

Experiment VP-1: Blood Pressure, Pulse, and Body Position

Background

When the heart pumps blood into the arteries, there is a sudden increase in pressure in the arteries. The highest level of pressure, that occurs immediately after the ventricles contract, is known as the systolic blood pressure. The pressure in the arteries slowly declines as the heart relaxes. The lowest level of pressure, that occurs just prior to the next contraction of the ventricles, is known as the diastolic blood pressure.

Systolic and diastolic blood pressures are commonly measured with a stethoscope and a sphygmomanometer (blood pressure cuff). The cuff is placed on the upper left arm as the stethoscope is used to listen to the pulsatile flow of blood in the major artery of the arm. Once the stethoscope is properly placed over the artery and the thumping sound of the pulse is heard, the cuff is inflated. If the pressure in the cuff is high enough, the cuff compresses the artery in the upper arm and the flow of blood through the artery to the lower arm stops and the thumping sound disappears. When the pressure in the cuff is released and the pressure in the artery is greater than the pressure in the cuff, blood resumes flowing to the lower arm. As the blood resumes flowing into the lower arm, the thumping sound of the pulse reappears. The pressure in the blood pressure cuff at the time that the thumping sound first reappears is equal to the systolic blood pressure. When more pressure is released from the cuff, the thumping sound eventually disappears, again. The pressure in the blood pressure cuff at the time that the thumping sound disappears is equal to the diastolic blood pressure.

Measuring blood pressure using a blood pressure cuff and a stethoscope takes a great deal of practice. To assist students in learning the technique of taking blood pressures with a stethoscope, a pulse plethysmograph will be used to record the appearance and disappearance of pulsatile blood flow in the artery that indicate when the pressures in the cuff are equal to the systolic and diastolic blood pressures. In addition to learning to measure the blood pressure and comparing blood pressures from different subjects, the effects of cuff location, body position, and arm position will be examined.

Warning: As explained above, this procedure involves stopping blood flow to the arm, which is potentially dangerous. Please take the following precautions.

Precautions

1. Know what you are doing ahead of time.
2. Do not leave the cuff inflated for any prolonged period of time (>20 seconds).
3. The subject should flex and extend their fingers between experiments to maintain blood flow.
4. This experiment should be performed by healthy individuals who do not have a personal or family history of cardiovascular or respiratory problems. It is preferable to use more than one subject during the course of the lab session.

Equipment Required

PC or Mac Computer

IX-ELVIS

USB cable

Power supply

PTN-104 Pulse plethysmograph

Stethoscope

BP-220 Non-invasive blood pressure transducer

GPSN-100 gas pressure sensor

A-BT-100 tubing

IX-ELVIS Setup

1. Place the IX-ELVIS unit on the bench, close to the computer.
2. Connect the IX-ELVIS to the computer with the supplied USB cable.
3. Insert the power plug into the rear of the IX-ELVIS and plug the transformer into the electrical outlet. Turn on the power switches on the rear and on the upper right side of the top of the unit and confirm that the LEDs are illuminated.

Start the Software

1. Click on the LabScribe shortcut on the computer's desktop to open the program. If a shortcut is not available, click on the Windows Start menu, move the cursor to All Programs and then to the listing for iWorx. Select LabScribe from the iWorx submenu. The LabScribe Main window will appear as the program opens.
2. On the Main window, pull down the Settings menu and select Load Group.
3. Locate the folder that contains the settings group, ELVISNI.iwxgrp. Select this group and click Open.
4. Pull down the Settings menu again. Select the BP-Pulse-BodyPosition-LS2 settings file.
5. After a short time, LabScribe will appear on the computer screen as configured by the BP-Pulse-BodyPosition-LS2 settings.
6. The settings used to configure the LabScribe software and the IX-ELVIS for this experiment are programmed on the Preferences Dialog window which can be viewed by selecting Preferences from the Edit menu on the LabScribe Main window.

Blood Pressure and Pulse Transducers Setup

1. Locate the BP-220 non-invasive blood pressure (NIBP) transducer, the A-BT-100 tubing, and the GPSN Pressure sensor. Assemble as illustrated in [Figure VP-1-S1](#).

