Medical Physics II

2nd semester

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Lectures 4

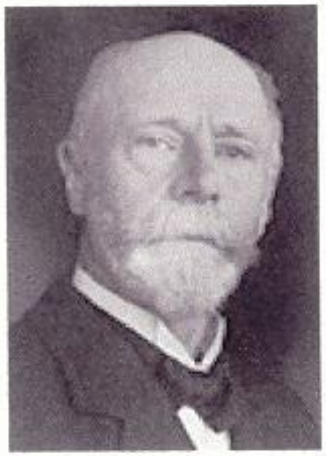
Electrocardiogram (ECG)

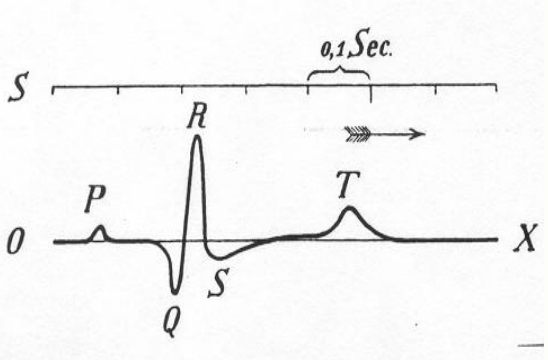
Brief History of ECG

The **ECG** is not only the oldest but, in fact, over **100** years after its introduction, continues as the most commonly used cardiovascular laboratory procedure.

The Nobel Prize in Physiology or Medicine 1924

"for his discovery of the mechanism of the electrocardiogram"





Willem Einthoven

the Netherlands

Leiden University
Leiden, the Netherlands

b.1860
(in Semarang, Java, then Dutch East Indies)
d.1927

What is 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.

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**.

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.**

Myocardiumconsists 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.**

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**.

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**,

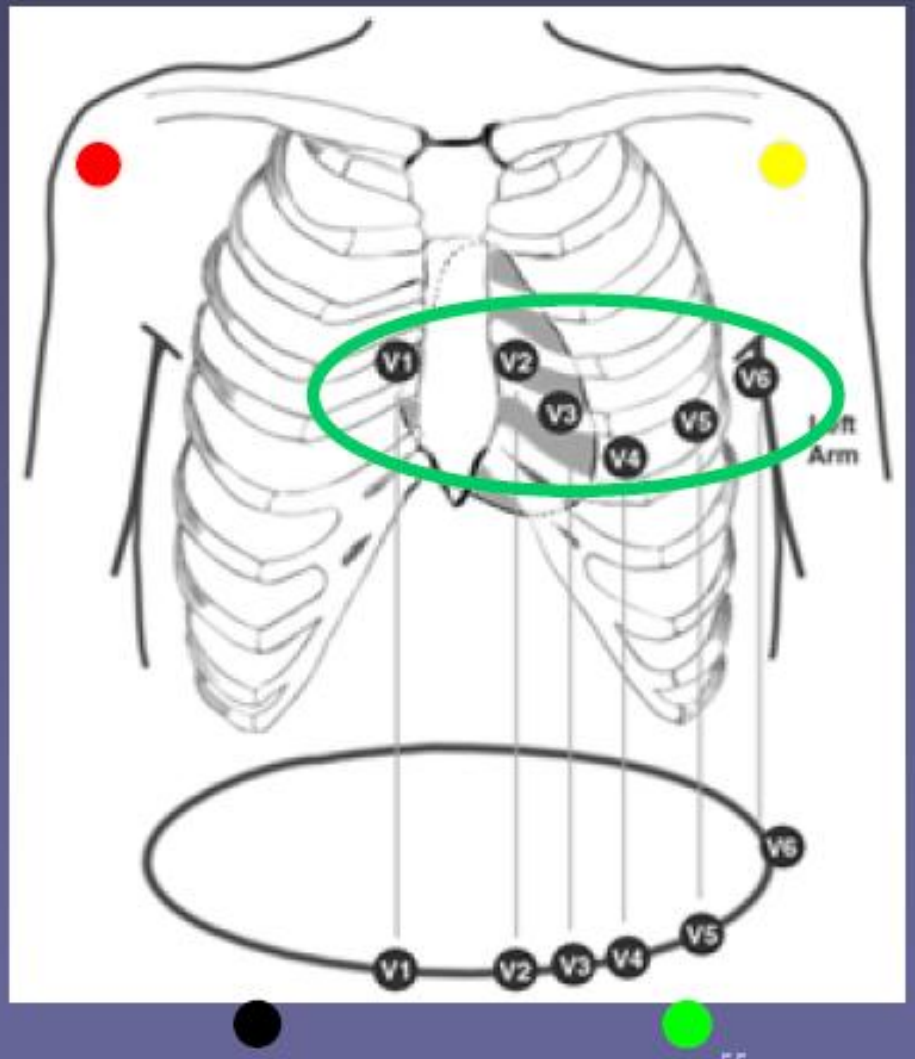
It has been agreed on the **colors** that **distinguish** the wires that connect to each of the electrodes, namely:

