Chapter 18
Sputum Analysis
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Sputum Definition

1. It is a secretion that is produced in the lungs and the bronchi (tubes that carry the air to the lung), also known as phlegm.

2. This mucus-like secretion may become infected, bloodstained, or contain abnormal cells that may lead to a diagnosis.
Sputum Definition, Cont’d

3. Tracheobronchial sections are an inconstant mixture of plasma, water, electrolytes and mucin.

4. As these mixture pass through the lower and upper respiratory tract, they become contaminated with cellular exfoliations, nasal and salivary gland secretions and normal bacterial flora of the oral cavity.

Normal Lung

- Trachea is split up into two bronchus that leads into both our lungs.
- The bronchi are further distributed into bronchi and bronchiole.
- The air travels along these tubes and finally ends up in the air sacs (alveoli).
- Alveoli are surrounded by a network of capillaries.
The major features of the lungs include the bronchi, the bronchioles and the alveoli.

Each alveolus is surrounded by a dense bed of capillaries.

The alveoli are the sites of the actual gas exchange and are regarded as the primary functional units of the lungs.

O₂ entering an alveolus dissolves in the film of water on its wall and moves by diffusion across the cells into the blood.

O₂ is in higher concentration inside the alveoli than in the blood.

O₂ moves from a higher concentration to a lower concentration by the process of diffusion.

Concentration of CO₂ is higher in the blood than in the alveoli.

CO₂ also moves from a high concentration to a lower concentration by the process of diffusion.
Sputum Collection

1. Drinking a lot of water and other fluids the night before the test may help to get the sample
2. To be asked to cough deeply and spit any sputum in a sterile cup
3. The sputum is then taken to the laboratory
4. There, it is placed in a special substance (medium) under conditions that allow the organisms to grow
**Sputum Analysis**

- This slide shows typical buccal squamous epithelial cells which are much larger than polymorphonuclear leukocytes (PMN) and take up most of the field in a high power view.
- This cell is covered with chains of Gram positive cocci typical of normal oral flora such as *peptostreptococci*. (oil immersion, 1000x)

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**Physical Properties of Sputum**

1. **Appearance**
   - It may be described as liquid (serous), mucoid, purulent, bloody or combination of these.

2. **Color**
   - Its color is determined by the material contained, and often color can indicate the pathological process.
   - Yellow color indicates pus and epithelial cells are present.
3. **Odor**
   - Usually no odor is present in normal and pathological sputum, but if bacterial decomposition has been taken place within the body or after expectoration, a variety of odor will be present.

**Miscellaneous Findings in Sputum**

1. **Cheesy Masses**
   - These are fragments of necrotic pulmonary tissue seen in such disease as pulmonary gangrene or tuberculosis.

2. **Bronchial Casts**
   - These are branching tree like casts of bronchi whose size varies with that of bronchi in which they are formed.
   - They are composed of fibrin and are white or gray color.
3. **Broncholiths (Lung Stones)**
   - They are formed by calcification of necrotic or infected tissues
   - Chronic tuberculosis is the most common cause for their formation

4. **Dietrich's Plugs**
   - They are frequently observed in putrid bronchitis and bronchiectasis
   - They are composed of cellular debris, fatty acids, crystals, fat globules and bacteria
Miscellaneous Findings in Sputum, Cont’d

5. Foreign Bodies
   • In children, they can be any small object a child may place it into his mouth
   • In adults, they are either food particles or gastric contents aspirated during convulsion, during intoxication or operative anesthesia

6. Parasites
   • They are extremely rare

Sputum Chemical Composition

<table>
<thead>
<tr>
<th>Component</th>
<th>% of Total Weight</th>
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<tbody>
<tr>
<td>Water</td>
<td>95</td>
</tr>
<tr>
<td>Solid</td>
<td>5</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>% of Total Solids</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Carbohydrates</td>
<td>Variable</td>
</tr>
<tr>
<td>Proteins</td>
<td>Variable</td>
</tr>
<tr>
<td>Lipids</td>
<td>Variable</td>
</tr>
<tr>
<td>DNA</td>
<td>Variable</td>
</tr>
<tr>
<td>Enzymes, α-antitrypsin, LDH, lysozyme, lactoferrin</td>
<td>Variable</td>
</tr>
</tbody>
</table>
1. Pneumonia occurs when the lungs become inflamed and infected. Because the lungs are infected, pneumonia makes it difficult to breathe. It often follows a common cold or the flu.

