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Textbook of MICROBIOLOGY for Diploma in General Nursing & Midwifery Students

As per the INC Syllabus for GNM



Surinder Kumar
Co-Editor
Sourabh Kumar

3rd Edition

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Chapter
8

Infection and Asepsis

Learning Objectives

After reading and studying this chapter, you should be able to:

- Define the terms saprophytes, parasite, commensal, pathogen.
- Discuss modes of spread of infection giving suitable examples.
- List the differences between exotoxins and endotoxins.

Infection and immunity involve interaction between the animal body (host) and the infecting microorganisms.

MICROORGANISMS AND HOST

Based on their relationship to their host they can be divided into:

- Saprophytes
- Parasites

Saprophytes

Saprophytes (from Greek sapros decayed; and phyton plant): are free-living microbes that live on dead or decaying organic matter.

Parasites

Parasites are microbes that can establish themselves and multiply in the hosts. Parasite microbes may be either pathogens or commensals:

Pathogens

Pathogens (from Greek pathos, disease, and gen, to produce) are the microorganisms or agents, which are capable of producing disease in the host. Its ability to cause disease is called pathogenicity.

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Types of Pathogens

They are two types—**primary** and **opportunist pathogens**.

1. **Primary (frank) pathogens:** Primary (frank) pathogens are the organisms, which are capable of producing disease in previously healthy individuals with intact immunological defences.
2. **Opportunist pathogens: Opportunist pathogens** rarely cause disease in individuals with intact immunological and anatomical defences.

Commensals

Commensals (organisms of normal flora) are the microorganisms that live in complete harmony with the host without causing any damage to it. Skin and mucous membranes are sterile at birth.

INFECTION AND INFECTIOUS DISEASE

Infection

The lodgment and multiplication of a parasite in or on the tissues of a host constitute **infection.**

Infectious disease: An **infectious disease** is any change from a state of health in which part or all of the host body is not capable of carrying on its normal functions due to the presence of an organism or its products. A clinically manifest disease of man or animals resulting from an infection.

Chain of Infection

For a microorganism to be transported and be effective in continuing contamination, it follows a definite cycle or chain of events. The following **six elements** are necessary for infection to occur **(Fig. 8.1)**:

1. **The infectious agent**—a pathogen
2. **Reservoir:** Any natural habitat of a microorganism that promotes growth and reproduction is a **reservoir.** Examples of reservoirs are soiled or wet dressings and hospital equipment such as a bedside stand, an overbed table, suction equipment, or urinary drainage bags. A **carrier,** or vector, is a person or animal who does not become ill but harbors and spreads an organism, causing disease in others.
3. **Exit route:** A microorganism does not have the capacity to cause disease in another host without finding a point of escape from

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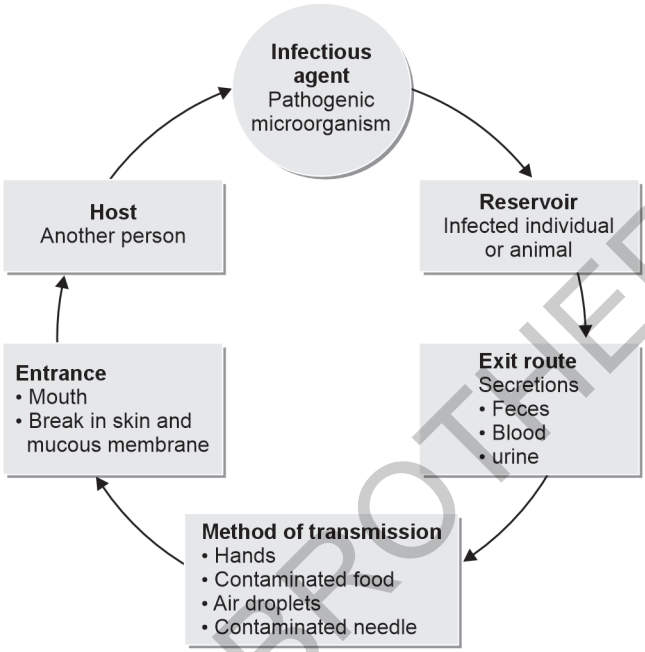

Fig. 8.1: Chain of infection.

the reservoir. Successful microbes must leave the body and then be transmitted to fresh hosts. Exit routes in humans are the gastrointestinal, respiratory, and genitourinary systems; tissue; blood; and wounds.

