PNEUMOCOCCUS

BY SURAJ DHARA, MMCH

Scientific Classification
Kingdom: Bacteria / Phylum: Firmicutes /
Class: Diplococci / Order: Lactobacillales /
Family: Streptococcaceae /
Genus: Streptococcus

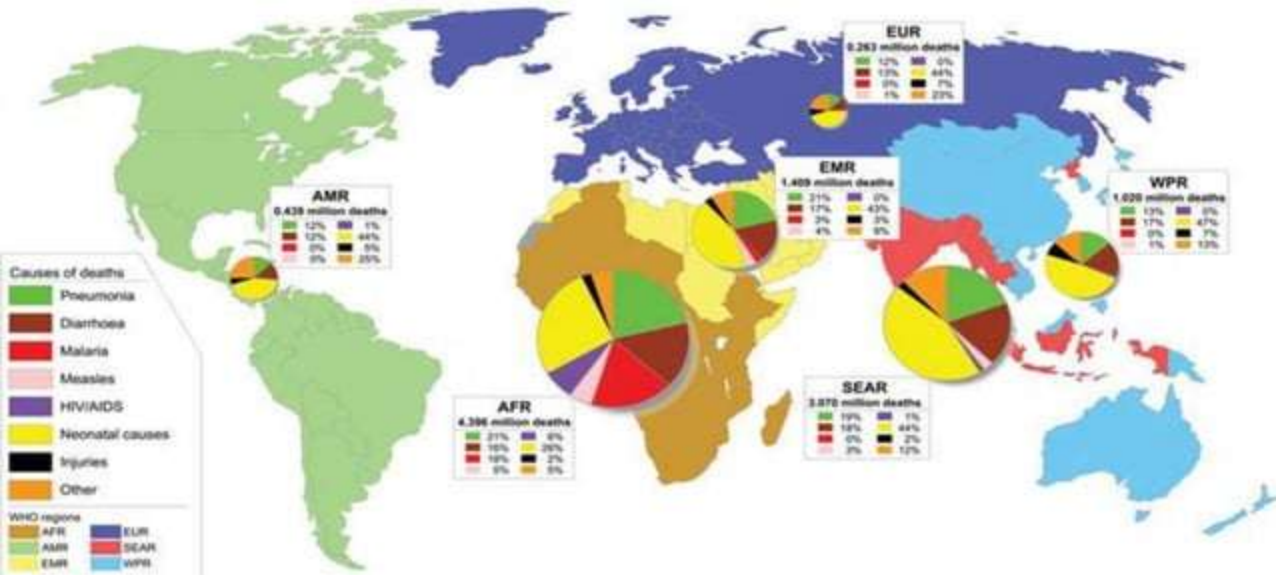
Binomial name:

Streptococcus pneumoniae

In 1881, the organism, then known as the pneumococcus for its role as an etiologic agent of pneumonia, was first isolated simultaneously and independently by the U.S Army physician George Sternberg and the French chemist Louis Pasteur.

Impact of Pneumonia in the World

Fig. 1. Distribution of deaths from pneumonia and other causes in children aged less than 5 years, by WHO regions.



Source: WHO. 2000. Epidemiology and etiology of childhood pneumonia

Streptococcus pneumoniae

- 5-40% normal inhabitants of upper respiratory tract; 40-70% of humans are natural carriers; 60% of all bacterial pneumonia
- Types of Pneumococci
  - Types 1- 8: adults
  - Types 6,14,19,23: children
- Predisposing factors:
  1. Viral & other respiratory tract infections
  2. Alcohol or drug intoxication
  3. Abnormal circulatory dynamics
  4. Other mechanisms: malnutrition, general debility, sickle cell anemia, hyposplenism, nephrosis or complement deficiency

Streptococcus pneumoniae

A. Morphology

1. Encapsulated, spherical, ovoid, lancet-shaped cocci
2. Size: 0.5-1.25 µm
3. Orientation: pairs or chains (length depends on environmental conditions)
4. Gram-stain: POSITIVE
   - Old cultures: NEGATIVE

