

Streptococcal and Enterococcal Infections

Mechanisms · Morphology · Clinicopathologic correlations

Streptococci and enterococci: distinct pathogens, overlapping lesions

Dr Abu Suraih Sakhri

MBBS, MD (Pathology)

www.abusuraihsakhri.com

Learning objectives

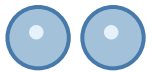
- Classify clinically important streptococci and enterococci by disease setting.
- Connect virulence factors with inflammatory and immune-mediated injury.
- Recognize characteristic tissue reactions, complications, and diagnostic clues.
- Explain enterococcal persistence and vancomycin resistance.

The organisms: A clinicopathologic map

Organism	Major disease context	Dominant theme
<i>S. pyogenes</i> (group A)	Pharyngitis; skin disease; postinfectious syndromes	Toxin, phagocyte evasion, autoimmunity
<i>S. agalactiae</i> (group B)	Chorioamnionitis; neonatal sepsis/meningitis	Maternal–neonatal infection
<i>S. pneumoniae</i>	Pneumonia; meningitis	Capsule and pneumolysin
Viridans / <i>S. mutans</i>	Endocarditis; dental caries	Oral flora and plaque
<i>Enterococcus</i> spp.	Healthcare-associated UTI; bacteremia; endocarditis	Persistence and antibiotic resistance

Gram-positive cocci: Arrangement is a clue, not a species ID

Pairs



Chains



Shared Gram-positive coccal morphology

- Streptococci and enterococci grow as cocci in pairs or chains.
- Enterococci can resemble streptococci on routine morphology.
- Culture and organism identification establish the etiology.

Schematic — not an authentic clinical or histologic specimen

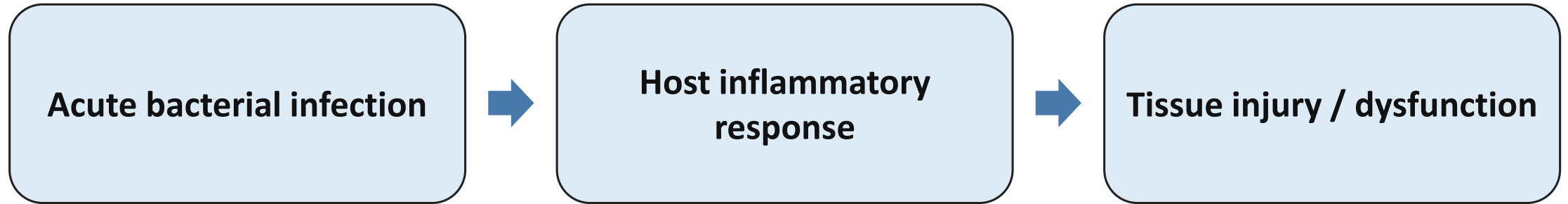
Hemolysis and antigens organize the streptococci

Group	Organisms	Teaching implication
β -hemolytic; group A	<i>S. pyogenes</i>	Pharyngitis, scarlet fever, skin infection
β -hemolytic; group B	<i>S. agalactiae</i>	Maternal colonization; neonatal infection
α -hemolytic	<i>S. pneumoniae</i>	Encapsulated pneumonia and meningitis
α - or nonhemolytic	Viridans streptococci	Oral flora; infective endocarditis

Same broad morphology, different clinical niches

Bacterial group	Source or niche	Illustrative consequence
Group A streptococci	Oropharynx and skin disease	Acute suppuration; immune sequelae
Group B streptococci	Female genital tract	Pregnancy and neonatal infection
Pneumococcus	Respiratory tract	Consolidating pneumonia; meningitis
Viridans streptococci	Oral microbiota	Endocarditis; dental plaque
Enterococci	Gut commensals	Healthcare-associated UTI and invasive infection

Two mechanisms of disease must be separated



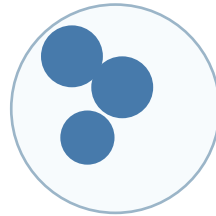
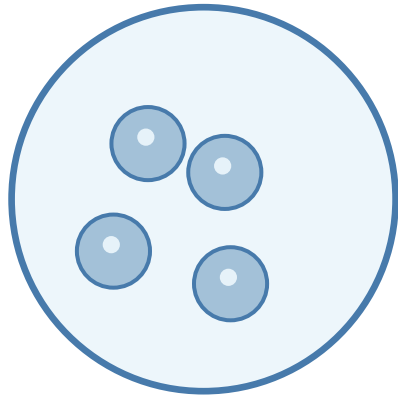
Postinfectious rheumatic fever and glomerulonephritis instead follow immune responses to prior streptococcal infection.

Virulence factors linked to injury

Organism	Factor	Consequences
S. pyogenes	Capsule; M protein; C5a peptidase	Impaired phagocytosis / recruitment
S. pyogenes	Pyrogenic exotoxin	Fever and scarlet-fever rash
S. pneumoniae	Capsule; pneumolysin	Resistance to phagocytosis; cell lysis
S. mutans	Acid + glucans	Enamel demineralization; bacterial plaque
Enterococci	Capsule, biofilm, enzymes	Persistence and host tissue injury

Capsules impair phagocyte clearance

Capsular barrier



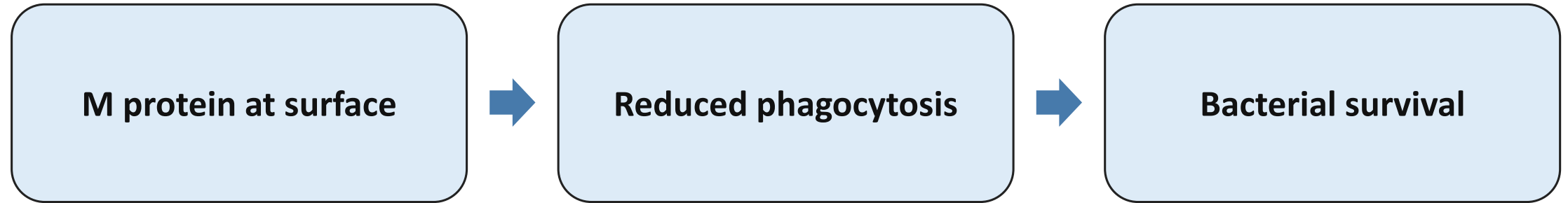
Phagocyte

Encapsulation → less efficient engulfment

- Capsules are present in *S. Pyogenes*, *S. Agalactiae*, and *S. Pneumoniae*.
- Antiphagocytic surface protection favors persistence despite host defenses.
- The pneumococcal capsule is its principal virulence factor.

Schematic — not an authentic clinical or histologic specimen

S. Pyogenes M protein: Surface-mediated evasion



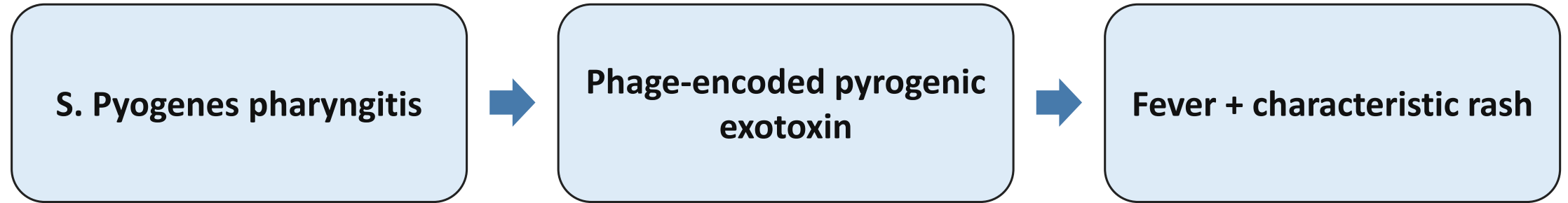
M-protein-directed adaptive immunity also links prior group A infection to rheumatic heart disease.

C5a peptidase blunts neutrophil recruitment



C5a is a complement-derived chemoattractant; Its degradation weakens early inflammatory recruitment.

A toxin-mediated syndrome: Scarlet fever



The rash is a toxin-associated manifestation, not simply a map of bacteria spreading through skin.