2. Locate the PTN-104 pulse transducer (Figure VP-1-S2)



Figure VP-1-S1: The BP-220 non-invasive blood pressure transducer.

2. Plug the mini-DIN connector of the PTN-104 into the Channel 3 input of the IX-ELVIS ([Figure VP-1-S3](#)).
3. Plug the mini-DIN connector of the GPSN-100 into the Channel 4 input of the IX-ELVIS ([Figure VP-1-S3](#)).



Figure VP-1-S2: The PTN-104 pulse plethysmograph.



Figure VP-1-S3: The PTN-104 pulse transducer and the BP-220 non-invasive blood pressure transducer connected to the IX-ELVIS.

Calibration of the Non-Invasive Blood Pressure Transducer

Procedure

1. With the supplied manometer in place, put the cuff of the BP-220 on the upper arm of the subject. Align the arrow on the cuff over the subject's brachial artery. Have the subject rest in the supine position while the blood pressure sensor is calibrated.
2. Click on the Record button, located on the upper right side of the LabScribe Main window ([Figure VP-1-L1](#)). The signal should begin scrolling across the screen.

Note: If the user clicks the Record button and there is no communication between the IX-ELVIS and computer, an error window will appear in the center of the Main window. Make sure the IX-ELVIS is turned on and connected to the USB port of the computer. Click OK and select the Find Hardware function from the LabScribe Tools menu.

3. Type "Calibration @ 70 mmHg" in the Mark box to the right of the Mark button. Inflate the pressure in the cuff to 70 mmHg as read on the manometer.
4. Click on the AutoScale button at the upper margin of the Pulse and Blood Pressure channels.

Your recording should look like [Figure VP-1-L1](#).

- If the signal on the Pulse channel is upside down when compared to trace in [Figure VP-1-L1](#), click on the downward arrow to the left of the channel title and select the Invert function. The trace should now look similar to the one in the figure.
 - If the pulse signal is small or noisy, adjust the tension on the strap holding the pulse plethysmograph to the finger.
5. While recording, press the Enter key on the keyboard to mark the pressure in the cuff on the data. Record the output of the BP-220 at 70 mmHg pressure for ten to fifteen seconds before increasing the pressure in the cuff ([Figure VP-1-L1](#)). While recording at a pressure of 70 mmHg, type “Calibration @ 140 mmHg” in the Mark box.
 6. As the recording continues, increase the pressure in the cuff to 140 mmHg and press the Enter key on the keyboard. Hold the pressure in the cuff at this level for ten to fifteen seconds. Then, click the Stop button to halt the recording.
 7. After the last measurement, use the blue valve to release all the pressure from the blood pressure cuff and remove the manometer. The subject should continue to relax in the supine position as he or she flexes and extends the fingers on the cuffed arm to return of blood to the arm. You can remove the BP-220 cuff from the subject until Exercise 3.
 8. Select Save As in the File menu, type a name for the file. Choose a destination on the computer in which to save the file. Designate the file type as *.iwxdata. Click on the Save button to save the data file.

Units Conversion

1. Scroll to the beginning of the calibration data for the BP-220 non-invasive blood pressure transducer.
2. Use the Display Time icons to adjust the Display Time of the Main window to show the data collected at 70 and 140 mmHg on the Main window at the same time ([Figure VP-1-L1](#)). The required data can also be selected by:
 - Placing the cursors on either side of data required
 - Clicking the Zoom between Cursors button on the LabScribe toolbar to expand the segment with the four selected pulse cycles to the width of the Main window.
3. Click the 2-Cursor icon ([Figure VP-1-L2](#)) so that two vertical cursors appear on the Main window. Place one cursor on the flat section of data collected when the pressure in the cuff was 70 mmHg and the second cursor on the flat section of data collected when the pressure was 140 mmHg.



Figure VP-1-L1: The output of the BP-220 non-invasive blood pressure transducer displayed on the Main window with cursors at the points where the pressures in the cuff were 70 and 140 mmHg.

