Respiration Laboratory Exercise

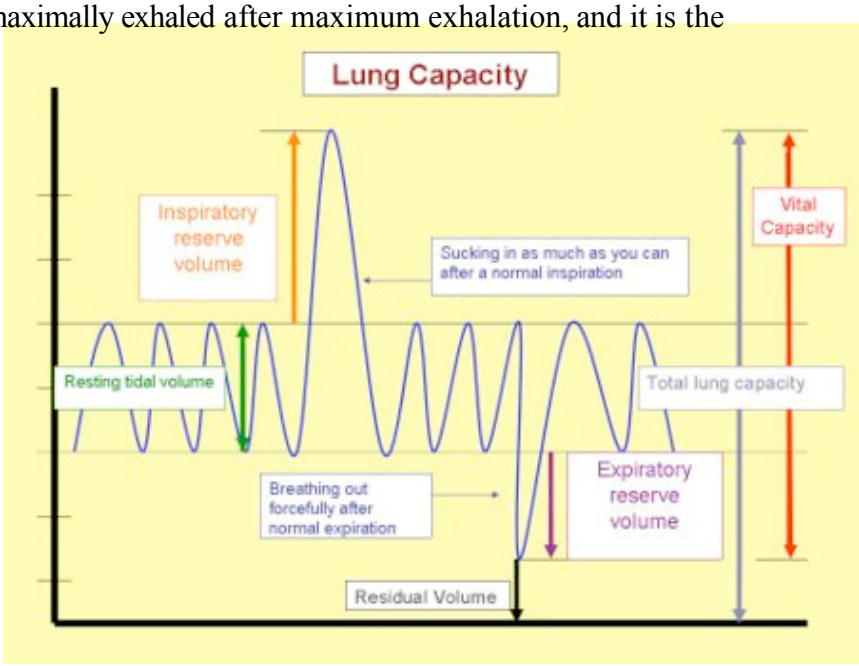
Adapted from www.pierce.ctc.edu/mbalogh/ 251/lab_notes/Lab%209%20notes.doc

Goals

In this exercise you will learn about the structure of a normal lung, as well as making several measurements of pulmonary function.

Introduction

A lung is a spongy organ consisting of irregularly shaped air sacs called alveoli. The alveoli are lined with a single layer of squamous epithelium and are supported by a mesh of fine elastic fibers. The alveoli are surrounded by a network of tiny blood vessels. The concentration of oxygen in the air is greater than that in the capillaries, and the concentration of carbon dioxide in the capillaries is greater than that in the air. This allows gas exchange in the lungs to take place by diffusion. A spirometer is an instrument used to measure the breathing capacity of the lungs. Various quantities of air can be determined with this instrument. The amount of air taken in (inspiration) or breathed out (expiration) during normal breathing is called **tidal volume**. **Expiratory reserve volume** is the air that can be forced out of the lungs after normal expiration. The amount of air that the lungs can bring in during forced inspiration is called **inspiratory reserve volume**. **Vital capacity** is the volume of air maximally exhaled after maximum exhalation, and it is the sum of inspiratory reserve volume, tidal volume, and expiratory reserve volume. The lungs are never completely empty of air. After forced expiration there may still be about a liter of air left in the lungs. This is called **residual volume.** Your vital capacity increases as you get older until about age 25. After this age, your vital capacity decreases gradually.



Recall that the normal pH value for body fluids is between 7.35 – 7.45. When the pH value of body fluids falls below 7.35, the condition is called acidosis; and when the pH value is above 7.45, the condition is called alkalosis.

Metabolism produces acidic products that lower the pH of body fluids. For example, carbon dioxide is a by-product of metabolism, and carbon dioxide combines with water to

form **carbonic acid** ($CO_2 + H_2O \rightarrow H_2CO_3 \rightarrow H^+ + HCO_3^-$). Also, **lactic acid** is a product of anaerobic metabolism; protein metabolism produces **phosphoric** and **sulfuric acid**; and lipid metabolism produces **fatty acids**. These acidic substances must continuously be eliminated from the body to maintain pH homeostasis. Rapid elimination of acidic products of metabolism may result in alkalosis, however; and the failure to eliminate acidic products of metabolism fast enough results in acidosis. The major effect of acidosis is depression of the central nervous system (CNS). When the pH of the blood falls below
7.35, the CNS malfunctions, and the individual becomes disoriented and possibly comatose as the condition worsens.The major effect of alkalosis is hyperexcitability of the nervous system. Peripheral nerves are affected first, resulting in spontaneous nervous stimulation of muscles. Spasms and tetanic contractions and possibly extreme nervousness or convulsions result. Severe alkalosis can cause death as a result of tetany of the respiratory muscles. Although **buffers** in body fluids help resist changes in the pH of those body fluids, the **respiratory system** and the **kidneys** are the main regulators of pH in the body fluids. Malfunctions of either the respiratory system or the kidneys can result in acidosis or alkalosis. Acidosis and alkalosis are categorized by the cause of the condition. **Respiratory acidosis** or **respiratory alkalosis** results from abnormalities of the respiratory system which, in turn, allow too much CO_2 to be retained or too much CO_2 to be eliminated. **Metabolic acidosis** or **metabolic alkalosis** results from all causes other than abnormal respiratory functions.

