

Analyzing the Heart with ECG

CONCEPTS

Physiology

- electrocardiogram (ECG)
- ECG lead
- activation / depolarization
- repolarization
- myocardial infarction
- cardiac wavefront propagation

Engineering

- electrodes
- impedance
- motion artifact
- threshold detection
- standard deviation

BACKGROUND

An electrocardiogram (ECG or EKG) is a graphical recording of the electrical events occurring within the heart. In a healthy heart there is a natural pacemaker in the right atrium (the *sinoatrial node*) which initiates an electrical sequence. This impulse then passes down natural conduction pathways between the atria to the atrioventricular node and from there to both ventricles. The natural conduction pathways facilitate orderly spread of the impulse and coordinated contraction of first the atria and then the ventricles. The electrical journey creates unique deflections in the ECG that tell a story about heart function and health (Figure 1). Even more information is obtained by looking at the story from different angles, which is accomplished by placing electrodes in various positions on the chest and extremities. A positive deflection in an ECG tracing represents electrical activity moving toward the active lead (the red lead in this experiment).

Five components of a single beat are traditionally recognized and labeled P, Q, R, S, and T. 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. The T wave results from ventricular repolarization, which is a recovery of the ventricular muscle tissue to its resting state. By looking at several beats

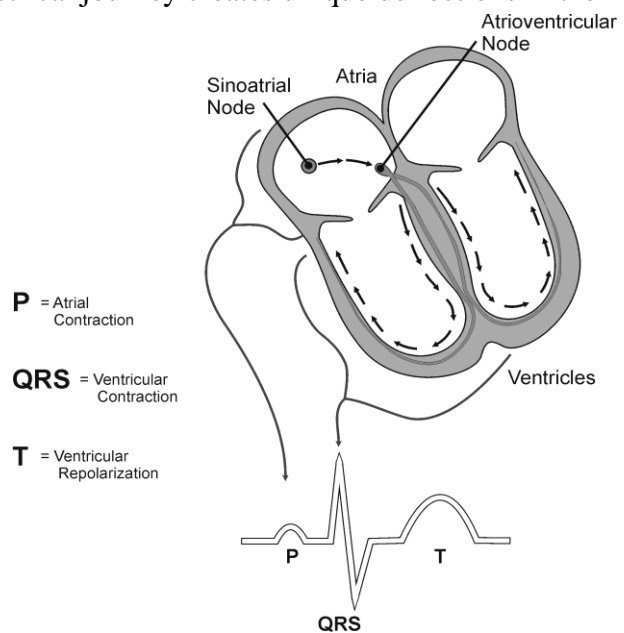


Figure 1

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you can also calculate the rate for each component.

Doctors and other trained personnel can look at an ECG tracing and see evidence for disorders of the heart such as abnormal slowing, speeding, irregular rhythms, injury to muscle tissue (*angina*), and death of muscle tissue (*myocardial infarction*). The length of an interval indicates whether an impulse is following its normal pathway. A long interval reveals that an impulse has been slowed or has taken a longer route. A short interval reflects an impulse which followed a shorter route. If a complex is absent, the electrical impulse did not rise normally, or was blocked at that part of the heart. Lack of normal depolarization of the atria leads to an absent P wave. An absent QRS complex after a normal P wave indicates the electrical impulse was blocked before it reached the ventricles. Abnormally shaped complexes result from abnormal spread of the impulse through the muscle tissue, such as in myocardial infarction where the impulse cannot follow its normal pathway because of tissue death or injury. Electrical patterns may also be changed by metabolic abnormalities and by various medicines.

In this experiment, you will use the ECG sensor to make a graphical recording of your heart's electrical activity, and then switch the red and green leads to simulate the change in electrical activity that can occur with a myocardial infarction (heart attack). You will identify the different components of the waveforms and use them to determine your heart rate. You will observe the effect of impedance changes and motion. You will also determine the direction of electrical activity for the QRS complex.

OBJECTIVES

In this experiment, you will

- Obtain graphical representation of the electrical activity of the heart over a period of time.
- Learn to recognize the different wave forms seen in an ECG and measure the variability in some features of the ECG.
- Determine the heart rate by using threshold detection on ECG.
- Observe the effects of varying electrode-skin impedance on the ECG.
- Determine whether ventricular wavefront propagates from left to right or right to left by comparing waveforms generated by alternate ECG lead placements.

MATERIALS

LabQuest
Logger Pro

Vernier ECG Sensor
electrode tabs

PROCEDURE

Part I Standard limb lead ECG

1. Connect the ECG Sensor to LabQuest and LabQuest to the Vernier computer interface. Open the file "12 Analyzing Heart EKG" from the *Human Physiology with Vernier* folder. Modify the data collection settings: Change the trial duration to 30 seconds.
2. Attach three electrode tabs to your 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).

3. Connect the ECG clips to the electrode tabs as shown in Figure 2. Sit in a relaxed position in a chair, with your forearms resting on your legs or on the arms of the chair. When you are properly positioned, have someone start data collection.
4. Print out an ECG graph showing about 2 seconds of data and label the various events of a heartbeat.
5. Create the table described in the DATA section. Determine the statistics for each of the intervals listed. Use Figure 3 as your guide when determining these intervals.
 - a. Tap the data point at the beginning of the interval.
 - b. Record the time component of this point.
 - c. Tap the point at the end of the interval.
 - d. Record the time component of this point.
 - e. Determine the difference between the two time values and record this value to the nearest 0.01 s as the length of the interval in your table.

