Chapter 14 Infection and Epidemiology

Objectives

After studying this chapter, the reader should be able to:
Define virulence and epidemiology.
Distinguish between infectivity and virulence.
List and describe the four host defenses used to resist infection.
Name five ways in which diseases are transmitted.

I. Resistance

A. General information
1. Infection, the introduction of parasitic microorganisms into a host, results in injury or death to the host cells

2. Infected host cells can be injured in several ways.
a. The microorganisms may compete with the host cell for nutrients, as in tapeworm infections

b. The microorganisms may release toxins, as in *Clostridium tetani* infections

c. The microorganisms may subvert host cell processes, as in viral infections

d. The microorganisms may trigger antigen-antibody reactions, which can result in cell death and inflammation, as in syphilis and gonorrhea

3. Resistance is the ability of an organism to withstand infection

a. Higher life forms, including humans, are relatively resistant to infection

b. Factors involved in resistance include the host's general state of health, personal hygiene, nutrition, psychological factors such as stress, and sanitation conditions in the environment

4. Specific defenses used to ward off infection include physical defenses, cellular defenses, antibodies, and normal flora

B. Physical defenses against infection

1. Physical barriers prevent disease-producing microorganisms from entering sites where infection can occur

2. Intact skin, tears, mucus, and the acidity of the stomach and genitourinary tract are examples of physical barriers

3. Physical defenses can be compromised by cuts and abrasions to the skin, burns, trauma, and excessively wet or dry conditions in the environment.

C. Cellular defenses against infection

1. Resistance to infection is enhanced by specific cells that can search out and destroy pathogenic microorganisms

2. Neutrophils, monocytes, and macrophages are cells that can phagocytize and lyse microorganisms

3. Infection can occur when there are too few phagocytic cells or when cell function is ineffective in producing lysis

D. Antibody defenses against infection

1. Antibodies are proteins that are produced in response to and react with antigens
   a. They are made by lymphocytes that come in contact with a microorganism's antigens
   b. Antibodies and antibody-like proteins protect higher life forms from pathogenic microorganisms

2. An antibody tends to react only with a specific antigen; exceptions are called cross-reactions

3. Antigen-antibody reactions result in agglutination (clumping) of the microorganisms, neutralization or destruction of the microorganisms, and increased phagocytosis

4. Antibody-like proteins that are nonspecific in their reactions include interferon (active against viruses), lysozyme (active against some gram-positive bacteria), and properdin (active against gram-negative bacteria and viruses)

5. Antibody defenses can fail when antibody production is deficient or genetically impaired

E. Normal flora as a defense against Infection

1. Normal flora are harmless microorganisms that reside on the skin and in the gastrointestinal and genitourinary tracts
   a. They are found in many of the sites where infectious agents can cause disease
   b. Normal flora compete with pathogenic microorganisms for nutrients

2. The presence of normal flora stimulates the immune system before infections occur

   a. During and after birth, the newborn acquires organisms of the normal flora

b. The normal flora stimulate development of the reticuloendothelial system (responsible for fighting infections) and increase antibody levels

3. The indiscriminate use of antimicrobial agents can eradicate normal flora, thereby eliminating this defense against infection

II. Infectivity

A. General Information

1. Infectivity is the ability of a microorganism to overcome resistance and establish a parasitic relationship with a host

2. Infection occurs only when specific conditions are met

a. Of primary importance is the microorganism's ability to survive on or in host tissues

b. Nutrients and suitable environmental conditions are also required

c. An ability to grow at body temperatures is fundamental (dermatophyte fungi cannot invade deeper tissues because of their inability to grow at 37° C)

d. Adherence to cell surfaces is also advantageous; the pili of bacteria, the receptor sites of viruses, and the hooks or suckers of helminths allow such adherence

B. Pathogenic nature of microorganisms

1. More than 100 years ago, bacteriologist Robert Koch recognized that culturing colonies of a single organism was vital to the study of microorganisms

2. He developed a system of related ideas, known as Koch's Postulates, that still serve to prove the pathogenic nature of microorganisms. These are:

