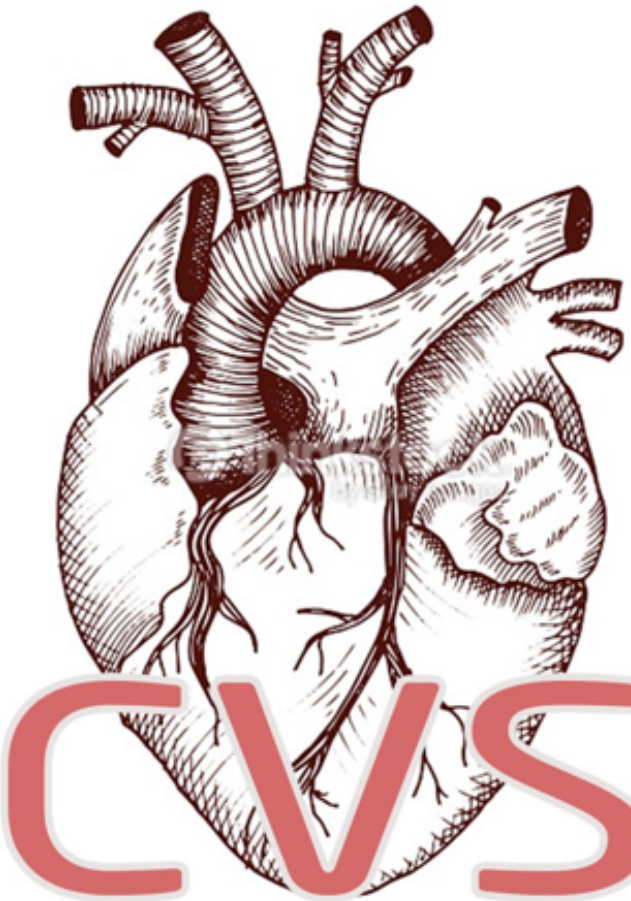

CVS

Physiology

♡ Slide Sheet ♥

Number:	7
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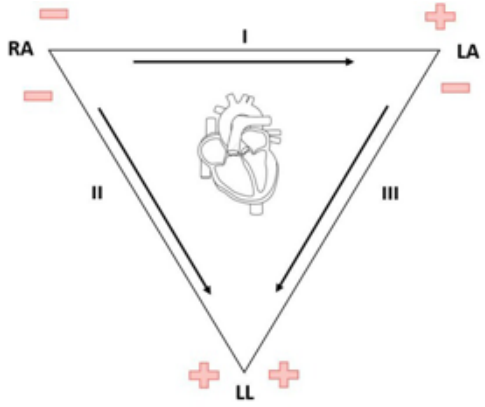
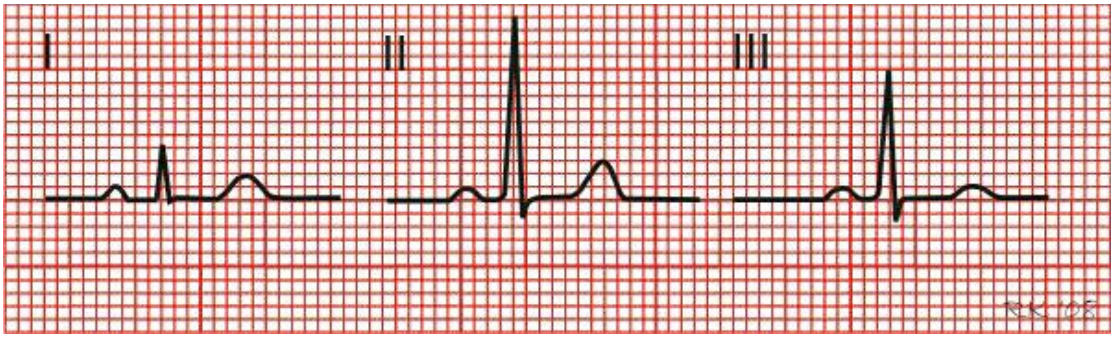
When you want to look to the heart, you have to look at the heart from different views, that's why we make electrical recording at different places.

Bipolar limb leads (we call them bipolar because we use two electrodes, positive and negative):

Lead I → between Rt. Arm (-) & Lt. Arm (+)
Lead II → between Rt. Arm (-) & Lt. Foot (+)
Lead III → between Lt. Arm (-) & Lt. Foot (+)



Remember the rule which tells us that all the electrodes on the left foot are positive, and all the electrodes on the right arm are negative (We do this arrangement in order to have positive recording).



