ECG Biosignal: Vital for Detecting Cardiovascular Diseases

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***Abstract*—The World Health Organization estimated that 31% mortality rate in the World is due to cardiovascular diseases such as heart arrhythmia and heart failure. Therefore there is a need to innovate methods to accurately detect those diseases from Electrocardiography (ECG) biosignals, and develop algorithms to analyze the signals for precise diagnosis by physicians. This paper is a study of ECG biosignals, detection of heart arrhythmia from characteristic pattern of the ECG waveform, and signal-processing techniques for analysis of the biosignals. Also in this study, ECG results of a male volunteer are shown to emphasize the importance of exercises as one of the factors for preventing cardiovascular diseases.**

***Index Terms*—Biosignals, cardiovascular diseases, ECG**

I. Introduction

CARDIOVASCULAR diseases have led to the highest number of deaths globally and they include heart arrhythmia, coronary heart disease (heart attack), hypertensive heart disease, stroke, rheumatic heart disease, cardiomyopathy, cerebrovascular disease and other bad heart conditions [1]. These heart diseases are disorders of the heart and blood vessels [2], and they can be detected from ECG biosignals. Biosignals are signals from our bodies and a lot of biomedical engineering research is been carried out on them for measuring and monitoring medical purposes [3]. Common examples of biosignals include Electrocardiography (ECG), Electroencephalography (EEG), and Electromyography (EMG) biosignals. This paper focuses on the study of ECG biosignal.

Quality monitoring of an individual's state of health particularly those prone to bad heart conditions has been made a lot easier with the advent of wearable technology. Frequent monitoring and analysis of ECG biosignals through ECG devices or wearables help discover heart diseases early enough. Electrocardiogram (ECG or EKG) is a noninvasive test that shows the details of heart conditions by measuring the electrical activity of the heart due to the electric ion flow in the body [4]. Researchers are continuously finding innovative ways to process ECG biosignals by adopting relevant mathematical formulae, algorithms and processing techniques (such as filtering, domain transforms, wave detection) to help physicians examine and detect key information embedded in these biosignals [5].

This paper is organized as follows: Section II presents a brief study on biosignals. Section III gives an overview of ECG biosignals. Then, section IV discusses the factors that help prevent or reduce cardiovascular diseases. Conclusions are given finally in section V.

II. Biosignals

Biosignals are physiological information from our bodies that can be acquired through biomedical sensors and devices to produce real-time results to the physicians. Key parameters that such biomedical devices measure are blood pressure, heart rate, blood glucose level, oxygen saturation level, ECG, EMG, EEG, and so on. All biosignals are used for diagnosis, patient monitoring, therapy and health risk assessment [6]. For example the EEG biosignals provide important information about the brain such as mental activity, aging and human-machine interaction [7]. One of the most useful processing techniques used for extracting vital information from the brain signals (EEG) is time-variant stochastic process model [6].

The analysis of biosignals is done through biomedical signal processing, which are techniques and tools that enable physicians make quality decisions to determine an individual's state of health [8]. The biomedical signal processing tools that are common to most biosignals are digital filtering, sampling, spectral analysis, functional transforms, classification of multi-dimensional signal components, and optimization processes (using neural networks) [7]. Biomedical signal processing aims at extracting significant information from biosignals [9]. All biosignals are analog signals and are usually non-linear, non-stationary and non-Gaussian in nature. The focus of our study is the widely used biosignal, which is ECG biosignal.

III. ECG Biosignals

Electrocardiography (ECG) is the acquisition of the electrical activity of the heart and derived parameters such as heart rate. For each heartbeat, an electrical impulse (or wave) flows through the heart, which is transmitted throughout the body and can be picked up on the skin. ECG is measured by placing electrodes or leads of an ECG sensing device or machine on specific chest locations, and then results are displayed graphically. ECG measurement is a simple, painless and noninvasive procedure. The most common type of ECG device used is the 12 Lead conventional ECG. The ECG tests can show important

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information about heart rhythms, damages to the heart, and other details of the cardiovascular activities of the body, by observing characteristic patterns of the ECG. It is the least expensive method of diagnosing cardiovascular diseases [10]. ECG is also applicable in monitoring breathing activities and mental stress of the body, and identifying a person when used as a biometric parameter [11].