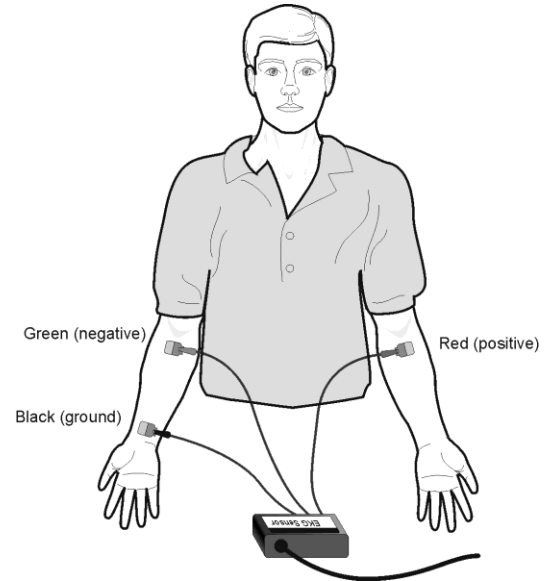


Figure 2

6. Calculate the heart rate in beats/min using the ECG data. Record the heart rate to the nearest whole number.
7. Store this run by selecting Store Latest Run from the Experiment menu (or tapping the File cabinet icon).

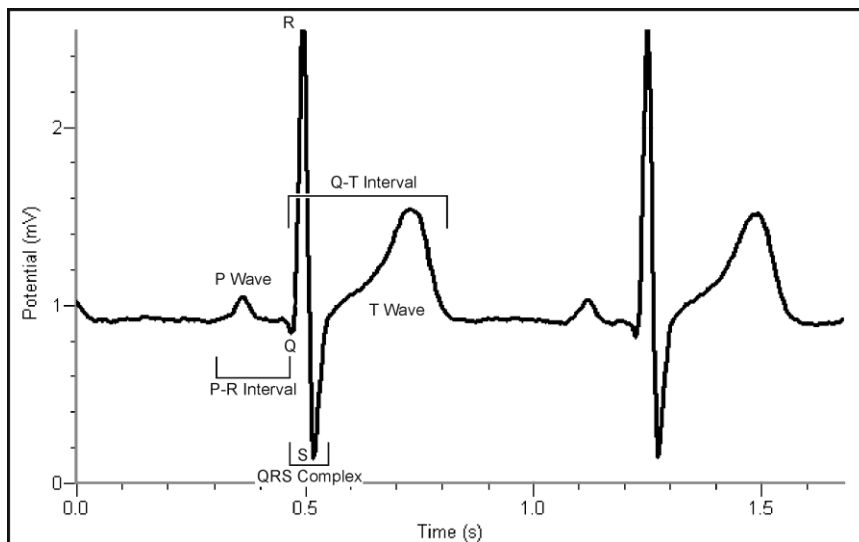


Figure 3

- **P-R interval:** time from the beginning of P wave to the start of the QRS complex
- **QRS complex:** time from Q deflection to S deflection
- **Q-T interval:** time from Q deflection to the end of the T

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Part II Effect of impedance and motion.

8. Now remove the clips from the tabs and tape them roughly in the same location as the tabs but onto the subject's skin.
9. Sit in a relaxed position in a chair, with your forearms resting on your legs or on the arms of the chair. When you are properly positioned, have someone start data collection.
10. Make any observations.
11. After about 10 seconds, re-attach the clips according to Figure 2, allowing the subject to remain stationary.
12. When the ECG recording has stabilized, wait about 5 seconds and then have the subject raise his/her left arm up and down, then right arm up and down, then place finger on either the green or red electrode and rub it back and forth so that there is some movement between the tab and the skin.
13. Store this run by selecting Store Latest Run from the Experiment menu (or tapping the File cabinet icon).

Part III Alternate limb lead ECG

14. Exchange the red and green ECG clips so that the green clip is now attached to the electrode tab on the left arm and the red clip is on the right arm.
15. Sit in a relaxed position in a chair, with your forearms resting on your legs or on the arms of the chair. When you are properly positioned, have someone start data collection.

DATA

Create a table which allows you to record the following data:

- P-R interval: values from 5 pulses; mean and standard deviation
- QRS interval: values from 5 pulses; mean and standard deviation
- Q-T interval: values from 5 pulses; mean and standard deviation
- R-R interval: values from 5 pulses; mean and standard deviation mean and standard deviation
- Heart rate from peak count

Table 1	
Standard Resting Electrocardiogram Interval Times	
P-R interval	0.12 to 0.20 s
QRS interval	less than 0.12 s
Q-T interval	0.30 to 0.40 s

DATA ANALYSIS

You are responsible for determining what you need to show and say in the Data Analysis / Results section of your lab report. However, here are some guidelines you can follow.

1. Part I: Show the waveforms and the events in the waveform. Use Excel to detect heart beats, find the average heart rate, and find the R-R interval from each of the heart beats recorded in Part I. Also compute the statistics for the various intervals, as described in the Data section.
2. Part II: Create figures which show the effect of impedance and of motion. You might want to add annotations to label different events.
3. Part III: What are the main differences between the ECG trace in Part I vs. Part II? Based on these observations, determine from your data whether ventricular depolarization proceeds from right to left or left to right. Focus on the 1st major deflection of a single QRS complex (R wave).