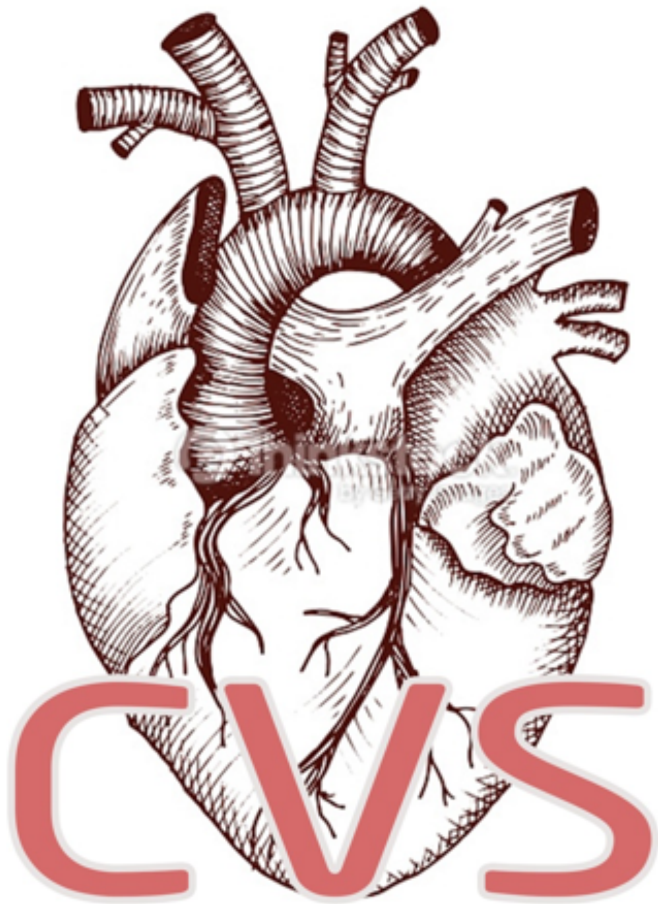


Physiology

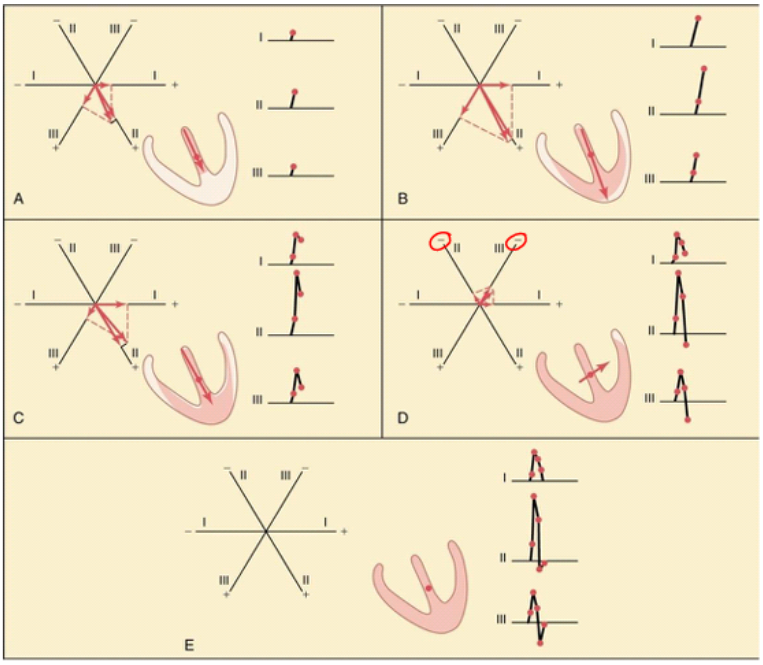
♡ Slide ❤ Sheet

Number:	8
Doctor:	Faisal Mohammed
Done by:	Ammar Ramadan
Corrected by:	Ghufran Touma

Recall:

The QRS is the recording of the depolarization of the ventricles. During ventricular depolarization, every instant the is a vector, which is the resultant of all vectors (remember that the vector goes from the depolarized area to the still polarized area).

In figure A, this is the depolarization of the septum. As you can see there is a vector which is the resultant of all vectors at that instant. How can we know its value on any lead ?



Simply we draw a perpendicular line from the top of this vector to intersect with the plane of any lead, here we can see lead I, lead II, and lead III.

