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Electrocardiography

Reem Mubarak Al Dawas
ECG TECH
Rymy1100@gmail.com

Salma Hasan Al Dawsary
ECG TECH
batarfly@hotmail.com

Lolo Shuaian Almutairy
ECG TECH
lalmutairi@pscc.med.sa

SALMA MUBARAK ALGHARBI
ECHO TECH ADULT
Snoe16@hotmail.com

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Abstract

Recently, many people suffer of different heart problems that might be fatal. Cardiovascular diagnosis is crucial for the treatment plans physicians generate and the earlier the diagnosis is the better control over cardio-diseases is better. ECG is usually documented on a device and printed on a paper which is used by the doctor to classify the cardiac arrhythmia and to offer precise treatment for the patients. ECGs are moderately low-cost and harmless in screening and diagnosing heart diseases. ECGs are also considered an easily applied diagnosis tool.

Different classifications of ECG signaling features had been implemented in research, however, 12-Lead method is the most commonly used.

ECG significance rises from being an easy, substantial tool of cardiovascular diagnosing status that is used to detect symptomatic and silent conditions, as it is also a health monitor. This review paper aims to identify this diagnostic tool, investigate its significance, mechanism and other important aspects and offer some recommendations.

Keywords: ECG, Electrocardiography, Cardiovascular diagnosis, ECG signaling, ECG classification

Introduction

The heart is made of muscle (myocardium) that regularly contracts and leads the circulation of blood all around the body. A wave of electrical current spreads in the heart before every normal heartbeat (systole), which stimulates myocardial contraction John R. Hampton. (2013). Heart pumping is controlled by the pacemaker, or sinoatrial node which is sited in the right atrium of the heart. An electrical impulse in this area is formed by the diffusion of calcium, sodium, and potassium ions across cells membranes. The impulse created first moves to the atria, triggering them to contract and force blood into the ventricles. After that the impulse passes to the ventricles forcing them to contract and pump blood out of the heart. This order regulates the involuntary pumping action of the heart which enables the whole cardiovascular system to function properly (JOSHI, TOMAR, & TOMAR, 2014).

The pattern of electrical spreading is organized, it expands over the heart in a harmonized pattern which results in an effective, corresponding systole, which in order leads to a detectible change in potential difference on the body surface of the subject (Reisner, Clifford, and Mark, 2006). The ECG device (Electrocardiogram) is used to detect and intensify the small electrical changes on the skin that occur when the heart muscle depolarizes through each heartbeat (JOSHI, TOMAR, & TOMAR, 2014).

Currently, a lot of people suffer of different heart problems that might even lead to a life threatening abnormal behavior of heart. Cardiovascular diagnosis is crucial for the treatment plan physicians create and the earlier the diagnosis is the better control over cardio-diseases is better. ECG is usually documented on a device and printed on a paper which is used by the doctor to classify the cardiac arrhythmia and to offer precise treatment for the patients (Sathya, 2015).

This paper aims to identify ECG, investigate all aspects surrounds it of mechanism, method, analysis, results and indications.

ECG Mechanism of Action

ECG, or sometimes (EKG) is the resulting magnified and filtered signal of the heart. Many factors affect the ECG such as: malfunctions of cardiac fibers,

metabolic insufficiency of the myocardium (e.g. lack of oxygen, or ischemia), and macroscopic malfunctions of the normal geometry of the heart. ECG analysis is a regular part of the full and comprehensive medical evaluation, due to the heart's vital role in human body health (Reisner, Clifford, and Mark, 2006). A clear ECG signal offers essential information about the electrophysiology of the heart disorders and ischemic changes that may occur (Sahoo, J., 2011).

An ECG device illuminates and records the electrical impulses of the heart for diagnosing health status, it is not considered a treatment for any heart condition, but a diagnosing tool, for example an ECG helps in detecting the cause of different symptoms such as palpitations or chest pain. An electrocardiogram examines and records the electrical action of the heart. The ECG test is not painful and leaves no harm, it does not apply electricity into the body. The ECG consists of several electrodes which are attached to the body of the patient and are connected by wires to the device (Mehran M., 2004). As mentioned above, the common ECG device consists of a graphing piece.

Each one of the conductors is able to sense a change in electrical charge of the skin that occurs when the heart muscle depolarizes during each heartbeat.

