



"Gram-Positive Cocci"



Introduction

- Two medically important genera:
 - Staphylococcus
 - Streptococcus
 - Both are Gram-positive, non-motile, and non-spore-forming organisms.
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Key Differences: Staphylococcus vs Streptococcus

Feature	Staphylococcus	Streptococcus
Microscopic appearance	Grape-like clusters 	Chains or pairs 
Catalase test	Positive 	Negative 
Oxygen handling	Facultative anaerobe	Facultative / aerotolerant

 Exam tip: Catalase test is the *first and fastest* lab step to differentiate these two genera.

Streptococcus: Overview

◆ Diseases Caused by Streptococci

-> Group A - *Streptococcus pyogenes*

- Pharyngitis , impetigo, cellulitis
- Necrotizing fasciitis, streptococcal toxic shock syndrome
- Post-infectious sequelae: (Rheumatic fever and Acute post-streptococcal glomerulonephritis)

-> Group B - *Streptococcus agalactiae*

- Neonatal sepsis & meningitis 

-> Group D

i. Enterococcus (*E. faecalis*, *E. faecium*)

○ Nosocomial UTI, endocarditis

ii. Streptococcus bovis (*S. gallolyticus*)

○ Endocarditis

○ ⚠ Strong association with colon carcinoma

• Viridans group streptococci

○ Most common cause of subacute endocarditis ❤

○ Includes: *S. mutans*, *S. mitis*, *S. sanguinis*, *S. salivarius*,
S. anginosus, *S. intermedius*



Summary Table: Streptococci of Medical Importance

Species	Lancefield Group	Hemolysis	Key Diagnostic Features 
<i>S. pyogenes</i>	A	β	Bacitracin sensitive
<i>S. agalactiae</i>	B	β	Bacitracin resistant, hippurate +
<i>Enterococcus faecalis</i>	D	$\alpha / \beta / \gamma$	Growth in 6.5% NaCl, bile-esculin + (black agar)

<i>S. bovis</i>	D (non-enterococcus)	α / γ	No growth in 6.5% NaCl, bile-esculin +
<i>S. pneumoniae</i>	NA	α	Optochin sensitive, bile soluble
Viridans streptococci	NA	α	Optochin resistant, not bile soluble

◆ Important Properties of Streptococci

Morphology

- Gram-positive cocci  arranged in chains or pairs
- Catalase-negative (important differentiating point)

Hemolysis on Blood Agar

☐ α -Hemolysis → Greenish discoloration (partial hemolysis)

- Due to H_2O_2 oxidation of hemoglobin → biliverdin
- *S. pneumoniae*, Viridans streptococci

② β -Hemolysis $\rightarrow$ Clear zone (complete hemolysis)

○ Due to streptolysin O & S

○ *S. pyogenes*, *S. agalactiae*

③ γ -Hemolysis $\rightarrow$ No hemolysis



Antigens of β -Hemolytic Streptococci

① C Carbohydrate (Cell Wall Antigen)

- Basis of Lancefield classification (Groups A-U)

- Example:

 - Group A $\rightarrow$ *S. pyogenes*

 - Group B $\rightarrow$ *S. agalactiae*

② M Protein (Major Virulence Factor of *S. pyogenes*) 

- Surface protein $\rightarrow$ antiphagocytic

- Inactivates C3b complement opsonin



Pathogenic significance:

- Strains lacking M protein $\rightarrow$ non-pathogenic

- ~100 serotypes $\rightarrow$ recurrent infections

- Rheumatogenic strains → rheumatic fever ❤️
 - Nephritogenic strains → acute glomerulonephritis 🧠
 - Anti-M protein antibodies → type-specific immunity
- ✚ Polysaccharide capsule: Additional antiphagocytic factor
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Flowchart: Classification of Streptococci

Gram-positive cocci in chains/pairs

→ Catalase test: Negative

→ Hemolysis on blood agar

- α -hemolysis

→ Optochin sensitive → *S. pneumoniae*

→ Optochin resistant → Viridans streptococci

- β -hemolysis

→ Bacitracin sensitive → Group A (*S. pyogenes*)

→ Bacitracin resistant → Group B (*S. agalactiae*)