A. ECG Waveform

The ECG biosignal waveform is usually in a regular pattern with one cycle comprising of P wave, QRS complex wave, and T wave, as shown in Figure 1 below. It is the right and left upper chambers of the heart that make the P wave, the right and left bottom chambers that make the QRS complex wave, and the final T wave represents a state of rest for the heart chambers or ventricles.

The P wave is a small deflection wave that represents atrial depolarization, and the PR interval is the time between the first deflection of the P wave and the first deflection of the QRS complex [12]-[13]. The QRS complex represent the ventricular depolarization and the ST interval is the time between the end of the QRS complex and the start of the T wave [12]. Then, the T waves represent ventricular repolarization.

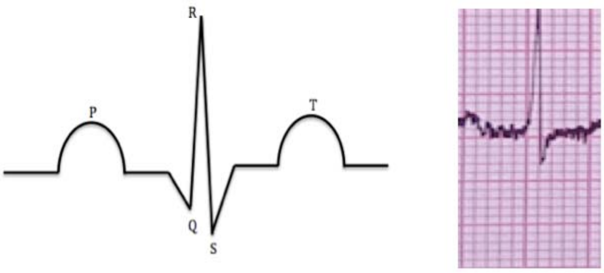

Fig. 1. Basic pattern of electrical activity across the heart

B. Abnormal ECG Patterns

Patterns of abnormal electric activity that are graphically displayed on an ECG machine mean that a patient has cardiac rhythm disturbances. Different cardiovascular diseases have different abnormal ECG biosignal patterns that can be diagnosed by a physician. One of the most common cardiovascular diseases is Cardiac Arrhythmia, which is an erratic heartbeat that produces irregular electrical impulses and heart rhythms that can reduce or stop the heart's ability to pump blood [14]. Untreated arrhythmia can lead to sudden death. There are two prevalent types of arrhythmia, which are Artrial fabrillation and Artrial flutter.

The ECG for atrial fibrillation has no P waves and the QRS complexes appear at random irregular intervals [12]. While the ECG for artrial flutter has saw tooth P waves [15].

C. ECG Processing Techniques

ECG biosignal analysis greatly helps to provide accurate diagnosis for heart diseases. Also, due to the large amount of ECG data acquired biosignal processing techniques help with ECG data classification and analysis [16]. Researchers have developed various algorithms and techniques to analyze ECG biosignal such as ECG Feature Extraction, ECG Filtering, Support Vector Machine (SVM), Denoising ECG wave, Discrete Wavelet Transform (DWT), Classification, Correlation Integral method (CIM), and Artificial Neural Network (ANN) [10], [17].

Raw ECG biosignals consist of artifacts, which affect measurement analysis and can be filtered by adopting various filtering techniques such as Wiener filtering or Kalman filtering [4]. Common sources of noise or artifacts in ECG include the following [18]:

--Baseline wander (low frequency noise), is present in the ECG system as a result of offset voltages in the electrodes, body movement and respiration. This noise can cause problems in the analysis of the ECG waveform. A useful method for removing baseline wander noise in real time is the application of digital linear phase filtering.

--Power line interference (50Hz or 60Hz noise from power lines), is filtered by implementing a notch filter at 50/60Hz in the digital domain. A notch filter is a band-stop filter that passes most frequencies unaltered, but attenuates (rejects) those in a specific range to very low levels [19]. It is the opposite of a band-pass filter, which passes frequencies within a certain range and attenuates frequencies outside that range [19]. A time-varying low-pass filter with variable frequency response, for example Gaussian impulse response, can also be used.

--Motion artifacts

--Instrumentation noise

--Electrode contact noise

IV. Factors for Healthy Cardiovascular System

It is estimated that 90% of cardiovascular diseases are avoidable by adopting some key factors for a healthy cardiovascular system [1]. The most important factors are:

--Eating health food

--Avoiding tobacco smoke and alcoholic drinks

--Exercising, regular exercises should be done at least 30 minutes every day of the week to prevent heart attacks and strokes [20]. Different studies state that lack of physical activity is one of the common risk factors for heart disease [14]. Exercise is certainly one of the vital components for a healthy life style.

