INTERNATIONAL JOURNAL OF
ALTERNATIVE AND
CONTEMPORARY THERAPY

Heart Rate Monitoring using ECG and MATLAB

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Abstract: The MATLAB program can be used to analyze ECG signals in several different ways. The role of MATLAB in analyzing ECG signals can be- Reading and checking data: MATLAB can be used to read and check ECG data to check the integrity of the signal and make sure there is no defect in it.

Signal filtering: MATLAB can be used to filter ECG signals and remove noise and distortion from medical devices and the patient's surroundings.

Wave analysis: MATLAB can be used to analyze ECG waves, determine the heart rate, and identify any abnormalities in the heart rhythm.

Signal visualization: MATLAB can be used to visualize ECG signals graphically and visually, which facilitates their understanding and analysis.

Statistics and analysis: MATLAB can be used for statistics and statistical analysis of ECG signals, which helps in analyzing the data and identifying any differences in the results.

Temporal and frequency analysis: MATLAB can be used for temporal and frequency analysis of ECG signals and to determine wave frequencies, pulse rates, and other events.

Mathematical Modeling: MATLAB can be used to create mathematical models of the heart and the electrical signals it generates, which helps in better understanding and analysis of heart function and the development of various diseases.

Keywords: ECG, MATLAB, Heart Rate, Pulse Rates

1. INTRODUCTION

The heart muscle, like any other tissue, needs a continuous supply of blood in order to survive and live. It is worth mentioning that the heart's feeding system is pneumatic only, as it is only fed by the presence of blood loaded with oxygen. The coronary arteries provide blood to the heart muscle, where coronary artery disease occurs when those arteries are damaged due to what Fats are deposited in them, as happens in the case of atherosclerosis of the arteries, and these fats impede the flow of blood to the heart muscle. These arteries are called coronary because they wrap around the heart like a crown or corona (coronal) around the head. Aorta) in its first part called the ascending artery.

The aorta (which is the largest artery in the body) sends blood to the left main coronary artery, and the latter in turn branches into two branches: the anterior descending artery and the circular artery.

These two branches carry blood to the anterior, lateral, and posterior parts of the heart. bottom of the heart.

The heart muscle is fed through the coronary (coronary) arteries. These vessels are filled in the phase of systole of the ventricles, and the nutrients are transferred to the heart muscle in the phase of diastole. The blood ends after it moves from the coronary arteries to the coronary veins, and from there it pours into the right atrium.

The cardiac muscle uses chemical energy to perform the contraction process, and it derives this energy from the aerobic metabolic processes to oxidize fatty acids to a lesser extent than other nutrients, especially amino acids and glucose, and one of the heart nutrition processes is the conversion of lactic acid in the presence of oxygen to pyruvic acid with hydrogen ion and oxidizes a large part To form large amounts of (ATP), and this is used in long strenuous exercises as an additional energy for the heart, but the aerobic metabolism takes place within the mitochondria particles in muscle fibers.

1.1 Problem Statement

There are several possible problems with measuring heart rate, including:

1. Inaccuracy of the device used: The device used to measure the heart rate may be inaccurate, resulting in the impulses not being recorded correctly.

2. Psychological pressure: Psychological stress can affect the heart rate, making it higher or lower than reality, and this can happen especially to people who feel stressed and anxious.

3. Physical activity: Physical activity can increase the heart rate, making it higher than it actually is.

4. Health status: Some diseases such as diabetes, thyroid disease, and heart disease can affect the heart rate, making it higher or lower than it actually is.

5. External factors: such as temperature, humidity, and exposure to heat stress can affect the heart rate.

6. Non-compliance with the instructions: The instructions specified for the heart rate measuring device must be followed accurately, as it must be placed on the body in the correct way and in the appropriate place. Otherwise, it may result in inaccurate reading.

1.2 Objective of Study

Heart rate measurement is being studied for many reasons, including:

1. Diagnosing health conditions: Heart rate measurement can be used to diagnose some health conditions such as heart rhythm disorders, high blood pressure, heart failure, inflammation of the heart, and others.

2. Fitness Assessment: Heart rate measurement is used to assess a person's physical fitness, as heart rate is measured at different levels of exercise and physical activity to determine the body's response to a challenge.

3. Determining the necessary treatment: heart rate measurement can be used to determine the type and dose of appropriate treatment for patients with cardiovascular diseases.

4. Scientific research: Heart rate measurement can be used in scientific research to understand the heart's work process and its response to various challenges and to study the effect of various factors on heart rates.

5. Tracking heart health: Heart rate measurement can be used to track heart health, find out if a person suffers from any heart-related health problems, and monitor the effectiveness of treatments and lifestyle changes.

1.3 Significance and Motivations

ECG, or electrocardiogram, is an acronym for "electrocardiography," and it's one of the important tools doctors use to diagnose heart disease and problems. The importance of the ECG is as follows:

1. Diagnosis of health conditions: ECG can identify and diagnose many health conditions related to the heart, such as arrhythmias, coronary artery blockages, inflammation of the heart, and others.

2. Medical evaluation: ECG can help evaluate a person suffering from heart disease and monitor the improvement of his health condition periodically.

3. Determine the necessary treatment: ECG can help determine the type and dose of appropriate treatment for patients with heart disease.

4. Scientific research: Researchers use ECG in scientific studies to better understand the heart's working process and to know the changes that occur in the heart due to diseases and various factors.

5. Early detection: The ECG can detect some heart-related health conditions in their early stages, which helps reduce the risk of serious complications.

6. Assisting in surgery: ECG can be used to help doctors make surgery decisions and decide whether to have open-heart surgery or coronary stents.

1.4 Project layout

This dissertation contains five chapters, starts with chapter one which is the introduction to the idea of the project, problem statement, objectives and the aim of the study.

Cardiac Muscle Characterized

The heart is a muscular organ with four cavities located in the chest cavity and occupies the middle part between the two lungs. The heart is located obliquely towards the bottom and the left, so that about two-thirds of the heart is to the left of the midline of the body, and its size is equal to the size of the >ist, and its weight ranges between (250-350) g. It is also divided longitudinally by a barrier that separates the right half from the left and consists of muscle >ibers Especially striated, involuntary, and there are four cavities in the heart, three surfaces (faces) and an apex, and it consists of four chambers and is surrounded by the pericardial membrane.

The muscular wall of the heart has three layers: a thin inner lining (the endocardium), a mass of working muscle (the myocardium), and an outer surface (the epicardium).

The cardiac muscle is characterized as the main thick layer of the heart muscle, and it consists of single muscle cells that work together with the aim of contracting and relaxing the heart chambers accurately, and the heart consists of four main chambers (the two atria and the two ventricles).

