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EXP.NO.6

Pulse Transit Time

Electrical activity of the heart is closely associated with pressure changes in the heart chambers and blood vessels. Understanding the events of the cardiac conduction system, the muscle activity of the heart and the pumping events that follow, is important for understanding how blood pressure is maintained during the cardiac cycle.

An electrocardiogram (ECG or EKG) is a graphical recording of the electrical events occurring within the heart. In a healthy heart, a natural pacemaker in the right atrium (the sinoatrial node) initiates an electrical sequence. This impulse passes down natural conduction pathways from the atria to the atrioventricular node and from there continues down the right and left bundle branches to both ventricles. The natural conduction pathways facilitate orderly spread of the impulse and coordinated contraction of first the atria and then the ventricles. Five components of a single EKG are traditionally recognized and labeled P, Q, R, S, and T (see Figure 1). The P wave represents the start of the electrical journey as the impulse spreads from the sinoatrial node downward from the atria through the atrioventricular node and to the ventricles. Ventricular activation is represented by the QRS complex, which initiates contraction of the ventricles. The T wave results from ventricular repolarization, which is a recovery of the ventricular muscle tissue to its resting state.

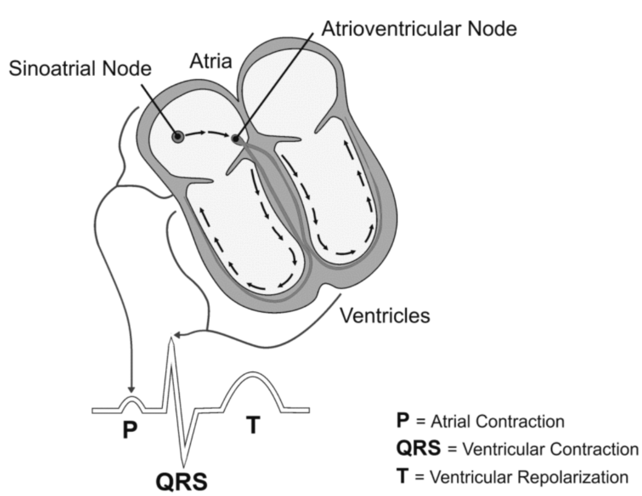

Figure 1

Blood pressure is a measure of the changing fluid pressure within the circulatory system. It varies from a peak pressure produced by contraction of the left ventricle, to a low pressure, which is maintained by closure of the aortic valve and elastic recoil of the arterial system. The peak pressure is called systole, and the pressure that is maintained even while the left ventricle is relaxing is called diastole.

If you could measure arterial blood pressure from an artery while you performed an EKG, you would see that each QRS complex precedes a pressure pulse in the artery. The time that it takes this pressure pulse to travel from the ventricles to the artery is referred to as the Pulse Transit Time. Because the ventricular contraction and the QRS complex happen almost simultaneously, you can use the peak of the R wave as an indicator of the time ventricular contraction occurred. Using a blood pressure cuff on the arm, you will be able to record the following pressure pulses in the brachial artery. By recording these events, you will be able to calculate the Pulse Transit Time.

Important: The equipment used in this experiment is for educational purposes only and should not be used to diagnose medical conditions.

Objectives

Obtain graphical representation of the electrical activity of the heart (EKG).
Obtain graphical representation of a pressure pulse from the brachial artery.
Calculate the transit time of a pressure pulse from the heart to the brachial artery.

MATERIALS

- Chromebook, computer, or mobile device
- Graphical Analysis 4 app
- Go Direct EKG Sensor
- Go Direct Blood Pressure Sensor
- electrode tabs

PROCEDURE

Select one person from your group to be the subject.

1. Set up the data-collection equipment.
a. Launch Graphical Analysis.
b. Connect the Go Direct EKG Sensor and the Go Direct Blood Pressure Sensor to your Chromebook, computer, or mobile device.
c. Click or tap Sensor Channels for Go Direct Blood Pressure (GDX-BP). Deselect all channels except Cuff Pressure. Then select Oscillations.
d. Click or tap Done. Note: The default channels for Go Direct EKG are correct for this experiment; there is no need to adjust the channels.

2. Adjust the view and graphs.

a. Click or tap View, , and select 2 Graphs.

b. Verify that a graph of EKG vs. time is displayed. If not, click or tap the y-axis label of one of the graphs, and select EKG. Deselect the data you do not want displayed, and click or tap the graph to dismiss the menu.
c. The second graph should be a graph of oscillations vs. time. Click or tap the y-axis label for the other graph. Select Oscillations and deselect all other columns. Click or tap the graph to dismiss the menu.

3. Click or tap Mode to open Data Collection Settings. Change Rate to 100 samples/s and End Collection to 40 s. Click or tap Done.

4. Attach three electrode tabs to the subject's arms as shown in Figure 2. Place a single patch on the inside of the right wrist, on the inside of the right upper forearm (distal to the elbow), and on the inside of the left upper forearm (distal to elbow).