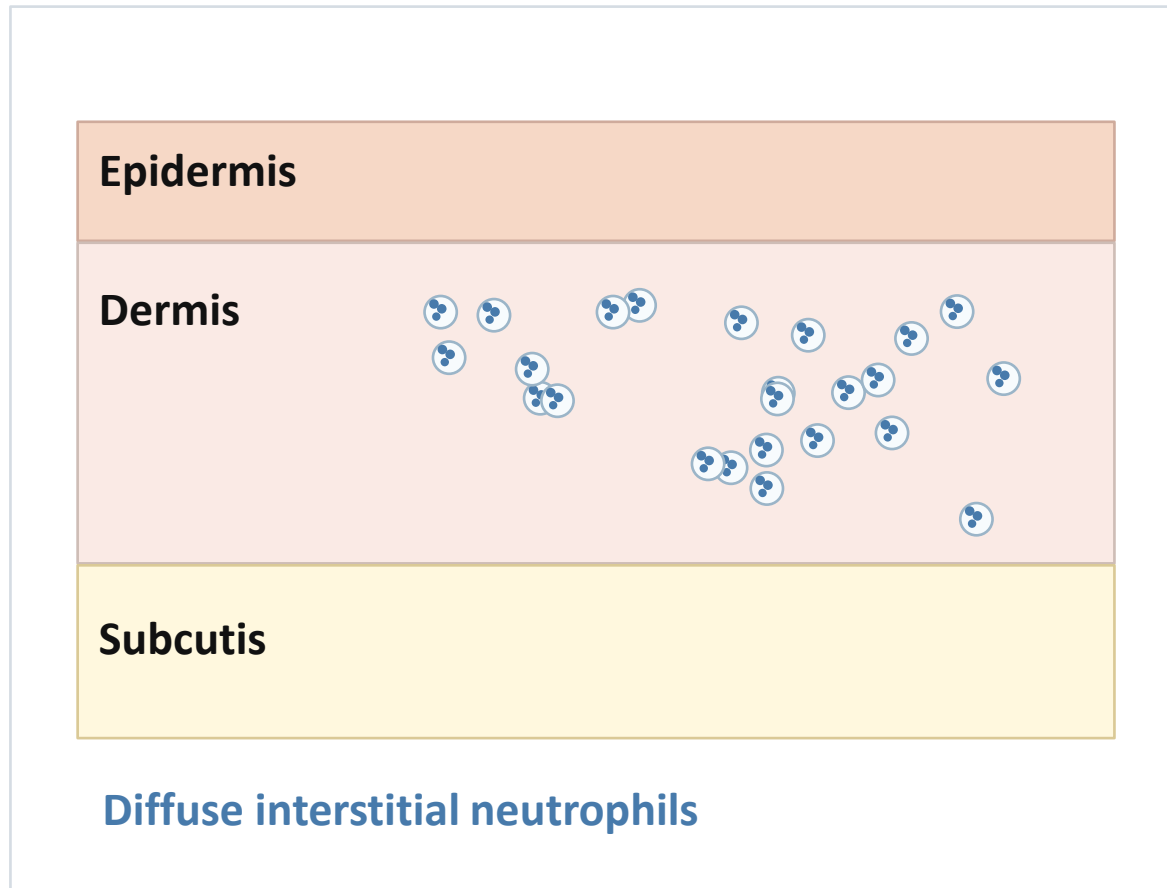
Mechanism predicts phenotype

Mechanistic pattern	Characteristic example	Pathologic interpretation
Antiphagocytic surface	Capsule and M protein	Persistent viable bacteria
Toxin-related	Pyrogenic exotoxin	Fever and rash
Direct destructive infection	Necrotizing fasciitis	Rapidly progressive soft-tissue necrosis
Postinfectious immune injury	Rheumatic fever / GN	Disease after preceding infection

Group A streptococcus: Disease spectrum

- Oropharyngeal infection: Pharyngitis with possible suppurative extension.
- Skin infection: Impetigo and erysipelas with a neutrophilic tissue reaction.
- Toxin-associated disease: Scarlet fever and toxic shock syndrome.
- Severe invasive phenotype: Rapidly progressive necrotizing fasciitis.

Most streptococcal lesions are diffusely neutrophilic



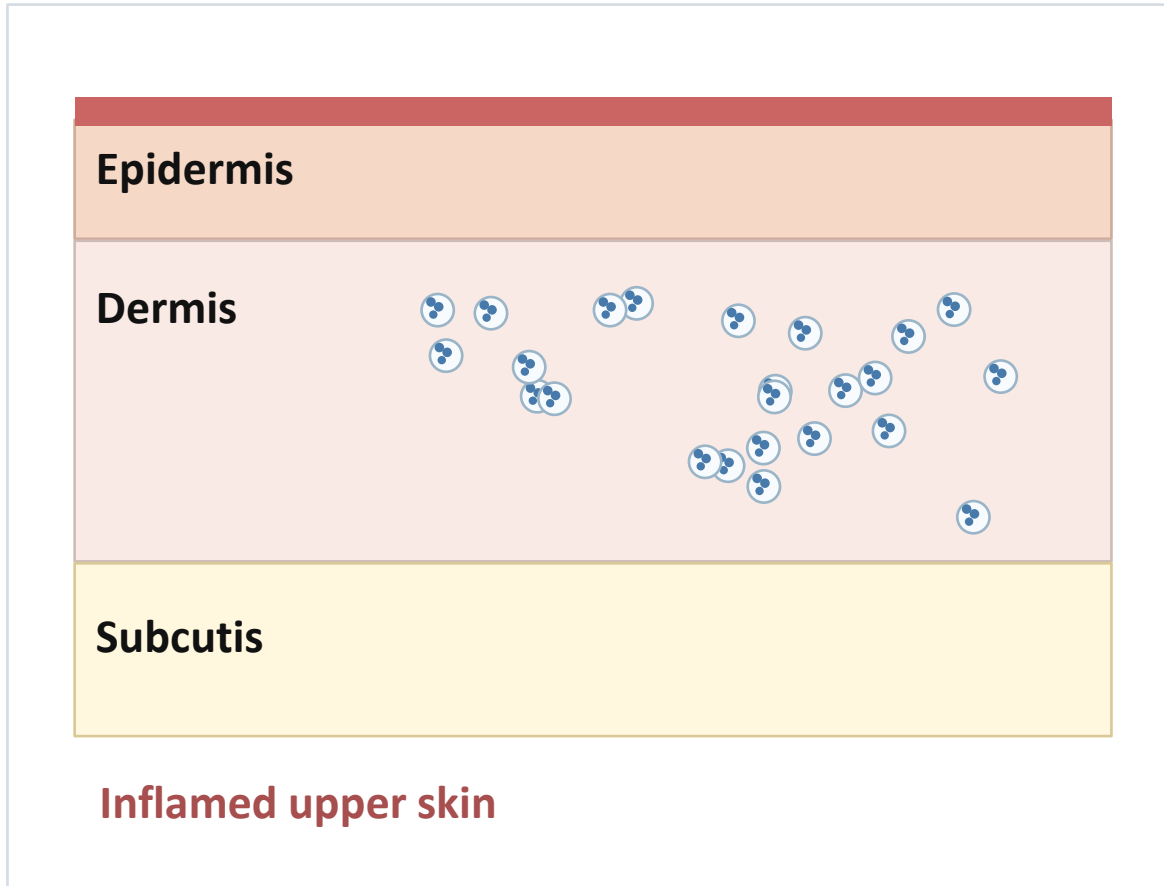
- Typical pattern: Interstitial neutrophils and tissue edema.
- Compared with destructive abscess-forming patterns, necrosis is often limited.
- Virulent necrotizing fasciitis is an important exception.

Schematic — not an authentic clinical or histologic specimen

Erysipelas: The clinical boundary matters

- Rapidly spreading erythematous swelling, often involving the face.
- A sharp, well-demarcated, serpiginous edge is characteristic.
- Facial disease may produce a bilateral “butterfly” distribution.
- Extremity or truncal involvement is also described.

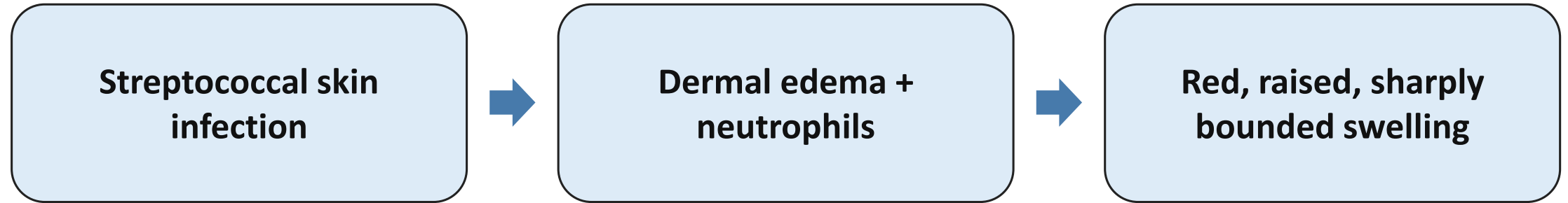
Erysipelas: Superficial tissue reaction



- Diffuse edema and neutrophilic inflammation involve dermis and epidermis.
- Inflammation can extend into subcutaneous tissue.
- Microabscesses may occur; Overt necrosis is generally minor.

Schematic — not an authentic clinical or histologic specimen

Erysipelas morphology from cause to appearance



The outline of erythema is a clinical clue; The tissue response explains swelling and warmth.

Skin manifestations: Shared versus exceptional features

Feature	Typical streptococcal lesion	Necrotizing fasciitis
Inflammatory cells	Interstitial neutrophils	Severe invasive inflammation
Tissue destruction	Usually relatively limited	Rapidly progressive tissue necrosis
Clinical pattern	Impetigo / erysipelas	Rapidly progressive soft-tissue disease
Interpretive caution	Surface appearance may mimic staph	Do not extrapolate “minor necrosis”

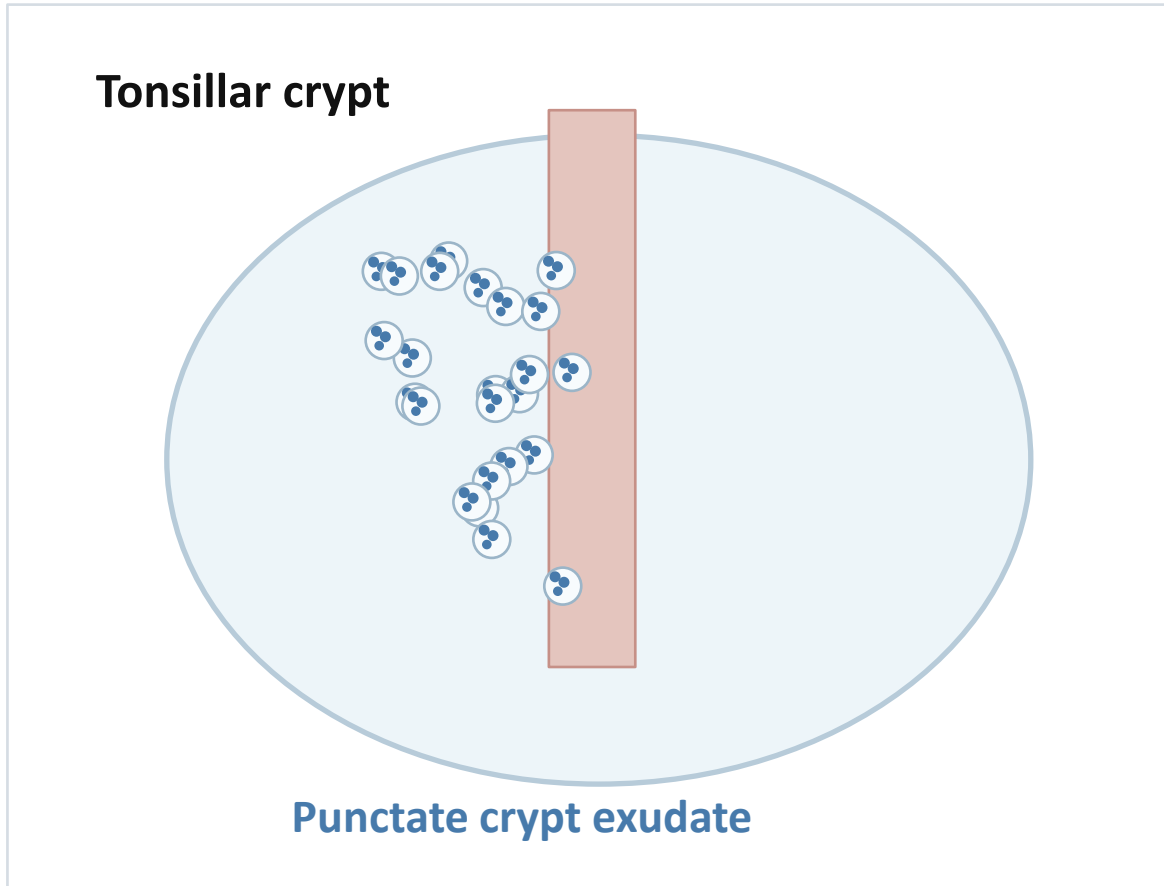
Impetigo and skin infection: Avoid morphology alone

- Overlap between streptococcal and staphylococcal skin lesions.
- Shared appearances do not establish the microbiologic species.
- Use an organism-directed diagnostic approach when etiology matters.