Streptococcus pneumoniae

A. Gram-positive bacteria
B. 90 known serotypes
C. Polysaccharide capsule important virulence factor
D. Type-specific antibody is protective

Streptococcus pneumoniae

A. Morphology

5. Ultrastructure

- Similar to other gram-positive organisms
- Lipid bilayer surrounded by rigid cell wall composed of peptidoglycan & teichoic acid, which contains the determinant for C polysaccharide antigenic activity
- Teichoic acid contains **AMINO ALCOHOL CHOLINE** (regulatory ligand)
- Plasma membrane contains choline-containing teichoic acid which carries the F antigen

Streptococcus pneumoniae

B. Physiology

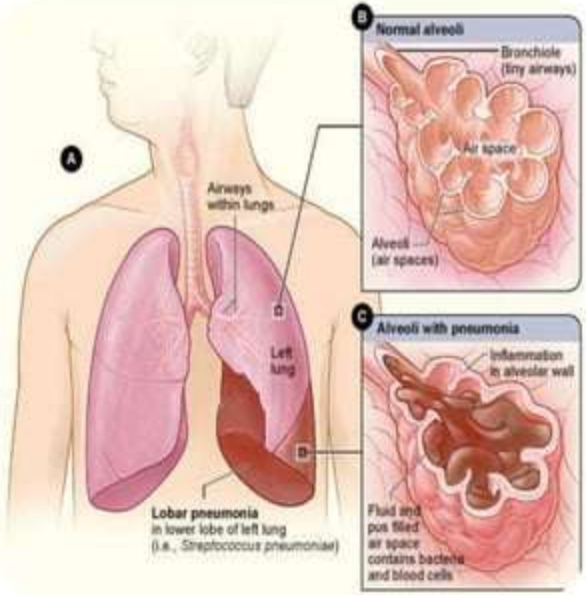
1. Cultural characteristics
   - i. Facultative anaerobe
   - ii. Optimal Growth pH: 7.4-7.8
   - **iii. CHOLINE**: absolute nutritional requirement
   - iv. Culture Media: brain heart infusion enriched with 5% defibrinated blood
     - Young cultures of encapsulated pneumococci produce circular, glistening, dome-shaped colonies 1 mm in diameter; later center of colonies collapse
     - Unencapsulated strain produce rough colonies

Pneumococcal Disease Clinical Syndromes

A. Pneumonia

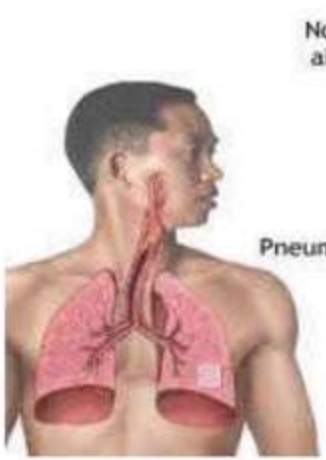
B. Bacteremia

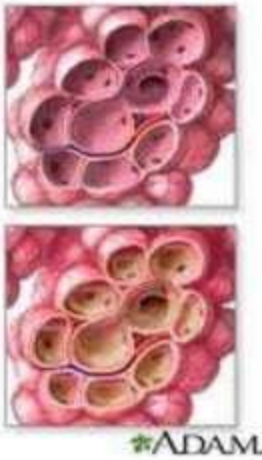
C. Meningitis



Pneumococcal Pneumonia
Clinical Features

A. Abrupt onset
B. Fever
C. Shaking chill
D. Productive cough
E. Pleuritic chest pain
F. Dyspnea, tachypnea, hypoxia





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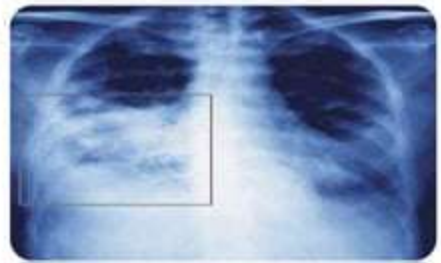
Pneumococcal Disease in Children

