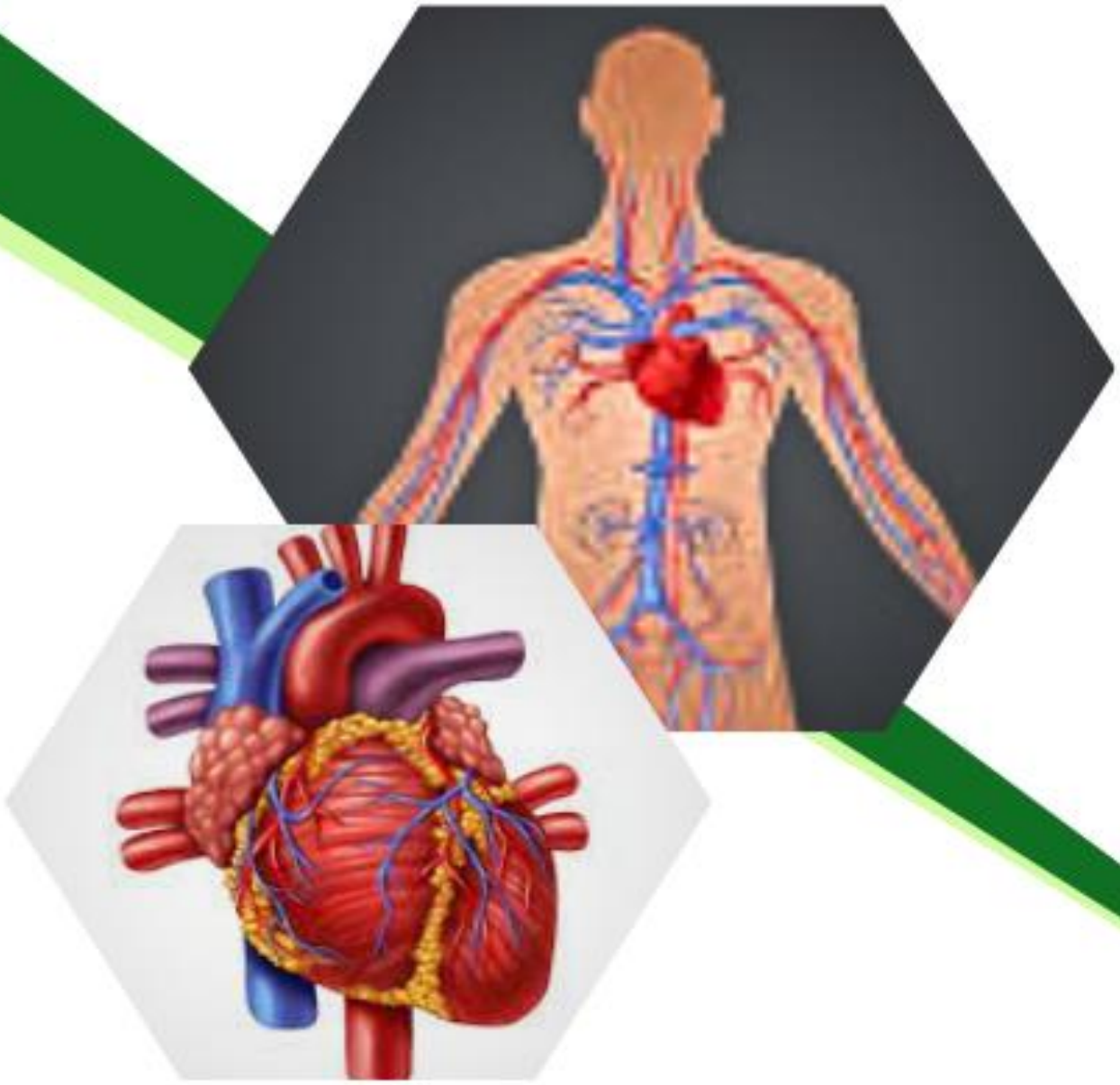
Doctor.021

no.6

CVS

PHYSIOLOGY



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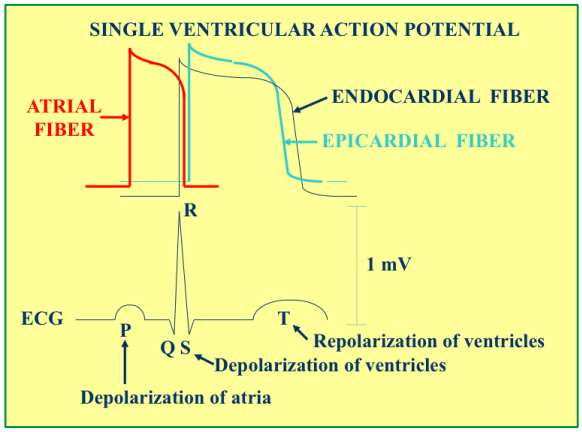
-You may need to refer to the lecture in some parts, red-border pics and blue-highlights are extras.

Let's continue our talk on ECG:

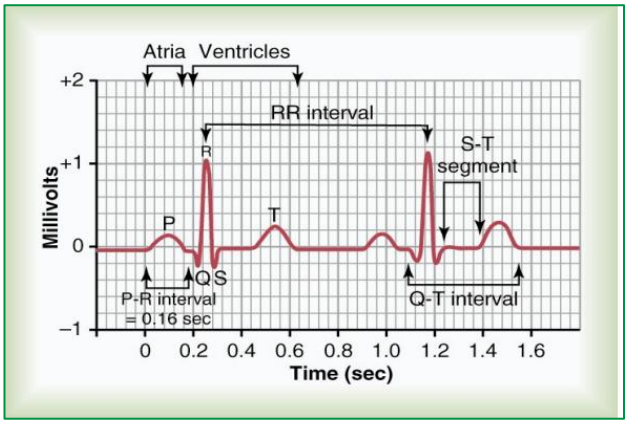
- In ECG, we record atrial depolarization (P-wave), ventricular depolarization (QRS complex) and ventricular repolarization (T-wave).



- Atrial repolarization occurs at the same time of ventricular depolarization, and since the ventricular mass is much larger, it masks the electrical activity of the atria in the ECG.
- If the delay time (av delay) was longer than normal, the atrial repolarization may be recorded and is called *atrial T-wave* or *inverted P-wave*.
