Bacterial Respiratory Infection (3rd Year Medicine)

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Introduction

• The respiratory tract is the most common site of body exposed for infection by pathogens and opportunistic pathogens.

• RT site becomes infected frequently because it comes into direct contact with the physical environment and is exposed continuously to many microorganisms & their spores in the air.. Smoke, dust & human air droplets.

• It has been calculated that the average individual inhaled & ingests at least 8 microbial cells per minute or 10,000 per day.
Before a *Respiratory Disease* is developed, the following conditions need to be met:

- There must be a **sufficient number** or "dose" of infectious agent inhaled.
- The infectious organism must remain **alive and viable** while in the air.
- The organism must be **deposited on susceptible respiratory mucosa & attached**.
- The infectious agent must **overcome the host immune system**.
- The importance role of normal flora
Fig. 1 Upper Respiratory Tract Infection
Most infections are mixed Viruses plus Bacteria

Common Cold - Rhinoviruses, Coronavirus, Adenoviruses, Myxoviruses, Echoviruses, Coxsackie A and B, Echoviruses, M. pneumoniae, C. pneumoniae

Dental caries - S. mutans
Thrush - C. albicans
Trench mouth - Treponema Vincentii, Fusobacterium fusiforme
Stomatitis - Herpes Simplex Virus

Pharyngitis - Adenovirus, Herpes Simplex Virus, Coxsackieviruses, S. pyogenes, C. diphtheriae

Otitis Media - S. pneumoniae, H. influenzae, M. catarrhalis
Otitis Externa - P. aeruginosa

Sinusitis - S. pneumoniae, H. influenzae

Croup - Parainfluenza viruses, Respiratory Syncytial virus
Epiglottitis - H. influenzae

Whooping Cough - Bordetella pertussis

Bronchitis - Parainfluenza viruses, Respiratory Syncytial virus, Influenza viruses, M. pneumoniae, C. pneumoniae

Bronchiolitis - Respiratory Syncytial Virus
Normal Bacterial Respiratory Flora

- Most of the surfaces of nasopharynx, oropharynx, and trachea) are colonized by normal flora. These organisms are usually normal inhabitants of these surfaces and rarely cause disease (Fig. 1):

- **Common types >10%**: Viridans Streptococci (S. mutans, S. mitis), Neisseria (N. flava, N. sicca) Haemophilus /Parahaemophilus, Corynebacteria, Anaerobic Bacteria (Bacteroides fragilis, Spirochities).

Common Bacteria Agents cause of Upper Respiratory Infections

- **Haemophilus influenzae** type b.: Capsule.. Lipooligosaccharides.. invasive ..Highly susceptible to cold & room and high temperatures .. Autolysis rapidly.

**Clinical Features:** Rare Sore Throat.. Common Otitis – Sinusitis.. Conjunctivitis.. Blood sepsis/ Meningitis.. Children (6 months-5 years), Fig.2, Hib-vaccine.. polysaccharide-protein conjugate vaccine.. combined with diphtheria-tetanus-pertussis and Hepatitis B vaccines.. starting after the age of 6 weeks.

- **Staph. aureus**: All ages.. Sinusitis, Pneumonia Conjunctivitis, Rare Sore Throat.. Blood sepsis.. Rare Meningitis.. Staphylococcal pneumonia is a frequent complication following influenza infection.. Infants, Elderly patients, immunosuppressed.
Fig. 2 Haemophilus influenzae
Gram-stain: G-ve coccobacilli + fimentes
Streptococcus infections

- The genus **Streptococcus** consists of gram-positive cocci, catalase-ve.. Human commensals & opportunistic pathogens Respiratory Tract.. **Beta-H-streptococci group, Viridans Streptococci group**

- Definitive identification of hemolytic pyogenic streptococci types based on the serologic reactivity of cell wall polysaccharide antigens (Lancefield groups).