When the heart is at rest, each heart muscle cell gains a negative charge, termed the membrane potential, across the cell membrane. When the negative charge is exposed to the influx of positive cations Na+ and Ca+, the negative charge gets closer to the zero, and this is termed as depolarization, which activates the mechanism of contraction (GOLDBERGER, 2017). The healthy heart has a normal progression of a depolarization wave during each heartbeat that is activated by the cells in the sinoatrial node, which in order moves through the atrium, passes within the atrioventricular node and then reaches the entire ventricles, this pathway is detected in the form of small rises and falls in the voltage between two the electrodes positioned on either side of the heart, and displayed as a curvy line on a screen or on paper (KumarGarg, Thakur, Sharma, & Bhardwaj, 2012; Gaurav, Paul, 2014), this demonstration specifies the overall rhythm of the heart and fragilities in different parts of the heart muscle (Leif, Pablo, 2006).

In his book, Bayés de Luna, A. (2014) indicated that sometimes ECG readings might be normal in patients with advanced cardiovascular disease, such as: acute heart attack, pulmonary embolism, inherited heart disease, Chronic ischemic patients with or without previous myocardial infarction**.**

ECG Classification

Classification of ECGs frequently contains three steps: signal pre-processing, feature extraction, and classification.

ECG indications are episodic signals, as they are made of an arrangement of waves that repeat periodically in time, these are: P wave, then Q, R and S waves (creating the QRS complex) and T wave. Infrequently, a U wave might be detected. The QRS complex is the most distinguishing part of an ECG signal (Laguna et al., 1996). Mostly, when ECG is analyzed and classified the signals are measured as beat-to-beat. To determine the type of features and signals numbers, the type of classification, analysis performed, and the results to be detected are crucial (Vulaj, Draganić, Brajović, and Orović, 2017).

Features utilized in characterizing the ECGs consist of: heartbeat interval characters, frequency-dependent features, higher demand cumulant features, Karhunen-Loeve extension of ECG morphology, and hermite polynomials (Orović, Stanković, Chau, Steele & Sejdić, 2010; Vulaj, Draganić, Brajović, and Orović, 2017). Older approaches of ECG classification include: linear discriminants, decision tree, neural networks, support vector machine, and Gaussian mixture model algorithm (Vulaj, Draganić, Brajović, and Orović, 2017). Disease recognition using ECG data with other clinical measurements is utilized by some researchers (Brajović, Orović, Daković & Stanković, 2017). However, the previously mentioned methods use coefficients of several basis functions as features for classification, the coefficients used are usually hard and not practical to interpret clinically. In addition, those methods that depend only on specific parts on ECGs for classification, range might be partial and lead to bias in the final results. A simple method using 12-lead ECG data is developed and most widely used, this method measures eight temporal intervals for each of the 12 leads of the device,

and it uses the number of the intervals above the control value by two standard deviations to detect medical conditions. The sensitivity and specificity of this method are comparatively high to others. However, it excludes variables other than temporal lengths and cannot confine the features well when the spreading of the measurements is heavy-tailed or skewed or display other abnormal patterns (Vulaj, Draganić, Brajović, and Orović, 2017). In spite of that, the 12-lead electrocardiogram (ECG) is the single most commonly performed investigation.

Figure 1 below, shows the standard setup of an ECG, (B) presents the machine, electrodes attached to the patient's chest, upper arm, and legs, the result display of a normal heart rhythm.

Figure 2 also presents a normal ECG waveform. Below the figure is a detailed description for the intervals and their indications according to (JOSHI, TOMA, & TOMAR, 2014; GOLDBERGER, 2017).

Figure 1: Standard setup of an ECG (NIH, 2019)

