Experiment IXECG12: 12-Lead Electrocardiograms (ECGs)

Background

Discrete areas of electrical activity in the heart can be defined by an electrocardiogram recorded simultaneously from different points of view around the heart. Each point of view is commonly called a lead. The multiple lead electrocardiogram that is most universally accepted as a clinical tool is known as the 12-Lead ECG. This electrocardiogram uses one electrode on each limb of the subject, and an electrode on each of six different positions on the chest. Many 12-Lead ECG monitors have inputs and wiring for each of the six chest electrodes. However, if the monitor has only one input and cable for recording from the chest, the cable must be moved from one chest electrode to another in order to complete the recording from all six positions on the chest.

Unipolar and Bipolar Leads

To record an electrocardiogram from twelve different points of view, the outputs of limb and chest electrodes need to be combined in nine of the twelve leads. On many ECG monitors, the combinations are created by rotating a simple switch called the ECG lead selector.

Each of the standard limb leads (Leads I, II, and III) record electrocardiograms between two of the three limb electrodes. These leads are classified as bipolar leads because two electrodes are involved in the recording. The voltage at the active (recording) electrode is referenced against the voltage at the indifferent electrode. For example, the voltage at the electrode on the left leg is compared to the voltage on the right arm or shoulder in Lead II recordings.

Each of the augmented limb leads (aVR, aVL, aVF) record electrocardiograms between an active limb electrode and an indifferent point which is formed by the joining of the two remaining limb electrodes through the ECG lead selector. The augmented leads are classified as unipolar because the voltage at the active electrode is referenced against a point that is equidistant between the two non-active electrodes.

The chest leads, known as V1 through V6, record electrocardiograms between an active chest electrode and another indifferent point formed by the joining of the limb electrodes through the ECG lead selector. The chest leads are also unipolar because the voltage at the active electrode on the chest is referenced against an indifferent point in the center of a triangle formed by the limb leads.

Plane of the Limb Leads

In the standard 12-Lead ECG, the six limb leads look at the heart along six directions in a vertical plane that is best described as being parallel to the floor when the subject is reclining. The information from these leads can determine the electrical axis of the atria and ventricles during depolarization (Figure HH-13-B1). A variation in the angle of this electrical axis can be caused by a variety of physiological or pathological conditions. For example, right-axis shifts are common in extremely thin and healthy persons; the causes of the shifts in these cases are physiological. Right-axis shifts also appear in persons with right bundle branch blocks or right ventricular hypertrophy; however, in these cases, the deviations are caused by pathological problems. All of the deviations detected by the limb leads are around a horizontal axis that is perpendicular to the vertical plane of these leads.

Plane of the Chest Leads

The six chest leads of the 12-Lead ECG are often called the precordial leads. The chest leads are in an almost horizontal plane that is best described as being parallel to the floor when the subject is standing. The electrocardiograms from these leads can be used for diagnosing damage to cardiac tissue caused by coronary occlusions or ventricular hypertrophy. These types of determinations are possible because chest leads are unipolar and placed in an array. The active electrodes in these leads respond to electrical activity directly beneath them whether the activity is moving towards or away from the electrode, or from side to side. The depolarizations that move toward an electrode appear as positive deflections; if the depolarizations are moving away from the electrode, the deflection is negative.

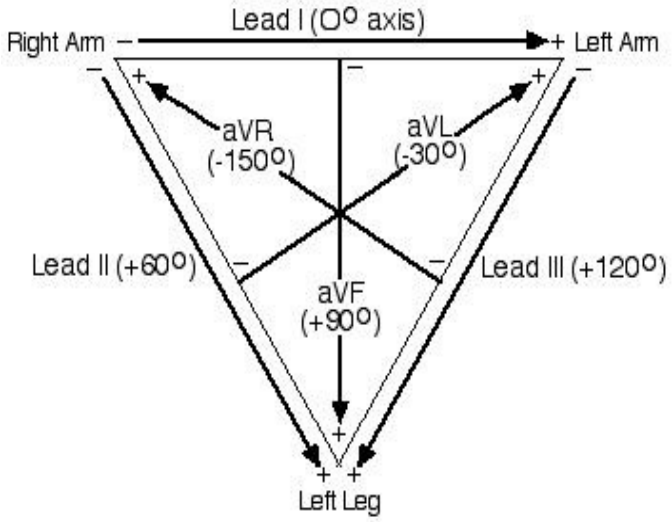

Figure HH-13-B1: Einthoven's Triangle identifying the axes of the six limb leads.

Recordings from a normal, healthy heart usually show a large S wave from the V1 and V2 leads. The V3 and V4 leads provide QRS complexes that are biphasic, R and S waves of equal magnitude in opposite directions. The lead with a biphasic QRS complex overlies the anterior edge of the interventricular septum, also known as the transition point. A shift in the transition point results from an abnormal orientation of the heart around a vertical axis that is perpendicular to the horizontal plane of the chest leads.

In this lab, you will record electrocardiograms from Lead I, Lead II, and one of the six chest leads (Figure HH-13-B2). Lead I will be used as a reference. The augmented limb leads; Lead III, aVR, aVL, and aVF, will be calculated from the reference electrode. The chest lead will be moved to the correct locations on the subjects chest to record each of 6 chest lead positions. The amplitudes and shapes from each chest lead will be compared, and the transition point of each subject will be determined.

Figure HH-13-B2: Electrocardiograms recorded from Lead I, Lead II, and Lead V1 positions at the same time. The other leads have been minimized.