- The ECG (electrocardiography) is a galvanometer.

Standardized EKG's

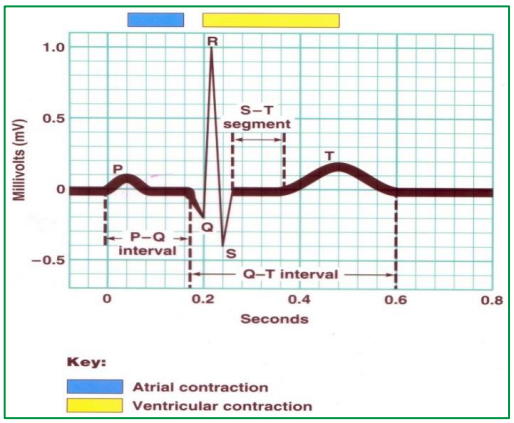
- Time and voltage calibrations are standardized
- ECG records on a graph paper with a speed of 25 mm per second, with 1mm for each small square which represents 0.04 secs (1/25), and each 5 small squares form one large square that represents 0.2 sec.



- The R-R interval represents the duration of a complete cardiac cycle which is approximately 5 large squares in healthy individuals, from this we can calculate heartbeat by either ways:
  - 60/(5*0.2) =60 beats per minute (each beat takes 1 sec to occur, then how many beats occur in 60 secs?).

- If you divide 300 by the number of large squares between 2 R waves, you will obtain the heart rate (300 represents one minute (60*5)).
  - e.g: 3 squares→ 300/3=100bpm.