Leads and Their Connections

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

Electrode placement in 12 lead ECG

- 6 are chest electrodes
  - Called V1-6 or C1-6
- 4 are limb electrodes
  - **Right arm** **Ride**
  - **Left arm** **Your**
  - **Left leg** **Green**
  - **Right leg** **Bike**
  - Remember
    - The right leg electrode is a neutral or "dummy"!



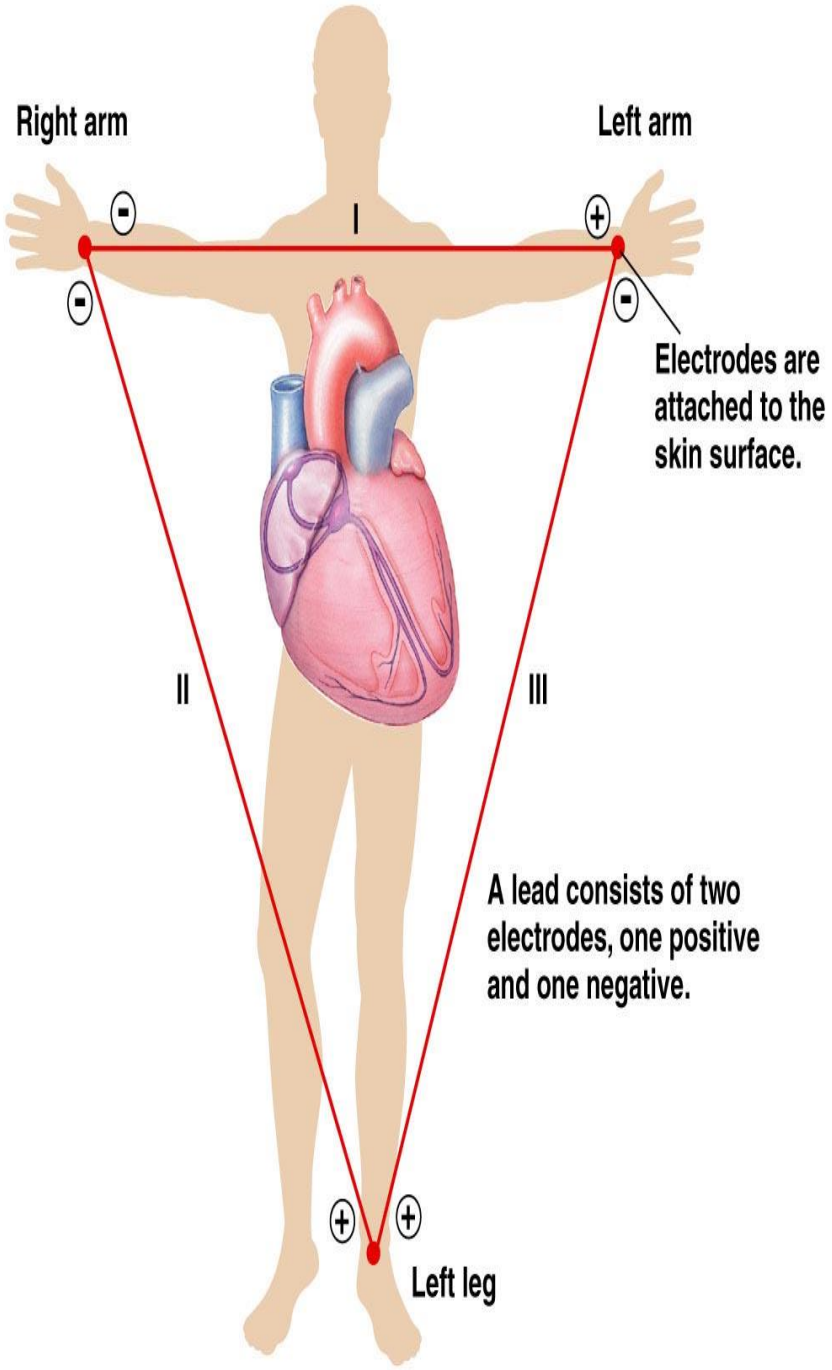
Types of Electrode Leads

