Blood Pressure and Exercise Lab

Rob MacLeod, Brian Birchler, and Brett Burton

March 26, 2012

1 Purpose and Background

Purpose:

To learn about external means to measure blood pressure, observe features of venous circulation, and observe the effects of exercise on blood pressure, heart rate, and electrocardiogram (ECG). This lab has the added feature of leaving one piece in need of experimental design by you! See below for more details.

Background

This lab will build on the class material we have covered on blood flow and pressure and cardiac contraction. It will also introduce some ideas we still have to cover on control of the cardiovascular system in response to exercise and the electrocardiogram.

To prepare, please review the notes and text on the vascular system and blood pressure and also read the section in your text (or any other good physiology book) on exercise.

1.1 Blood Pressure measurement

Arterial blood pressure is measured by a sphygmomanometer. See the web site www.ktl.fi/publications/ehrm/produ for a nice description of this measurement.

The manometer consists of:

- 1. A rubber bag surrounded by a cuff.
- 2. A manometer (usually a mechanical gauge, sometimes electronic, rarely a mercury column).
- 3. An inflating bulb to elevate the pressure.
- 4. A deflating valve.

and is team with a stethoscope to better hear the characteristic sounds that will guide you.

Figure 1 below shows a schematic diagram from the class notes about the concept behind this measurement. For the palpatory measurement technique, after the cuff is placed snugly over the arm, the radial artery is palpated while the pressure is increased until the pulse can no longer be felt, then the pressure is raised an additional 30 mm Hg. As the pressure is slowly released, the artery is palpated until the pulse is felt again. This palpatory method will detect systolic pressure only.

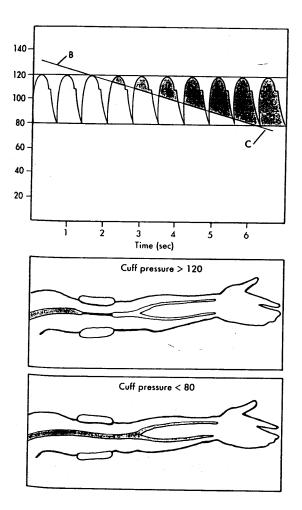


Figure 1: Schematic diagram of arterial blood pressure measurement by Korotkow sounds.

The auscultatory method, in contrast, requires the stethoscope and detects diastolic as well as systolic pressure. The sounds heard when a stethoscope bell (or diaphragm) is applied to the region below the cuff were described by Korotkow in 1905 and are called Korotkow's sounds. The artery is compressed as for the palpatory technique and as the pressure is released the first sound heard is a sharp thud which becomes first softer and then louder again. It suddenly becomes muffled and later disappears. Most people register the first sound as Systolic, the muffled sound as the "first diastolic" and the pressure at which the sound disappears as the "second diastolic". It requires practice to distinguish the first diastolic, so, for our laboratory, we will record only the first sound (systolic) and the disappearance of the sound (second diastolic). These will not be difficult to elicit, and a little practice will enable you to get almost the same reading on a fellow student three times in succession.

1.2 Sources or error in blood pressure measurement

1.2.1 Faulty Technique

1. Improper positioning of the extremity. Whether the subject is sitting, standing, or supine, the position of the artery in which the blood pressure is measured must be at the level of the

heart. However, it is not necessary that the sphygmomanometer be at the level of the heart.

- 2. Improper deflation of the compression cuff. The pressure in the cuff should be lowered at about 2 mm Hg per heartbeat. At rates slower than this venous congestion will develop and the diastolic reading will be erroneously high. If the cuff is deflated too quickly the manometer may fall 5 or 10 mm Hg between successive Korotkow sounds, resulting in erroneously low readings.
- 3. Recording the first blood pressure measurement. Spasm of the artery upon initial compression and the anxiety and apprehension of the subject can cause the first blood pressure reading to be erroneously high. After the cuff has been applied, wait a few minutes before inflating the cuff to record the blood pressure. Make several measurements. Generally the third value recorded is the most basal.
- 4. Improper application of the cuff. If the rubber bladder bulges beyond its covering, the pressure will have to be excessively high to compress the arm effectively. If the cuff is applied too loosely, central ballooning of the rubber bladder will reduce the effective width, thus creating a narrow cuff. Both bulging and ballooning result in excessively high readings.