The right foot is considered earth point, for electrical discharge.

If we switch the electrodes, we will get reverse recording. And we put them like that to have positive recording in these 3 limb leads (this is what we call bipolar limb leads).

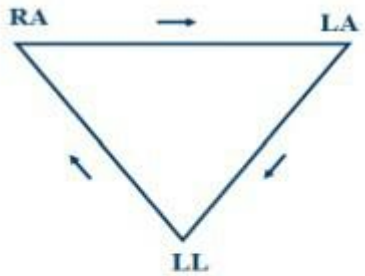
Einthoven thought that you might draw a triangle around the heart, making an equilateral triangle. The sides of this triangle are between the right arm, left arm and left foot (The heads of this triangle represent the RA, LA and LL), with the heart at the center. An equilateral triangle is also equiangular; and here you must know that all three internal angles are 60 degrees, also that the midpoint of this triangle is a midpoint for a circle that you can draw around this triangle in addition to that when you draw a perpendicular line from the midpoint to the sides you are going to half the sides. You will see that you are going to put an electrode on the right foot for electrical discharge.

The current usually goes from the negative to the positive direction, as we know it is a vector (has a direction & magnitude (value)).

Einthoven says that the QRS algebraic summation: when you add the QRS (in positive or in negative); QRS in lead II equals the QRS in lead I + the QRS in lead III and this is called Einthoven's law.

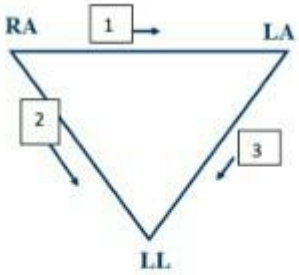
Einthoven's triangle and law

If ELECTROCARDIOGRAMS are taken simultaneously with the three limb LEADS, at any given instant the POTENTIAL in lead II is equal to the algebraic sum of the potentials in leads I and III.



According to Kirchoff's law:
LI + LII + LIII = 0

Because the three vectors are forming a closed network.



As the direction is changed in this case:

LI+ LIII + (-LII) = 0
→ LII = LI + LIII

Second kirchoff's law: if a current goes in a circle, the summation of the currents of lead I, lead II and lead III equals zero. Einthoven reverses the direction of lead II; so there is no circle.

Depolarization of the ventricles (atria are not that important like ventricles), starts from the septum, then it spreads to the right and left ventricles. The last part of the heart to be depolarized is the posterior aspect of the left ventricle. When the way of depolarization goes on, there are always vectors from the depolarized to the still polarized areas; the heart is a hollow organ so the vectors move in all directions. So there will be a resultant vector for all those vectors, and in order to see its value on X, Y & Z axes, we have to draw a perpendicular line on each axis to know the value of the **resultant** on the axis and then from the center to the point where they met, we draw another line between them which is the **resultant vector.** After that we analyze it by drawing perpendicular lines on these axes.

Why we call it EKG? The first people invented it (Einthoven's) were German, and in German cardiology is written with K not with C, but in English we never use K.

Depolarization is followed by contraction, and repolarization is followed by relaxation.

Note: The resultant vector is directed downwards, leftwards and anteriorly.

When the positive vector is directed towards the:

- Positive electrode, it will be recorded as a positive deflection.
- Negative electrode, negative deflection.
- When there's no current flowing, there would be an isoelectric line.

Remember that (P-R) interval is the time of conduction of the impulse between atria and ventricles, normal P-R interval is 0.16 sec, and if it is prolonged, we suspect AV block; **Third Degree.**

There are three degrees of AV block :

1. **First Degree; Incomplete AV Block:** If P-R interval is > 0.20 sec.
2. **Second Degree; Incomplete Block:** P-R interval increases to 0.25-0.45 sec.
3. **Third Degree Complete Block:** Total block through the A-V node or A-V bundle.