- The most important groups are A, B,C D, G, F

- **Group A Hemolytic Streptococcus** cause about 10% Pharyngitis-Tonsillitis/Sore Throat.. less Otitis–Sinusitis, Skin in all Children..Virulence factors (Fig-4).

- Complication: Post-streptococcal diseases
**S. pyogenes** (Group A Hemolytic-1)

- **Groups A**: common human pathogens. **beta hemolytic reaction** on blood agar (Fig-3).
- **Group A** is one of the most frequent pathogens of humans. It is estimated that between 5-15% of normal individuals carry this bacterium, usually in the respiratory tract, without signs of disease as normal flora. Healthy Carriers
- **Streptococcal Infections**: Mostly occur in Children < 12 years. Begin as acute Pharyngitis/Tonsillitis. Also infection by contact with infected skin wound. **Strept. Diseases** (Fig-5)
- About 1-3% infected children may develop post-streptococcal complications.
Fig. 3 - Beta-Hemolytic Streptococci
Pathogenesis of Group A-2

- Systemic infections found mostly children. *Strept.virulence* is related to cell structures, enzymes & toxins produced (Fig-5).
- It has ability to colonize and rapidly multiply and spread in host while resist phagocytosis due to the hyaluronic acid capsule + cell surface T, R, M-proteins. About 100 serotypes
- Resistance & Immunity to infection developed by presence of specific M-protein antibodies
- Infection may spread easily to other body sites. Children. Common sinusitis, otitis, blood sepsis. Skin. rarely pneumonia. Repeat Streptococcal Throat infection is common in young children. each 1-3 months.
Fig. 4 - Infections of *Streptococcus pyogenes*
Fig. 5- Streptococcus pyogenes
Group A Streptococcus-3

- **Scarlet fever:** children.. begins as pharyngitis ..Few lysogenic strains producing **pyrogenic/erythrogenic exotoxins** (A,B,C).. Diffuse erythematous rash in **oral mucous membranes** (Red Tong) & Skin.. Results in lifelong immunity.

- **Pyoderma** .. superficial localized blisters (**impetigo**) associated with massive brawny edema.

- **Cellulitis/Erysipelas:** Skin infection rapidly spread to subcutaneous tissues & lymphatic system.. highly communicable in children.. may cause later **Glomeronephritis**

- **Streptococcal Toxic Shock Syndrome:** Few strains.. Host systemic responses to increased circulating **pyrogenic toxins superantigens** ..High fever, Bacteriemia, Diarrhea, Shock & Organ failures, high fatal.
Scarlet Fever
Group A *Streptococcus*-4


- Rarely **Puerperal fever**. blood sepsis (caused mostly Group B *Streptococcus*). infected injured uterus after delivery. neonatal sepsis.

- **Post streptococcal diseases:**

- **Rheumatic fever & Glomerulonephritis:** followed repeat throat infection. Autoimmunological reactions.

- Both diseases and their pathology are not due to dissemination of bacteria, but to late immunological reactions to Group A streptococcal antigens. mainly Cell wall antigens & M-protein.
Diagnosis & Treatment

- **Lab Diagnosis:** Culture on sheep blood agar. Hemolytic Strept. Type confirmed by using specific antistreptococcal sera by slide agglutination test.

- **Detection Specific Antibodies:** 2-4 weeks after throat or skin infection. Antistreptolysin 0 (ASO) titer > 240 IU, positive Streptokinase, Anti-M Protein

- **Treatment:** Clinical cases/ healthy Carrier. Penicillin G /V. Monthly injection for children. Cotrimoxazole

- **Group A** is still highly susceptible to Penicillin. Less to Cephalosporins & Macrolides and other antibiotics

- **No Vaccine is available**
Corynebacterium diphtheriae, C. ulcerans

- Sore Throat..Not invasive.. Intensive inflammation pharyngeal mucosa, Gray Pseudomembranous.. Release Diphtheria exotoxin.