Atrium: They are the two small chambers that receive blood returning from the body (the right atrium) or from the lungs (the left atrium). The right atrium is about (0.3) cm more than the left atrium, which is thicker and stronger, but its size is almost the same. The heart can also pump enough blood to the body even if the atria do not shrink at all, but their contraction contributes to the overall ef>iciency of the heart and allows it to pump more blood with less effort. Supplementary ef>iciency is important when the ventricles are particularly pathologically damaged.

Ventricles: They are the two main chambers that pump blood in the heart, where the blood is pushed to the lungs and the body. The thickness of the wall of the right ventricle is three times less than the left, as the left ventricle is the strongest chamber in the heart at all, because of its function, as it pushes blood to all parts of the body except the lungs[1].

The heart beats (100,000) 100,000 beats per day, almost in normal conditions. It has a regulating tool called the sinoatrial node. It is located at the connection area of the superior vena cava with the right atrium. Electrical signals are generated from this node and spread initially in the atria, causing them to contract and push blood into the ventricles. After a short delay period that allows the ventricles to >ill, the signals pass through the ventricles, which contract and pump blood to the body and the lungs. Heart rate and rhythm.

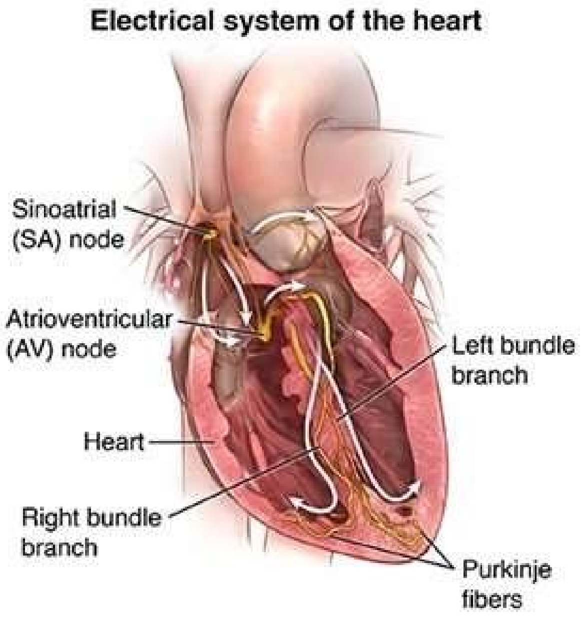


Figure 1: Electrical heart

The heart works in perfect timing and harmony because:

1. Cardiac muscles consist of >ibers linked together, thus forming a functional fusion. If a speci>ic cardiac muscle >iber is stimulated, the effect of the stimulation is quickly transmitted to the adjacent muscle >ibers, unlike the skeletal muscle

>ibers, which are functionally separate.

2. Presence of a linear pacemaker and a device that transmits the stimulus wave of the heartbeat quickly and at an accurate time to the different muscles of the heart.

3. Presence of heart valves between the atria and the ventricles and at the beginning of the aorta and pulmonary artery that regulate the process of >illing and emptying the atria and ventricles.

The heart volume for men is on average (700-800) cm3 and for women (500-600) cm3 and it usually increases for athletes (100-300) cm3 so that it can sometimes reach (1000-1200) cm3, while its length is on average 14 cm long and 12 cm wide. The size of the ventricles is about 250-3000 mm, and it is somewhat less for women. (B.W. ,1994) Given the connection of the heart size with the length and weight of the body, it is preferable to take this into account when calculating the size of the heart in relation to these measurements. It turns out that for every kilogram of body weight, the heart size is 11 cm3 for non-athletes, while it is 13-14 cm3 for athletes.

The cardiac cycle includes all the functions that occur between two successive beats of the heart in the states of contraction and relaxation, and one cardiac cycle measures the time between one contraction and the next. In trained athletes who have a slow heart rate during rest, they have a longer period of rest or recovery heart rate compared to normal individuals[2].

The heart receives instructions from the sympathetic and parasympathetic nerves, and the sympathetic nerves mainly release norepinephrine, while the parasympathetic nerves release acetylcholine. The diameter of the left ventricle is in systole. As for the parasympathetic nerve, it is connected to the vagus nerve, which is the tenth cerebral nerve, while the sympathetic nerve >ibers come out of the cervical and thoracic sympathetic ganglia[3].

Factors affecting heart rate

The normal heart rate for a person is in the range of (70-80) ppm, but it is not possible to talk about a single pulse for individuals, and this depends on:

1. Age: It ranges from (130-150) z/d at birth, and decreases to 120 z/d in the

>irst year and 90 z/d at the age of 10, and continues to decrease until a slight increase occurs in adolescence as a result of hormonal secretions and emotions However, it decreases again at the age of (17-18) to reach (72-75) d/d, then with the increase of age in late manhood, the pulse rises to a rate of (80-90) d/d.

2. The times of one day: it decreases in the hours of sleep to (10-30)% z/d of the average in wakefulness. As for when waking up, it is lowest in the early morning hours, then it rises at (12-2) in the afternoon, then it decreases in the evening (4- 7) in the evening, and this is very important in determining the time of the training unit in a manner consistent with biological competence.

3. Gender: Because of the ef>iciency of the bodily vital systems, their size, mass, and other measurements, the heart rate is higher in women than in men, as the small size of the heart muscle in females and the small cavities of its chambers, in addition to the large volume of blood in men, which leads to >illing the body's need for de>iciency. into oxygenated blood by increasing the number of beats.

4. Body position: when lying down, it is lower than it is when sitting, and the latter is lower than when standing, and the difference is between (1-5) z / d. The importance lies in paying attention to harmony in intensity and volume during physical and skillful exercise, because of its effect that raises the heart rate and is evident This is in weight-lifting and body-building exercises that are performed in different positions.

5. Heat: The high temperature of the body and the surroundings increases the heart rate and vice versa. The importance of preparing training curricula in the summer is more important than in the winter because it has an effect on functional ef>iciency.

6. Highlands: At high altitudes, the molecular pressure of oxygen decreases, which reduces the saturation of hemoglobin with oxygen, which leads to an increase in heart rate to compensate the body for the de>iciency. Therefore, it is necessary to gradually ascend to highlands in order to cause adaptation and not add burdens to the heart directly[4].

7. Atrial pressure: It causes an increase in heart rate. Part of this increase results from the direct effect of increasing the size of the atrium, which extends the sinus node, and it affects the increase in heart rate (15%). The additional increase in speed also results from the (Bainbridge) re>lex, as it

transmits signals Afferents from dilatation receptors in the atria generated by the Bainbridge re>lex through the medulla oblongata increase heart rate through sympathetic nerves.

8. Nerve stimuli: they come from the sympathetic and parasympathetic nerves to control the heart rate, where the >irst increases it and the other inhibits it, and both are balanced according to the body’s need for blood. In large loads, the sympathetic nerves increase their alerts to a certain extent, which the parasympathetic inhibits.