- You can calculate any time interval by counting the number of small boxes from left to right, then multiplying it by 0.04 secs.
  - e.g: in this graph PQ interval (also called PR interval if the q wave is absent) contains 4 small squares → 4*0.04=0.16 secs.



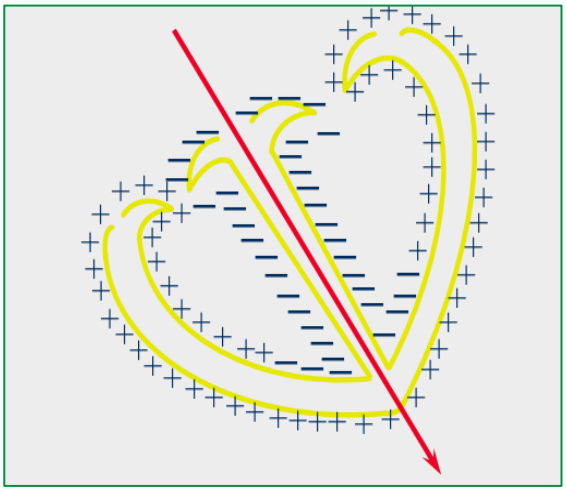
- PQ interval less than or equal 0.2 secs is considered normal, while more than 0.2 secs is prolonged, which indicates AV block.
- QRS interval contains 3 small squares *0.04=0.12 secs (normal), any value more than 0.12 secs is considered a wide QRS complex.
- Q wave may be absent in some ECG leads so QT interval becomes RT, so on and so forth.
- Currently, there's no need for more details about normal/abnormal ranges, just grasp the concept.

Remember: the term interval refers to a period that contains a wave, while segment is the isoelectric line without waves.

Flow of electrical currents in the chest around the heart

- Mean vector through the partially depolarized heart.

- Mean electrical axis of the ventricle is the resultant direction of depolarization.
- It is typically directed downward and to the left (60 degrees angle) towards the apex.
- Deviations in this mean axis may indicate certain abnormalities, which we'll discuss later.
- There are 12 leads that allow us to see the heart in three dimensions and record its electrical activity various angles. They are divided into 6 limb leads, which are frontal leads, consisting of 3 bipolar leads and 3 unipolar leads, in addition, there are 6 chest leads positioned around the heart, representing horizontal transverse leads.

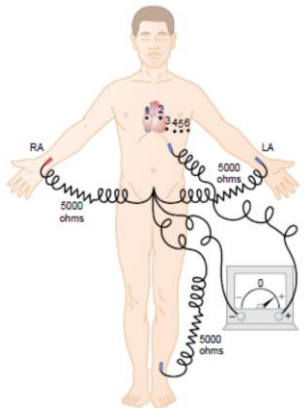


Other EKG Leads

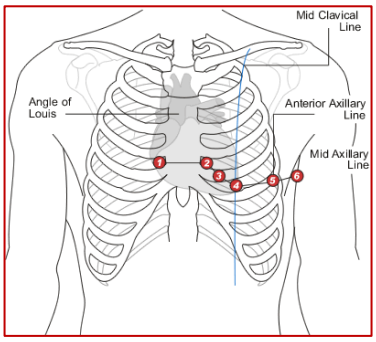
- The 3 bipolar limb leads form a triaxial reference system is formed by lead I, being the horizontal line, lead II at an angle of 60^{o} and lead III at an angle of 120^{o}.
- Wilson's lead system introduced new leads using the three leads from Einthoven's triangle, keeping the right arm (RA), left arm (LA), and left leg (LL) as the triangle vertices.
- Unlike the bipolar limb leads, these leads don't lie between two points. Instead, there is one electrode with the average of the heart's electrical activity, assumed to be zero voltage.
- For instance, if the positive electrode is attached to the LA, the negative one is divided into three parts for LA, RA, and LL, each with an electrical resistance of 5000 ohms. Given Ohm's Law (I = V/R), when the resistance is 5000 ohms, there is negligible current flow and that is why the negative electrode is termed an indifferent electrode, functioning as a zero-voltage reference.