You can measure QRS at any instant, but here we took 4 instances; in each one of them we have the resultant vector and its value on lead I, lead II and lead III.

Figure b, after analysing the vector, you can see that the value has increased in lead I, lead II and lead III. When half of the ventricle is depolarized, the vector will have the highest value.

Figure c (when the depolarization spreads to ventricles), after analysing the vector, you can see that the value has decreased in lead I, lead II and lead III.

Figure d, the **last part** of the heart that gets depolarized is the posterior aspect of the left ventricle. The mean electrical axis (the resultant vector) at that instant is going to be reflected. If you analysed the vector, you can see that it has a negative value on both lead III and lead II and a decreased value on lead I.

** the values (of the analysis of the instantaneous vectors on lead I,II,III) are what gives the QRS complex its shape.

** You can also analyse the T waves and see how it occurs, but here you will see the mean electrical axis of ventricular repolarization. The doctor didn't say much about it, you can refer to slide 50 for further details.

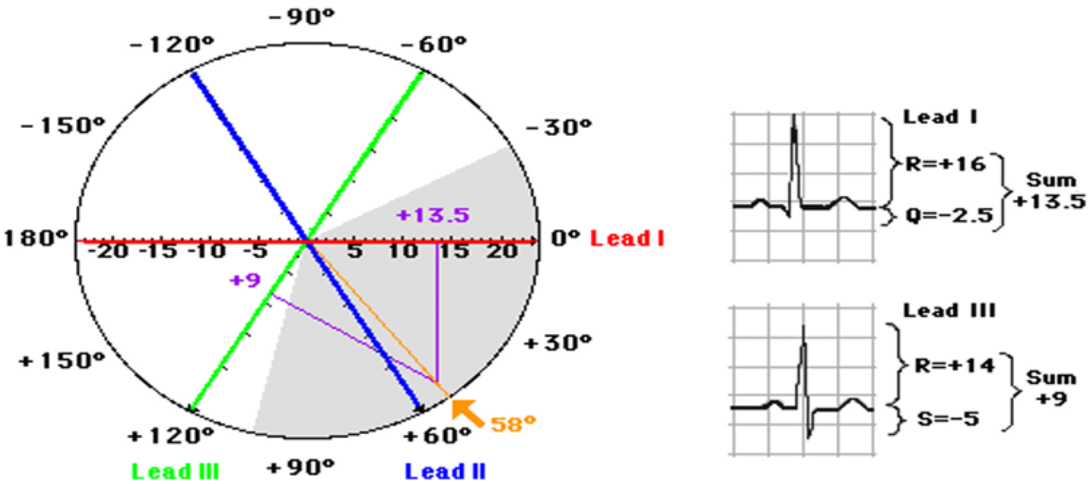
** Atrial repolarization waves or Atrial T waves cannot be seen, because it is masked by QRS complex. It may appears in the case of complete heart block (when PR interval is long). If it appeared, it would have a downward deflection. Why?

Because the pressure in the atria isn't as high as the pressure in the ventricle. The high pressure in the ventricle caused a reverse in the repolarization (first area to depolarize is the last area to repolarize).

Note: after the ventricle is completely depolarized, it will go back to the isoelectric line. After the ventricle is completely repolarized , it will go back to the isoelectric line.

How to calculate the mean electrical axis:

● Use any 2 different leads. For the simplicity, use lead I and AVF as they are perpendicular to each other. We calculate the mean electrical axis in the frontal plane only (we don't use the chest leads). In example below we used lead I and lead III

