Laboratory 15: The Circulatory System, ECG and Blood Pressure
Dr. Michael Kunz

Corresponding Reading:
Campbell Ch. 23

Introduction
The circulatory system plays a central role in maintaining homeostasis. Thick-walled arteries carry blood under high pressure to different parts of the body; capillaries exchange materials with different organs; veins return blood to the heart to complete one loop of circulation. Without sufficient pressure in the arteries, circulation will not happen; too much pressure in the arteries stresses the body and leads to various diseases, including deadly strokes.

The contraction of heart muscles generates the pressure needed to push blood through the arteries. The heart has four chambers that contract: two thick-walled ventricles and two thin-walled atria. Atria receive the blood from the veins and pump the blood into the ventricles. Since atria only pump blood a short distance, they do not need to generate much force. Ventricles must pump blood through arteries to distant parts of the body, so they must generate much more force.

In this lab we will measure two important indicators of cardiac function. We will measure blood pressure using a sphygmomanometer and stethoscope. Normal blood pressure when the ventricles contact reaches "120mm" (the height a column of mercury can be supported under this pressure). This is called the "systolic pressure." When the ventricles relax, the pressure in the arteries drops to the "diastolic pressure" of approximately 80mm.

We will also track the heart's cardiac cycle of contraction and relaxation. When heart muscles contract, they send a faint electric current throughout the body that can be measured by sensors attached to the wrists and ankles. Another current is generated when heart muscles relax. The cardiac cycle begins with the atria contracting, followed by the ventricles contracting and atria relaxing, followed by the ventricles relaxing. "Systole" is the part of the cycle when the ventricles are contracted; "diastole" is the part of the cycle when the ventricles are relaxed. The electrical trace that is generated by an ECG can detect how long the heart remains in systole and diastole, as well as detect many cardiac abnormalities. We will compare the ECG before and after exercise.

Materials
1. Sphygmomanometer and stethoscope for measuring arterial blood pressure

2. Laptop computers

3. electrocardiogram data acquisition software & hardware

Objectives
1. Measure systolic and diastolic pressure and interpret their significance.

2. Use computer-assisted software to acquire and interpret electrocardiogram data regarding the cardiac cycle.

3. Determine the effect of exercise on the cardiac cycle.

4. Present data in tabular form and draw appropriate conclusions from data.
Blood Pressure Measurement

1. Orient yourself to cardiac function by reviewing the chapter in your text on the circulatory system. Review the differences between arteries and veins, ventricles and atria of the heart, and the cardiac cycle.
2. Obtain a sphygmomanometer and stethoscope.
3. Wrap cuff of the sphygmomanometer around the upper arm. Note the patch that tells where to place the stethoscope drum. Arrange so that the drum is on the front of elbow bend.
4. Shut the valve of the cuff by turning the silver knob on the bulb clockwise until it stops. Begin to inflate the cuff by pumping the bulb.
5. Note the attached gauge that measures the pressure in the cuff. Inflate the cuff until the pressure completely compresses the underlying arteries (160mm of pressure should be sufficient). Do not leave the cuff at high pressure for prolonged periods of time, as you will be cutting off circulation to the volunteer’s lower arm.
6. Clean the earpieces of the stethoscope with alcohol wipes. Then place them into your ears (not the volunteer’s ears). Slowly release the pressure in the cuff by gently turning the silver knob on the bulb counterclockwise to let air out. Listen in the earpieces for any sound coming from the artery in the arm. The needle in the gauge will fluctuate or bounce but it does not correlate to the sounds so do not be distracted by the fluctuations.
7. No sound will be heard as long as the artery is pinched shut by the high cuff pressure. When the cuff pressure drops below the systolic pressure, pulses of blood will pass through the artery. The turbulent flow can be heard in the stethoscope as a light tapping sound. Record the gauge pressure when the first sound was heard. This is the systolic blood pressure.
8. Continue slowly releasing pressure from the cuff until no sound is heard. This is when the cuff pressure drops below the diastolic pressure. Blood then flows smoothly through the arteries and the turbulence is no longer audible. The cuff pressure when the last sounds are heard is the diastolic pressure. Record this value.
9. Repeat the procedure several times. It takes practice to obtain accurate blood pressure measurements. Remember to completely deflate the cuff between measurements.
10. Comment on whether this blood pressure is normal, high, or low. Note that these measurements are not being done in a professional manner and this lab is not meant to be diagnostic. If you get abnormal readings please see your personal physician and describe your concerns.

