



Physiology Lessons
for use with the
Biopac Student Lab

For Windows® 98SE, Me, 2000 Pro, XP
or Mac® OS X 10.3-10.4

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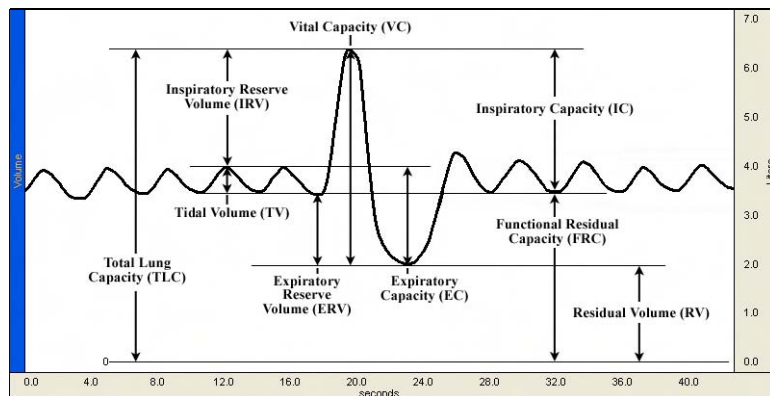
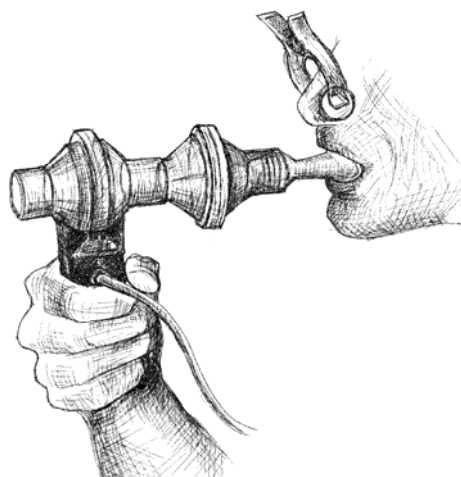
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Lesson 12 *New Procedure* PULMONARY FUNCTION I *Volumes and Capacities*



New Lesson Procedure

The Lesson 12 procedure was changed based on feedback from instructors. BSL 3.7.1-Windows (with journal date 10/27/2005) and BSL 3.7.1-Mac incorporate an updated breathing procedure and new analysis instructions to help students obtain accurate Tidal Volume values.

- **OLD OVERVIEW:** This recording shows normal breathing for 3 breaths, full inhale, return to normal breathing, full exhale, then a return to normal breathing.
- **REVISED TO:** This recording shows normal breathing for 5 breaths, full inhale, full exhale, then a return to normal breathing.

Segment 1 Guide:

- **OLD:** After the recording begins, Subject will do the following: Breathe normally for 3 breaths, then inhale as deeply as possible, then return to normal breathing for 3 breaths. Next, breathe out completely, then normally for 3 breaths. Recorder should click on the 'Stop' button when Subject is finished.
- **REVISED TO:** After the recording begins, Subject will do the following: Breathe normally for 5 breaths, then inhale as deeply as possible, then breathe out completely, then breath normally for 5 breaths. Recorder should click on the 'Stop' button when Subject is finished.

Segment 2 Guide:

- **OLD:** Subject will breathe normally for 3 breaths, then inhale as deeply as possible, then return to normal breathing for 3 breaths. Next, Subject will exhale completely, then breathe normally for 3 breaths. Keep the Airflow transducer upright at all times. When Subject is finished, Recorder should click on 'Stop.'
- **REVISED TO:** Subject will breathe normally for 5 breaths, then inhale as deeply as possible, then exhale completely, then breathe normally for 5 breaths. Keep the Airflow transducer upright at all times. When Subject is finished, Recorder should click on 'Stop.'

Analysis

- Analysis revised to match recorded data.

I. INTRODUCTION

The introductory text has not changed from the previously supplied lesson, but **Fig. 12.2** was updated:

