Physiology Team 434

ElectroCardioGram (ECG)

Color index

- Important
- Further Explanation

Focus on the things written in red

Explained in:
-Guyton Chapter 11

Physiology Team 434
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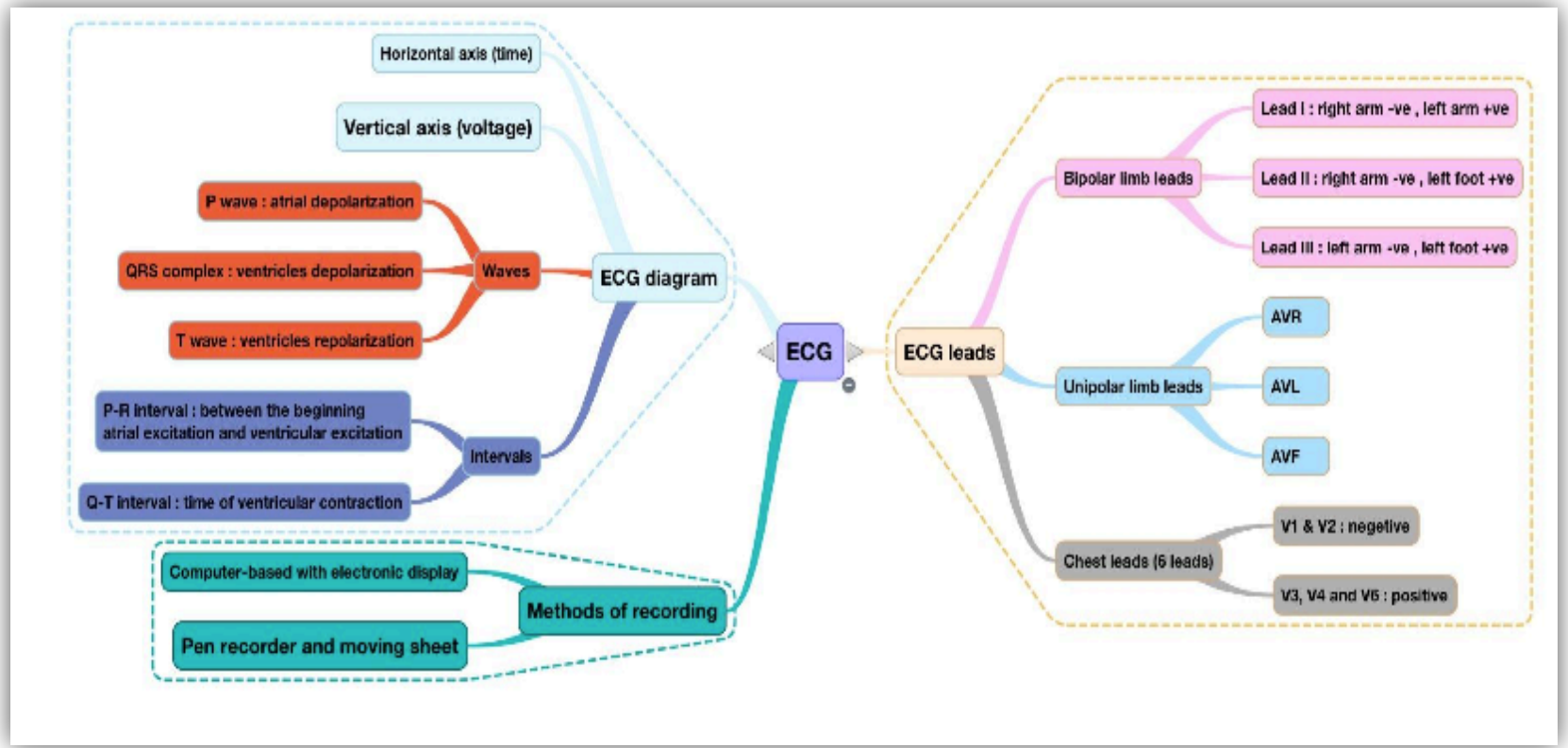
Objectives

- Describe the procedure of recording an electrocardiogram.
- Define the different ECG leads.
- State Einthoven's law and describe its physiological significance.
- Discuss the ECG waves, intervals and segments.
- Calculate the electrical axis of the heart and discuss its diagnostic uses.
- Discuss usefulness of ECG.
- Define and interpret normal sinus rhythm.



