

# Bacterial Respiratory Tract Infections

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Respiratory module / 3<sup>rd</sup> year

- Contents:

- Streptococcus pneumoniae* (pneumococcus)

- Haemophilus influenzae* (blood liking bacteria )

# *Streptococcus pneumonia*

45 years old man, smoker.

Sudden onset fever and chills

Shortness of breath and pleuritic chest pain

Productive rusty coloured sputum (blood stained)

Examination:

Vitals: RR 24 (normal 12-16), PR 110 (normal 60-100), T 39,  
B.P normal, O2 Saturation 90% (decreased)

Chest: decreased air entry, dull on percussion, decreased chest expansion

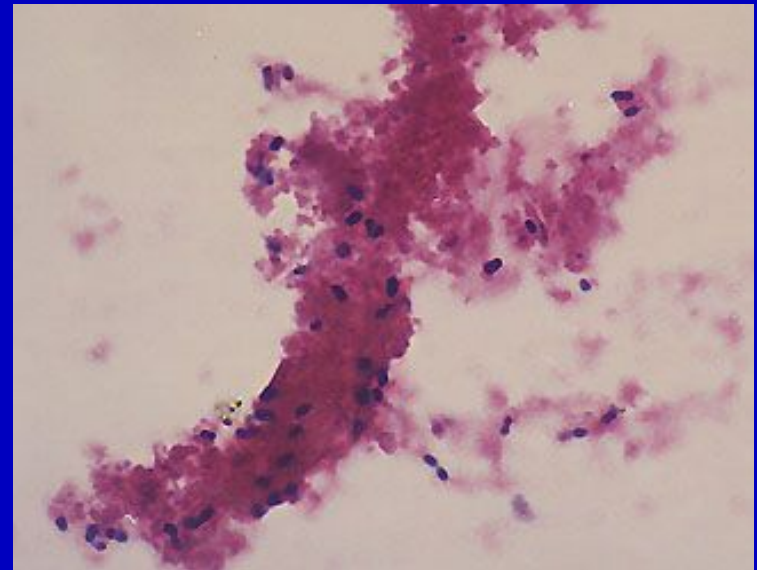
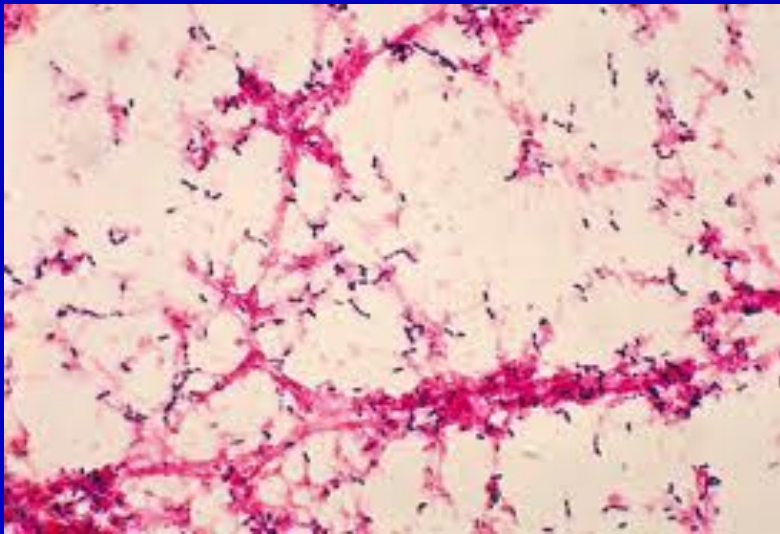
CXR: Right upper lobe consolidation

WBC 16000/mm<sup>3</sup> (normal 4-11) mainly neutrophils

# *Streptococcus pneumoniae*

member of the oropharyngeal flora of 5-70% of the < population, with the highest isolation rate in children during .the winter months

:A *gram positive* diplococci catalase negative



# *Streptococcus pneumoniae*

:An important pathogen <

It primarily causes disease of the upper and lower \*  
respiratory tract

May spread to other sites, such as the joints, peritoneum, \*  
.endocardium, biliary tract and, in particular, the meninges

# *Streptococcus pneumoniae*

- **Virulence factors**

## **1. Capsule**

- The capsular polysaccharide is a crucial virulence factor.
- Antiphagocytic and anticomplement.
- A total of more than 90 different capsular serotypes have been identified.
- About 90% of cases of bacteraemic pneumococcal pneumonia and meningitis are caused by some 23 serotypes.