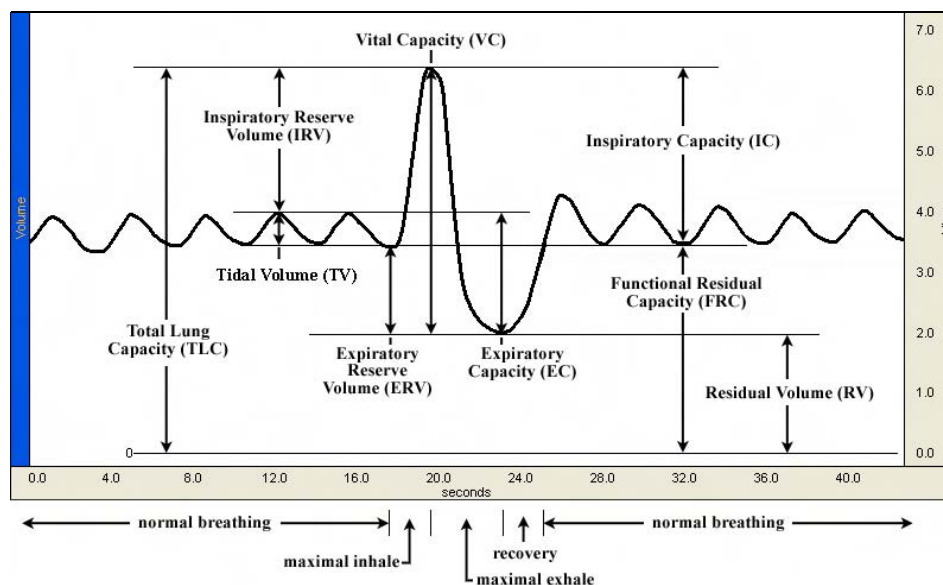


Figure 12.2 Example of respiratory volumes and capacities

II. EXPERIMENTAL OBJECTIVES

The objectives have not changed from the previously supplied lesson.

III. MATERIALS

The materials have not changed from the previously supplied lesson.

IV. EXPERIMENTAL METHODS

Key to Symbols

The symbols below are used to prompt you throughout Experimental Methods and Data Analysis.



If you encounter a problem or need further explanation of a concept, refer to the Orientation Chapter for more details.



The data collected in the associated step needs to be recorded in the Data Report (in the section indicated by the alpha character). You can record the data individually by hand or choose **Edit > Journal > Paste measurements** to paste data to your journal for future reference.



You need to manually insert an event marker and key in a label similar to the text in quotes. You insert an event marker during acquisition by pressing “F9” and can insert or edit markers and labels once acquisition is completed.

Each section of this lesson is presented in a two-column format, as described below.

FAST TRACK STEPS

This side of the lesson (left, shaded column) is the FAST TRACK through the lesson, and contains a basic explanation of each step.

DETAILED EXPLANATION OF STEPS

This side of the lesson contains more detailed information to clarify the steps and/or concepts in the FAST TRACK, and may include reference diagrams, illustrations, and screen shots.

A. SET UP

FAST TRACK SET UP

1. Turn your computer **ON**.
2. Make sure the BIOPAC MP35/30 unit is turned **OFF**.
3. Plug the airflow transducer (SS11LA) into Channel 1.
4. Turn on the MP35/30 Data Acquisition Unit.

Set Up continues

DETAILED EXPLANATION OF SET UP



The desktop should appear on the monitor. If it does not appear, ask the laboratory instructor for assistance.

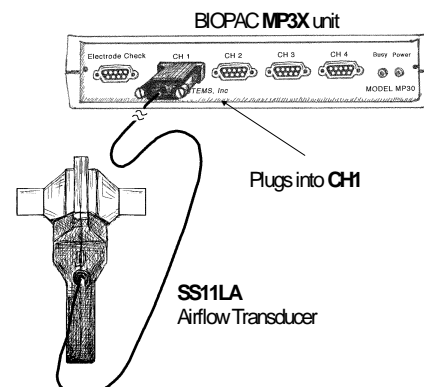


Fig. 12.3

5. Place a filter onto the end of the calibration syringe.

6. **Insert** the Calibration Syringe/Filter Assembly into the airflow transducer (Fig. 12.4).

IMPORTANT!
Always insert on the side labeled "Inlet"

The **filter is required** for calibration and recording because it forces the air to move smoothly through the transducer. This assembly can be left connected for future use. You only need to replace the filter if the paper inside the filter tears.

The bacteriological filter **must be used** between the transducer and calibration syringe in order for the data to be accurate.

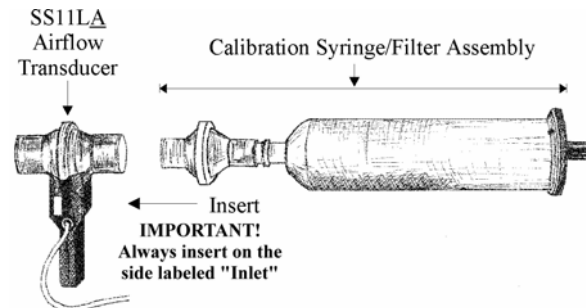


Fig. 12.4

If using SS11LA transducer with removable, cleanable head, always insert syringe assembly on the transducer side labeled "**Inlet**" so that the transducer cable exits on the left, as shown in Fig. 12.4.

- **If using SS11L** transducer with non-removable head, insert syringe assembly into the larger diameter port.

IMPORTANT: If your lab sterilizes the airflow heads after each use, make sure a clean head is installed now.



Use a unique identifier.

This ends the Set Up procedure.

7. **Start** the Biopac Student Lab program.

8. Choose Lesson 12 (**L12-LUNG-1**).

9. Type in your filename.

10. Click **OK**.

END OF SET UP

B. CALIBRATION

The calibration procedure establishes the hardware's internal parameters (such as gain, offset, and scaling) and is critical for optimum performance. **Pay close attention to the entire calibration procedure.**

FAST TRACK Calibration

1. Pull the Calibration Syringe Plunger all the way out and hold the Calibration Syringe/Filter Assembly upright (Fig. 12.5).

