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المرحلة الثالثة

Medical Physics

Lecture 1

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Electrocardiogram Machine (ECG) :

The ECG device is an essential medical device that must be available in clinics and hospitals, Where doctors rely on this device in the initial diagnosis of heart function.

The electrocardiogram device works to record the electrical signals of the heart that are captured from the surface of the body by the electrodes and display them on the display screen or printed on paper tapes.



The Electrical Activity of the Heart :

The human heart has the ability to self-pulse, so it is called myogenic hearts because its ability to contract lies in its muscles and it is called the myocardium, and it consists of muscle cells that have the ability to receive electrical signals and be affected by them. The heart beats continuously and regularly as a result of the activity of a node of specialized cells located in the wall of the right atrium between the entrance to the two hollow veins called the SA node.

The contraction of a large number of heart muscle cells simultaneously generates an amount of vital effort. This dynamic voltage in turn generates an amount of electrical current that spreads from the heart through the body, and the electrical current spread from the heart is a voltage difference between different locations on the body. This voltage can be measured and recorded as a time signal. By placing vital electrodes on the surface of the skin, this is called the ECG signal, which we obtain using an electrocardiogram ECG .

Leads and Their Connections :

It is possible to record the wave of electrical change in the heart muscles by placing the vital electrodes on the surface of the body. The electrodes are flat metal sensors that have good signal conductivity. Electrodes are placed on the skin of the person whose heart signal is to be drawn using Jell to increase the efficiency of signal delivery

For the standard recording of the heart signal, we need five electrodes that are installed in different places on the patient's body, and to avoid error in connecting the electrodes, it has been agreed on the colors that distinguish the wires that connect to each of the electrodes, namely:

- 1- The right arm (RA) is white
- 2- The left arm (LA) is black
- 3- The right leg (RL) is green
- 4- The left leg (LL) is red
- 5- The chest (C) is brown



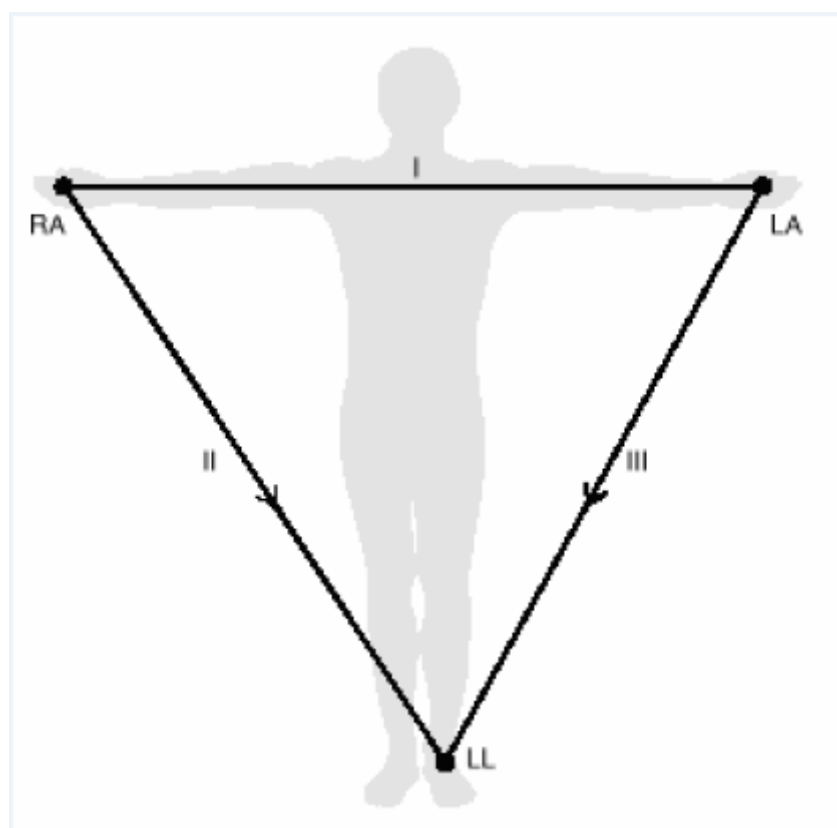
Types of Electrode Leads:

1- Bipolar Limb Lead: are symbolized and this type represents the most famous location for the electrodes on the body and is called the Einthoven Triangle.