4. **Method or vehicle of transportation**, such as exudate, feces, air droplets, hands, and needles.
5. **Entrance through skin, mucous lining, or mouth.**
6. **Host:** Another person or animal where organism is nourished and harbored.

Prevention

To prevent the spread of a microorganism, the cycle must be interrupted. This is possible through daily practices of medical asepsis. These practices help to inhibit (to stop or slow a process) the growth and reduce the number of microorganisms.

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Classification of Infections

Infections may be classified in various ways **(Table 8.1)**:

1. **Primary infection:** Initial infection with a parasite in a host is termed *primary infection.*
2. **Reinfections:** Subsequent infections by the same parasite in the host are termed *reinfections.*
3. **Secondary infection:** When a new parasite sets up an infection in a host whose resistance is lowered by a preexisting infectious disease, this is termed *secondary infection.*
4. **Local infection:** The term *local infection* (more appropriately *local sepsis)* indicates a condition where, due to infection or sepsis at localized sites such as appendix or tonsils, generalized effects are produced.
5. **Cross infection:** When in a patient already suffering from a disease a new infection is set up from another host or another external source, it is termed *cross infection.*
6. **Nosocomial infections:** Cross infections occurring in hospitals are called *nosocomial infections* (from Greek *nosocomion* hospital).
7. **Iatrogenic infection:** The term *iatrogenic infection* refers to physician induced infections resulting from investigative, therapeutic or other procedures.

   Based on the clinical effects of infections, they may be classified into different varieties.
8. **Inapparent infection:** Inapparent infection is one where clinical effects are not apparent.
9. **Subclinical infection:** The term *subclinical infection* is often used as a synonym to inapparent infection.
10. **Atypical infection:** Atypical infection is one in which the typical or characteristic clinical manifestations of the particular infectious disease are not present.
11. **Latent infection:** Some parasites, following infection, may remain in the tissues in a latent or hidden form proliferating and producing clinical disease when the host resistance is lowered. This is tanned *latent infection.*

Sources of Infection

- **Human beings:** The commonest source of infection for human beings is human beings themselves. The parasite may originate

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Table 8.1: Classification of infections

1. Primary infection	Initial infection with a parasite in a host
2. Reinfections	Subsequent infections by the same parasite in the host
3. Secondary infection	When a new parasite sets up an infection in a host whose resistance is lowered by a preexisting infectious disease
4. Local infection	The term *local infection* (more appropriately *local sepsis)* indicates a condition where, due to infection or sepsis at localized sites such as appendix or tonsils, generalized effects are produced
5. Cross infection	When in a patient already suffering from a disease a new infection is set up from another host or another external source
6. Healthcare-associated infections	**Healthcare-associated infections (HAIs)** include those with hospital onset and those with community onset in patients with previous healthcare encounters
7. Iatrogenic infection	Physician induced infections resulting from investigative, therapeutic or other procedures. Depending on whether the source of infection is from the host's own body or from external sources, infections are classified as *endogenous* or *exogenous,* respectively
8. Inapparent infection	Inapparent infection is one where clinical effects are not apparent
9. Subclinical infection	The term *subclinical infection* is often used as a synonym to inapparent infection
10. Atypical infection	Atypical infection is one in which the typical or characteristic clinical manifestations of the particular infectious disease are not present
11. Latent infection	Some parasites, following infection, may remain in the tissues in a latent or hidden form proliferating and producing clinical disease when the host resistance is lowered. This is termed *latent infection*

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from a patient or carrier. Humans play a substantial role as microbial reservoirs.

- Carrier: A carrier is person who harbors the microorganisms without suffering from any ill effect because of it. There are several types of carriers.

