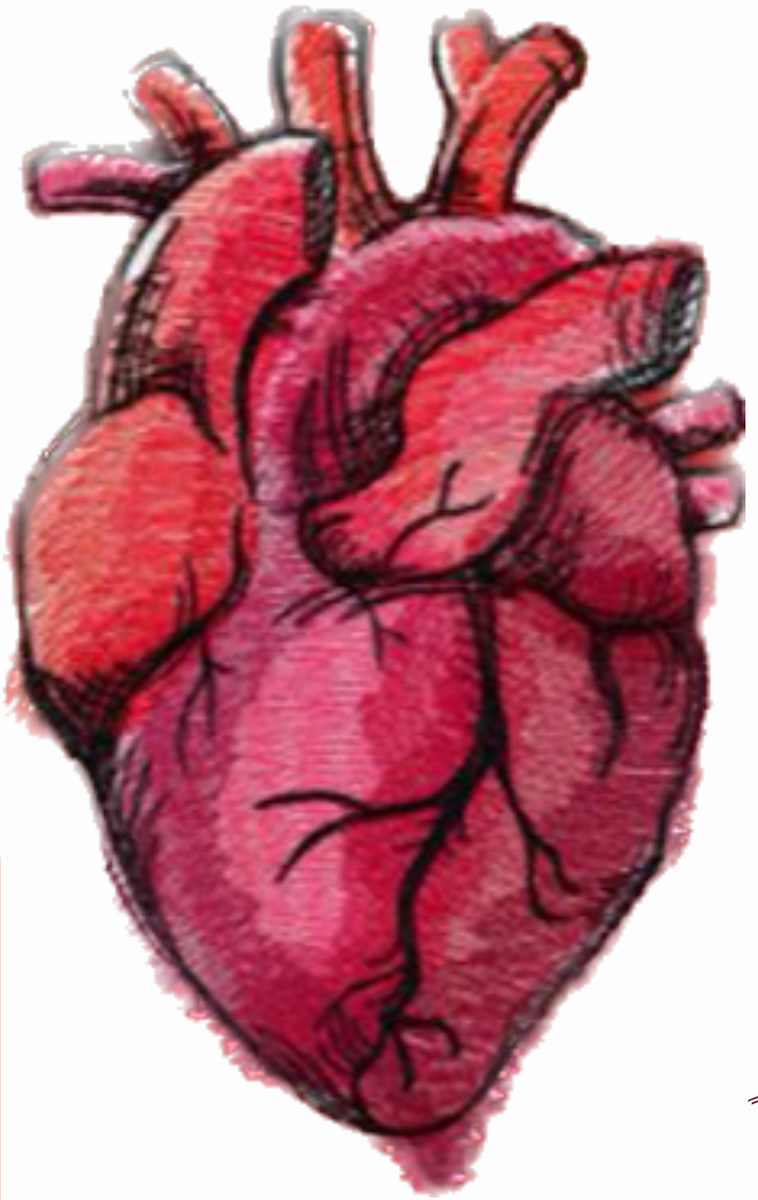


النادي الطبي

CARDIOVASCULAR SYSTEM

SUBJECT : physiology

LEC NO. : 4

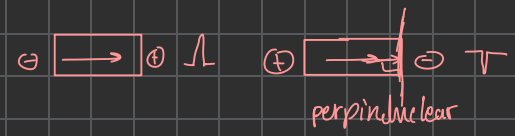
DONE BY : Abdullah Bani Mustafa

وَقُل رَّبِّ زِدْنِي عِلْمًا

SCAN ME!

The Electrocardiography (ECG) II

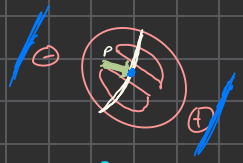
Dr. Waleed R. Ezzat



electropositivity direction → apex of the heart

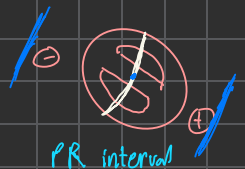
electronegativity direction → base of the heart.

this is lead II



P wave

① SA node creat AP and transmit it to AVN causing depolarization of the atria this depolarization wave is called the P wave



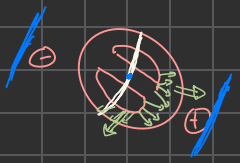
PR interval

. then as we said before there is a delay of AP in the AVN causing stop in the electrical activity givin a flat line on ECG after the P wave

its very important clinically because in case of heart block the AVN will take more time causing increase in the flat line.

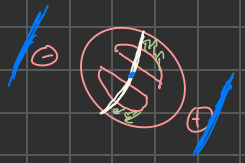
Q wave

after that it will pass to the bundle of his the to the left and right branch, so now the septum is depolarized from the left branch and the wave is going to the right sides closer to the (+) electrode



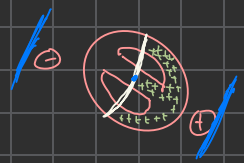
R wave

depolarization of both ventricles through both branches left ventricle has higher voltage due to its larger mass so the net direction is towards the positive electrode this depolarization wave called R wave



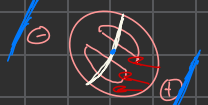
S wave

now the depolarization wave is directed towards the base of the heart so to the negative electrode giving the S wave



ST segment

so the heart is completely repolarized so there is no different in potentials so it's iso-electric



T wave

repolarization of the heart take place now so the charge will be negative towards negative electrodes making the T wave

Summery

P wave → depolarization of atria

Q wave → depolarization of intraventricular septum

R wave → depolarization of lower parts of ventricles

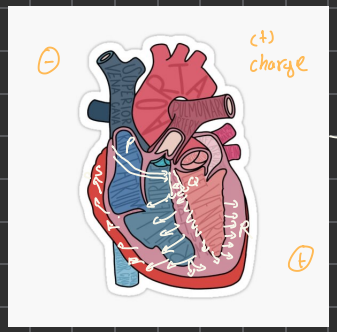
S wave → depolarization of the upper parts of ventricles

T wave → repolarization of the heart

what is ECG: it's a way to measure the electrical waves in the heart by placing electrodes on differents parts of the body, so it shows how the depolarization wave move during each heart beat

in other words it's graphical representation of the electrical activity of the heart

* Note that (+) charges going towards (+) electrodes give upper deflection
* (-) charge going towards (+) electrodes give lower deflection
* (-) charge going towards (+) electrode give upper deflection
* (-) charge going towards (-) electrode give lower deflection



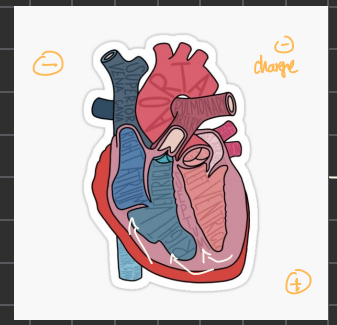
→ depolarization waves

P wave → depolarization wave from the SAN to AVN (-) to (+) electrode

Q wave → depolarization wave from the intraventricular septum wich is (+) to (-) electrode

R wave → depolarization wave from both ventricles (+) to (-) electrode

S wave → depolarization wave the upper parts of the ventricles (+) to (-) electrode



→ Repolarization

T wave → repolarization of ventricles (-) to (-) electrode

the heart beat could be determine by $\frac{1600}{R\text{-}R \text{ interval}}$ → 1600 is the distance of the paper in a minute

R-R interval: the space between each contraction

in other words: $\frac{\text{the whole distance}}{\text{the distance needed for each heart beat}}$

60 – 90 normal
>110 tachycardia
<60 bradycardia

P wave represents the depolarizing of atri before its contraction
QRS represent the depolarizing of the ventricles before its contraction
T wave represent repolarizing of the ventricles

there is no electrical activity on ECG if the cells are completely depolarized such as between the QRS complex and T wave or completly repolarized such as between the T & P waves