NOTE: If you have previously calibrated the SS11LA Airflow Transducer for Lesson 12 or 13, and have not exited the BSL software or changed the transducer, BSL has saved the prior calibration data.

- Go to **Step 1** of the **Recording Data** section of this lesson if you wish to begin recording data.
- Click **Redo Calibration** if you wish to recalibrate the transducer.

2. Click **Calibrate**.
3. Prepare for the second calibration stage.
4. Click **Yes** after reading the alert box.
5. Cycle the syringe plunger in and out completely 5 times (10 strokes).
6. Click **End Calibration**.

Calibration continues...

DETAILED EXPLANATION OF CALIBRATION STEPS

The Airflow Transducer is sensitive to gravity so it needs to be held upright throughout the calibration and recording.

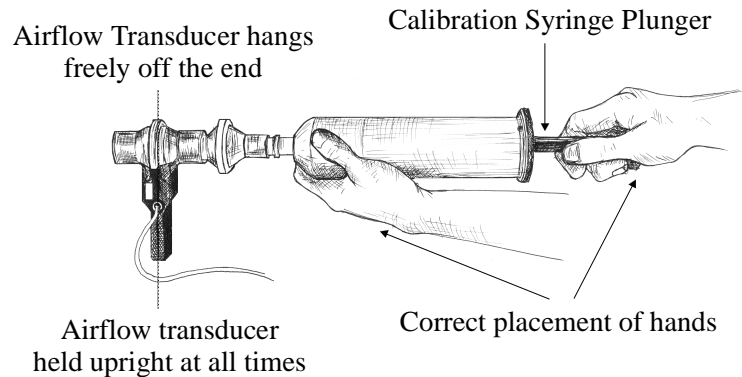


Fig. 12.5

IMPORTANT: Never hold onto the airflow transducer handle when using the calibration syringe or the syringe tip may break.

The first calibration procedure stage will run for 8 seconds and end with an alert box.

IMPORTANT: Leave the plunger extended and hold the assembly steady and upright during the entire calibration procedure. Do not touch the plunger because any pressure at this stage will cause inaccurate results.

Stage 1 of the calibration procedure ends with an alert box asking if you have read the directions in the journal. Read the directions in Step 5 and/or the journal so that, once the second calibration procedure starts, you understand the procedures.

Do not click on the **Yes** button until you are completely ready to proceed. When you click **Yes**, the second stage of the calibration procedure will begin, and will run until you click **End Calibration**.

Hold the syringe assembly as shown in Fig. 12.5 above.

Use a rhythm of about 1 second per stroke with 2 seconds rest between strokes, i.e., push the plunger in for approximately 1 second, wait 2 seconds, pull the plunger out, wait 2 seconds, and repeat 4 more times. Click **End Calibration** when done.

Note: The calibration procedure is required because of the complexity of the Airflow to Volume calculation. The accuracy of this conversion is aided by analyzing the airflow variations occurring over five complete cycles of the calibration syringe. Additional cycles would also help, but only with diminishing return rates. Five cycles turns out to be an adequate number of cycles for accurate calibration.

7. **Check** your calibration data.

At the end of the calibration recording, your screen should resemble Fig. 12.6.

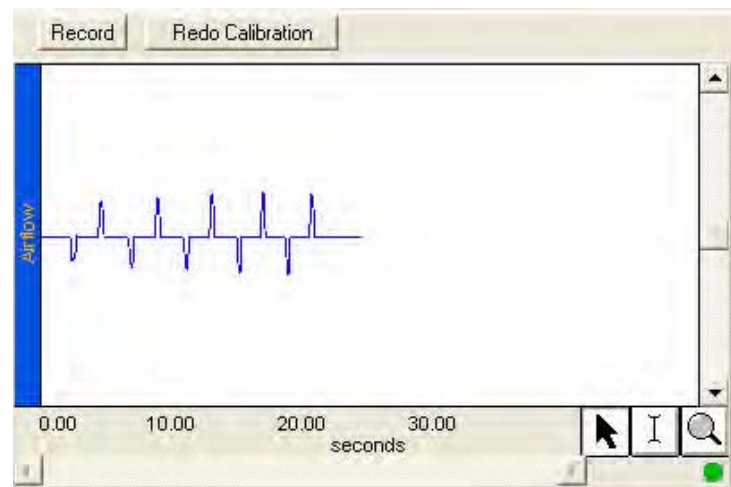


Figure 12.6

- If correct, go to the Data Recording section.
- If incorrect, **Redo Calibration**.

If your data shows 5 downward deflections and 5 upward deflections, you may proceed to the Data Recording section.

If the data shows any large spikes, then you must redo calibration by clicking **Redo Calibration** and repeating the entire calibration sequence.

END OF CALIBRATION

C. RECORDING LESSON DATA

FAST TRACK Recording

1. **OPTIONAL:** Validate Calibration:
 - a) Click Record.
 - b) Cycle the AFT6 syringe plunger in and out completely 5 times (10 strokes).
 - c) Click Stop.
 - d) Measure P-P on CH2 Volume to confirm the result is 0.6 liters (Fig. 12.7)
 - e) Click Redo and proceed with Subject recording (or click Done and repeat calibration if necessary).
2. Prepare for the recording.