# *Streptococcus pneumonia*

## 2. Lipotechoic acid and coline binding proteins:

□ Adhesion molecule

## 3. IgA1 protease

- Pneumococci produce an extracellular protease that specifically cleaves human IgA1 in the hinge region.
- This protease enables these pathogens to evade the protective functions of the principal immunoglobulin isotype of the upper respiratory tract.

# *Streptococcus pneumonia*

## 4. Pneumolysin (pore forming toxin)

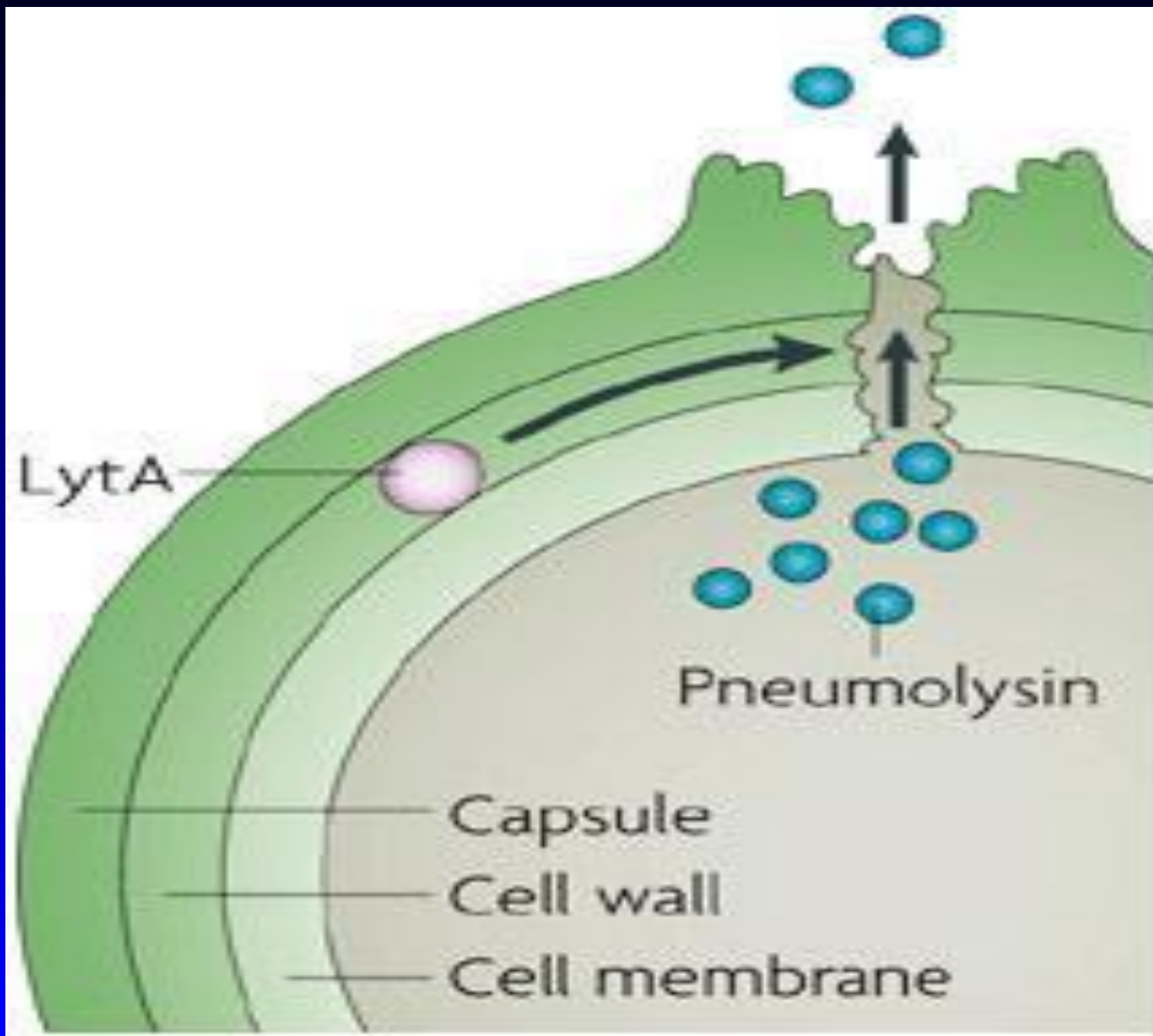
- Pneumococci produce an intracellular membrane-damaging toxin known as pneumolysin, which is released by autolysis.
- Pneumolysin also suppresses organism-targeted immunity (Neutrophils, lymphocyte proliferation and immunoglobulin synthesis).
- Pneumolysin is immunogenic and might be suitable for a new pneumococcal vaccine.

