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ECG AND ITS ROLE AS DIAGNOSTIC TOOL

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ABSTRACT *Electrocardiography (ECG) is the interpretation of the electrical activity of human heart over a period of time. The ECG is the most widely used noninvasive diagnostic and prognostic test administered to patients with suspected or proven coronary artery disease. When considering appropriate use of the electrocardiogram, physicians need to examine the clinical question being asked, the additional information that can be derived, whether or not a diagnosis can be established, and application of the information to make appropriate management decisions. It will focus on amplifiers for the small ECG signals as well as some of the various ways of reducing various noises in the system; this includes explaining the Right Leg Drive circuit.*

INTRODUCTION

Cells in humans act like little batteries. These cells have different ion concentrations inside and outside of their membranes which create small electric potentials called biopotentials. When there is a disturbance in a biopotential this gives rise to an action potential which is the depolarization and repolarization of the cell.

The most obvious way to record the ECG is between the Right Arm (RA) and the Left Arm (LA) although another two combinations using the Left Leg (LL) are also used clinically (RA−LL and LA−LL).

Bipolar limb leads (frontal plane):
- Lead I: RA (-) to LA (+) (Right Left, or lateral)
- Lead II: RA (-) to LL (+) (Superior Inferior)
- Lead III: LA (-) to LL (+) (Superior Inferior)

Augmented unipolar limb leads (frontal plane):
- Lead aVR: RA (+) to [LA & LL] (-) (Rightward)
- Lead aVL: LA (+) to [RA & LL] (-) (Leftward)
- Lead aVF: LL (+) to [RA & LA] (-) (Inferior)

Unipolar (+) chest leads (horizontal plane):
- Leads V1, V2, V3: (Posterior Anterior)
- Leads V4, V5, V6:(Right Left, or lateral)

Lead Placement Diagrams:

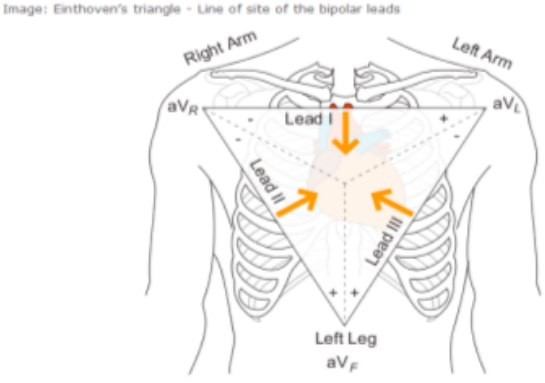

Figure 1 Line of site of the bipolar leads

Another electrode is also used to connect the patient to the common ground of the instrumentation. Usually, this ground electrode is attached to the right leg.

Essentially, the action potentials from different nodes in the heart are what make up electrocardiograph (ECG) signals. ECG signals are comprised of the superposition of the different action potentials from the heart beating as shown in Figure 1. ECG machines use electrodes to convert the ionic signals from the body into electrical signals to be displayed and used for data analysis. However, due to the size of the signals and outside noise, ECG requires amplification and filtering to produce high quality signals.

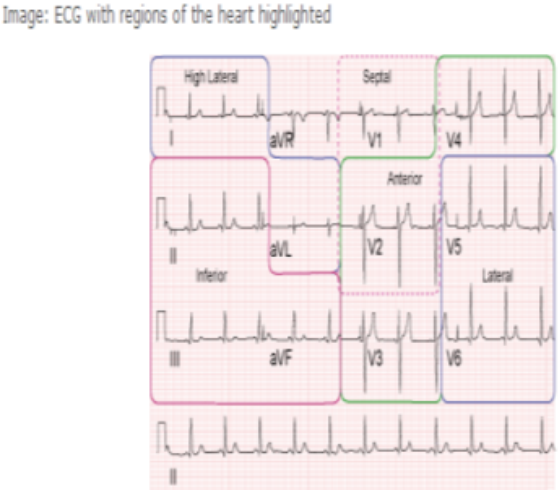

Figure 2 ECG with regions of the heart

An ECG's job is to amplify the small signal measured from the heart as well as to filter outside and internal noise. The amplification is mainly implemented through a differential amplifier whereas filtering is completed through common and differential mode filtering. There is also the Right Leg Drive circuit which cancels noise and maintains the common mode voltage ECG signals vary from the microvolt to the millivolt range. Due to this small range, the signals measured need to be amplified in order to be better interpreted. Typical biopotential amplifiers have high input impedance and are designed for safety first. This is due to the fact that the signal amplified is