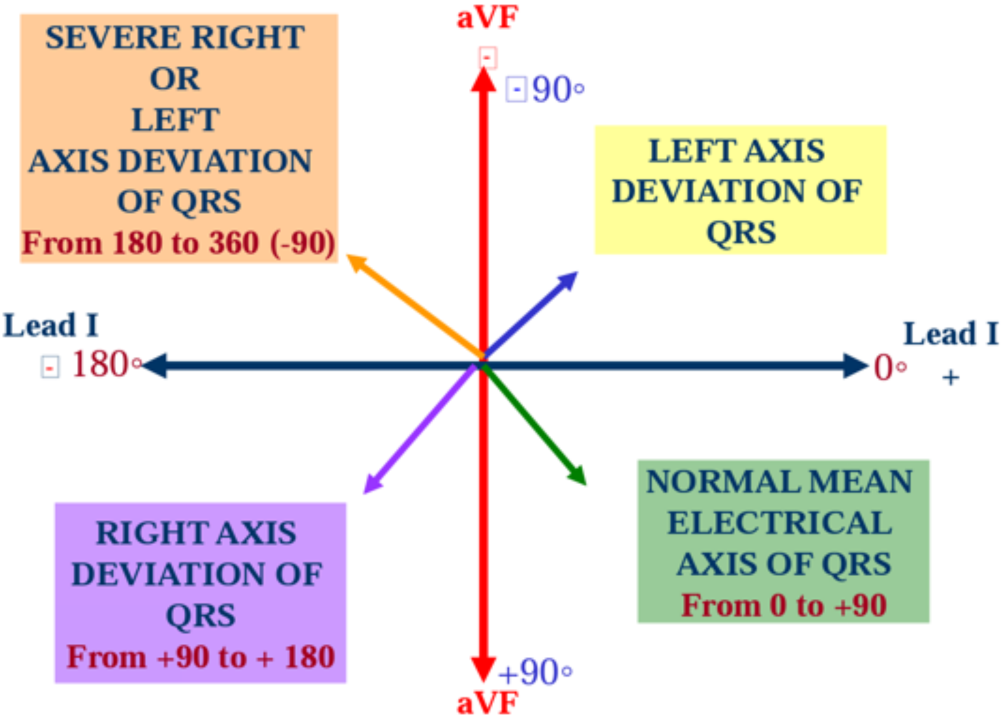


● Measure the sum of the height and the negative depth of the QRS complex and mark it on the plane of the lead: +13 in lead I, and +9 in the lead III.

● Draw a perpendicular line (perpendicular to the plane of the lead) on the values that you marked.

● The two perpendicular lines will eventually intersect. After that, draw a line from the centre of the circle to the point of intersection.

● now you can calculate the value of the mean electrical axis and the angle. Here the angle equals 58° >> normal because it is between -30 and 110°. Please check slide 54 and slide 55 for extra examples.



*In this figure we used lead I and AVF for the simplicity.

* you can calculate the angle by pressing shift + tan (value on AVF/value on lead I). Because these two leads are perpendicular to each other, it is easier to calculate the angle.

*The angle of the mean electrical axis θ "more explanation "

tan θ = Opposite/Adjacent; the opposite is aVF and the adjacent is lead I

θ = tan-1 (aVF value / lead I value)

After looking at the figure above:

• If Both lead I and AVF were positive >> this is normal

• If AVF was negative and lead I was positive >> left axis deviation

1- This is caused normally in short and obese people >> the heart is shifted to the left.

2- Caused also by hypertrophy in the left ventricle caused by hypertension, aortic stenosis or aortic regurgitation. How? Left axis deviation means that most of the time the vectors are going from the right (depolarized) to the left (still polarized). Because the ventricle is hypertrophic, it will need more time to be depolarized. Thus the vectors will point towards the left most of the time.

3- Left bundle branch block. How? If the left bundle branch was blocked the depolarization in the ventricle doesn't occur fast; because the rate of conduction in the ventricular muscles is slower compared to the branch. However, the depolarization in the right ventricle is normal. Thus the vectors will point to the left.

• If AVF was positive and lead I was negative >> right axis deviation

1- Caused normally in tall and thin people >> Because the heart is shifted to the right. Hi hamzeh :p
2- Right bundle branch block
3- Hypertrophy in the right ventricle caused by pulmonary hypertension, pulmonary valve stenosis.

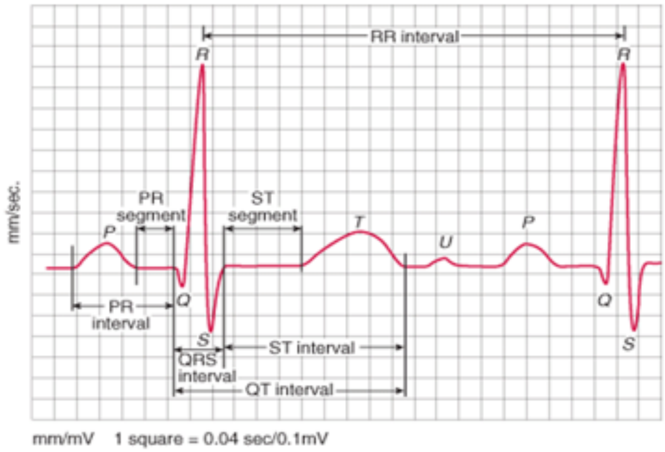
• If both lead I and AVF were negative >> severe right or left axis deviation. You decide either right or left depending on the questions(history) that you ask to your patient. If your patient has right heart problems, the patient has severe right axis deviation and vice versa.

