The Cardio-VASCULAR System

- ○ Anatomy
- ○ Histology
- ○ Pathology
- ○ Pharmacology
- ● Physiology
- ○ Microbiology

Lec #: 6

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- ○ Handout
- ● Sheet
- ○ Slide

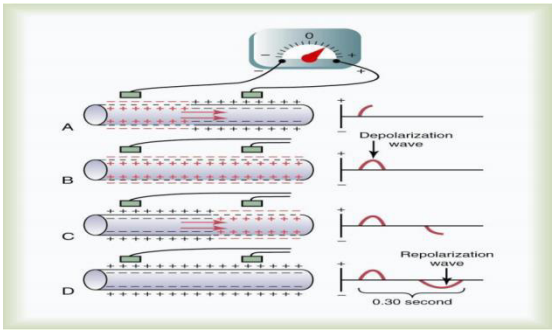
ELECTROCARDIOGRAPHY

What we have taken so far:

***normal ECG:** is recording the electrical changes of the heart.

****what are the electrical changes in the heart:** depolarization of atria, repolarization of atria, depolarization of ventricle and repolarization of ventricle.

*****distinguish between depolarization and repolarization waves**



****when I write rep:it mean repolarization ,,,and dep =depolarization**

*****imp terms:**

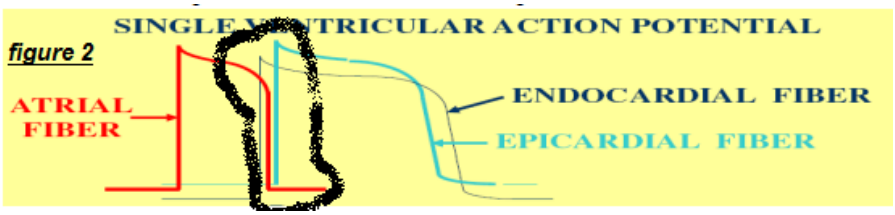
#PQRST: waves seen in ECG

P: dep of the atria,signal onset(اشارة البداية)of atrial contraction

QRS: dep of ventricle, signal onset (اشارة البداية)of ventricular contraction

T:rep of ventricle

****the repolarization of the atria is missing, why?** Because it happen at the same time of ventricular depolarization (QRS complex) so it is masked by it (look at figure 2), only in case of AV block it appears and it appears as downward deflection

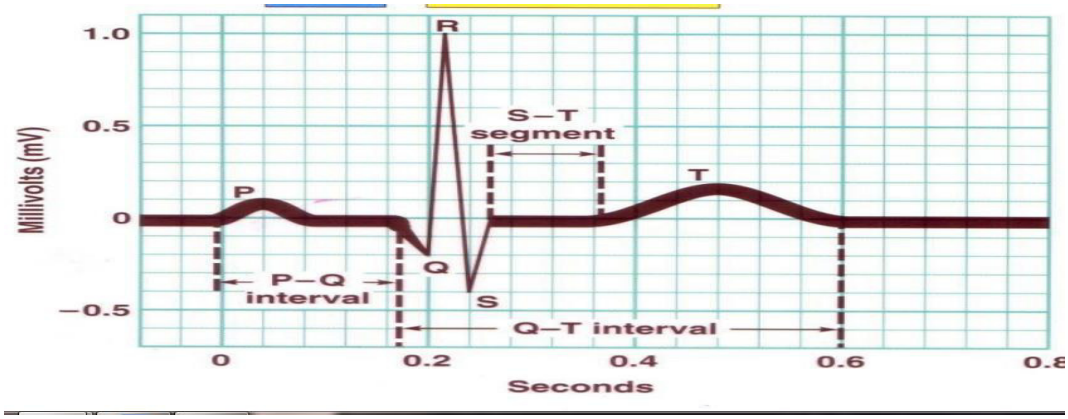


***interval (it include waves) ////segment (don't include wave)**

**PQ or PR interval*: time between the beginning of atrial contraction and the beginning of ventricular contraction contraction (if PR is prolong {more than0 .2s} then it means AV block and we can see the atria rep.

