Chapter 21

Microbial Diseases of the Skin and Eyes

Part 1: Bacterial Skin Infections

Lectures prepared by Christine L. Case
Expected Student Learning Outcomes for Bacterial Skin Infections

1. Describe skin and mucous membrane structure and ways pathogens can invade the skin.

2. Provide examples of normal skin microbiota, and state the general locations and ecological roles of its members.

3. Differentiate staphylococci from streptococci, and name several skin infections caused by each.

4. List the causative agent, mode of transmission, and clinical symptoms of *Pseudomonas* dermatitis, otitis externa, and acne.
Skin Anatomy and Physiology

Complete epidermis replaced monthly

Inhospitable environment for most microbes

Sweat and sebum provide H$_2$O, aa, and lipids for some microbes

Salt inhibits microbes

Lysozyme hydrolyzes peptidoglycan

Antimicrobial fatty acids and defensins (peptides)

compare to Fig 21.1
Mucous Membranes

Line body cavities.

Epithelial cells are attached to extracellular matrix.

Some cells secrete mucus.

Some cells have microvilli and/or cilia.
Normal Microbiota of the Skin

Prevent colonization by pathogens

Are opportunistic pathogens

Mostly Gram+, salt-tolerant bacteria:

1. Staphylococci
2. Micrococci
3. Diphtheroids

Also present: Fungi

(a) Bacteria (orange spheres) on the surface of the nasal epithelium

Fig 14.1a
<table>
<thead>
<tr>
<th>Name</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diphtheroids</td>
<td>Variably shaped nonmotile, Gram-positive rods of the <em>Corynebacterium</em> and <em>Propionibacterium</em> genera</td>
</tr>
<tr>
<td>Staphylococci</td>
<td>Gram-positive cocci arranged in packets or clusters; coagulase negative; facultatively anaerobic</td>
</tr>
<tr>
<td><em>Malassezia</em> sp.</td>
<td>Small yeasts that require oily substances for growth</td>
</tr>
</tbody>
</table>
Normal Skin Flora: Diphtheroids

- Resemble *C. diphtheriae* but do not produce exotoxin
- Aerobes on surface
  - *Corynebacterium xerosis*
- Anaerobes in hair follicles
  - *Propionibacterium acnes*
- Associated with acne and odor
Normal Skin Flora: Staphylococci / Micrococci and Fungi

- Universally present
- Salt tolerant
- Prevents colonization by pathogens
- *Staphylococcus epidermidis*

- Tiny lipophilic yeasts universally present (*Malassezia* species)
- Mostly harmless but can cause **dandruff** (*Malassezia furfur*)
Microbial Diseases of the Skin

- Exanthem vs. enanthem
- Vesicles and bullae
- Macules
- Papules
- Pustules

See Fig 21.2
Bacterial Diseases of the Skin

1. Staphylococcal Skin Infections
2. Streptococcal Skin Infections
3. Infections by Pseudomonads
4. Acne
Staphylococcal Skin Infections

1. *Staphylococcus epidermidis*
   - Gram-positive cocci, **coagulase-negative**; most common of skin microbiota

2. *Staphylococcus aureus*
   - Gram-positive cocci, almost all pathogenic *S. aureus* are **coagulase-positive**

**Clinical Focus**, p. 593

| Negative control | Isolate from patient | Clinical Focus, p. 593 |
**S. aureus**

- Antibiotic resistance: Many strains of *S. aureus* produce penicillinase
- Leukocidin
- Resists opsonization
- Survives in phagolysosome
- Lysozyme resistant
- *S. aureus* can produce toxins, *eg.*: exfoliative toxin and enterotoxins.
- Superantigen
- Epidemiology: “nostril carriers” (20% perm., 60% temp.)
Types of Staph Skin Infections

- **Folliculitis**: Infections of the hair follicles
- **Sty**: Folliculitis of an eyelash
- **Furuncle (Boil)**: deep-seated infection in and around hair follicles. Type of abscess. Hard to treat.
- **Carbuncle**: Extensive invasion of neighboring tissues. Several openings for pus discharge. Generalized symptoms.
Boil (furuncle)

- **Epidermis**
- **Dermis**
- **Subcutaneous tissue**
- **Staphylococcus aureus** infects hair follicle
- **Sebaceous gland**
- **White blood cell**
- **Blood vessel**
- **Hair**
- **Infection spreads to subcutaneous tissue**
- **Accumulation of white blood cells**
- **Abscess**
Types of Staph Skin Infections  cont.