IMPORTANT!
**Subject must be relaxed to
 obtain accurate measures.**

Recording continues...

DETAILED EXPLANATION OF RECORDING STEPS

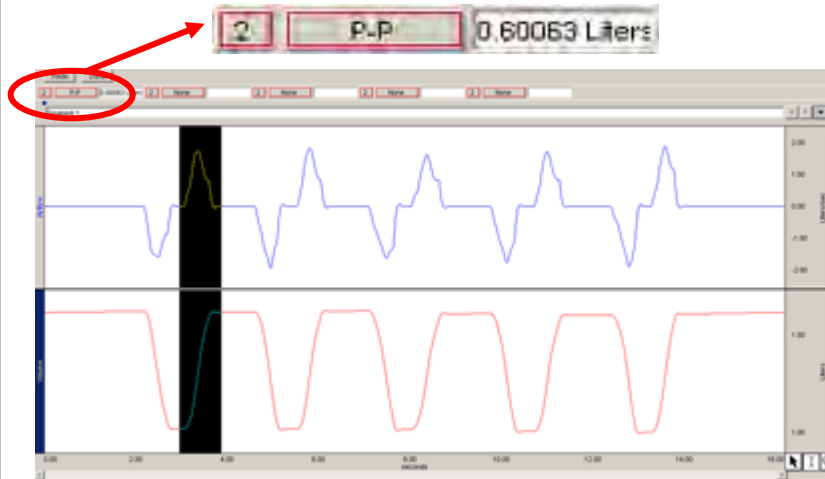


Figure 12.7 Calibration Validation shows P-P result 0.6 liters

In order to work efficiently, read this entire section so you will know what to do for each recording segment.

Following the procedure precisely is very important, as the calculation from airflow to volume is very sensitive.

Subject should be seated, facing away from the computer monitor, relaxed, with eyes closed while you review the lesson.



Check the last line of the journal and note the total amount of time available for the recording. Stop each recording segment as soon as possible so you don't use an excessive amount of time (time is memory).



Note: Residual Volume (RV) cannot be determined using a normal spirometer or airflow transducer, so the Biopac Student Lab software uses a default of 1 Liter. If 1 Liter of RV is not desired, see your Instructor to change the Preference.

Hints for obtaining optimal data:

- a) **Subject** should be seated, facing away from the computer monitor, relaxed, with eyes closed.
- b) **Subject** should insert mouthpiece and begin breathing normally **BEFORE** the recording is started since the mouthpiece may influence normal values.
- c) Always insert on and breathe through the transducer side labeled "Inlet."
- d) Keep the Airflow Transducer upright at all times (Fig. 12.11).
- e) A breath is considered a complete inhale-exhale cycle. If you start the recording on an inhale, try to end on an exhale, and vice-versa. This is not absolutely critical, but does increase the accuracy of the Airflow to Volume calculation.

3. Insert a clean mouthpiece (and filter if applicable) into the airflow transducer as described below:

To be safe, follow this procedure precisely to make sure the airflow transducer is sterile.

- If using the SS11LA transducer and **sterilizing** the head after each use:

IMPORTANT!
Always insert on the side labeled "Inlet"

- If using the SS11LA transducer and **not sterilizing** the head after each use:

IMPORTANT!
Always insert on the side labeled "Inlet"

- If using the SS11L:

4. Subject should place his/her personal nose clip on nose.

Recording continues...

IMPORTANT: If your lab sterilizes the airflow heads after each use, make sure a clean head is installed now.

Have the **Subject** personally remove the filter and mouthpiece from the plastic packaging. This mouthpiece will become the **Subject's** personal mouthpiece. It is advisable to write the **Subject's** name on the mouthpiece and filter with a permanent marker so they can be reused later.

If using SS11LA transducer and sterilizing the head after each use, insert a disposable mouthpiece (BIOPAC AFT2) or an autoclavable mouthpiece (BIOPAC AFT8) into the airflow transducer on the side labeled "Inlet."

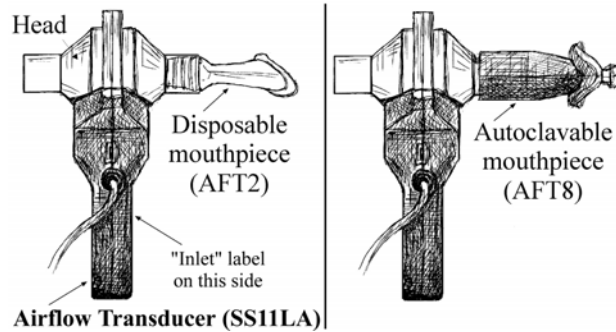


Fig. 12.8 SS11LA with sterilized head

If using SS11LA transducer and not sterilizing the head after each use, insert a filter and mouthpiece into the airflow transducer on the side labeled "Inlet."