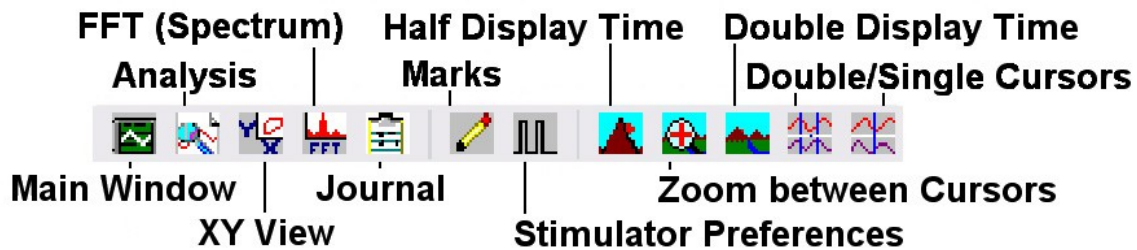


Figure VP-1-L2: The LabScribe toolbar.

4. To convert the voltages at the positions of the cursors to pressure values, use the Simple Units Conversion dialogue window (Figure VP-1-L3). To access this dialogue window, click on the arrow to the left of the channel title, Blood Pressure, to open the channel menu. Select Units from the channel menu, and select Simple from the Units submenu.
5. On the units conversion window, make sure 2 point calibration is selected in the pull-down menu in the upper-left corner of the window. Put a check mark in the box next to Apply units to all blocks. Notice that the voltages from the positions of the cursors are automatically entered into the value equations. Enter the two pressures used in the calibration recording in the corresponding boxes on the right side of the conversion equations. Enter the name of the units, mmHg, in box below the pressures. Click on the OK button in the lower right corner of the window to activate the units conversion.

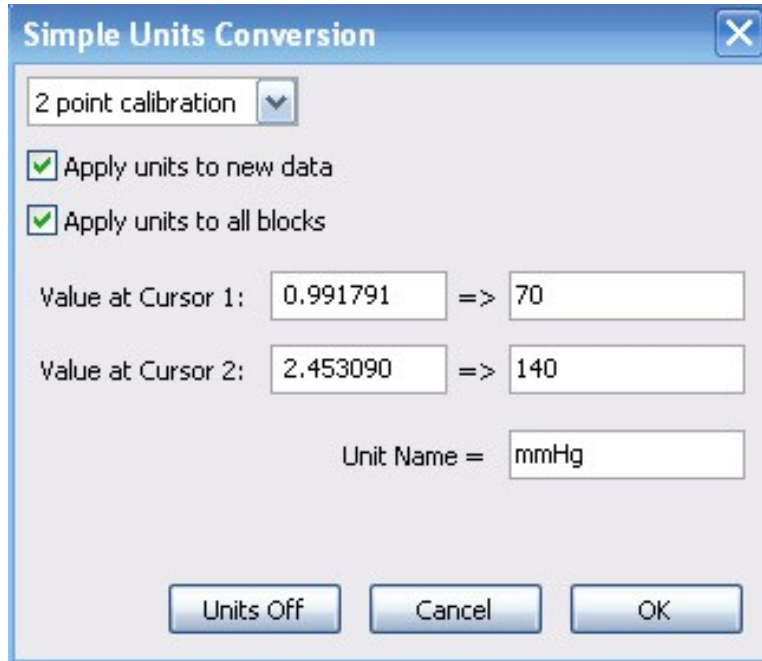


Figure VP-1-L3: The Simple Units Conversion dialogue window with the voltages at the cursors set to equal the pressures used in calibration.

Exercise 1: Blood Pressures from the Left Arm

Aim: To determine the systolic and diastolic blood pressures in a reclining subject, and if the subject is hypotensive (low blood pressure), normotensive, or hypertensive (high blood pressure).

Procedure

1. Instruct the subject to rest in the supine position for at least five minutes before his or her blood pressure is taken.
2. While the subject is resting, place the blood pressure cuff of the BP-220 around the upper portion of the left arm, just above the elbow. Place the PTN-104 pulse plethysmograph on the volar surface (where the fingerprints are located) of the distal segment of the left middle finger or thumb. Wrap the Velcro strap around the end of the finger to attach the unit firmly in place.
3. At the end of the rest period, click on the Record button to begin recording the subject's pulse and the blood pressure.
4. Inflate the blood pressure cuff until the finger pulse wave on the Pulse channel disappears ([Figure VP-1-L4](#)).
5. Once the pulse wave disappears, use the blue valve to release the cuff pressure at the rate of ~10 mmHg/second. Continue to release the pressure in the cuff until the aneroid gauge reads 20 mmHg.
6. Click the Stop button. Make sure the blood pressure cuff is completely deflated and is not

putting any unnecessary pressure on the subject's arm.