1. The same microorganism must be found in all cases of a disease host
2. The microorganism must be isolated in pure culture from the infected host
3. The microorganism must reproduce the disease when introduced into a susceptible similar species of host
4. The microorganism must be isolated in pure culture from the experimentally infected host and compared to the original host microorganism

Know exceptions to these Postulates: 1) virus can not be grown on culture
2) Some microbes can not be grown on artificial media
3) Some microbes may cause several different diseases

C. Special characteristics and infectivity

1. Some organisms have special characterisitics that contribute to their infectivity

a. The presence of a capsule helps to deter phagocytosis and antibody formation; *Cryptococcus, Klebsiella*, and *Streptococcus* are encapsulated organisms

b. The presence of mucolytic and proteolytic enzymes can neutralize host defenses; Haemophilus possesses such a characteristic

c. The ability to alter surface antigens and evade antibody reactions can increase infectivity; *Borrelia* and *Neisseria* have this ability

d. The ability to mask surface antigens so that they resemble host antigens is another way of increasing infectivity; *Escherichia coli* and *Teponema* have this characteristic

e. Some pathogenic organisms can overcome the strict conservation of iron that is typical of host cells, freeing the iron for the metabolic needs of the organisms

2. More than one of these characteristics may be combined in a single, highly infectious organism

III. Virulence

A. General information

1. Virulence refers to the disease-producing, or pathogenic, ability of microorganisms

a. An organism's virulence depends on the degree of cell damage and produced inflammation

b. Virulence also is a function of the release of toxins that directly affect host cell processes

2. Virulence can be increased through latent infections, which is the case with many viruses

3. In some instances, an infection with one type of microorganism enhances the virulence of other microorganisms; for example, infection with the human immunodeficiency virus allows opportunists to cause life-threatening diseases in the infected host

B. Production of disease

1. Direct cell damage is caused by obligate intracellular parasites, such as *Chlamydia*, *Rickettsia*, and viruses

   a. Cell damage results in acute inflammation

   b. Examples include streptococcal pneumonia and viral hepatitis

2. The production of toxins, such as the endotoxins of gram-negative bacteria and the exotoxins of gram-positive bacteria, results in sepsis

3. The production of certain enzymes, such as the coagulase produced by *Staphylococcu*s, can contribute to an organism's pathogenicity

C. Opportunism

1. Opportunists are considered to be of low virulence

   a. They are commonly members of the normal flora

   b. They produce infection only when introduced into a normally sterile body site, when populations of flora are upset, or in immuno-compromised hosts

2. Opportunism increases with increasingly latent infection rates

3. Bacteria must first adhere to a host

   a. Adhesins projections on the surface of bacterium adhere to complementary receptors of host cells.

      (1) Adherence is followed by colonization of tissues by microbes.

   b. Mechanism of disease-causing bacteria

      (1) produce toxins or special enzymes
         (a) Hemolysins which destroy red blood cells;
         (b) Leukocidins which destroy neutrophils and macrophages;
         (c) Coagulase which helps in blood clotting;
         (d) Fibrinolysin such as Staphylokinase that is produced by *Straphylococcus aureus*. Bacterial kinases are used to dissolve clots in plasma, which is the host cell's attempt to isolate the infection.
         (e)Collagenase - Produced by *Clostridium* (spp) and breaks down the connective tissue of the host, allowing the pathogen to spread.

(f) M protein which produced by *Streptococcus pyogenes* and assists the attachment of the bacterium to the host epithelial lining. The M protein increase the virulence of the bacterium.
(g) Capsule - Slime capsules increase the virulence of a microbe by inhibiting the host's natural defense of phagocytosis.
(h) Necrotizing factors are produced by bacteria and cause the death of somatic cells. Necortizing factors increase the virulence of the bacteria.

4. Bacterial Exotoxins

a. Exotoxins produce and excreted mostly by gram positive bacteria
(1) Usually proteins of enzymatic activity.

b. Three types of exotoxins
(1) Cytotoxins - which cause the death of the host cell
Corynebacterium diphtheria produces diphtheria toxin, which is a cytotoxic to human cells by inhibition of protein synthesis.