Lead I: The left arm (LA) is connected to the positive terminal of the amplifier input. The right arm (RA) is connected to the negative terminal.

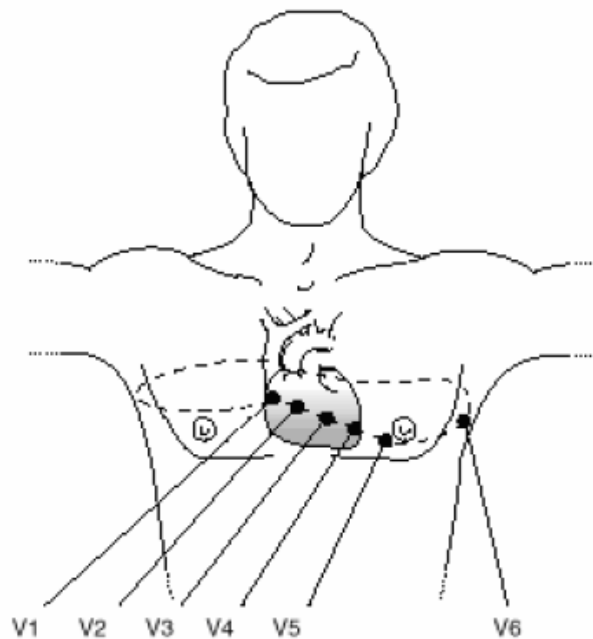
Lead II: the left leg (LL) is connected to the positive terminal while the right arm (RA) is connected to the negative terminal and the (LA) connection is shortened to the (RA).

Lead III: the left leg (LL) is connected to the positive terminal, the left arm (LA) is connected to the negative terminal, and the (RL) connection is shortened with (RA).



2- Unipolar Limb Lead of The Chest :

This second type of electrode connection is denoted by (V1-V6) It consists of six positions distributed on the Chest , one of which is connected to the positive terminal, while the three poles of the three terminals (RA, LA and LL) are joined by the resistor Wilson network and are connected to the negative terminal.



The Main Waves of The Heartbeat :

1- P wave : It is the first positive wave in the diagram and represents the excitation of the atria and the depolarization in them and starts at the beginning of blood pumping through the heart (atrial systole). The wave is positive in all electrodes except in the AVR electrode is negative, its duration is (0.11sec) .

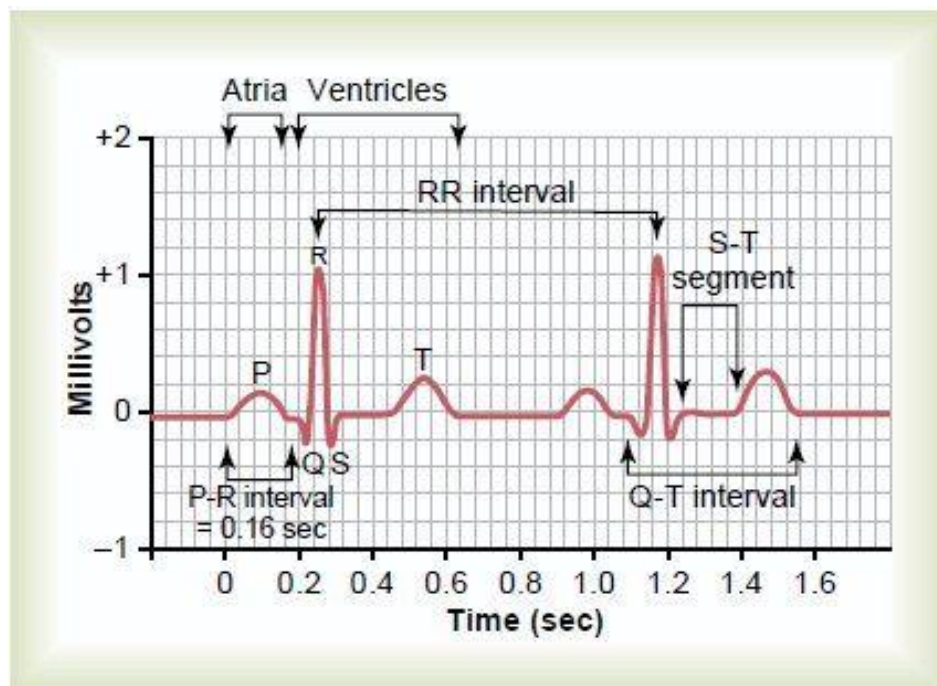
2- QRS Complex : It represents the excitation of the two ventricles and depolarization in them (ventricular systole) and its duration ranges between (40-80 ms) and the (QRS) consists of the following waves:

