Using Electrocardiograms (ECG) to Evaluate the Cardiac Cycle

Background
The cardiac cycle is a pattern of physiological events exhibited during each beat of the heart. This cycle – comprising an atrial systole (contraction) and diastole (relaxation), followed by a ventricular systole and diastole – may be evaluated by a number of methods. Blood pressure, pulse and heart sounds are all effective, and easy, clinical tools for monitoring this ever-important cycle. A variety of more sophisticated (and expensive) visual analysis tools are available: an angiogram – using X-rays; an MRI – using magnetic energy; or an echocardiogram – using sound energy. A good trade-off between these techniques makes use of the heart’s electrical activity to produce and electrocardiogram (ECG or EKG). This technique also produces a detailed picture of the heart’s function, but is relatively easy and inexpensive to perform. It is commonly used on both healthy and ill persons.

An ECG is a graph that records the changes in the electrical properties of the heart during the cardiac cycle. The electrocardiogram is produced by an electrocardiograph machine. This is simply a voltmeter that measures the rise and fall of voltage (electric potential) between two points. Electrodes are generally placed on the right arm, left arm and left foot. Using only these three electrode leads, it is possible to look at the heart from six possible orientations. Additional leads may be placed around the chest to provide even more detailed pictures of cardiac muscle activity. Ultimately, the ECG allows a health professional to evaluate the function and integrity of the heart relative to the proper depolarization (contraction) and repolarization (relaxation) of the atria and ventricles.

Focus Questions
- What is the relationship between the cardiac cycle, heart sounds, blood pressure and ECG?
- How is the electrocardiogram (ECG) used to collect important cardiovascular data?
- How is ECG data used to interpret normal and abnormal cardiac function?

Basic Rules for Reading Electrocardiograms

Rule 1: Each small square on the EKG strip represents 0.04 seconds in time. Each large square represents 0.20 seconds in time.

Rule 2: The first (little) wave is the P wave and reflects atrial depolarization and contraction. The flat line following the P wave reflects the delay in ventricular contraction as the conduction signal moves through the AV node to the ventricles. The length of time from the beginning of the P wave to the beginning of the QRS complex is the PR interval, normally 0.20 seconds or less. If the PR interval is greater than 0.20 seconds, then some form of sinoatrial heart block is occurring.

Rule 3: The next set of jagged lines is the QRS complex, and represents the contraction of the ventricles. The first downward wave, if followed by an upward wave, is the Q wave. The first upward wave is the R wave. The first downward wave following an R wave is the S wave. It is during the QRS complex that the atria repolarize, but this electrical activity is overshadowed by the massive electrical activity of the ventricles. The width of the QRS should be 0.12 seconds or less, otherwise some form of heart block exists. With blockage of electrical conduction through the AV bundles, there may be multiple R or S waves, symbolized as R’ or S’. R’ or S’ waves can signify heart block in the ventricles if the QRS complex exceeds 0.10 seconds.

Rule 4: Following the QRS complex is the T wave, normally upright (in the chest leads) and having a fairly smooth wave crest. Peaked T waves generally indicate elevation of serum potassium. Inverted T waves may indicate low serum potassium.

Rule 5: With regard to the P wave and the QRS complex, when a wave of cellular depolarization is moving away from a lead, the pen or line of the ECG will move downward. When a wave of cellular depolarization (heart muscle cell contraction) is moving towards a lead, the pen or line on the ECG will move upward. The degree of upward deflection (voltage) will be proportionate to the number of cells depolarizing (contracting).

Rule 6: When examining data from multiple leads, the R wave should progressively get higher as you move from V1 to V6. This is because of the greater thickness of the left ventricle. Loss of R wave progression suggests loss of left myocardial tissue (such as from a myocardial infarction) or an increase in the size of the right ventricle (such as occurs in many pulmonary diseases).