2 Arterial and Venous Pressure Measurements

The lab is divided into 4 sections, the first 3 of which you should do in parallel in the usual paired groups. For the final section, please form groups of 4–5 as this exercise needs this many people to carry out.

2.1 Arterial blood pressure measurement

Have the subject relax with both arms resting comfortably at his sides. Wrap the sphygmomanometer cuff about the arm so that it is at heart level. The air bag inside the cuff should overlay the anterior portion of the arm about an inch above the antecubital fossa (the interior angle of elbow). The cuff should be wrapped snugly about the arm.

Palpatory method: Palpate the radial pulse with the index and middle fingers near the base of the thumb on the anterior surface of the wrist. While palpating the radial pulse, rapidly inflate the cuff until there is no detectable pulse and then add another 30 mm Hg, to a value in the range of 160–180 mm Hg. Set the valve on the rubber bulb so that the pressure leaks out slowly (about 5 mm per second). Continue palpating the radial pulse, and watch the manometer while air leaks out of the cuff. Note the pressure at which the pulse reappears.

Record the pressure: _____ mm Hg.

This is Systolic pressure as detected by palpation. Allow the pressure to continue to decrease, noticing the changes in the strength of the radial pulse.

Auscultatory method: Elevate the pressure in the cuff 20 mm Hg higher than the pressure at which the radial pulse reappeared in the palpatory measurement. Apply the stethoscope bell lightly against the skin in the antecubital fossa over the brachial artery. There will be no sounds heard if the cuff pressure is higher than the systolic blood pressure because no blood will flow through the artery beyond the cuff. As the cuff is slowly deflated, blood flow is turbulent beneath the stethoscope. It is this turbulent flow that produces Korotkow's sounds. Laminar flow is silent. Thus when the cuff is deflated completely, no sounds are heard at the antecubital fossa. Deflate the cuff completely and allow the subject to rest for a few minutes. DO NOT REMOVE THE CUFF.

Palpatory and Auscultatory methods simultaneously: Palpate the radial artery, and elevate the pressure in the cuff to 20 mm Hg higher than that at which the radial pulse reappeared. Apply the stethoscope to the skin over the brachial artery, and allow pressure to leak slowly from the cuff. Note the pressures:

- (1) At which the radial pulse is first felt: _____ mm Hg.
- (2) At which the sound is first heard with the stethoscope: _____ mm Hg.

The pressure at which the sound was first heard is recorded as systolic blood pressure. Allow the pressure to continue to fall. The Korotkow's sounds grow more and more intense as the pressure is reduced. Then they suddenly acquire a muffled tone and finally disappear.

The pressure observed at the first muffled tone is the first Diastolic pressure.

The pressure observed when the sound disappears is the second diastolic pressure. Record this pressure as the diastolic pressure for this laboratory. (Note: In practice you should record both diastolic pressures.)

Repeat the blood pressure determination at least three times, or until sufficient proficiency is acquired that agreement within 5 mm Hg is obtained between consecutive readings. Blood pressure is recorded with the systolic pressure reading first, *e.g.*, 120/80 means Systolic 120 mm Hg; Diastolic 80 mm Hg. Pulse Pressure is the difference between Systolic and Diastolic blood pressure.

How do the measurements from these two methods compare? Which do you think was more accurate and why? Try and explain any differences in results in the Discussion section of lab report.

2.2 Measuring venous blood pressure

One can measure the approximate venous pressure by noting how much above the level of the heart an extremity must be so that hydrostatic and venous pressures are equal. At that point, there is barely enough venous pressure to lift blood against the hydrostatic pressure of the elevate limb.

