What is an electrocardiogram (ECG)?

An electrocardiogram (commonly abbreviated as ECG or sometimes EKG) is a recording of the electrical signal of the heart over time. From these electrical signals, we can infer the mechanical activity of the heart. Electrical activity of the heart varies throughout the ECG signal, as shown in Figure 1.

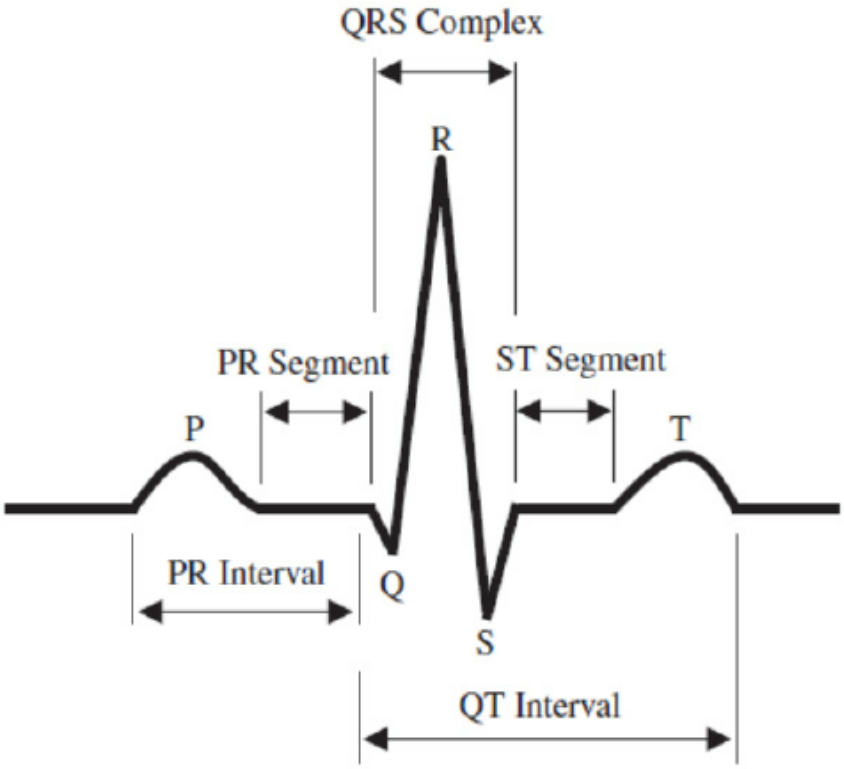

Figure 1. Components of a standard ECG signal.

A typical ECG signal of the cardiac cycle captures three main events: atrial depolarization or contraction (P wave), ventricular depolarization or contraction (QRS complex), and ventricular repolarization or relaxation. Atrial repolarization or relaxation occurs during ventricular depolarization, so no visible wave of this atrial activity is present on the ECG signal since it is masked by the much larger ventricular-generated QRS complex.

ECG Signal Acquisition

Since the body contains fluids with ions that allow electrical conduction, it is possible to measure the electrical activity in and around the heart of the surface of the skin. The most common way to acquire an ECG signal involves the placement of three limb leads as sensing points: a right arm electrode, a left arm electrode, and a left leg electrode. An electrode is placed on the right leg that will serve as a ground for all measurements. This electrode placement results in the formation of Einthoven's triangle (Figure 2) and the ability to measure three different leads (Lead I, Lead II, and Lead III) to capture the electrical activity of the heart.

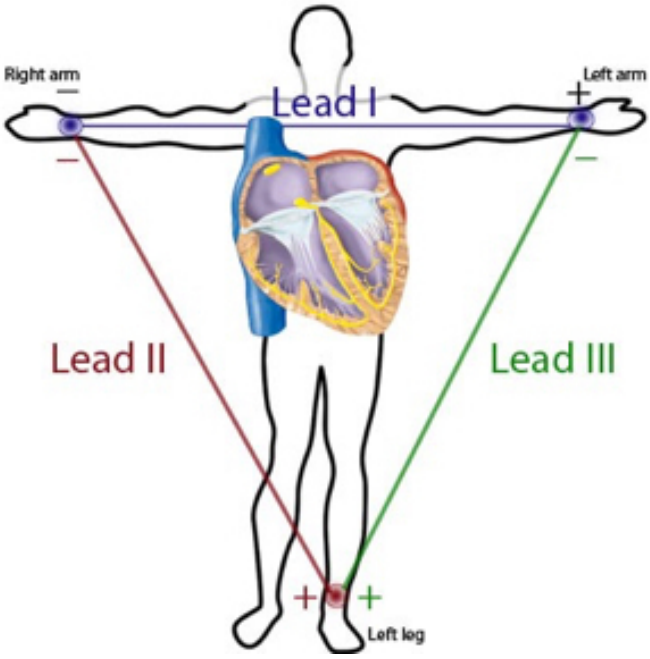

Figure 2. Einthoven's triangle with three major limb electrodes shown.

Noise Sources in ECG

Noise affects the ECG signal during its acquisition and transmission. The main two forms of ECG noise are high frequency noise (power line interference and electromyogram noise) and low frequency noise (baseline wandering). Noise artifacts in ECG signals can result in improper interpretation of ECG signals and heart activity, emphasizing the importance of addressing sources of noise in ECG signals. More information on specific types of noise is included below.

Power Line Interference. This type of interference is mainly caused by the electromagnetic interference of powerlines and the electromagnetic field of nearby machines, such as elevators, air conditioners, and x-ray units which draw a heavy powerline current. This noise results in a 50/60 Hz noise signal that is present in the ECG signal.

Electromyogram (EMG) Noise. EMG noise is generated from the electrical activity of the muscle and consists of a maximum frequency of 10 kHz. Surface EMG signals can also be considered as a motion artifact, since it commonly occurs when a patient is cold and shivering or when a patient's muscles are tense if they are propping themselves up on their arms.

Wandering Baseline. Wandering baseline is a low-frequency noise-component in the ECG signal. It presents as a slow, undulating baseline on the ECG and is mainly due to respiration and body movements. Baseline wanders usually have a frequency of greater than 1 Hz.