Bacterial infection

SCPA 202 Basic Pathology

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Bacteria

- Bacteria cells are prokaryotes
- There are two forms of cell wall structures
  - **Thick wall** → retains crystal-violet stain (Gram-positive bacteria)
  - **Thin wall** → Gram-negative bacteria
# Bacteria

<table>
<thead>
<tr>
<th>Step</th>
<th>Microscopic Appearance of Cell</th>
<th>Chemical Reaction in Cell Wall (very magnified view)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Crystal violet (primary dye)</td>
<td>Gram (+)</td>
<td>Gram (+) Both cell walls stain with the dye</td>
</tr>
<tr>
<td></td>
<td>Gram (-)</td>
<td>Gram (-) No effect of iodine</td>
</tr>
<tr>
<td>2. Gram’s iodine (mordant)</td>
<td></td>
<td>Dye crystals trapped in cell</td>
</tr>
<tr>
<td>3. Alcohol (decolorizer)</td>
<td>Crystal remains in cell</td>
<td>Outer membrane weakened; cell loses dye</td>
</tr>
<tr>
<td>4. Safranin (red dye counterstain)</td>
<td>Red dye has no effect</td>
<td>Red dye stains the colorless cell</td>
</tr>
</tbody>
</table>
Bacteria

• Bacteria are classified by
  • **Gram staining** (positive or negative)
  • **Shape** (e.g., cocci, rod-shaped, bacilli)
  • **Form of respiration** (aerobic, anaerobic)
  • **Their survive and replication**
    • Facultative intracellular bacteria $\rightarrow$ both
    • Obligate intracellular bacteria $\rightarrow$ grow only inside host cells
Bacteria

Gram-positive cocci in cluster
Gram-positive cocci in pairs
Gram-positive and Gram-negative rods

Gram-negative intracellular rods
Gram-negative diplococci
Helical spirochetes
Mechanism of bacterial injury

**Bacterial virulence**
- Bacterial adherence to host cells
- Virulence of intracellular bacteria
- Bacterial toxin
  - **Endotoxin** (lipopolysaccharide)
  - **Exotoxins**
    - **Enzymes** (proteases, hyaluronidases, coagulases, fibrinolysin)
    - **Toxin** (alter intracellular signaling or regulatory pathway)
    - **Neurotoxins** (*Clostridium botulinum* and *Clostridium tetani*)
    - **Superantigens** (stimulate large number of T cells → toxic shock syndrome)
Pathology from bacterial infection

- **Suppurative (Purulent) Inflammation**
  - characterized by increased vascular permeability and leukocytic infiltration, predominantly of neutrophils
  - mostly extracellular **gram-positive cocci** and **gram-negative rods**

- **Granulomatous Inflammation**
  - intracellular bacteria (resist eradication)
  - *M. tuberculosis*
Pathology from bacterial infection

• Gangrenous necrosis
  – *Clostridium perfringens* and other organisms that secrete powerful toxins can cause such rapid and severe necrosis
  – Dry gangrene = infarction
  – Wet gangrene = infarction + bacterial infection
Gram-Positive Bacterial infection
Gram-Positive Bacterial infections

- Staphylococcal infections
- Streptococcal infections
- Diphtheria
- Anthrax
Staphylococcal infection

**Staphylococcus aureus**
- + cocci that form grapelike clusters
- cause a myriad of skin lesions (boils, carbuncles, impetigo and scalded skin)

**Staphylococcus epidermidis**
- causes opportunistic infections in catheterized patients, patients with prosthetic cardiac valves

**Staphylococcus saprophyticus**
- common cause of urinary tract infections
Pathogenesis of Staphylococcal infection

**Lipase**
- degrades lipids on the skin surface

**Hemolytic toxin**
- α-toxin, pore forming protein

The pore-forming mechanism for the *S. aureus*
Pathogenesis of Staphylococcal infection

Exfoliative toxin
epidermis split away from deeper skin

Superantigens
food poisoning, toxic shock syndrome
S. aureus causes pyogenic inflammation

- Impetigo, which is streptococcal infection restricted to the superficial epidermis
- Boil
- Carbuncle
- Paronychia
- Staphylococcal scalded skin syndrome (Ritter disease)
Pathology