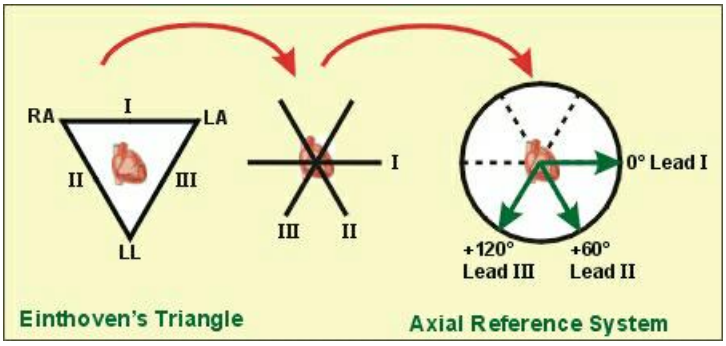
HR=37

(Q-T) is around half the value of cardiac cycle.

After the end of depolarization, we calculate the resultant. When depolarization of the ventricle ends, we record the QRS wave, so we summate the QRS after making the resultant. We can do it in the reverse direction; I know the ECG and I know lead l, ll and lll, I will make algebraic summation of lead I QRS also for II and III and then I got the resultant and draw the diagram.

We want to draw all of these axes in order to meet at one point, how to make them meet at one point without changing anything? I will not change the value and without changing the direction, I will transfer them parallel.

After moving lead l, ll and lll (without changing neither magnitude nor the direction) they meet at the center, we call it **trigonal axis** .This is the advantage of equilateral triangle.

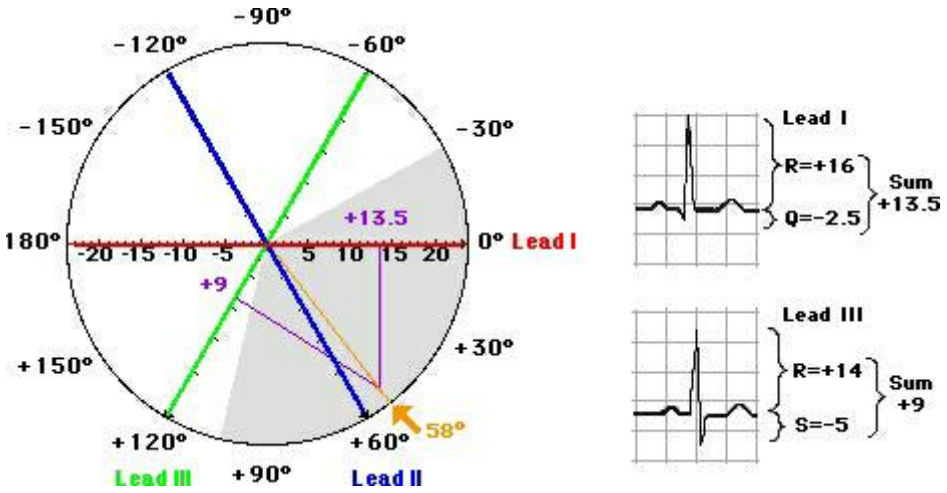


This is the advantage of the equilateral triangle, we move them in the same distance without change anything because the distance from the center to the sides is the same, the angles between them= 60.

We begin from zero in Lead I to 60, 180...etc.

Mean Electrical Axis of QRS complex= resultant (ventricular depolarization)

The normal physiological range is between **-30** and **+110**, and it is clinically between **0** and **+90** (easier). So if the mean electrical axis of your cardiogram is between **-30** and **+110 you are normal.** The average is **+60 (+58).**



Augmented Unipolar Limb Leads (between zero and positive electrode)

Here, we use the three limbs as the bipolar leads but the difference is that we connect two of the limbs to the negative electrode (with high resistance about 500ohme so the current there is almost zero), and the third to the positive electrode of the galvanometer.

We call the positive electrode → recording/exploring electrode
Negative electrode→ indifferent electrode

We put the positive electrode on the right arm and this is called vector right arm VR and other time we put it on the left arm we call it VL, on the third time we put it on the left foot VF these are the three unipolar limb leads. Goldberg put the names, Welson tried another thing; when he wanted to measure the current of the right arm he just removed the high resistance from the right arm so the high resistance now is on the left arm and on the left foot he found the recording augmented ”increased” the next time when he wanted to measure from the left arm he just left the high resistance of the right arm and the left foot and removed the high resistant from the left arm also he found it augmented and when he

wanted to measure from the left arm he left the high resistance from the left arm and right arm and removed from the left foot and he measured the left foot also he found it augmented he recorded these three and he called them aVR, aVF and aVL (source of electricity is from the center of the triangle "heart", they are unipolar limb lead between the zero (negative electrode (indifferent electrode) connected with the very high resistance and the positive electrode (exploring electrode/recording electrode) we put it in different places).