* the ventricles contract until the heart completly depolarized so until the end of T wave.
* the atria repolarize when QRS is generated so it's not recorded on ECG.
* PQ or PR interval last 0.12 – 0.20 , Q-T interval → 0.35 – 0.45

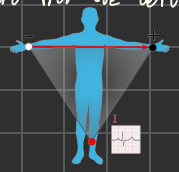
remember that depolarizing occur from the endocardium towards the epicardium, the last area to get depolarized is the base of the heart

Now lets discuss the leads of the ECG

① 3 bipolar leads look at the heart in frontal plane

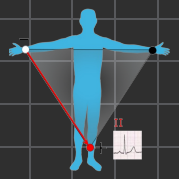
bipolar mean that the electrodiagram is being recorded by two electrodes, so the lead is not a single wire but a combination of two wires and two electrodes to make a complete circuit between the body and the electrocgraph

Lead I → when the negative electrode is connected to the right arm & the (+) electrode connected to the left arm, so when the right arm is (-) and left arm is (+) it will record (+) voltage, vice virsa, it looks at the heart from the left lateral side

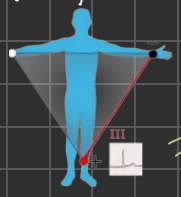


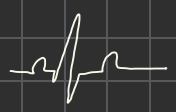
→ (+) electrode on apex & (-) electrode in the base

Lead II → when the (-) end of the electrocardiograph is placed on the right arm & the (+) end of the electro cardiograph is placed on the left foot → when right arm is (-) and left foot is (+) it will record positively, look at the heart from the inferior side

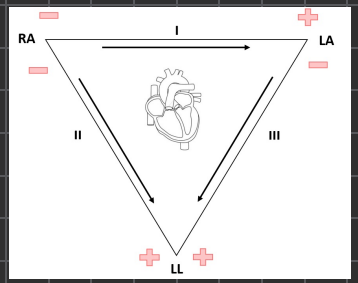


Lead III when the (-) end of the electrocardiograph is placed on the left arm & the (+) end is placed on the left foot so it will record positively when left foot is (+) & left arm is (-) looking at the inferior view of the heart





Eithoven's triangle



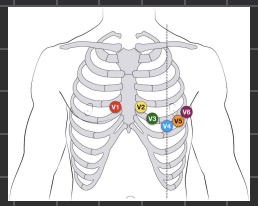
→ it's a triangle made up of the 3 leads so it's it has 3 equal sides, the two upper apices represents the right and left arm while the lower apex represents the left foot

Eithoven's Law state that if we know the the electrical potential of lead I & III ab anytime the sum of them will = the III lead so I + III = II

for arrhythmical diagnosis any lead could be used because it depend on the time relations between the different waves of cardiac cycle. but for diagnosis of atria, ventricles or Purkinje fibres which lead is used matter because it may appear normal in one lead & abnormal in other ones

lead II has the higher voltage strength because it's the difference between the potential on the right arm (the highest negative charge of the body) & left leg which is the highest positive charge of the body so as result greater potential difference → the fastest

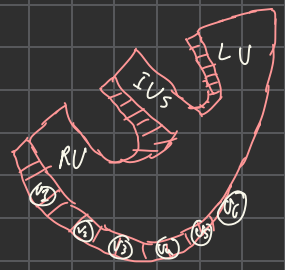
② 6 cheast leads unipolar → look at the heart in horizintal / transverse section
because the previous leads only look at the heart from lateral sides
we added new six leads which looks at the anterior & posterior sides of the heart V1 → right side of 4th intercostal spaace V2 → same as 1 but left side, V3 between 2 & 4
V4 → 5th intercostal space in middle clavicull line, V5 → 5th intercostal space in anterior axoillary line
V6 → 5th intercostal space in middle axillary line, they are all (+) electrodes



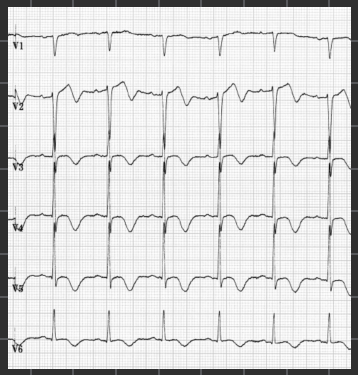
V1 & V2 the QRS complexs reading mostly negative because the chest electrodes in these leads are closer to the base of the heart which is the electronegative direction during depolarization so they are downwords on the ECG

while V4-V6 leads are near the apexs of the heart which is is the direction of electropositivity during most of depolarization so they are upwords

like we slice the heaart

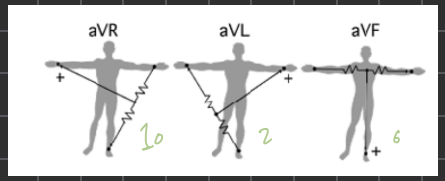


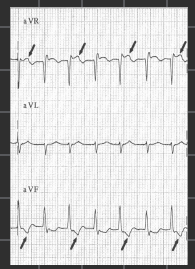
V1/V2 → septum electrical activity → ±posterior
V3/V4 → anterior part of ventricles
V5/V6 → left lateral wall



we can notice that V2, V4 & V6 is taller than the other leads and that is because the electrodes are closer to the heart than other leads (there is no lung or pleura that covers the heart in that area)

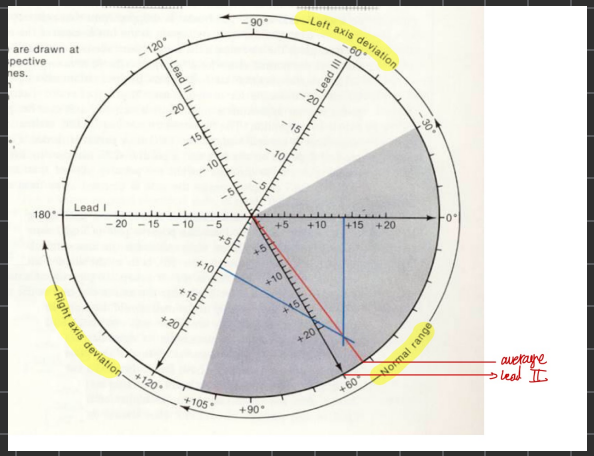
③ Augmented unipolar limp leads → look at the heart in frontal plane : they are unipolar limb leads while two of the limbs are connected through electrical resistances to the negative terminal of electrocardiograph & the third limb is connected to the positive terminal. giving
① aVR (+) on the right arm, looking at the right side of the heart
② aVL (+) on the left arm, looking at the left lateral of the heart
③ aVF (+) on the left leg, looking at the inferior side of the heart





the cardiac vector or axis

the depolarization wave or current flows from depolarized areas to still polarized areas, depolarization wave go from the endcardial surface to epicardial surface, where repolarization wave goes the opposite direction, that is why T wave is always up except in aVR



the gray area represent the normal range of the electrical axis of the heart

the range of cardiac axis is

-30 to +100

abnormalities of the cardiac axis

≤ -30 → left shift → inferior myocardial infarction or left branch block

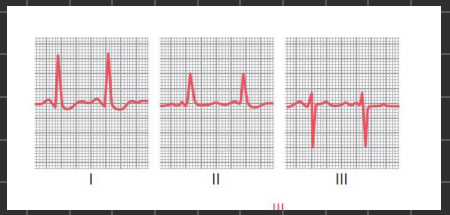
≥ 100 → Right shift → LV hypertropy or Right bundle branch block

why there is wide range

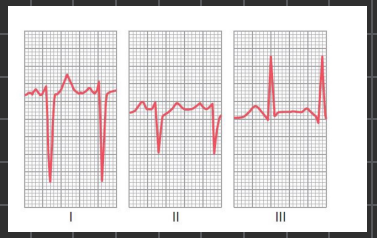
1) depend on the postion & rotation of the heart in individual
2) in short obese humans it tend to shift to the left
3) in tall thin humans it tend to shift to the right

For fast diagnosis we use this rule

in normal ECG the I II III leads should be up, and lead 2 has the highest voltage (length) but in case of left shift the III will be downword & lead I will be the tallest



Right shift cause I & III will be down & the III cause would be the tallest and upwards



Lecture Objectives:

1. Describe methods of recording ECG.
2. Explain the differences in QRST configuration in various leads.
3. State the right and left deviations of the electrical axis of the heart.

