Purpose

The movement of air in and out of the lungs is essential to maintain the important process of cellular respiration, the oxidation of nutrient molecules. The rhythmic inflation and deflation of the lungs (ventilation) simultaneously satisfies the continuous demands of cells for supply of oxygen and subsequent elimination of carbon dioxide. The volumes of air involved in pulmonary ventilation may be measured with a device known as a spirometer.A spirometer coupled with a kymograph is capable of measuring and recording several human lung capacities. Today, plugged into a computer's USB port, a digital pneumotach can be used to measure lung volumes. This is what we will use in the first two sections of Lab 14. The record obtained from spirometry may be analyzed to determine the relative pulmonary condition of humans.In this laboratory, the lung capacities of tidal volume, vital capacity, inspiratory capacity, inspiratory reserve volume, expiratory capacity and expiratory reserve volume will be recorded for student volunteers. The timed vital capacity (TVC) or forced expiratory volume (FEVT) will also be calculated for these students. The students will be introduced to the use and theory behind incentive inspiratory devices and a portable spirometer. Impedance pneumography, the measurement of ventilation rates by recording the changing impedance of an expanding and contracting thorax, may be demonstrated.

Procedures

1. The Morgan ComPAS computer program has already calculated and factored in the BTPS

(Body Temperature Pressure Saturation) correction factor for the spirometer temperature.

Ex.: spirometer temperature = 25C BTPS correction factor = 1.075

454 ml x 1.075 = 488.05 ml (rounded off to 488 ml)

2. Fully insert the Pneumotrac filter/mouthpiece you purchased at the bookstore. If you have difficulty keeping air from leaking through your nose, you may need to wear a nose clip, as air leakage will result in inaccurate results.

3. Be sure the correct student information is loaded up before you start the SVC (slow vital capacity) test.

4. After starting the SVC test, follow the verbal instructions of your instructor: begin with your mouth off the mouthpiece so the pneumotach can equilibrate; then get a good seal with your lips and begin normal quiet (tidal) breathing.

5. Watch the screen to be sure you are showing stable tidal breathing; the moving line should be around a half liter and NOT drifting up or down. (NOTE: speed or rate of expiration is not important for slow vital capacity 14-A.)

6. After stable tidal breathing, you will be instructed to take the deepest breath in as you can, then blow it all out, and finally return to normal tidal breathing. Your instructor will print out your SVC Volume Time Curve. This will be a part of your 14-A results. Be sure to follow the Lab 14 Data Management Instructions for GLR-14.

7. Your SVC Volume Time Curve should look similar to Figure 14-1.

Fig. 14-1: Typical lung volumes as recorded by the Morgan ComPAS Pneumotrac.

8. Label your spirometer tracing and calculate the amount for each lung volume and capacity. Descriptions for lung volumes and capacities are on the next page. Average values based on a 5'10", 70-kg. (~170 lbs.) male are provided, as well as some percent values needed to calculate volumes and capacities for other individuals.

Tidal Volume (TV) – Air moved in and out of lungs during quiet breathing. Average = 500 ml

Expiratory Reserve Volume (ERV) – Air expelled during a forced expiration less the tidal volume. Average = 1200 ml or 25% of VC.

Expiratory Capacity (EC) – Air expelled during forced expiration plus the tidal volume. (EC = ERV + TV) Average = 1700 ml.

Inspiratory Reserve Volume (IRV) – Air drawn into the lungs during a forced inspiration less the tidal volume. Average = 3100 ml.

Inspiratory Capacity (IC) – Air drawn into the lungs during a forced inspiration plus the tidal volume. (IC = IRV + TV) Average = 3600 ml or 75% of VC.

Vital Capacity (VC) – Air expelled from the lungs during a forced expiration after the deepest inhalation. (VC = IRV + TV + ERV) Average = 4800 ml..

Values not measured by the spirometer:

Minute Reserve Volume (MRV) – Air volume that passes in and out of the lungs during quiet breathing per minute. (MRV = TV x Number of breaths per minute)

Residual Volume (RV) – Air that remains within the lungs at all times. Average = 1200 ml.

Total Lung Capacity (TLC) – Total air that the lungs contain. (TLC = VC + RV) Average = 6000 ml.

9. To calculate the six lung volumes and capacities we are measuring in 14-A: convert the millimeter measurement into milliliters by measuring the height of the volume in mm in the SVC graph (see Fig. 14-1 on p. 92) and multiplying that length in mm by 64.17 ml/mm (our SVC conversion factor). Then round off ml to whole numbers. Use the gridlines to double check that your figures are in the ballpark (e.g., if you calculated the vital capacity in Fig. 14-1 to be 3800

ml, you must be off because you can tell from just looking at the gridlines that it is much closer to 5000 ml than 3800 ml). Can you see this in Fig. 14-1?