ECG

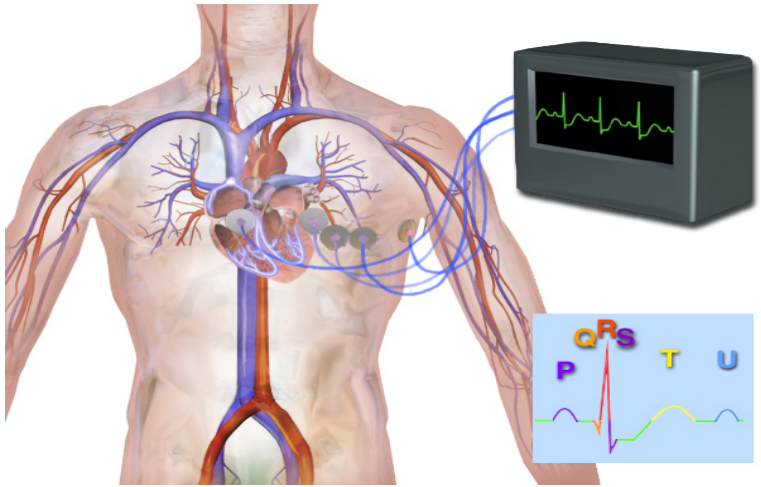
The heart is considered as an electric generator; This electric activity that is generated with in the heart is transmitted to the surface of the body because the body tissues functions as an electrical conductors do to the electrolytes in the tissue, so the **ECG** is used to record this electric activity on the surface of the body.

How the ECG works?

How we can measure the voltage of a battery?

- ✓ We use an electric circle > two wires one end connected to the battery and the other is connected to voltmeter; it will gave us a reading which is the potential of the battery.

- ✓ We apply this principle to the heart so the heart is our battery and the **ECG** is a modified voltmeter and we connect the two wires to the surface of the body.



Electrodes (the wires)

Two electrodes are required:
1- active electrodes +ve (Used to **record** the electric activity)
2- reference electrodes –ve (Used to **close** the electric circle)

The effect of the electrodes on the wave

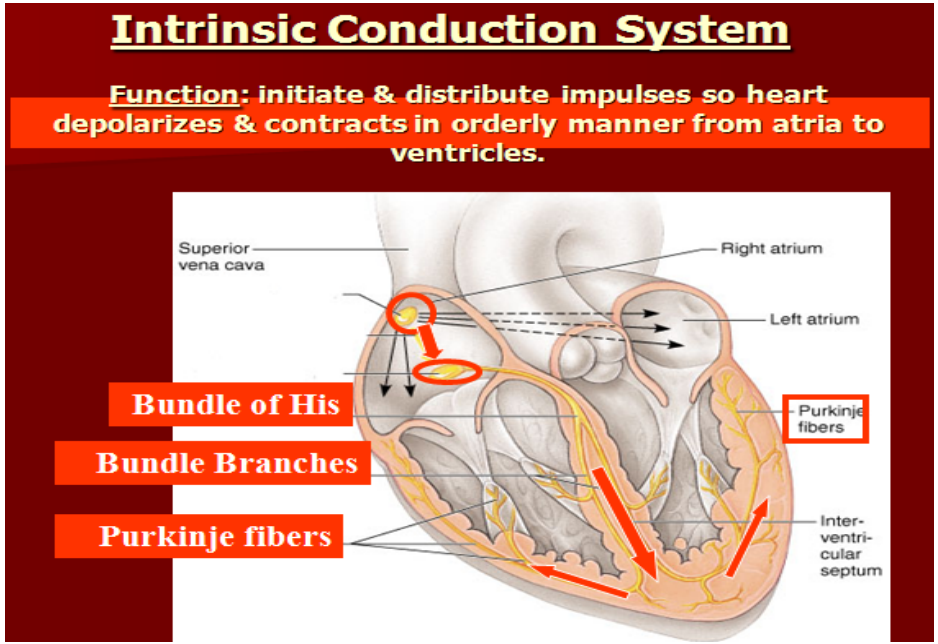
- ✓ When there is a depolarization propagating **TOWARDS** the active electrodes it make a positive wave.
- ✓ When there is a Repolarization propagating **AWAY** from the active electrodes it make a positive wave.
- ✓ When the depolarization propagating **AWAY** from the active electrodes it make a negative wave.
- ✓ When the Repolarization propagating **TOWARDS** the active electrodes it make a negative wave.
- ✓ When **NO** propagating potentials >> **NO** depolarization or Repolarization, then no wave is recording it will make a line called the isoelectric line.