**QT interval: ventricular contraction (ventricular dep &rep), its time is variable (heart rate is faster then QT is shorter, if heart rate is slower then QT is larger)

***ST segment: if it shows upward or downward deflection (انحراف) then it means ischemia



**we talked about standardized ECG paper (to understand better look at this video)

https://www.youtube.com/watch?v=4UO84aJP4LI)

***we can calculate heart rate from ECG:

Heart rate=#beat /time

1 beat is 1 cardiac cycle and it is 1 RR interval

***If RR interval is 1 sec(1/60min)

1 beat →1/60 min

??-→ 1min

ضرب تبادلي so the heart 60 beat /min

Heart rate=beat/time

So if cardiac cycle (RR interval)(time) is more so the heart rate will be lower

***Look at ECG paper if RR interval is 0.6 sec (we convert sec to min by divide on 60 so it become .6/60 min)

1 beat →.6/60 min

??-→ 1min

ضرب تبادلي so the heart 100 beat /min

***usually in normal adult RR interval is .8sec(.8/60min)

1 beat →.8/60 min

??-→ 1min

ضرب تبادلي so the heart 75 beat /min

How we can record the ECG

We use 12 lead it will give me a complete ECG (you can think of it as looking at the heart from 12 different views)

In figure below is complete ECG, 12 lead

***from the net: what is the lead (look at the figure)

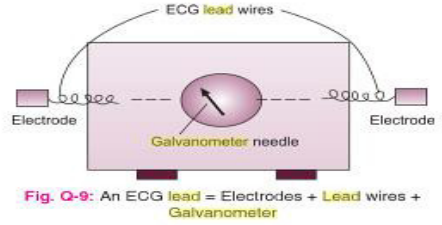


Fig. Q-9: An ECG lead = Electrodes + Lead wires + Galvanometer

****these **leads make us look at the heart from 2 planes** (watch this video https://www.youtube.com/watch?v=JSxd0UTt5gQ)

1) Horizontal or transverse (unipolar chest or pericardial lead) from v1-→v6 {some time they are called c1→c6 {where c represent chest}

2) Frontal →a) ***augmented*** unipolar limb leads {aVR .aVL,aVF}

b) Bipolar limb leads {lead 1, 2, 3}

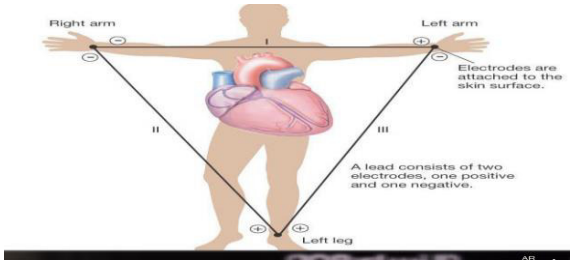
*****bipolar limb lead:** bipolar mean that 2 electrode record the ECG from 2 different side of the heart (in this case the limb)

*Einthoven law: the electrical potential of any limb equals sum of the other 2 (+, - must be observed)

Lead 2=lead 1+lead 3

Example in the book: lead 1=.5mv, laed 3=.7mv then lead 2 should be 1.2mv

**we replace lead 1,2,3 as the figure below(I:right arm ,always +///II:left leg, always -)



NOW LETS BEGIN THE LECTURE

Bipolar limb lead:

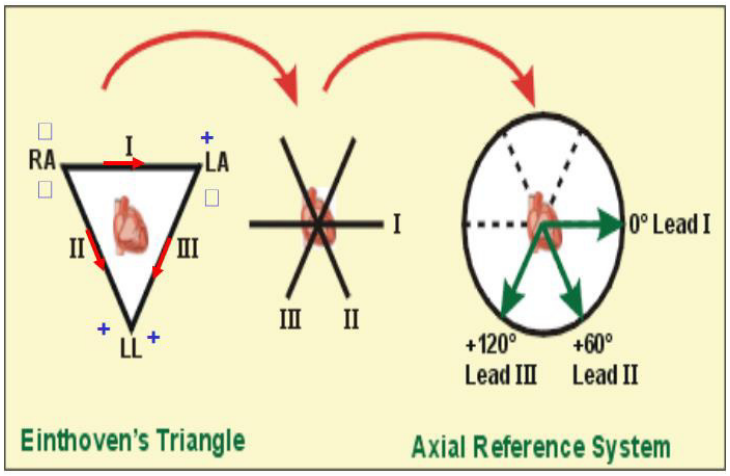
***Einthoven triangle is equilateral (**متساوي الاضلاع)

