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II. EXPERIMENTAL OBJECTIVES

1. To use an auscultatory method for an indirect determination of systemic arterial systolic and diastolic blood pressures and to correlate the appearance and disappearance of vascular sound with systolic and diastolic pressures respectively.
2. To measure, record, and compare systemic arterial blood pressure in the right arm and the left arm of the same Subject under identical conditions.
3. To compare the systemic arterial systolic and diastolic blood pressures detected audibly to those recorded by the stethoscope microphone.
4. To measure, record, and compare systemic arterial blood pressures in the same Subject under different experimental conditions of rest and exercise.
5. To compute and compare pulse pressure and mean arterial pressure under different experimental conditions of rest and exercise.
6. To compute the pulse pressure wave velocity by measuring the time between the R-wave of the ECG and the Korotkoff sounds.

III. MATERIALS

- BIOPAC Pressure Cuff (SS19L with gauge dial or SS19LA with onscreen gauge display)
- BIOPAC Stethoscope (SS30L)
- BIOPAC Electrode Lead Set (SS2L)
- BIOPAC Disposable Electrodes (EL503,) 3 electrodes per Subject
- Rubbing alcohol and swab (to clean stethoscope earpieces and stethoscope diaphragm)
- *Optional*: felt pen (to mark stethoscope placement on arm)
- Biopac Student Lab System: BSL 4 software, MP36, MP35 or MP45 hardware
- Computer System (Windows 8, 7, Vista, XP, Mac OS X 10.5 – 10.8)
- Stopwatch or watch/clock with a second hand.
- Fabric tape measure
- *Optional:* BIOPAC Headphones (OUT1/OUT1A for MP3X or 40HP for MP45)

IV. EXPERIMENTAL METHODS

A. SETUP

FAST TRACK Setup

CAUTION!
Subject selected must not have had or now have any disorder, hypertension, heart surgery, stroke, or any history of cardiovascular degeneration.

Subject should not have consumed caffeine, smoked, or performed heavy exercise within one hour of the recording.

1. Turn the computer **ON**.
   - If using an MP36/35 unit, turn it **OFF**.
   - If using an MP45, make sure USB cable is connected and "Ready" light is **ON**.

Setup continues…

Detailed Explanation of Setup Steps

Lab Group Requirements:

You should work in a group of at least 3 people. One person will be **Subject**, one (**Recorder**) will operate the computer, and another person (**Director**) will perform the blood pressure measurement.

Subject must meet the qualifications listed to the left.

Recorder is responsible for starting and stopping the recording, and adding markers to the recording. Only **Recorder** should look at the computer screen.

Director should perform the measurement normally, without regard to the recording aspect, but should call out the points of systolic and diastolic pressure so that **Recorder** can add the markers to the data recording.

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2. **Plug the equipment in** as follows (Fig. 16.7):

   BP Cuff (**SS19L/LA**) — **CH 1***
   Stethoscope (**SS30L**) — **CH 2**
   Electrode Lead Set (**SS2L**) — **CH 3** **

   _____

   If MP45 is used for recording:
   *The SS19L cuff must be used. *(SS19LA not compatible with MP45.)*
   ** ECG is not recorded

   OPTIONAL – BSL 4.0.2 and higher: Korotkoff sounds transmitted through the SS30L stethoscope may also be heard via headphone connection with the MP device. This can be useful when a second observer wishes to monitor the stethoscope output. (See page 8 for details.)

3. Turn **ON** the MP36/35 unit.
4. Select your lab group.

Fig. 16.7 MP3X (top) and MP45 (bottom) equipment connections

IF ECG is not used, proceed to Step 8.

5. Clean and abrade skin.
6. Attach three electrodes on the **Subject** as shown (Fig. 16.8).

ECG may or not be recorded depending on hardware used and/or lesson preference setting.

If the skin is oily, clean electrode sites with soap and water before abrading.

If electrode is dry, apply a drop of gel.

Remove any jewelry on or near the electrode sites.

Place one electrode on the medial surface of each leg, just above the ankle. Place the third electrode on the right anterior forearm at the wrist (same side of arm as the palm of hand).

For optimal electrode contact, place electrodes on skin at least 5 minutes before start of Calibration.

Fig. 16.8 Standard Electrode placement

Setup continues…

7. Clip the Electrode Lead Set (SS2L) to electrodes in a Lead II setup as shown, paying close attention to the lead colors (Fig. 16.9).
   - RIGHT forearm = WHITE lead
   - RIGHT leg = BLACK lead (ground)
   - LEFT leg = RED lead

Fig. 16.9 Standard electrode lead attachment

The pinch connectors work like a small clothespin, but will only latch onto the nipple of the electrode from one side of the connector.

8. **Subject** gets in a seated, relaxed, position.

Subject should sit with arms relaxed at side of body and hands apart in lap, with legs flexed at knee and feet supported.

Position the cables and leads such that they do not pull on the electrodes; connect the electrode cable clip to a convenient location on **Subject's** clothes. Arrange leads so **Subject's** arms can be easily raised.

Do not place pressure cuff on **Subject** until after calibration.

Fig. 16.10 Calibration positioning

Setup continues…

9. Clean the stethoscope earpieces and diaphragm.

Clean each earpiece with rubbing alcohol and allow it to dry completely. You should also clean the surface of the stethoscope diaphragm (the part that comes in contact with the skin) for each new **Subject**.

10. Open cuff valve, flatten and roll to remove <u>all</u> air and close valve.

The pressure release valve must be in the open (counter-clockwise) position to allow air to be released.

11. **Start** the Biopac Student Lab Program.

Start Biopac Student Lab by double-clicking the Desktop shortcut.

12. Choose lesson **"L16 – Blood Pressure"** and click **OK**.

13. Type in a unique **filename** and click **OK**.

A folder will be created using the filename. This same filename can be used in other lessons to place the **Subject's** data in a common folder.

14. Make sure the pressure cuff shown in the journal (Hardware tab) matches your setup. If it does not, change the "**Blood Pressure Cuff Type**" preference as described in Step 15.

The SS19L uses a mechanical pressure gauge and the SS19LA uses an on-screen gauge.

