes responding to *H. pylori* colonization.
- Peptic ulcer disease can be effectively treated with antibiotics.