With the subject lying on his/her back, hands placed alongside the body, observe the veins on a relaxed, dependent hand¹. While the subject is reclining, passively raise and lower the subject's arm and observe filling and collapsing of the veins of the back of the hand. Measure the distance in millimeters from the position where the veins are just barely collapsed to the level of the heart (in the supine subject approximately midway between the spine and the sternum). This will give the venous pressure in millimeters of blood.

Venous pressure ______ mm of blood. The specific gravity of blood is 1.056. The specific gravity of mercury is 13.6. Compute the venous pressure in mm Hg: Mm of blood * Sp.Gr. of blood = mm of mercury * Sp.Gr. of mercury

¹If it is difficult to see the veins on the back of the subject's hand, have the reclining subject hang the hand loosely over the edge of the table, with muscles relaxed. If veins do not become visible, slap the back of the hand a few times (gently, please!) to stimulate blood flow.

_____ X _____ = ____ X ____

Venous pressure = _____ mm Hg.

2.3 Demonstration of valves in veins

Choose a student with prominent arm veins. Apply a fairly tight band around the arm above the elbow. Notice any swellings in the veins. Place a finger on a vein about six inches below the band and, with another finger, press the blood from the vein up towards the heart. This will empty the vein. Remove the second finger.

What do you observe? Please include your response in the lab report.

3 Response to exercise: Design your own experiment

In this part of the lab, you are to evaluate the response of the body to exercise. The challenge will be that you will have to develop the protocol and decide what data to collect and how to analyze it. At your disposal, you will have the ECG recording system you have used before, blood pressure measurements as you have just learned, a pulse oxymeter (a device that you have heard about in the mountaineering video and will learn more about soon), and bicycles installed in resistance trainers.

First, of course, it is necessary to identify a scientific question you wish to address with the lab. For this, first review the qualitative relationships between mean arterial pressure, heart rate, and total peripheral resistance as we discussed them in class. The broad goal is to determine the sequence of systemic cardiovascular events that accompanies exercise and to specifically establish the mean arterial blood pressure response to exercise. Does the pressure increase with time or level of exercise? Does heart rate predict blood pressure? And does the oxygen saturation influence these mechanisms? Finally, how does the ECG respond to exercise? We will discuss this background also in class.

Your task, then, is to create a protocol that will provide the data needed to address these questions. The constraints in terms of equipment are outlined above and you are free to ask the instructors about measurement options that might be available. The challenge is to think through the many details necessary to conduct an experiment and generate quality data.

To this end, for a deadline specified elsewhere on the web site, create the measurement protocol for this experiment and make sure it includes the following:

- Include as many of the details as you would need to perform both the experiment and the post processing of the data.
- Be sure to clarify your rational for all the small decisions you will have to make along the way.
- Assume that you will work in groups of 4–5 students and prepare and submit the protocol as a group (by a group representative) and make sure the protocol lists all team members (and, of course, all team members should normally be present for the experiment and each should play a substantial role in the project).
- Describe in detail the role of each participant in the experiment.



Figure 2: Group of 4 performing the exercise testing. What are the roles of each team member?

4 Lab Report

The lab report should contain the following sections:

Introduction: a brief overview of the purpose and goals of the lab as you understand them.

- Methods: For the pressure measurement segment, include only a very brief summary of methods; do not reproduce material (figures or text) from the lab description. For the exercise measurements, include your protocol. You may modify it from the original submission in order to reflect what you have learned by actually doing the lab.
- **Results:** include all **relevant** (you must decide what is relevant) data you recorded in all the various components of the lab, with a brief explanation for each, along with any qualitative observations you made (*i.e.*, responses you observed but for which you did not collect specific or quantitative data).

From the exercise protocols, make sure to include all the relevant results you gathered. There should be data to cover all the questions listed above.

Discussion: Discuss your results, especially from the exercise component of the lab.

Describe briefly the physiological mechanisms of some of the changes you observed. Make sure to answer all the questions marked **in bold** in the lab description.

Describe any experimental challenges you had to face in the lab and how you dealt with them or how you would plan to deal with them were you to repeat these experiments in the future.