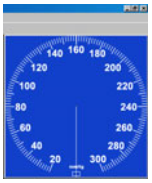
15. ***Optional*** Set Preferences.
    - Choose File > **Lesson Preferences**.
    - Select an option.
    - Select the desired setting and click **OK**.

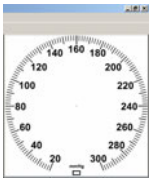
This lesson has optional Preferences for data and display while recording. Per your Lab Instructor's guidelines, you may set:

Grids: Show or hide gridlines.

Blood Pressure Cuff Type: Select type of Blood Pressure Cuff Transducer.

Gauge Color*: Choose blue or white background with contrasting dial





* *Only available when default SS19LA Gauge Preference is selected*

Lesson Recordings: Specific recordings may be omitted based on instructor's preferences.

ECG Lead II data: Set option to show or hide ECG Lead II channel.

END OF SETUP

B. CALIBRATION

Calibration establishes the hardware's internal parameters (such as gain, offset, and scaling) and is critical for optimal performance. **Pay close attention to Calibration**. (Click the **Calibration** tab to view example Calibration video.)

FAST TRACK Calibration

Cuff is not on Subject **during calibration.**

1. **Subject** is seated, relaxed and still.
2. Click **Calibrate**.

If Using SS19LA

3. At the prompt, confirm cuff is completely deflated and click OK.

4. At the prompt, roll the cuff onto itself so when completed, the Velcro will prevent it from unrolling when inflated.
5. Inflate the cuff to 100 mmHg and click **OK**.

If using SS19L (with mechanical gauge)

6. At the next prompt, deflate cuff to 40 mmHg and click **OK**.

Calibration continues…

Detailed Explanation of Calibration Steps

Calibration is only required once for multiple subjects.

Subject must remain relaxed and as still throughout calibration to minimize baseline shift and EMG artifact.

The SS19LA uses the on-screen pressure gauge.

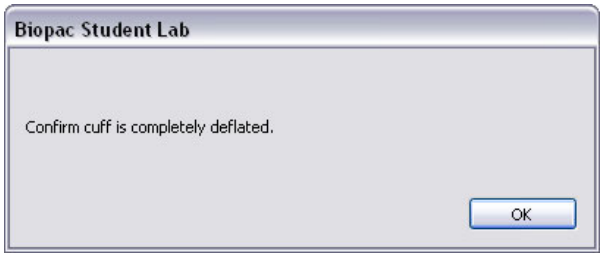


Fig. 16.11 SS19LA Prompt

Make sure the pressure release valve is closed (fully clockwise).

An alternate method is to inflate the rolled cuff slightly, then squeeze to obtain the desired calibration pressures.

Do not click **OK** until the pressure is stabilized at 100 mmHg.

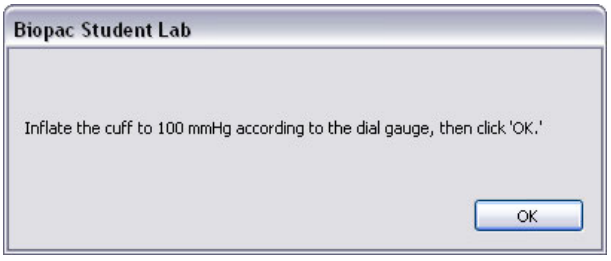


Fig. 16.12 SS19L first prompt

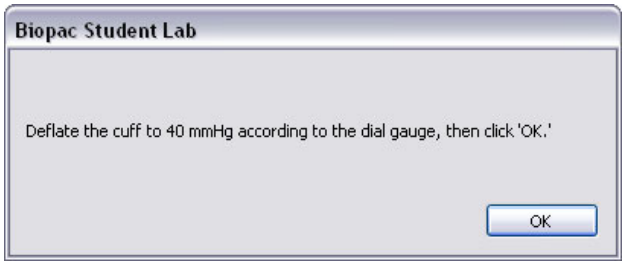


Fig. 16.13 SS19L second prompt

Slowly turn the pressure release valve counter-clockwise to deflate the cuff pressure to 40 mmHg then close the valve (fully clockwise).

Do not click **OK** until the pressure is stabilized at 40 mmHg.

The calibration recording will begin when **OK** is clicked.

7. **Director** lightly taps stethoscope diaphragm twice.
8. Wait for Calibration to stop.
9. Verify recording resembles example data.

Calibration will stop automatically after 8 seconds.

The pressure data will be a flatline at either 0 (SS19LA) or 40 mmHg (SS19L). The stethoscope data must show clear spikes to indicate when it was tapped. If ECG is displayed*, it should be a recognizable ECG waveform with baseline at or near 0 mV, no large baseline drift and no significant EMG artifact.

- If <u>similar</u>, click **Continue** and proceed to Data Recording.

  NOTE*: The ECG channel may or not be displayed depending on hardware used and/or lesson preference setting.

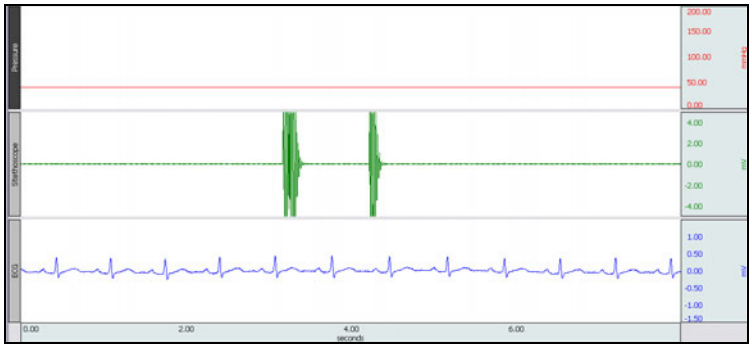


Fig. 16.14 Example Calibration Data

<u>If recording does not resemble the Example Data…</u>

- If data is noisy or flatline, check all connections to MP unit.
- If indicated Pressure is less than 0 mmHg, redo calibration and follow the steps precisely.
- If the ECG displays baseline drift or excessive EMG artifact:
  - Verify all electrodes are making good contact with the skin and that the leads are not pulling on the electrodes.
  - Make sure the **Subject** is in a relaxed position. (Fig. 16.10)

- If necessary, click **Redo Calibration**.