(2) Neurotoxins - which interfere with the normal nervous function
(a) *Clostridium botulinum* produces the neurotoxin botulinum toxin. Botulinum toxin binds to acetylcholine, a neurotransmitter, and causes paralysis.
(b) *Clostridium tetani* produces the neurotoxin tetanospasmin or tetanus toxin. This toxin binds specifically to the cells that control the contraction of the skeletal muscle. The result of toxin binding is uncontrollable muscle contraction (lockjaw).

(3) Enterotoxins - which affect the intestinal lining of the host
(a) *Vibrio cholerae* produces the enterotoxin cholera toxin. The vibrio enterotoxin consists of two polypeptides, one involved in the symptoms of the disease and the second involved in binding. The bacterial binds to the host's intestinal epithelium and causes the epithelium to excrete fluids and electrolytes. This result in diarrhea, vomitting, and disturbances of normal muscular contraction.

5. Inactivation
(1) heat or chemical treatment

(2) host immune system produces antitoxins as antibodies against exotoxins

6. Bacterial Endotoxins
(1) Produced by gram - negative bacteria
(a) by outer membrane structure - lipopolysaccharides (LPS - Lipo poly A)

(2) Endotoxin produce following Gram (-) cell death as LPS are released from the membrane into the host's bloodstream. Host responses to endotoxins:

Chills, fever, weakness, generalized aches, and in some cases, shock and death.

(3) Host macrophages secrete interleukin-1 (IL-1) and or tumor necrosis factor (TNF) in response to phagocytized Gram (-) bacterial. IL-1 causes the hypothalamus to release Prostaglandins resulting in fever. Severe reaction include fluid loss, loss of blood pressure, and septic shock

IV. Epidemiology

A. General Information

1. Epidemiologists use the tools of microbiology to study the causes of outbreaks, or epidemics, of infectious diseases

2. They determine how infections are transmitted and recommend preventive measures, such as quarantine, vaccination, or improved sanitation and education

3. Epidemiologists are employed by health care institutions, local and state health departments, and federal agencies such as the Public Health Service and the Centers for Disease Control

B. Sources of Infection

1. Community-acquired infections are the most common

a. These infections commonly are self-limiting, require no treatment, and pose no threat to life

b. Examples include colds and such childhood diseases as mumps and measles

2. Hospital-acquired, or nosocomial, infections are spread in a health care setting

a. Many of these infections are life-threatening and difficult to treat

b. Examples include staphylococcal infections in newborns and burn patients and *Pseudomonas* infections in patients with respiratory disease

C. Disease transmission

1. Diseases are transmitted from an infectious agent to a susceptible host in several ways
a. Inanimate objects (fomites), such as eating utensils, hypodermic needles, or contaminated clothes, can harbor pathogenic organisms

b. Vectors, such as fleas, lice, mites, ticks, flies, and mosquitoes, can be a source of

disease transmission

(1) The vector acquires the pathogenic parasite from an animal, referred to as a reservoir
(2) The vector then passes the parasite to a new host

c. Human carriers can incubate an infection or remain symptom-free while transmitting an infection to others

d. Contaminated food or water can spread disease

e. Airborne agents, such as bacteria, viruses, fungal spores, and helminth eggs, can transmit disease

(1) Direct contact with a dead or diseased organism can be a cause of infection
(2) The chain of infection comprises the relationships between fomites, vectors, reservoirs, carriers, and hosts

D. Preventing infection

1. Quarantining infected persons can limit the spread of disease

2. Vaccinating susceptible hosts can stimulate antibody formation

3. Disposing of contaminated wastes properly can discourage the transmission of disease

4. Educating people in the value of personal hygiene, the causes of infection, and the means of controlling exposure to pathogenic microorganisms can help control disease transmission

Watch: http://www.pbs.org/wgbh/nova/sciencenow/3318/02.html