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being drawn from a living organism so precautions must be taken in order to prevent macro and micro shock. Isolation and protection circuitry are used to limit current through electrodes to safe levels. The output impedance of the amplifier should be very low to drive any external load with minimal distortion. Again, due to the small size of the signal, the gain should be large. Typically a gain of over 1000 is implemented in biopotential amplifier circuits. The amplifiers should have a high common mode rejection ratio to eliminate large offset signals. Finally, most biopotential amplifiers are differential. Differential amplifiers are used to make sure that noise from the inputs are not amplified thus yielding a higher integrity signal.

ECGs are subject to many different kinds of noise internally and externally. These artifacts can be filtered digitally as well as through analog practices.

Right Leg Drive

The motivation of the right leg drive circuit is to reduce interference from the amplifier. It is possible to amplify an ECG signal and create a DC common mode bias electrically off the inputs of the differential amplifier. However, when this is done there is extreme susceptibility to common mode interference which is where the need for the right leg drive comes in. This action cancels 60 Hz noise from AC power and creates a cleaner ECG output signal. The more gain that can be used in the feedback loop also improves the common mode rejection ratio. Canceling noise in this way relaxes the attenuation needed from the common mode rejection of the instrumentation amplifier.

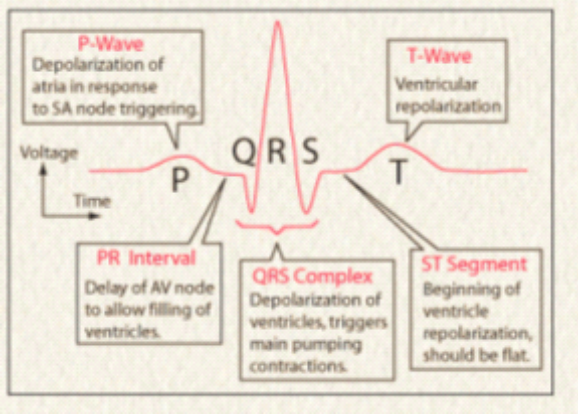

Figure 3

As has already been mentioned, diagnostic information can be obtained from the ECG waveform, by analysis of the amplitude and relative timing of the various segments. In general, cardiac muscle damage, or infarcts, is correlated with loss of amplitude. Abnormal heart rates (arrhythmias) can be observed and treated; for examples slow rhythms (bradycardia) can be treated with stimulants or a pacemaker whilst in the case of fast rhythms (tachycardia) depressants can be prescribed. Ectopic beats are beats which originate from a region of the heart other than the SA node. An ectopic beat in the ventricle causes an extra R–wave, indicative of a premature ventricular contraction (PVC).

These abnormal conditions are usually identified by one of two means:

- Ambulatory monitoring for up to 24 hours of patients who have been identified as being at risk of heart attacks. Data compression techniques (eg beat–to–beat interval histograms) are often used although an advance in memory technology is reducing the need for these.

- Exercise stress ECGs in which the patient is taken close to maximum heart rate by exercising, for example on a tread mill. Changes in the ECG waveform during this process give the cardiologist indications as to the efficiency and capacity of the heart's pumping action. PVCs may only occur when the body is under physical stress, as this makes demands for higher cardiac output. Exercise testing can also be used to assess the effectiveness of therapeutic and surgical treatm

CONCLUSIONS:

Over the last 60 years, the principles of recording the ECG have changed very little. Ways of interpreting the 12-lead ECG to diagnose is chaemia and infarction and guide therapy continue to advance with pace. Once AMI is detected, the ECG diagnosis is highly specific and effective in localizing the region of is chaemia. However it is less accurate at predicting the coronary artery involved and, used in the conventional fashion, detects only around 50% of life-threatening AMIs in patients admitted with chest pain.

REFERENCE

[1] A precision low-level DAS/ECG Cardio tachometer Demo Board, a Texas Instruments technical presentation created by John Brown. |[2] Analog Fundamentals of the ECG Signal Chain, a Texas Instruments technical presentation prepared by Matthew Hann.|[3] ECE 445 Biopotential amplifiers prepared by Professor Andrew Mason INA333 data sheet