A. Bacteremia without known site of infection most common clinical presentation

B. *S. pneumoniae* leading cause of bacterial meningitis among children <5 years of age

C. Common cause of acute otitis media

Streptococcus pneumoniae



- **CLINICAL MANIFESTATION**

1. Pulmonary infections
   - i. URTI (sinusitis, otitis media)
   - ii. Pneumonia
   - iii. Complications: Pleural effusion, empyema
2. Extra-pulmonary Infections (complications)
   - i. Meningitis, brain abscess
   - ii. Pericarditis, Endocarditis
   - iii. Bacteremia
   - iv. Osteomyelitis, septic arthritis, cellulitis
   - v. Peritonitis

Pneumococcal Disease

Epidemiology

A. Reservoir — Human carriers

B. Transmission — Respiratory
"Autoinoculation“

A. Temporal pattern — Winter and early spring

B. Communicability — Unknown
Probably as long as organism in respiratory secretions

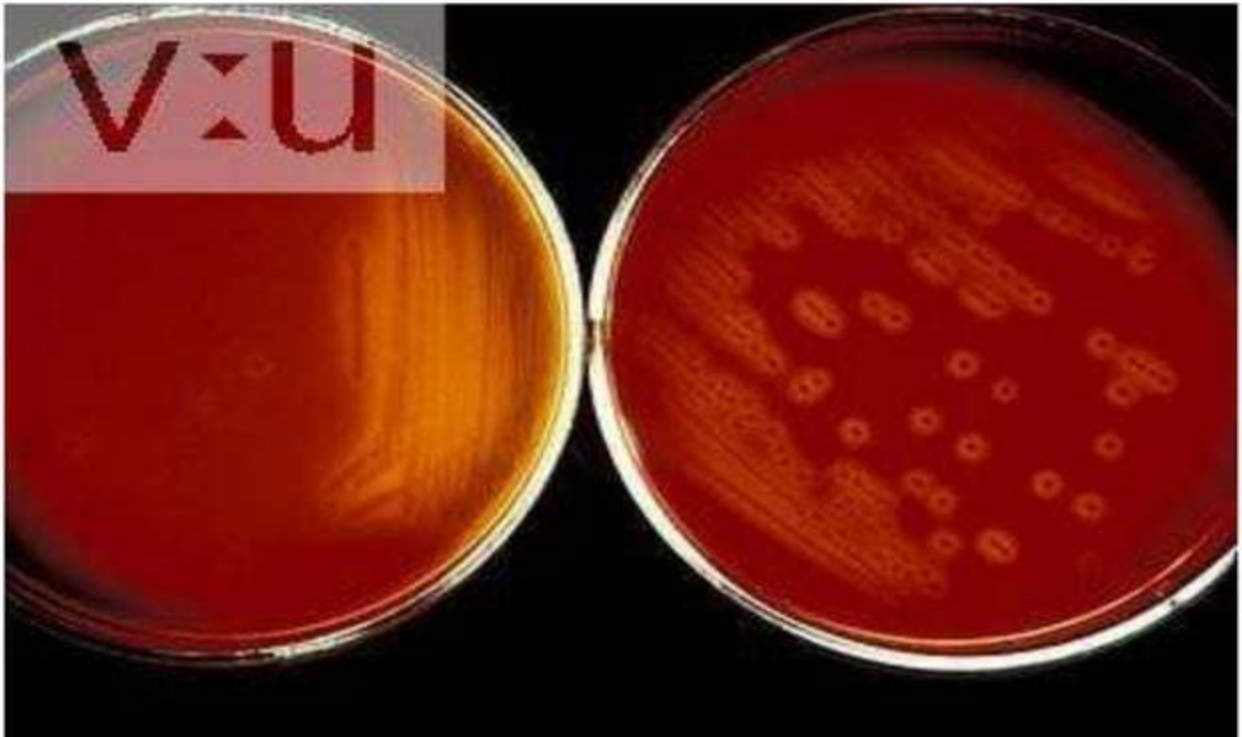
Children at Increased Risk of Invasive Pneumococcal Disease

A. Functional or anatomic asplenia, especially sickle cell disease
B. HIV infection
C. Alaskan native, Native American, African American
D. Day care attendance