Streptococcal pharyngitis: Gross features

- Edema and swelling in the oropharyngeal region.
- Punctate suppurative foci in the tonsillar crypts.
- Cervical lymphadenopathy may accompany the infection.
- Marked swelling can threaten airway patency.

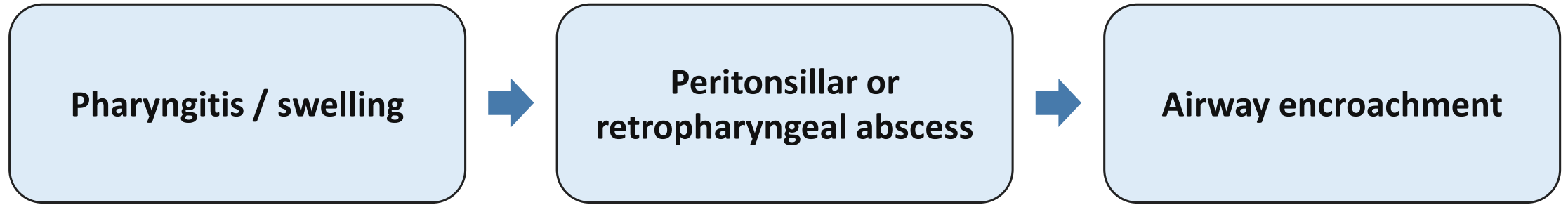
Tonsillar crypt abscesses: Focal pus within inflammation



- Punctate abscesses form in the tonsillar crypts.
- Local edema and lymphoid reactivity can enlarge tonsils.
- The site of the inflammatory exudate explains focal pale spots.

Schematic — not an authentic clinical or histologic specimen

Anatomic progression can threaten the airway

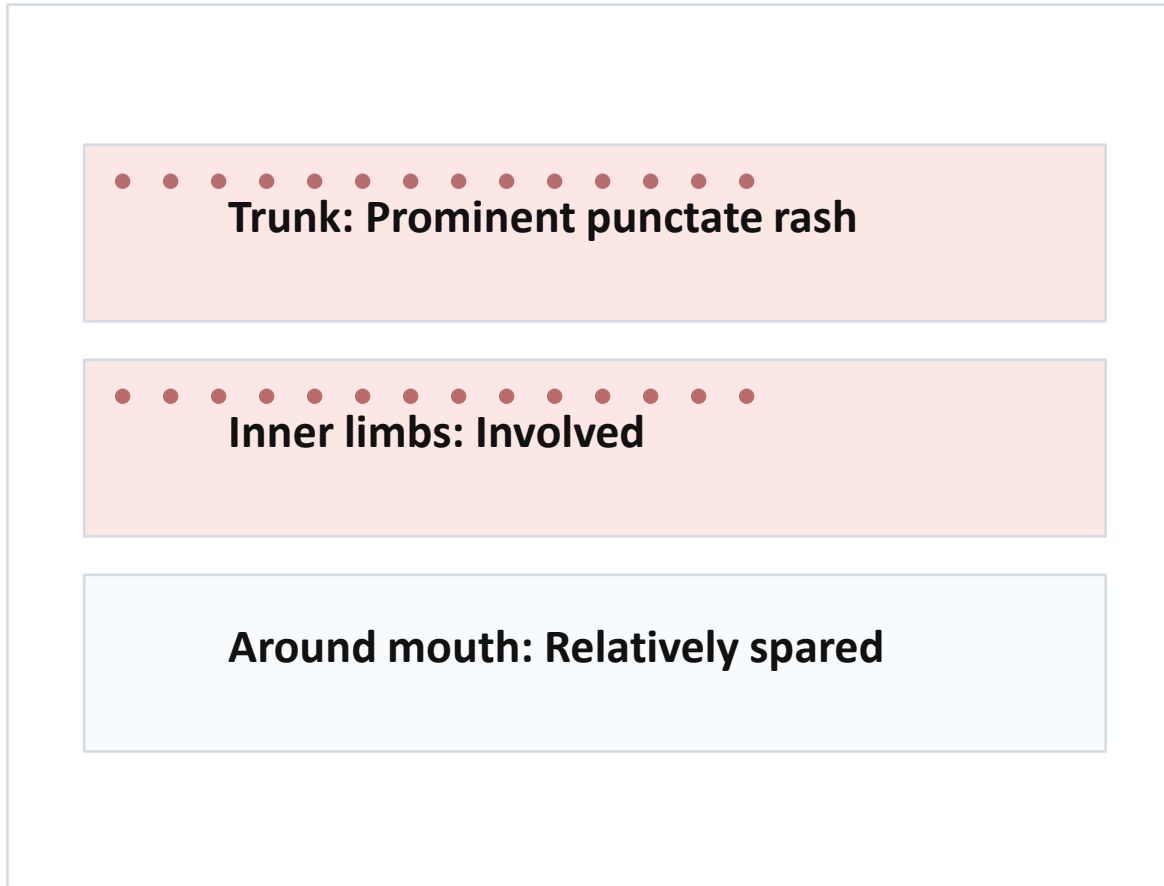


Severe pharyngeal swelling is important because obstruction is a structural complication, not just pain.

Scarlet fever: Clinical distribution

- Occurs in association with *S. Pyogenes* pharyngitis.
- Punctate erythematous rash favors the trunk and inner limbs.
- Facial involvement with relative circumoral pallor is characteristic.
- During recovery, skin may become scaly and hyperkeratotic.

Scarlet fever: Localization of the rash



Schematic — not an authentic clinical or histologic specimen

- A generalized toxin-associated eruption is most prominent over trunk and proximal limbs.
- Relative sparing around the mouth creates circumoral pallor.
- Desquamation occurs as fever subsides.

Erysipelas and scarlet fever are not the same rash

Feature	Erysipelas	Scarlet fever
Primary setting	Localized skin infection	Associated with GAS pharyngitis
Distribution	Sharply bounded expanding plaque	Diffuse punctate eruption
Histopathology	Edematous neutrophilic dermatitis	Rash attributed to pyrogenic exotoxin
Characteristic clue	Serpiginous edge	Circumoral pallor / later scaling

Necrotizing fasciitis: The severe invasive phenotype

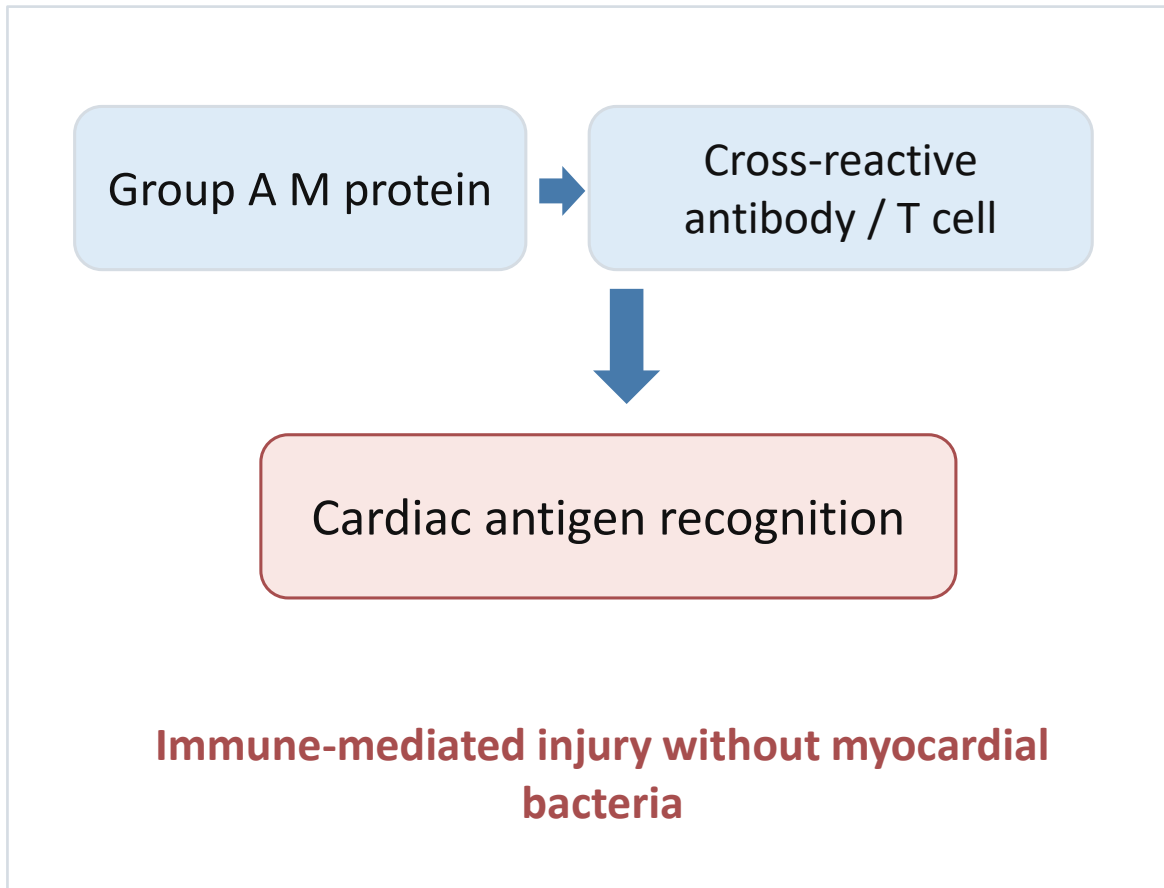
- Some highly virulent *S. Pyogenes* strains cause rapidly progressive fascial infection.
- Necrosis—not merely a dense neutrophilic infiltrate—defines the danger.
- Clinical progression may far exceed the apparent initial surface findings.