Flow of Electrical current in the Heart

- ✓ Current flows from the *electronegative* inner surface of the heart to the *electropositive* outer surface (from the ***base*** of the heart to the ***apex***)
- ✓ An electrode placed near the **base** of the heart is **electronegative**, and near the **apex** is **electropositive**

The conduction system

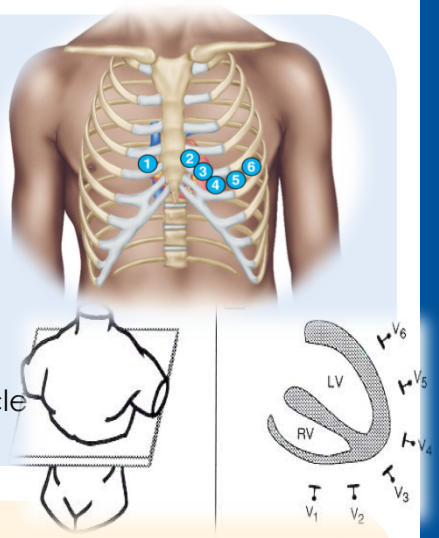
We can see in this picture the conduction system and the direction of the electric activity of the heart.



The recording points on the body surface

There are 9 points that we can record from: (A. 6 in the chest named from V1 to V6. B. the other 3 on the limbs)

Chest points(6)



V_1: at the right 4th intercostals space near the sternum "anterior" facing the right ventricle

V_2: at the left 4th intercostals space near the sternum "anterior" facing the right ventricle

V_3: midway between V_2 and V_4 "anterior" facing the septum.

V_4: at the left 5th intercostals space at the midcalvicular line "anterior" facing the septum

V_5: at the left 5th intercostals space at the anterior axillary line "antrolateral" facing the left ventricle

V_6: at the left 5th intercostals space at the midaxillary line "antrolateral" facing the left ventricle

Limbs points(3)

1. **VL**: **at the junction of the left arm with the trunk**. Any point on the left upper limb has the same potential facing antrolateral >> the left ventricle

2. **VR**: **at the junction of the right arm with the trunk.** Any point on the right upper limb has the same potential anterior >> the right ventricle

3. **VF: at the junction of the left lower limb with the trunk.** Any point on the left or right lower limbs has the same potential facing inferior of the heart

ECG leads

It is the outcome of recording points.

1- Unipolar ECG leads

It is the recording when the reference electrode is at zero potential and the active electrode on the recording point on the body. There are nine unipolar leads six at the chest and three at the limbs

Note: the benefit of unipolar leads is that it record a part of the heart. For example V1 lead is used to obtain the electro activity for the right ventricle.