Click **Redo Calibration** and repeat Steps 2 – 8 if necessary.

END OF CALIBRATION

PRACTICE PRESSURE RELEASE

To obtain accurate measurements, it is important that the cuff pressure is released at a rate of 2 – 3 mmHg per second. You are encouraged to practice pressure release several times before proceeding to the recording. To practice, you'll need a watch or clock with a second hand. The following steps will help you develop a consistent pressure release technique:

a) Open the cuff valve and roll the cuff in on itself, then press to flatten and close the valve.
   - This will release all pressure from the cuff.

b) Pump the cuff bulb until the pressure dial reads 160 mmHg.

c) Tell the timer when you are ready, and slowly turn the valve counter-clockwise to begin releasing the cuff pressure.
   - Open the valve slowly so that you don't have a large pressure drop, and try to maintain an even release.
   - To keep the release rate constant, you may need to open the valve more as the cuff pressure diminishes.

d) When pressure is at 100 mmHg, say "Stop" and ask the timer how much time elapsed.
   - It should take you about 20 – 30 seconds to drop 60 mmHg.

e) Repeat as necessary until you can release cuff pressure at 2 – 3 mmHg per second.

C. DATA RECORDING

FAST TRACK Recording

1. Prepare for the recording.

CAUTION!
Do not inflate the cuff higher than is needed. Never leave the cuff on the **Subject** at high pressure (more than 120 mmHg) for more than 1 minute.

2. Make sure all air is expelled from cuff and close the pressure release valve.
3. Locate the brachial artery on <u>each arm</u> and mark the stethoscope position with a felt pen.
4. **Review** Cuff placement and positioning:
   - "Artery" label should be positioned over the brachial artery (with the arrow on the label facing down).
   - Lower edge of cuff should be 40 – 50 mm (1.5 – 2 inches) above the antecubital fossa (inner aspect of elbow).
   - Wrap the cuff evenly and snugly on **Subject's** arm.
   - When in the seated position, the arm must rest at heart level; use books or a pillow to raise arm if necessary (Fig. 16.16).
   - Find a position that is comfortable for **Director** and Subject (Fig. 16.16).
   - Place stethoscope diaphragm over brachial artery, with firm pressure.

Detailed Explanation of Recording Steps

Seven data recordings will be acquired*:

Recording 1 – 2: Left arm, seated.
Recording 3 – 4: Right arm, seated.
Recording 5 – 6: Right arm, supine.
Recording 7: Right arm, seated, after exercise.

***IMPORTANT**
This procedure assumes that all lesson recordings are enabled in lesson Preferences, which may not be the case for your lab. Always match the recording title to the recording reference in the journal and disregard any references to excluded recordings.

Hints for obtaining optimal data:

- **Subject** should relax for a few minutes before each recording begins.
- **Director** must be positioned to easily inflate cuff while viewing the pressure dial indicator.
- For greater stethoscope comfort, twist the earpieces slightly forward before inserting.
- Room must be quiet in order to easily hear sounds through stethoscope.
- To minimize EMG artifact and baseline drift:
  - **Subject's** arms and legs must be relaxed.
  - **Subject** must remain still and should not talk during any recordings.
  - Make sure electrodes do not peel up and that the leads do not pull on the electrodes.

Turn the release valve fully counter-clockwise and roll the cuff up while squeezing it. Turn the pressure release valve fully clockwise.

Use your first (index) and second (middle) fingers to feel the pulsation of the brachial artery on the inside of the elbow. This can be tricky, but after a few tries you should get the hang of it. It may help if **Subject** makes a fist while you are trying to locate the pulse.

Once you have located the pulse, mark the spot by tracing along the edge of the top and bottom of the stethoscope diaphragm.

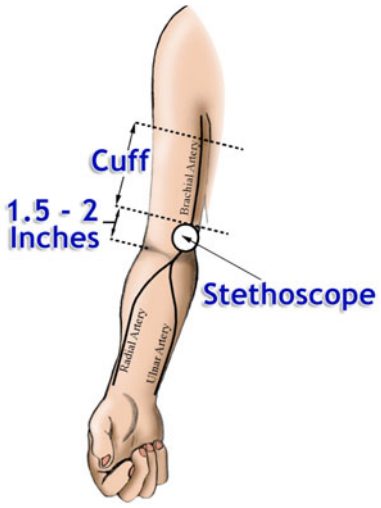


Fig. 16.15 Cuff and stethoscope placement

The cuff edge should be high enough to avoid covering any part of the stethoscope diaphragm.
The Velcro® wrap should hold the cuff in place.
Make sure rubber tubing and cables do not become tangled or pinched.
Exert enough pressure on stethoscope diaphragm to establish good contact, but do not press too hard.

Recording continues…

- **Director** should hold the pump bulb with both fingers on the release valve so it can be easily turned.

Fig. 16.16 Subject and Director Positioning

- For greater Stethoscope comfort, rotate the ear tubes slightly forward (Fig. 16.17).

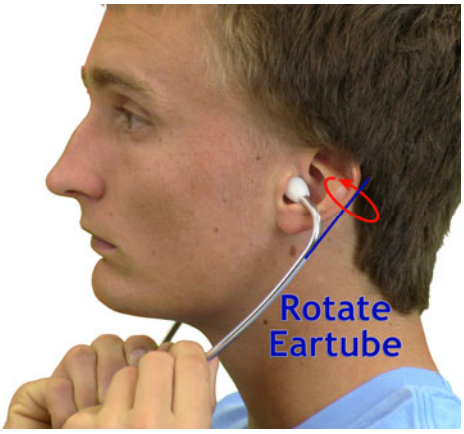


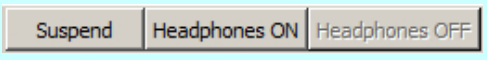
Fig. 16.17 Rotate ear tube for comfort

OPTIONAL – BSL 4.0.2 and higher: Korotkoff sounds from the SS30L stethoscope may also be heard via the following MP headphone connections:

- OUT1 headphones into Analog Out (MP35).
- OUT1 headphones into Analog Out or OUT1A into the headphone output jack (MP36).
- 40HP headphones into the headphone output jack (MP45).