Electrocardiogram Recordings

1. Make a table containing ECG measurements. The table columns should include the cardiac rate, the P-R interval, the length of systole (R to T), and length of diastole (T to R). Data will be collected from the same volunteer “before exercise” and after exercise”. Label the table in proper scientific formatting; include mathematical units of measurement; a descriptive sentence as the title; proper row and column descriptions.
2. Go to a station that is set up with a computer, Biopac machine, and electrocardiogram equipment (Biopac lesson 5, electrode lead set and tabs).
3. Open the software on the computer entitled “Biopac student lab 4.0”; Select “Lesson 5” and click “OK”.
4. Connect the three leads to the ankles and wrist of one member of a group according to instructions on the Biopac Lesson 5. Ground “G” black lead goes on the right ankle, the white negative “-” lead goes on the right wrist, and the positive “+” red lead goes on the left ankle.
5. The volunteer should lay down face-up (supine) on the bench top or some chairs. Follow instructions on screen to “calibrate” the equipment before collecting data.
6. To collect the ECG reading, follow Biopac instructions on bottom of computer screen. The “Record” button starts the data collection. Collect data and or redo until you obtain some good data. When all data is collected, choose “Done”. This will close you out of the data collection software and prompt you into another software program to “Analyze current data set”.
7. Refer to an ECG diagram to note the different waves of the ECG cardiac cycle measurement (in the Biopac lab manual or your text). The first smaller wave is the P wave, formed by the contraction
of the atria. The larger jagged trace is the QRS wave, formed by the contraction of the ventricles (note R is the top of the wave form). The final wave is the T wave, formed by the relaxation of the ventricles.

8. Zoom into an area of about 5 seconds of good data on the Biopac graph. To do this, ensure the cursor is in the “arrow” format and double click the horizontal axis (x axis) of the graph. This should pop up a window asking you to enter in the time period of interest (for example, the data recorded at time period 15 seconds to 20 seconds)

9. The time between any two waves can be measured by choosing the “I” beam cursor tool from the toolbar (this toolbar is sometimes at top of screen & sometimes at right of graph), then drag the “I” across the graph selecting the area from point to point on the ECG trace. Measure the time from one QRS wave to the next. Record the time in the table prepared earlier. Locate the drop down menu for BPM or mathematically divide the time into 60 seconds to determine the cardiac rate (in beats per minute). Normal resting pulse is approximately 70 beats per minute.

10. Measure the distance from the beginning of the P wave to the beginning of the QRS waves. This interval records the time it takes for the waves of contraction to spread from the atria to the ventricles. The normal P - R interval is 0.2 seconds or less. Longer intervals can signify heart damage called a “block”.

11. Measure the time from the R peak to the beginning of the T wave. This is the length of systole.

12. Measure the time from the beginning of the T wave to the next R peak. This is the length of diastole.

13. Unhook the leads from the ankles and wrists. The student being measured should then do two minutes of vigorous exercise by stepping up and down a stair (there are two sets of stairs in AIMS Hall).

14. Reconnect the student to the leads and as quickly as possible take another ECG reading. Repeat the same measurements as taken before exercise.

15. Make a table containing ECG measurements before and after exercise. The table should include the cardiac rate, the P-R interval, the length of systole (R to T), and length of diastole (T to R). Label the table in proper scientific format with a sentence description along with row and column descriptions.

For Thought and Discussion

1. Based upon your analysis, what part of the cardiac cycle is most affected by exercise?

2. What would you predict to be the maximum heart-rate (in beats per minute) of a typical person? Explain how you determined this value.

Course Evaluation

1. The Biology Department sincerely hopes this introductory course has been challenging, interesting and useful to your education. In order to improve our courses and instruction, we ask that you give us feedback on your courses and instructors. You should be receiving an email from FPU with online instructions on how submit course evaluations. Thank you ahead of time for taking the time to complete these surveys.