Staphylococcus

Members of the genus *Staphylococcus* (staphylococci) are Gram-positive cocci that tend to be arranged in grape-like clusters. Worldwide, *Staphylococcus aureus* is one of the most common and virulent causes of acute purulent infections(التهابات قيحية) commonly found in the environment (soil, water and air) and is also found in the nose and on the skin of humans.

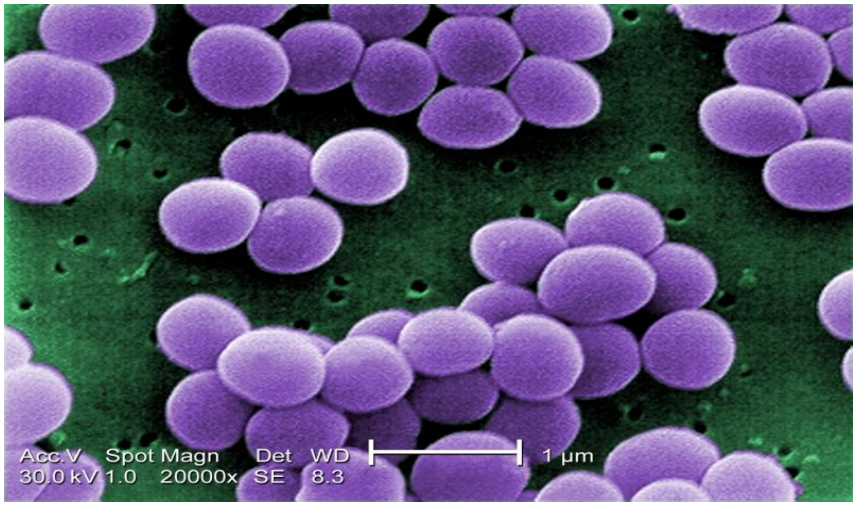


Figure 1-1 The *Staphylococcus aureus* bacteria under an electron microscope

Morphology & Identification

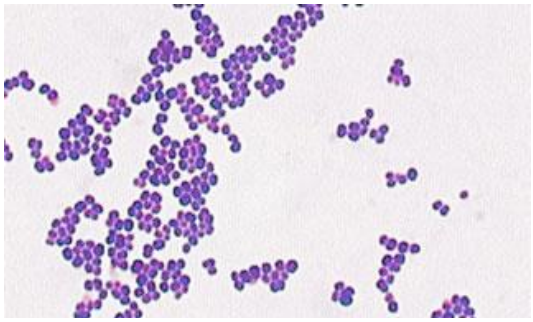
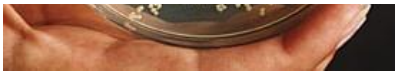


Figure 1-2 Gram-positive cocci grapelike clusters

- Gram-positive cocci occurring in grapelike clusters
- They are non-motile and non-spore formation.
- A few strains possess capsules.
- They are aerobes and facultative anaerobes
- Optimum temperature for growth is 37°C (range being 12-44°C)

- Optimum pH is 7.5.
- Resistant to drying, heat (40°C) and 10% NaCl.
- The staphylococci produce catalase, which differentiates them from the streptococci
- In blood agar- Most strains produce β- haemolytic colonies.

Figure 1-3 *Staphylococcus* growing in N.A



Alpha hemolysis (incomplete hemolysis)
Beta hemolysis (complete hemolysis)
Gamma does not induce hemolysis

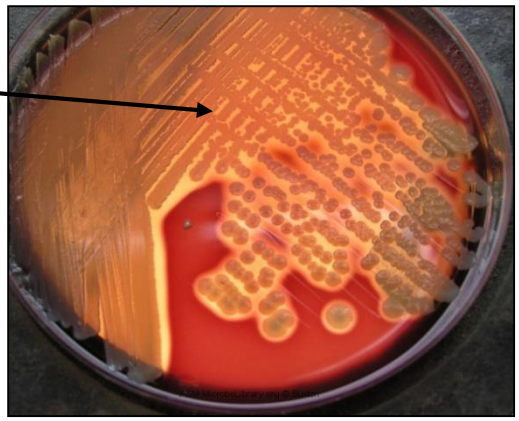


Figure 1-4 *Staphylococcus* growing Blood agar showing alpha hemolysis

Classification:

A) Based on coagulase production:

1. Coagulase positive: *S. aureus*
2. Coagulase negative: *S. epidermidis, S. saprophyticus*

B) Based on pathogenicity:

1. Common pathogen: *S. aureus*
2. Opportunistic pathogens: *S. epidermidis, S. saprophyticus*
3. Non pathogen: *S. homonis*

Enzymes & Toxins

Staphylococci can produce disease both through their ability to multiply and spread widely in tissues and through their production of many extracellular substances

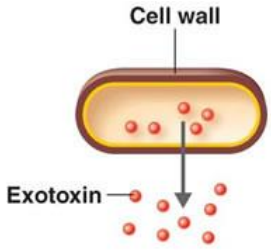
A. Catalase

Staphylococci produce catalase enzyme, which converts hydrogen peroxide into water and oxygen

B. Coagulase

Fibrinogen Plasma —Coagulase enzyme→ Fibrin Visible Clot

Produced by most *S. aureus* on the cell wall surface; binds to fibrinogen and converts it to fibrin.



- **Coagulase may deposit fibrin on the surface of staphylococci, perhaps altering their ingestion by phagocytic cells**

D. Exotoxins

- **Alpha α-toxin** protein acts on eukaryotic cell membranes (resulting in hemolysis)
- **Beta b toxin** toxic for human red blood cell
- **Gamma (γ) toxin** has pronounced hemolytic activity, mode of action is not known
- **Delta (δ) toxin** has a wide spectrum of cytolytic activity

E. leukocidin

It can kill white blood cells of humans and rabbits.

F. Exfoliative Toxins

Responsible for a form of epidermolysis.

G. Toxic Shock Syndrome Toxin-1 (TSST1)

Produced by about 1% of Staphylococcus strains give rise to the clinical symptoms of toxic shock.

Coagulase-positive Staphylococci (*Staphylococcus aureus*)

Pathogenicity

Source of infection: shedding human lesions, fomites contaminated from such lesions, and the human respiratory tract and skin

A. Cutaneous Infections

These include: wound and burn infection, pustules (البثور) (small cutaneous abscesses الخراجات الجلدية الصغيرة), furuncles or boils(الدمامل)(large cutaneous abscesses), impetigo (الحصف داء جلدي).

B. Deep Infections

These include: osteomyelitis (التهاب العظم والنقي), tonsillitis (إلتهاب اللوزتين), pharyngitis (التهاب البلعوم), sinusitis (التهاب الجيب), septicemia(تسمم الدم) , and meningitis(التهاب السحايا) .

C. Toxin-Mediated Diseases

i. Food Poisoning

- Food poisoning results from ingestion of food contaminated with enterotoxins.
- The types of food usually responsible are meat, fish, milk and milk products.
- Staphylococcal food poisoning symptoms are (nausea, vomiting and diarrhea)