The idea here is that we connect the two limbs to the negative electrode through very high resistance (5000 ohms). So, there would be no current moving because of the high resistance and the voltage will be almost zero.

The third limb is connected to the positive electrode and its voltage is thus recorded.

- **aVR** → Right arm to the positive electrode and the other two to the negative.

The positive electrode is attached to the right arm (i.e. the resultant vector is against the positive electrode), so the recording would be negative.

- **aVL** →Left arm to the positive and the other two to the negative.

- **aVF**→ Left foot to the positive and the other two to the negative. (20-30)

Remember that the six limb leads (**Normally we have 6 chest limbs (c=chest)(v=vector))** we talked about are recorded at the **frontal** plane.

We can use any pair of these limb leads to measure the mean electrical axis.

And because the electricity travels in all direction within the heart, we can also analyze it in the **horizontal** plane by what we call it **unipolar chest leads.**

C1 we put it in the right side parasternal, right 4th intercostal space

Opposite to it in the left side we put **C2** 4th intercostal space parasternal left side

C3 we determine the surface anatomy by 2 lines perpendicular line and horizontal line, midpoint between C2 and C4

C4 we put it in the midclavicular 5th intercostal space

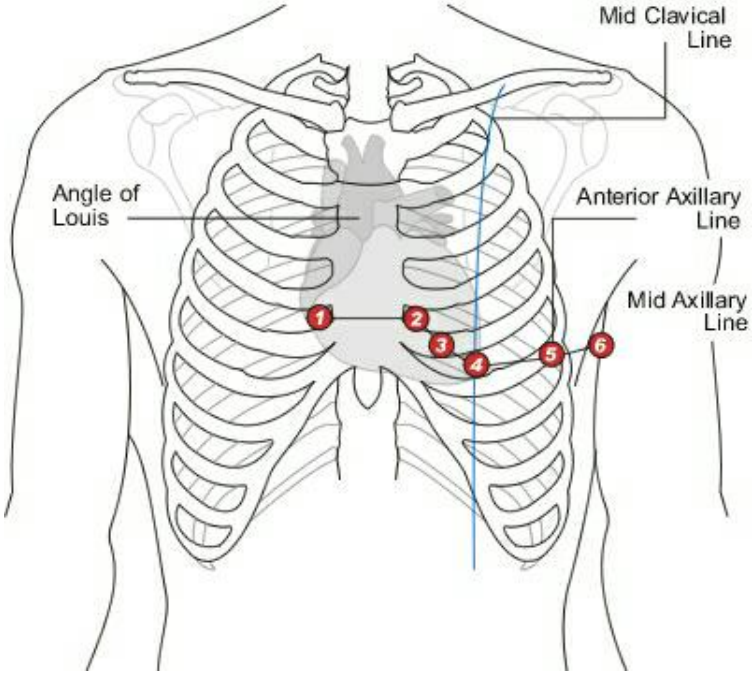
C5 we put it anterior axillary, 5th intercostal space.

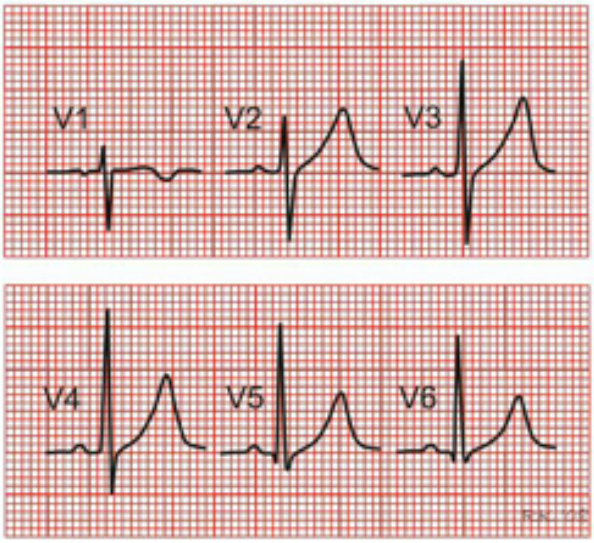
C6 mid axillary, 5th intercostal space.