This can be useful when a second observer wishes to monitor the stethoscope output.

To enable or mute headphone output, toggle the "Headphones ON/Headphones OFF" buttons while data recording is in progress.



CAUTION:
Cuff pressure release sounds may be very loud through the headphones. It's advisable to toggle "Headphones OFF" prior to pressure release. Then toggle back ON during the next data recording.

Recording continues…

Problems you may encounter:

a) **You can't hear the Korotkoff sounds**.

Some **Subjects** may not produce loud enough Korotkoff sounds. This does not mean that anything is wrong with the person's physical state. If this is the case, wait one minute and repeat the measurement using a slightly different position for the stethoscope diaphragm and/or using the other arm.

Another possibility is that your hearing is not acute enough to detect the sounds, but the recording is picking them up, which for the purposes of this lesson is ok. In a real clinical setting, if you could not hear the sounds, you would need to try a strictly palpatory method to get the reading. For this lab, since you probably have a time constraint, consider changing **Subjects**.

b) **You hear an auscultatory gap**.

Wait at least 1 minute, and then try the measurement again. If this second reading fails, then use the palpatory method with the brachial or radial artery while inflating the cuff and note the point where the pulse is no longer felt. This value will be **Subject's** approximate systolic pressure value. The diastolic value should be found the normal way (disappearance of all sounds). The recording will not be accurate, but it will allow you to finish the lessons and answer the questions.

Left arm, Seated 1

5. Prepare for Recording:
   - **Subject** is seated, relaxed and still.
   - Left arm is positioned at heart level.
   - Cuff and stethoscope are placed on left arm following guidelines in Step 4.
   - **Review** recording steps.

6. Inflate cuff to 160 mmHg.

The majority of **Subjects** in the physiology lab will have systolic pressures below this pressure.

Note that the gauge display (when using SS19LA) may respond slowly.

7. Click **Record**.

Upon start of the first recording, a confirmation prompt will appear. Click OK to proceed.

CAUTION!
Do not leave the cuff at this pressure for more than 1 minute.

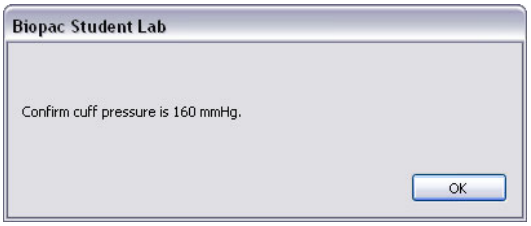


Fig. 16.18 Confirmation prompt

If Korotkoff Sounds appear at the *start* of the recording, click **Suspend**, **Redo**, inflate cuff to 180 mmHg.

8. Release pressure at a constant rate of 2 to 3 mmHg/second.

The first sound (which may resemble a sharp tapping) indicates the pressure closest to the **systolic pressure**.

9. **Director** announces when Korotkoff sounds first appear **(systolic).**
   - **Recorder** presses **F4 = ∇ Systolic**

10. **Director** continues listening, and announces when sounds disappear completely **(diastolic).**
    - **Recorder** presses **F5 = ∇ Diastolic**

This pressure is close to the point of **diastolic pressure**.

- If sound diminishes but never disappears, note diastolic at the point sound diminishes.

11. Wait an additional five seconds, and then click **Suspend**.

Waiting an additional five seconds will allow the stethoscope microphone to pick up any final Korotkoff sounds that may be inaudible to **Director.**

12. Deflate cuff as rapidly and completely as possible.

When the cuff is deflated rapidly, the stethoscope will pick up significant noise artifact. Try to click Suspend before deflating the cuff.

Release cuff pressure rapidly to reduce distal vasculatory engorgement (reduce venous congestion) and minimize patient discomfort.

13. Verify recording resembles the example data.
    - If similar, click **Continue** and proceed to the next recording.
    - If necessary, click **Redo**.
    - If all required recordings have been completed, click **Done**.

The pressure data should decline linearly, at approximately 2 – 3 mmHg/sec. To verify:

- Select one second of data (Delta T) and note Delta measurement for rate of pressure release.

The Korotkoff sounds (data “spikes”) should be visible in the Stethoscope data and there should be minimal noise artifact. IF ECG is displayed, the waveform should show little baseline drift or EMG artifact. Both event markers should be present (use horizontal scroll bar to search all data).

Recording continues…

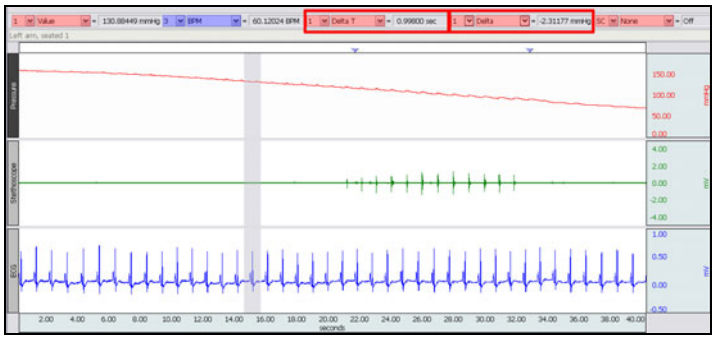


Fig. 16.19 Example data

If recording does not resemble the Example Data…

- If data is noisy or flatline, check all connections to MP unit.
- If the cuff pressure was released before clicking Suspend, the stethoscope data will include noise artifact from the rapidly deflating cuff – this is normal.
- If event markers are missing, redo and remind Recorder to press F4 and F5 at the appropriate times.
- If the Korotkoff sounds are not present, make certain the diaphragm is properly located over brachial artery and try applying more pressure.
- If there is too much noise artifact in the stethoscope data, make sure to hold the stethoscope with constant pressure and to minimize movement of the Subject's arm, the cuff, the tubing and the stethoscope.
- If the ECG baseline is not stable, or there is excessive EMG artifact, verify electrodes are making good contact and that the leads are not pulling on the electrodes.