9. Physical exercise: as the organized training for 3 years reduces the heart rate, and if the organized training continues, it leads to a further decrease.

3. METHODOLOGY

3.1 Heart sounds

The person who listens to the sounds of the heart with a stethoscope does not hear the sounds of opening the valves because it is a relatively slow process and does not generate any sound or noise.

The ventricles contract >irst, so the mitral and pulmonary valves open, and the valves close between the atria and the ventricles, but this sound is low and relatively long, and it is the >irst sound of the heart. And the pulmonary hears the sound of a sudden and rapid closing because these two valves close very quickly and what surrounds them vibrates for a very short time, which is the second sound of the heart[5].

3.2 Fuse function

Atrioventricular valves: The tricuspid and bicuspid valves prevent the involuntary >low of blood from the ventricles to the atria during systole, and the semilunar valves (aortic and pulmonary) prevent the return >low from the pulmonary and aortic arteries to the ventricles during diastole. These valves open and close in a passive manner, that is, they close when a gradient pushes The return pressure of the blood backwards and opens when the pressure gradient pushes the progressive anterior direction, and for obvious anatomical reasons, the thin diaphragm valves do not need almost any return >low for their contraction, while the thicker semilunar valves need a relatively stronger return

>low and for some milliseconds to contract them[6].

As for the function of the papillary muscles, they are connected to the lea>lets of the two valves (bicuspid and tricuspid) by tendon cords. These muscles contract when the ventricular wall contracts, but contrary to what is expected, they do not help the valves to close. Instead, they pull the valve lea>lets inward towards the ventricles to prevent them from protruding to a large distance backward Towards the atria during ventricular contraction, and if one of the tendons is severed, one of the papillary muscles is paralyzed, and the valve protrudes backward into the atrium, sometimes to an extent that makes it leaky and causes severe heart failure that may lead to death[7].

3.3 Pericardium

It is a sac that surrounds the heart. The pericardial sac has two membranes that form two inner and outer layers. There is a sliding >luid between them, and this enables the heart to beat with the least possible friction with neighboring structures such as the lungs. The chest to >ix the heart in its place, and although the pericardium provides some support and lubrication for the heart, it is somewhat expandable. It is also possible to live without the pericardium, and it can be surgically removed, especially in cases of in>lammation. Some diseases may lead to an increase in >luid in the pericardial sac, so if a large amount of >luid accumulates It can put pressure on the wall of the heart, which reduces its ability to expand and receive blood during diastole, and this condition called cardiac tamponade may lead to limiting the effective pumping function of the heart, which may require withdrawal of >luid with a needle inserted gently through the chest wall. As for pericarditis It is a condition that can lead to chest pain, and some types of pericarditis may lead to thickening and hardening of the pericardium with time, which encircles the heart in a hard container. This is called constrictive pericarditis, which may also lead to a decrease in cardiac function, which may require surgical removal of the pericardium[8].

3.4 Stroke Size:

It is symbolized by the symbol (SV). The amount of blood that is ejected from the left ventricle during systole is called the systolic blood volume (EDV), while the amount of blood remaining in the ventricle after the blood exits into the aorta is called the cystic volume (ESV), and the difference between them represents the true stroke volume. (SV = EDV - ESV)

ejected part:

It is symbolized by the symbol (EF). The remaining part of the blood between each contraction and relaxation of the heart muscle is de>ined by the value difference or the difference of the impulsive part of the ventricle. It shows the amount of blood entering the ventricle that was actually pumped during the systole process and is expressed as a percentage ranging from 60-70. % resting time and increases when the ventricles contract in the event of physical exertion. (EF=SV / EDV)

Cardiac impulse (cardiac output):

It is symbolized by the symbol (C.Q), which is the total volume of blood pumped by the left ventricle per minute, which is the product of the heart rate (HR) multiplied by the stroke volume (SV) during rest and varies according to the position of the body and the effort that it performs. (C.Q = SV.HR)

3.4.1 properties of the cardiac muscle

1. Connection: the cardiac muscle combines the characteristics of both smooth muscle and skeletal muscle, as it is striated as a result of the arrangement of thick protein >ilaments (myosin) and thin >ilaments (actin), but they are shorter and more branched than skeletal muscle cells, and the ends of the cells are connected to each other by structures called intercalated discs (intercalated discs) which allows the free diffusion of ions so that the action potentials are transmitted from one cell to another, which makes the conductivity between cardiac cells very high[9].

2-Excitability: This characteristic appears when arousal appears under the in>luence of various stimuli, and the duration of excitation must not be less than the threshold ((the minimum that the heart muscle can respond to)) and the heart muscle is subject to the law of all or nothing (ALL OR NONE LAW)[10].

The degree of contraction of the heart muscle is not only related to the strength of the stimulus, but also to the degree of its stretching before contraction, as well as the temperature and components of the blood supplying it. The phenomenon of heart rhythm is one of the well-known and continuous phenomena throughout life. The reason for this is due to the fact that the heart muscle cannot contract (continuous contraction) like the skeletal muscle. The contraction period, then the latency period, and the relaxation period.

3. The period of disobedience: that is, not responding to stimuli despite the strength of the stimulus if the muscle is in the contraction phase, but it responds in the diastole phase, but it is followed by a long diastole period, i. On the function of the heart as a pump to push blood through fullness in the phase of diastole and systole to ejaculate blood.

4. The heart muscle is characterized by its self-contraction, i.e. contractile muscle, as it contains specialized cells with the ability to remove and repolarize and thus stimulate the muscle >ibers of the heart muscle, and these specialized cells are called the sinus node.

5. The heart muscle is affected by mineral salts through removal and repolarization in it, and what determines that movement across the cell membrane is the difference in concentration on both sides of the membrane, as calcium and sodium affect the process of depolarization and contraction of the muscle, while potassium is in>luential in the process of diastole and prolongation of its phase.

6. The heart is not nourished by blood >lowing inside the chambers of the heart, but rather receives its supplies from the coronary arteries.

7. The heart muscle meets its energy needs through aerobic metabolic processes only.

3.4.2 Internal regulation of heart pumping (Frank-Starlink mechanism)

The amount of blood pumped by the heart per minute is determined by the speed of blood >low from the veins to it, and this is called the venous return, meaning that every peripheral tissue in the body controls the blood >low in it, and the total amount of blood returns from the local channels through the peripheral tissues to the right atrium via The veins, and the heart pumps this incoming blood automatically into the systemic arteries so that it can circulate again, and this internal ability of the heart to adapt to a change in the volume of blood supplied to it is called the Frank-Starlink mechanism of the heart in appreciation of the two physiologists Frank and Starlink nearly a century ago, meaning the Frank mechanism - Basically Starlink: that the greater the >illing of the heart with blood during diastole, the greater the amount of blood that it pumps into the aorta. In other words, the heart pumps within physiological limits all the blood it reaches without allowing large amounts of it to accumulate in the veins[11].