Why immune sequelae appear after infection



A temporal gap and a second pathogenic mechanism distinguish postinfectious disease from local suppuration.

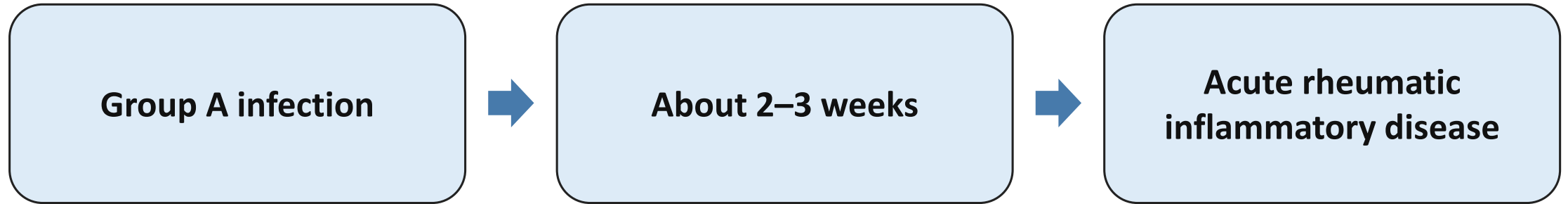
Rheumatic fever: Molecular mimicry



- Antibodies and CD4+ T cells against streptococcal M proteins recognize cardiac antigens.
- Complement and recruited immune cells produce cardiac inflammation.
- Bacteria are absent from the rheumatic cardiac lesions.

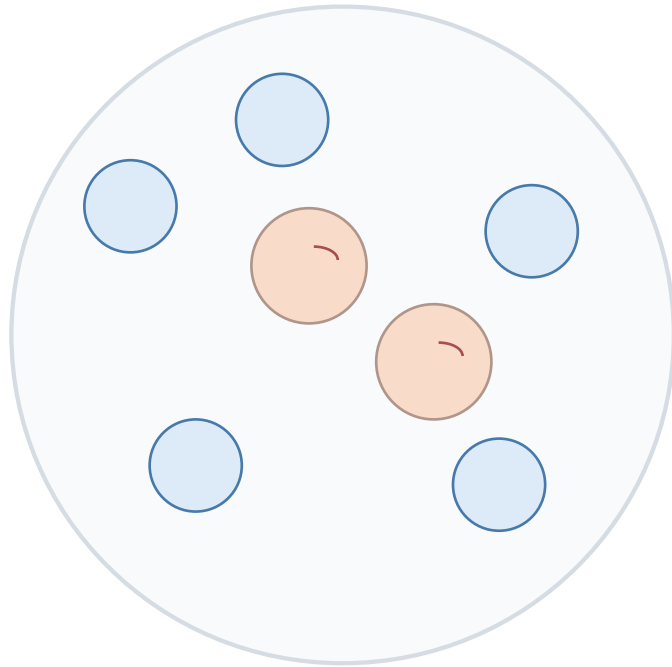
Schematic — not an authentic clinical or histologic specimen

Rheumatic fever follows an immune-response interval



The latency is compatible with time needed to mount cross-reactive adaptive immune responses.

Aschoff bodies: The signature cardiac lesion



Activated macrophages + lymphocytes

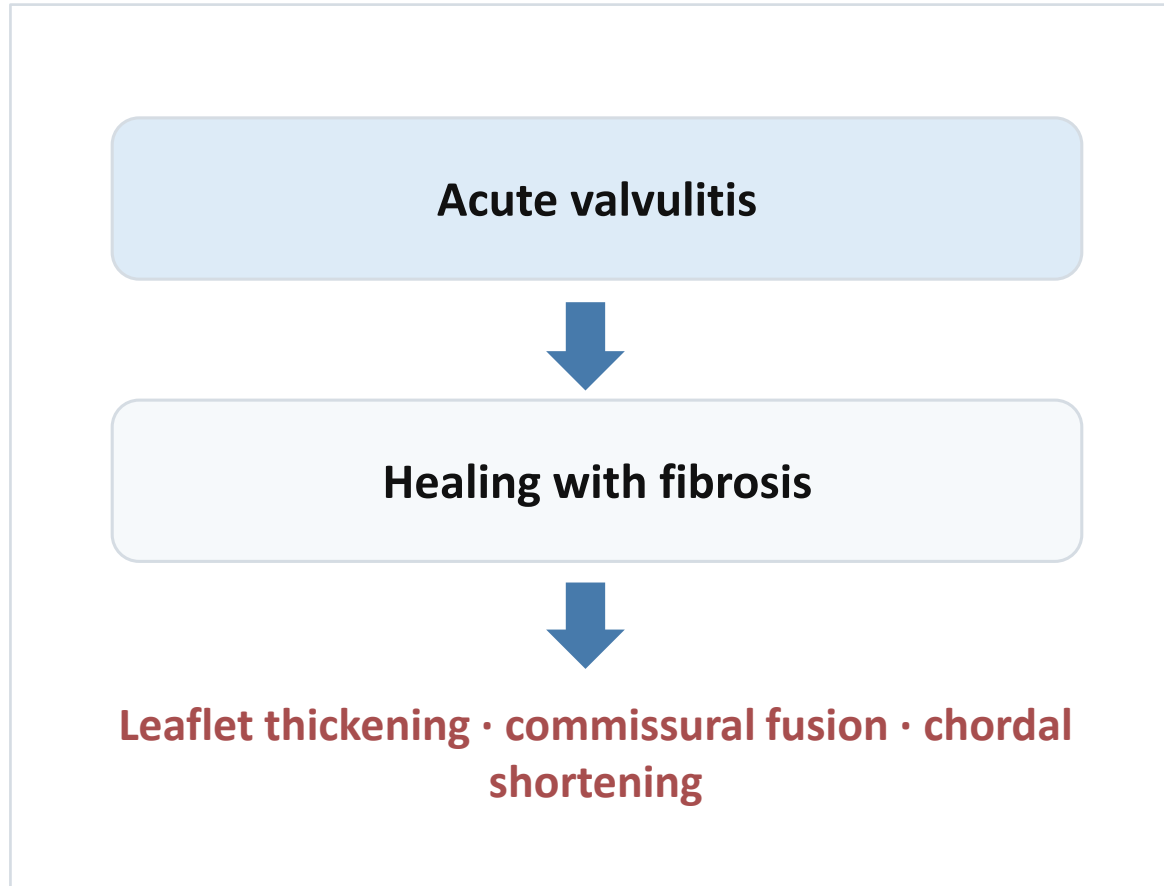
Schematic — not an authentic clinical or histologic specimen

- A focal aggregate contains T lymphocytes and activated macrophages.
- Anitschkow cells display a central ribbon-like (“caterpillar”) nuclear chromatin pattern.
- The lesion reflects immune-mediated myocardial inflammation, not bacterial colonies.

Rheumatic carditis spans three heart layers

Site	Acute inflammatory consequence
Pericardium	Pericarditis
Myocardium	Myocarditis and Aschoff bodies
Endocardium / valves	Valvulitis, fibrinoid necrosis, small verrucae

Chronic rheumatic disease: Scarring reshapes valves



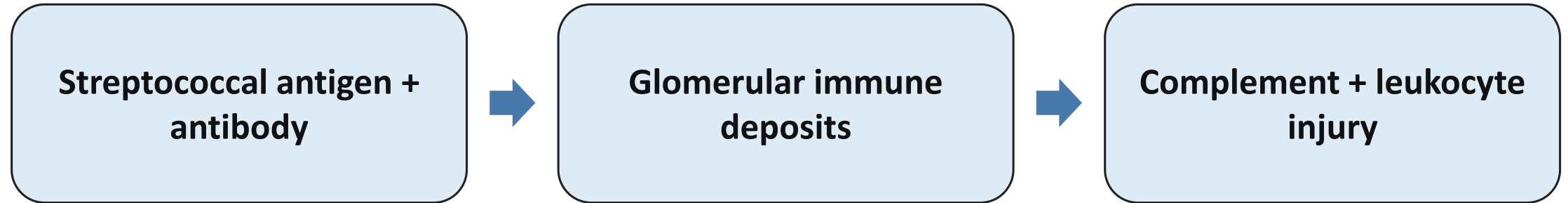
- Mitral leaflets thicken and commissures fuse.
- Chordae tendineae shorten, thicken, and may fuse.
- Valve deformity produces chronic dysfunction, especially mitral stenosis.