If necessary, click **Redo** to repeat the last recording. Note that once **Redo** is clicked, the most recent recording will be erased.

Left arm, seated 2

14. Repeat Steps 6 through 12.

The **Subject's** arm should rest for a few minutes after the first recording (with no cuff pressure).

15. Verify recording resembles the example data.
    - If similar to Fig. 16.19, click **Continue** and proceed to the next recording.
    - If necessary, click **Redo**.
    - If all required recordings have been completed, click **Done**.

Data requirements are the same as described in Step 13.

If necessary, click **Redo** and repeat the last recording.

Note that when **Redo** is clicked, the most recent recording will be erased.

Recording continues…

Right arm, seated 1

16. **Subject** remains seated and relaxed, with cuff attached to right arm.
    - Right arm is positioned at heart level.
    - Cuff and stethoscope are placed on right arm following guidelines in Step 4.
17. Repeat Steps 6 through 12.
18. Verify recording resembles the example data.
    - If similar to Fig. 16.19, click **Continue** and proceed to the next recording.
    - If necessary, click **Redo**.
    - If all required recordings have been completed, click **Done**.

Data requirements are the same as described in Step 13.

If necessary, click **Redo** and repeat the last recording.

Note that when **Redo** is clicked, the most recent recording will be erased.

Right arm, Seated 2

19. Repeat Steps 6 through 12.

The **Subject's** arm should rest for a few minutes after the first recording (with no cuff pressure).

20. Verify recording resembles the example data.
    - If similar to Fig. 16.19, click Continue and proceed to the next recording.
    - If necessary, click **Redo**.
    - If all required recordings have been completed, click **Done**.

Data requirements are the same as described in Step 13.

If necessary, click **Redo** and repeat the last recording.

Note that when **Redo** is clicked, the most recent recording will be erased.

Right arm, Supine 1

21. **Subject** is Supine (lying down, face up) and relaxed with cuff attached to right arm.
    - Right arm is positioned at heart level.
    - Verify cuff and stethoscope placement as described in Step 4.
22. Repeat Steps 6 through 12.

Fig. 16.20 Supine positioning (SS19LA Shown)

Recording continues…

23. Verify recording resembles example data.
    - If similar to Fig. 16.19, click **Continue** and proceed to the next recording.
    - If necessary, click **Redo**.
    - If all required recordings have been completed, click **Done**.

Data requirements are the same as described in Step 13.

If necessary, click **Redo** and repeat the last recording.

Note that when **Redo** is clicked, the most recent recording will be erased.

Right arm, Supine 2

24. Repeat Steps 6 through 12.

The **Subject's** arm should rest for a few minutes after the first recording (with no cuff pressure).

25. Verify recording resembles the example data.
    - If similar to Fig. 16.19, click **Continue** and proceed to the next recording.
    - If necessary, click **Redo**.
    - If all required recordings have been completed, click **Done**.

Data requirements are the same as described in Step 13.

If necessary, click **Redo** and repeat the last recording. Note that when **Redo** is clicked, the most recent recording will be erased.

Right arm, after exercise

26. Unclip leads and remove cuff to allow **Subject** to perform moderate exercise to elevate heart rate.

Confirm that **Subject** has no history of disorders and meets the requirements listed to the left before performing any exercise.

> **CAUTION**!
> **Subject** selected must not have had or now have any disorder, hypertension, heart surgery, stroke, or any history of cardiovascular degeneration.
> **Subject** must not have consumed caffeine, smoked, or performed heavy exercise within one hour of the recording.

Subject does 50 push-ups or runs in place for 5-minutes to elevate heart rate to a moderate level.

27. After exercise, **Subject** sits down to recover.
28. Reattach leads and attach cuff to **Subject's** right arm.
    - Right arm is positioned at heart level.
    - Verify cuff and stethoscope placement as described in Step 4.
29. Inflate cuff to **180** mmHg.

The starting cuff pressure is higher than in previous recordings.

30. Repeat Steps 6 through 12.
31. Verify recording resembles the example data.
    - If similar to Fig. 16.19, click **Continue** to proceed to optional recording section, or **Done** to finish the lesson.
    - If necessary, click **Redo**.

Data requirements are the same as described in Step 13.

If necessary, click **Redo** and repeat the last recording.
Note that when **Redo** is clicked, the most recent recording will be erased.

Recording continues…

OPTIONAL ACTIVE LEARNING PORTION

With this lesson you may record additional data by clicking **Continue** following the last recording. Design an experiment to test or verify a scientific principle(s) related to topics covered in this lesson. Although you are limited to this lesson's channel assignments, the electrodes or transducers may be moved to different locations on the subject.

Design Your Experiment

Use a separate sheet to detail your experiment design, and be sure to address these main points:

A. ***Hypothesis***

Describe the scientific principle to be tested or verified.

B. ***Materials***

List the materials you will use to complete your investigation.

C. ***Method***

Describe the experimental procedure—be sure to number each step to make it easy to follow during recording.

Run Your Experiment

D. ***Set Up***

Set up the equipment and prepare the subject for your experiment.

E. ***Record***

Use the **Continue**, **Record**, and **Suspend** buttons to record as much data as necessary for your experiment.

Click **Done** when you have completed all of the recordings required for your experiment.

Analyze Your Experiment

F. Set measurements relevant to your experiment and record the results in a Data Report.

32. After clicking **Done**, choose an option and click **OK**.

If choosing the **Record from another Subject** option: Repeat Setup Steps 4 – 9 then proceed directly to Recording (re-calibration not required*).

33. Remove the Pressure cuff and electrodes.

Note*: If Recalibration is desired, Quit then re-launch the application.

If ECG was recorded, remove the electrode cable pinch connectors and peel off all electrodes. Discard the electrodes. (BIOPAC electrodes are not reusable.) Wash the electrode gel residue from the skin, using soap and water. The electrodes may leave a slight ring on the skin for a few hours which is quite normal.