The voltage obtained from point Vr Vl Vf are small and not shown on an ECG lead so we make them strong by adding a resistant to it known as augmented VR >> aVR aVl aVF

2- Bipolar ECG leads

These records obtained when the active electrode is applied to a recording point and the reference electrode is applied to another recording point. (Two electrodes)

There are three bipolar leads named:

Lead I: records the potential between left arm(+) and right arm(-). The active electrode is at VL and the reference electrode is at VR.

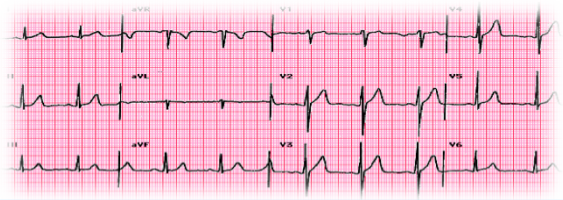
Lead II: records the potential between left leg(+) and right arm(-). The active electrode is at VF and the reference electrode is at VR.

Lead III: records the potential between left leg(+) and left arm(-). The active electrode is at VF and the reference electrode is at VL

The leads and the border of the heart

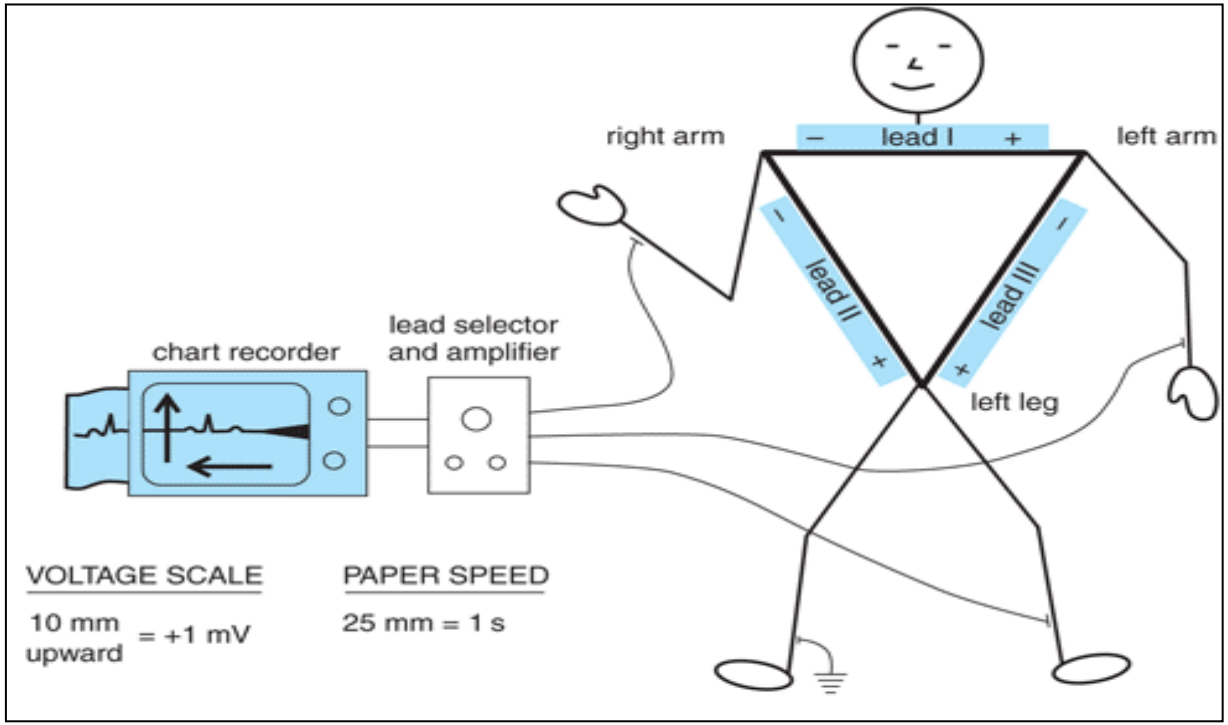
- Anterior leads: V1 V2 V3 V4 VR
- Antrolateral : V5 V6 and leads I VL
- Inferior: aVF leads II and lead III
- Note all the leads are taken at ones