- **Animals**
  - *Reservoir hosts:* Many pathogens are capable of causing infections in both human beings and animals. Therefore, animals may act as a source of infection of such organisms. These, animals serve to maintain the parasite in nature and act as **reservoir** and they are, therefore, called **reservoir hosts**.
  - *Zoonosis*: The diseases and infections, which are transmissible to man from animals are called **zoonosis**. Humans contract the pathogens by several mechanisms.
    Examples of zoonotic diseases:
    - Bacterial: Anthrax, brucellosis, Q fever, leptospirosis, bovine tuberculosis, bubonic plague, *Salmonella* food poisoning.
    - Viral: Rabies, yellow fever, cowpox, monkeypox.
    - Protozoal: Leishmaniasis, toxoplasmosis, trypanosomiasis, babesiosis.
    - Helminthic: Echinococcosis, taeniasis, trichinellosis.
    - Fungal: Microsporum canis, trichophyton verrucosum.
- **Insects**
  - *Arthropod borne diseases:* Blood-sucking insects such as mosquitos, ticks, mites, flies, and lice may transmit pathogens to human beings and diseases so caused are called *arthropod borne diseases*.
  - *Vectors:* Insects that transmit infections are called *vectors*.
  - *Reservoir hosts:* Besides acting as vectors, some insects may also act as reservoir hosts (for example, ticks in relapsing fever and spotted fever). Infection is maintained in such insects by transovarial or transstadial passage.
- **Soil and water**
  - **Soil:** Some pathogens can survive in the soil for long periods. *Examples*: (a) Spores of tetanus and gas gangrene; (b) Fungi and parasites
  - **Water**
- **Food**

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MODES OF TRANSMISSION OF INFECTION

Pathogenic organisms can spread from one host to another by a variety of mechanisms. These include:

Contact

Infection may be acquired by contact, which may be direct or indirect.

- **Direct contact:** Such as sexually transmitted diseases.
- **Indirect contact:** Indirect contact may be through the agency of fomites, which are inanimate objects, such as clothing, pencils or toys which may be contaminated by a pathogen from one person and act as a vehicle for its transmission to another.

Inhalation

Respiratory infections such as common cold, influenza, measles, mumps, tuberculosis and whooping cough are acquired by inhalation.

Ingestion

Intestinal infections are generally acquired by the ingestion of food or drink contaminated by pathogens. Infection transmitted by ingestion may be water-borne (cholera), food-borne (food poisoning) or hand-borne (dysentery).

Inoculation

The disease agent may be inoculated directly into the skin or mucosa, e.g., rabies virus deposited subcutaneously by dog bite, tetanus spores implanted in deep wounds, and arboviruses injected by insect vectors.

Infection by inoculation may be iatrogenic when unsterile syringes and surgical equipment are employed, e.g., hepatitis B and the human immunodeficiency virus (HIV).

Insects (See Under Sources of Infection)

Vector is defined as an arthropod or any living carrier (e.g., snail) that transports an infectious agent to a susceptible individual.

Congenital

Some pathogens are able to cross the placental barrier and reach the fetus in utero. This is known as **vertical transmission**.

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Examples: So-called TORCH agents (*Toxoplasma gondii*, rubella virus, cytomegalovirus and herpes virus), varicella virus, syphilis, hepatitis B, Coxsackie B and AIDS.

Iatrogenic and Laboratory Infections

If meticulous care in asepsis is not taken, infections like AIDS and hepatitis B may sometimes be transmitted during administration of injections, lumbar puncture and catheterization.

FACTORS PREDISPOSING TO MICROBIAL PATHOGENICITY

Pathogenicity and Virulence

Pathogenicity: Denotes the ability of a microbial species to cause disease. The term virulence (Latin *virulentia*, from *virus*, poison) denotes the ability of a strain of a species to produce disease.

Virulence: Provides a quantitative measure of pathogenicity, or the likelihood of causing disease.

Determinants of Virulence

Transmissibility

The first step of the infectious process is the entry of the microorganism into the host by one of several ports: the respiratory tract, gastrointestinal tract, urogenital tract, or through skin that has been cut, punctured, or burned.

Adhesion

The initial event in the pathogenesis is the attachment of the bacteria to body surfaces.