Rule 7: Look at the regularity of heartbeats and look for premature ventricular contractions (PVC’s). If the heart rhythm is irregular, it suggests a malfunctioning SA node. When the SA node does not initiate a signal to the heart, other heart muscles cells can take over as a pacemaker site: sometimes occasional isolated sites of the heart initiate the heartbeat and this is seen on the ECG as a PVC. Isolated PVC’s are not dangerous, but the more PVC’s seen in a row, the greater the danger of impending heart arrhythmias.
Procedure

Part A. Understanding the Cardiac Cycle

1. Use textbook pages 330-335 and the two (2) coloring topics included with this lab, "Cardiac Cycles: Heart as a Pump" and "Cardiovascular System: Cardiac Conduction System", to complete the following statements. You should finish with a strong understanding of the main concepts behind each topic.

   a. The period during which a heart chamber is contracting is called ____________________________.

   b. The period during which a heart chamber is relaxing is called ____________________________.

   c. During ventricular contraction, the A-V valves (tricuspid and bicuspid) are ____________________________.

   d. During ventricular relaxation, the A-V valves are ____________________________.

   e. Heart sounds are due to ____________________________ in the heart tissues associated with the closing of the valves.

   f. The first sound of the cardiac cycle occurs when the ____________________________ valves are closing.

   g. The second sound of the cardiac cycle occurs when the ____________________________ valves are closing.

   h. When blood leaks back through a heart valve an abnormal sound called a ____________________________ is produced.

   i. The fibers of the cardiac conduction system are specialized ____________________________ tissue.

   j. Normally, the ____________________________ node serves as the pacemaker of the heart.

   k. The ____________________________ node is located in the inferior portion of the interatrial septum.

   l. The large fibers on the distal side of the A-V node make up the ____________________________.

   m. The fibers that carry cardiac impulses from the interventricular septum into the myocardium are called ____________________________.

   n. An ____________________________ is a recording of electrical changes occurring during a cardiac cycle.

   o. Between cardiac cycles, cardiac muscle fibers remain ____________________________ with no detectable electrical changes.

   p. The P wave corresponds to the depolarization of the muscle fibers of the ____________________________.

   q. The QRS complex corresponds to the depolarization of the muscle fibers of the ____________________________.

   r. The T wave corresponds to the repolarization of the muscle fibers of the ____________________________.

   s. One type of cardiac arrhythmia is called ____________________________.

   t. The instrument that detects changes in the hearts electrical potential is called a(n) ____________________________.

2. Draw a scaled six (6) second normal ECG pattern. Identify the P, QRS, and T portions of one cardiac cycle. Remember: standard trace velocity is 25 mm/sec (2.5 cm/sec).

   [Draw an ECG pattern here]

3. Use your knowledge from the coloring topics and text reading to answer the following questions.

   a. Briefly describe the mechanical events (pressure and volume) of the cardiac cycle. ____________________________

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b. Briefly describe the electrical events of the cardiac cycle.

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c. Discuss the relationship amongst pulse, heart sounds, electrocardiogram in the cardiac cycle.

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d. What do the ‘P’, ‘QRS’ and ‘T’ segments of a normal ECG indicate?

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e. What occurs during the ‘P-R’ and ‘S-T’ intervals of a normal ECG?

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Part B. Individual Electrocardiograms
1. Your instructor will record, using a computer-based ECG probe, your actual ECG pattern for an (8) second sequence. You will receive a printed copy of your ECG.
2. Identify the P, QRS and T components of one ECG cycle on your trace. Turn this copy in with your lab.

Part C. Analyzing Electrocardiograms
1. Briefly look at the various abnormal ECG’s found in the lab. Note various differences in rate, strength and sequence between normal and abnormal traces.
2. Select one (1) of the abnormal ECG’s. Write a comparison of the important differences between a normal ECG pattern and your abnormal pattern, including the clinical implications of your selected abnormality.

Analysis and Conclusions
1. Briefly explain how and why an ECG provides useful information about cardiac function.

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2. Briefly, research and describe a specific cardiac arrhythmia. Your description should include the difference in ECG patterns (between normal and abnormal), as well as the clinical implications of the abnormality.

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