- The subject should continue to rest in the supine position between Exercises 1 and 2. To improve circulation in his or her arm, the subject should flex and extend their fingers to encourage blood circulation.
- Select Save in the File menu.

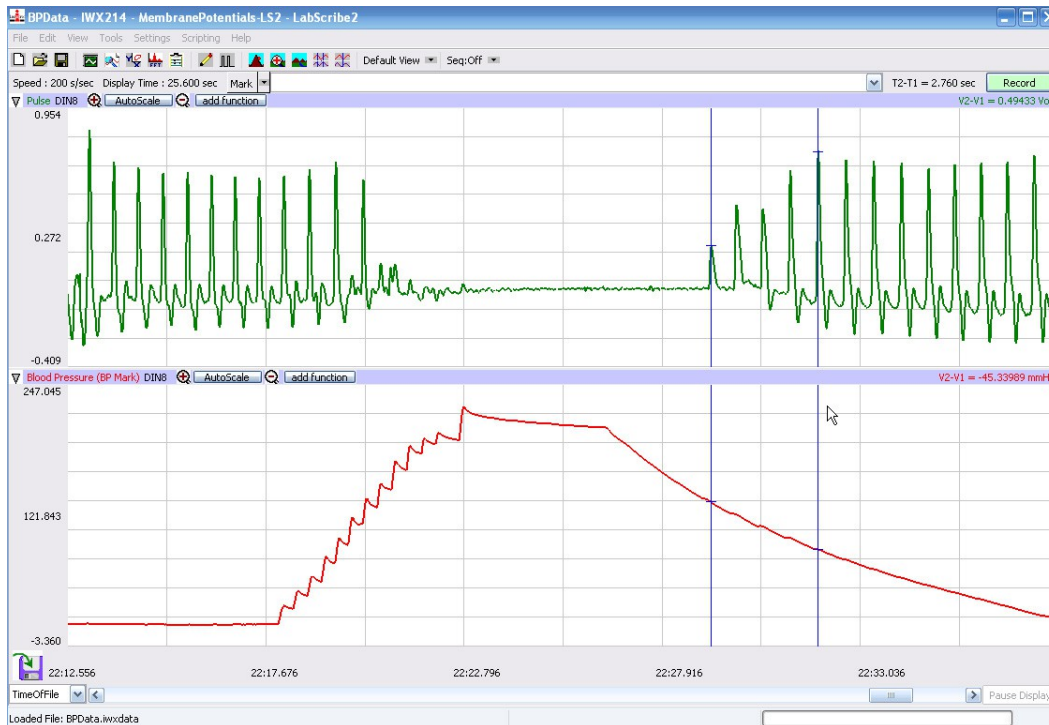


Figure VP-1-L4: The pulse wave and the pressure in the cuff of the BP-220 recorded before, during, and after the occlusion of the brachial artery. Pulses disappeared as the pressure in the cuff exceeded the pressure in the artery. As the pressure in the cuff is released, the pulse wave reappears.

Data Analysis

- Scroll through the recording and find the section of data recorded before, during, and after the pressure in the cuff was occluding the pulse ([Figure VP-1-L4](#)).
- Use the Display Time icons to adjust the Display Time of the Main window to show the pulse and the pressure in the cuff of the BP-220 from the occlusion of the artery to the pressure in the cuff being 20 mmHg. This section of data can also be selected by:
 - Placing the cursors on either side of the section of data needed, and;
 - Clicking the Zoom between Cursors button on the LabScribe toolbar to expand the segment of data to the width of the Main window.
- Click on the Analysis window icon in the toolbar ([Figure VP-1-L2](#)) or select Analysis from the Windows menu to transfer the data displayed in the Main window to the Analysis window.