Heart Rate Calculation

If the heart rate was regular, you take one cycle (R-R interval) and calculate its time >> time for one cycle. Then you divide 60 sec by time for one cycle to get the heart rate per minute.

To know if the heart rate is regular or not. Take a paper and draw two points on it; one on one R and the other on the next R. Slide the paper on the ECG to the next cycle, if the 2 points stopped exactly or close on the two R then it is regular.

In the ECG we care about 3 intervals:



PR interval: from the start of P to the start of Q or R.

QRS interval: from the beginning of Q to the end of S.

QT interval: from the beginning of Q to the end of T.

Isoelectric lines :

-PR segment: from the end of P to the beginning of R or Q

-ST segment: from the end of S to the beginning of T

-The most important isoelectric line is the TP segment.

** rarely a **<u>U wave</u>** appear in the TP segment, due to depolarization of the papillary muscle.

**Regularity of the heart rate could be regular or irregular:

-The regular heart rate is explained above.

-The irregular heart rate might be:

<u>regular irregularity</u>: in case of 2nd degree heart block.

<u>irregular irregularity</u>: in case of 3rd degree heart block.

☆ The first thing you do when you have an ECG; look at the rate (regular or not) then calculate it. If it was <40 then this is 3rd degree heart block.

Abnormalities (Arrhythmias)

Causes of Cardiac Arrythmias

▪ Abnormal rhythmicity of the pacemaker

▪Shift of pacemaker from sinus node

▪Blocks at different points in the transmission of the cardiac impulse

▪Abnormal pathways of transmission in the heart; bundle branch block in the right side will lead to right axis deviation because the impulse will be conducted at the rate of the ventricular muscles which is slower.

▪Spontaneous generation of abnormal impulses from any part of the heart; Purkinji fibres in case of MI starts to generate impulses at rate of 140 per minute and become the ectopic pacemaker.

Abnormal Sinus Rhythms

Tachycardia when heart rate is above 100 beats/minute (the normal between 60 and 100). It is caused by:

(1) increased body temperature; especially in children(fever). Heart rate might reach up to 120 and 150 beats/minute. So there will be problems in filling of the heart and will end in heart failure.

(2) sympathetic stimulation (When you are in a state of stress)

(3) toxic conditions of the heart; hypercalcemia, hyperthyroidism, and drugs.

Sinus tachycardia: there is P wave followed by QRS followed by T wave but at higher rate.

Etiology: SA node is depolarizing faster than normal:

** sinus tachycardia is a response to physical or psychological stress, not a primary arrhythmia.

To calculate the heart rate : if it was regular you can calculate it simply as we discussed it previously. However, if it wasn't regular; you count how many cycles in 20 seconds for example then you multiply by 3 to get the heart rate per minute, or you count for 15 seconds and multiply by

4. Remember that each minute has 1500 small squares or 300 big squares, and each second has 5 big squares or 25 small squares.

A faster method from Dr Faisal: you look for one cycle that has the R on a hardline, if the next R is located on the next hardline then the rate is 300 beats/minute why? Because the distance between two adjacent hardlines equals 5 small squares or 1 big square, which means that each cycle duration is 0.2 seconds and the rate = 60/0.2= 300.

What is heart rate if one R occurs one the first hardline and the second R occurs on the:

-3rd hardline ?

-4th hardline ?

Bradycardia: when the heart rate is below 60 beats/min.

Presents normally in athletes who have hypertrophy in their hearts, so their hearts have a large stroke volume, which means that they pump more blood per beat.

Cardiac output = stroke volume*heart rate

Stroke volume: amount of blood ejected from either ventricles per beat

Normal cardiac output is around 5 litres per minute. (70 heart beats in 1 minute and 70 ml stroke volume)

As they have high stroke volume let’s say 100 ml, they will have lower heart rate at physiological states, about 50 heart beats per minute. To achieve the normal cardiac output. so they have bradycardia at physiological states.

Sinus bradycardia:

Notice that PR interval is less than 0.2 >> which means that this is a normal PR interval not a heart block.

