Al-Mustaqbal University

College of Science

Medical physics Department

Medical Physics II

Second Semester

3rd stage

Lesson 7

Electricity within the body (Part 2)

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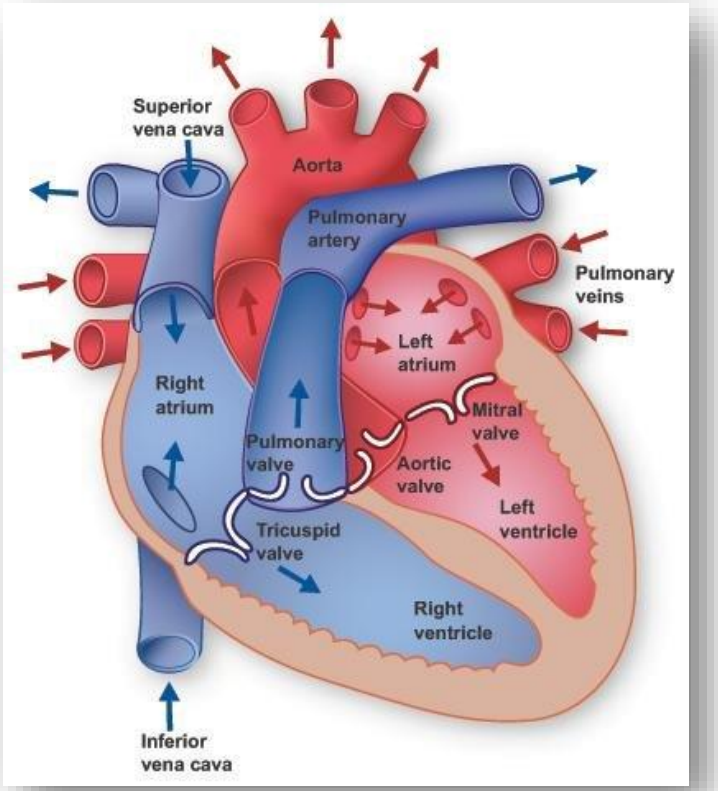
The Electricity of Human Heart

Heart has four chambers; the two upper chambers, the left and right atria, are synchronized to contract simultaneously, as are the two lower chambers, the left and right ventricles.

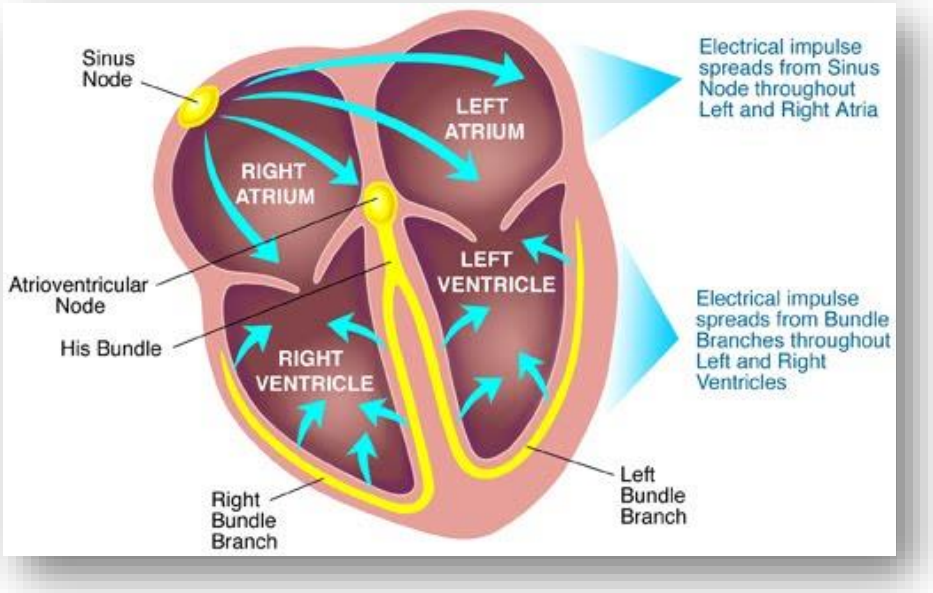


- The right atrium receives blood from the body and pumps it to the right ventricle.
- The right ventricle pumps the blood through the lungs, where it is oxygenated.
- The blood then flows into the left atrium.
- The contraction of the left atrium moves the blood to the left ventricle,
- The left ventricle contracts and pumps it into the general circulation; the blood passes through the capillaries into the venous system and returns to the right atrium.