- γ -hemolysis
 - Growth in 6.5% NaCl → *Enterococcus*
 - No growth in 6.5% NaCl → *S. bovis*
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Classification of Streptococci

β -Hemolytic Streptococci

- Classified by Lancefield C carbohydrate antigen
 - ◆ Group A - *Streptococcus pyogenes*
- Major human pathogen
- Causes pharyngitis, cellulitis, impetigo, necrotizing fasciitis, toxic shock
- Virulence factors:
 - M protein + lipoteichoic acid (adherence)
 - Hyaluronic acid capsule (antiphagocytic)
- Diagnostic clue: Bacitracin sensitive 
- ◆ Group B - *Streptococcus agalactiae*

- Colonizes female genital tract
 - Neonatal meningitis & sepsis
 - Diagnostic clues:
 - Bacitracin resistant
 - Hippurate hydrolysis positive 
 - ◆ Group D
 - Enterococci (*E. faecalis*, *E. faecium*)
 - Normal colon flora
 - Cause UTI, biliary infections, endocarditis
 - Grow in bile & 6.5% NaCl 
 - Require synergistic therapy (Penicillin + Aminoglycoside)
 - VRE common 
 - Non-enterococcal Group D - *S. bovis*
 - Endocarditis, bacteremia
 - Associated with colon cancer 
 - Killed by penicillin G
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2 Non- β -Hemolytic Streptococci

α -Hemolytic

- *S. pneumoniae*

→ Optochin sensitive

→ Bile soluble

→ Capsule = major virulence factor

- Viridans streptococci

→ Normal oral flora

→ Subacute endocarditis 

→ *S. mutans* → dextran → dental caries 

γ -Hemolytic

- Some viridans & Group D species
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③ Peptostreptococci

- Anaerobic / microaerophilic
- Normal flora of gut, mouth, genital tract
- Cause mixed anaerobic infections
- Example: Brain abscess after dental procedures

Transmission

- *S. pneumoniae*, *viridans* → Oropharynx
 - *S. pyogenes* → Skin & oropharynx
 - *S. agalactiae* → Vagina, colon
 - Enterococci → Colon
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Pathogenesis of Streptococci

- ◆ *Streptococcus pyogenes* (Group A)

Three Mechanisms of Disease

- 1 Pyogenic → Local tissue invasion
 - 2 Toxigenic → Exotoxin-mediated disease
 - 3 Immunologic → Immune-mediated sequelae 
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Key Virulence Factors

- M protein → most important antiphagocytic factor 
 - Hyaluronic acid capsule → non-immunogenic camouflage
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Enzymes Enhancing Spread

- Hyaluronidase → spreading factor
 - Streptokinase → dissolves fibrin clots (used in MI )
 - DNase → liquefies pus (Anti-DNase B diagnostic in skin infections)
 - IgG protease → prevents opsonization
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Toxins & Hemolysins

- Erythrogenic toxin → scarlet fever rash (superantigen)
 - Streptolysin O → oxygen-labile; ASO titer diagnostic 
 - Streptolysin S → oxygen-stable
 - Pyrogenic exotoxin A → streptococcal TSS
 - Exotoxin B → necrotizing fasciitis ("flesh-eating") 
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Flowchart: Disease Mechanisms of *S. pyogenes*

Infection with *S. pyogenes*

- ↳ Pyogenic → pharyngitis, impetigo, cellulitis
 - ↳ Toxigenic → scarlet fever, toxic shock
 - ↳ Immunologic → rheumatic fever, PSGN
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Exam Pearls

- M protein = most important virulence factor 
 - ASO titer → rheumatic fever diagnosis
 - Exotoxin B → necrotizing fasciitis
 - Group B strep → *no exotoxins, no immune sequelae*
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Clinical Findings of Streptococcal Infections

- ◆ *Streptococcus pyogenes* (Group A)

1. Types of Diseases

- Pyogenic → Pharyngitis, cellulitis, impetigo, erysipelas, necrotizing fasciitis
- Toxigenic → Scarlet fever, Streptococcal toxic shock syndrome
- Immunologic (post-streptococcal) → Rheumatic fever, Acute Glomerulonephritis (AGN) 