# *Streptococcus pneumonia*

## 5. Autolysin

- When this enzyme activated, the pneumococcal autolysin breaks the peptide cross-linking of the cell wall peptidoglycan, leading to lysis of the bacteria.
- Autolysis:
  - ✓ Enables the release of pneumolysin
  - ✓ Release of peptidoglycans from cell wall leading to massive inflammatory response and sepsis to these peptidoglycan fragments.





# *Streptococcus pneumonia*

- **EPIDEMIOLOGY**

- **Source:**

- Humans are the reservoir of pneumococci, which are commonly found in the upper respiratory tract of healthy persons throughout the world.

- **Occurrence:**

- Pneumococcal infections are among the leading causes worldwide of illness and death for young children, persons who have underlying debilitating medical conditions and the elderly.

# *Streptococcus pneumoniae*

- 1 million deaths yearly worldwide
- 6 million cases of otitis media in USA
- The estimated global annual incidence is 1-3 per 1000 of the population, with a > 5% case fatality rate.
- **Mode of Transmission:**
- Pneumococci are transmitted from person-to-person by droplet spread, by direct oral contact and indirectly through articles freshly soiled with respiratory discharges.

# *Streptococcus pneumonia*

- **Period of Communicability:**
- Communicability associated with respiratory infection likely persists while pneumococci are present in respiratory secretions.
- Healthy persons is the major source of transmission
- Treatment with an antibiotic to which the infecting organism is sensitive can be expected to terminate communicability within 24 hours.
- **Incubation Period:**
- The incubation period varies by type of infection and can be as short as 1-3 days.

# *Streptococcus pneumonia*

## Clinical features:

### ❖ Predisposing factors:

- Most *Str. pneumoniae* infections are associated with various predisposing conditions.
- ✓ Pneumonia results from aspiration of pneumococci contained in upper airway secretions into the lower respiratory tract; for example:  
Loss of consciousness: general anaesthesia, convulsions, alcoholism, epilepsy or head trauma
- ✓ respiratory viral infections, such as influenza, chronic bronchitis.

# *Streptococcus pneumonia*

- ✓ Young and elderly people
- ✓ Immune suppressed people (e.g Chronic diseases, drugs, asplenia)
- ✓ Structural respiratory abnormalities.

# *Streptococcus pneumoniae* / Respiratory Presentation

## 1- Pneumonia (chest infection):

- Pneumonia is defined as an acute respiratory illness associated with recently developed radiological pulmonary shadowing which may be segmental, lobar or multilobar.
- *Str. pneumoniae* is a frequent cause of pneumonia where vaccination is not available.

# *Pneumonia*

- Contiguous spread commonly results in complications such as:
- Inflammatory involvement of the pleura, Empyema and Pericarditis.
- Bacteraemia may complicate pneumococcal pneumonia in up to 15% of patients. This can result in metastatic involvement of the meninges, joints and, rarely, the endocardium.



# *Pneumonia*

- **Signs and symptoms:**
- The patient rapidly becomes more ill with a high temperature (up to 39.5°C), pleuritic pain and a dry cough.
- A day or two later, rusty-coloured sputum is produced
- The patient breathes rapidly and shallowly, the affected side of the chest moves less, and signs of consolidation may be present together with a pleural rub.
- The mortality rate from pneumococcal pneumonia in those admitted to hospital is approximately 15-25%.

# *Streptococcus pneumonia*

- **2- Otitis media and sinusitis**
- Middle ear infections (otitis media) affect approximately half of all children between the ages of 6 months and 3 years
- Approximately one-third of cases are caused by *Str. pneumoniae*. Disease occurs after acquisition of a new strain to which there is no pre-existing immunity.
- The prevalence is highest among children attending primary school, where there is a constant exchange of pneumococcal strains.
- Pain, fever, ear discharge...