- Clinical Features: Myocarditis.. Peripheral nervous system/ Neuritis, Adrenal glands.. Laryngeal obstruction.. Respiratory & Heart Failure, Death

- Permanent Immunity by Vaccination.. Rapid diagnosis .. antibiotic treatment + Diphtheria Antitoxin

- Lab Diagnosis: Throat swab .. Direct Smear not significant, Culture for C. diphtheria.. selective Tellurite Blood agar ..Toxin test..Not all strains are toxigenic.

- Vincet Angina / Trench Mouth : Mixed infection.. Oral Normal flora..Borrelia /Treponema vincenti/ Fusobacterium ..Oral mucosa Lesions/ Gingivitis.. gum swelling (gingivitis)
Gingivitis
Lower Bacterial Respiratory Infection

- Mostly endogenous source of Infection. Opportunistic organisms spread directly from the upper respiratory tract to the lung...rarely through blood.

- A combination of factors including virulence of infecting organism, status of the local defenses, and overall health of the patient may lead to bacterial pneumonia.

- The patient become more susceptible to infection by presence Chronic obstructive lung disease (COPD), Followed Viral Respiratory infection.. Infant , Old age, dysfunction of immune defense mechanisms..
Lung Infections
Acute/Chronic bronchitis


- Acute bronchitis in children is rarely a primary bacterial infection. Mostly viral agents.

Whooping cough & Bronchitis

*Bordetella pertussis / B. parapertussis*: Release Endotoxin, Cytotoxins. Attachment & Obstruction ciliated epithelium cells of small Bronchi..

- **Clinical Features:**

- **Clinical Diagnosis** & Laboratory test by PCR for detection bacterial DNA in nasopharyngeal swab. Specific antibodies blood & Urine.
Pneumonia

- **Pneumonia** is a common illness that affects millions of people each year worldwide. Associated with high fatality.
- The symptoms of pneumonia range **mild -severe-fatal**. The severity depends on the type of organism, Patient’s Age, Health condition & general immunity.
- **Mild Pneumonia**: inflammation of the lungs - Fever – few Sputum.. caused by many different opportunistic organisms .. **Bacteria & Viruses** (single or mixed)
- **Severe pneumonia**: Bacterial Lung Inflammation, fluid buildup, Purulent sputum.. containing pus / blood.. High Fever, Malaise, Nausea, Vomiting, Breath shortness Increased heart beats, Mental confusion..few % blood sepsis.
Bacterial Causes of Pneumonia

- Pneumonia categorized into community-acquired pneumonia (CAP), or Hospital-acquired pneumonia (HAP)/often in ICU followed Intubation & use ventilator. 

Health care-acquired pneumonia

- **CAP**. .. mostly *Strep. pneumoniae*. .. followed viral infection in children & elderly patients

- **HAP**. .. Gram-ve *P. aeruginosa, Klebsiella pneumonia, Acinetobacter baumannii*. ..Less by *Haemophilus influenzae type b, S. aureus* or others. .. May be associated with blood sepsis.

- Both produce similar clinical features. .. Fatal without antibiotic & Supportive respiratory treatment.
Streptococcus pneumoniae

- **90 Capsular Serotypes**: Common Healthy Carriers.. normally found in the nasopharynx of 5-10% of healthy adults.. 20-40% of healthy children

- **Several virulence factors**: Polysaccharide capsule & Pneumolysins (invasion), Both resist phagosytosis & host's immune system.. Released Proteases damages mucosa IgA ..overcome host defense.