Schematic — not an authentic clinical or histologic specimen

Endocarditis has two different streptococcal contexts

Feature	Poststreptococcal rheumatic valvulitis	Infective endocarditis
Driver	Cross-reactive host immunity	Microbial colonization of valve
Organisms within lesion	Absent	Present in infective vegetation
Main morphologic clue	Small verrucae and later fibrosis	Friable, potentially destructive vegetation
Example	Group A postinfectious disease	Viridans streptococci / enterococci

Poststreptococcal glomerulonephritis: Immune complexes

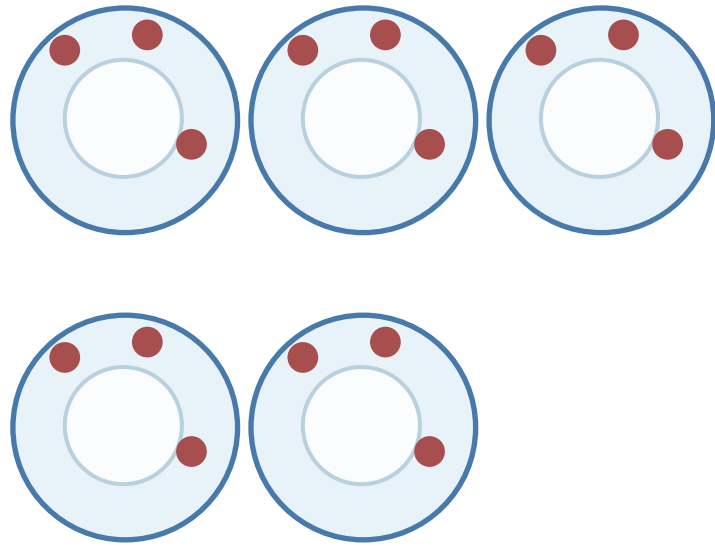


The disease is postinfectious: Immune-mediated glomerular inflammation follows pharyngeal or skin infection.

Poststreptococcal GN: Timing and setting

- Typically appears 1–4 weeks after a throat or skin infection.
- Occurs most frequently in childhood but may affect other age groups.
- The lag is consistent with antibody production and immune-complex formation.

Postinfectious GN: A glomerular morphologic triad



Glomerular capillary loops + deposits

Schematic — not an authentic clinical or histologic specimen

- Light microscopy: Diffuse endocapillary proliferation and leukocyte infiltration.
- Immunofluorescence: Granular IgG/C3 pattern.
- Electron microscopy: Characteristic subepithelial humps.

Immune injury: Distinguish rheumatic fever from GN

Feature	Rheumatic fever	Poststreptococcal GN
Major target	Heart (including valves)	Glomeruli
Dominant immune mechanism	Cross-reactive antibodies and T cells	Immune complexes
Morphology	Aschoff bodies; valvulitis	Proliferative GN; granular deposits
Persistent bacterial invasion	No	No required glomerular infection

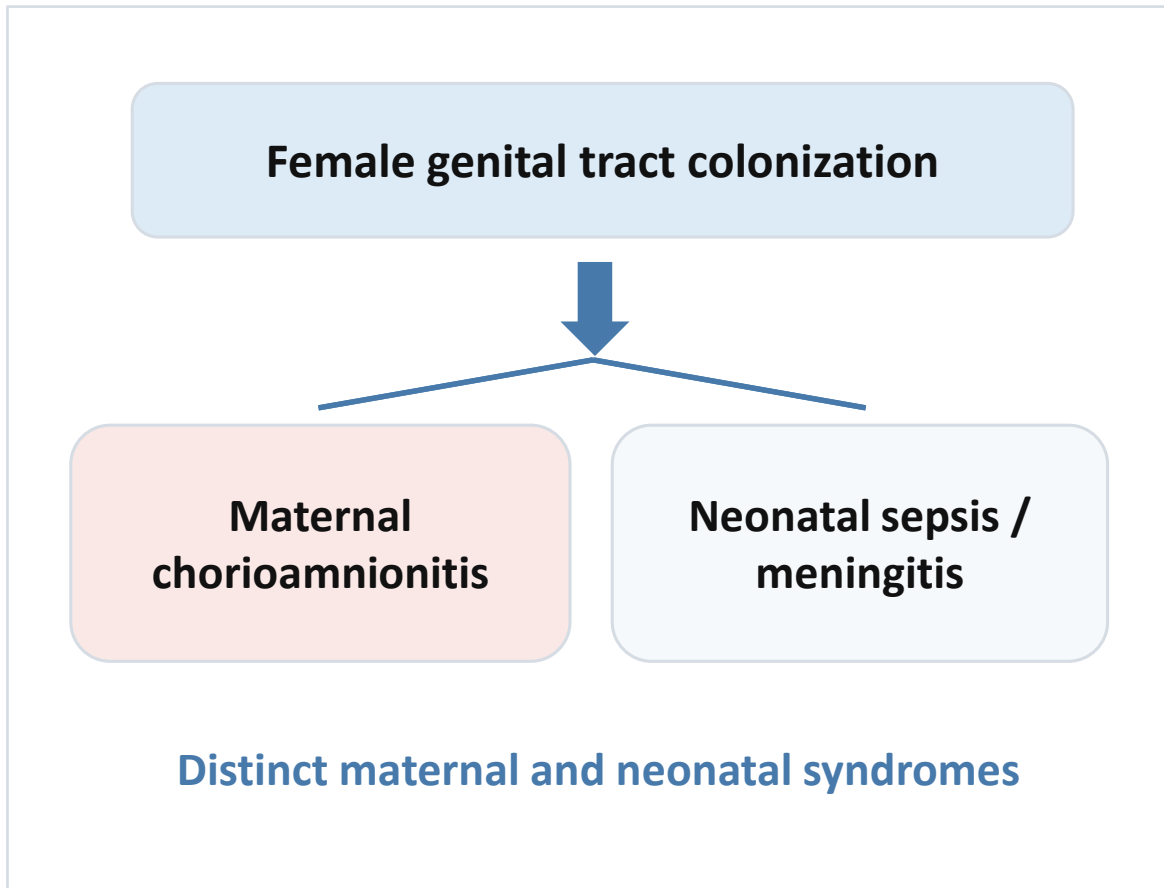
Nephritic syndrome connects pathology to symptoms

- Inflamed glomerular capillary loops lead to hematuria and red-cell casts.
- Glomerular injury may produce proteinuria and edema.
- Fluid retention and altered renal hemodynamics contribute to hypertension.

Group B streptococcus: The obstetric reservoir

- *S. Agalactiae* is a group B streptococcus.
- It colonizes the female genital tract.
- During pregnancy, ascending infection may cause chorioamnionitis.
- Neonatal sepsis and meningitis are major clinical consequences.

Group B disease may affect mother or neonate

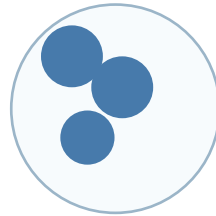
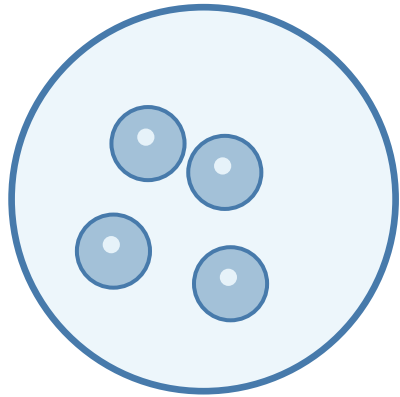


- Female genital tract carriage is the maternal reservoir.
- Maternal chorioamnionitis and neonatal invasive disease are distinct outcomes.
- Neonatal sepsis and meningitis are especially important presentations.

Schematic — not an authentic clinical or histologic specimen

Group B streptococcus: Capsule and invasive disease

Capsular barrier



Phagocyte

Encapsulation → less efficient engulfment

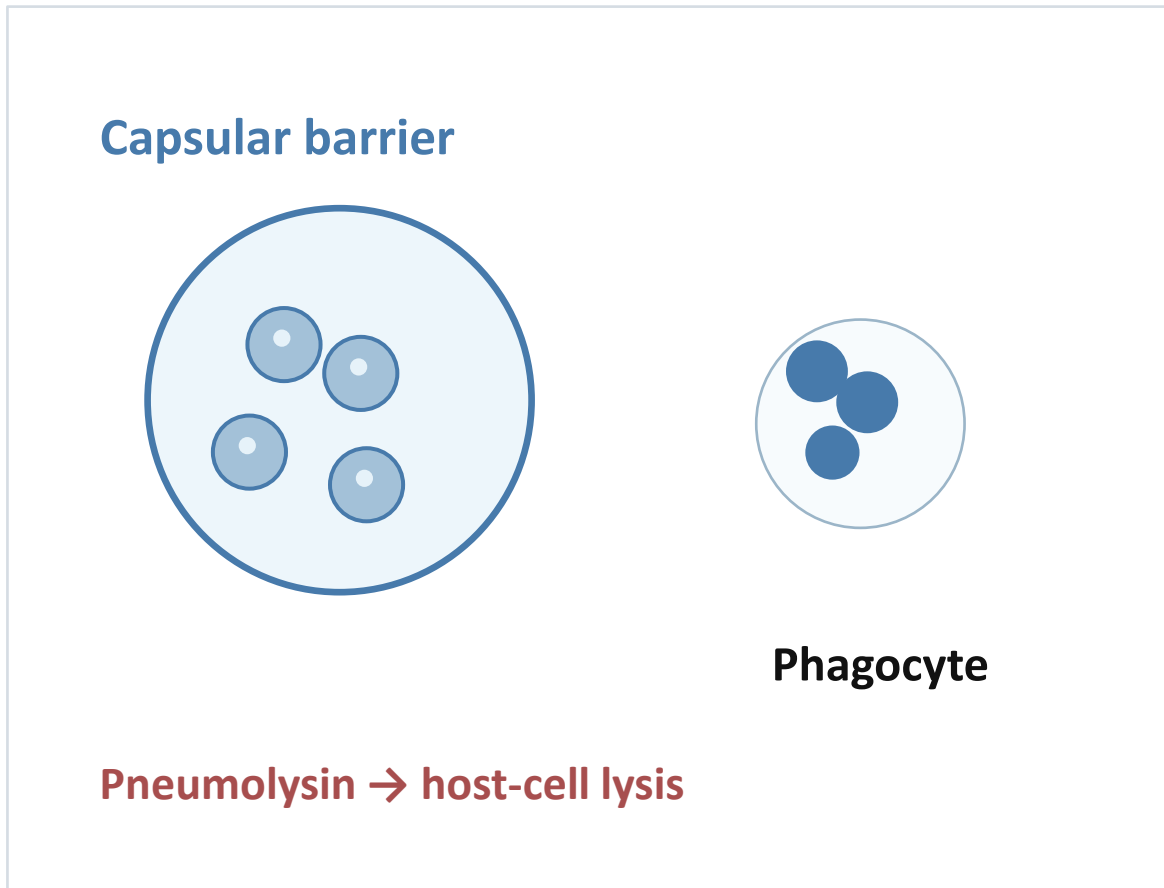
- *S. Agalactiae* has an antiphagocytic capsule.
- A vulnerable neonatal host may develop disseminated infection.
- Clinical setting and identification both matter: Appearance is not enough.