## *Streptococcus pneumonia*

Chest X-ray confirms the area of consolidation (lobar), but \*  
;radiological changes lag behind the clinical course

So that X-ray changes may be minimal at the start of the illness. Conversely, consolidation may remain on the chest .X-ray for several weeks after the patient is clinically cured

The chest X-ray usually returns to normal by 6 weeks \*

# *Streptococcus pneumoniae*



# *Streptococcus pneumonia*

## LABORATORY DIAGNOSIS

### Collection of specimens

- Throat swab, pus, blood cultures, expectorates, otitis media discharge or urine according to the site of infection.
- **Blood cultures** are of value in patients with invasive streptococcal infections. This is also the case in patients with suspected pneumococcal pneumonia, particularly when this is severe, as up to 15% of patients are bacteraemic.

# *Streptococcus pneumonia*

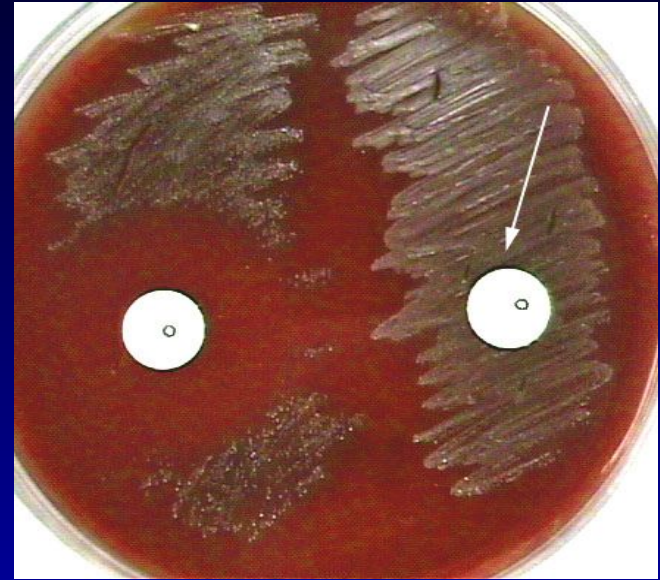
## ❑ Cultivation and identification :

- Blood or chocolate agar , 37°C, 5%CO<sub>2</sub>
- Colonies of pneumococci are α-haemolytic and smooth dome shaped.
- During prolonged incubation, autolysis of bacteria within the flat pneumococcal colonies results in a typical subsidence of the centre (*'draughtsman colonies'*).
- Gram positive cocci in pairs, alpha hemolytic, Catalase negative.
- Optochin sensitive and bile soluble,