2. Although people of all ages can get pneumonia, it is especially dangerous for people with chronic illnesses, very young children, and older adults.

3. Pneumonia can be caused by either bacteria, fungi, amoebae, parasites or a virus.

4. One or both lungs can be affected.
Pneumonia, Cont’d

- The alveoli filled with mucus such as submucosa widened by smooth muscle hypertrophy, edema, and inflammation (mainly eosinophils)
- These are changes of bronchial asthma
- The peripheral eosinophil count or the sputum eosinophils can be increased during an asthmatic attack.
Pneumonia, Cont’d

Symptoms of Pneumonia

- Pneumonia symptoms vary depending upon the type of pneumonia. Symptoms may include:
  - Fever
  - Chest pain and/or muscle pain
  - Cough that may produce white, yellow, or green mucus (phlegm)
  - Lack of energy
White nail syndrome may also be called leukonychia. Leukonychia can occur with arsenic poisoning, heart disease, renal failure, pneumonia, or hypoalbuminemia.

Symptoms of Pneumonia

Sputum Analysis: Pneumonia

Moraxella catarrhalis, a large number of Gram negative (red) cocci are seen and many appear to be attaching to or residing within the PMNs. Some physicians confuse these organisms with the Gram negative coccobacillary.
Sputum Analysis: Pneumonia, Cont’d

- *Hemophilus influenzae* pneumonia demonstrating the typical Gram negative coccobacillary forms
- Because of the red background produced by the Gram stain method, these organisms can be difficult to see (oil immersion, 1000x)

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Sputum Analysis: Pneumonia, Cont’d

- *Hemophilus influenzae* pneumonia
Sputum Analysis: Pneumonia, Cont’d

- *Klebsiella pneumoniae* pneumonia demonstrating Gram negative bacillary organisms. (oil immersion, 1000x)

Sputum Analysis: Pneumonia, Cont’d

- Gram stain of the sputum from a patient with *Staphylococcus aureus* pneumonia demonstrating clusters of Gram positive cocci some of which are associated with the PMNs (oil immersion, 1000x)
Sputum Analysis: Pneumonia, Cont’d

- Gram-positive, spherical bacteria, *Streptococcus pneumoniae*, is the cause of many human diseases, including pneumonia

Treatments of Pneumonia

1. Treatments depend upon the type of pneumonia and the seriousness of the symptoms
2. **Bacterial pneumonia** is usually treated with antibiotics. **Viral pneumonia** is not treated with antibiotics but with rest, fluids, and time. Recovery for viral pneumonia is usually longer than bacterial pneumonia
Treatments of Pneumonia, Cont’d

3. Doctor may also recommend taking over-the-counter medicines to reduce fever and treat aches and pains. Because coughing is important to help clear your lungs, it is important to avoid cough suppressants.

Definition of Asthma

1. It is a chronic lung condition that is characterized by a difficulty in breathing. A person with asthma will have extremely sensitive airways that react by becoming narrow when agitated.

2. Often, asthma is confused with allergies, such as the wheezing and coughing that comes when a person is allergic to pollen and dust in the air.

3. Too much exposure to allergens can lead to the development of asthma.
Definition of Asthma, Cont’d

3. The allergens cause the immune system to kick into high gear in the same way it would if fighting off a virus or parasite
4. For most people, this reaction induces coughing
5. But if the airways become inflamed, and if it happens with frequency, the body reacts with wheezing and general difficulty in breathing

Normal and Asthmatic Bronchiole

- When an asthma attack occurs, mucus production is increased
- Muscles of the bronchial tree become tight, and the lining of the air passages swells, reducing airflow and producing the characteristic wheezing sound
Normal and Asthmatic Bronchiole

- During an asthma attack, smooth muscles located in the bronchioles of the lung constrict and decrease the flow of air in the airways.
- The amount of air flow can further be decreased by inflammation or excess mucus secretion.