Lead I:-right hand (–ve) & left hand (+ve)

Lead II: - right hand (-ve) & left foot (+ve)

Lead III: - left hand (-ve) & left foot (+ve)

**we translocate the vector so they can meet at the center and we put around them a circle that touches the head of the arrow, we had angles from 0 to +180 or zero to –ve 180 (opposed direction)



***from book (axis mean the direction from (–) to (+) electrode)

****lead 1 axis at 0 angles

Lead 2 axis at +60

Lead 3 axis at +120

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* RA=right arm

** LA=left arm

*** LL=left foot

Augmented unipolar limb lead

At the beginning we connected LA/RA/LL with very high resistance (5000Ω) and connect them together at the center then connect it to the (-) electrode so at the center we have very high resistance so the potential =zero,,, and we put (+) electrode

on RA then we measure potential, between the zero &the RA, it is called VR (vector of right arm)

If we measure the potential between zero &LA it is called VL (vector of left arm)

If we measure the potential between zero &LL it is called VF (vector of left foot)

Wilson came with an idea: he **said that the recording of these leads is not too much so we need to amplify it (augment) how???**

2 limb are connected through high resistance to the (–) electrode (zero) and the limb that we want to record from should be connected to the (+) electrode (exploring or recording electrode) without resistance (no resistance so it is amplified)

Why it is called unipolar????

in the unipolar limb we put one pole on one limb **but** we did not put the other pole on the other limb ***rather*** we connected it to high resistance (zero potential) as if we are measuring the potential between heart and right arm(aVR),,,between heart and left arm(aVL),,,between heart and left foot(aVF)

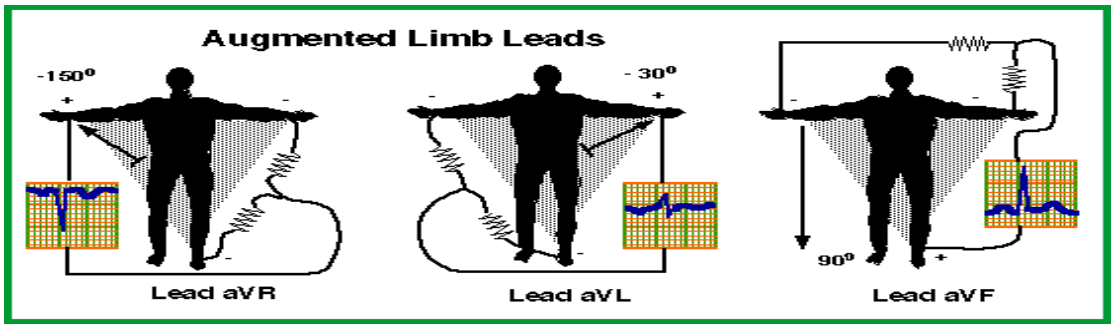
So if we want to measure

aVR: connect (+) electrode on RA with no resistance, and on the (–) electrode connect it with LA&LF (left foot) with high resistance.

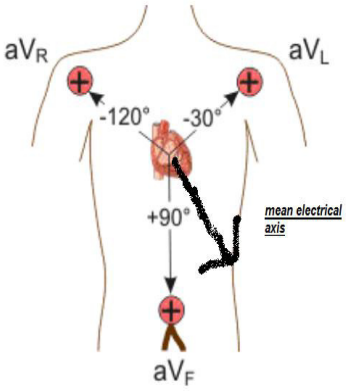
aVF: connect (+) electrode on Left foot with no resistance ,and on the (–) electrode connect it with LA&RA with high resistance.

aVL: connect (+) electrode on LA with no resistance ,and on the (–) electrode connect it with RA&LF with high resistance.