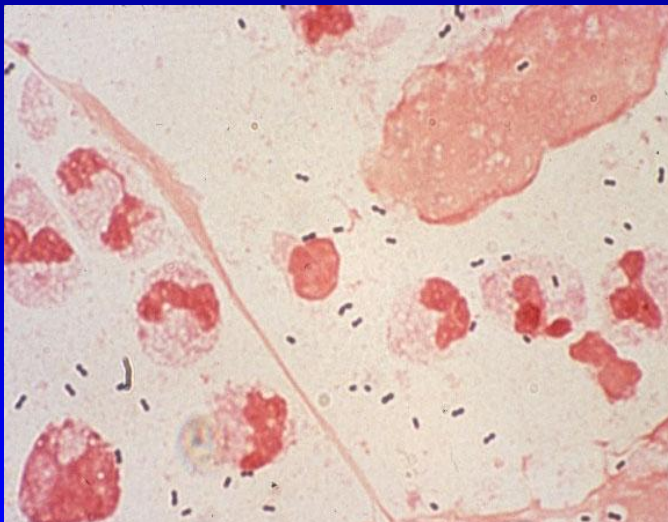
# *Streptococcus pneumoniae*



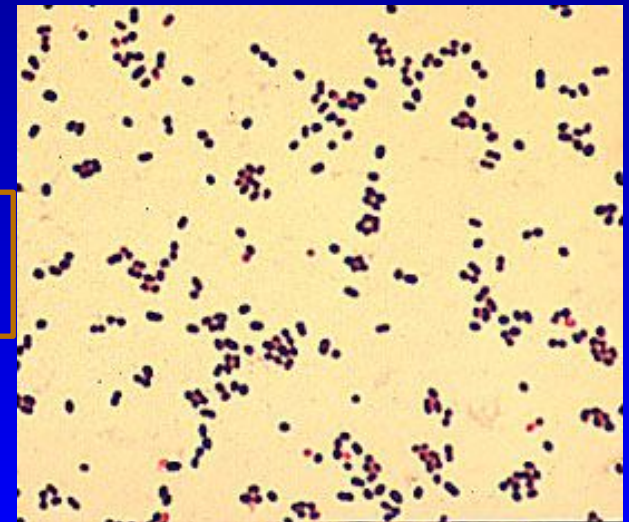
Alpha hemolysis



Optochin sensitive

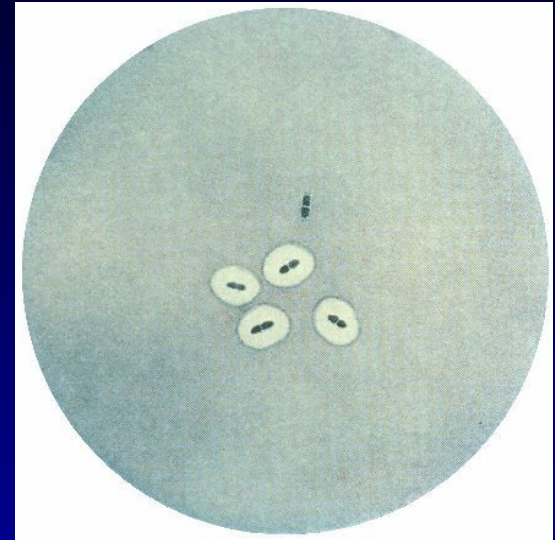


Gram positive  
diplococci



# *Streptococcus pneumoniae*

- Capsule:
- ✓ Typing :



- Pneumococci are typed on the basis of the differences in capsular polysaccharides, of which 90 have been described (in reference lab.
- Mixing a suspension of pneumococci with type-specific antisera increases the visibility of the capsule in the microscope, and is the basis of the *quellung reaction* or *capsular swelling test*.