Frank-Starlink's explanation for their mechanism is that the heart expands to a greater degree when an additional amount of blood >lows to it, and this in turn causes its muscles to contract more strongly because the actin and myosin

>ilaments are now close to the optimal degree to interlock and to generate a stronger contraction. And the heart, due to its increased ability to pump automatically, pumps the additional amount of blood into the arteries, as the ability of the muscle stretched to an appropriate amount to contract with greater intensity is one of the characteristics of all striated muscles. In addition to the important effect of stretching the heart muscle, there is another factor that increases the pumping of the heart when its size increases, as stretching the wall of the right atrium exponentially increases the heart rate by (10-20)%, and this also helps in increasing the amount of blood that is pumped per minute, although This contribution is much less than the contribution of the Frank-Starlink mechanism[12].

3.4.3 The effect of ions on contraction and relaxation:

An increase in potassium in the >luids outside the heart muscle cells causes severe expansion of the heart muscle and slows its speed. If the rate of increase is large, it may block the delivery of cardiac impulses from the atria to the ventricles via the AV bundle. Doubling the concentration of potassium generates a very weak heart and abnormal rhythm. So that they lead to death, and this is because the high concentration of potassium in the >luids outside the cells generates a decrease in the resting effort of the membranes of the cardiac muscle

>ibers[13].

As for calcium, an increase in its ions has a completely opposite effect of what potassium ions generate and leads to a convulsive contraction of the heart. It is usually regulated within narrow limits, so it is rare that these effects, which are generated by the abnormality of its concentration, be a matter of concern.

As for sodium, it causes a difference in the action potential (depolarization in the muscle). Sodium is the factor affecting it. When an action potential appears to the myocardial membrane, it spreads within the cardiac muscle >iber through the transverse tubules. The action potentials of these tubules, in turn, act on the membranes of the longitudinal tubules of the muscular cytoplasm and lead to To the immediate liberation of large quantities of calcium ions to the muscle cytoplasm of the muscle from its network, and within parts of a second, calcium ions spread to the muscle >ibrils and stimulate chemical reactions that create sliding of actin and myosin >ilaments on each other, which in turn generates muscle contraction.

The intensity of cardiac muscle contraction depends very much on the concentration of calcium ions in the extracellular >luid, then the leakage of calcium ions into the muscle >iber is suddenly interrupted after the end of the action potential plateau, and as a result the contraction stops until a new action potential is generated[14].

3.5 Cardiac muscle action:

The resting action potential in the normal heart muscle is approximately

-85 to -95 millivolts, and it is about -90 to -100 millivolts in the specialized conductive >ibers (Purkinje >ibers). The recorded action potential of the ventricular muscle is about 105 millivolts, which means that the membrane voltage rises. The negative normal to a positive level of about 20 millivolts, and the positive voltage is called the bypass voltage, and the membrane after that remains depolarized for 0.2 of a second in the atrial muscle and for 0.3 of a second in the ventricular muscle, forming a plateau, then followed at the end of the plateau by sudden depolarization. The presence of this plateau in the action potential causes contraction to last 3 to 15 times longer in cardiac muscle than in skeletal muscle[15].

3.6 Common heart tests

There are many tests that are used to measure and test multiple aspects of the heart, including:

1. Blood samples:

Most of the common blood tests that take place in heart diseases, in particular, measure the level of blood lipids (cholesterol and triglycerides), cardiac enzymes,

oxygen content, and prothrombin time (which is the time required for your blood to clot). The method of drawing blood is known and often conducted by ordinary people with the help of a microscope.

2. Electrocardiogram (ECG):

It is sometimes called (EKG), and it is an indispensable procedure in evaluating many heart diseases. It is simply a recording of the electrical activity of the heart. The final profile of the layout can be displayed on a paper tape or on a screen (Monitor). The electrodes transmit the electrical signals in the heart to the electrocardiogram, and with the help of body fluids that work to transmit the electrical signal to the surfaces of the skin, and the electrical signals are usually recorded in the form of waves that appear on the planning paper that moves in this device at a specific speed, and it is

worth noting that these electrodes try to detect small electrical currents Therefore, good contact with the skin must be maintained and a gel should be used to improve this conduction. In the graph that appears, the horizontal line represents the timeline, while the vertical line represents the voltage or the strength of the electrical impulses of the heart.

An EKG records the electrical signals in the heart. It is a common and painless test used to quickly detect heart problems and monitor heart health.

An electrocardiogram — also called an ECG or EKG — is often done in a health care provider's office, clinic, or hospital room. ECG machines are standard equipment in operating rooms and ambulances. Some personal devices, such as smart watches, provide ECG monitoring.

Figure 2: electrocardiogram

An electrocardiogram is a painless, noninvasive way to help diagnose many common heart problems. A health care provider might use an electrocardiogram to determine or detect:

- Irregular heart rhythms (arrhythmias)
- If blocked or narrowed arteries in the heart (coronary artery disease) are causing chest pain or a heart attack
- Whether you have had a previous heart attack
- How well certain heart disease treatments, such as a pacemaker, are working
- You may need an ECG if you have any of the following signs and symptoms:
- Chest pain
- Dizziness, lightheadedness or confusion
- Heart palpitations
- Rapid pulse
- Shortness of breath
- Weakness, fatigue or a decline in ability to exercise

4. RESULTS AND DISCUSSION

An electrocardiogram (ECG) is one of the simplest and fastest tests used to evaluate the heart. Electrodes (small, plastic patches that stick to the skin) are placed at certain spots on the chest, arms, and legs. The electrodes are connected to an ECG machine by lead wires. The electrical activity of the heart is then measured, interpreted, and printed out. No electricity is sent into the body.

Natural electrical impulses coordinate contractions of the different parts of the heart to keep blood flowing the way it should. An ECG records these impulses to show how fast the heart is beating, the rhythm of the heart beats (steady or irregular), and the strength and timing of the electrical impulses as they move through the different parts of the heart. Changes in an ECG can be a sign of many heart-related conditions[16].

To look for the cause of chest pain

To evaluate problems which may be heart-related, such as severe tiredness, shortness of breath, dizziness, or fainting

To identify irregular heartbeats

To help determine the overall health of the heart before procedures such as surgery; or after treatment for conditions such as a heart attack (myocardial infarction, or MI), endocarditis (inflammation or infection of one or more of the heart valves); or after heart surgery or cardiac catheterization

To see how an implanted pacemaker is working

To determine how well certain heart medicines are working

To get a baseline tracing of the heart's function during a physical exam; this may be used as a comparison with future ECGs, to determine if there have been any changes

It must be remembered that an EKG is a real-time recording of the electrical messages that the heart sends through the chest wall until they reach the exploration electrodes in the EKG.