10. Compare your values to the average values given above. Explain possible causes for any differences between the two values. After completing 14-C, you will have a predicted VC from a nomogram; compare your actual VC from the SVC test (14-A) with that predicted VC from the 14-C nomogram.

14-B: The Forced Vital Capacity (FVC) or Forced Expiratory Volume (FEVT) – Morgan ComPAS Pneumotrac

A Forced Vital Capacity (FVC) is an important test in that it measures the rate at which air is expelled from the lungs. Healthy lungs should be able to forcefully expel at least 80% of the vital capacity within one second and about 95% within three seconds. Failure to expel these volumes indicates an apparent air entrapment in the lungs indicative of asthma, chronic bronchitis, or emphysema.

Procedure

1. The Morgan ComPAS computer program has already calculated and factored in the BTPS

(Body Temperature Pressure Saturation) correction factor.

2. Fully insert the Pneumotrac filter/mouthpiece you purchased at the bookstore. If you have difficulty keeping air from leaking through your nose, you may need to wear a nose clip, as air leakage will result in inaccurate results.

3. Be sure the correct student information is loaded up before you start the FVC test.

4. After starting the FVC test, follow the verbal instructions of your instructor: begin with your mouth off the mouthpiece so the pneumotach can equilibrate; after getting a good seal with your mouth, start with tidal breathing; when you are ready, take in the deepest breath possible, then forcefully blow it out as fast as you can and keep squeezing until instructed to stop. The instructor will print out your “FVC Volume Time Curve” (part of yFig. 14-2: A sample FVC from the Morgan ComPAS Pneumotrac.

5. To calculate the vital capacity for the FVC test (also called the forced expiratory volume), measure the height of the highest peak of the curve in mm and multiply that length in mm by 66.67 ml/mm (our FVC conversion factor). Then round off ml to whole numbers. (NOTE: this is similar to the 14-A SVC calculations, but with a different conversion factor.) Just like in 14-A, use the gridlines to double check that your figures are in the ballpark (e.g., if you calculated the vital capacity in Fig. 14-2 on p. 94 to be 3635 ml, you must be off because you can tell from just looking at the gridlines that it is much closer to 4500 ml than 3635 ml). Can you see this in Fig. 14-2?

6. Go to the “1 second” vertical line in your FVC graph and measure the height where the curved line crosses the 1 second vertical line in the same way as you did for the FVC in step 5. This is your FEV1 volume.

7. Divide the volume you calculated for FEV1 by the volume you calculated for the vital capacity in step 6, and then multiply by 100 to determine the percentage of the vital capacity exhaled at one second.

8. Go to the “3 second” vertical line in your FVC graph and measure the height where the curved line crosses the 3 second vertical line in the same way as you did in steps 5 and 6. This is your FEV3 volume.

9. Divide the volume you calculated for FEV3 by the volume you calculated for the vital capacity in step 6, and then multiply by 100 to determine the percentage of the vital capacity exhaled at three seconds.

10. Compare these values to the predicted values and explain possible causes for any differences.

14-C: Portable spirometry

A portable spirometer enables the health care practitioner to measure a person’s vital capacity when computer technology is not available.

Procedure

1. Open the grey plastic box on your lab desk that says “BASELINE Lung Capacity Spirometer” on the lid. Inside the lid of the box is a white paper that has specific instructions, please read the whole inside page with “how to use.”
2. Insert the clear plastic mouthpiece on the “Windmill-Type” spirometer and make sure the measurement indicator is at the zero position before beginning.
3. Make sure you only exhale into the spirometer, DO NOT inhale from it.
4. After exhaling, record the measurement from the spirometer. Be sure to place your used plastic mouthpiece in the correct tub after use (the tub is labeled).
5. Calculate your predicted vital capacity from the nomograms available in lab. Using a straightedge, make a line matching your height and age to the vital capacity prediction. Note that the VC is in liters whereas other measurements have been taken in milliliters.
6. Compare the values obtained from the portable spirometer, the predicted values from the nomograms, and the value obtained from the Koko spirometer, if available. How can you account for any differences? (NOTE: your predicted VC from the nomogram, and a comparison to the measured VC in 14-A should be included in your discussion of 14- A).