Look at the picture below:



The axis for unipolar limb lead:(as we said the axis from – to +) so the



* aVR axis from center(-)to RA(+)

**aVL axis from center to LA

***aVF axis from center to left foot

Remember:

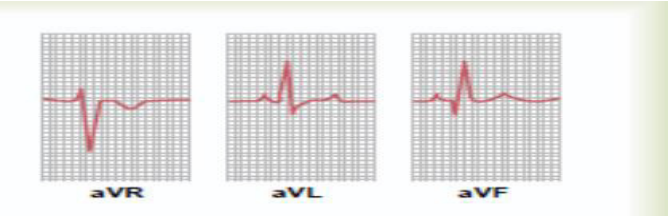
*mean electrical axis (QRS vector) is pointed to left anterior and inferior

**IF current is moving toward the (+) electrode so the recording will be (+)

This explains why aVR record (-)?? because aVR axis is directed to RA so it is in opposite direction of mean electrical axis(current),also mean electrical axis is going away from aVR so away from (+) electrode

aVL: (+) recording(same direction as mean electrical axis)

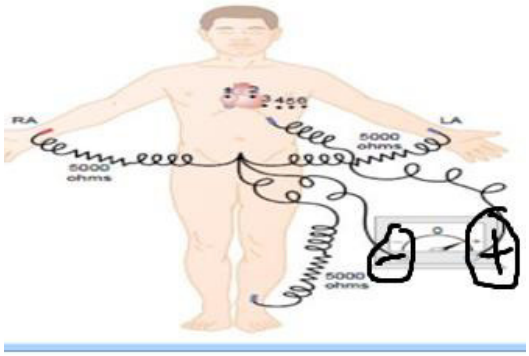
aVF: (+) recording (same direction as mean electrical axis),but here is more (+) than aVL because the current is going down so closer to left foot.



(However ,if you want to record a positive QRS (recording) from the aVR lead ,you can reverse the electrodes & in that case ,QRS recorded from aVL & aVF will be negative} not conventional.

So we have taken 6 limb lead:3 unipolar(aVR,aVL,aVF)&3 bipolar(lead1,2,3)

***unipolar Chest lead (**pericardial lead)



Negative electrode is connected through 3 equal resistances to RA, LA, and left foot

And the (+) electrode is replaced directly on anterior surface of the chest as following

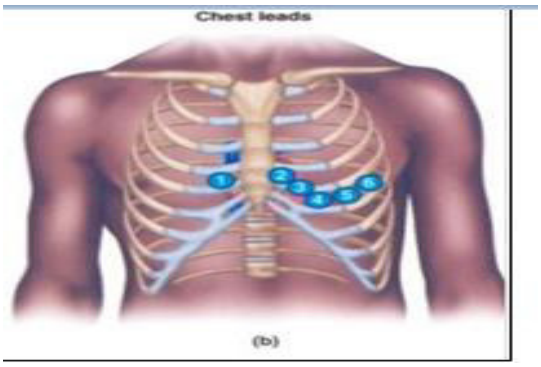
.{surface anatomy} You determine any point using two planes **vertical** and **horizontal**

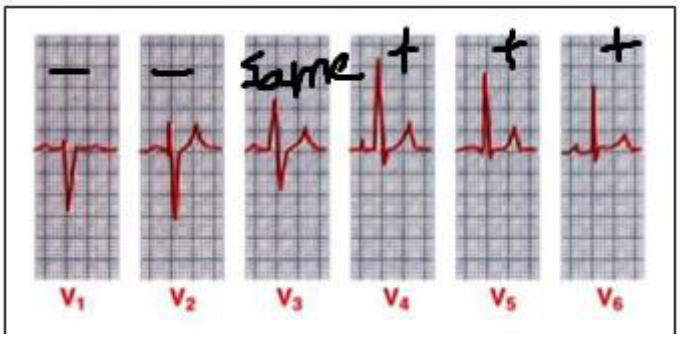
Position according to sternum				Recording(+/-)
On the right side	V1	Vertical	Parasternal line right	Negative
		Horizontal	4th Intercostal space right	
On the left side	V2	Vertical	Parasternal line left	Negative
		Horizontal	4th Intercostal spaceleft	
	V3	Between leads V2 and V4		Same(equel)
	V4	Vertical	Mid-Clavicular line left	Positive
		Horizontal	5th Intercostal Space left	
	V5	Vertical	Anterior Axillary lineleft	Positive
		Horizontal	5th Intercostal Space left	
	V6	Vertical	Mid-Axillary line left	Positive
		Horizontal	5th Intercostal Space left	

**why recording of v1, v2 is (-)??V1 and v2 are the (+) electrode and they are on the right; the mean electrical axis goes to the left anterior so it goes away from (+) electrode so the recording is –ve.