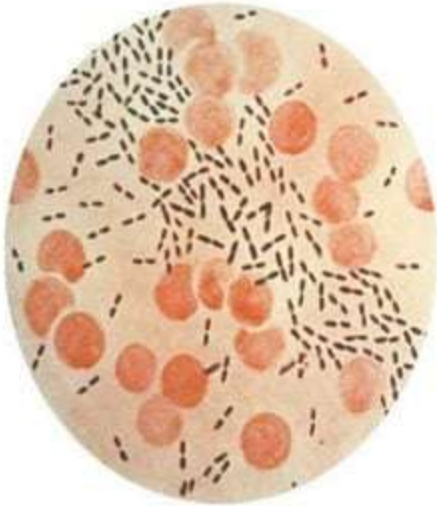
Pneumococcal Disease Outbreaks

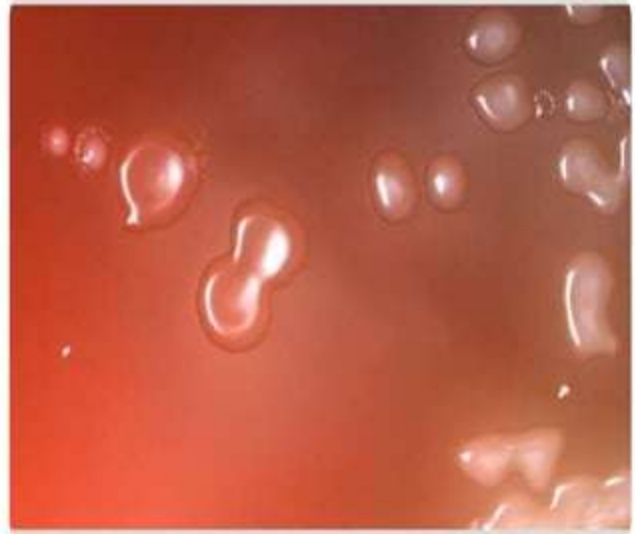
A. Outbreaks uncommon
B. Generally occur crowded environments (jails, nursing homes)
C. Persons with invasive disease often have underlying illness
D. May have high fatality rate

Streptococcus pneumoniae



Pneumococcus





Streptococcus pneumoniae

B. Physiology

2. Metabolism

i. Facultative anaerobe

- Catalase-negative: accumulation of hydrogen peroxide kills microorganism in culture medium

ii. Carbohydrate fermentation yields lactic acid, hydrogen peroxide, acetic & formic acids

- Aerobic incubation produce zone of alpha hemolysis
- Anaerobic incubation: produce zone of beta hemolysis

Streptococcus pneumoniae

CATALASE NEGATIVE

1. 2 H202 → 2 H20 + 02
2. Differentiates *Staphylococcus* from *Streptococcus*

Streptococcus pneumoniae

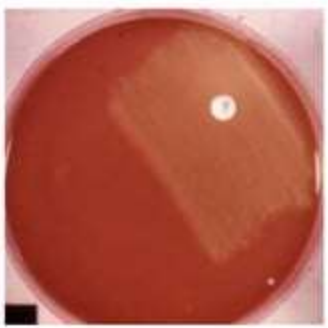
B. Physiology

3. Laboratory Identification

   OPTOCHIN TEST (ethylhydrocupreine HCl)

   - Inhibits growth of pneumococci but not viridans

Optochin positive



Optochin negative

Streptococcus pneumoniae

B. Physiology

3. Laboratory Identification

BILE SOLUBILITY TEST

- Bile or bile salts (surface-active agents) activate an autolytic AMIDASE which cleaves the bond between alanine & muramic acid in the peptidoglycan resulting in lysis of microorganism
- Amidase is present in pneumococcus but not in viridans streptococci

Streptococcus pneumoniae

B. Physiology

3. Laboratory Identification

(Neufeld) QUELLUNG (capsular precipitation) REACTION

- Most rapid & most useful: identifies & specifies type of pneumococci in sputum, spinal fluid, exudates, or culture
- Pneumococcal specimen mixed with (polyvalent) antipneumococcal serum & methylene blue:
  - Positive result: refractile & swollen capsules on oil immersion