4. Look at the Function Table that is above the uppermost channel displayed in the Analysis window. The mathematical functions that are listed should include V2-V1, Value1, Value2, and T2-T1. The values for these parameters from each channel are seen in the table across the top margin of each channel.
5. Once the cursors are placed in the correct positions for determining the blood pressures, the values for the blood pressures can be recorded in the on-line notebook of LabScribe by typing the names and values directly into the Journal.
6. The functions in the channel pull-down menus of the Analysis window can also be used to enter the names and values of the parameters from the recording to the Journal. To use these functions:
 - Place the cursors at the locations used to measure the cuff pressures from the Blood Pressure channel.
 - Transfer the name of the mathematical function used to determine the blood pressure to the Journal using the Add Title to Journal function in the ECG Channel pull-down menu.
 - Transfer the value for the blood pressure to the Journal using the Add Ch. Data to Journal function in the ECG Channel pull-down menu.
7. Once the cursors are placed in the correct positions for determining the systolic, diastolic, and pulse pressures, record the values for these pressures in the Journal using the one of the techniques described in Steps 5 or 6.
8. Use the mouse to click on and drag the cursors to specific points on the pulse and blood pressure recording to measure the following:
 - Systolic blood pressure. Place a cursor on the first of the smallest pulse waves that reappear after the pressure from the cuff of the BP-220 is released. Value1 on the Blood Pressure channel is the systolic blood pressure. Enter this pressure in [Table VP-1-L2](#).
 - Diastolic blood pressure. Place the other cursor on the first of the largest pulse waves that reappear as the pressure from the cuff of the BP-220 is released. Value2 on the Blood Pressure channel is the diastolic blood pressure. Enter this pressure in [Table VP-1-L2](#).
 - Pulse pressure, which is the difference between the systolic and diastolic pressures. To measure the pulse pressure, leave the cursors on the pulses that occur at the systolic and diastolic pressures. The value for V2-V1 on the Blood Pressure channel is the pulse pressure. Enter this pressure in [Table VP-1-L2](#).
9. Determine the subject's blood pressure class from [Table VP-1-L1](#). List it in [Table VP-1-L2](#).

Table VP-1-L1: Classification of Blood Pressure Levels According to the 7th Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC 7).

Class	Systolic Pressure (mmHg)	Diastolic Pressure (mmHg)
Hypotensive	less than 90	less than 60
Normal	120	and 60-80
Prehypertensive	120-139	or 80-89
Hypertensive Stage 1	140-159	or 90-99
Hypertensive Stage 2	greater than 60	or greater than 100

Table VP-1-L2: Blood Pressures from Different Arms in Different Positions

Subject _____	Systolic Pressure (mmHg)	Diastolic Pressure (mmHg)	Pulse Pressure (mmHg)	BP Class
Cuff Location/Hand Position				
Upper Left Arm/Hand Low, Ex.1				
Upper Left Arm/Hand Low, Ex.2				
Upper Right Arm/Hand Low				
Lower Right Arm/Hand Low				
Left Arm/Left Hand Low				
Left Arm/Right Hand High				
Left Arm/Left Hand High				

Exercise 2: Repeatability of Blood Pressure Measurements

Aim: To determine the repeatability of the blood pressure measurement from the upper left arm of the same subject.

Procedure

1. Repeat the procedures outlined in Exercise 1 on the same subject.
2. The subject should continue to rest in the supine position between Exercises 2 and 3.

Data Analysis

Use the same techniques used in Exercise 1 to determine the systolic and diastolic blood pressures of the subject.

Questions

1. Are the systolic and diastolic blood pressures from Exercises 1 and 2 identical? What are the possible sources of variation?
2. Since the pressures are determined using changes in the pulse amplitude, would slowing the rate at which pressure is released from the cuff make your readings more accurate?

Warning: If you decide to slow the release from the cuff pressure, remember that restricting circulation for a prolonged period can be dangerous. Do not release the pressure in the cuff at a rate any slower than 5 mm Hg per second.

Exercise 3: Blood Pressures from the Right Arm

Aim: To measure blood pressure from the right arm.

Procedure

1. The subject should continue to rest in the supine position before and during this exercise.
2. Place the blood pressure cuff of the BP-220 around the upper portion of the right arm, just above the elbow. Place the PTN-104 pulse plethysmograph on the volar surface of the distal segment of the right middle finger or thumb. Wrap the Velcro strap around the end of the finger to attach the unit firmly in place.
3. Use the same procedures outlined in Exercise 1 to record the subject's blood pressures from his or her upper right arm.
4. The subject should continue to rest in the supine position between Exercises 3 and 4.