1. The initial component of the P wave represents the generation of the stimulus in the sinus node (a microscopic structure located in the upper part of the right atrium in close connection with the superior vena cava)

2. The second part of the P wave represents the real-time transmission of the stimulus to the left atrium through the Bachmann bundle or the anterior atrial band transmitted at a speed of 1 m/s.

3. The interval of isophasic PR corresponds to the propagation of the stimulus towards the chambers of the ventricle, where it is located (the physiological delay of the av node and propagation through its bundle and its branches). Q wave patterning in DI corresponds to depolarized first ventricular region (ventricular septum).

4. The R wave pattern corresponds to the depolarization of all left ventricular mass, and the normal electrical axis in the left quadrant because the sum of all ventricular vectors has left the dominant because there is more muscle mass in the LV.

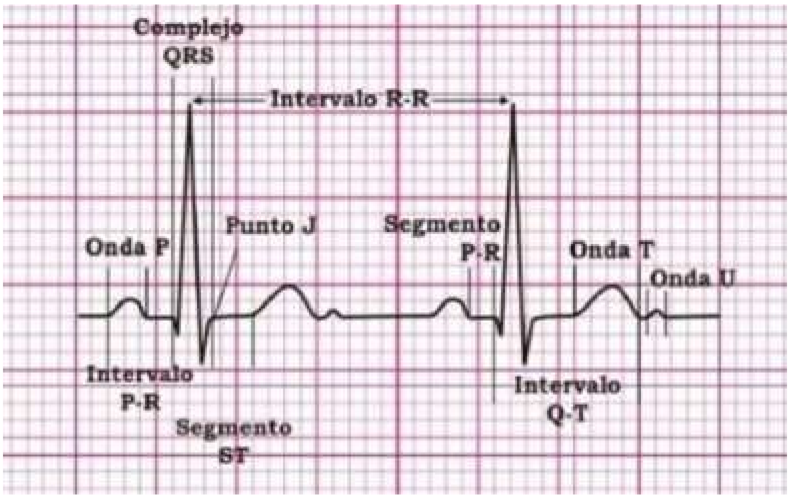
5. The S wave is patterned due to ventricular basal depolarization

6. The isphasic ST segment coincides with the moment when the entire ventricular mass remains depolarized and there are no differences in extracellular potentials to generate deviations in the ECG.

7. The T wave corresponds to massive repolarization of the ventricular mass

There are several theories about the origin of the U-wave pattern in the surface of the ECG, but the most widely accepted is that issued by Dr. Charles Antzelewicz, which suggests that the U-wave corresponds to the postpotential near the aortic ring generated by kinetic energy. It causes the aforementioned sigmoid valve to close

8. The real-time TP fraction corresponds to the moment when the entire core remains polarized and ready for a new electrical cycle.



ECG is nothing more than a set of waves which Einthoven named P, Q, R, S, T and U according to the order of appearance in time. These letters were used because before and after there are other letters if any wave is detected. The detected waves were medium, so the Greek alphabet had to be available[17].

It must be remembered that the P wave is registered as a consequence of the activation of the atria and that, immediately, Q, R and S appear, with the merging of the ventricular complex due to the propagation of the excitation wave to the muscles of both ventricles, and the interventricular septum.

At the end of the process of depolarization of the entire atrial and ventricular muscle mass, there is a short pause (which we will later define as S-T segment) after which the T wave is recorded, an expression of the restorative T wave repolarization process, which corresponds to the expression.

Electrocardiography is the recording of the electrical impulses that are generated in the heart. These impulses initiate the contraction of cardiac muscles. The term vector is used to describe these electrical impulses. The vector is a diagrammatic way to show the strength and the direction of the electrical impulse. The vectors add up when they are going in the same direction and they get cancelled if they point in the opposite directions. But in case if they are at an angle to each other, they add or subtract energy and change their resultant direction of flow. Now just imagine, how many cells the heart is composed of?... Millions of cells right! So there are millions of vectors formed. When these millions of vectors add up, subtract or change direction, we finally get a resultant vector! This resultant vector is known as electrical axis of the ventricle. Therefore, ECG is the measurement of these vectors that pass under the electrode. Now let's refine ECG, it is a graphical representation of the electrical movement of the main vector passing under an electrode or a lead. Electrodes are the sensing devices that pick up the electrical activity occurring under it. When a positive impulse is moving away from the electrode, the ECG machine converts it into a negative wave. When a positive impulse is moving towards the electrode, the ECG machine converts it into a positive wave.

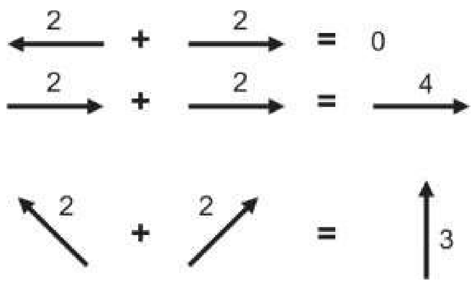


Fig 3: Examples for adding vector

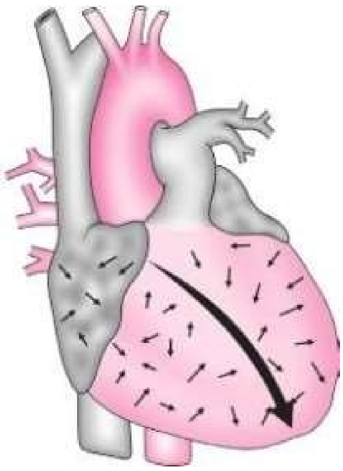


Fig 4: Sum of all the ventricular vectors is equal to electyrical axis

But when the electrode is in the middle of the vector, the ECG machine converts it into positive deflection for the amount of energy that is coming towards the electrode and the negative wave for the amount of energy that is going away from the electrode.