Streptococcus pneumoniae

Streptococcus pneumoniae

B. Physiology

3. Laboratory Identification

ANIMAL INOCULATION

- Fatal infection within 16-48 hours to mice injected intraperitoneally with sputum infected with pneumococci
- For experimental purposes

Streptococcus pneumoniae

C. Antigenic Structure

1. Capsular antigens

i. Forms hydrophilic gels on the surface of microorganisms

ii. Antigenicity produces immunity

iii. Basis for separation of serotypes

iv. Cross-reactions with other bacteria due to common polysaccharide N-acetyl-D glucosamine

Streptococcus pneumoniae

C. Antigenic Structure

2. Somatic antigens

i. C polysaccharide (species-specific)

- Major cell wall structural component
  - Teichoic acid polymer with phosphocholine (major antigenic determinant), galactosamine, glucose, phosphate, ribitol & trideoxydiaminohexose
  - Phosphocholine responsible for agglutination of pneumococci
- C polysaccharide binds with C reactive protein to activate complement-mediated phagocytosis

Streptococcus pneumoniae

C. Antigenic Structure

2. Somatic antigens

ii. F or FORSSMANN Antigen

- Lipoteichoic acid consisting of C polysaccharide covalently linked to lipids
- Inhibits N-acetyl-L-alanine amidase

iii. M protein

Streptococcus pneumoniae

D. Determinants of Pathogenicity

1. Polysaccharide Capsule (91 types)
   - antiphagocytic capability by inhibiting C3b opsonization of the bacterial cells
2. Choline binding protein A/Pneumococcal surface protein A (CbpA/PspA) - Adhesins
   - Attachment to mucosal surface by attaching with N-acetyl-galactose
3. Enzymes
   a) Neuraminidase: cleaves terminal N-acetylneuraminic acid to invade nasopharynx
   b) Proteases: degrades IgG, IgM & secretory IgA

Streptococcus pneumoniae

D. Determinants of Pathogenicity

4. Toxins

a) Pneumolysin O (Ply)

- A 53-kDa protein that is cytolytic to eukaryotic cells that have cholesterol as a component of their cell membranes particularly the respiratory epithelium; also activates complement

b) Autolysin (LytA)

- Causes lysis of pneumococci in the presence of surface-active agents or antimicrobials that inhibit cell wall synthesis
- Release toxic proteases

5. Cell wall components

- **Teichoic acid** & **peptidoglycan** beneath the capsular polysaccharide

Streptococcus pneumoniae

D. Determinants of Pathogenicity

6. Hydrogen peroxide –

- causes damage to host cells (can cause apoptosis in neuronal cells during meningitis) and has bactericidal effects against competing bacteria (Haemophilus influenzae, Neisseria meningitidis, Staphylococcus aureus)

7. Pili –

- hair-like structures that extend from the surface
- contributes to colonization of upper respiratory tract and increase the formation of large amounts of TNF by the immune system during sepsis, raising the possibility of septic shock

Streptococcus pneumoniae

E. Laboratory Diagnosis

1. Direct examination of Sputum
   - Gram-stain (PRESUMPTIVE DIAGNOSIS)
2. Culture
   - Appearance of α-hemolytic colonies that are bile soluble & optochin sensitive & positive Quellung reaction: (if typing sera is available - simplest, most rapid & accurate)

Streptococcus pneumoniae

E. Laboratory Diagnosis

3. Serologic Diagnosis
   - i. Detection of pneumococcal antibodies
     - radioimmunoassay
   - ii. Detection of capsular polysaccharide
     - counterimmunoelectrophoresis

Streptococcus pneumoniae

- **MANAGEMENT**
  - CHEMOTHERAPY:
    - Based on sensitivity teating
    - DOC: IM PCN G (uncomplicated pneumonia) OR oral PCN V (milder URTI)
    - PCN-allergic alternatives: cephalosporin or erythromycin (pneumonia),chloramphenicol (meningitis), quinolones
  - **PREVENTIVE:**
    - **Pneumococcal conjugate vaccine for high-risk cases**