1- Biopolar Limb Lead: are **symbolized** and this **type represents** the **most famous location for the electrodes** on the body and is **called** the **Enthoven 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**)



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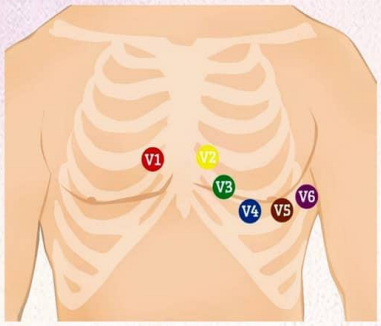
Knowledge Of ECG

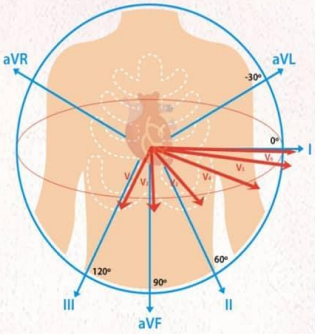
12-LEAD ECG ELECTRODE PLACEMENT



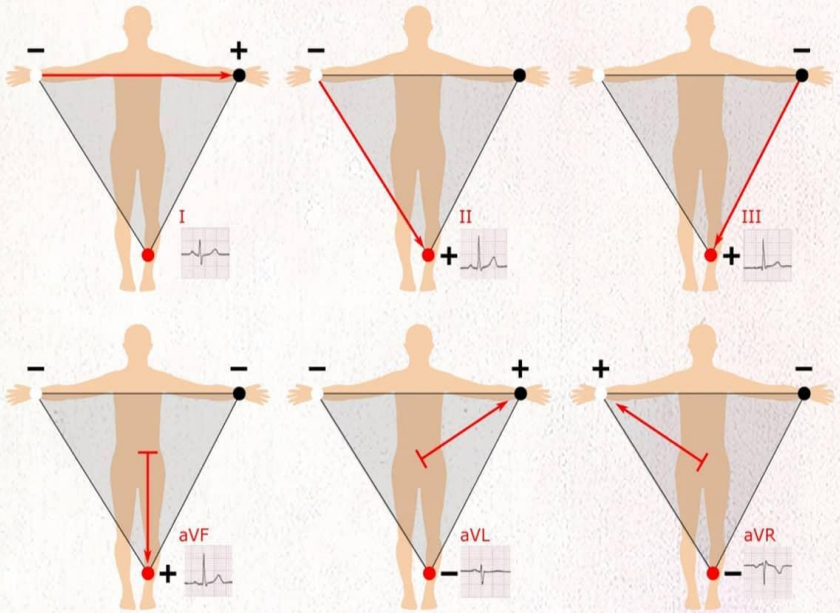
Chest (Precordial) Electrodes and Placement