**why recording of v3 is same?? Because it is located in the middle

**why recording of v4, v5, v6 is (+)?? Because they are on the left and mean electrical to left, toward (+) electrode,





****as you noticed unipolar lead (limb or chest) use – electrode with high resistance attach to the limb to get zero potential & the (+) electrode is moving

(so if we put it on RA it gives aVR, if we put it on LA it gives aVL, if we put it on left foot it gives aVF ,if we put it on chest so it gives v1 or v2 ……etc)

***Although this is called a 12 lead ECG you only need to put on the patient 10 on chest, 4 electrode on the limb (record unipolar and bipolar limb lead) where electrode on right foot is earth and 6 for chest

*heart rate=beat /min

**rhythm: is the ECG is regular or irregular?

Rhythmic mean regular

Arrhythmia mean **irregular**

***segment deflection: upward or downward deflection, it indicate ischemia

****current in the heart flow from depolarized area to still polarized area, the electrical potential generated can be represented by arrow (vector) in the (+) direction, length of vector is proportional to the voltage of potential

Generated potential at any instant can be represented by instantaneous mean vector.

*mean QRS vector (left, anterior, inferior)

In Guyton it says +59, but because there are variations between individual so we take interval instead of number

So <u>normally</u> the mean QRS vector is between -30→+110

<u>Clinically</u> mean QRS vector is between 0→+90

How to draw hexagonal axis

: ***<u>axis</u> is the direction from (–) to (+) electrode

Lead 1 between RA (-) and LA (+) so the axis is horizontal and equal 0

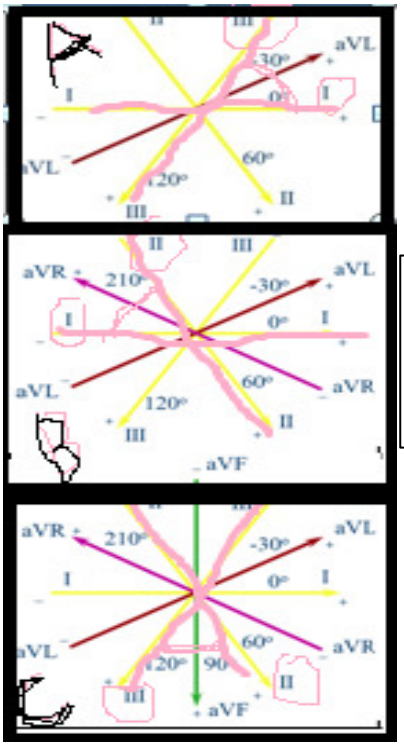
Lead 2 between RA (-) and left foot (+) so the axis is + 60

Lead 3 between left arm (-) and left foot (+) so axis is +120

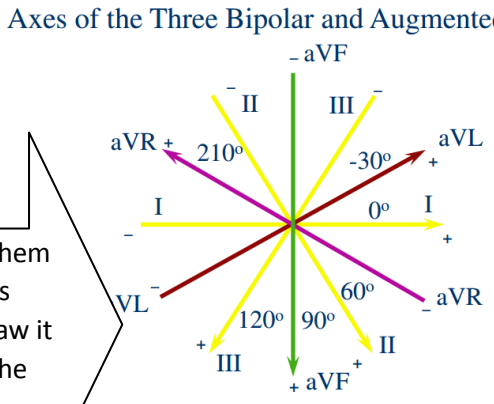
Figure a>>aVL: axis between center (-) and LA (+), it intersects (bisect) the angle between lead I and III

Figure b>>aVR: axis between center (-) and RA (+) it Bisects the angle Between lead I and II

Figure c>>aVF: axis between center (-) and left foot (+) it Bisects the angle between lead II and III



You need to draw them because doctor says that if you don't draw it you will not know the axis in the exam



How to draw mean electrical axis(normally mean electrical axis is left ,anterior ,inferior, between 0 and 90 we use ECG and hexagonal axis to draw mean electrical axis if it was between 0 and 90 so its normal but some time it is not so we have some abnormality as we will see);:

1) Take any 2 limb lead {unipolar or bipolar} it is easier to take aVF and lead 1