Etiology: SA node is depolarizing slower than normal, impulse is conducted normally (i.e. normal PR and QRS interval) rate is slower than 60 beats per minute.

figure a shows a sinus rhythm : alternative P,QRS, and T waves.

what is the heart rate in this case ?

(a) Sinus rhythm (normal)

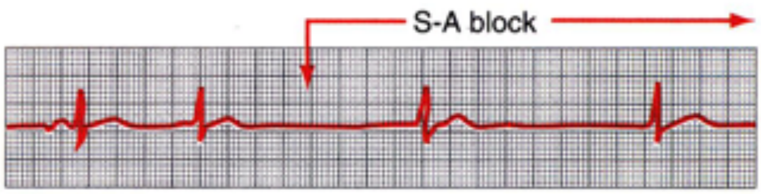
In figure b there is no SA node activity, this is called atrial fibrillation.

There is no P waves.

(b) Nodal rhythm – no SA node activity

Sinoatrial Block

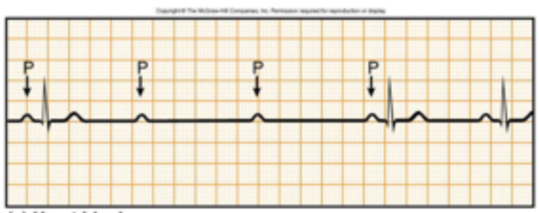
In rare cases, impulses from S-A node are blocked. This causes cessation of P waves (no P waves). The new pacemaker is region of heart with the fastest discharge rate, usually the A-V node (ectopic pacemaker).



Note: no P waves and slow rate

Figure (c) shows heart block. We have heart block because the PR interval is more than 0.2

Notice that there are some P waves not followed by QRS.

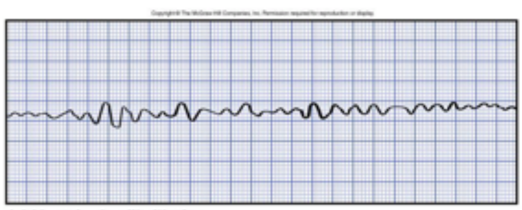


(c) Heart block

Arrhythmia: conduction failure at AV node

This figure shows ventricular fibrillation. There is no QRS. (Saw shaped ECG).

This is very dangerous because there is no pumping action occurs. You have to interfere immediately by defibrillation.



(e) Ventricular fibrillation

No pumping action occurs

Atrioventricular Block: Impulses through A-V node and A-V bundle are slowed down (1st and 2nd degree) or blocked (3rd degree).

Causes:

(1) Ischemia of A-V nodal or A-V bundle fibres (decrease in blood flow or infarction).

(2) Compression on A-V bundle (by scar tissue or calcified tissue)

(3) A-V nodal or A-V bundle inflammation

(4) Excessive vagal stimulation; the heart will stop for a while then the ventricle will start to contract at the rate of Purkinje fibres.

Incomplete Heart Block: First Degree Block

- every P is followed by QRS.
- PR interval is more than 0.2 sec

- Etiology: Prolonged conduction delay in the AV node or Bundle of His.

Second Degree Incomplete Block

- P-R interval is also above 0.2 sec
- Some impulses pass through the A-V node and some do not thus causing “dropped beats”. (Some P waves are not followed by QRS)
- atrial beat is faster than the ventricles.
- sometimes it is called 2:1 2nd degree heart block why? Because the skipped/dropped beat is usually the third one (A 2:1 block implies that there are 2 p waves for every QRS complex)).

**when there is no QRS after the P wave, this means that there is no pumping in the heart.

Third Degree Complete Block

• Total block through the A-V node or A-V bundle.

• heart rate is below 40 (around 37); ventricles own intrinsic pacemaker beats at around 15-40 beats/minute (the Purkinje fibres rate).

• There is no association between the P waves and QRS complexes, each occurs on its own. Because there is complete block of conduction in the AV junction, so the atria and ventricles form impulses independently from each other.

• Ventricles escape, and A-V nodal rhythm ensues.

• Prolonged QRS; due to bundle branch block.

Stokes-Adams Syndrome

Compression from the carotid on the vagus nerve causes stimulation of the vagus nerve. Thus the heart rate will decrease and it will stop for 15-30 sec, then it resumes the contraction by the rate of Purkinje fibres. Remember that Purkinje fibres doesn't work by its rate because of overdrive suppression.

We treat this conditions by artificial pacemakers connected to right ventricle.

Extra details will be discussed in lecture 10