Impetigo

Carbuncle

Boil

Paronychia

Staphylococcal scalded skin syndrome (SSSS)
Streptococcal infections

Facultative or obligate anaerobic Gram-positive cocci in pairs or chains

– *Streptococcus pyogenes* (group A) causes pharyngitis
– *Streptococcus agalactiae* (group B) causes sepsis and meningitis in neonates
– *Streptococcus pneumoniae* causes community-acquired pneumonia
Pathology of Streptococcal infections

- Resemble with staphylococci
- **Erysipelas** is erythematous cutaneous swelling like “butterfly” (caused by exotoxins from *S. pyogenes*)
- Streptococcal pharyngitis
- Scarlet fever
Diphtheria

- Result from blocking the airway and create a barking cough as in croup
- *Corynebacterium diphtheriae*
- Aerosols or skin shedding
- Pseudomembrane in the posterior pharynx

Gram-positive rod with clubbed ends
Anthrax

• *Bacillus anthracis*

• Potent biologic weapon

• Pathology
  • Cutaneous anthrax, vesicle with black eschar
  • Inhalation anthrax, shock and death
  • Gastrointestinal anthrax, severe bloody diarrhea

Spore-forming Gram-positive rod-shaped bacterium

eschar
Gram-Negative Bacterial infection
Gram-Negative Bacterial infection

- Neisserial infections
- Pseudomonas infection
- Chancroid
Neisserial infection

Gram-negative diplococci, shape of coffee bean

- **Neisseria meningitidis**
  - Cause of meningitis in young people
  - Invade respiratory epithelial cells → enter the blood

- **Neisseria gonorrhoeae**
  - Important cause of sexually transmitted disease
  - Men → urethritis
  - Woman → asymptomatic → pelvic inflammatory disease → infertility, neonatal *N. gonorrhoeae*

*Your computer needs to clean up.*

infection causes blindness
Pseudomonas infection

- **Pseudomonas aeruginosa**
- Opportunistic aerobic Gram-negative bacillus
- Deadly pathogen of patient with severe burns
- Complex bacteria, very resistant to antibiotics
- Hospital-acquired infections
- Corneal keratitis in wearers of contact lenses
**Pseudomonas aeruginosa: Corneal keratitis**

Common in immunocompromised patients, contact lens wearers with faulty hygiene.

Typical Gram-negative corneal ulcer: Rapid evolution, marked tendency to spread.

Can perforate in 48 hours.

**Treatment:** Topical tobramycin, ciprofloxacin, moxifloxacin, gatifloxacin
Pseudomonas infection

• Pathogenesis
  • **Alginate**, which is mucoid exopolysaccharide
    → protected from host antibodies, complement, phagocytes and antibiotic
  • **Exotoxin** that inhibits protein synthesis
  • **Elastase** degrades IgGs and extracellular matrix proteins (keratitis)
Pseudomonas infection

• Pathology
  • Necrotizing inflammation
  • Well-demarcated necrotic and hemorrhagic skin lesions of oval shape often arise during these bacteremia, called ecthyma gangrenosum

http://www.antimicrobe.org
Chancroid

• Caused by *Hemophilus ducreyi*
• Sexually transmitted
• Chancroid is a tender, erythematous papule and multiple lesions may be present
Mycobacteria infection
Mycobacteria

- Mycobacteria cannot be demonstrated by Gram stain
- Possess a capsule containing long chain fatty acid (mycolic acid) that makes them hydrophobic
- Can be stained by a strong stain like carbol fuchsin
Mycobacteria

- Tuberculosis
- Mycobacterium Avium-Intracellulare Complex (MAC)
- Leprosy
Tuberculosis

• *Mycobacterium tuberculosis* is responsible for most cases
• Delayed hypersensitivity to *M. tuberculosis* antigens
• Enters macrophage by endocytosis
• Blocking fusion of the phagosome and lysosome to inhibit phagocytosis
Pathogenesis of tuberculosis

A. PRIMARY PULMONARY TUBERCULOSIS (0–3 weeks)

- Mycobacteria
- Alveolar macrophage
- Mannose-capped glycolipid
- Macrophage mannose receptor
- "Endosomal manipulation":
  - Maturation arrest
  - Lack of acid pH
  - Ineffective phagolysosome formation
- Unchecked bacillary proliferation
- Bacteremia with seeding of multiple sites
- NRAMP1 polymorphism