Limb (Extremity) Electrodes and Placement

RA Right Arm
LA Left Arm
LL Left Leg
RL Right Leg



Vertical plane (Frontal Leads)



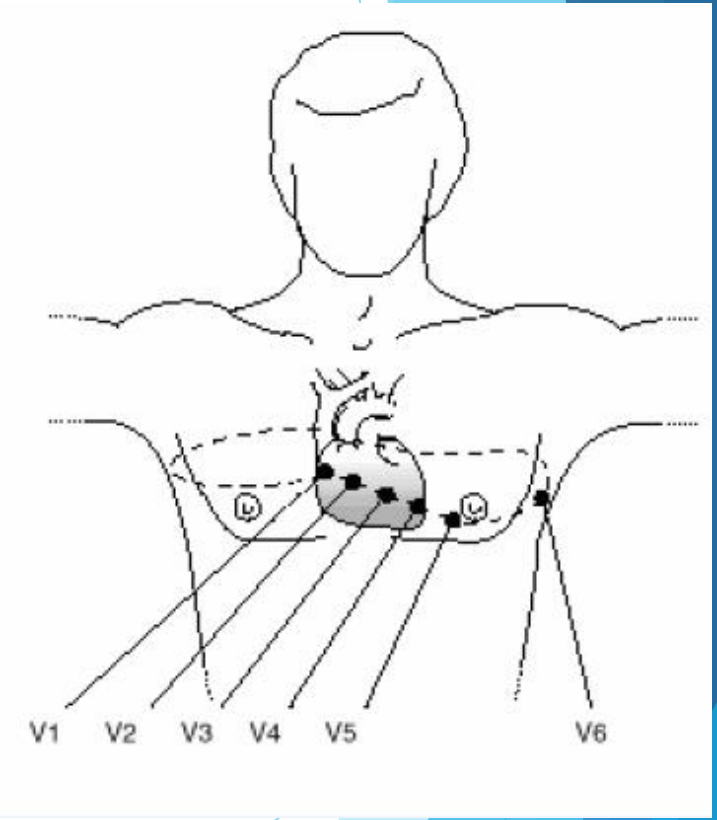
Einthoven's Triangle

2- Unipolar Limb Lead of The Chest

This **second type of electrode** connection is denoted by (V1-V6).

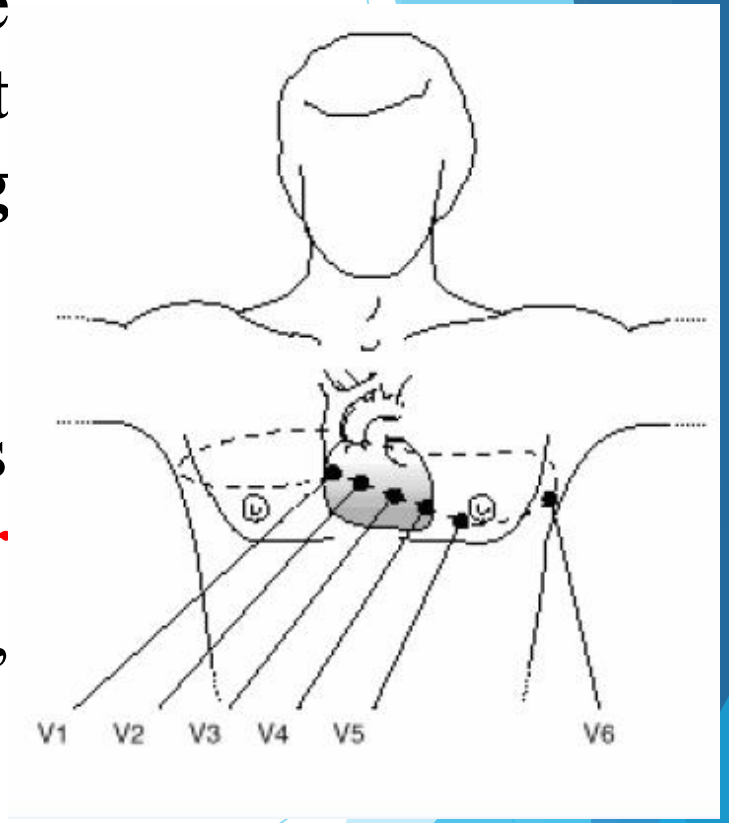
It consists of **six** positions distributed on the **Chest** , **one of which is connected to the positive terminal.**