Invasiveness

Invasiveness signifies the ability of a pathogen to spread in the host tissues after establishing infection. For many disease-producing bacteria, invasion of the host's epithelium is central to the infectious process. Highly invasive pathogens characteristically produce spreading or generalized lesions (e.g., streptococcal septicemia following wound infection), while less invasive pathogens cause more localized lesions (e.g., staphylococcal abscess).

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Toxigenicity

Some bacteria cause disease by producing toxins, of which there are two general types: the exotoxins and the endotoxins **(Table 8.2).**

1. **Exotoxins:** Exotoxins are soluble, heat-labile proteins inactivated at 60–80°C which are secreted by certain species of bacteria and diffuse readily into the surrounding medium.
2. **Endotoxins:** These are heat-stable, lipopolysaccharide (LPS) components of the outer membranes of gram-negative but not gram-positive-bacteria. Their toxicity depends upon the component (lipid A). Intravenous injections of large doses of endotoxin and massive gram-negative septicemias cause endotoxic shock .

Avoidance of Host Defense Mechanisms

Bacteria also have evolved many mechanisms to evade host defenses. Several of these evasive mechanisms are such as **capsules**.

Table 8.2: Differences between exotoxins and endotoxins

Exotoxins	*Endotoxins*
Proteins	Lipopolysaccharide on outer membrane. Lipid A portion is toxic
Heat-labile (inactivated at 60°–80°C)	Heat-stable
Actively secreted by the cells; diffuse into the surrounding medium	Form integral part of the cell wall; do not diffuse into surrounding medium
Readily separable from cultures by physical means such as filtration	Obtained only by cell lysis
Action often enzymic	No enzymic action
Specific pharmacological effect for each exotoxin	Nonspecific action of all endotoxins
Specific tissue affinities	Nonspecific tissue affinities
Highly toxic and fatal in microgram quantities	Moderate toxicity Active only in very large doses
Highly antigenic	Weakly antigenic
Action specifically neutralized by antibody	Neutralization by antibody ineffective

Contd…

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Contd…

Exotoxins	*Endotoxins*
Usually do not produce fever	Usually produce fever by release of interlukin-1
Produced by both gram-positive bacteria and gram-negative bacteria	Produced by gram-negative bacteria only
Frequently controlled by extrachromosomal genes (e.g., plasmids)	Synthesized directly by chromosomal genes
Disease, e.g., botulism, diphtheria, tetanus	Gram negative infections, meningococcemia

Enzymes

Many species of bacteria produce tissue-degrading enzymes that play important roles in the infection process.

- **Coagulase:** Coagulase is produced by *S. aureus* and prevents phagocytosis.
- **Hyaluronidases:** Hyaluronidases facilitate the spread of infection along tissue spaces.

Plasmids

Plasmids are extrachromosomal DNA segments that carry genes for antibiotic resistance known as R-factors. Multiple drug resistance (R) plasmids increase the severity of clinical disease by their resistance to antibiotic therapy.

Bacteriophages

The classical example of phage directed virulence is seen in diphtheria.

Communicability

The ability of a microbe to spread from one host to another is known as communicability.

Infecting Dose

Adequate number of bacteria is required for successful infections. The dosage may be estimated as the *minimum infecting dose* (MID) or *minimum lethal dose (MLD).*

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Route of Infection

Certain bacteria are infective when introduced through optimal route, for example, cholera vibrios can produce lesion only when administered by oral route, but unable to cause infection when introduced subcutaneously.

Types of Infectious Diseases

Infectious diseases may be localized or generalized.

A. **Localized:** Localized infections may be superficial or deep seated.
B. **Generalized:** Bacteremia, septicemia and pyemia.

ASEPSIS

Asepsis is absence of pathogenic microorganisms. It is divided into two categories—medical and surgical.

Medical Asepsis (Clean Technique)

It consists of techniques that inhibit the growth and spread of pathogenic microorganisms. Medical asepsis is also known as **clean technique** and is used in many daily activities. They include handwashing, bathing, cleaning environment, gloving, gowning, wearing masks, hair and shoe covers, disinfecting articles and use of antiseptics changing patients' bed linen. You follow principles of medical asepsis in the home, for instance, with the common practice of washing your hands before preparing food.

