Course: Medical Microbiology, PAMB 650/720 2009/2010

Lecture 46: *Streptococcus pneumoniae* and Staphylococci (Gram positive cocci)

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Suggested reading: Murray, 6th Edition *S. pneumoniae* (Chapter 21) *Staphylococcus* (Chapter 22)

S. pneumoniae
- diplococci
- Pneumococcus
- autolysin
- bile solubility test
- C polysaccharide
- optochin susceptibility
- capsule
- Quellung reaction

Staphylococcus aureus (MRSA)
- opportunistic diseases
- food poisoning/enterotoxins
- toxic shock syndrome
- toxic shock toxin
- exfoliative toxin/scalded skin syndrome
- α, β, γ and δ cytotoxins
- leucocidin
- lipase
- hyaluronidase
- protein A
- coagulase positive or coagulase negative
- *Staphylococcus epidermidis*

S. pneumoniae (The Pneumococcus)

Pairs of cells on Gram stain (diplococci). The organism is commonly found in the normal flora (as a harmless carrier) of the upper respiratory tract. After "damage" to the upper respiratory tract (e.g. following viral infection) the organism multiplies and spreads to the lungs. It is the leading cause of pneumonia in all ages (particularly the young and old). Also causes middle ear infections (otitis media) in the young. The organism often spreads causing bacteremia and meningitis. *S. pneumoniae is* α hemolytic and there is no group antigen (compare with preceding streptococcus lecture).

Direct Gram staining or detection of capsular antigen (e.g. in spinal fluid) is diagnostic but of limited sensitivity. The organism grows well on sheep blood agar.

Autolysin: Pneumococci are identified by solubility in bile. An autolysin (peptidoglycan degrading enzyme) is released by bile from the cell membrane (from the lipoteichoic acid) and binds to a choline-containing teichoic acid attached to the peptidoglycan. The autolysin then digests the bacterial cell wall resulting in lysis of the cell. The teichoic acid is sometimes referred to as C polysaccharide since it precipitates a serum globulin fraction present in inflammatory states (C-reactive protein).

The organisms are also identified by susceptibility to optochin.

The Capsule is highly prominent in virulent strains and its carbohydrate antigens vary greatly in structure among strains. The capsule is anti-phagocytic and immunization is primarily against the capsule. A capsular vaccine is highly recommended for susceptible individuals (e.g. young children and the elderly). Immunity is serotype-specific, thus the vaccine consists of a mixture of capsular antigens. Using appropriate type-specific anti-sera the capsule on isolated bacteria can be "fixed" and becomes visible microscopically (the Quellung reaction) which is useful in microbial identification.

The organism also produces pneumolysin that degrades red blood cells under aerobic conditions (observed as α hemolysis).

Complement activation by teichoic acid may explain the attraction of large numbers of inflammatory cells to the focal site of infection.

Most strains of *S. pneumoniae* are susceptible to penicillin. However, resistance is quite common. Vancomycin is one alternative.

STAPHYLOCOCCI

Facultative anaerobes, Gram positive, occur in grape like-clusters and are catalase positive. The organisms are major constituents of the normal flora of skin and nares.

Staphylococcus aureus

S. aureus is one of the commonest causes of opportunistic infections (acquired in both the community and hospital) and including pneumonia, osteomyelitis, septic arthritis, bacteremia, endocarditis, abscesses/boils and other skin infections.

Food poisoning: The food becomes contaminated with the organism from human contact, grows and produces enterotoxin. The organism does not "infect" on ingestion of food. Thus onset and recovery both occur within a few hours. Vomiting, nausea, diarrhea and abdominal pain are seen.

Toxic shock syndrome particularly (after super-tampon use which is now off the market); includes fever, rash, desquamation, vomiting, diarrhea; toxic shock toxin involved. The organism does not disseminate. However, the toxin does disseminate and is responsible for the clinical features.

Both enterotoxin and toxic shock toxin are super-antigens (see streptococci).

Exfoliative toxin causes scalded skin syndrome in babies.

Identification:
β hemolytic on sheep blood agar
Mannitol fermentation
Golden pigmented (aureus) - often
Coagulase-positive
Phage-typing is rarely used nowadays.

As noted above *S. aureus* causes a number of different disease entities associated with production of certain exotoxins. In addition to these "disease-specific" exotoxins other cell lytic exotoxins (α, β [sphingomyelinase C], γ and δ toxins and leucocidins) may be produced. Also some tissue-degrading enzymes may be involved in spreading (e.g. lipase and hyaluronidase).

Free protein A binds to immunoglobulin and complement blocking Fc and complement receptors and is thus anti-phagocytic.

Staphylococcus epidermidis

Less common cause of opportunistic infections than *S. aureus*, but still significant, mediator of nosocomial infections (e.g. catheters, shunts) and artificial heart valves/joints. *S. epidermidis* is a major member of the skin flora and thus commonly a contaminant of cultures.

Identification:
Non-hemolytic on growth on sheep blood agar
Does not ferment mannitol
Non-pigmented
Coagulase-negative

Staphylococcus saprophyticus

S. saprophyticus is a significant cause of urinary tract infections. Also coagulase-negative and not usually differentiated from *S. epidermidis* in the clinical microbiology laboratory.

Antibiotic therapy: Staphylococci (including both coagulase positive and coagulase negative organisms) can produce a phage-coded penicillinase that degrades beta lactam antibiotics. Some strains of *S. aureus* also have modified penicillin binding proteins; thus other β lactam antibiotics (including methicillin) are often ineffective – referred to as MRSA (methicillin-resistant *S. aureus*). Vancomycin is currently the drug of choice.

Summary Figure (Identification Scheme)