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).**

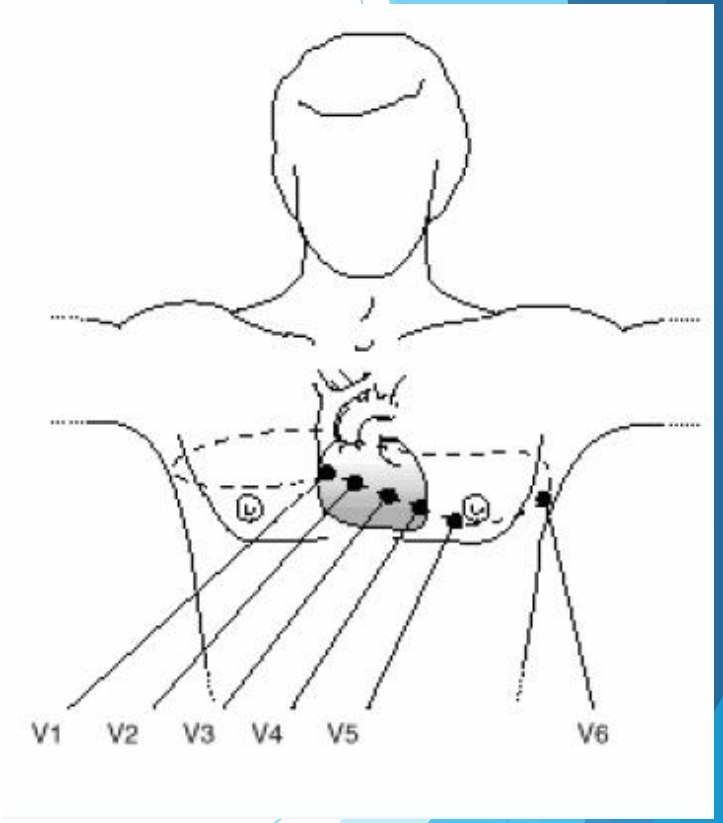


The wave is **positive** in all electrodes **except** in the **augmented Vector Right (AVR electrode)** is **negative**, its **duration** is (**0.11**sec)

Atrial begin contracting about **25msec after** the start of the p-wave.

The Main Waves of The Heartbeat :

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:



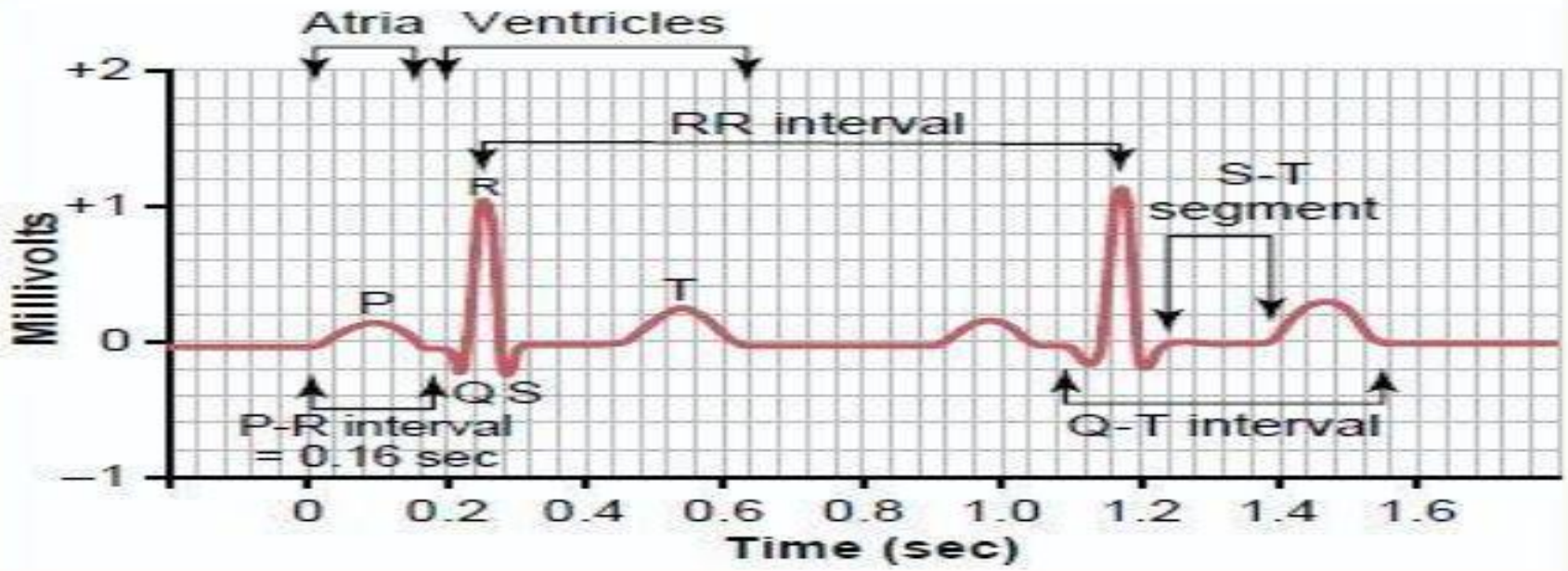
Q wave: negative wave with duration from (0.01 - 0.02 sec) .