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*	*Units*
CH 1	Pressure	mmHg
CH 2	Stethoscope	mV
CH 3*	ECG Lead II	mV

*ECG may not have been recorded.

   - Note measurement box settings:

Channel	*Measurement*
CH 1	**Value**
CH 3	**BPM**
CH 1	**Delta T**

2. Setup your display window for optimal viewing of the first recording.

3. Use the **I-Beam** cursor to select the point at the first event marker and record the pressure (CH 1 – Value).

   A

Data analysis continues…

Detailed Explanation of Data Analysis Steps

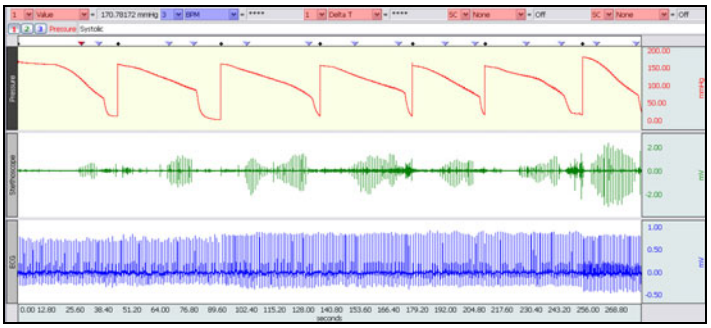


Fig. 16.21 Example Data

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 them.

Brief definition of measurements:

Value: Displays the amplitude value for the channel at the point selected by the I-beam cursor. If a single point is selected, the value is for that point, if an area is selected, the value is the endpoint of the selected area.

BPM: **B**eats **P**er **M**inute first calculates the difference in time between the end and beginning of the area selected by the I-Beam tool (same as Delta T,) and then divides this value into 60 seconds/minute.

Delta T: Measures the difference in time between the end and beginning of the selected area.

The "selected area" is the area selected by the I-Beam tool (including endpoints).

Note: The append event markers ✦ mark the beginning of each recording. Click on (activate) the event marker to display its label.

Useful tools for changing view:

Display menu: Autoscale Horizontal, Autoscale Waveforms, Zoom Back, Zoom Forward

Scroll Bars: Time (Horizontal); Amplitude (Vertical)

Cursor Tools: Zoom Tool

Buttons: Overlap, Split, Show Grid, Hide Grid, -, +

Hide/Show Channel: "Alt + click" (Windows) or "Option + click" (Mac) the channel number box to toggle channel display.

This is the Systolic pressure that was audibly detected; event marker manually inserted.

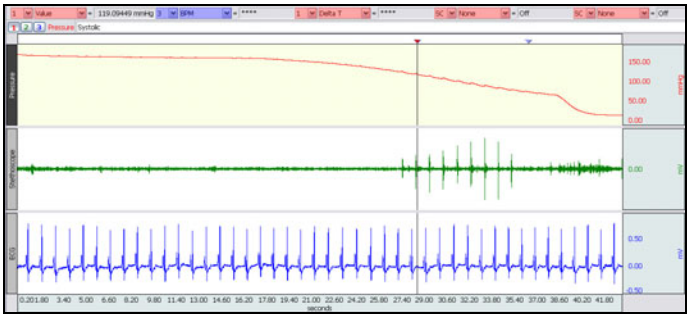


Fig. 16.22 Point of audibly detected Systolic pressure

Note: In the figure, the **Value** measurement represents cuff pressure at the selected point and the **BPM** measurement is not giving an accurate reading because only one point is selected with the I-beam cursor.

4. Select the point that corresponds to the first Korotkoff sound the stethoscope detected and record the pressure.

   A

This is the Systolic pressure that was detected by the stethoscope.

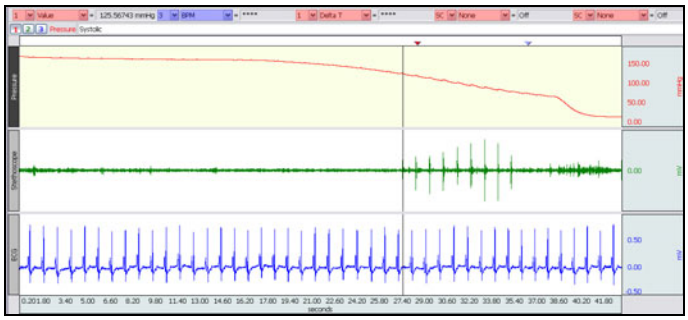


Fig. 16.23 Point of first Korotkoff sound

IF ECG is recorded: To help distinguish a Korotkoff sound from noise artifact, note that the sound normally appears near the time of the ECG T-wave. If needed, zoom in the data to see the details.

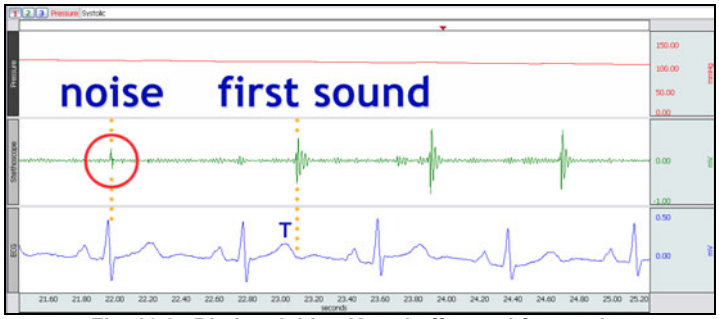


Fig. 16.24 Distinguishing Korotkoff sound from noise

5. Select the point that corresponds to the second event marker and record the pressure.

   B

This is the Diastolic pressure that was audibly detected.

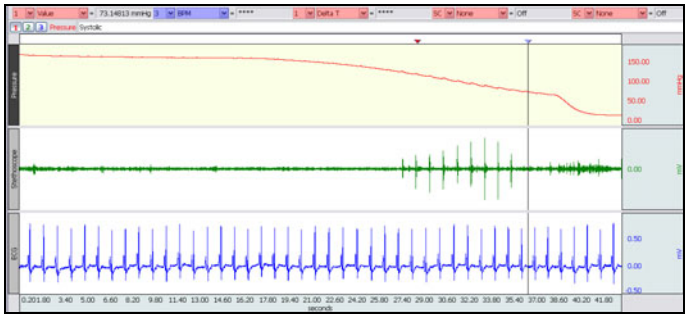


Fig. 16.25 Point of audibly detected Diastolic pressure

6. Select the point that corresponds to the last Korotkoff sound the stethoscope detected and record the pressure.

   B

This is the Diastolic pressure that was detected by the stethoscope.