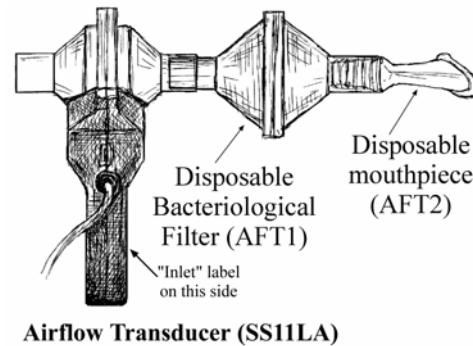


Fig. 12.9 SS11LA with unsterilized head

If using SS11L transducer with non-removable head, insert a new filter and mouthpiece into the larger diameter port.

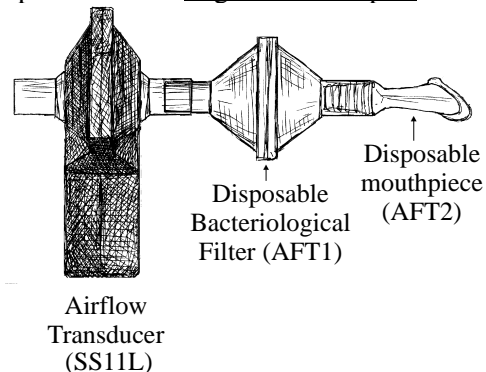


Fig. 12.10 SS11L

5. Breathe normally for 20 seconds through the Airflow Transducer **BEFORE** clicking Record.

IMPORTANT!
Subject must remain relaxed and always breathe through the side labeled "Inlet"

6. Click **Record**.
- Breathe normally for 5 breaths.
 - Inhale as deeply as you can.
 - Exhale as deeply as you can.
 - Breathe normally for 5 breaths.

7. Click **Stop**.

8. Review the data on the screen.
- If correct, go to Step 7.

- If incorrect, click **Redo**.

Recording continues...

A breath is considered a complete inhale-exhale cycle. Subject should be relaxed with eyes closed for "normal breathing." Allow time for Subject to acclimate to the mouthpiece **BEFORE** clicking Record.

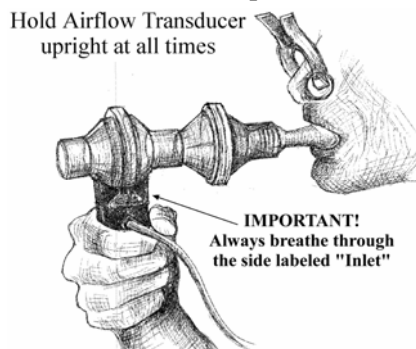


Fig. 12.11 Keep the Airflow Transducer upright at all times

For accurate measures, the Subject must be completely relaxed, with eyes closed, and breathing normally. The mouthpiece will influence the Subject's breathing, so allow time for the Subject to acclimate to the mouthpiece **BEFORE** clicking Record.

- **A breath is considered a complete inhale-exhale cycle.** Subject should be relaxed with eyes closed and not facing the computer.
- If you start the recording on an inhale, try to end on an exhale, and vice-versa.

As soon as the **Stop** button is pressed, the Biopac Student Lab software will automatically calculate volume data based on the recorded airflow data. At the end of the calculation, both waveforms will be displayed on the screen (Fig. 12.12).

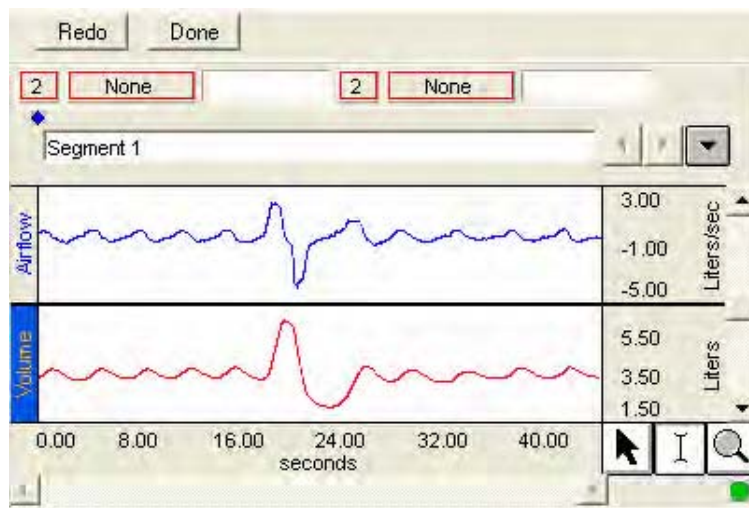


Fig. Fig. 12.12

Your data should resemble Fig.12.12, showing a positive spike for inhalation and a negative spike for exhalation.

The data would be incorrect if you feel you didn't follow the procedure precisely, i.e. you coughed or air escaped.

In this case, you should redo the recording by clicking **Redo** and repeating Steps 5-8. Note that once you press **Redo**, the data you have just recorded will be erased.

9. Click **Done**.

After you press **Done**, your data will automatically be saved in the specified “Data Files” folder. A pop-up window with options will appear. Make your choice, and continue as directed.