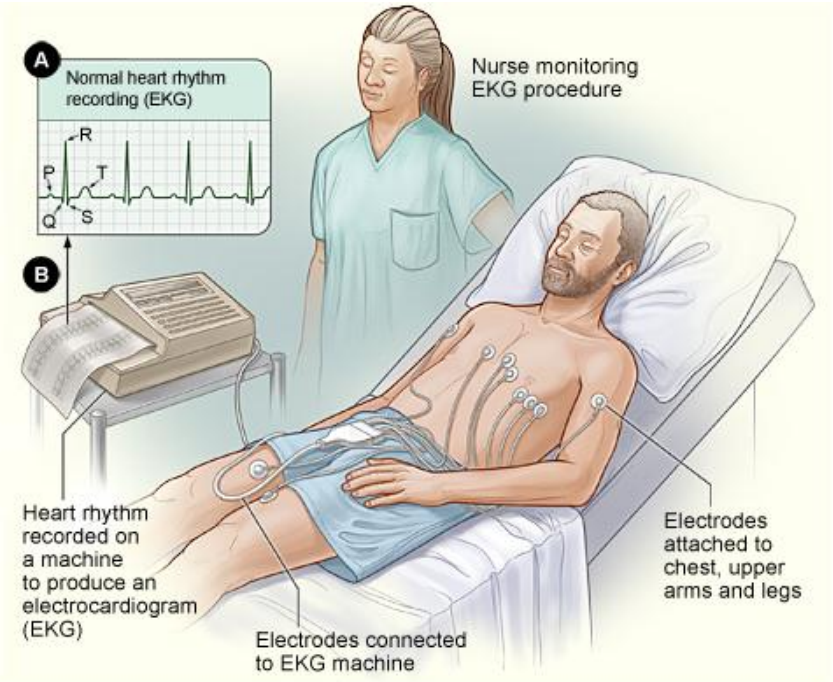

Figure 2

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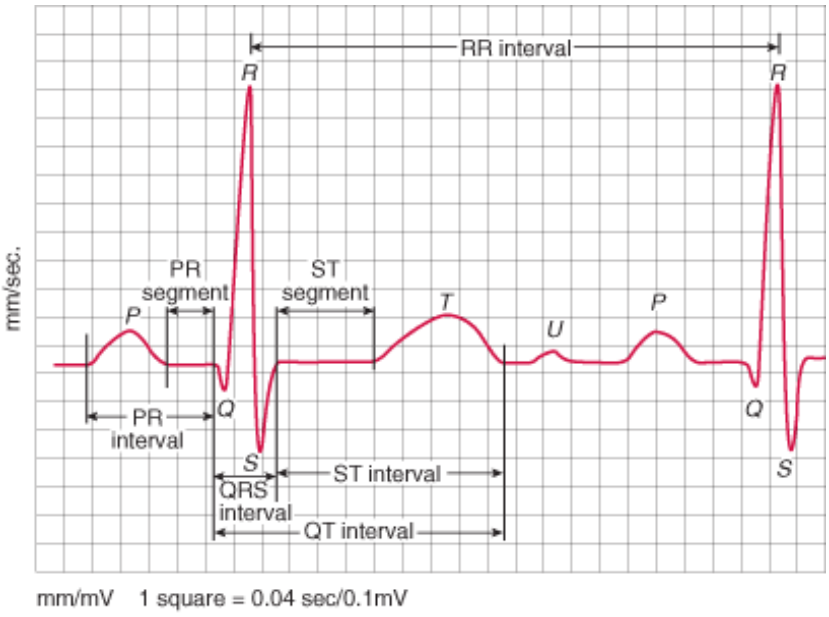

The displayed parameters in Figure 2, represent the intervals that are used to examine the heart rhythms and are indicatives for different clinical conditions as follows:

A. RR-Interval: indicates a normal resting heart rate is between 60 and 100 bpm Duration of *RR-Interval 0.6 to 1.2s.*

B. P-Wave: - presents the atrial depolarization (contraction). Duration of *P-Wave is 80ms.*

C. PR-Interval: - presents the interval between the beginning of the P wave to the beginning of the QRS complex. The PR interval is, therefore, a good estimate of AV node function. Duration of *PR-Interval is 120 to 200ms.*

D. QRS-Complex: - The QRS complex reflects the quick depolarization of the right and left ventricles. Duration of *QRS-Complex is 80 to 120ms.*

E. ST segment, T wave, and U wave, present the ventricular repolarization (recovery).

F. QT-Interval: - The QT interval starts from the beginning of the QRS complex to the end of the T wave. When QT interval is prolonged then it indicates a risk factor for ventricular tachyarrhythmia and sudden death. Duration of *QT-Interval is up to 420 ms in heart rate of 60 bpm.*

The 12-Lead Position of ECG is presented in Figure 3, as it shows the positions of each as should be placed on patients.