- Note that all three connections are considered one negative electrode and the net current is zero, then we place the positive on different positions which called the exploring electrode to calculate (VR, VL and VF).
  N.B: right leg is considered earthing electrode.

Unipolar limb leads



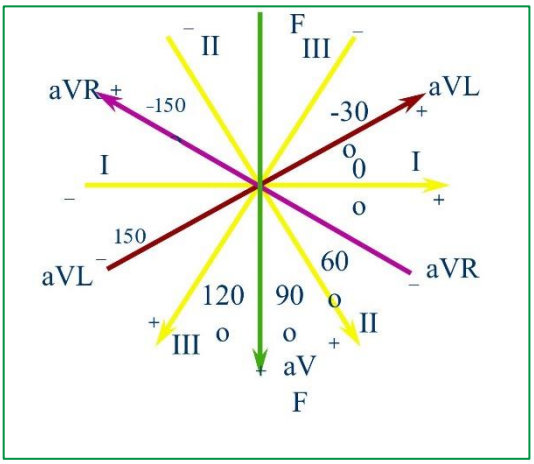
- IG leads concept seems a bit confusing, so here's an *extra* summary:
- In ECG, we use 12 different leads that are classified as:
  - 6 limb leads:
    - 3 bipolars→ lead I (-RA to +LA)
      → lead II (-RA to +LL)
      →lead III (-LA to +LL)
      -Bipolar means that we have 2 exploring electrodes (positive and negative).
    - 3 unipolars→ aVR (+RA, indifferent electrodes L/F)
      → aVL (+LA, indifferent electrodes R/F)
      →aVF (+LF, indifferent electrodes L/R)
      -The concept of these leads is discussed later on.
  - 6 chest leads (precordial): 6 horizontal leads (V1-V6) on the chest and the indifferent electrodes placed on the three limbs.
    - V1: Rt 4th intercostal space (parasternal).
    - V2: Lt 4th intercostal space (parasternal).
    - V3: between V2 and V4.
    - V4: Lt 5th intercostal space (mid-clavicular line).



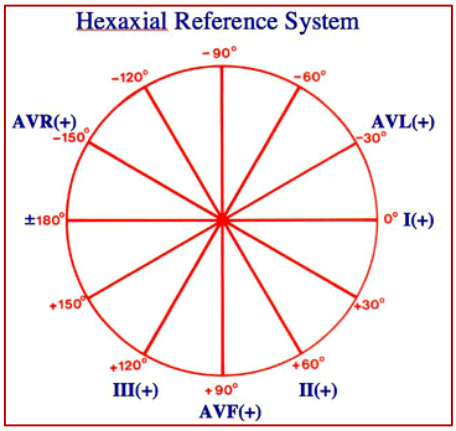
- V5: Lt 5th intercostal space (anterior axillary line).
- V6: Lt 5th intercostal space (mid-axillary line).
  -These leads are very close to the heart, hence no need for augmentation.

Principles of vectorial analysis of EKG's (cont'd)

Axes of three bipolar and augmented leads:



- Lead I is our zero-axis.
- Again, clockwise rotation is positive, while counter-clockwise is negative.
  - aVL: -30°, +150°
  - aVR: +30°, -150°
  - aVF: 90°, -90°
- VL: vector left arm.
- It's now hexaxial reference system rather than triaxial.