# *Streptococcus pneumonia*

## □ TREATMENT

- Follow the antibiotic guidelines

## □ Vaccines:

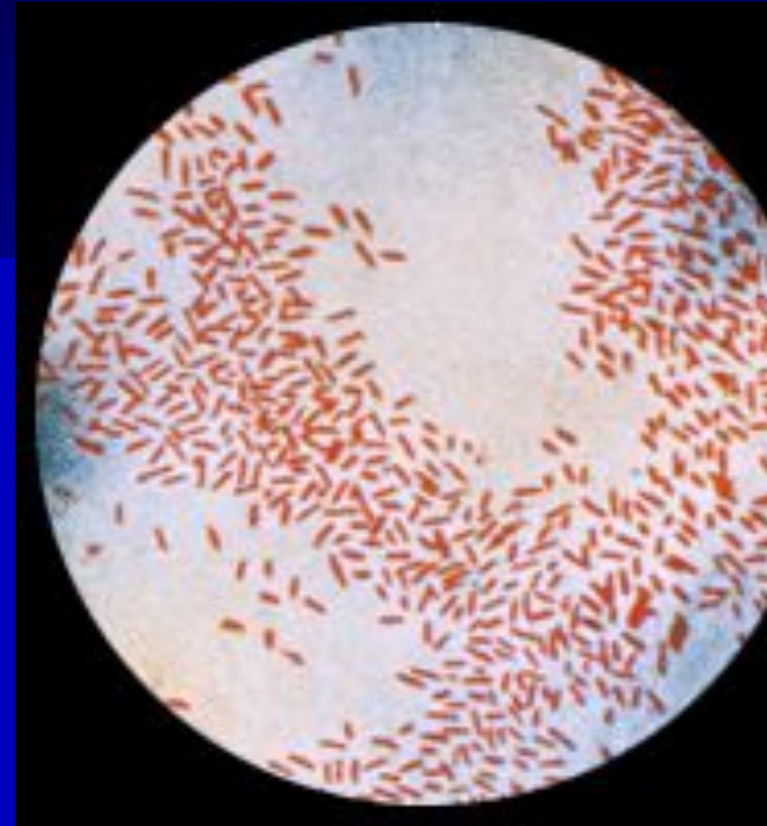
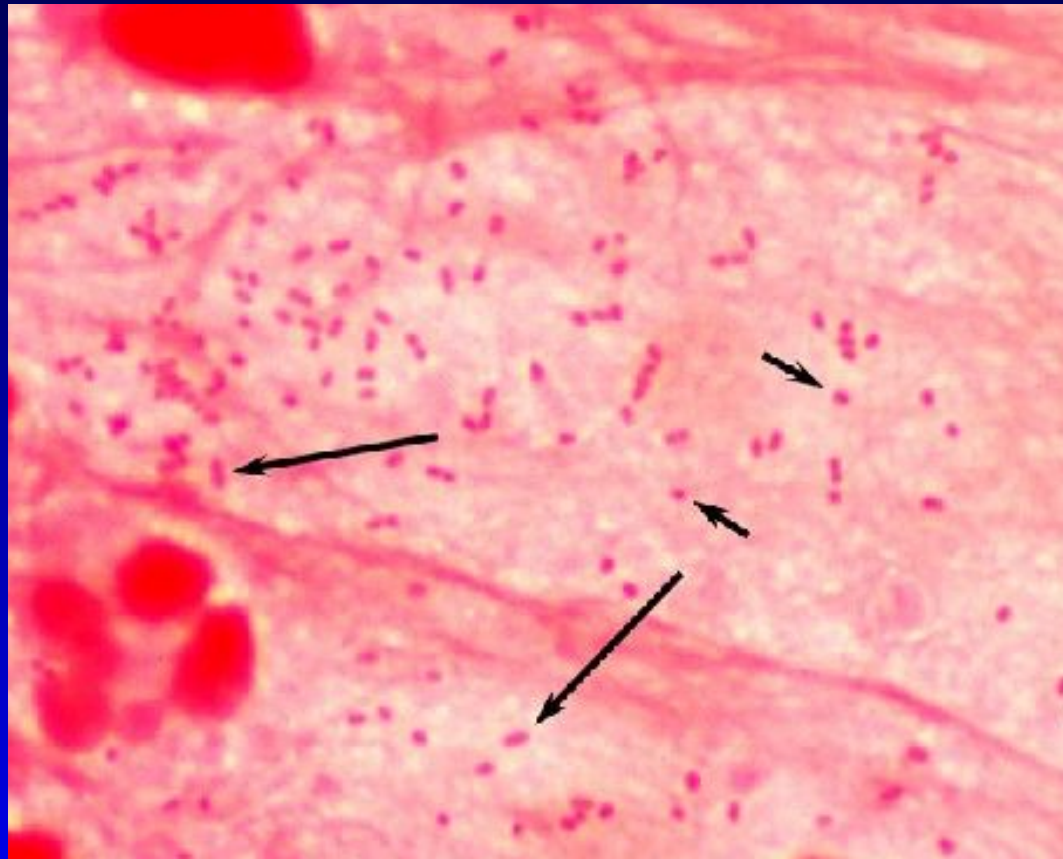
- Protein Conjugated vaccine (PCV): protection for 7-13 ty
- 3 doses for those < 2 years age
- Non-conjugated polysaccharides : 23 polyvalent vaccine > 2 years who are at risk