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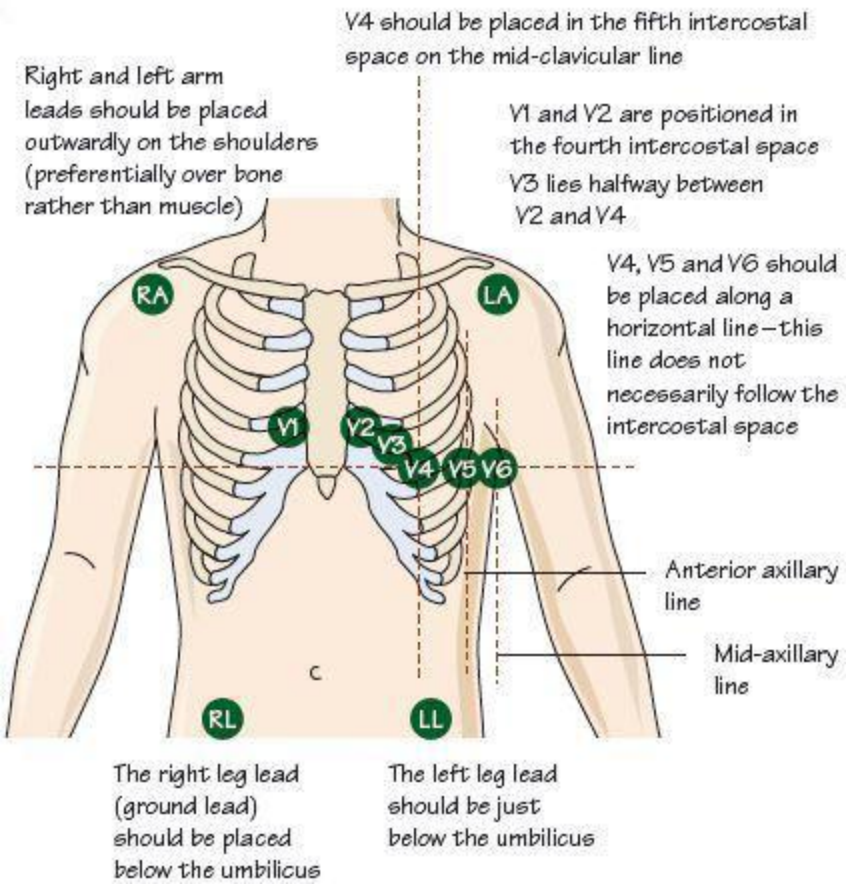
Figure 3: **12-Lead Position of ECG, (JOSHI, TOMAR, & TOMAR, 2014)**



ECG Importance

In the recent decades, classification, identification and characteristic discovery have attracted a lot of attention. Particularly, disease classification and biomarker detection are tremendously important in contemporary biological and medical research. ECGs are moderately low-cost and harmless in screening and diagnosing heart diseases and development of personal ECG monitors lead to large amounts of ECGs stored data records. (Huang,& Zhou, 2015).

Dodo-Siddo, M. et al. (2015) mentioned that the understanding of systematic electrocardiogram assists in detecting earlier cardiac abnormalities and place in a reasonable secondary prevention. In their cross-sectional study, included 73 Senegalese patients of both sexes aged at least 18 years,

researchers investigated the electrocardiographic abnormalities in population patients with rheumatoid arthritis while clinically, no evident cardiovascular manifestations were noted. After clinical diagnosis, laboratory tests were done (CRP, fibrinogen, ESR, Rheumatoid factors, Latex and Waaler Rose, Anti-CCP, antinuclear factors and antibodies anti-ENA), and a standard ECG. The study concluded the need for systematic electrocardiogram in patients with rheumatoid arthritis, specially in early diagnosis as cardiovascular involvement is clinically silent. Electrocardiographic abnormalities occur and they are serious and leads physicians to the initiation of suitable therapy that may help reduce the incidence of cardiovascular death in RA patients.

ECG is also an important diagnostic tool recommended for preparticipation in health examination in athletes, as it is a strong indicator of cardiac health status. (Berge, H. et al. (2014).

Summary and Conclusion

In summary, normal or abnormal ECG reading, both express two main events in the heart, depolarization, which is the spread of a trigger through the heart muscle, and repolarization, the return of the triggered heart muscle to the resting state.

ECG is considered an important routine test within a full medical examination and might reveal asymptomatic heart conditions, and heart conditions associated with other diseases. Early detection of such conditions gives the physician better treatment opportunities.

ECG classification is a developing topic in ECG manifestation. In the 12-lead method of ECG, a correct placement is crucial for ideal readings.

Researchers has concluded that the 12-Lead ECG method is the most practical among health providers and a very accurate one, however ECG sometimes might not reveal some cardiac conditions.

Recommendations

- ECG when accompanied with other examining tools gives best diagnosis, clinical examination and laboratory testing aid in doing that.

- Using more than one ECG classification for patients might result in better and more accurate diagnosis, however, physicians and care givers need to be professionally trained for such systems.
- More papers are needed in literature to cover all aspects of ECG, as most research papers are specified either in the device, the signal interpretation.

Limitations

This review paper presented ECG in its general aspects, not specifying in details each one. More detailed review papers for each aspect would be more significant in depth.

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