Q wave: negative wave with duration from (0.01 - 0.02 sec) .

R wave: a positive wave in the complex, whether positive (Q) preceded it or not.

S wave: the next negative of the (R wave) .

3- T wave : The repolarization of the ventricle, i.e. the diastole of the ventricles, at which the blood flows into the arteries (ventricular diastole), while the atrial diastole does not appear in the diagram due to the prevalence of the QRS, and the height of the T wave is from 5-10m in any pole of the heart. Means (ST Elevation) .



Components of ECG :

1- Calibration : This part works effectively to adjust and calibrate the device properly before starting the ECG process, as it creates a square pulse of (1mV) height showing that the device is in good condition.

2- Sensitivity : This part is very important in preserving the sensitivity of the device, as in its normal state it emits 1mV using the sensitivity point

and the wave can be enlarged or reduced according to the patient's condition.

3- Position Control : All done to adjust the thermal index.

4- Mark : This wave is used at an abnormal wave in planning so that the doctor can know the disease.

5- Stylus : The thermal indicator in the ECG device draws the wave on paper, and it is precisely a thermal resistance that a limited current passes inside it that raises the temperature of the tracer to perform the required drawing process .

6- Speed Limitation : The ECG device contains two speeds of (25,50 ms) and each speed is used according to the existing condition and determined by the doctor back to the heart, so if the patient is old, the pulse is somewhat weak.

7- Fuse : From the protection circuits in the device, as it uses a protection circuit from high currents and voltages, and it is truly a successful method in all devices.

8- Amplifiers : Its function is to enlarge the ECG signals captured by the electrodes because this signal is of low height and it is difficult to process without zooming.

9- Filters : are limited to filtering the wave from external influences that could affect the ECG.

10- Ground : is used as usual for leakage of excess charges and protection from electrical shocks .

11- Leads : The device consists of five electrodes that are placed in specific places in the body.

12- Screen : When the doctor is empty of paper or not needed for a continuous reading of the heart .

How Dose ECG Works :

- 1- The electrodes are installed safely on the patient's skin in the designated places with the use of the gel. After that, the ECG device is turned on, where the standard value of the voltage equal to (1mV) is recorded .
- 2- The electrical activity of the heart is recorded by measuring the potential difference between the electrodes.
- 3- The change in the voltage difference between the electrodes is recorded and this results in the heart signal of those electrodes, which is transmitted through the wires to the inside of the device.
- 4- The signal to be measured is chosen by Lead Selector .
- 5- The signal is magnified because it is very weak, and this is considered the first stage of magnification .
- 6- Filtering the signal with filters to get rid of noise and get a pure heart signal only .
- 7- The signal is then passed through two parallel paths :
 - Signal processing circuit to detect heartbeats and calculate their rate and altitude.
 - Power amplifier to enlarge the signal again in preparation for displaying it on the screen or drawing it on paper by Stencil.