A standard 12-lead Normal ECG



Einthoven's Law

In the ECG, at any given instant, the potential of any wave in lead II is equal to the sum of the potentials in lead I and III. So I + III = II



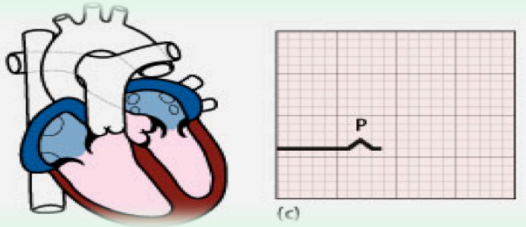
The P Wave

How the electro activity wave transmitted to the paper

To understand we need to take one lead as n example: lets say aVL
Note the active electrode placed on the left arm and the reference electrode at zero potential
Lets start first the SA node will fire the stimulus as an action potential and it will make the atria depolarize and this depolarization is moving towers the active electrode making a positive wave called the **P wave**

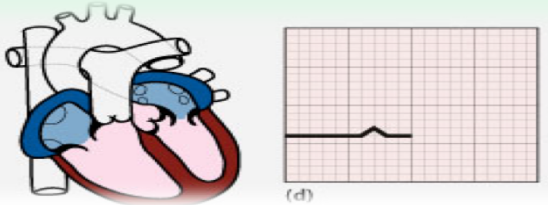
The P wave

✓ Atrial depolarization generates a 'P wave' on the ECG



✓ After that the impulse travels to the AV node

Note the AV node famous for keeping the impulse for a little while and this called the AV nodal delay causing no depolarization or Repolarization so it makes an isometric line

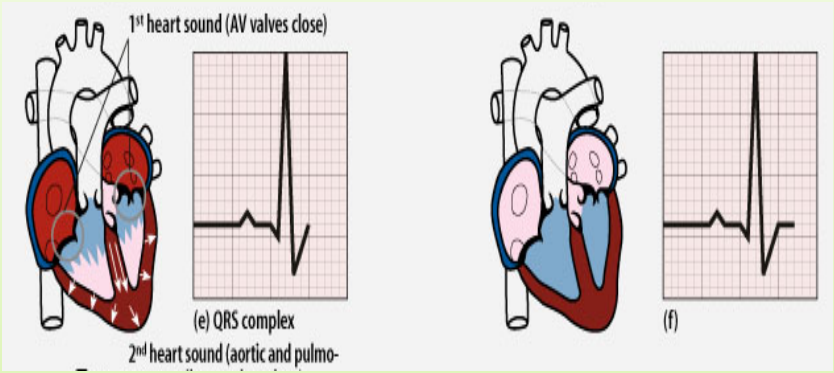


QRS complex

After the impulse goes to bundle of His and after that goes to bundle branch, the first part which depolarize in the ventricle is the septum and the depolarization comes from the left bundle branch so that means that the direction of the depolarization is away from active electrode so it make a negative wave called the **Q wave**

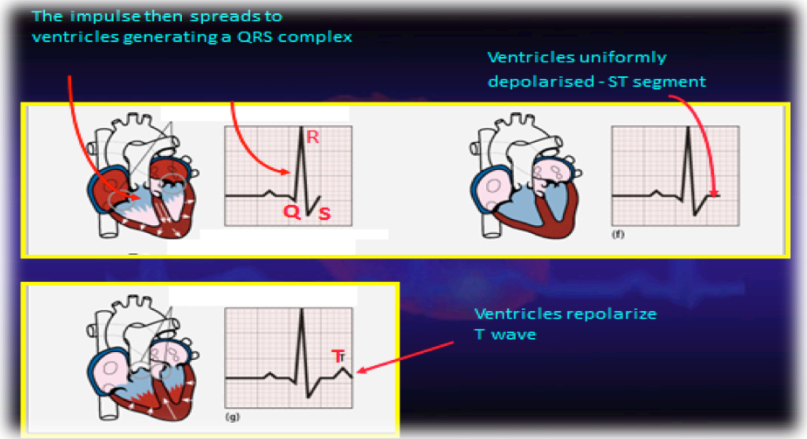
- After that ventricles depolarization take place as a fact the depolarization happens from the endocardial to the epicardial means from inside to outside so the direction is going towers both the active and the reference electrodes so what happens ? Negative or positive wave ..?