If choosing the “Record from another Subject” option:

- a) You will not need to recalibrate the airflow transducer. For this reason, we recommend that all recordings be completed before you proceed to Data Analysis.
- b) Remember to have each person use his/her own mouthpiece, bacterial filter and nose clip.
- c) Repeat Recording Steps 1-7 for each new **Subject**.
- d) Each person will need to use a unique file name.

END OF RECORDING

V. DATA ANALYSIS

FAST TRACK Data Analysis

1. Enter the **Review Saved Data** mode and choose the correct file.

Note channel number (CH) designations:

| Channel | Displays |
|---------|----------|
| CH 1 | Airflow |
| CH 2 | Volume |

2. Turn **OFF** Channel 1, Airflow.

Optional: Review Airflow data before turning Channel 1 off.

3. Set up the measurement boxes as follows:

| Channel | Measurement |
|---------|-------------|
| CH 2 | P-P |
| CH 2 | Max |
| CH 2 | Min |
| CH 2 | Delta |

Data Analysis continues...

DETAILED EXPLANATION OF DATA ANALYSIS STEPS



Enter the Review Saved Data mode.

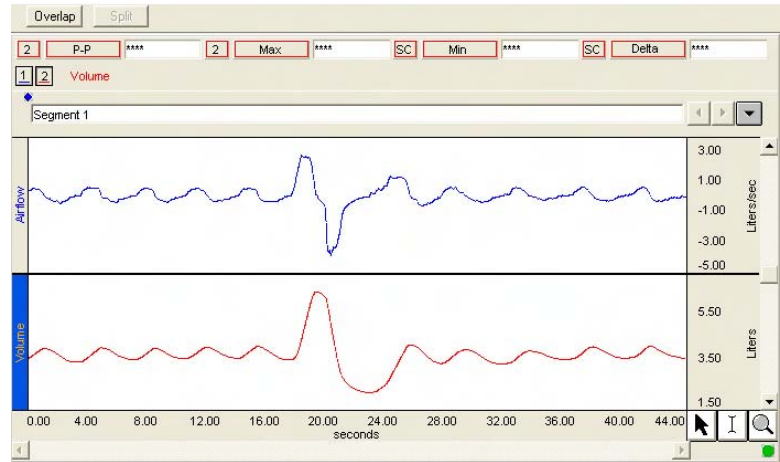


Fig. 12.13

Note: Airflow (Channel 1) and Volume (Channel 2) data are shown simultaneously. First, concentrate on the Volume data.



To toggle a channel ON/OFF, click on the channel number box and hold down the “Ctrl” key.

The Airflow data does not have a lot of meaning for this lesson and may be confusing at first glance, but it contains an interesting perspective on the recording. Note that the vertical scale of the airflow waveform is in Liters per second (Liters/sec.), and that the data is centered on zero. Looking at the graph, you can see that with each exhale, a downward pointing curve appears. The deeper an inhale, the larger the positive peak; the more forceful an exhale, the larger the negative peak.

The measurement boxes are above the marker region in the data window. Each measurement has three sections: channel number, measurement type, and result. The first two sections are pull-down menus that are activated when you click on them. The following is a brief description of these specific measurements.

P-P: finds the maximum value in the selected area and subtracts the minimum value found in the selected area.

Max: displays the maximum value in the selected area.

Min: displays the minimum value in the selected area.

Delta: computes the difference in amplitude between the last point and the first point of the selected area.

The “selected area” is the area selected by the I-Beam tool (including the endpoints)

4. Review the measurements described in the Introduction to identify the appropriate selected area for each:

- Total Lung Capacity
- Tidal Volume
- Inspiratory Reserve Volume
- Expiratory Reserve Volume
- Vital Capacity
- Expiratory Capacity
- Inspiratory Capacity
- Functional residual Capacity
- Residual Volume

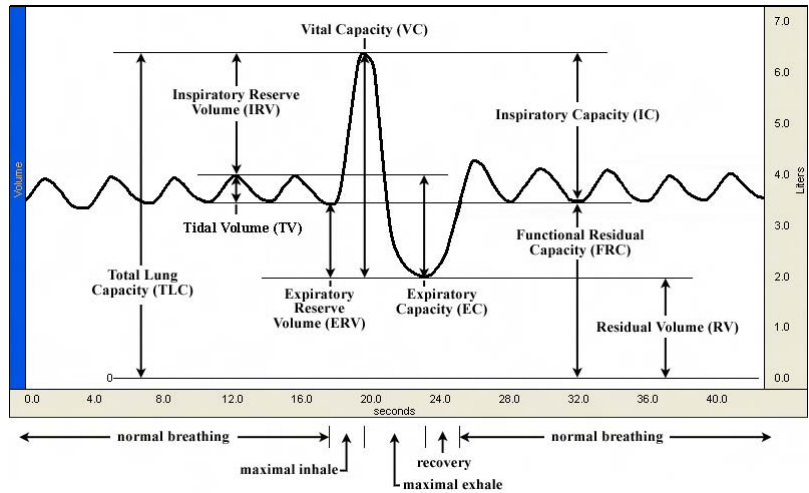


Fig. 12.14 Measurement areas for respiratory volumes and capacities

5. Measure observed VC (P-P).



The **P-P** measurement can be used to obtain VC (Fig. 12.15).

