CHAPTER (9)

BACTERIAL PATHOGENESIS

Bacteria could be classified into:

① Saprophytic bacteria:

- Those which **live freely in nature** → on decaying organic matter, in soil or water
- They do **not require a living host**

② Parasitic bacteria:

- Those which **live on or in a living host**
- **They are classified according to their relation to the host into:**
  - ❶ **Pathogenic:** bacteria capable of **causing disease**
  - ❷ **Non-pathogenic (commensals):** bacteria that do **not cause disease** & are part of the **normal flora**
  - ❸ **Opportunistic pathogens:**
    - ∗ These are **potentially pathogenic bacteria** → that do **not cause disease under normal conditions** but can cause disease in:
      - ① **Immunocompromised patients**, or
      - ② When they **find their way to another site** other than their **normal habitat**
    - ∗ Many of these **opportunistic pathogens** are **originally commensals**

Infection:

- Infection is a process by which the **organism enters into relationship with the host**
- Although microbial **infections occur frequently**, most infections **end without occurrence of pathological changes** and thus are **not manifested as clinical disease** → these infections are termed **subclinical, silent** or **abortive infections**
- **Outcome of bacterial infections** depends on **mutual relationship between bacteria** & **host** → depends on **interaction between microbial factors (virulence)** & **host resistance factors (immunity)**

Stages of the Infectious Process:

① Source of infection: → which may be man (case or carrier), animal or soil

② Mode of transmission: → e.g. droplet inhalation, ingestion, injection, insects, contact & transplacental

③ Portal of entry: → e.g. respiratory tract, gastrointestinal tract, skin... etc → the organism then starts to multiply within the host causing tissue damage (disease)

④ Portal of exit: → e.g. urine, stools, blood, respiratory or genital discharge → from which the organism is transmitted to a new host

Carriers

- **Apparently healthy individual** harbouring **pathogenic organism**, **without having clinical manifestations**, and can transmit this organism to others

- Carriers are **more dangerous than cases as a source of infection →** because they move freely among people without being detected

- **According to the duration of the carriage state, carriers may be:**
  - ❶ **Transient carriers →** e.g. during the incubation period & early convalescence
  - ❷ **Chronic carriers →** e.g. hepatitis-B virus

- Organism may be **discharged from the carrier** in **intermittent or continuous manner**

- **Conditions in which carriers play important role include:**
  - ❶ Enteric fever (gall bladder)
  - ❷ Cholera (intestine)
  - ❸ Epidemic cerebrospinal meningitis (nasopharynx)
  - ❹ Diphtheria (throat)
  - ❺ Hepatitis B virus infection (blood)
  - ❻ *S. aureus* carriage (skin and nose)

Pathogenicity

Qualitative description of a species of bacteria → denoting ability to produce disease

Virulence

• **Quantitative character** (**degree of pathogenicity**) of strain belonging to pathogenic species

• Virulence is **genetically determined** by **genes carried on** plasmids, phages, pathogenicity islands & chromosomes

Virulence Factors of Bacteria: Virulence factor is either **structure (e.g. capsule) or product (e.g. toxins)** that **enables organism to cause disease**

A- Adherence factors

• Enable bacteria to **attach to host surfaces** → contributing to **establishment of infection** → **For example:**

❶ **Fimbriae** of ***Neisseria gonorrhoeae*** & ***E. coli*** → help **attachment** of these organisms to **urinary tract epithelium**

❷ **Glycocalyx** of ***Staphylococcus epidermidis*** and certain ***viridans streptococci*** allows the organisms to **adhere** strongly to **heart valves**

• **Mutants that lack these factors** are often **avirulent**

B- Invasion factors

Invasion of tissue followed by **inflammation** is one of the **main mechanisms by which bacteria** can cause **disease** → **this invasion is helped by:**

① Enzymes:

❶ **Immunoglobulin A protease** → which degrades IgA

❷ **Lecithinase** → that breaks down lecithin of cell membrane

❸ **Deoxyribonuclease** → that breaks down DNA

❹ **Collagenase & hyaluronidase** → which degrade collagen & hyaluronic acid → allow bacteria to spread through subcutaneous tissues

❺ **Leukocidin** → which can destroy both polymorphonuclear leucocytes & macrophages

② Anti-phagocytic factors:

❶ **Capsule** → prevents phagocytes from attachment to bacteria → e.g. ***Strept. Pneumonia***

❷ **Cell wall proteins of Gram-positive cocci** → such as:

① **M protein** of ***Strept. pyogenes*** ② **Protein A** of ***Staph. Aureus***

❸ **Coagulase** → accelerates formation of fibrin clot from fibrinogen → this clot can protect bacteria from phagocytosis → e.g. ***Staph. Aureus***

③ Toxin production:

• Toxin production is **another mechanism by which bacteria can produce disease**

• Bacterial toxins are either **exotoxins** or **endotoxins**

	Exotoxins	Endotoxins
Source	Secreted by **living organisms** both **Gram-positive** (mainly) & **Gram-negative**	**Integral part of the cell wall** of **Gram-negative** organisms → liberated upon **cell disintegration**
Nature	Protein	Lipopolysaccharide (lipid A)
Toxicity	High	Low
Antigenicity	Highly antigenic	Poorly antigenic
Heat stability	Unstable to temp. above 60°C	Stable to temp. above 60°C for several hours
Specificity	Every toxin has specific action	Same generalized effect (non-specific action) → all give fever & shock
Coding genes	Encoded by **plasmids**, **bacteriophages**, **PAI** or **chromosomes**	Encoded by genes on **Chromosome**
Examples	❶ *Cl. tetani* (plasmid) ❷ *C. diphtheriae* (phage) ❸ *H. pylori* (PAI) ❹ *B. pertussis* (chromosome)	*E. coli* & *meningococcal* Endotoxins
Detoxification	Can be converted into toxoid*	Can not

* **Treatment of exototoxin with formalin** (or other agents) **removes its toxicity** & **retains its antigenicity** → converting it into **toxoid**, that can be **used for immunization**

Koch's postulates:

These are criteria that were **proposed by Koch** in order to **determine if the organism isolated from the patient actually caused the disease** → i.e. these criteria must be satisfied to confirm the causal role of organism → **these criteria are as follows:**

1. The organism must be **isolated from every patient** with the disease
2. The organism must be **isolated free from all other organisms** and **grown in pure culture in vitro**
3. The pure organism must **cause the disease in a healthy, susceptible animal**
4. The organism must be **recovered from the inoculated animal**

Test Yourself

1) Opportunistic pathogens:

a- Are never the cause of a clinical infection
b- Are usually highly pathogenic
c- Are rarely part of the normal flora
d- Are resistant to killing by steam sterilization
e- Cause disease mainly in immunocompromised individuals

2) Exotoxins have the following characters, EXCEPT:

a- They may be encoded by genes on the chromosome
b- They can be converted to toxoids
c- They have specific action
d- They are polypeptides
e- They are heat stable

3) Endotoxins:

a- Are secreted mainly by Gram-positive bacteria
b- Are highly antigenic
c- Are stable at temperatures above 60°C
d- Can be converted into toxoid
e- Have specific action