2) Sum the QRS for lead 1 and aVF (you sum the mille volt{y axis} or small square {x axis}, when you sum you should include - &+ signs {if upward then + if downward then -})

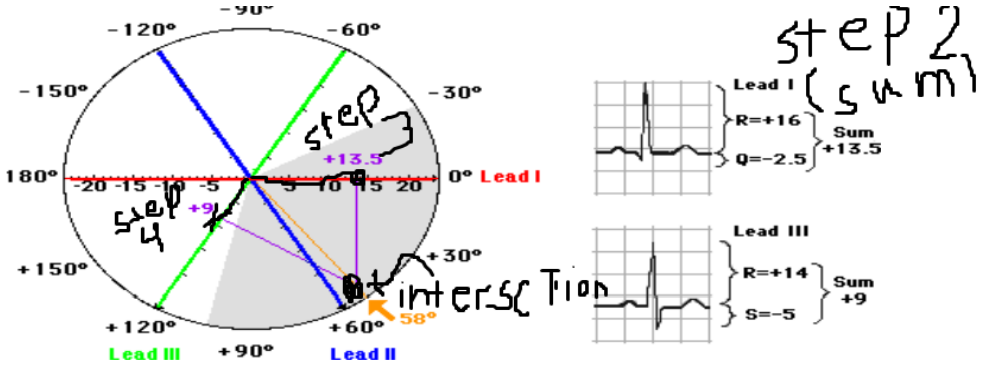
3)let's suppose the sum lead 1 QRS is +5 so we go to the hexagonal plane and from the center go 5 mm to the + axis of lead 1 and draw a perpendicular line

4) let's suppose the sum aVF lead QRS is +4 so we go to the hexagonal plane and from the center go 4 mm to the + axis of aVF lead 1 and draw a perpendicular line

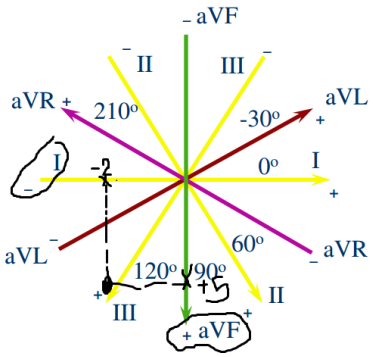
5) The intersection of the two perpendicular lines is between 0 and 90 so it is normal electrical axis because we said that it is normal between -30 and +110

*Look at this video (https://www.youtube.com/watch?v=jg5X3V5IPS4&app=desktop)

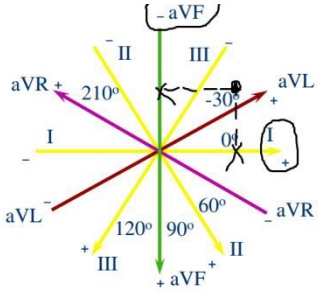
**Another example from slide in the next picture:



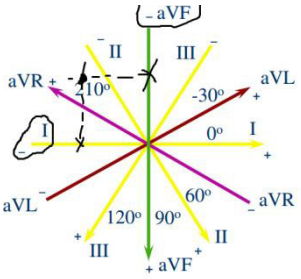
***Now if the aVF is +5 and lead 1 is -2 so the mean electrical axis between +90 and +180→ we call it right axial deviation (happen in case of right bundle branch block)



**** Now if the aVF is negative and lead 1 is positive so the mean electrical axis between 0 and -90→ we call it left axial deviation (happen in case of left bundle branch block)



****if lead 1 is negative and aVF is negative then mean electrical axis between 180 and 210..it is <u>sever</u> left axial deviation or <u>sever</u> right axial deviation we determine which one the patient has according to the history if he has problem in the right side of heart then sever right axis deviation, history if he has problem in the left side of heart then sever left axis deviation



**ventricular depolarization is 3 waves (QRS), not simple wave like P wave or T wave why?? QRS is the recording of vectors during ventricular dep//it is the contribution of vector to the resultant vector during the spread of dep

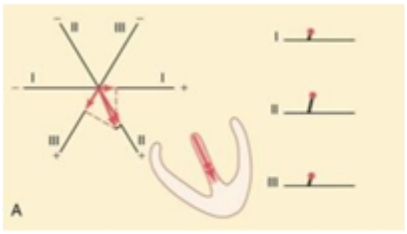
This vector begins at the septa -→give septal dep there is a vector analyze it an lead 1 ,2 ,3,, ,then when dep spread there is another vector(because vector change direction and magnitude),, ,the last one recorded is S wave at the posterior of left ventricle