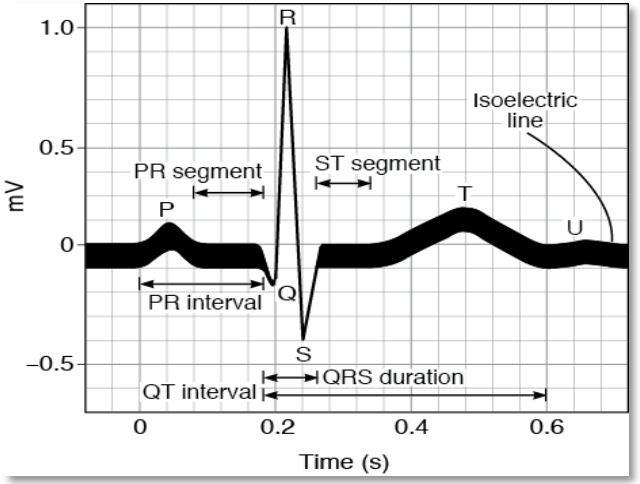
It will be positive because the left ventricle is more thick than the right >> 3 time the thickness so the depolarization is 3 time greater on the left than the right we call it the R wave. The last part that will be depolarized is an area in the beginning of the pulmonary trunk called the pulmonary conus it will make a negative wave because it is away from the active electrode it called an **S wave**
(***So the QRS complex means ventricles depolarization***)



The T wave

It is a Repolarization of the ventricles it happens from outside to inside that means it is away from the active electrode it will make a positive wave >> remember it is a Repolarization.
Note why there is not a atrial Repolarization? Because it happens in the ventricle depolarization period and it is small so it is not shown





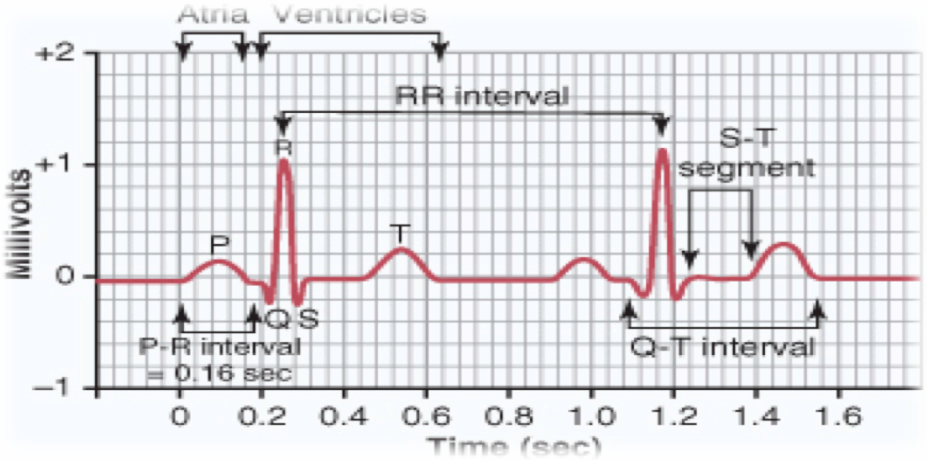
ECG segment

- ✓ Definition: Something connect two waveforms.
- ✓ Type of ECG segment:

1. PR segment between P wave and QRS complex, which show us AV nodal delay (If the AV nodal prolongs the impulse you well see the impulse become longer).
2. ST segment which is a flat isoelectric between S and T wave. It shows us the period between ventricle depolarization and repolarization.
3. TP segment between two pulses.