2. Streptococcal Pharyngitis (Strep Throat)

- Most common bacterial cause of pharyngitis.
- Symptoms → throat pain + fever.
- Exam findings → inflamed throat & tonsils, yellowish exudates, tender cervical lymph nodes.
- Course → self-resolving in ~10 days, but  may lead to rheumatic fever if untreated.
- Complications:
 - Otitis media
 - Sinusitis
 - Mastoiditis

- Meningitis
- Peritonsillar/retropharyngeal abscess

3. Toxin-Mediated Diseases

- Scarlet fever → erythrogenic toxin + no antitoxin
- Strawberry tongue 🍓
- Streptococcal Toxic Shock Syndrome
- Recognizable focus of infection
- Blood cultures often positive

4. Skin & Soft Tissue Infections

- Cellulitis
- Erysipelas → sharply demarcated raised erythema
- Necrotizing fasciitis → rapid tissue destruction
- Impetigo → honey-colored crust 🍯
- Lymphangitis → esp. forearm

5. Other Infections

- Endometritis (puerperal fever)

- Sepsis
 - Post-streptococcal AGN (after skin infections)
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◆ Streptococcus agalactiae (Group B)

- Neonatal sepsis & meningitis (hallmark)
 - Prolonged rupture of membranes
 - Prematurity
 - Lack of maternal IgG
 - Neonatal pneumonia
 - Adult infections → pneumonia, endocarditis, arthritis, cellulitis, osteomyelitis
 - Diabetes = major risk factor
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◆ Viridans Streptococci

- Most common cause of infective endocarditis (post dental procedures)
 - Brain, lung, liver abscesses (mixed infections)
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◆ Enterococci (Group D)

- UTI (catheterized patients)
 - Endocarditis (post GI/GU procedures)
 - Intra-abdominal & pelvic infections
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◆ Streptococcus bovis

- Endocarditis
 - Strong association with colon carcinoma 🗝️
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◆ Peptostreptococci

- Brain, lung, abdominal, pelvic abscesses (mixed)

Flowchart: Clinical Spectrum

S. pyogenes (Group A) → Pyogenic → Pharyngitis, cellulitis, impetigo, erysipelas, necrotizing fasciitis

- OR - Toxigenic → Scarlet fever, TSS

- OR - Immunologic → Rheumatic fever, AGN

S. agalactiae (Group B) → Neonatal sepsis, meningitis, pneumonia

Viridans streptococci → Endocarditis, abscesses

Enterococci → UTI, endocarditis, abdominal infections

S. bovis → Endocarditis + colon cancer

Peptostreptococci → Anaerobic abscesses



Poststreptococcal Diseases

◆ Acute Glomerulonephritis (AGN)

- 2-3 weeks post skin infection
- Triad → Hypertension, edema, smoky urine
- Immune complex deposition in glomeruli
- Usually complete recovery

◆ Acute Rheumatic Fever (ARF)

- ~2 weeks post pharyngitis
- JONES criteria
- Autoimmune molecular mimicry
- Prevented by early treatment of pharyngitis

Flowchart: Poststreptococcal Disease Mechanism

Streptococcal infection



Antibody formation against M protein



Cross-reaction with host tissues



AGN (immune complex) OR ARF (autoimmune)



Laboratory Diagnosis

- Blood agar culture

- Bacitracin sensitivity → Group A
 - Hippurate & CAMP → Group B
 - Bile-esculin & 6.5% NaCl → Group D
 - ASO titers → Rheumatic fever
 - Anti-DNase B → AGN
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Treatment & Prevention

- Group A → Penicillin G / Amoxicillin
- Penicillin allergy → Macrolide / Clindamycin
- Invasive GAS → Clindamycin + IVIG
- Enterococci → Penicillin/Vancomycin + Aminoglycoside
- VRE → Linezolid / Daptomycin
- Group B → Intrapartum Penicillin prophylaxis
- Endocarditis prophylaxis → Amoxicillin (dental only)



Flowchart: Antibiotic Choice

Strep identified



Group A → Penicillin

Group B → Penicillin / Ampicillin

Viridans → Prolonged Penicillin

Enterococci → Combo therapy

VRE → Linezolid / Daptomycin

Peptostreptococci → Penicillin G

-> The End <-