Schematic — not an authentic clinical or histologic specimen

Group A versus group B: Clinical discrimination

Feature	<i>S. pyogenes</i> (A)	<i>S. agalactiae</i> (B)
Representative source	Pharynx / skin infections	Female genital tract carriage
Typical context	Pharyngitis, erysipelas, scarlet fever	Chorioamnionitis; neonatal sepsis
Shared virulence	Antiphagocytic capsule	Antiphagocytic capsule
Distinct late sequelae	Rheumatic fever / PSGN	Not emphasized in the source

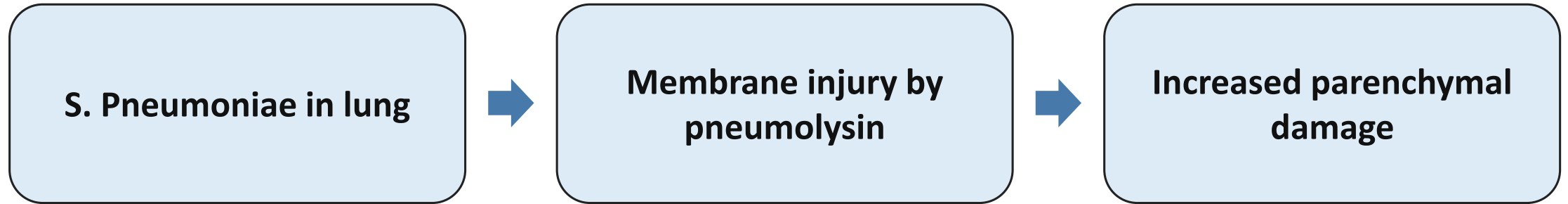
Pneumococcus: Capsule plus pneumolysin



- The capsule is the principal pneumococcal virulence factor.
- Pneumolysin inserts into membranes and lyses host cells.
- The combination promotes persistence and tissue damage.

Schematic — not an authentic clinical or histologic specimen

Pneumolysin amplifies the inflammatory injury

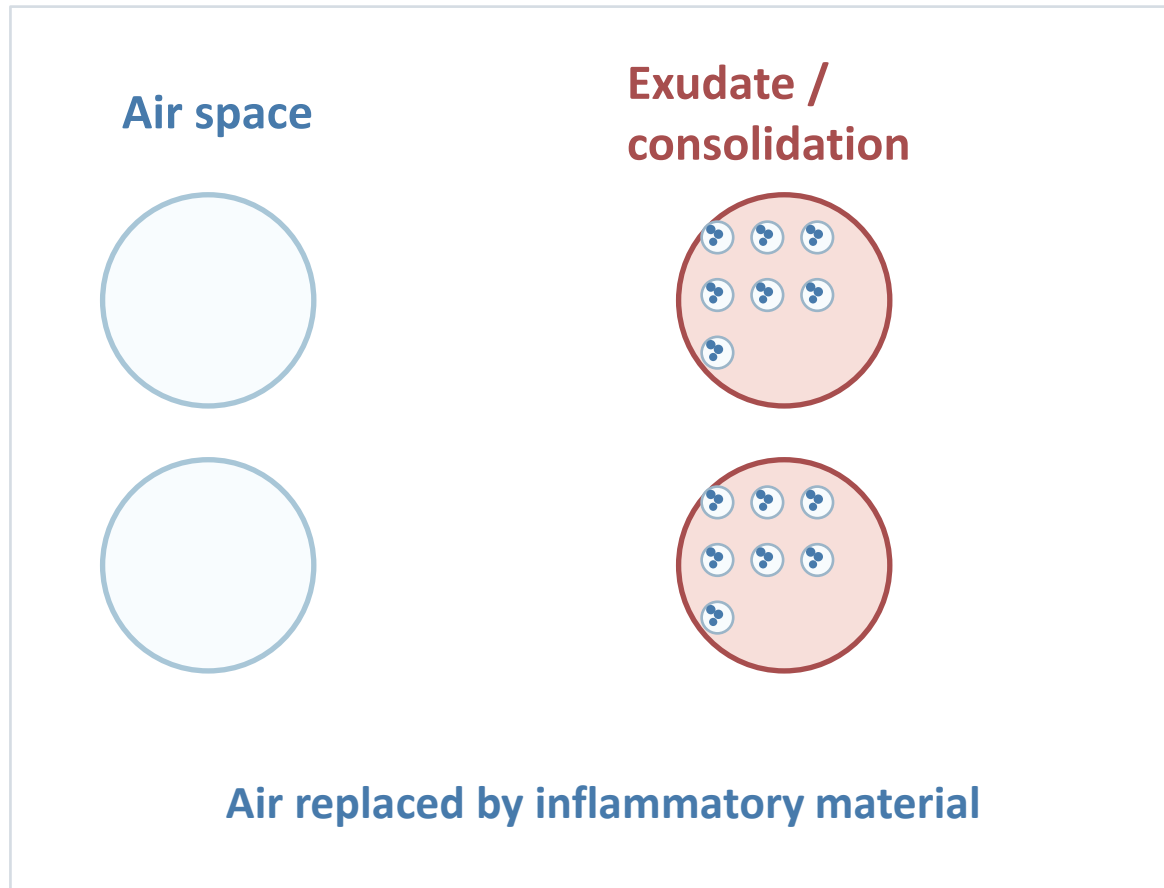


The toxin is distinct from the antiphagocytic effect of the polysaccharide capsule.

Pneumococcal pneumonia: An alveolar exudate

- *S. Pneumoniae* is a major cause of community-acquired acute pneumonia.
- Bacterial invasion fills alveolar spaces with inflammatory exudate.
- Accumulation of alveolar exudate causes airspace consolidation.

Lobar consolidation: Why the lung becomes solid



- Normal alveolar spaces are air-filled.
- Acute bacterial exudate replaces air with neutrophils and protein-rich fluid.
- Confluent involvement produces a consolidated lung region.

Schematic — not an authentic clinical or histologic specimen

Pneumococcal diagnosis: Sample and inference

Test / finding	Interpretation	Limitation
Sputum Gram stain	Lancet-shaped gram-positive diplococci with neutrophils	Airway colonization can confound
Blood culture	A specific invasive-disease clue when positive	Insensitive early in some cases
Clinical / radiology	Identifies pneumonia syndrome	Alone cannot reliably define organism

Host vulnerability to encapsulated pneumococci

- Defective or absent splenic function increases susceptibility to encapsulated bacteria.
- Extremes of age, chronic illnesses, and immunodeficiency predispose to pneumonia.
- An antiphagocytic capsule explains the importance of host clearance mechanisms.

Pneumococcal prevention targets the capsule

- Pneumococcal vaccines include polysaccharide and conjugate formulations.
- Vaccines are recommended for young children, older adults, and selected risk groups.
- Capsule-directed immunity reduces vulnerability to invasive pneumococcal infection.

Pneumococcus also causes meningitis

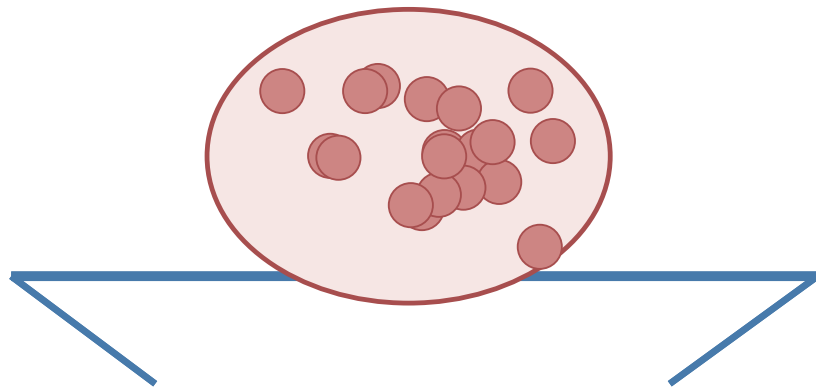
- *S. Pneumoniae* causes meningitis in children and adults.
- Clinical presentation and the site of infection define the diagnostic workup.
- A single organism can cause both pulmonary and central nervous system disease.

Viridans streptococci: Oral residents, valvular pathogens

- The viridans group comprises α -hemolytic and nonhemolytic streptococci.
- They are normal components of oral microbiota.
- They are a common cause of infective endocarditis.

Infective endocarditis: Vegetations differ from scarring

Attached infective vegetation

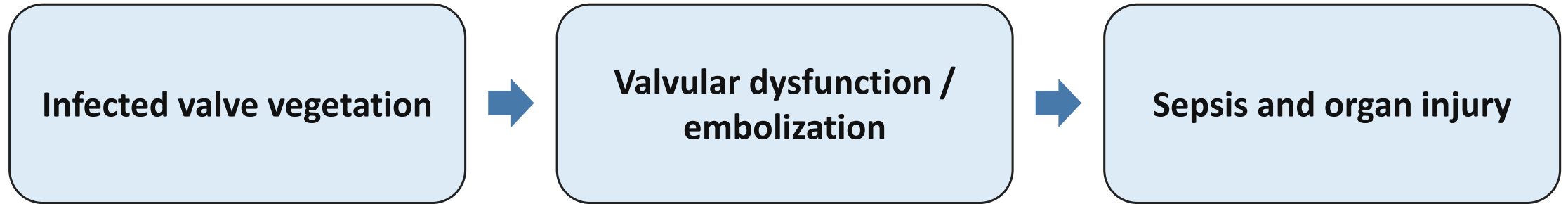


Simplified valve surface — not an anatomical cross-section

Schematic — not an authentic clinical or histologic specimen

- Viridans endocarditis can produce large, friable valve vegetations.
- The lesion is microbial and potentially embolic.
- It is not synonymous with sterile rheumatic verrucae.