Voltage and Calibration of the ECG

The vertical calibration lines: **Voltage(millivolt)**
5 small lines = 1 mV
The horizontal calibration lines: Time (seconds)
1 inch(25 small lines) = 1 second
Each inch is divided by 5 dark vertical lines
The interval between the dark lines= 0.2 second
thin line=0.04 second



P-R interval

- It is the time between the beginning of the *P wave* and the beginning of the *QRS complex*
- It is the interval between the beginning of electrical excitation of the atria and the beginning of excitation of the ventricles
- The P-R interval is about 0.16 second

Q-T interval

Contraction of the ventricles last from the beginning of the Q wave to the end of the T wave
Q-T interval is the time from the beginning of the *Q wave* to the end of the *T wave*
Q-T interval is about 0.35 second

ECG does not provide any info about pulping and mechanical
Only in electric activity
You can calculate the rate of the heart by using 300 rule
300 rule is counting the big square between two R waves then divide it on 300
Example: 4/300 = 75 pulps per minute

So If the interval between two beats is 1 sec (5 dark horizontal lines) the hear rate is : 300 \ 5 = 60 beats pet min

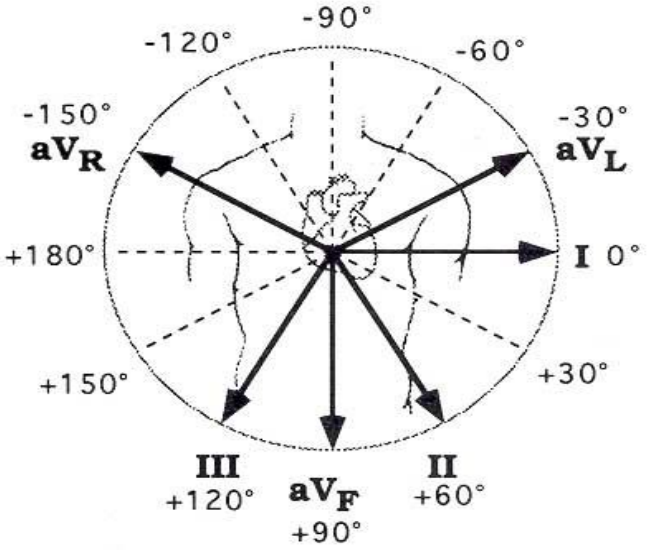
Electrical Axis

- ✓ Electrical axis is the sum of all current flow in the heart.
- ✓ The vector is an arrow that point the in the direction of the electrical potential generated by the current flow
- ✓ the normal axis for the heart is between 0 to 90
- ✓ The axis could show us if there is change of the position of the heart also it could show us if there hypertrophy or not

Table 4–1. The Limb Leads

	(+) electrode	(−) electrode
Bipolar leads		
I	LA	RA
II	LL	RA
III	LL	LA
Unipolar leads		
aVR	RA	*
aVL	LA	*
aVF	LL	*

LA = left arm; LL = left leg; RA = right arm; * = (−) electrode constructed by combining all other electrodes together.



A video explains the axis

MCQs

1- Which ONE of these waves is caused by the repolarization of the ventricles?

A. P wave
B. Q wave
C. T wave
D. R wave

2- Which ONE of these segment does the AV nodal delay happens?

A. S-T
B. P-R
C. T-P

3- What is the last place in the ventricle to be depolarized?

A. Septum
B. Pulmonary conus
C. Purkinje fibers

4- In the ECG if the P-R segment is prolong means ap roblem in the:

A. SA node
B. AV node
C. Purkinge fiber

5- Time between the beginning of electrical excitation of the atria and the beginning of excitation of the ventricles?

A. S-T segment
B. Q-T interval
C. P-R interval

1.C
2.B
3.B
4.B
5.C

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