The machine ∴ electrocardiograph
The paper produced by the device ∴ electrocardiogram
The mechanism of ECG ∴ electrocardiography

The leads:

The electrical connections between electrodes placed on certain points on the patient's body and electrocardiograph for recording electrocardiograms.

how we apply the wires of ECG on the surface of the patient

Standard bipolar limb leads:

They are lead I, II, and III. Each records the differences in potential between two limbs. This means that the electrocardiogram represents a record of a potential difference between two locations on different sides of the heart.

Lead I → Rt. arm (-ve) and left arm (+ve)
Lead II → Rt. arm (-ve) and left leg (+ve)
Lead III → left arm (-ve) and left leg (+ve)

we have 3 ways to connect the electrodes in Einthoven triangle

I ⊕ on the left arm ⊖ on the right arm → lead one

II ⊕ on the left leg & ⊖ on the right arm → lead two

III ⊕ on the left leg & ⊖ on the left arm → lead three

→ standered bipolar limb leads

difference in voltage between 2 points

* no difference between the shoulder & the arm
  → same electricity

any sum of two leads = the third one

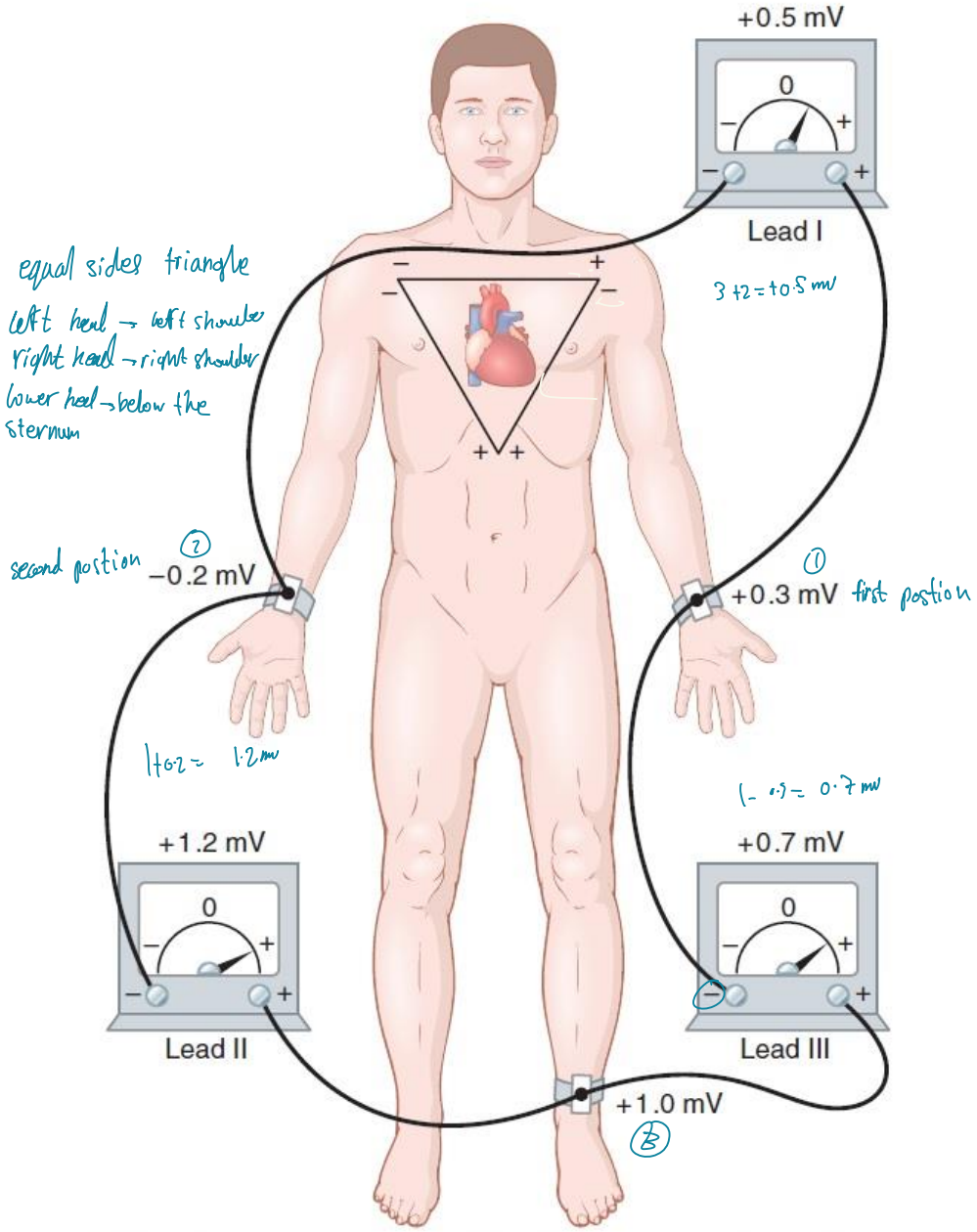
Einthoven's triangle

A diagrammatic equilateral triangle surrounding the heart in which the base of the triangle is directed upward and the head is down. The upper two apices of the triangle represent the electrical connection of the two arms (Lead I). The lower apex is the point at which the left leg connects.

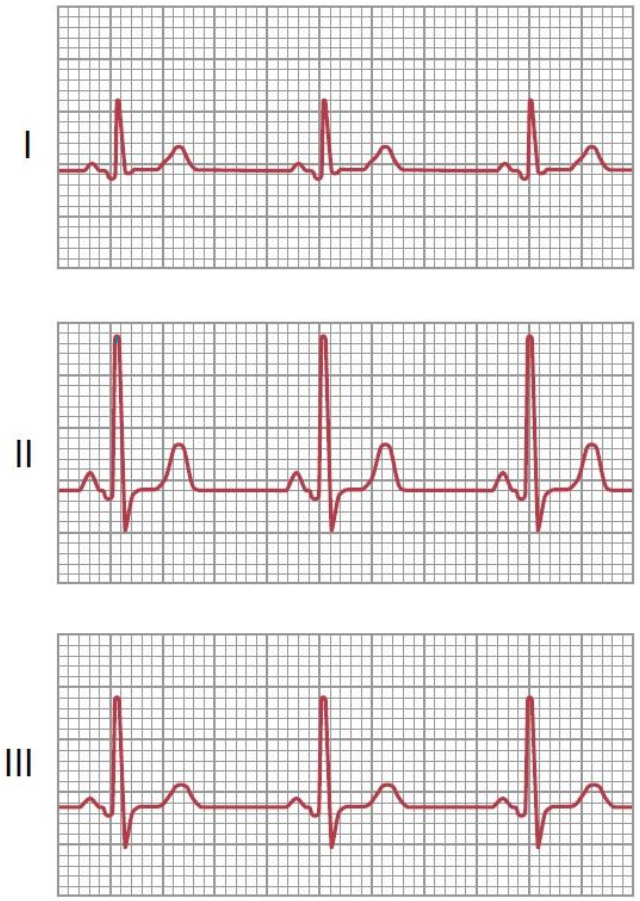
Einthoven's law:

voltage in Lead I + Lead III= voltage in Lead II

the most negative region of the body is the Right shoulder & the most positive region is epigastric region thats why lead II is the higher voltage between the leads



Conventional arrangement of electrodes for recording the standard electrocardiographic leads. Einthoven's triangle is superimposed on the chest.