ECG tests (with heart rate readings) of a male volunteer was carried out before and after exercise to further emphasize the importance of exercise for healthy living. Figures 2 and 3 show the ECG pattern before exercise, and normal ECG Sinus rhythm pattern after exercise, respectively. While, figures 4 and 5 show heart rate of 49 beats per minute before exercise, and heart rate of 84 beats per minute after exercise respectively. The ECG with heart rate results after exercise indicates that exercise keeps the heart healthy on a daily basis, because the normal adult resting heart rate ranges from 60 to 100 beats per minute.

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Fig. 2. ECG result before exercise

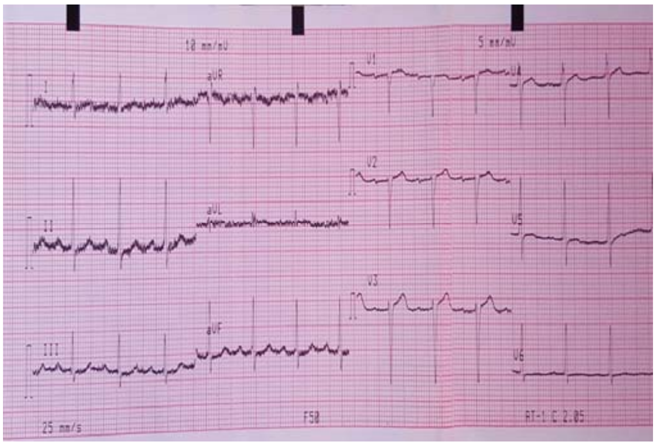

Fig. 3. ECG result after exercise

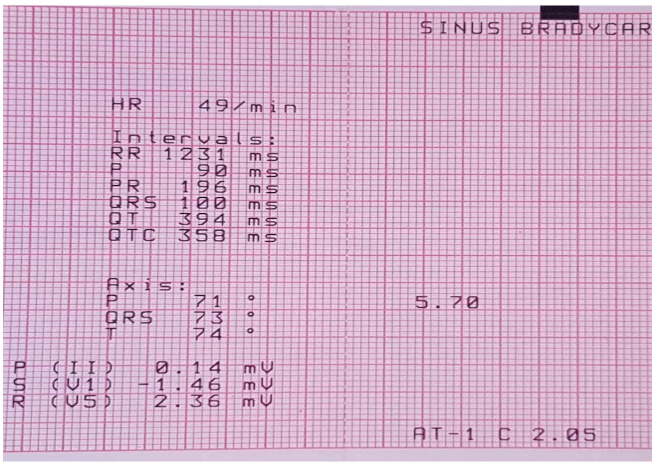

Fig. 4. Heart rate of 49 beats per minute before exercise

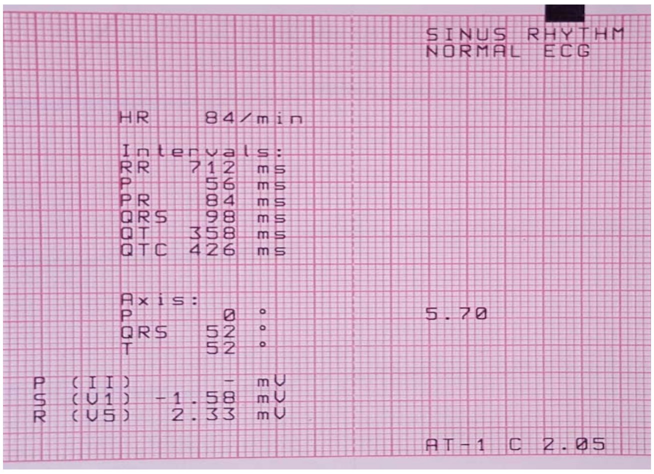

Fig. 5. Heart rate of 84 beats per minute after exercise

V. Conclusion

This paper has studied a vital biosignal for detecting cardiovascular diseases. An overview of what ECG is all about has been discussed. Innovating novel methods for analyzing ECG signal is key to diagnosing cardiac failures. Therefore, further work will be done in the area of ECG biosignal processing. Also, the ECG results obtained showed the need to adopt daily exercise as a healthy lifestyle particularly for those prone to cardiac disease.

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