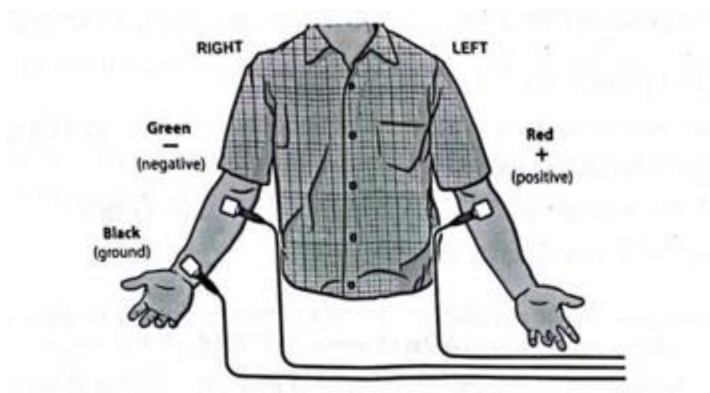

Figure 2

5. Connect the EKG clips to the electrode tabs as shown in Figure 2.

6. Attach the blood pressure cuff firmly around the subject's left upper arm, approximately 2 cm above the elbow. The two rubber hoses from the cuff should be positioned over the biceps brachii muscle (near the brachial artery) and not under the arm (see Figure 3).

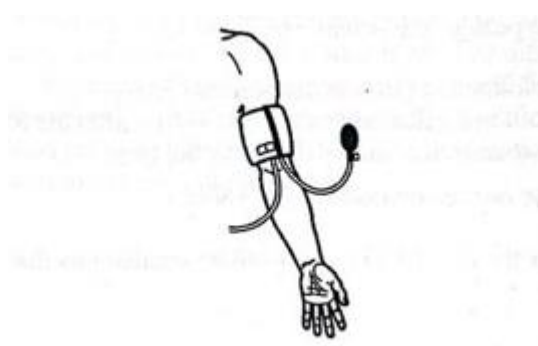

Figure 3

7. Have the subject sit quietly in a chair with his or her forearm resting on a table surface. Important: The subject must remain still during data collection; there should be no movement of the arm or hand during measurements.

8. In the next step, you will start data collection and inflate the cuff. To help you know when a sufficient pressure has been reached, the sensor indicator light, located in the upper-right corner of the sensor label, will blink green. Identify the light before moving on to the next step.

9. Collect data.

a. Click or tap Collect to start data collection.
b. Immediately pump the bulb until the cuff pressure reaches at least 160 mmHg, and then stop pumping. Note: The sensor indicator light will blink green when sufficient pressure has been reached.
c. The cuff will slowly deflate and the pressure will fall.
d. When data collection stops, release the remaining pressure in the cuff.

10. Edit the graph options for the EKG graph to prepare the graph for analysis and turn on Interpolate tool.

a. For the EKG graph, click or tap Graph Tools,
b. Click or tap Interpolate to activate the tool, and then click or tap Edit Graph Options
c. Click or tap Edit Graph Options.
d. Set the left x-axis range to **25 s** and the right x-axis range to **30 s**.
e. Dismiss the dialog box to save the settings.

11. Edit the graph options for the oscillations graph to prepare the graph for analysis.

a. For the oscillations graph, click or tap Graph Tools,
b . Click or tap Interpolate to activate the tool, and then click or tap Edit Graph Options.
c. Set the left x-axis range to **25 s** and the right x-axis range to **30 s**.
d. Dismiss the dialog box to save the settings.

12. Determine the time of the first visible R wave.

a. Click or tap the peak of the R wave for the first visible EKG trace on the EKG graph. **Note:** You can also drag the examine line to adjust its position to align with the peak of the R wave.
b. Record the time of the peak of the R wave in Table 1.

13. Determine the time of the following pulse in the brachial artery.

a. Click or tap the peak of the oscillation (pulse) that occurs after the R wave you measured, You can adjust the position of the line by dragging the line.
b. Record the time that the oscillation occurred in Table 1.

14. Repeat Steps 12 and 13 for the four EKGs and resulting oscillations that follow.

DATA

Table 1			
Event	**QRS Wave time (s)**	**Oscillation time (s)**	**Pulse transit time (s)**
1			
2			
3			
4			
		Mean	

DATA ANALYSIS

1. Subtract each Oscillation Time from its corresponding QRS Wave Time. The result is the Pulse Transit Time. Record the Pulse Transit Time in the space provided in Table 1.

2. Calculate the subject's mean pulse transit time. Record this value in the space provided in Table 1.

3. You have calculated the pulse transit time in the artery of the bicep. Would the pulse transit time be longer for the fingertips or toes? Explain your response.

EXTENSIONS

1. Pulse transit time is inversely related to the subject's blood pressure. As blood pressure decreases, the pulse transit time should increase in duration. Determine the subject's blood pressure when standing and when lying prone. Then determine the subjects pulse transit time in both conditions. Do your results also indicate that pulse transit time increases as blood pressure decreases?

2. Determine if the difference observed in the extension above is statistically significant. Because you have before and after data for each subject, you can use a paired t-test to determine if any change in pulse transit time is significant.

3. Several studies indicate that women tend to have lower blood pressure, including SP, DP, and MAP, on average than men of similar age and fitness level. The difference in MAP is quite small (6-10 mmHg). Compare the pulse transit times of male and female subjects. Is there a difference in pulse transit time? Is the difference statistically significant? Is any difference observed related to blood pressure? Determine the blood pressure of male and female subjects and compare your results to the pulse transit time.