14-D: Incentive inspiratory devices

Incentive inspiratory devices are used in clinical settings, such as hospitals, for rehabilitating respiratory and cardiac patients. When patients undergo open-heart surgery, for example, the respiratory muscles are cut and need to be strengthened following surgery to avoid complications such as pneumonia. In addition, these incentive inspiratory devices are sometimes used by patients who remain bed-ridden for long periods. Since inspiration is an active process, these muscles are targeted during rehabilitation. The patient can see the progress that is being made and have incentive to improve. Several different models of these instruments are available but all are based on the same premise of having the patient breath in as deeply as possible. You will have the opportunity to try one or more of these devices and measure your inspiratory capability.

Procedure

1. Obtain an incentive device and attach your disposable cardboard mouthpiece and white

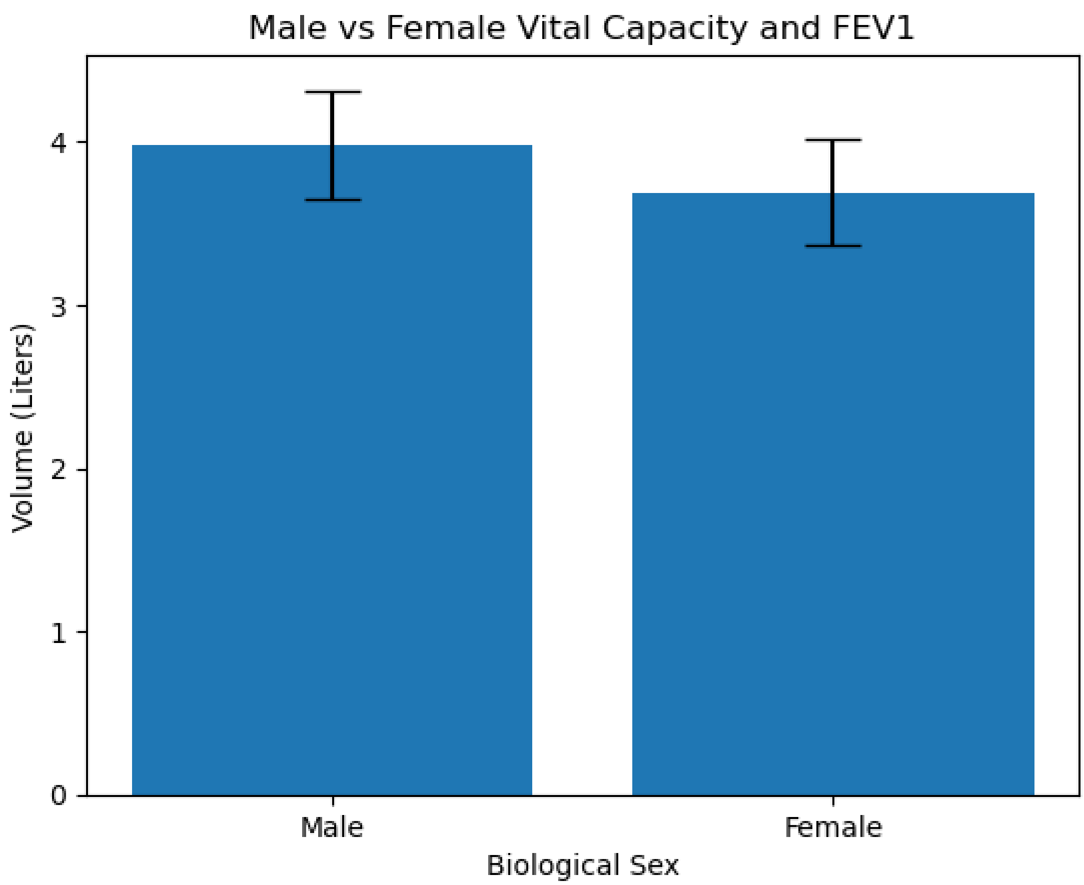
(or blue) filter to the breathing tube. The filter is quite a bit bigger than the breathing tube, so use your hand to try to get the best seal possible, it is not crucial to have a complete seal.

2. Breathe in as deeply as possible and record the measurement given on the device. Depending upon the model, you may have to move colored balls up plastic columns or move a bellows within a column.

3. Record your values. Discard the disposable cardboard mouthpiece and place the filter in the correct tub after use (the tub is labeled).

our 14-B results), and it should look similar to Figure 14-2.

Results



Discussion

There is a difference between male and female in the measurement of Vital Capacity and FEV1 because females have smaller airways and smaller lung size than males.

Conclusion

The VC decreases with respiratory systems that are weak. FEV1 are higher the healthier your lungs are.