Normal electrocardiograms recorded from the three standard electrocardiographic leads (I–III).

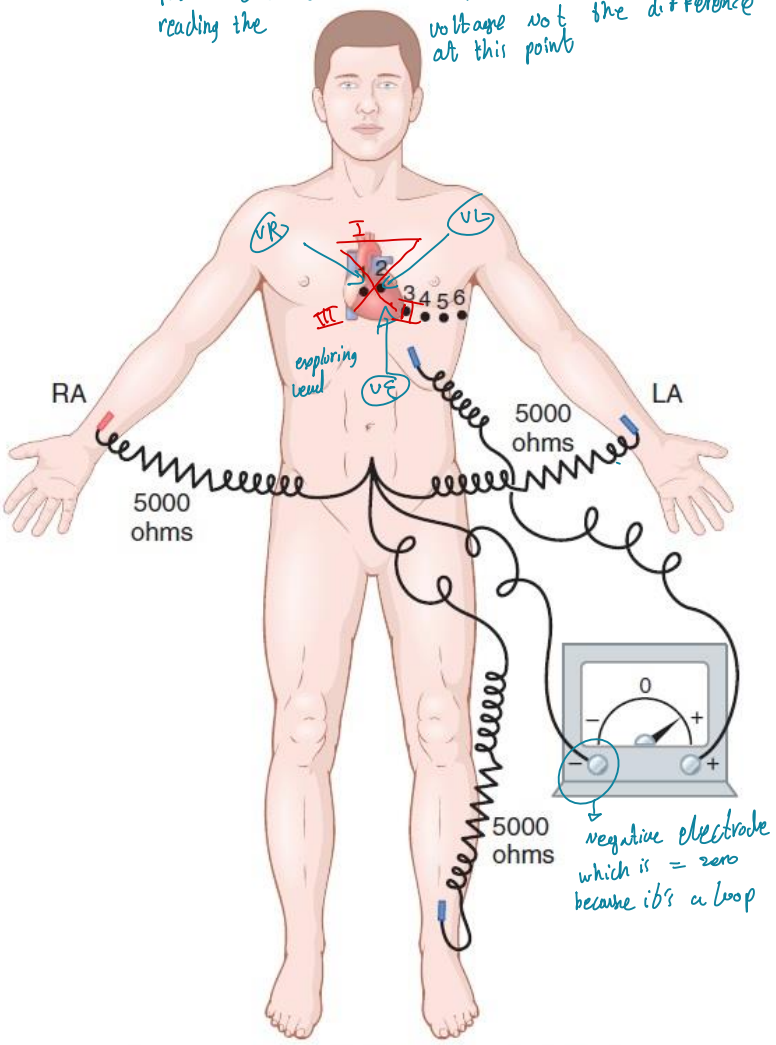
The Unipolar (V) leads

why many electrode? allow us to look at the heart from different sides

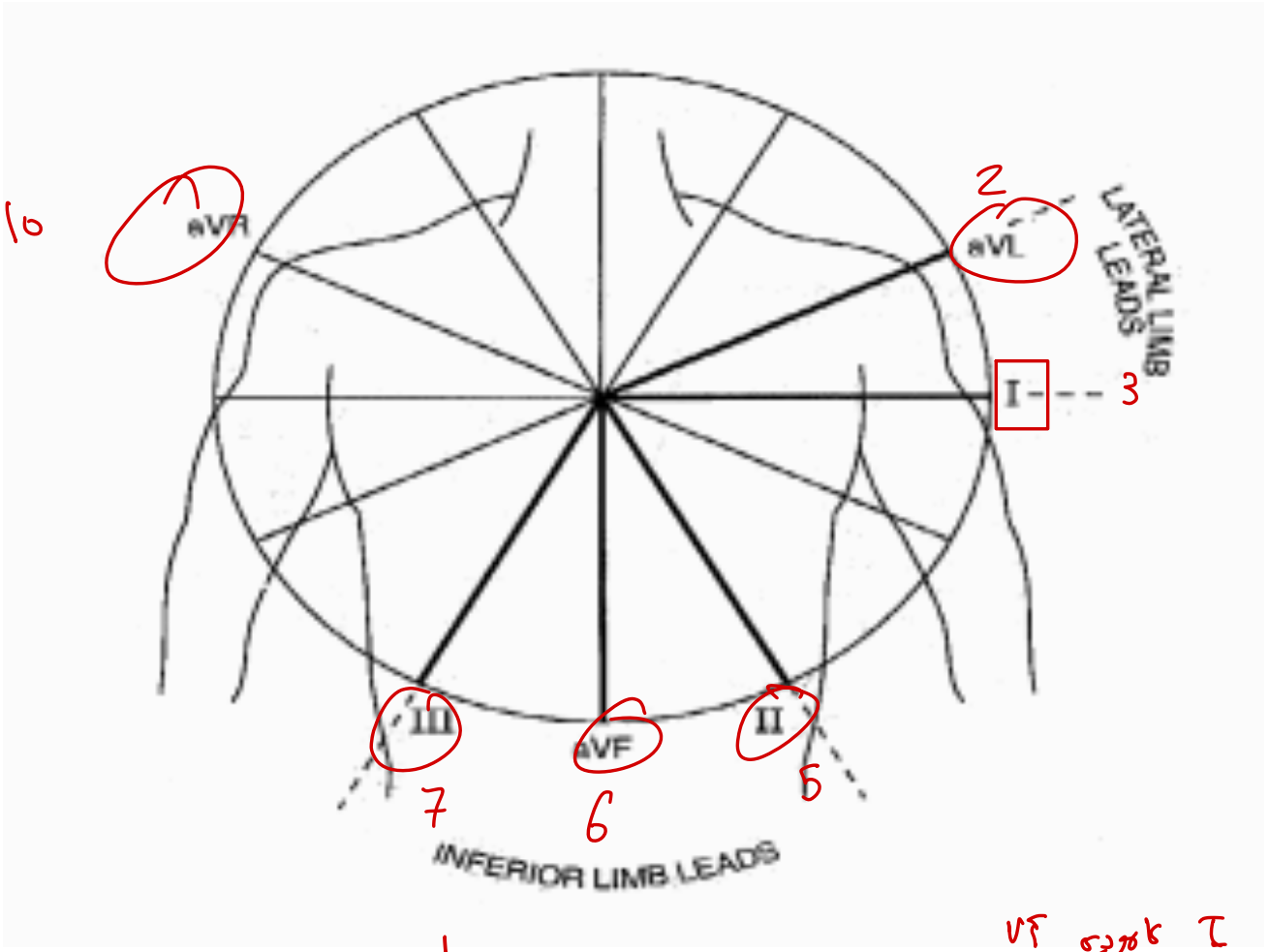
or the V lead

- The unipolar lead records the potential difference between an exploring (+ve) electrode and an indifferent (-ve) electrode.
- They are nine leads, six unipolar chest leads (precordial leads) designated V1-V6 and three unipolar limb leads; VR, VL, and VF.
- Some special unipolar leads are also used in medical practice. (Note that; VR+VL+VF= O).

So when we sum the difference in voltage where the start & the end is the same point it will = zero so the negative electrode will always = zero and the positive electrode will read depend on the postion reading the voltage not the difference at this point



Connections of the body with the electrocardiograph for recording chest leads. LA, left arm; RA, right arm.