Inadequate ventilation of the lungs causes respiratory acidosis, because the rate at which CO_2 is eliminated from the body fluids through the lungs decreases. The result of this is an increase in the concentration of carbon dioxide in body fluids. As carbon dioxide levels increase, excess carbon dioxide reacts with water to form carbonic acid. The carbonic acid then dissociates to form hydrogen ions (H^+) and bicarbonate ions (HCO_3^-) as per the following (reversible) reaction: $H_2CO_3 \rightarrow H^+ + HCO_3^-$. The increase in H^+ concentration causes the pH of body fluids to decrease. If the pH of body fluids falls below 7.35, symptoms of respiratory acidosis become apparent.

If you have any health problems that may interfere with you performing this experiment please notify me.

Experiment 1: Measuring **TIDAL VOLUME**
Measure the amount of air exhaled or inhaled during normal, quiet breathing (TV).

The student should sit by the spirometer, breathing quietly and normally for about a minute.
After inhaling a normal breath, places the mouthpiece between the lips (get a good "seal") and exhale in a normal, unforced way, into the spirometer mouthpiece. The volume should
be read and recorded from the horizontal scale.

Experiment 2: Measuring **EXPIRATORY RESERVE VOLUME**
Measure the amount of air that can be forcibly breathed out after normal expiration (ERV).

Stand up, breathing normally for a minute or so, then, after a normal exhalation, put the mouthpiece between the lips, and forcibly exhale all the additional air possible.

Experiment 3: Measuring **INSPIRATORY RESERVE VOLUME**
Measure the amount of air that can be inhaled following normal TV inhalation (IRV).

Stand up, breathing normally for a minute or so, then inhale as deeply as possible. With the mouthpiece inserted, exhale normally, without forcing additional air out. The IRV reading is obtained by subtracting TV from the measurement recorded on the spirometer.

Experiment 4: Measuring **VITAL CAPACITY**
Measure the maximum amount of air that can be forcibly exhaled immediately following a maximal inhalation (VC). VC = TV + IRV + ERV

Stand up, then slowly and deeply inhale and exhale for several breaths, then inhale as deeply as possible. Place the spirometer mouthpiece in position, and exhale as completely as possible.

In addition to the experiments described above, four other measurements of lung capacity should be calculated:

1.*Residual Volume (RV)*: The lungs are never completely emptied, always containing about 1200 ml of air in adults. Obviously, this measurement cannot be obtained by conventional spirometry. Just assume that is 1200 ml.

2. *Functional Residual Capacity (FRC)*: This is the amount of air remaining in the lungs after normal exhalation. FRC = ERV + RV.

3. *Inspiratory Capacity (IC)*: The amount of air that can be inhaled after normal expiration. IC = TV + IRV.

4. *Total Lung Capacity (TLC*): This is the amount of air contained in the lungs after a maximal inhalation. TLC = TV + IRV + ERV + RV.

Experiment 5: Effect of Carbon Dioxide Loss and Retention

1. Rest and breathe normally for two minutes. Then inhale and hold your breath for as long as you can. Have your partner time you. Time:_____

2. Rest and breathe normally for two minutes. Then breathe rapidly and deeply for six breaths. Then inhale and hold your breath for as long as you can while your partner times you. Time: _____

3. Rest and breathe normally for two minutes. Then breathe deeply into the paper bag six times. Hold your breath for as long as you can while your partner times you. Time: _____

Experiment 6: Examining Human Lung Pathology

Smoking-related diseases claim an estimated 430,700 American lives each year. Smoking costs the United States approximately $97.2 billion each year in health-care costs and lost productivity. It is directly responsible for 87 percent of lung cancer cases and causes most cases of emphysema and chronic bronchitis (American Lung Association). Examine prepared slides of a stained section of normal lung and lung from a smoker. Draw and record your observations below.

Post Lab Questions

1. Describe the flow of oxygen into the respiratory system beginning at the mouth or nose.

2. How is oxygen carried through the body?

3. Why do your cells need oxygen?

4. What does a spirometer measure?

5. What part of the brain controls breathing? How is this control regulated?