The rhythmical action of the heart is controlled by an electrical signal initiated by spontaneous stimulation of special muscle cells. These cells make up (1) the pacemaker or the **sinoatrial (SA) node** and (2) the **atrioventricular (AV) node.**

During each heartbeat, the conduction pathways in the heart as following:

1. A natural pacemaker, or *Sinoatrial Node*, generates electrical impulses at a regular rate.
2. This spreads throughout the right and left atrium, causing them to contract and pump blood into the ventricles.
3. An electrical signal passes into the *atrioventricular (AV) node* through a special nerve fiber, which provides the delay in propagation.
4. At this point, the A.V. node spreads signal into the ventricle throughout *bundles of His.*
5. Then into the left and right bundle branches (*purkinje fibers*), causing contraction of both ventricles.

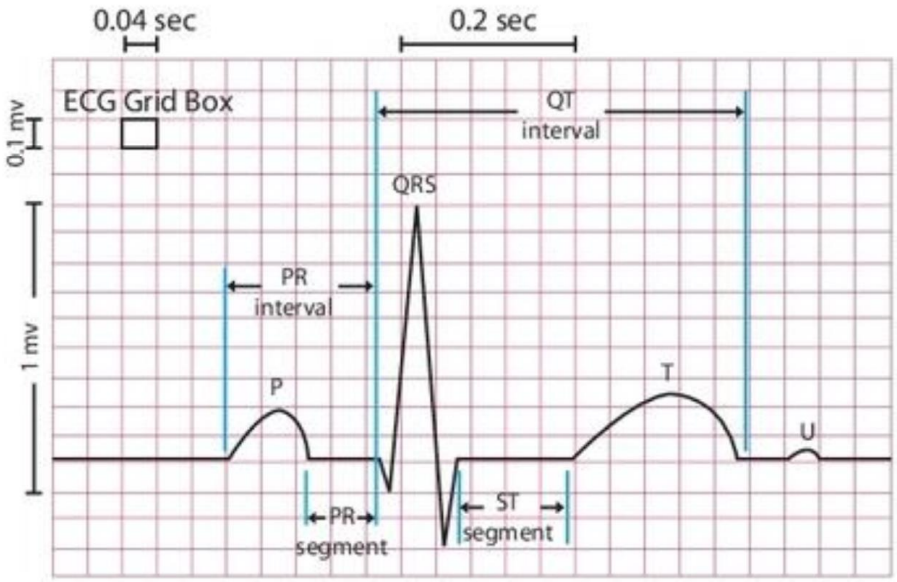


The electrical signal from the Heart (Electrocardiogram) (ECG)

As the heart undergoes depolarization and repolarization, the electrical currents that are generated and spread not only within the heart, but also throughout the body. This electrical activity generated by the heart can be measured by an array of electrodes placed on the body surface. The recorded tracing is called an Electrocardiogram (ECG).

A “typical " ECG graph paper is shown below. The different waves that comprise the ECG represent the sequence of depolarization and repolarization of the atria and ventricles.

- The P wave represents the wave of atrial depolarization. The duration is 0.08 to 0.1 seconds.
- The QRS complex represents ventricular depolarization. The duration of the QRS complex is normally 0.06 to 0.1 seconds.
- The T wave represents ventricular repolarization and is longer in duration than depolarization.
- The U wave represents the state of heart when all four chambers of heart receive the blood. This wave is not present in the normal ECG graph.



Measuring ECG

The voltage generated by the pumping action of the heart is actually signals. The ECG signal is measured from electrodes applied to the surface of the body.

To record the ECG pattern of a subject (human body), it is necessary to apply ECG metal electrodes to the patient's limbs in special formats called Leads, located in left arm (LA) , right arm (RA) , & left Leg (LL) .