10

2

3

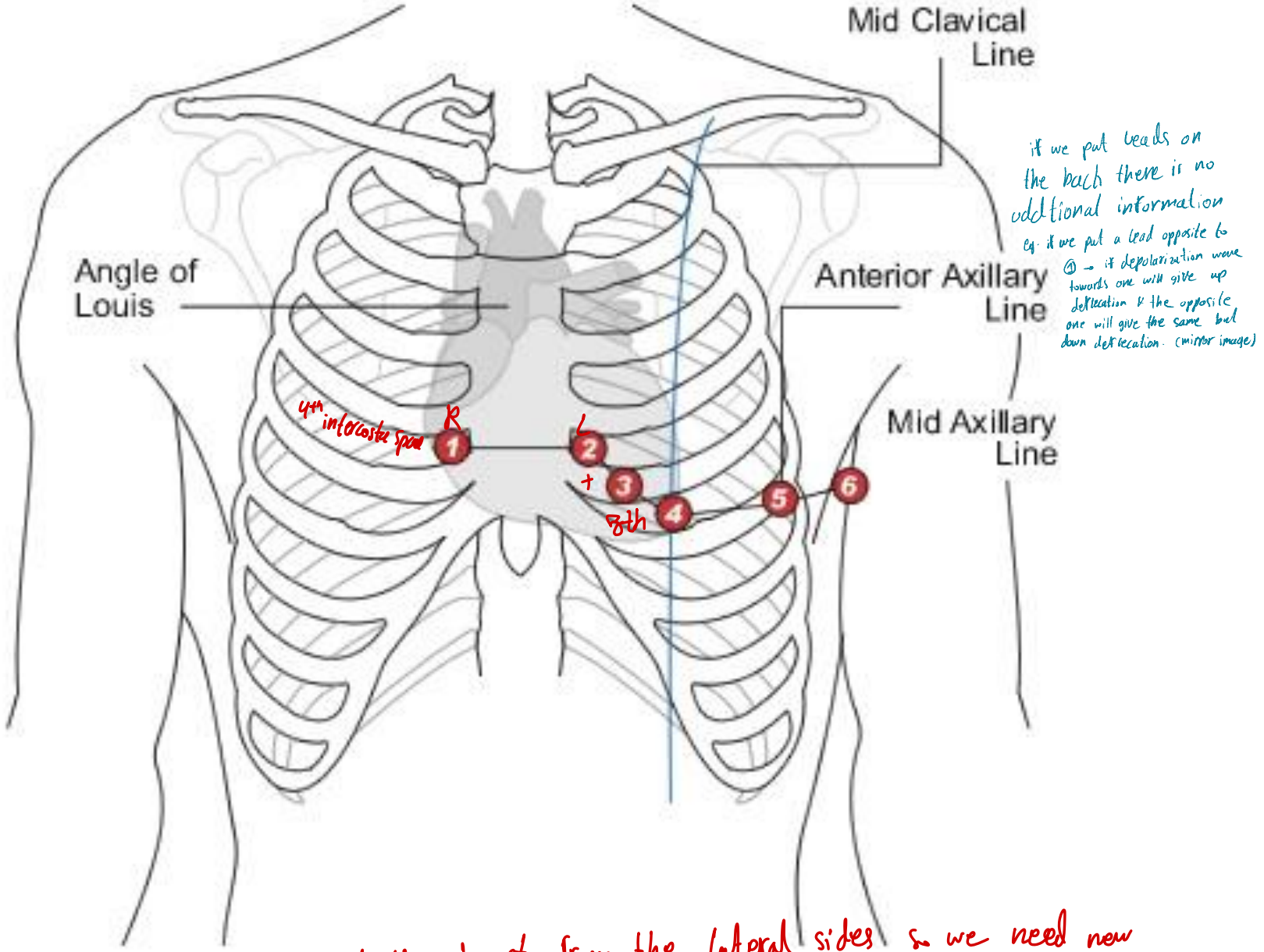
7

6

5

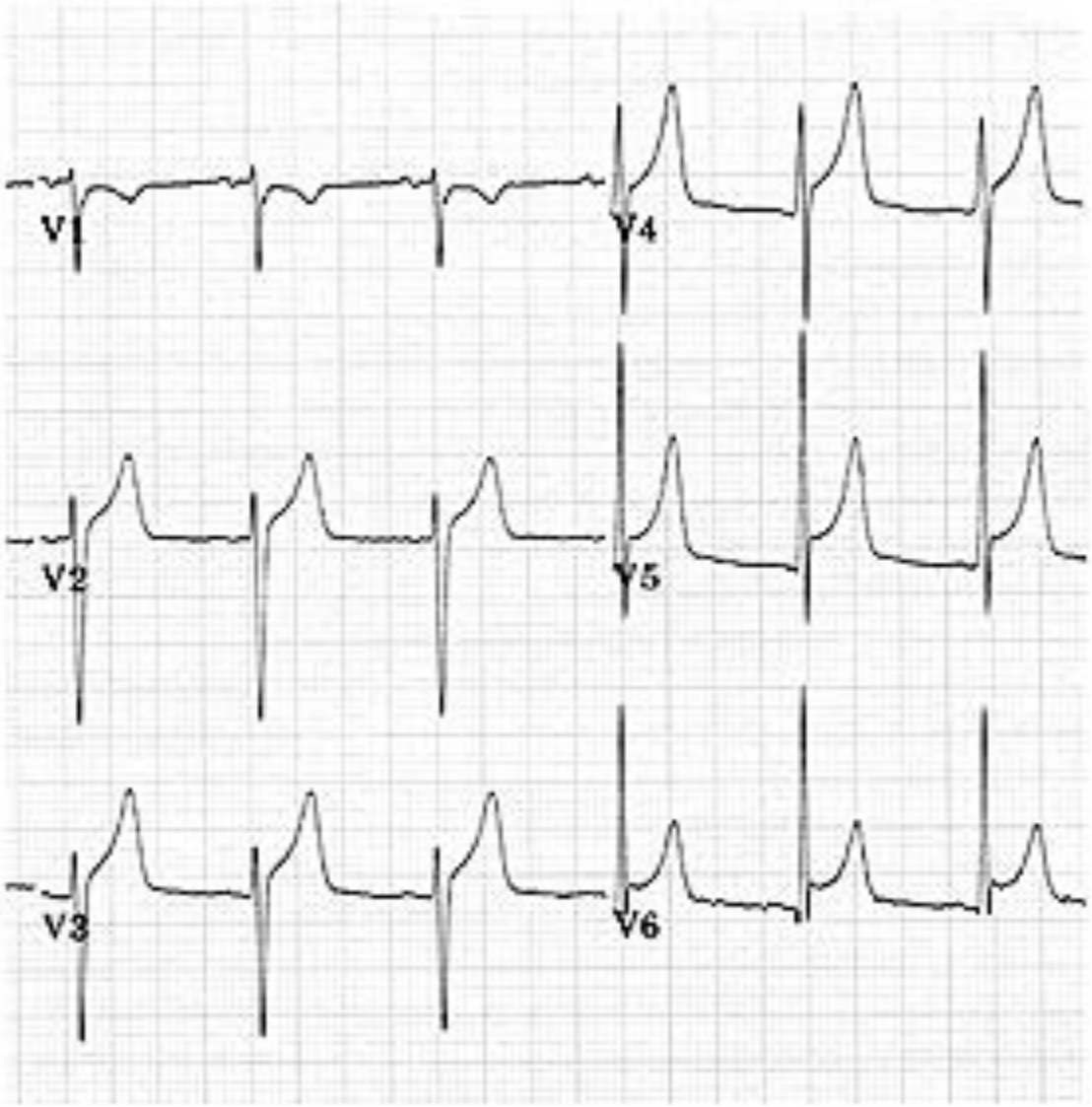
vertiche plan leads

I لیدهای اندام
II لیدهای VL
III لیدهای VR



if we put leads on the back there is no additional information
eg. if we put a lead opposite to ① → if depolarization wave towards one will give up deflection & the opposite one will give the same but down deflection. (mirror image)

the previous leads only look at the heart from the lateral sides so we need new leads to look at the anterior & posterior part of the heart. so the total leads are 12
6 → vertical 6 → horizontal



direction depend on the direction of depolarization wave

why the voltage increase in V2, V4 & V6 ?