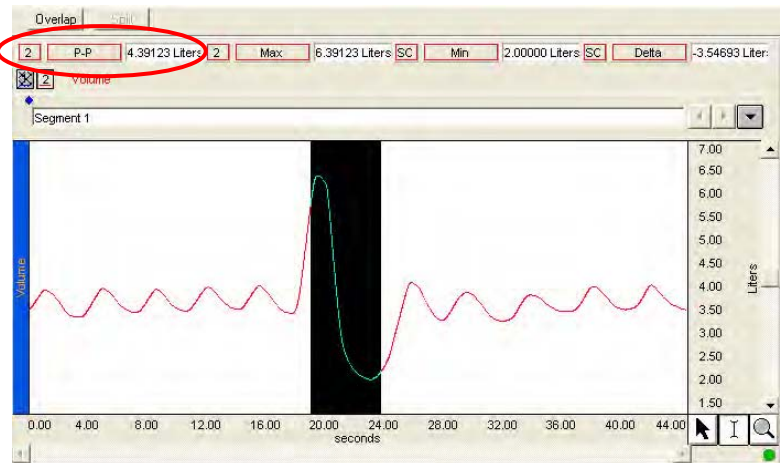


Figure 12.15 Example of VC from P-P measure

6. Take two measures for an averaged TV calculation:

- a) Use the **I-beam** cursor to select the **inhalation** of cycle 3 and note the P-P result (Fig. 12.16). The selected area should be from the valley to the peak of the third cycle.



The **P-P** measurement in Fig. 12.16 represents the first value required for the averaged TV calculation.

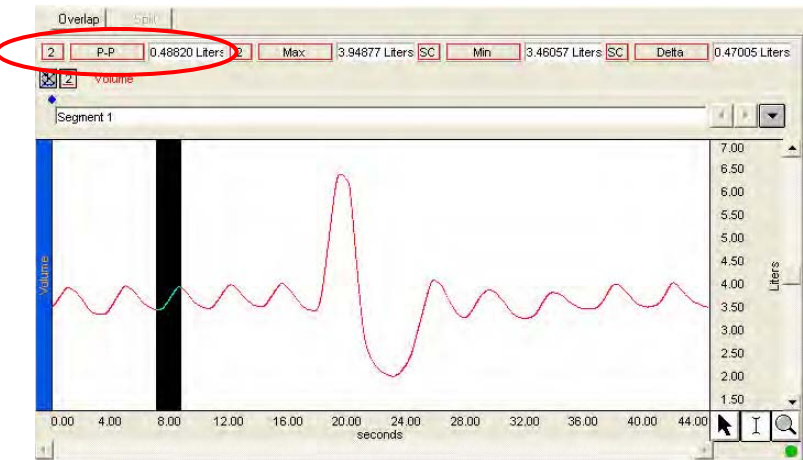


Fig. 12.16 Inhalation of third breath cycle selected to measure P-P

Data Analysis continues...

- b) Use the **I-beam** cursor to select the **exhalation** of cycle 3 and note the P-P result (Fig. 12.17). The selected area should be from the peak to the valley of the third cycle.



The **P-P** measurement in Fig. 12.17 represents the second value required for the averaged TV calculation.

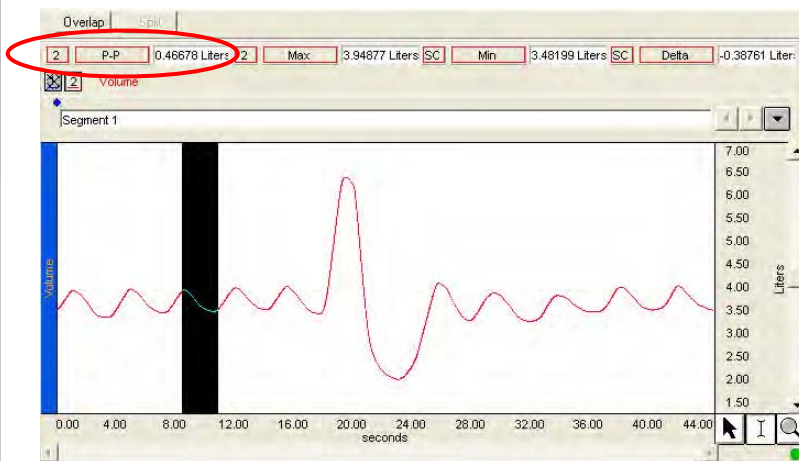


Fig. 12.17 Exhalation of third breath cycle selected to measure P-P

- 7. Use the I-beam cursor and measurement tools to observe the following volumes and capacities (defined in Fig. 12.14):

- a) IRV (Delta)
- b) ERV (Delta)
- c) RV (Min)
- d) IC (Delta)
- e) EC (Delta)
- f) TLC (Max)



The **Delta** measurement can be used to obtain IRV, ERV, and other measurements (Fig. 12.18).