ECG graphing contains (12) sections:

- 3 Limb Leads (Bipolar)
- 3 Augmented Limb Leads (Unipolar) } Frontal Plane
- 6 Chest Leads (Unipolar) ⟶ Transverse plane

These electrode Leads are connected to a device that measures potential differences between selected electrodes to produce the characteristic electrocardiographic graph.

ECG Leads (Electrodes)

To measure the electric activity of the heart in the frontal plane, the Limb leads and augmented lead should be used:

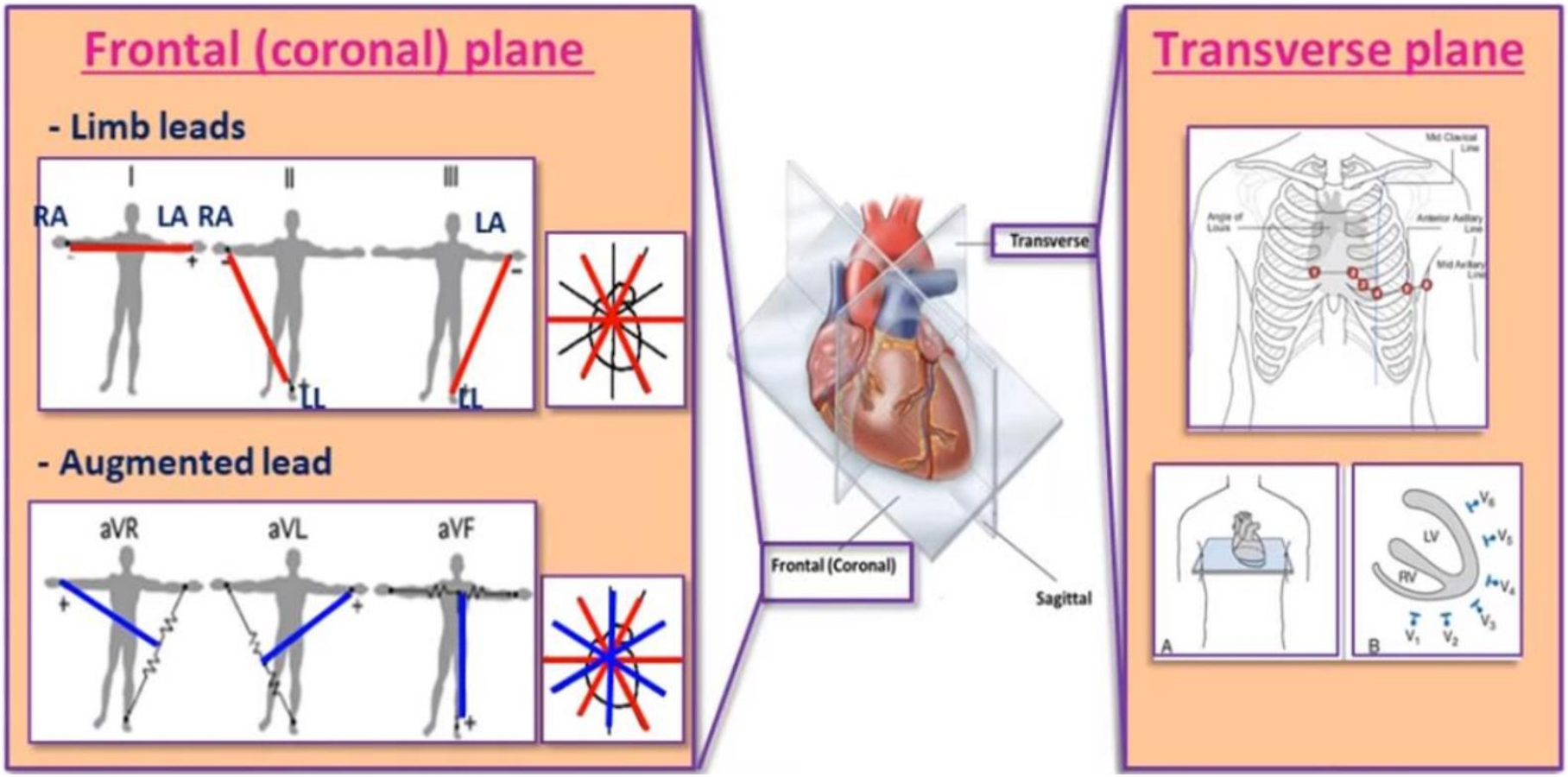
Limb leads I, II and III (Einthoven Triangle):