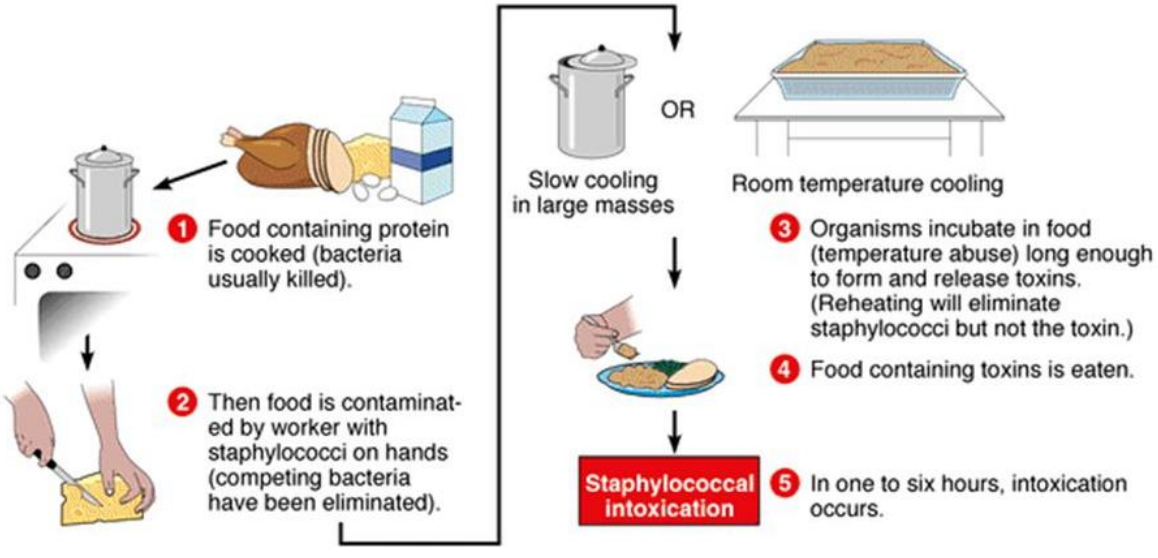


Figure 1-5 Event leading to Staphylococcal food poisoning

ii. Toxic Shock Syndrome (TSS)

- The main symptoms are hypotension(انخفاض ضغط الدم), fever, and a scarlatiniform rash (طفح جلدي قرمزي).

iii. Exfoliative Diseases ‘staphylococcal scalded skin syndrome’ (SSSS)

- Caused by *S. aureus* which produce epidermolytic toxins.
- This toxin is responsible for the ‘staphylococcal scalded skin syndrome’ (SSSS) (متلازمة الجلد المتقشرة)
- Skin diseases in which the outer layer of epidermis gets separated from the underlying tissues.
- SSSS is seen mostly in young children and only rarely in older children and adults.