- *H. influenzae*

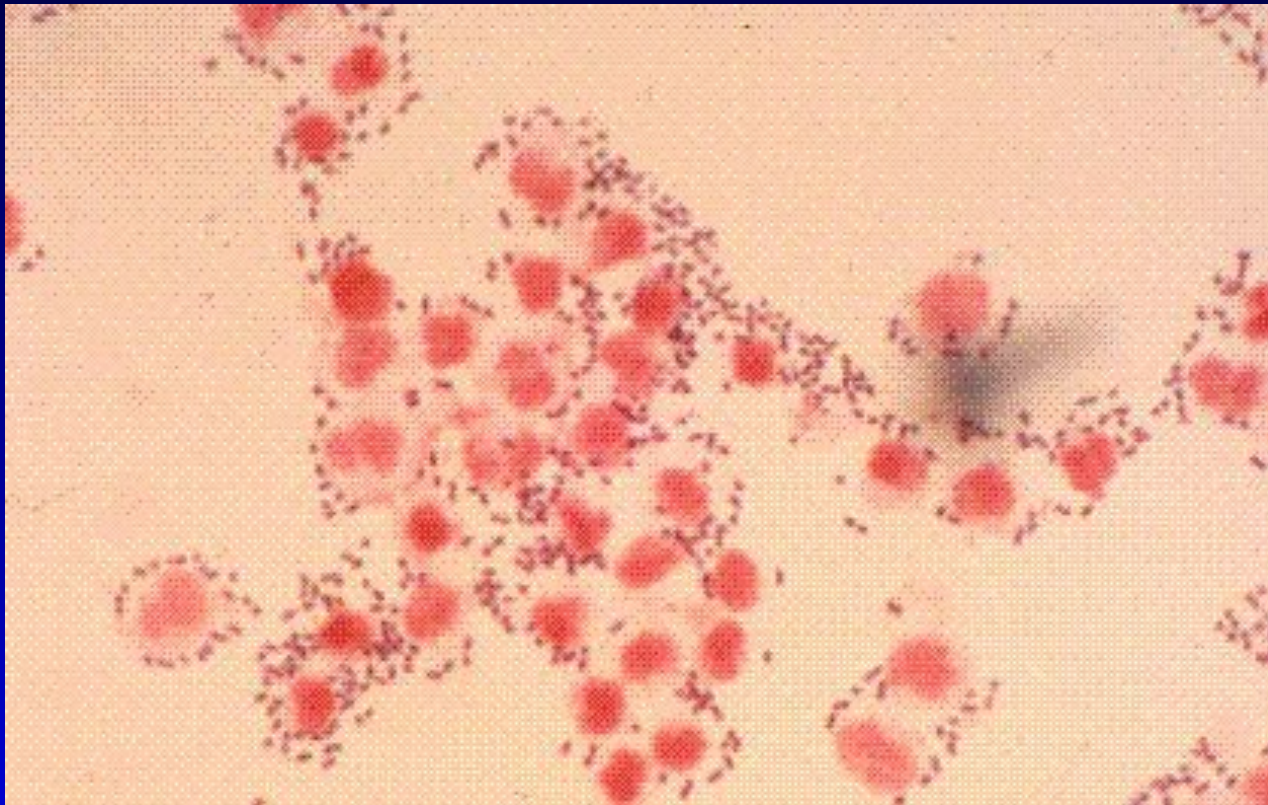
## *H. influenzae*

- Carriage rate in respiratory tract:
  - Capsulated (types A-F):  
10% (50% are type B)
  - Non caps: 80%
- Gram negative small bacilli (old culture) or coccobacilli (young culture)
- Fastidious, Non motile non spore forming
- Catalase and Oxidase positive
- Facultative anaerobic (5% CO<sub>2</sub>)

# *H. influenzae*



# *H. influenzae*



# *H. influenzae*

## Virulence factors:

- 1-Polysaccharides **capsule** (in 10% of strains): inhibits phagocytosis and complement activation
- ✓ six capsular types, designated a-f, which can be identified by a polymerase chain reaction (PCR) method
- ✓ The most important is type b, has a polymer of ribosyl ribitol phosphate capsule.

## *H. influenzae*

- 2- Fimbriae: which assist attachment to epithelial cells
- 3- Immunoglobulin (Ig) A proteases, which are also involved in colonization
- 4- Outer membrane proteins and lipopolysaccharide, which may contribute to invasion at several stages

# *H. influenzae*

- Growth requirements:
- Growth depends on a requirement for two factors, termed X and V (found on chocolate agar):
- ✓ X factor (haemin) is required for the synthesis of cytochrome *c* and other iron-containing respiratory enzymes.

Unlike most bacteria, haemin-dependent haemophili cannot synthesize protoporphyrin

- ✓ V factor is nicotinamide adenine dinucleotide (NAD),
- It is essential for oxidation-reduction processes in cell metabolism.



# *H. influenzae*

## :Clinically

- Host and organism factors?
- Respiratory route – direct and indirect
- Common age: 5m-5years (capsulated) / elderly (mainly non-capsulated)

□ invasive infections and non-invasive infections

### 1- Invasive: (encapsulated types)

Meningitis (50-60%), epiglottitis, pneumonia and septic-arthritis, acute exacerbation of COPD

Commonly caused by encapsulated types mainly serotype b-

# *H. influenzae*

## 2- Noninvasive (Non encapsulated types)

- localized disease of the respiratory tract including bronchitis and otitis media
- Can also sometimes cause invasive diseases mainly pneumonia and bacteremia
- More in elderly
- Is becoming commoner since the admission of Hib vaccine

# *Diagnosis*

History and Examination

Lab:

## Samples:

- Respiratory samples
- Blood for culture in invasive conditions and in epiglottitis
- Blood cultures are usually positive in epiglottitis.
- throat swabs in patients with suspected acute epiglottitis should NOT be carried out, as attempts to obtain the sample may precipitate complete airway obstruction

## *H. Influenzae / diagnosis*

- The viability of *H. influenzae* in clinical specimens declines with time, particularly at 4°C > immediate transfer