1. Lead 1: Measure the potential between RA & LA
2. Lead II: Measure the potential between RA & LL
3. Lead III: Measure the potential between LA & LL

Einthoven's triangle is used when determining the electrical axis of the heart. The stretch between two (arm or leg) electrodes is called a lead. Einthoven named the leads between the three electrodes "standard leads I, II, and III", referring to the two arm electrodes and the left leg electrode. The relationship between these electrodes, forming a triangle is called Einthoven's triangle.

Augmented lead av_R, av_L and av_F

1. av_R Lead , (RA center of LL and LA)
2. av_L Lead , (LA center of RA & LL)
3. av_F Lead , (LL center of RA & LA)

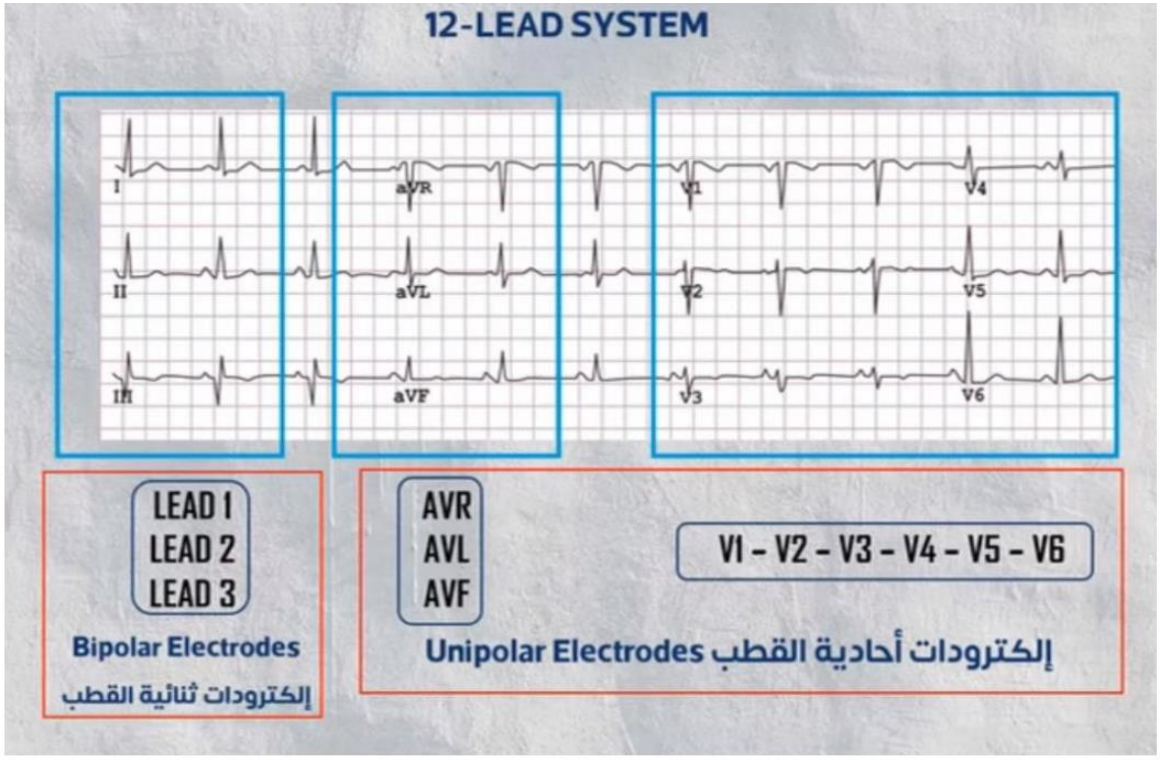

Frontal (coronal) plane
- Limb leads
I
II
III
RA
LA
RA
LA
LL
LL
- Augmented lead
aVR
aVL
aVF
Transverse
Frontal (Coronal)
Sagittal
Transverse plane
A
B
LV
RV

To measure the electric activity in the transverse plane of heart, the chest leads should be used:

Chest leads V1, V2, V3, V4, V5 and V6

The negative terminal is attached to an indifferent electrode at the center point of three resistors connected to RA, LL and LA and the other is moved across the chest wall to the six different positions.