As in Step 4, the ECG – T wave can be used to distinguish a Korotkoff sound from noise artifact.

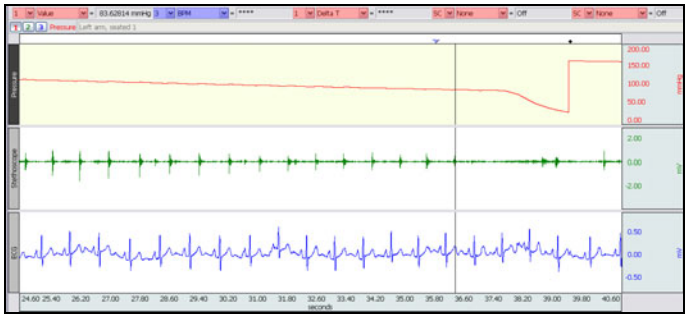


Fig. 16.26 last sound detected by stethoscope

Data Analysis continues…

7. Measure BPM.
   - Using ECG signal:

     In the region between Systolic and Diastolic pressure, select one R-R interval and record the BPM measurement (Fig. 16.27).

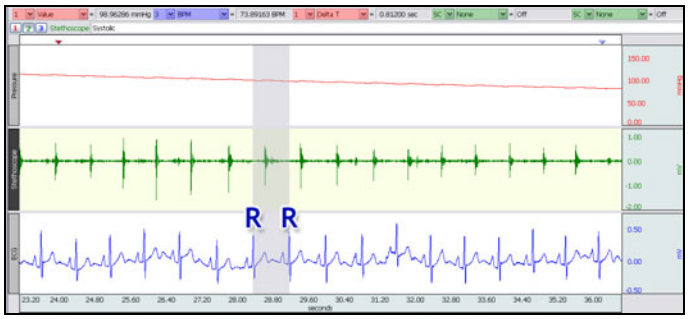


Fig. 16.27 One R-R interval selected

   - Using Korotkoff sounds:

     If ECG was not recorded, select the area between two successive Korotkoff sound peaks and record the BPM measurement (Fig. 16.28).

C

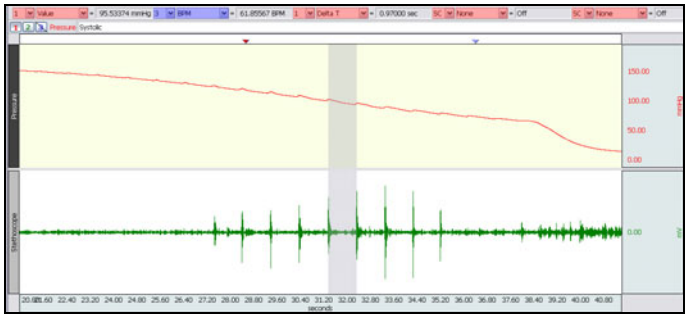


Fig. 16.28 Sound interval selection approximates R-to-R interval

Repeat this measurement on two successive R-waves (or sound peaks).

C

BPM changes on a beat-by-beat cycle, so for more accurate measurement you should take BPM (R-R) measurements on 3 successive R-waves and find the average BPM.

8. *If ECG was not recorded skip to Step 9.* Zoom in on one of the ECG complexes in the time between systolic and diastolic pressure.

TIP: You may hide CH 1 (Pressure) to make it easier to see the other channels. (Alt + click on PC, option + click on Mac.)

9. Using the I-beam cursor, select the area from the peak of the R-wave to the beginning of the sound detected by the stethoscope.

   Note the Delta T measurement.

E

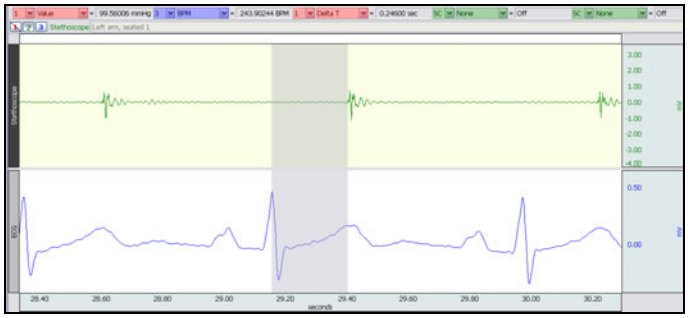


Fig. 16.29 Timing of Korotkoff Sounds

10. Repeat Steps 3 – 8 for each recording to complete the Data Report.

This lesson acquired seven recordings (unless modified for your lab session). Recordings are identified by their append event markers. ◆

11. Perform measurements and calculations for Pulse Speed per Table 16.7.
12. Answer the questions at the end of the Data Report.

An electronically editable **Data Report** is located in the journal (following the lesson summary,) or immediately following this Data Analysis section. Your instructor will recommend the preferred format for your lab.

13. **Save** or **Print** the data file.
14. **Quit** the program.

END OF DATA ANALYSIS

END OF LESSON 16

Complete the Lesson 16 Data Report that follows.

BLOOD PRESSURE

- *Indirect measurement*
- *Ventricular Systole & Diastole*
- *Korotkoff sounds*
- *Mean Arterial pressure*

DATA REPORT

Student's Name: _____

Lab Section: _____

Date: _____

I. Data and Calculations

Subject Profile

Name:_____ Height:_____

Age:_____ Time: _____ Gender: Male / Female Weight:_____

A. Systolic Measurements

Complete Table 16.2 with the systolic measurements for all data recordings. Note the pressure measurement at the event marker insertion point (where Director audibly detected and marked systolic) and where the first Korotkoff sound was detected with the stethoscope microphone. Calculate the Delta difference (Δ) between the trials for each condition, the trial average pressure, and the Delta difference between the event marker and stethoscope microphone average pressure measurements.