### 1. Antigen detection

- The detection of type b polysaccharide antigen in body fluids or pus is useful, particularly in patients who received antibiotics before specimens were obtained.
- A rapid latex agglutination test with rabbit antibody to type b polysach. Capsular antigen is used most commonly.
- Cross reactivity with *pneumococcus* and *E.coli*

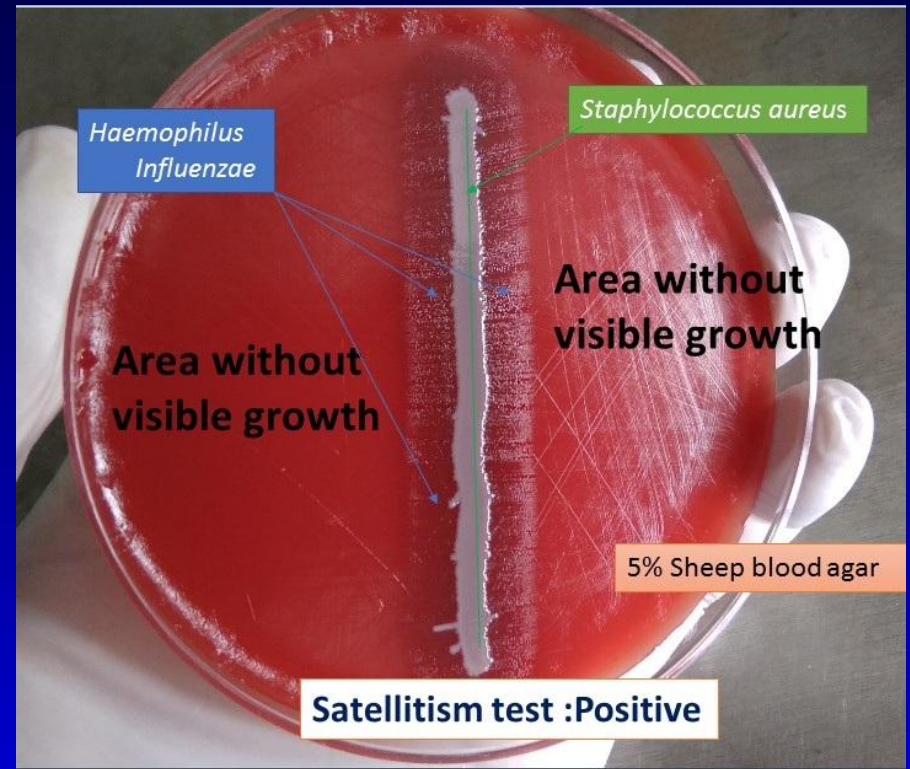
## *H. Influenzae / diagnosis*

2. Culture on chocolate agar - incubate in an aerobic atmosphere enriched with 5-10% carbon dioxide.

(or on blood agar with staph streak - satellitism)

- On chocolate agar the colonies are smooth, mucoid, grey or colorless
- Gram stain: Gram negative CB
- Catalase and oxidase tests are positive
- Antibiotic sensitivity

# *H. Influenzae* / diagnosis



## *H. Influenzae / treatment*

- Untreated invasive infection: Mortality rate of 90%
- Start empirically until you get sensitivity results:

I. Non-invasive: Clav. Acid / Amoxicillin or  
Macrolides orally

(to overcome the beta lactamase production by the bacteria)

II. Invasive: Cephalosporins IV

III. Skilled medical and nursing care is also vital in the management of acute epiglottitis, where maintenance of a patent airway is crucial.

## *H. Influenzae / prevention*

- Conjugate vaccines for type b :
- ✓ polysaccharide capsule is covalently coupled to proteins such as a non-toxic variant of diphtheria toxin or *Neisseria meningitidis* outer membrane protein
- 3 doses separated by a month 2,3,4 months age and a booster at 12 months of age



## *H. Influenzae / prevention*

- Immunization of infants significantly reduces pharyngeal carriage of Hib, but has no effect on the carriage of other capsular types or non-capsulate strains.
- Conjugate Hib vaccine is recommended for children and adults with splenic dysfunction, sickle cells disease, malignancies because they are at increased risk of invasive Hib infection.

## *Other haemophilus*

- H. parainfluenza:
  - ✓ As H. influenza
  - ✓ Usually less serious
  - ✓ Requires factor V only
  
- H. Ducreyi:
  - ✓ Causes sexually transmitted chancroid
  - ✓ Requires factor X only

The End