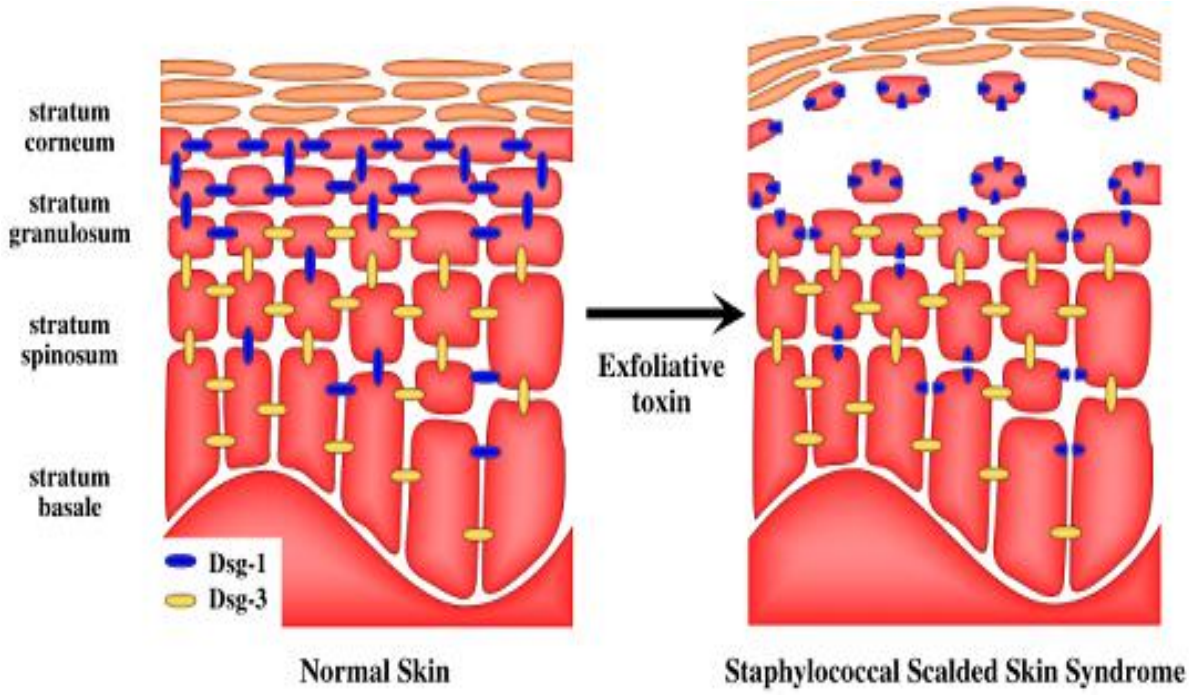


Figure 1-6 Exfoliative effect

Lab Diagnosis:

1. Specimens

Surface swab pus, blood, tracheal aspirate, or spinal fluid for culture, depending upon the localization of the process.

2. Direct microscopy:

Direct microscopy with Gram stained smear is useful in case of pus, where cocci in clusters are seen.

4. Culture:

- Specimens planted on blood agar plates give rise to typical colonies in 18 hours at 37 °C, but hemolysis and pigment production may not occur until several days later and are optimal at room temperature.

- *S aureus* but not other staphylococci ferment mannitol. Specimens contaminated with a mixed flora can be cultured on media(**Mannitol salt agar**) containing 7.5% NaCl; the salt inhibits most other normal flora but not *S aureus*

Figure 1-7 *S aureus* growing on MSA

Figure 1-8 *S aureus* showing B hemolysis on blood agar

5. Biochemical reactions:

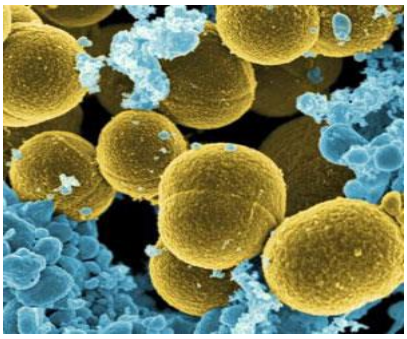
1. Catalase Test
2. Coagulase Test

6. Antibiotic sensitivity tests done as a guide to treatment.

Treatment:

1. Drug resistance is common.
2. Benzyl penicillin is the most effective antibiotic, if the strain is sensitive.
3. Cloxacillin or Methicillin is used against beta-lactamase producing strains.
4. Methicillin Resistant Staphylococcus aureus (MRSA) strains have become common .
5. Vancomycin is used in treatment of infections with MRSA strain

Coagulase-negative Staphylococci



They are normal flora of human skin and mucosa. They are classic opportunists that only cause infections given a certain host disposition.

Staphylococcus epidermidis

- *Staph. epidermidis* present in large numbers on the skin
- Some strains also produce a slime layer (glycocalyx), which appears to facilitate adhesion and protect the microorganism from antibiotics and host defenses.
- Infections include subacute endocarditis(التهاب بطانة القلب), and urinary tract infections(التهاب المجاري البولية)

Lab Diagnosis:

As with Staphylococcus aureus infections

Treatment

- The antibiotics of choice are oxacillin
- vancomycin for oxacillin-resistant strains

For further information you can refer to

1. Kayser, Medical Microbiology © 2005
2. Jawetz, Melnick, & Adelberg's Medical Microbiology 23ed.
3. Jaypee_Textbook of Microbiology 1st ed 2012.
4. Lecture notes. Medical microbiology and infection 5th ed -Wiley-Blackwell (2011).