because the heart is close to the electrode → only the chest wall while the other leads there is the lungs

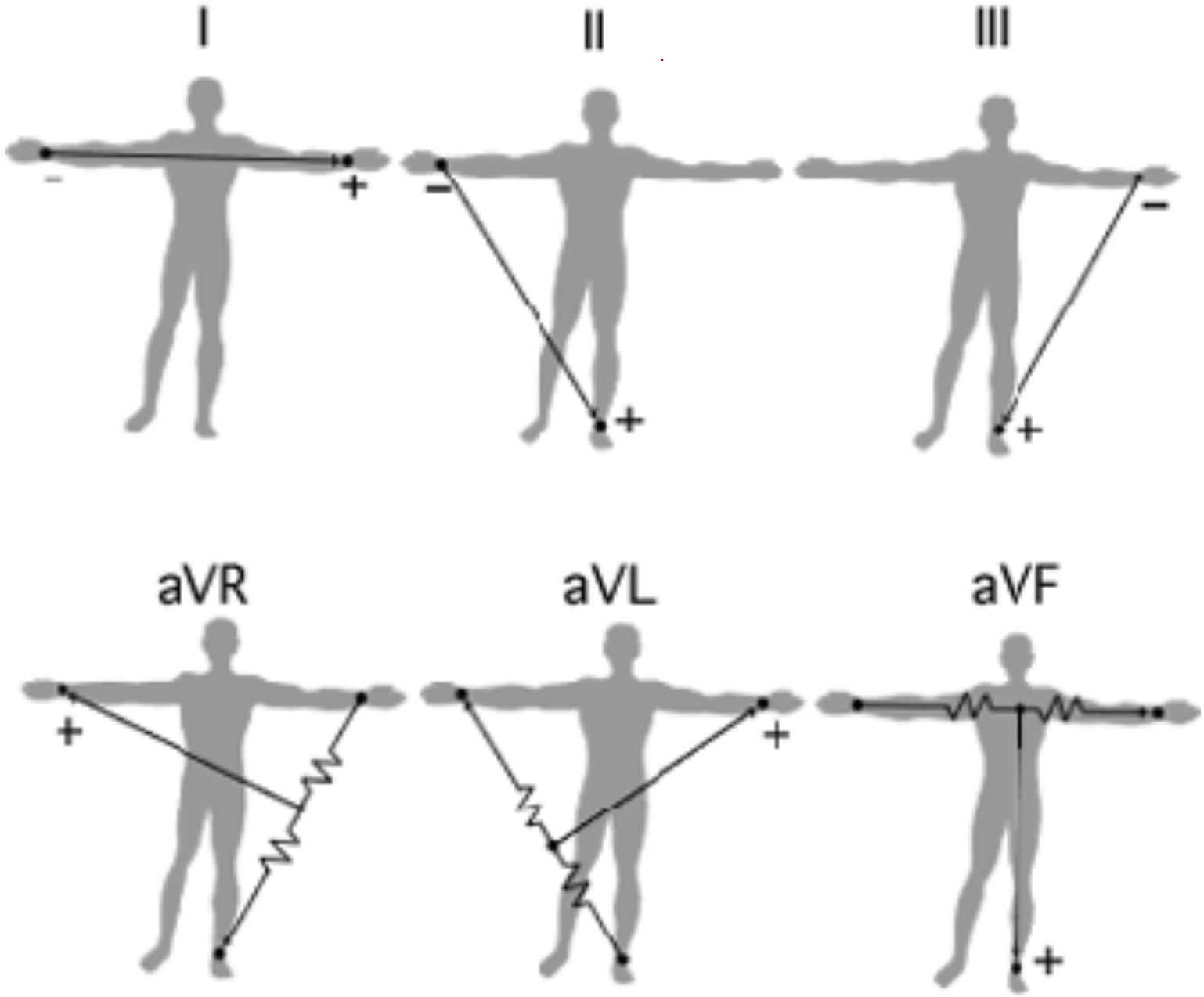
Augmented limb leads

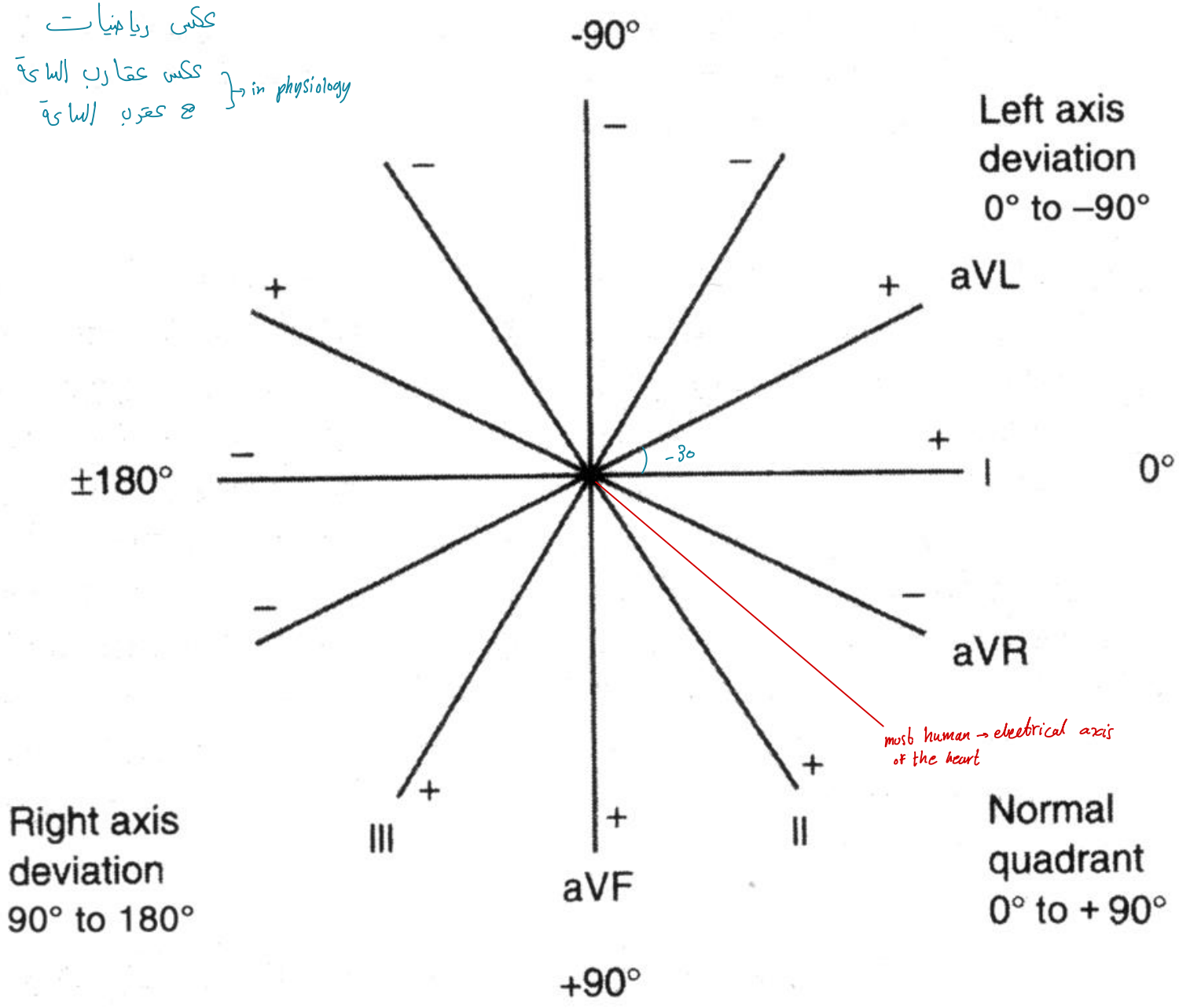
They are aVR, aVL, and aVF. The augmented limb lead records the potential difference between one apex and the other two apices of Einthoven's triangle. Such connection increases the size of potentials by 50% without any change in configuration from the non-augmented record.

so to not put two wires on one point when we measure the VR, VL, VF so they remove the wire on the right shoulder from the 3 wires of the negative electrode the result will be the same but augmented

Note:

1. Any lead can be used to diagnose cardiac arrhythmias → passing of AP or depolarization wave from the SA node to the conducting system
2. Diagnoses of damage in the ventricular or atrial muscle, or in the Purkinje conducting system requires to decide which lead is involved, since some leads can record the abnormalities in conduction while others may not be affected.