- **S.pneumoniae** starts as intrapulmonary abscess.. Lung necrosis.. can be associated with **Empyema** (Pus, fluid & bacterial cells accumulate in the pleural cavity). . Often more associated with Blood sepsis, Meningitis, Sinusitis, Otitis Media in young children than adults.
Strept. pneumoniae & Viridans Streptococci Group
Lab Diagnosis

- *S. pneumoniae* can be differentiated from *S. viridans*, which is also alpha hemolytic on Blood agar. Optochin / bile solubility test. Gram-positive diplococci.
- About 80% *S. pneumoniae* are R-Penicillin in Jordan & other Arab countries.
- Treatment: Amoxycillin-clavulanate, Macrolides (Azithromycin, clarithromycin), Fluoroquinolones (Levofloxacin, ciprofloxacin). For Bacteremia +meningitis. Vancomycin, ceftriaxone/cefotaxime.
Atypical Pneumonia

• Atypical pneumonia caused by *Mycoplasma*, *Chlamydia*, *Legionella*. These related to Gram-ve bacteria. Have few amount LPS. Attached to respiratory mucosa. Not common part of Respiratory flora. *Opportunistic pathogens*

• Causing mostly **milder forms of pneumonia**. characterized by slow development of symptoms. dry cough & mild fever unlike other forms of pneumonia

• *M. pneumoniae*: The smallest size Bacteria. Lack true Cell wall. Lipid bi-layer membrane. Aerobic Growth, Respiratory Mucosa. Other *Mycoplasma* spp. cause other human diseases. Also in Animals, Birds
Mycoplasma

- **Acute/Subacute Pharyngitis**. **Bronchitis**. Common infection in Fall-Winter. Mostly **Old children** & **Jung Adults**.
- Severe forms of *M. pneumoniae* have been described in all age groups.
- Lab Diagnosis: Special culture medium. PCR. Sputum, Pleural fluid, Blood.
- **Serological Cold-Agglutination Test**. Increased antibody titers. **Treatment**: levofloxacin, moxifloxacin, Macrolides/Azithromycin. No Vaccine.
Chlamydia species

- **Chlamydia**.. Species cause human Respiratory/ both genital tract diseases or both.. Obligate intracellular.. Causing intracytoplasmic inclusions..Rapidly killed outside body.. Dryness, High temperature.
- **Live cycle**: *Infectious elementary bodies* attached to mucosa and promoting its entry..
- **Reticulate bodies** developed as inclusion bodies in cytoplasm phagosomes & released new *Infectious elementary bodies*

1- **Chlamydia trachomatis**  Common cause of sexually transmitted disease (STD)  *Nonspecific urethritis* .. transmitted from mother to newborn babies..maternal fluid.. causes severe pneumonia & Eye infection..Conjunctivitis & Trachoma.

- Infection in adults often asymptomatic, mild. May include sore throat, headache, fever, dry cough.
- Clusters of infection have been reported more common in children than adults.
- **Diagnosis & treatment**: Sputum, throat-nasal swabs, MaCoy Cell Culture, ELSA Specific antibodies, PCR.
- Treatment: Macrolides, Tetracyclines, levofloxacin, moxifloxacin. No Vaccine.
**Legionella pneumonophila**

- **Legionella**: Carry flagella, Pathogenic/Nonpahogenic spp. often found in natural aquatic bodies and wet soil. Facultative Anaerobes Growth in Cold/Hot (4-80C) Water. Transmitted, Inhalation water drops via air condition system. Wet Soil. Cause single /outbreak of disease.

- Attached Lung Mucosa..multiply intracellular within the macrophages..High Fever..rarely blood sepsis.

- **Incubation period** 2-10 days .. Nonproductive / Productive dry cough.. Shortness of breath, Chest pain, Muscle aches, Joint pain, Diarrhea, Renal Failure.
**L. pneumophila-2**

- **Risk factors** include heavy cigarette smoking, old age, underlying diseases such as renal failure, cancer, diabetes, chronic obstructive pulmonary, suppressed immune systems, corticosteroid therapy.

- **Diagnosis & treatment:** Special culture media, blood/urine specimen for detection Specific antibodies or Antigens by PCR, or ENSA .. Macrolides (azithromycin), levofloxacin, moxifloxacin .. No Vaccine.