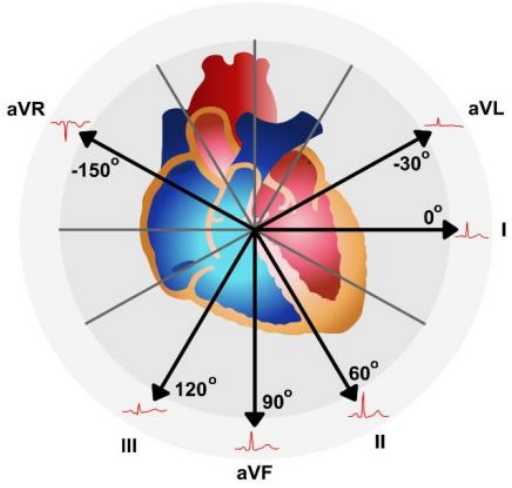
1. V1-V2: Right ventricle
2. V3-V4: Interventricular septum
3. V5-V6: Left ventricle

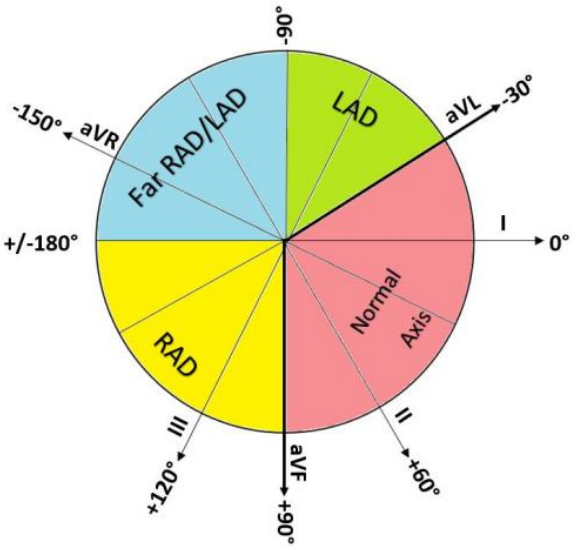


Electrical axis of heart

The heart electrical axis refers to the general direction of the heart depolarization wave front or (mean electrical vector) in the frontal plane. It is usually oriented in a right shoulder to left Leg direction, which corresponds to the left inferior quadrant of the hex-axial reference system, although -30° to + 90° is considered to be normal.

- Left axis deviation: (-30 ° to -90 °) may indicate left anterior fascicular block or Q waves from inferior myocardial infraction.
- Right axis deviation: (+ 90 ° to + 180 °) may indicate left posterior fascicular block, Q waves from high lateral myocardial infraction or a right ventricular strain pattern.





Exercises

1 The ---------- pumps the blood through the lungs, where it is oxygenated.

(a) Right atrium (b) right ventricle (c) left atrium (d) left ventricle (e) None of them

2 The ---------- in the right atrium generates electrical impulses at a regular rate.

(a) Sinoatrial (SA) Node (b) atrioventricular (AV) node (c) purkinje fibers (d) Axon (e) None of them

3 The electrical activity generated by the heart can be measured by an array of electrodes placed on the body surface. This technique is called;

(a) EMG (b) AV (c) SA (d) ECG (e) None of them

4 In the limb leads of ECG, lead 1 measure the potential between RA & LA

(a) right arm and left leg (b) right arm and left arm (c) right leg and left leg (d) right arm and right leg (e) left arm and brain

5 To measure the electric activity in the transverse plane of heart, the ---------- should be used

(a) limb leads (b) neck leads (c) arm leads (d) head leads (e) chest leads