I
II
III
aVR
aVL
aVF



عكس رياضيات

(-) عكس عقارب الساعة
(+) مع عقرب الساعة

} in physiology

The cardiac vector or axis

electrical axis of the heart

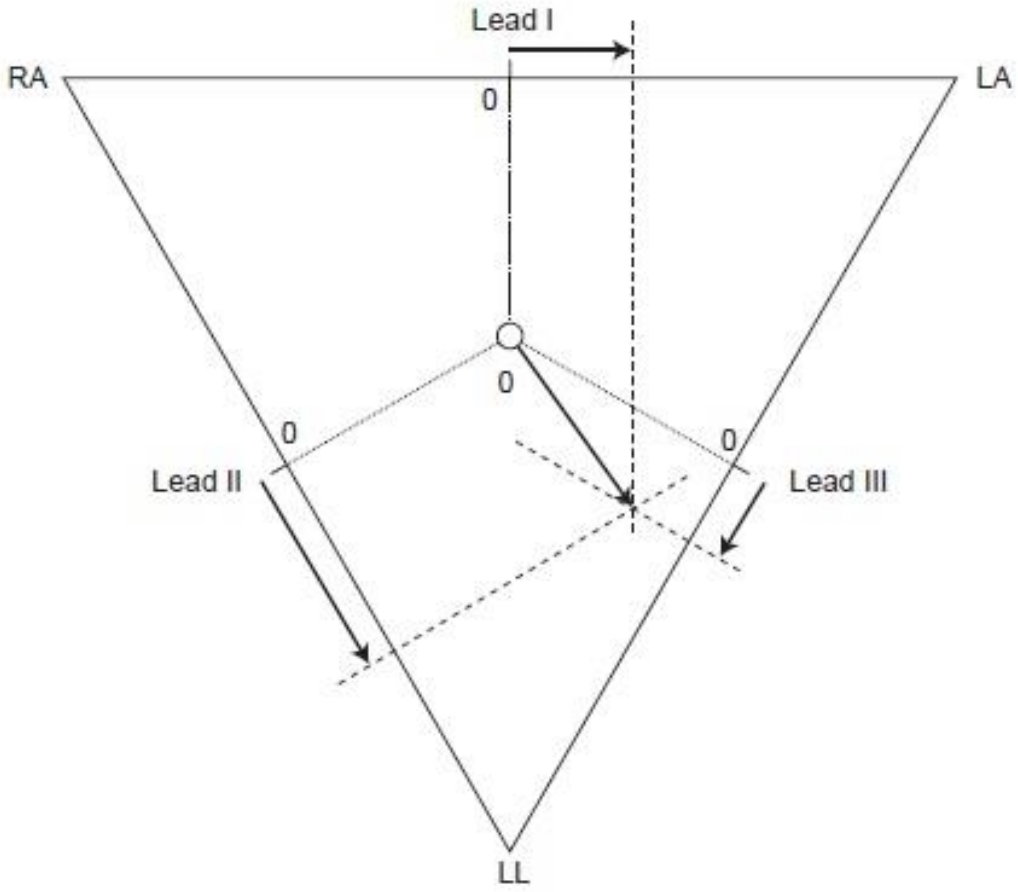
- The depolarization wave or current flows from the depolarized toward the still polarized areas. Depolarization starts from the endocardial surface toward the epicardial surface, whereas repolarization runs in the opposite direction. That's why the direction of the T wave is always up (except in aVR).
- The vector is the summated generated potentials. It is represented by an arrow. The mean QRS vector is about +59 degrees, directed from the base of the heart toward the apex, i.e. the apex of the heart remains +ve with respect to the base of the heart. The vector can be drawn by using the hexagonal reference system.

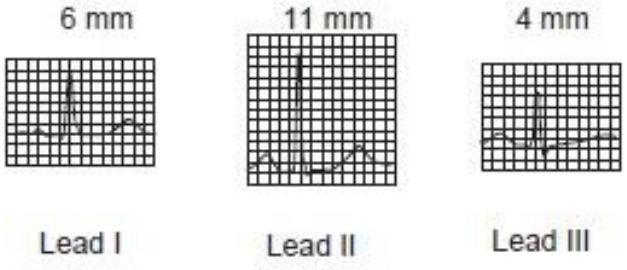
almost same as lead II

- Normal range: -20° to +100°

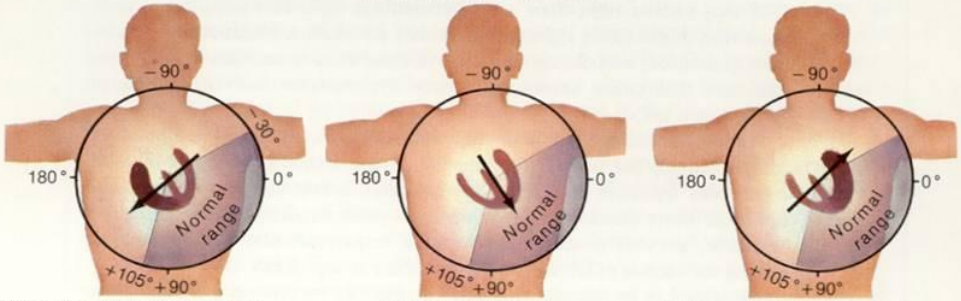
Axis ≤ -30° → left axis deviation (e.g. left bundle branch block and inferior myocardial infarction).

Axis ≥ +110° → Rt. axis deviation (e.g. Rt. vent. Hypertrophy and Rt. bundle branch block).


Lead I
RA
LA
0
0
0
0
Lead II
Lead III
LL


6 mm
11 mm
4 mm
Lead I
Lead II
Lead III

Electrical Axis of Heart



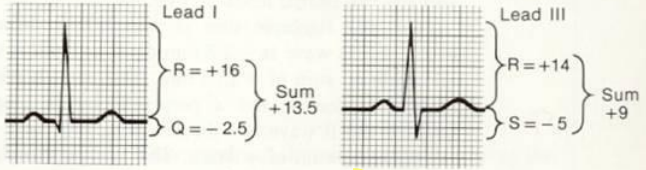
Right axis deviation: ≥ +105°, e.g., chronic obstructive lung disease and pulmonary hypertension