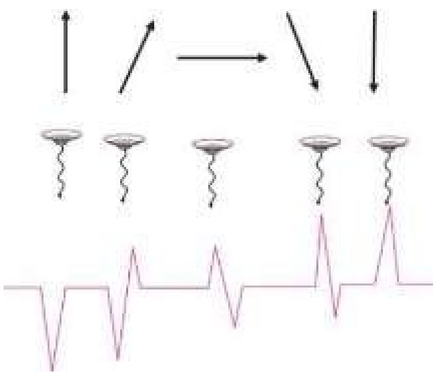


Fig 5: Different vectors showing different deflections in ECG wave patterns

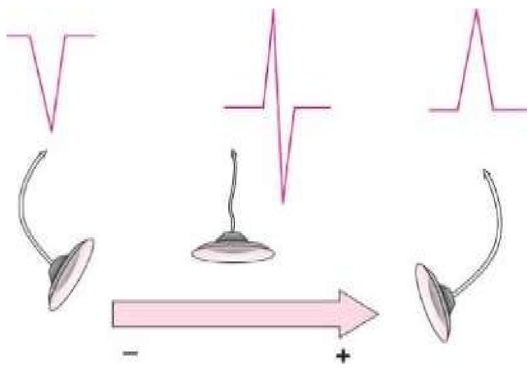
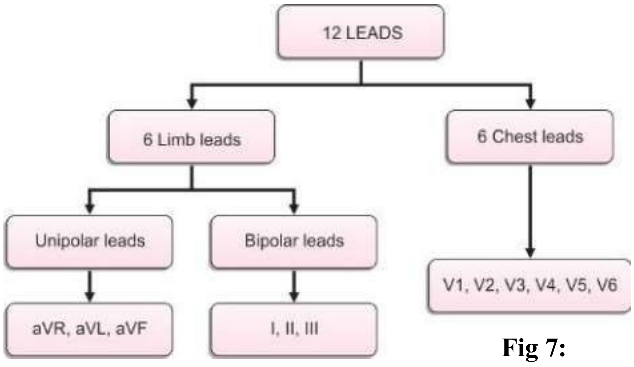


Fig 6: Three different ECG's resulting from the same vector due to the different lead placement

There are twelve leads consisting of six limb leads (I, II, III, aVR, aVL and aVF) and six chest leads (V1–V6). The limb leads consists of standard bipolar (I, II and III) and augmented (aVR, aVL and aVF) leads. The bipolar leads were so named because they record the difference in electrical voltage between two extremities. For example: Lead I: Records the difference in voltage between the left arm and the right arm electrodes. Lead II: The difference in voltage between the left leg and the right arm electrodes. Lead III: The difference in voltage

between the left leg and the left arm electrodes.



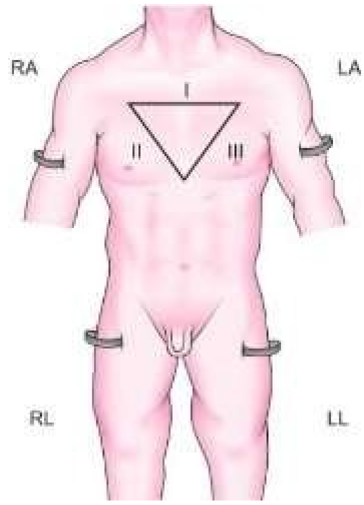


Fig 7:

In augmented limb leads, the abbreviation ‘a’ refers to augmented; V to voltage; R, L and F to right arm, left arm and left foot (leg) respectively. They record the electrical voltage of corresponding extremity.

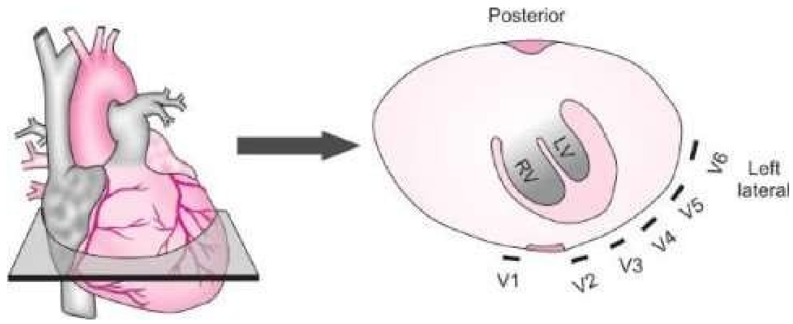


Figure 8: Limb leads are placed in such a way that they bisect the heart at the center in the coronal plane

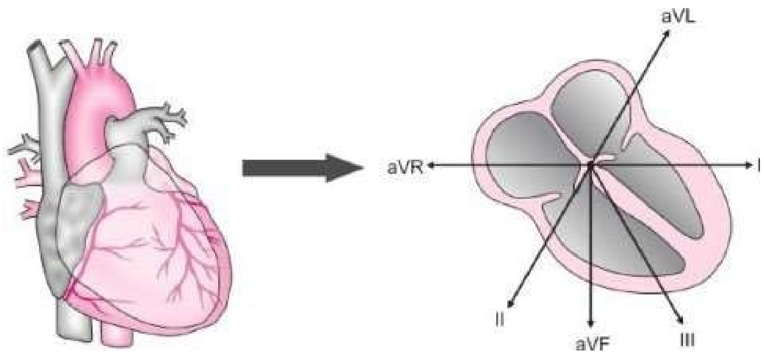


Figure 9: Chest leads are placed in such a way that they bisect the heart in the horizontal plane

The body acts as a giant conductor of electrical current. Electrical activity that originates in the heart can be detected on the body’s surface through an electrocardiogram (ECG). Electrodes are applied to the skin to measure voltage changes in the cells between the electrodes. These voltage changes are amplified and visually displayed on an oscilloscope and graph paper. This chapter focuses on the ECG and its analysis and interpretation.

The following summarizes a basic ECG:

- An ECG is a series of waves and deflections recording the heart's electrical activity from a certain "view."
- Many views, each called a lead, monitor voltage changes between electrodes placed in different positions on the body.

- Leads I, II, and III are bipolar leads, which consist of two electrodes of opposite polarity (positive and negative). The third (ground) electrode minimizes electrical activity from other sources.
- Leads aVR, aVL, and aVF are unipolar leads and consist of a single positive electrode and a reference point (with zero electrical potential) that lies in the center of the heart's electrical field.
- Leads V1 through V6 are unipolar leads and consist of a single positive electrode with a negative reference point, found at the electrical center of the heart.
- Voltage changes are amplified and visually displayed on an oscilloscope and graph paper.
- An ECG tracing looks different in each lead because the recorded angle of electrical activity changes with each lead[18].

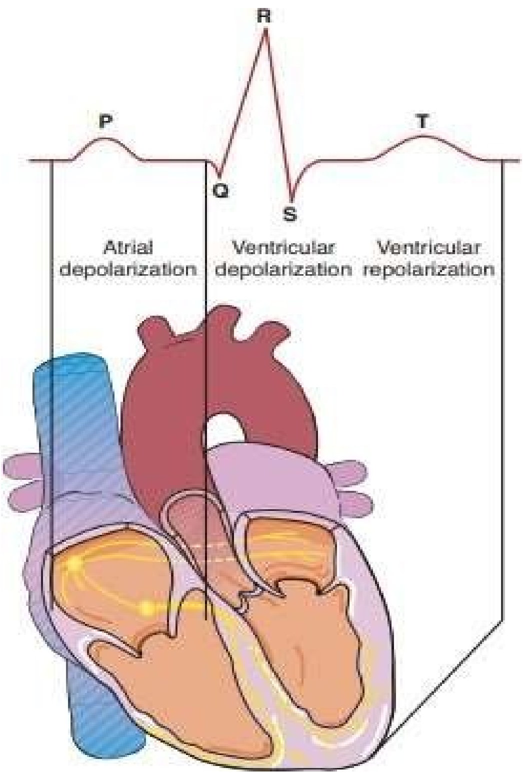


Figure 10: Correlation of depolarization and repolarization with the ECG.