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

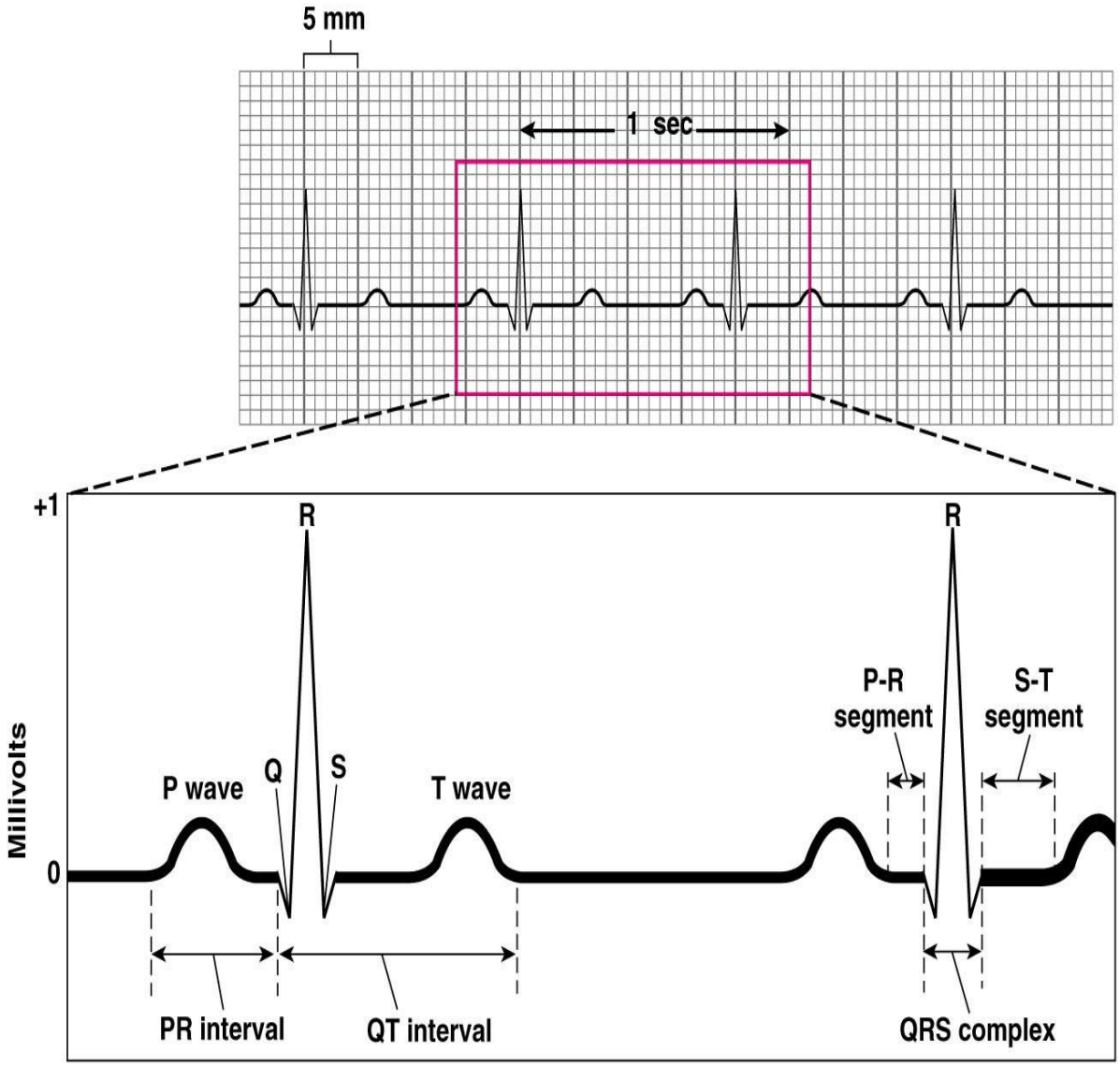
S wave: the next negative of the (R wave) .

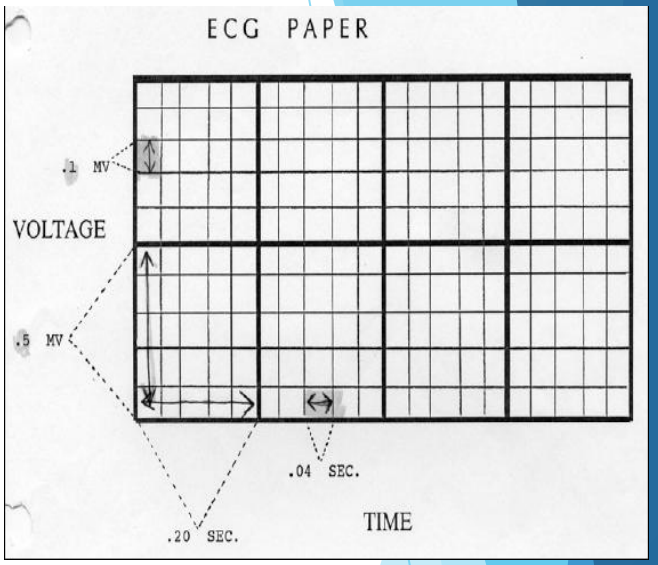
The Main Waves of The Heartbeat :

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 5-10 mm in any pole of the heart. Means (ST Elevation) .