Symptoms of Asthma

1. Shortness of breath
2. Wheezing (a whistling noise in the chest)
3. Cough and chest tightness
   - Not everybody will have all these symptoms
   - Young children often present only with a cough with no other symptoms hence often the asthma diagnosis is overlooked or misdiagnosed
   - A history of asthma, eczema or hay fever in the family may mean that your chances of developing asthma are slightly higher than those without
Process of Asthma

Mechanism of Asthma Attack
Mechanism of Asthma Attack, Cont’d

Asthma, Cont’d

Before an Asthma Episode
Asthma, Cont’d

Provolks Asthma

- It attacks are provoked by two factors:
  - Triggers, which result in bronchoconstriction (tightening of the airways), or
  - Causes, which result in inflammation of the airways
Analysis of Sputum: Asthma

• Note thick basal membrane under the epithelial layer, which is covered with much mucus in fatal case of status asthmaticus

Analysis of Sputum: Asthma, Cont’d

• Small airways show considerable hyperplasia and hypertrophy of smooth muscle, goblet cells and thickening of the mucosa
• The airway wall is covered with unusually large amounts of mucus, and projects into the lumen like villi
• With minimal additional smooth muscle shortening or edema the airway is fully closed
Analysis of Sputum: Asthma, Con’td

- This very large spiral was found in lavage fluid from an asthmatic patient being evaluated for a lung mass.
- The Papanicolaou stain gives a reddish core with a fuzzy margin to which many cells are attached secondarily.
- The arrow points out a macrophage for comparison of size. The spiral is about 1 mm long.

Causes of Asthma

- They are also known as inducers, cause airway inflammation and airway hyperresponsiveness, both causes of asthma.
- The most common causes are allergens and viral respiratory illness.
**Asthma Triggers**

- Many of the same substances that trigger allergies can also trigger asthma.
- Common allergens include pollen, dust mites, mold, and pet dander.
- Other asthma triggers include irritants like smoke, pollution, fumes, cleaning chemicals, and sprays.
- Asthma symptoms can be substantially reduced by avoiding exposure to known allergens and respiratory irritants.

**Treatments of Asthma**

- There are different types of treatment for asthma sufferers.
- The type of treatment depends on the severity of the asthma and its attacks.
- Asthma may not be able to be cured, but it can be controlled.
- By controlling the asthma, people who suffer from the disease are able to live relatively normal, active lives.
Treatments of Asthma, Cont’d

1. **Antihistamines**
   - For the person who suffers allergies along with asthma, the doctor might prescribe antihistamines to help control the reaction to allergens.
   - Antihistamines are not without their downside.
   - They can cause drowsiness, limiting a person’s ability to work at peak level, and also they can also cause dry mouth, urinary problems, and constipation.

Treatments of Asthma, Cont’d

2. **Bronchodilators**
   - It helps to relax the muscle of the bronchial tubes, making breathing easier. There are several different bronchodilators: β-agonist, theophylline, and anticholinergics.
   - β-agonist bronchodilators can be short-term or long-term treatments.
     - The short-term treatments are used as quick relief medications.
     - The long-term version is meant to be used regularly to control the asthma over a long period of time.
Theophylline has been used for over 30 years as an asthma treatment. It is taken as either a pill or intravenously. People who use this treatment must have their blood levels monitored closely.

Anticholinergics are always inhaled and can be used with the $\beta$-agonist.

Treatments of Asthma, Cont’d

3. **Corticosteroids**

- Better known as steroids, corticosteroids are one of the most effective ways of treating asthma.
- They act as an anti-inflammatory, and should not be confused with the anabolic steroids taken by athletes for muscle enhancement.
- Steroids are available in creams, nasal sprays, pills, or by injection, and their use must always be monitored by a doctor.
Treatments of Asthma, Cont’d

- Oral steroids work best for short-term use
- Long-term use of steroids is best treated by inhaled methods
  - Long-term use does have lingering effects, particularly with oral methods, which include weight gain, menstrual irregularities, ulcers, high blood pressure, weakened bones, and a tendency to bruise
- Steroid use for children should be done with extreme care, as it can stunt their growth. It is widely accepted that the benefits of steroid use outweighs the potential side effects

THE END

Any questions?