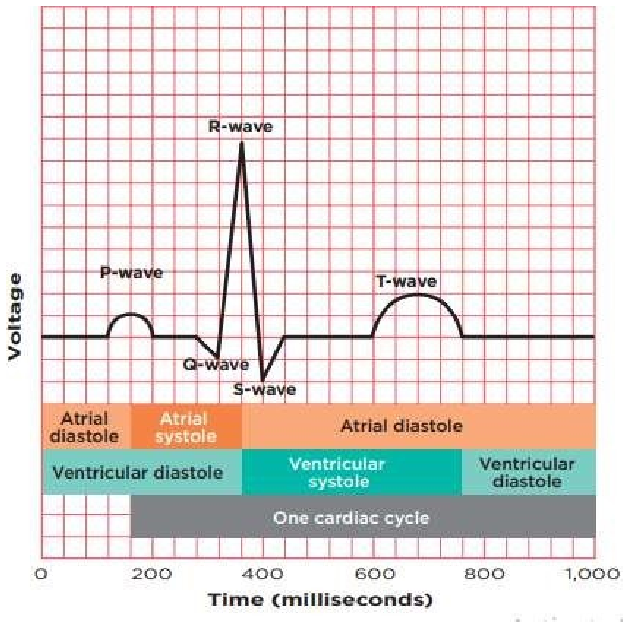


Fig 11: Relationship between ECG and cardiac cycle stages

The ECG is a graphical representation of the heart's electrical activity, plotting its voltage on a vertical axis against time on a horizontal axis. It is recorded onto ECG paper, which runs at a speed of 25mm per second. Standard pink ECG paper is made up of 5 x 5mm squares, each containing 25 smaller 1 x 1mm squares. The 1mm width of each small square represents 40 milliseconds. On the vertical axis, the height of an ECG wave or deflection represents its amplitude[19]. Fig 11 shows what a normal ECG looks like and its relationship with the stages of the cardiac cycle.

During the normal cardiac cycle, the atrial contraction that takes place is associated with a P-wave (atrial depolarisation) and is of low amplitude because the muscle is relatively thin in the atria. This contrasts with the QRS complex, which represents the electrical impulse as it spreads through the ventricles (ventricular depolarisation)[20].

The first deflection of the QRS complex is the Q-wave, which is a negative wave that begins septal depolarisation. The R-waverepresents depolarisation of the left ventricular myocardium and the next negative deflection is the S-wave, which represents terminal depolarisation. The T-wave occurs after that and represents the repolarisation of the ventricles.

The ECG also records a number of other parameters:

-PR interval – the duration of time from the start of the P-wave to the start of the QRS complex, this represents the conduction through the AVN.

- QT interval – the time duration between the onset of the QRS complex and the end of the T-wave, this represents the time taken for the ventricles to depolarise and repolarise; it is calculated using lead II or chest leads V5-6 (described later in this piece).

- ST segment – the flat line (isoelectric line) on the ECG between the end of the S-wave and the start of the T-wave; when there is a lack of blood supply (myocardial infarction) or reduced blood supply (ischaemia), the ST segment may be elevated or depressed respectively.

It is important to know the normal ranges for the various ECG parameters (Table 1): if any measurements are outside the normal range, thought and investigation are needed to ascertain why and decide on a course of action. Parts 2 and 3 of this series will discuss this in more detail.

Lead positioning

It is important to remember that the electrical 'lead' actually represents the differences in electrical potentials measured in two points in space. The conduction of electrical impulses between these two points in space can be detected via electrodes that are positioned at various points on the body; this is then displayed as a

waveform on the ECG machine/monitor[21].

There are several configurations of electrode positioning; continuous ECG monitoring uses a 3-lead configuration but the standard 12-lead ECG comprises:

- Six chest (precordial) leads, which are

referred to as leads V1, V2, V3, V4, V5 and V6 (Fig 3a);

- Six limb leads, referred to as leads I, II, III, aVR, aVL, and aVF (Fig 3b).

To position the chest electrodes accurately, it is important to first identify the sternal angle (angle of Louis); this is done by feeling the bony prominence at the top

of the sternum, which articulates with the second rib above the second intercostal space. By moving the fingers downwards, the fourth intercostal space can be felt: here, the electrodes for V1 and V2 should be placed to the right and left of the sternum respectively. By feeling the fifth intercostal space and moving the fingers to the middle of the clavicle, V4 can be placed on the midclavicular line. V3 should then be placed midway between V2 and V4. V5 is placed in the fifth intercostal space, more lateral to the anterior axillary line, and V6 is placed in the fifth intercostal space in the midaxillary line.

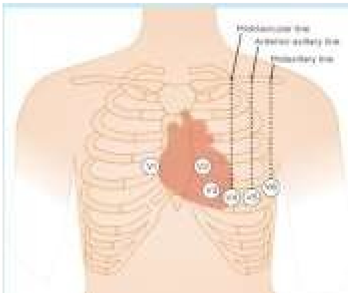


Figure 12: Positioning of a 12-lead ECG

To record the limb leads (Fig 12), four electrodes are placed on the body. In the upper limbs, an electrode pad is placed

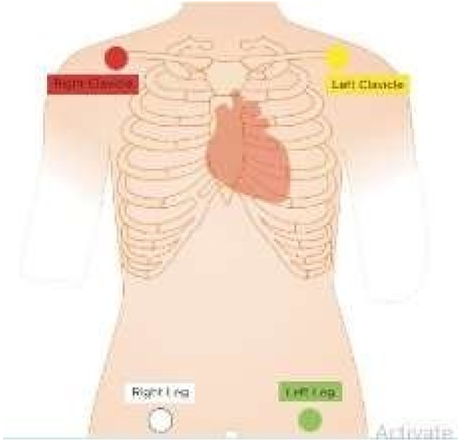


Figure 13: Limb leads

Table 2 Troubleshooting in ECG monitoring

Problem	Considerations
Incorrect paper speed, which will alter the ECG's appearance and affect proper assessment	• Ensure paper speed is 25mm per second • Ensure gain is 10mm per millivolt
ECG not reading properly or intermittent signal	• Check cables, leads, connections and settings • Replace electrode, cable or lead wire if needed • Check electrodes are securely attached to patient • Check for electrode gel dry-out • Remove possible static charge by touching metal before touching the patient
Wandering baseline, caused by the patient moving excessively due to: • Nervousness • Shivering	• Ensure patient is comfortable • Ask them to relax • Keep them warm if cold • Ensure electrodes are placed over bone, not muscle

ECG = electrocardiogram; mV = millivolts.

