Lab #17H - Lung Volumes and Capacities

Measurement of lung volumes provides a tool for understanding normal function of the lungs as well as disease states. The breathing cycle is initiated by expansion of the chest. Contraction of the diaphragm causes it to flatten downward. If chest muscles are used, the ribs expand outward. The resulting increase in chest volume creates a negative pressure that draws air in through the nose and mouth. Normal exhalation is passive, resulting from “recoil” of the chest wall, diaphragm, and lung tissue.

In normal breathing at rest, approximately one-tenth of the total lung capacity is used. Greater amounts are used as needed (i.e., with exercise). The following terms are used to describe lung volumes (see Figure 1):

Tidal Volume (TV)
The volume of air breathed in and out without conscious effort

Inspiratory Reserve Volume (IRV)
The additional volume of air that can be inhaled with maximum effort after a normal inspiration

Expiratory Reserve Volume (ERV)
The additional volume of air that can be forcibly exhaled after normal exhalation

Vital Capacity (VC)
The total volume of air that can be exhaled after a maximum inhalation: VC = TV + IRV + ERV

Residual Volume (RV)
The volume of air remaining in the lungs after maximum exhalation (the lungs can never be completely emptied)

Total Lung Capacity (TLC)

TLC = VC + RV

Minute Ventilation
The volume of air breathed in 1 minute: (TV)(breaths/minute)

In this experiment, you will measure lung volumes during normal breathing and with maximum effort. You will correlate lung volumes with a variety of clinical scenarios.

OBJECTIVES
In this experiment, you will
- Obtain graphical representation of lung capacities and volumes.
• Compare lung volumes between males and females.
• Correlate lung volumes with clinical conditions.

MATERIALS
LabQuest
LabQuest App
Vernier Spirometer
disposable mouthpiece
disposable bacterial filter
nose clip

PROCEDURE

Important: Do not attempt this experiment if you are currently suffering from a respiratory ailment such as the cold or flu.

1. Connect the Spirometer to LabQuest and choose New from the File menu.

2. On the Meter screen, tap Rate. Change the data-collection rate to 100 samples/second and the data-collection length to 60 seconds. Select OK.

3. Attach the larger diameter side of a bacterial filter to the “Inlet” side of the Spirometer. Attach a gray disposable mouthpiece to the other end of the bacterial filter (see Figure 2).

4. Hold the Spirometer in one or both hands. Brace your arm(s) against a solid surface, such as a table, and choose Zero from the Sensors menu. Note: The Spirometer must be held straight up and down, as in Figure 2, and not moved during data collection.

5. Collect inhalation and exhalation data.
   a. Put on the nose plug.
   b. Start data collection.
   c. Taking normal breaths, begin data collection with an inhalation and continue to breathe in and out. After 4 cycles of normal inspirations and expirations fill your lungs as deeply as possible (maximum inspiration) and exhale as fully as possible (maximum expiration). It is essential that maximum effort be expended when performing tests of lung volumes.
   d. Follow this with at least one additional recovery breath.


7. To view a graph of volume vs. time, tap the y-axis label and select Volume. If the baseline on your graph has drifted, choose Baseline Adjustment from the Analyze menu to...
bring the baseline volumes closer to zero, as in Figure 3. Select OK.

8. Determine the $\Delta y$ for the Tidal Volume portion of your graph.
   a. Select a representative peak and valley in the Tidal Volume portion of your graph.
   b. Tap the peak and note the volume value.
   c. Tap the bottom of the valley that follows it and note the volume value.
   d. Calculate the $\Delta y$ value and record it, to the nearest 0.1 L, as the total Tidal Volume in Table 1.

9. Determine the $\Delta y$ for the Inspiratory Reserve Volume portion of your graph.
   a. Tap the peak that represents your maximum inspiration and note the volume value.
   b. Using the level of the peaks graphed during normal breathing from Step 8, calculate the $\Delta y$ value and record it, to the nearest 0.1 L, as the total Inspiratory Reserve Volume in Table 1.

10. Determine the $\Delta y$ for the Expiratory Reserve Volume portion of your graph.
    a. Tap the valley that represents your maximum expiration and note the volume value.
    b. Using the level of the valleys graphed during normal breathing from Step 8, calculate the $\Delta y$ value and record it, to the nearest 0.1 L, as the total Expiratory Reserve Volume in Table 1.

11. Calculate the Vital Capacity and enter the total to the nearest 0.1 L in Table 1.
    \[ VC = TV + IRV + ERV \]

12. Calculate the Total Lung Capacity and enter the total to the nearest 0.1 L in Table 1. (Use the value of 1.5 L for the RV.)
    \[ TLC = VC + RV \]

13. Share your data with your classmates and complete the Class Average columns in Table 1.
Table 1

<table>
<thead>
<tr>
<th>Volume measurement (L)</th>
<th>Individual (L)</th>
<th>Class average (Male) (L)</th>
<th>Class average (Female) (L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tidal Volume (TV)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inspiratory Reserve (IRV)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expiratory Reserve (ERV)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vital Capacity (VC)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Residual Volume (RV)</td>
<td>≈1.5</td>
<td>≈1.5</td>
<td>≈1.5</td>
</tr>
<tr>
<td>Total Lung Capacity (TLC)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**DATA ANALYSIS**

1. What was your Tidal Volume (TV)? What would you expect your TV to be if you inhaled a foreign object which completely obstructed your right mainstem bronchus?

2. Describe the difference between lung volumes for males and females. What might account for this?

3. Calculate your Minute Volume at rest.

\[
(TV \times \text{breaths/minute}) = \text{Minute Volume at rest}
\]

If you are taking shallow breaths (TV = 0.20 L) to avoid severe pain from rib fractures, what respiratory rate will be required to achieve the same minute volume?
3. Exposure to occupational hazards such as coal dust, silica dust, and asbestos may lead to fibrosis, or scarring of lung tissue. With this condition, the lungs become stiff and have more “recoil.” What would happen to TLC and VC under these conditions?

4. In severe emphysema there is destruction of lung tissue and reduced recoil. What would you expect to happen to TLC and VC?

5. What would you expect to happen to your Expiratory Reserve Volume when you are engaged in intense physical activity?