B. PRIMARY PULMONARY TUBERCULOSIS (>3 weeks)

- Alveolar macrophage
- IL-12
- T-cell
- T_{H1}
- γ-IFN
- "Activated" macrophage
- TNF, chemokines
- Monocyte recruitment
- Caseous necrosis
- Epithelioid granuloma ("hypo-sensitivity")

- MTb antigen
- Tuberculin positivity ("hypersensitivity")
- Bactericidal activity ("immunity")
Pathology of tuberculosis

Primary pulmonary tuberculosis

Miliary tuberculosis

Granulomatous inflammation
Mycobacterium Avium-Intracellulare Complex (MAC)

- MAC is common in soil, water, dust and domestic animals
- Infection in HIV patient
- Causes widely disseminated infections in lung and gastrointestinal system
- Pathology
  - Enlargement of involved lymph nodes, liver and spleen

*Mycobacterium avium* with acid-fast organism
Leprosy

- Caused by *Mycobacterium leprae*
- Affected the skin and peripheral nerves and resulting in disabling deformities
- Transmitted from person to person through aerosols from lesions in the respiratory tract
- It grows more slowly than other mycobacteria and grows best at 32°C to 43°C

Acid-fast bacilli ("red snappers") within macrophages
Leprosy

Pathology

- **Tuberculoid leprosy** → scaly skin lesions that lack sensation
- **Lepromatous leprosy** → symmetric skin thickening and nodules (mycobacteria invade to Schwann cells)
Spirochetes bacterial infection
Spirochetes

- Spirochetes are **Gram-negative**, slender corkscrew-shaped bacteria
- Periplasmic flagella
- Morphology is too slender to be seen in Gram stain, but it can be visualized by silver stains, **dark-field examination**
Syphilis

- A chronic venereal disease
- Caused by *Treponema pallidum*
- Sexual intercourse is the usual mode of spread
- Transplacental transmission during pregnancy results in congenital syphilis
Pathology of syphilis

Primary syphilis

- 3 weeks after contact
- Chancre, a single firm, nontender, raised, red lesion

Secondary syphilis

- 2-10 weeks after primary chancre
- The skin lesions, which frequently occur on the palms or soles of the feet, may be maculopapular, scaly or pustular
Pathology of syphilis

**Tertiary syphilis**
- Cardiovascular syphilis
- Neurosyphilis

**Congenital syphilis**
- Nasal discharge
- Hepatomegaly and skeletal abnormalities
- Interstitial keratitis with blindness
Anaerobic bacterial infection
Clostridial infections

**Clostridium perfringens**

- Cellulitis and myonecrosis of traumatic and surgical wounds (*gas gangrene*)
- Uterine myonecrosis often associated with illegal *abortions*

**Clostridium tetani**

- Convulsive contractions of skeletal muscles (*lockjaw*)
**Clostridial infections**

**Clostridium botulinum**
- Grows in inadequately sterilized canned foods
- Severe *paralysis* of respiratory and skeletal muscles (botulism)

**Clostridium difficile**
- Overgrows other intestinal flora in antibiotic-treated patients, releases toxins, and causes pseudomembranous colitis
Clostridial infections

Gangrenous cellulitis

• Differentiated from infection caused by pyogenic cocci by its foul odor, its thin, discolored exudate
• Quick and wide tissue destruction
Gas gangrene

- Characterized by marked edema and enzymatic necrosis
- **Large bullous vesicles**, gas bubbles caused by bacterial fermentation
- Severe **myonecrosis** is the result of massive proteolytic bacterial enzymes
Obligate intracellular bacterial infection
Chlamydial infections

• Obligate intracellular bacteria proliferate only within host cells

• *Chlamydia trachomatis*
  • Causes genital infection (*Urethritis*)
  • Is the most common bacterial sexually transmitted disease in the world
  • Is the cause of about half the cases of nongonococcal urethritis (NGU)
Reference


• Jawetz, Melnick & Adelberg’s. Medical Microbiology. 26th Edition. LANGE®