Impetigo, highly contagious

1. Nonbullous (crusting) sores,
   - Spread by autoinoculation
   - Usually self limiting
   - Common skin disease in children.
   - Peak incidence at 2-6 years of age.
   - Most often around nose and mouth.

2. Bullous
   - Also known as pemphigus neonatorum or impetigo of the newborn.
   - Exotoxing A → remains localized. Exfoliation
   - Localized form of SSSS
(Bullous) Impetigo of the Newborn cont.

Thin walled vesicles (bullae) → rupture. Any body site may be involved

Most common in children and infants < 2 years.

Often 1\textsuperscript{st} or 2\textsuperscript{nd} week of life (Hospital nurseries)

Extremely contagious → isolation

Treatment with systemic antibiotic particularly for lesions around umbilicus.
Scalded Skin Syndrome (SSSS):

- Exotoxin B (exfoliatin) producing *S. aureus* (phage encoded)
- Toxemia $\Rightarrow$ can affect 100% of body surface
- Large blisters filled with clear fluid do not contain *S. aureus*
- Danger of secondary infections
- Epidemiology: $\sim$ 5% of *S. aureus* produce exfoliatins (A or B)
SSSS
Superficial desquamation.
No inflammation.
Toxic Shock Syndrome (TSS)

- Sudden onset of fever, vomiting, diarrhea, muscle aches and rash.
- Can rapidly progress to severe and intractable hypotension → shock and organ failure.
- Superantigen exotoxin (TSST-1).

- Associated with use of tampons and intravaginal contraceptive devices in women. Also complication of skin abscesses or surgery.
Streptococcal Skin Infections

- Gram-positive cocci often grow in chains
- Most important: **Group A β-hemolytic streptococci** (GAS), namely *S. pyogenes*
- Classified according hemolytic enzymes and cell wall antigens

**Virulence factors:**
- Hemolysins
- Streptokinase
- Hyaluronidase
- M protein (prevents complement activation)
Erysipelas

- Red patches, raised margins
- Often preceded by strep throat
- Commonly first affects dermal layers face
- High fever
- Sepsis possible
- *S. pyogenes* is sensitive to β-lactam antibiotics
Necrotizing Fasciitis

Caused by highly invasive S. pyogenes

Severe and rapid tissue destruction due to phage encoded toxins:

- **Exotoxin B**: Protease leading to widespread tissue necrosis

- **Exotoxin A**: Super antigen $\Rightarrow$ often leads to streptococcal toxic shock syndrome (streptococcal TSS)

- Mortality rate > 40%. ~ 15,000 cases / year in US resulting in 2,000-3,000 deaths
Tommy Rettig, leader of Homeless Island, died in September 2003 of Necrotizing Fasciitis.
Infections by Pseudomonads

**Pseudomonas aeruginosa**
- Gram-negative, aerobic rod; ubiquitous
- Pyocyanin produces a blue-green pus
- Resistant to many disinfectants and antibiotics
- Endotoxin and several exotoxins.

**Opportunistic pathogen** – frequent cause of nosocomial infections, some community-acquired

**Diseases:**
- *Pseudomonas* dermatitis
- Otitis externa, or “swimmer’s ear”
- Respiratory infections
- Post-burn infections
Treatment difficult because of antibiotic resistance

⇒ Do sensitivity testing followed by high dosage of IV drug
Acne

Classifications:
1. Comedonal (mild) acne
2. Inflammatory (moderate) acne
3. Nodular cystic (severe) acne

Whiteheads (comedo) vs. blackheads (comedons or open comedos)
Comedonal Acne

- Mild; also known as *acne vulgaris*
- Sebum channels blocked with shed cells
- Treatment with topical agents that do not affect sebum production
Inflammatory Acne

- Moderate *acne vulgaris*
- *Arises from bacterial action:*
  - Gram-positive, anaerobic rod: *Propionibacterium acnes*

**Treatment**

- Preventing sebum formation: Isotretinoin (Accutane), Vitamin A derivative – inhibits sebum production – is teratogenic!
- Antibiotics
- Benzoyl peroxide to loosen clogged follicles
- Visible (blue) light (kills *P. acnes*)
Nodular Cystic Acne

- Severe; leaves scars
- Treatment same as moderate form