Left bundle branch block:

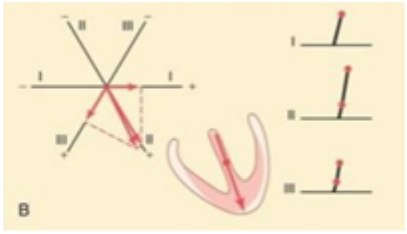
The <u>left ventricle is depolarized slowly,,,,</u> (the last to dep)why??because there is no purkinjy fiber (speed conduction is 4m/s)the dep goes through ventricular muscle (speed of conduction is 0.5m/s)<u>,,,,,,,,where as right ventricle dep fast</u> so there will be a vector between right and left ventricles of heart &the mean electrical axis deviate to the left.

Right bundle branch block:

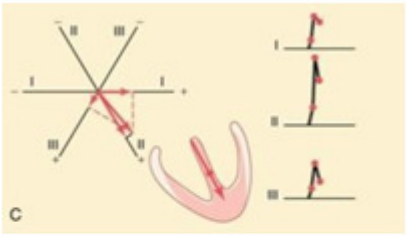
Most of the time there will be a vector between left and right ventricles of heart, right axis deviation



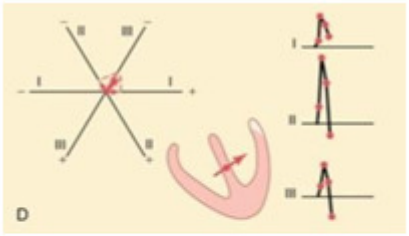
- The first vector represents the depolarization of the septum, which is the resultant/ mean instantaneous vector. If you analyze it on the plain of lead I, II and III, you will get values for each one.



- The depolarization wave spreads. There is another resultant/ another instantaneous vector. You analyze it again on the 3 leads caz vector changes the direction and magnitude
- **Book**::All leads' values areincreasing lead 2 is largest caz mean vector is 60
- The depolarization vector is large because half of the ventricle is depolarized (much of the ventricular mass has become depolarized(



- **Book**::By analyzing the resultant instantaneous vector on the third instance, we notice that the values of lead I, II and III are decreasing; because the outside of the heart apex is now electronegative; neutralizing much of the electro-positivity on other epicardial surfaces of the heart.
- The mean vector is shifting toward the left side of the chest because the left ventricle is slightly slower to depolarize than the right ventricle.



- Here, the last part of the heart that depolarizes is the posterior aspect of the left ventricle . It gives a negative vector(s wave)
- **Book**::The vector went from the depolarized to the polarized area.
- Note that on lead I, the reading became less positive, however, on lead II & lead III the readings became negative with more negativity on lead III.

Completely depolarized}no mean instantaneous vector} ... reading is zero... isoelectric line
now we have a complete S wave & thus a complete QRS complex

Q wave :depolarization of the ventricular septa(from slide: it appears if the left side of septa depolarize first),some time it present but if it shows too much it represent infarction(usually it don't appear if it shows then it is minimal but if it shows too much then there is a problem)

T wave: Ventricular repolarization ,has a positive value in ECG because **the last area to depolarize is the first area to repolarize**) the reason for that is the high blood pressure inside the ventricles during contraction ,which greatly reduces the coronary blood flow to the endocardium, thereby slowing the repolarization in the endocardium area & (because of that ,the mean vector during repolarization is directed towards the apex of the heart & that explains the positive value of the T wave in the 3 leads I, II & III

Atria:

P wave: atrial depolarization from the beginning of SA node to AV node, it is positive in lead 1,2,3'

atrial t wave: atrial repolarization, usually can't be seen because it is masked by QRA complex but in case of AV block the PR interval prolong so we can see it as negative deflection why?????Because atrial dep is slower than ventricle dep,,,, so the 1st to dep is the 1st to rep

dedication to Salsabeela bani hamad,,,Noor hammad,,,Dania essam ,,,.and Amneh hammad,,amani alhalbi