Pneumococcal Vaccines

A. 1977 14-valent polysaccharide vaccine licensed

B. 1983 23-valent polysaccharide vaccine licensed

C. 2000 7-valent polysaccharide conjugate vaccine licensed

Pneumococcal Polysaccharide Vaccine

A. Purified capsular polysaccharide antigen from 23 types of pneumococcus
B. Account for 88% of bacteremic pneumococcal disease
C. Cross-react with types causing additional 8% of disease

Pneumococcal Conjugate Vaccine

A. Polysaccharide conjugated to nontoxic diphtheria toxin (7 serotypes)
B. Vaccine serotypes account for 86% of bacteremia and 83% of meningitis among children <6 years

Pneumococcal Polysaccharide Vaccine

A. Purified pneumococcal polysaccharide **(23 types)**
B. Not effective in children <2 years
C. 60%-70% against invasive disease
D. Less effective in preventing pneumococcal pneumonia

Pneumococcal Polysaccharide Vaccine Recommendations

A. Adults ≥65 years of age
B. Persons ≥2 years with
   1. chronic illness
   2. anatomic or functional asplenia
   3. immunocompromised (disease, chemotherapy, steroids)
   4. HIV infection
   5. environments or settings with increased risk

Pneumococcal Conjugate Vaccine

A. Routine vaccination of children age <24 months and children 24-59 months with high risk medical conditions
B. Doses at 2, 4, 6, months, booster dose at 12-15 month
C. Unvaccinated children >7 months require fewer doses

Pneumococcal Polysaccharide Vaccine Revaccination

A. Routine revaccination of immuno-competent persons is not recommended

B. Revaccination recommended for persons age ≥2 years at highest risk of serious pneumococcal infection

C. Single revaccination dose ≥5 years after first dose

Pneumococcal Polysaccharide Vaccine Candidates for Revaccination

A. Persons ≥2 years of age with:
   1. Functional or anatomic asplenia
   2. Immunosuppression
   3. Transplant
   4. Chronic renal failure
   5. Nephrotic syndrome

B. Persons vaccinated at <65 years of age

The currently licensed vaccine

A. The polyvalent polysaccharide vaccine contains per dose (0.5 ml) 25 micrograms of purified capsular polysaccharide from each of the 23 capsular types of S. pneumoniae that together account for most cases (90%) of serious pneumococcal disease in Western industrialized countries..

Effectiveness of Current Vaccine

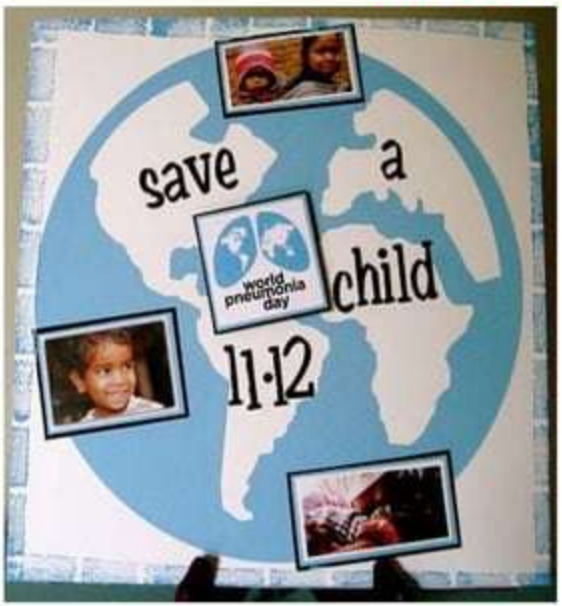
The currently licensed pneumococcal polysaccharide vaccine has been shown to protect adults and children under two years of age against invasive pneumococcal infection, and its use is recommended for adults and children at high risk of pneumococcal disease. Such groups include splenectomised patients and persons with chronic organ failure or sickle-cell disease, and the elderly population

Pneumococcal Vaccines Contraindications and Precautions

A. Severe allergy to vaccine component or following prior dose of vaccine

B. Moderate to severe acute illness

Save the Children from Pneumonia



world pneumonia day

Fight Pneumonia.
Save a Child.

THANK U