Normal electrical axis: −29° to +105°

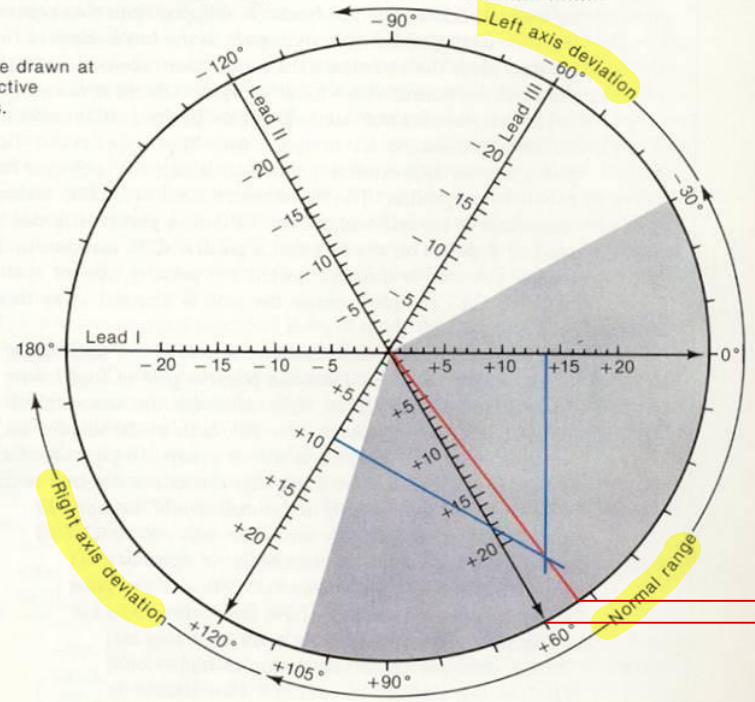
Left axis deviation: ≥ −30° (more negative), e.g., hypertension or aortic stenosis with major left ventricular predominance

Triaxial reference (vectorial) method of axis determination

Sum of QRS in mm in lead I and lead III (or in leads I and II) is determined and plotted on vectorial diagram below



Perpendiculars (blue) are drawn at plotted points on respective vectorial reference lines. Line (red) drawn from central point through intersection of perpendiculars gives electrical axis (in this case about +53°, which is within normal range)



the gray area represent the normal range of the electrical axis of the heart

average lead II

Clinical Significance of axis deviation:

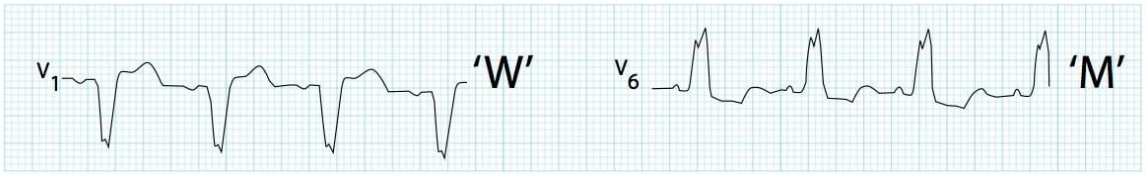
- Changes in the mean electrical axis may occur if the anatomical position of the heart is altered, if the relative mass of the right or left ventricle is enlarged (as it is in certain cardiovascular disturbances), or if there is conduction defects.
- Normally the axis tends to shift toward the left (more horizontal) in short, stocky (obese) individuals

why the range is large

- Normally the axis tends to shift toward the right (more vertical) in tall, thin persons.

also same human the electrical axis may change depend on their position eg. when we are standing it's more vertical, during pregnancy

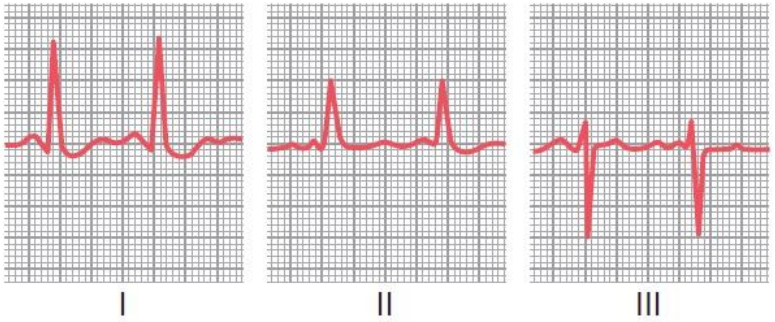
- The axis shifts toward the left in left ventricular hypertrophy, left anterior fascicular block (or hemiblock) and in left bundle branch block. This results in 'M'-shaped R wave in the lateral leads (i.e. lead I, V_5, and V_6) with absence of Q waves.

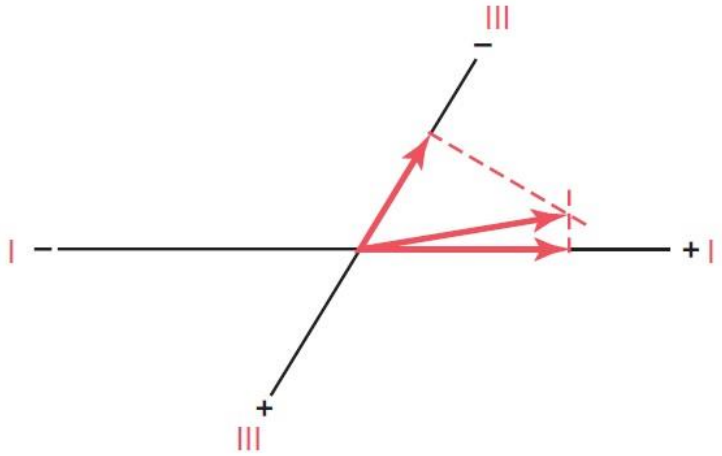


to leads on the R wave

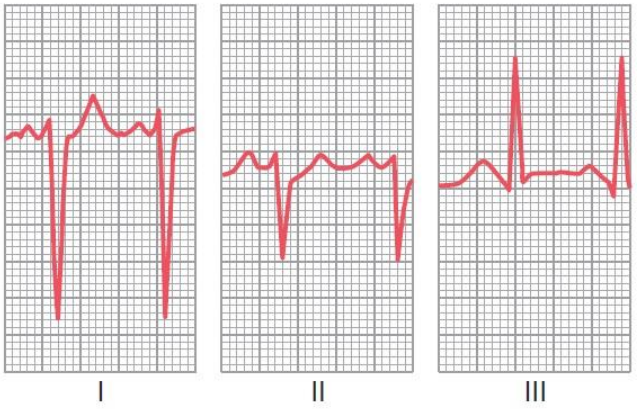
- The axis shifts to the right in right ventricular hypertrophy, in left posterior fascicular block or in right bundle branch block.

in normal ECG the I II III leads should be up, and lead 2 has the highest voltage (length)
but in case of left shift the III will be downward & lead I will be the tallest

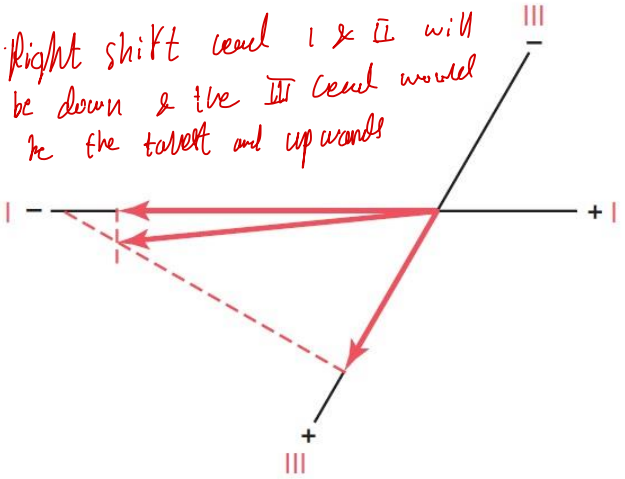




Left axis deviation in a *hypertensive heart (hypertrophic left ventricle)*. Note the slightly prolonged QRS complex as well.



Right shift lead I & III will be down & the III lead would be the tallest and upwards



A high-voltage electrocardiogram for a person with *congenital pulmonary valve stenosis with right ventricular hypertrophy.* Intense right axis deviation and a slightly prolonged QRS complex also are seen.

Test Question:

Q. The 'T' wave in ECG is above the isoelectric line because of?

A. Depolarization of ventricles

B. Depolarization of bundle of His

C. Repolarization of Purkinje fibers

D. Effect of the AV node on the conduction of the depolarization wave from atria to ventricles

E. The direction of ventricular repolarization wave is opposite to that of depolarization