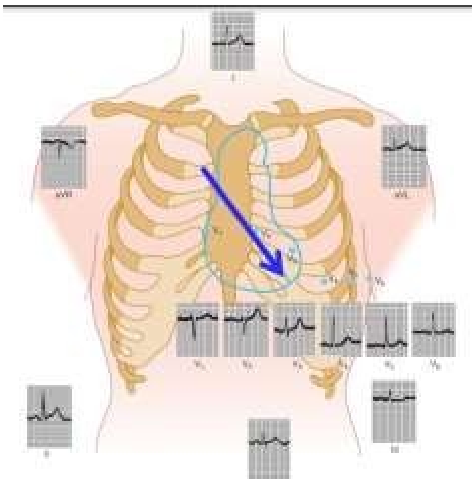


Figure 14: STEMI

5. CONCLUSION AND RECOMMENDATIONS

As cardiomyocytes depolarize and propagate action potentials throughout the heart, a charge separation (or dipole) is created. By utilizing the resultant electrical field present in the body, electrodes can be placed around the heart to measure potential differences as the heart depolarizes and repolarizes. This measurement gives rise to the ECG, normally consisting of the P wave for atrial depolarization, the QRS complex for ventricular depolarization, and the T wave for ventricular repolarization. There are up to 12 different standard positions, or leads, available to detect the ECG. Most commonly, a 5-wire system is used clinically and can be used for the 3 bipolar limb leads (which make up Einthoven' s triangle), the 3 unipolar limb leads, and 1 precordial (chest) lead at a time. At least two lead traces are needed to calculate the heart's electrical axis, which gives the general direction of the heart's dipole at any given instant. The recorded ECG remains one of the most vital monitors of a patient's cardiovascular status and is used today in nearly every clinical setting. Electrocardiography has come a long way since it was first used in the early 1900s. New instruments and analysis techniques are continually being developed. The ECG has also been used in combination with other implantable devices, such as pacemakers and defibrillators. The trend has been toward developing smaller, easier-to-use devices that can gather a wealth of information for use in patient diagnosis and treatment. To evaluate problems that may be related to the heart, such as severe fatigue, shortness of breath, dizziness or fainting, and to identify irregular heartbeats. Thus, the scientific development that has taken place in the use of software such as Matlab constitutes one of the advanced means in accurate data output, and to enhance this in the educational curricula for students trained in Medical specialties. help determine the general health of the heart before procedures such as surgery; or after treatment for conditions such as a heart attack (myocardial infarction or MI), endocarditis (inflammation or infection of one or more heart valves); Or after heart surgery or cardiac catheterization, which enhances the information gained about the patient's health condition in a clearer way, allowing the possibility of making the right medical decision in treating the condition. To determine the effectiveness of some heart medications and measure their effect accurately, especially since the results that can be analyzed by MATLAB lead to more reassurance of their accuracy and ingenuity of purity by not taking signals that are not related to the signals produced by the heart muscles.

REFERENCES:

1. B. J. Drew, "Bedside electrocardiogram monitoring," AACN Clinical Issues, vol. 4, pp. 25–33, 1993.
2. R. W. Alexander, R. C. Schlant, and V. Fuster, Eds., Hurst's The Heart, Arteries and Veins, 9th ed. New York, NY, USA: McGraw-Hill, 1998.
3. J. W. Hurst, "Naming of the waves in the ECG, with a brief account of their genesis," Circulation, vol. 98, pp. 1937–1942, 1998.
4. C. Jacobson, "Optimum bedside cardiac monitoring," Progress in Cardiovascular Nursing, vol. 15, pp. 134–137, 2000.
5. H. B. Burchell, "A centennial note on Waller and the first human electrocardiogram," American Journal of Cardiology, vol. 59, pp. 979–983, 1987.
6. L. R. Johnson, Ed., Essential Medical Physiology, 3rd ed. San Diego, CA, USA: Elsevier Academic Press, 2003.
7. C. E. Kossmann, "Unipolar electrocardiography of Wilson: A half century later," American Heart Journal, vol. 110, pp. 901–904, 1985.
8. D. M. Krikler, "Historical aspects of electrocardiography," Cardiology Clinics, vol. 5, pp. 349–355, 1987.
9. D. E. Mohrman and L. J. Heller, Eds., Cardiovascular Physiology, 5th ed. New York, NY, USA: McGraw-Hill, 2003.
10. P. M. Rautaharju, "A hundred years of progress in electrocardiography I: Early contributions from Waller to Wilson," Canadian Journal of Cardiology, vol. 3, pp. 362–374, 1987.

11. A. M. Scher, “Studies of the electrical activity of the ventricles and the origin of the QRS complex,” Acta Cardiologica, vol. 50, pp. 429–465, 1995.
12. R. R. Chamley et al., “ECG interpretation,” European Heart Journal, vol. 40, no. 32, pp. 2663–2666, 2019.
13. S. Jarvis and S. Saman, “Cardiac system 1: Anatomy and physiology,” Nursing Times, vol. 114, no. 2, pp. 34–37, 2018.
14. E. N. Marieb and S. Keller, Essentials of Human Anatomy and Physiology. Pearson, 2018.
15. D. E. Newby and N. R. Grubb, “Cardiovascular disease,” in Davidson’s Principles and Practice of Medicine, S. H. Ralston et al., Eds. Elsevier, 2018.
16. K. E. Sandau et al., “Update to practice standards for electrocardiographic monitoring in hospital settings: A scientific statement from the American Heart Association,” Circulation, vol. 136, no. 19, pp. e273–e344, 2017.
17. Society of Cardiological Science and Technology, Clinical Guidelines by Consensus: ECG Reporting Standards and Guidance. London, U.K.: SCST, 2020.
18. L. Sun et al., “Clinical impact of multiparameter continuous non-invasive monitoring in hospital wards: A systematic review and meta-analysis,” 2020.
19. J. M. Prutkin, “ECG tutorial: Electrical components of the ECG,” UpToDate, 2020.
20. Journal of the Royal Society of Medicine, vol. 113, no. 6, pp. 217–224, 2020.
21. X. L. Yang et al., “The history, hotspots, and trends of electrocardiogram,” Journal of Geriatric Cardiology, vol. 12, no. 4, pp. 448–456, 2015.