Data Analysis

Use the same techniques used in Exercise 1 to determine the systolic and diastolic blood pressures recorded from the upper right arm of the subject.

Question

Are the values the same as those obtained for the left arm? Explain any differences.

Exercise 4: Blood Pressures from the Forearm

Aim: To examine whether blood pressure declines with distance from the heart.

Procedure

1. The subject should continue to rest in the supine position before and during this exercise.
2. Move the blood pressure cuff from the upper right arm to the lower right arm.
3. Use the same procedures enumerated in Exercise 1 to record the subject's blood pressures from his or her lower right arm.

Data Analysis

Use the same techniques used in Exercise 1 to determine the systolic and diastolic blood pressures recorded from the lower right arm of the subject.

Question

Are the values from the forearm the same as those obtained with the cuff on the upper arm? Explain any variations that you see.

Exercise 5: Blood Pressures with Different Arm Positions

Aim: To examine the effects of gravity on blood pressure and peripheral circulation.

Procedure

1. Select a new subject and instruct the subject to sit and relax for at least five minutes before his or her blood pressure is taken.
2. While the subject is relaxing, place the blood pressure cuff of the BP-220 around the upper portion of the left arm, just above the elbow and the PTN-104 on the volar surface of the distal segment of the left middle finger. Wrap the Velcro strap around the end of the finger to attach the unit firmly in place.
3. At the end of the relaxation period, use the same procedures used in Exercise 1 to determine the blood pressures of the subject while the subject is resting both hands in his or her lap.
4. Instruct the subject to place his or her right hand on top of their head. Determine the blood pressures of the subject while his or her right hand in this position. Instruct the subject to return his or her hand to their lap after the blood pressures in this position are determined.
5. Instruct the subject to place his or her left hand on top of their head. Determine the blood pressures of the subject while his or her left hand in this position. Instruct the subject to return his or her hand to their lap after the blood pressures in this position are determined.
6. Select Save in the File menu.

7. The subject should continue to sit and relax between Exercises 5 and 6.

Data Analysis

Use the same techniques used in Exercise 1 to determine the systolic and diastolic blood pressures recorded from the upper left arm of the subject.

Question

What is the effect of raising each hand on the blood pressure in the left arm? Explain your results.

Exercise 6: Blood Pressures from the Leg

Aim: To measure blood pressures from the leg.

Procedure

1. Instruct the subject used in Exercise 5 to sit and relax before his or her blood pressure is taken.
2. While the subject is relaxing, place the blood pressure cuff of the BP-220 around the lower left leg, just above the ankle, and the PTN-104 on the volar surface of the distal segment of the left large toe. Wrap the Velcro strap around the end of the toe to attach the unit firmly in place.
3. At the end of the relaxation period, use the same procedures used in Exercise 1 to determine the blood pressures in the subject's left leg while he or she is sitting with the left foot on the floor.
4. Determine the blood pressures in the subject's left leg when he or she is:
 - reclining in the supine position.
 - lifting his or her left leg perpendicular to the bench while reclining; support the leg with a chair.
 - standing.
 - standing for three minutes.
5. Select Save in the File menu.

Data Analysis

Use the same techniques used in Exercise 1 to determine the systolic and diastolic blood pressures recorded from the left leg of the subject. Record all data in [Table VP-1-L3](#).

Questions

1. Are the blood pressure values from the leg the same as those obtained from the arms? Explain any differences.
2. What happens to the blood pressures in the subject's left leg when the subject reclines? When the subject lifts his or her left leg perpendicular to the bench? When the subject stands? After

the subject has been standing for three minutes?

3. What is happening physiologically to cause the changes discussed in Question 2?

Table VP-1-L3: Blood Pressures from the Left Leg in Different Positions

Subject_____	Systolic Pressure (mmHg)	Diastolic Pressure (mmHg)	Pulse Pressure (mmHg)	BP Class
Leg Position				
Sitting				
Reclining				
Leg Vertical				
Standing				
Standing 3 Mins				