Valve infection generates systemic hazards

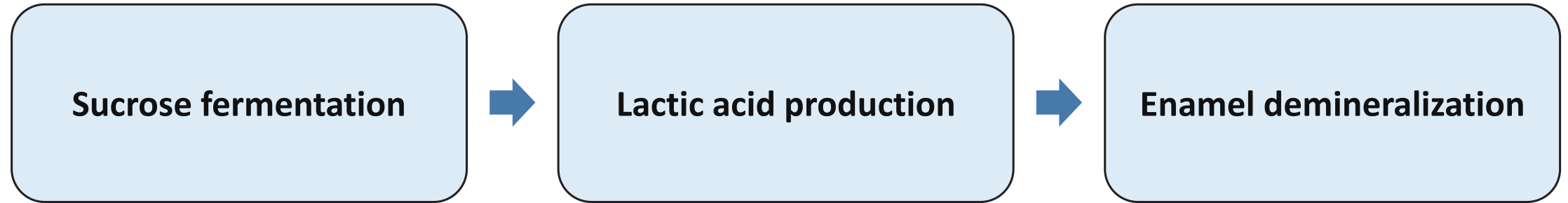


The heart-valve lesion creates both local mechanical disease and distant infectious consequences.

Infective endocarditis: Clinicopathologic diagnosis

- Evidence combines microbiology with valve/implant imaging and examination.
- Repeated blood cultures and anatomic evidence support the diagnosis.
- Embolic and immunologic phenomena provide additional clues.

S. Mutans: The metabolic pathway to dental caries



Acid production is a direct biochemical route from oral carbohydrate metabolism to tooth destruction.

S. Mutans: Glucans stabilize dental plaque



Glucan-mediated adherence and acid production reinforce the cariogenic niche.

Two viridans-related clinical pathways

Context	<i>S. mutans</i> caries	Viridans endocarditis
Setting	Tooth surface; oral plaque	Heart valve
Key mechanism	Acid + glucan biofilm matrix	Valve colonization with vegetations
Main damage	Demineralization of enamel	Valve dysfunction and embolism

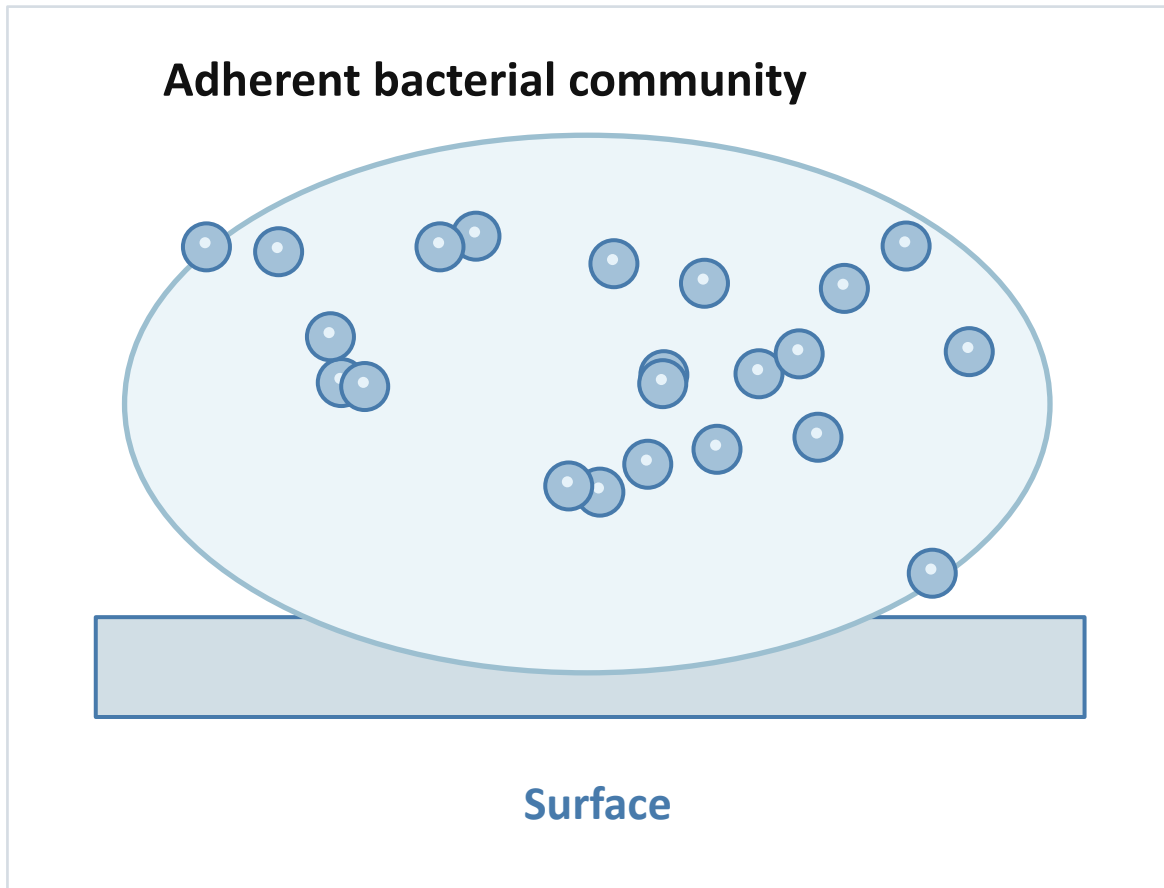
Enterococci: Commensals with invasive potential

- Enterococci normally inhabit the gut.
- *E. Faecalis* and *E. Faecium* are the main clinical species.
- They produce urinary, wound, intraabdominal, bloodstream, and valve infections.
- Pairs or chains do not reliably separate them from streptococci.

Enterococcal clinical burden: Interpret context

Setting	Clinical significance
Hospital-associated UTI	Enterococci are major nosocomial uropathogens
Bloodstream infection	Bacteremia may have serious outcomes
Infective endocarditis	A significant cause of valve infection
Immunosuppressed hosts	Increased risk, particularly after transplantation

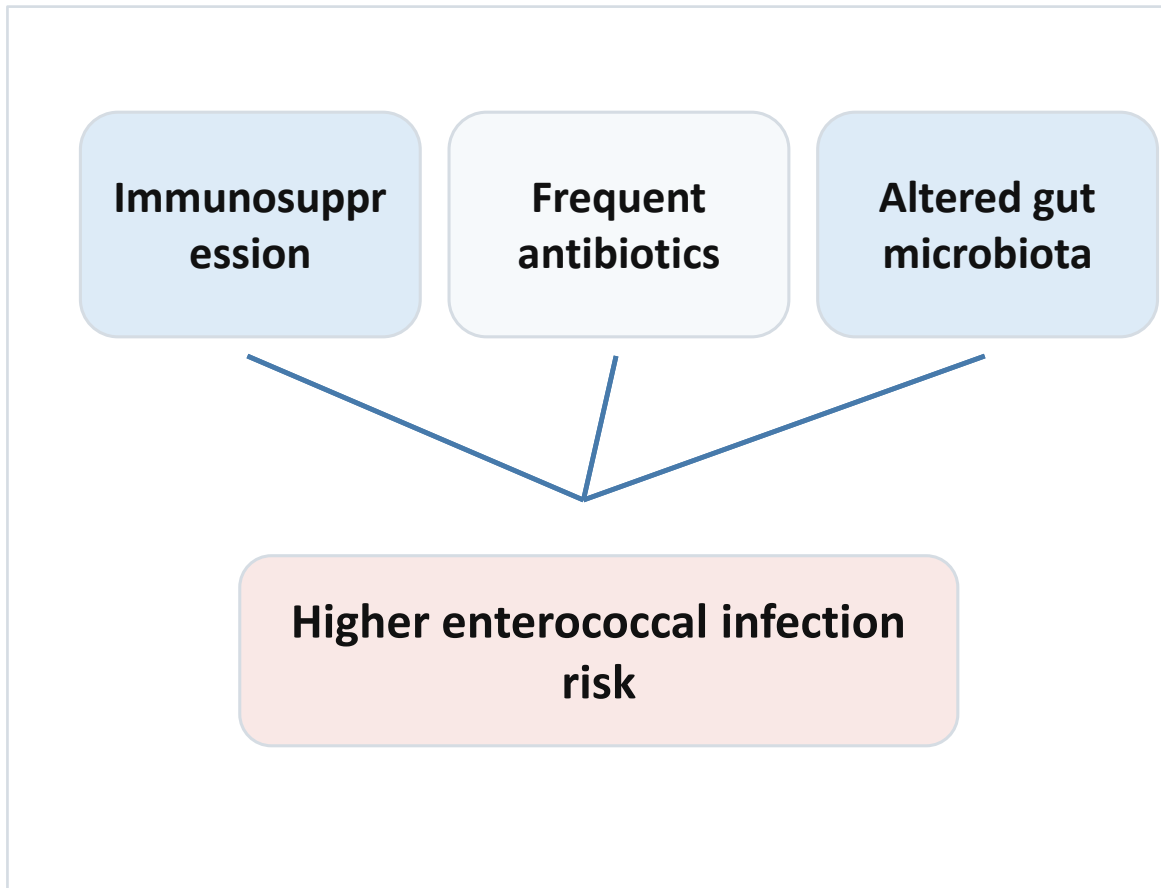
Enterococcal biofilm: Persistence on a surface



- An antiphagocytic capsule contributes to biofilm formation.
- Adherent communities support persistent colonization.
- Tissue-damaging enzymes contribute to host injury.