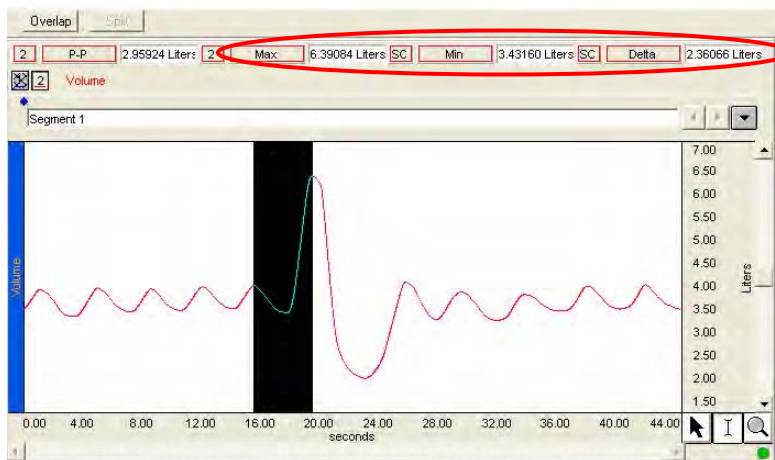


Fig. 12.18 Example of measurements for TLC (Max result), RV (Min result), and IRV (Delta result)T

- 8. Save or Print the data file.
- 9. Exit the program.



You may save the data to a drive, save notes that are in the journal, or print the data file.

END OF DATA ANALYSIS

END OF LESSON 12

Complete the Lesson 12 Data Report that follows.

Lesson 12

PULMONARY FUNCTION I

Volumes and Capacities

DATA REPORT

Student's Name: _____

Lab Section: _____

Date: _____

Subject Profile

Name _____

Height _____

Age _____

Weight _____

Gender: Male / Female

I. Measurements

A. Vital Capacity

i) **Predicted:** Use the equation below to calculate your **Predicted Vital Capacity:** _____ liters
A1

| Equations for Predicted Vital Capacity | |
|--|-------------------------------|
| Male | V.C. = 0.052H - 0.022A - 3.60 |
| Female | V.C. = 0.041H - 0.018A - 2.69 |

Where

- V.C. Vital Capacity in liters
- H Height in centimeters
- A Age in years

ii) **Observed:** Use the P-P measurement result to note **Observed Vital Capacity:** _____ liters
A2

iii) **Observed vs. Predicted**

What is the Subject's observed Vital Capacity to predicted Vital Capacity as a percentage?

Observed VC / Predicted VC = A1/A2 = _____ liters x 100 = _____ %

Note: Vital capacities are dependent on other factors besides age and height. Therefore, 80% of predicted values are still considered "normal."

B. Volume & Capacity Measurements

Complete Table 12.2 with the requested measurement results and calculate results per the formulas provided.

Table 12.2 Measurements

| Title | | Measurement Result | Calculation |
|-------------------------------------|-----|--|-------------------------------------|
| Tidal Volume | TV | a = P-P Cycle 3 inhalation: b = P-P Cycle 3 exhalation: | $(a + b) / 2 =$ |
| Inspiratory Reserve Volume | IRV | Delta | |
| Expiratory Reserve Volume | ERV | Delta | |
| Residual Volume | RV | Min | Default = 1 (Preference setting) |
| Inspiratory Capacity | IC | Delta | $TV + IRV =$ |
| Expiratory Capacity | EC | Delta | $TV + ERV =$ |
| Functional Residual Capacity | FRC | | $ERV + RV =$ |
| Total Lung Capacity | TLC | Max | $IRV + TV + ERV + RV =$ |

C. Observed vs. Predicted Volumes

Using data obtained for Table 12.2, compare the Subject's lung volumes with the average volumes presented in the Introduction.

Table 12.3 Average Volumes vs. Measured Volumes

| Volume Title | | Average Volume | Measured Volume |
|-----------------------------------|-----|---|---------------------------------------|
| Tidal Volume | TV | Resting subject, normal breathing: TV is approximately 500 ml. During exercise: TV can be more than 3 liters | greater than equal to less than |
| Inspiratory Reserve Volume | IRV | Resting IRV for young adults is males = approximately 3,300 ml females = approximately 1,900 ml | greater than equal to less than |
| Expiratory Reserve Volume | ERV | Resting ERV for young adults is males = approximately 1,000 ml females = approximately 700 ml | greater than equal to less than |

II. QUESTIONS

D. Why does predicted vital capacity vary with height?

E. Explain how factors other than height might affect lung capacity.

F. How would the volume measurements change if data were collected after vigorous exercise?

G. What is the difference between volume measurements and capacities?

H. Define **Tidal Volume**.

I. Define **Inspiratory Reserve Volume**.

J. Define **Expiratory Reserve Volume**.

K. Define **Respiratory Volume**.

L. Define **Pulmonary Capacity**.

M. Name the **Pulmonary Capacities**.

End of Lesson 12 Data Report