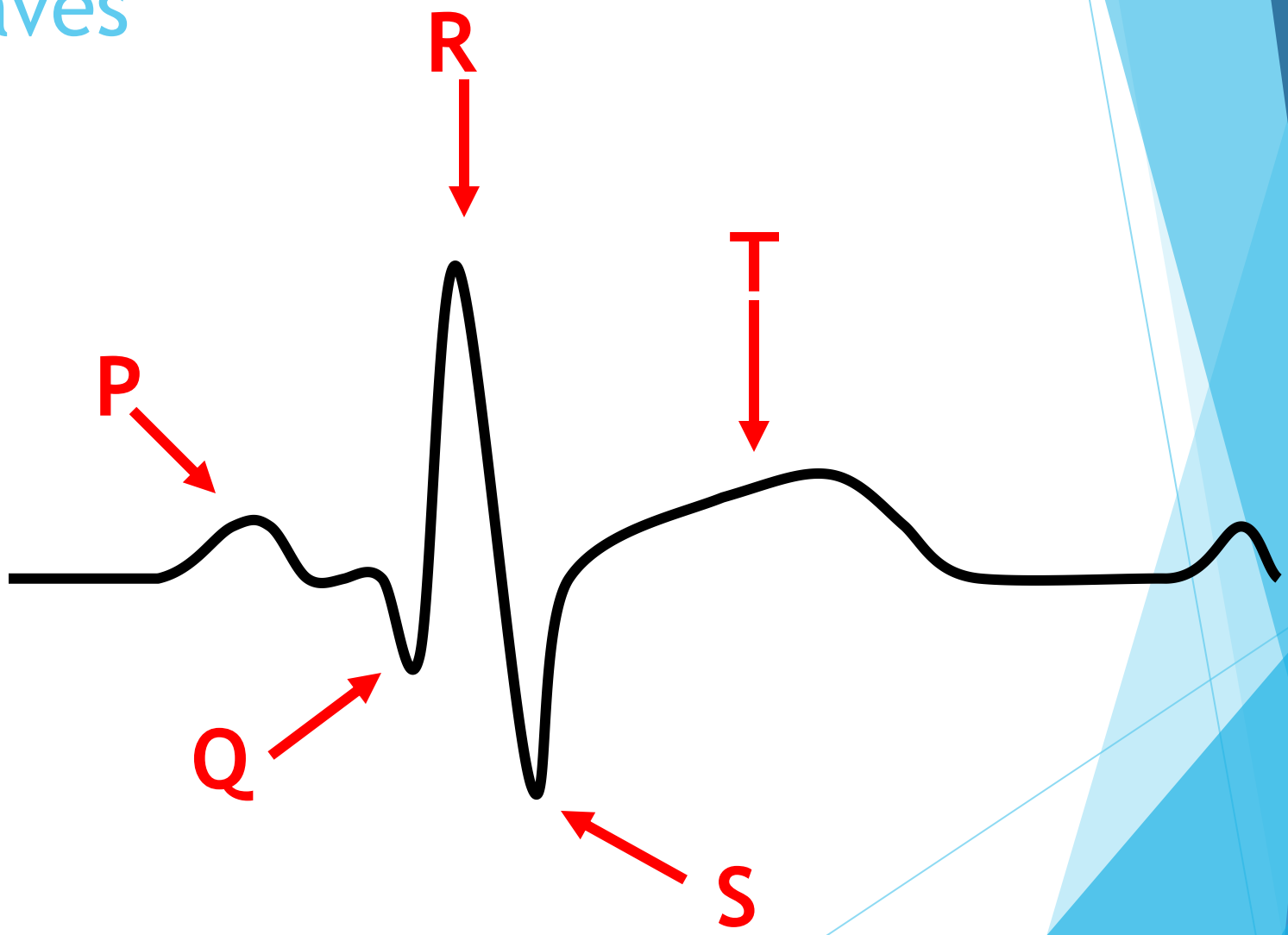


What does the ECG look like?





Waves



The Normal ECG