Schematic — not an authentic clinical or histologic specimen

Transplant recipients: Converging infection risks



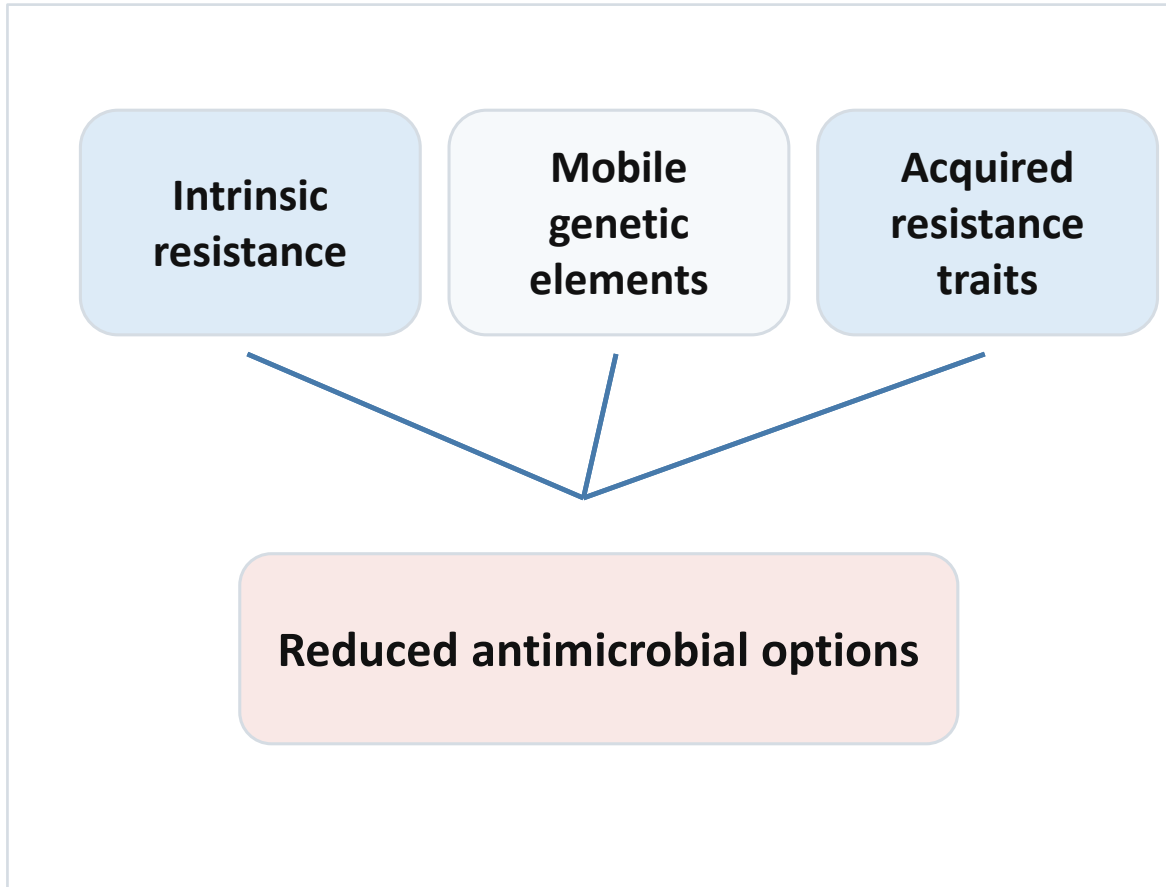
- Immunosuppression impairs host defense.
- Frequent antimicrobial exposure selects altered microbial communities.
- Changes in commensal microbiota coexist with enterococcal infection risk.

Schematic — not an authentic clinical or histologic specimen

Enterococcal pathogenicity is not mainly exotoxin driven

Streptococcal strategy	Enterococcal strategy
Pyrogenic exotoxin / pneumolysin	No comparable toxin repertoire in Robbins account
Capsular immune evasion	Antiphagocytic capsule and biofilm
Immune complications after group A infection	Persistence and antimicrobial resistance
Species-specific tissue injury	Tissue-damaging enzymes

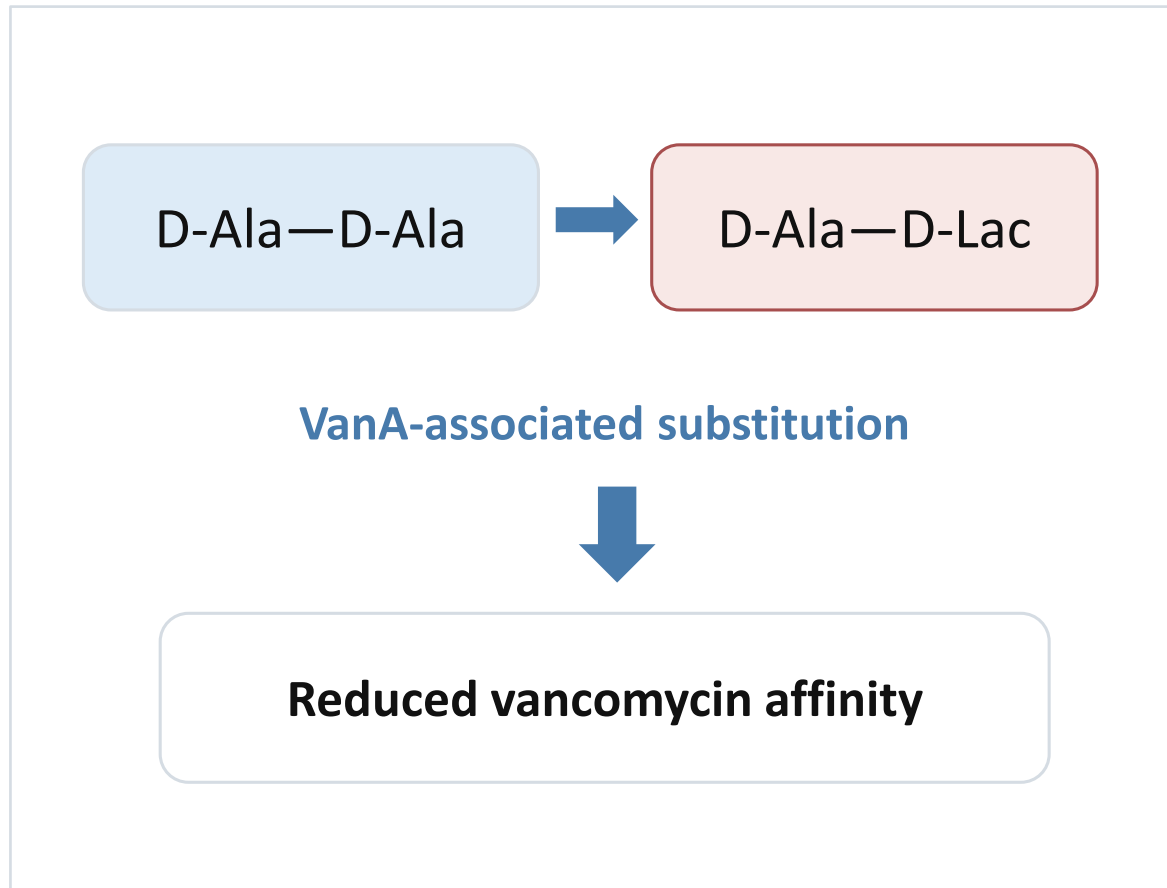
Intrinsic and acquired resistance coexist



- Enterococci have intrinsic resistance to several antibiotic classes.
- Additional resistance can be transferred on mobile genetic elements.
- Both mechanisms contribute to difficult-to-treat infection.

Schematic — not an authentic clinical or histologic specimen

VanA changes the vancomycin binding target



- VanA-associated resistance alters the cell-wall peptide terminus.
- D-Ala—D-Ala is replaced by D-Ala—D-Lac.
- The altered terminus has reduced affinity for vancomycin.

Schematic — not an authentic clinical or histologic specimen

VanA mechanism: Molecular cause and consequence

Step	Cell-wall precursor	Vancomycin consequence
Usual target	D-Ala–D-Ala	High-affinity binding target
vanA-associated alteration	D-Ala–D-Lac	Reduced vancomycin binding
Phenotypic effect	Modified precursor is used	Resistance mechanism

Resistance is not a species identification test

- E. Faecalis and E. Faecium both require organism-level identification.
- Resistance phenotype must be determined separately from Gram morphology.
- Antimicrobial-resistance mechanisms are clinically consequential but do not define the inflammatory lesion.

Laboratory logic: Choose samples by syndrome

Syndrome	Diagnostic direction	Key caution
Streptococcal pharyngitis	Culture or rapid group A antigen test	A clinical rash alone is insufficient
Pneumonia	Respiratory specimens; selected blood cultures	Colonization can confound sputum
Suspected endocarditis	Blood culture and cardiac imaging	Requires clinicopathologic integration
Enterococcal infection	Culture with species and susceptibility	Morphology alone is nonspecific

Clinicopathologic application: Pharyngitis plus rash

Case

A school-age child develops pharyngitis and fever, followed by a fine punctate erythematous eruption and relative circumoral pallor.

Which virulence factor links the infection to the systemic rash?

Discuss before revealing the explanation in speaker notes

Clinicopathologic application: Delayed renal syndrome

Case

A child has hematuria and edema several weeks after a sore throat. Kidney biopsy shows endocapillary neutrophils and granular immunodeposits.

What explains the delay and glomerular injury?

Discuss before revealing the explanation in speaker notes

Clinicopathologic application: A transplant recipient

Case

An immunosuppressed stem-cell transplant recipient develops a culture-confirmed enterococcal bloodstream infection despite repeated antibiotic courses.

What two source-supported factors favor this setting?

Discuss before revealing the explanation in speaker notes

Final diagnostic contrasts

Entity	Mechanism / hallmark	Important consequence
Group A streptococcus	Pyogenic + toxin + immune sequelae	Erysipelas, scarlet fever, RF, GN
Group B streptococcus	Genital colonization; capsule	Maternal / neonatal invasive disease
Pneumococcus	Capsule + pneumolysin	Pneumonia and meningitis
Viridans / S. mutans	Oral flora, glucans, acid	Endocarditis or caries
Enterococci	Biofilm + antibiotic resistance	Healthcare-associated infection

Take-home synthesis

- Streptococcal syndromes range from local suppuration to toxin-mediated and delayed immune injury.
- Organism identity, anatomic site, and virulence mechanism jointly predict the tissue lesion.
- Enterococcal disease is distinguished by gut origin, healthcare exposure, biofilm, and resistance.
- A schematic teaches mechanism; Microbiologic assays and true specimens establish diagnoses.

Primary reading

- Robbins, Cotran & Kumar. Pathologic Basis of Disease. 11th edition (2026).
- Topic section: Streptococcal and Enterococcal Infections.
- Relevant discussions of rheumatic heart disease, postinfectious glomerulonephritis, pneumonia, and infective endocarditis.
- Related organ-system chapters clarify cardiac, pulmonary, renal, and oral manifestations.