Surgical Asepsis (Sterile Technique)

It destroys all microorganisms and their **spores** (the reproductive cell of some microorganisms, such as fungi or protozoa). Surgical asepsis is known as **sterile technique** and is used in specialized areas or skills, such as care of surgical wounds, urinary catheter insertion, invasive procedures, and surgery.

HEALTHCARE-ASSOCIATED INFECTIONS

Healthcare-associated infections (HAIs) include those with hospital onset and those with community onset in patients with previous healthcare encounters.

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Sources of Infections

- **Exogenous:** Exogenous source may be another person in the hospital *(cross-infection)* or a contaminated item of equipment or building service *(environmental infection)*.
- **Endogenous:** The infecting organism are derived from the patient's own skin, gastrointestinal or upper respiratory flora.

Types of Healthcare-associated Infections

1. Catheter-associated urinary tract infections (CAUTI)
2. Ventilator-associated pneumonia (VAP)
3. Central line-associated bloodstream infection (CLABSI)
4. Surgical site infections (SSIs)

Diagnosis and Control of Hospital Infection

The most important steps in preventing nosocomial infections are to first recognize their occurrence and then establish policies to prevent their development. Hospital infection may occur sporadically or as outbreaks.

Infection control policy: There will normally be two parts:

1. **Infection control committee (ICC)**
2. **Infection control team**

Prevention of Hospital-associated Infections

- Standard/universal precautions
- Precautions for prevention of transmission of infection
- **Bundles in infection:** Care "bundles" are simple sets of evidence-based practices that, when implemented collectively, improve the reliability of their delivery and improve patient outcomes.

Specific care bundles include bundles for the prevention of central line-associated bloodstream infections (CLABSI), bundle for the prevention of catheter-associated urinary tract infections (CAUTI), bundle for the prevention of ventilator-associated pneumonia (VAP), and bundle for the prevention of surgical site infection.

Defenses Against Infection

Natural barriers and the immune system defend the body against organisms that can cause infection.

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Natural barriers include the skin, mucous membranes, tears, earwax, mucus, and stomach acid. Also, the normal flow of urine washes out microorganisms that enter the urinary tract.

The immune system uses white blood cells and antibodies to identify and eliminate organisms that get through the body's natural barriers *(For details see Chapter 10 Immunity)*.

KEY POINTS

Parasites are microbes that can establish themselves and multiply in the hosts. Parasite microbes may be either pathogens or commensals:

- **Sources of infection: (**a) Human beings; (b) Animals; (c) Insects; (d) Soil and water; (e) Food.
- **Modes of transmission of infection: (**1) Contact; (2) Inhalation; (3) Ingestion; (4) Inoculation; (5) Insects; (6) Congenital; (7) Iatrogenic and laboratory infections.
- Pathogenicity denotes the ability of a microbial species to cause disease. The term virulence denotes the ability of a strain of a species to produce disease. Enhancement of virulence is known as *exaltation*. Reduction of virulence is known as *attenuation.*

IMPORTANT QUESTIONS

1. Describe in detail the sources of infections to human beings.
2. What are the various modes of spread of infection? Describe each in brief giving suitable examples.
3. Distinguish between exotoxins and endotoxins in a tabulated form.

MULTIPLE CHOICE QUESTIONS (MCQs)

1. The organisms can be transmitted vertically by all the following ways, *except:*
   a. Sexual contact
   b. Through the placenta
   c. Within the birth canal
   d. Through breast milk
2. Which of the following may cause teratogenic infections?
   a. Toxoplasma
   b. Rubella virus
   c. Cytomegalovirus
   d. All of the above

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3. Which of the following statement is not true for exotoxins?
   a. They are proteins
   b. They are highly antigenic
   c. They are heat-labile
   d. They are obtained by cell lysis
4. Which of the statement is not true for endotoxins?
   a. These are lipopolysaccharides component of outer membrane of gram-negative bacteria
   b. These are heat-stable
   c. They cannot be toxoided
   d. They are highly antigenic
5. The disease that spreads rapidly, involving many persons in a particular area at the same time is known as:
   a. Sporadic
   b. Endemic
   c. Epidemic
   d. Pandemic

Answers (MCQs): 1. (a); 2. (d); 3. (d); 4. (d); 5. (c)

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