Table 16.2 Systolic Data

Systolic Pressure mmHg 1 Value						
Condition	**Trial**	**Audibly Detected Pressure (Event marker)**	**Average Pressure (Calculate) A**	**Microphone Detected Pressure (In data, unmarked)**	**Average Pressure (Calculate) B**	**Δ Average Pressure B minus Average Pressure A**
Left arm, seated	1					
	2					
	Δ					
Right arm, seated	1					
	2					
	Δ					
Right arm, lying down	1					
	2					
	Δ					
Right arm, after exercise*	1					

*For 'Right arm, after exercise' recording, calculate the Delta difference between the 'Audibly Detected Pressure' and the 'Microphone Detected Pressure' values, and record the result in the right column.

B. **Diastolic Measurements**

Complete Table 16.3 with the diastolic measurements for all data recordings. Note the pressure measurement at the event marker insertion point (where Director audibly detected and marked diastolic) and where the sound disappeared from the stethoscope microphone. Calculate the Delta difference (Δ) between the trials for each condition, the trial average pressure, and the Delta difference between the event marker and stethoscope microphone average pressure measurements.

Table 16.3 Diastolic Data

Diastolic Pressure mmHg 1 Value						
Condition	**Trial**	**Audibly Detected Pressure (Event marker)**	**Average Pressure (Calculate) A**	**Microphone Detected Pressure (In data, unmarked)**	**Average Pressure (Calculate) B**	**Δ Average Pressure B minus Average Pressure A**
Left arm, seated	1					
	2					
	Δ					
Right arm, seated	1					
	2					
	Δ					
Right arm, lying down	1					
	2					
	Δ					
Right arm, after exercise*	1					
*For 'Right arm, after exercise' recording, calculate the Delta difference between the 'Audibly Detected Pressure' and the 'Microphone Detected Pressure' values, and record the result in the right column.						

C. **BPM Measurements**

Complete Table 16.4 with the BPM measurements from three cycles of each data recording and calculate the mean BPM for each.

* **Cycle** measurements: If ECG was recorded, use 3 BPM; if ECG was not recorded, use 1 BPM.

Table 16.4 BPM

Condition	**Trial**	**Cycle***			**Calculate the Mean**	
		1	**2**	**3**	of Cycles 1 – 3	of Trial 1 – 2 means
Left arm, seated	1					
	2					
Right arm, seated	1					
	2					
Right arm, lying down	1					
	2					
Right arm, after exercise	1					

D. **Summary of Mean Blood Pressure Data**

Complete Table 16.5 with the average from sound data from tables 16.2 and 16.3 and then calculate the pulse pressure and the mean Arterial Pressure (MAP).

Pulse pressure = Systolic pressure – Diastolic pressure

$$\text{MAP} = \frac{\text{pulse pressure}}{3} + \text{diastolic pressure} \qquad \textit{OR} \qquad \text{MAP} = \frac{(\text{systolic pressure} + 2\,\text{diastolic pressure})}{3}$$

Table 16.5

CONDITION	SYSTOLE Table 16.2 Sound Average	DIASTOLE Table 16.3 Sound Average	BPM Table 16.4	Calculations: Pulse pressure	Calculations: MAP
Left arm, seated					
Right arm, seated					
Right arm, lying down					
Right arm, after exercise					

E. **Timing of Korotkoff Sounds** NOTE: This table requires ECG data, which is not recorded on MP45 systems.
Complete Table 16.6 with the Delta T for each condition, and calculate the means.

Table 16.6

Condition	Trial	Timing of Sounds 1 Delta T	Mean (calc)
Left arm, seated	1		
	2		
Right arm, seated	1		
	2		
Right arm, lying down	1		
	2		
Right arm, after exercise	1		

F. **Calculation of Pulse Speed**
Complete the calculation in Table 16.7 using "Left arm, seated" data.

Table 16.7

Distance	Distance between Subject's sternum and right shoulder	cm
	Distance between Subject's right shoulder and antecubital fossa	cm
	Total distance	cm
Time	Time between R-wave and first Korotkoff sound	secs
Speed	Speed = distance/time = _____cm / _____sec	cm/sec

II. Questions:

1. Note the difference in systolic pressure value between when (a) the sound actually began, (b) was detected by the stethoscope transducer, and (c) was recorded, and the time when the observer first heard the sound and pressed the event marker keystroke. (Example: 141 mmHg – 135 mmHg = 6 mmHg.) What factors could account for this difference? Would the observed difference be the same if measured by another observer? Explain your answer.

_____

_____

_____

2. a) Does your systolic and/or diastolic arterial pressure change as your heart rate increases?

_____

_____

_____

b) How does this change affect your pulse pressure?

c) How would you expect the systolic, diastolic and pulse pressures to change in a normal healthy individual as the heart rate increases?

3. Give three sources of error in the indirect method of determining systemic arterial blood pressure.

4. Use an equation that relates flow, pressure, and resistance to define mean arterial pressure:

5. Blood flow (liters per min). through the pulmonary circuit equals blood flow through the systemic circuit, but pulmonary resistance to flow is 5 times less than the systemic resistance to flow. Using the equation in Question 4, show that mean pulmonary pressure is 5 times less than mean systemic pressure.

6. Define the first and second sounds of **Korotkoff**. Which sound is used to approximate systolic pressure and which sound is used to approximate diastolic pressure?

7. Why is mean arterial pressure not equal to (systolic pressure – diastolic pressure)/2?

8. Define **pulse pressure**. Explain, in terms of changes in systolic and diastolic pressures, why pulse pressure increases during exercise.

9. Give one reason why blood pressure in the left arm may be different than blood pressure in the right arm of a Subject at rest.

_____

_____

_____

10. Name an artery other than the brachial that could be used for an indirect measurement of blood pressure and explain your choice.

_____

_____

_____

III. OPTIONAL Active Learning Portion

A. ***Hypothesis***

B. ***Materials***

C. ***Method***

D. ***Set Up***

E. ***Experimental Results***

End of Lesson 16 Data Report