Unipolar chest leads

Here the positive electrode is placed on the anterior surface of the heart and the negative electrode is attached to the three limbs with very high resistance.

We have six chest leads:





3 bipolar and 3 unipolar, we use 2 limb leads to measure the mean electrical axis weather they are bipolar or unipolar, we use either lead I lead II, lead III, aVR aVL. We see what is the value on each lead and draw a perpendicular line between the center and intersection point.

If they are negative so the heart is on the right side (something abnormal), the current goes to positive but if the current progress in the opposite side from the positive; negative results of aVR because the mean electrical axis is going away from the positive electrode

Important note: The first two chest leads have a negative recording because they are opposite to the positive electrode. However the last three leads have positive recording because they are going toward the positive electrode.

What does it mean if you find the ECG for someone inversely? The patient may have **Dextrocardia**. (We know that when we make ECG).

In some cases you might suspect that there is something abnormal in the posterior aspect of the heart and you want to check so you can put the positive electrode on the esophagus just behind the heart because it is very close to the heart (**esophageal leads**) we don't do it regularly only in some cases.

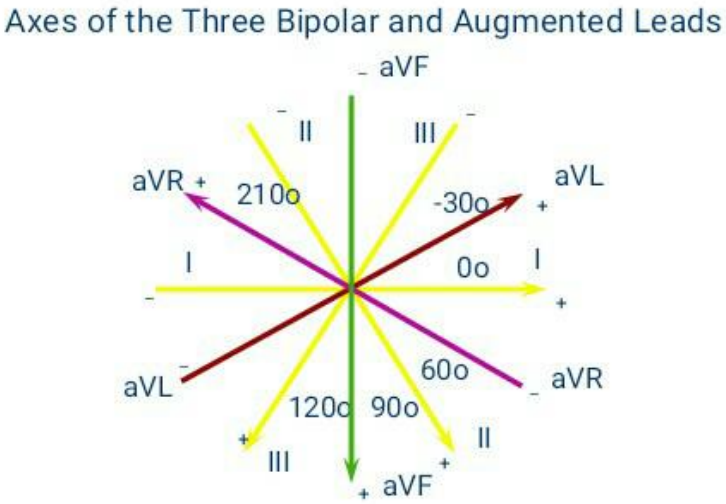
So totally we have 12 leads, aVR positive it record negative on the right arm, aVL positive electrode on the left arm record positive but not too

much positive, aVF is more positive because it is in the same direction (they are unipolar).

Chest leads: mean electrical axis goes to the left and anteriorly, V1 negative, V2 negative, V3 the same - in the meddle-, V4+V5+V6 positive because they are going toward the positive electrode. There is no angle in the chest lead, transverse or horizontal plane. Chest leads are unipolar.

Bipolar=3 leads

This the triangle p wave= atria, QRS= ventricles, T wave= repolarization of the ventricle



The angle between lead l and aVF is between 0 and +90°.

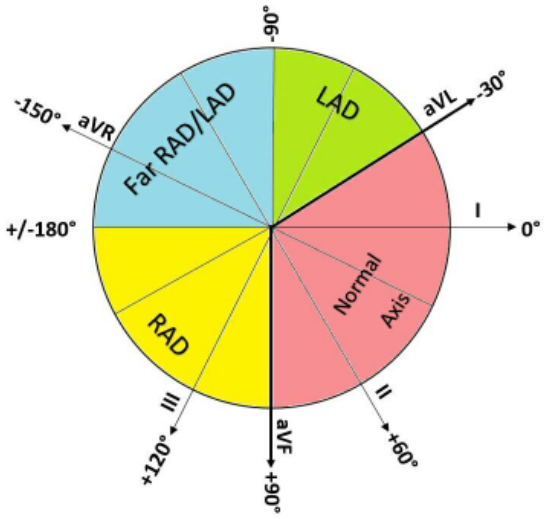
aVR and aVF between the center and the right arm, between the center and the left arm, between the center and the left foot.

The normal clinical range of the mean electrical axis of the QRS is between 0 & +90°, physiologically between +110 and -30

Right axial deviation: when lead l is negative and aVF is positve. Between 0 & +180.

Left axial deviation: when lead l is positive and aVF is negative. Between 0 & -90.

Far RAD/LAD: when lead l & aVF are negative= severe left axis deviation. Between -90 & 180



"Wear gratitude like a cloak and it will feed every corner of your life"