This is a better illustration with same numbers mentioned by the DR.↑

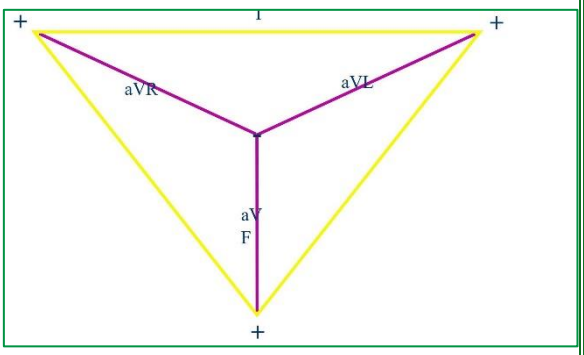
-Hexaxial diagram is in the <u>frontal</u> plane. Normal QRS axis from -30 to +90. Lt axis deviation from -30 to -90. Rt axis deviation from +90 to +180.

- Starting with aVL:
  - If we want to reach aVR, we will cross over lead I (we have a 30° rotation with each move).
  - From aVR to aVF, we will cross over lead II, and a total of 60° clockwise rotation.
  - By reaching aVF, we've reached 90°, then we move to lead III (120°).
- The principle of vector analysis is basically; assuming our vector is directed at 50° angle, to determine the respective vector on each lead, we extend a perpendicular line from the tip of the vector to each lead line and by

that we get the respective vectors (direction and length), lead II> lead I> lead III.

Axes of the Unipolar Limb Leads

- Placing the heart centrally on the negative electrode; each angle has a positive electrode and an indifferent electrode with high resistance, hence the current is zero (constructing an artificial reference potential).
- This was done by Einthoven and Wilson, afterwards Goldman improved it by *augmenting* the voltage by 50% so that ECG is easier to interpret.
- The concept of augmentation was basically done by removing one indifferent electrode (augmented: between 1 limb and the other two, non-augmented: between 1 limb and the 3 limbs).

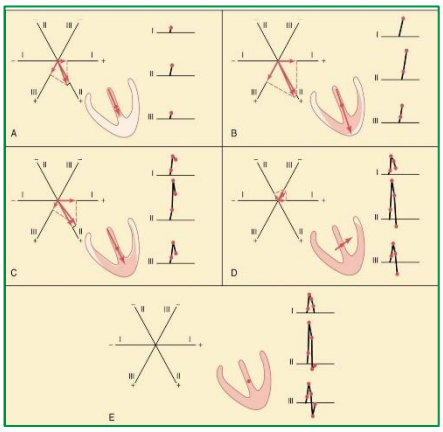


IG, I don't have to tell you don't need to know these info, just for the curious ones.

- So now we have 6 leads; 3 bipolars (2 electrodes) and 3 unipolars (one electrode and an indifferent electrode).
- Chest leads (6 in number) are also unipolar with no need for augmentation as we are close to the heart.

Principles of Vectorial Analysis of EKG's (cont'd)

- *The axis of lead I is zero degrees (reference)* because the electrodes lie in the horizontal direction on of the arms.
- *The axis of lead II is +60 degrees* because the right arm connects to the torso in the top right corner, and left leg connects to the torso in the bottom left corner.
- *The axis of lead III is 120 degrees.*



- Here we're elaborating depolarization in the ventricles, mean vector, and interpretation on ECG (lead I, II and III).
- E is complete depolarization.
- Depolarization in all leads is moving towards positive but with different values.
- For further elaboration; in lead I and III, depolarization occurs with an angle (~60°), while in lead II, the vector is parallel to the lead (maximum vector length) and this is reflected on ECG.
- The summation of lead I and III must equal lead II.
- For more detailed explanation of the figure:
    - A: the ventricular muscle has just begun to be depolarized, representing an instant about 0.01 second after the onset of depolarization only a small portion of the ventricles—the septum—is depolarized. Therefore, all electrocardiographic voltages are low. The voltage in lead II is greater than the voltages in leads I and III because the heart vector extends mainly in the same direction as the axis of lead II.
    - B: which represents about 0.02 second after onset of depolarization, the heart vector is long because much of the ventricular muscle mass has become depolarized. Therefore, the voltages in all electrocardiographic leads have increased.
    - C: about 0.035 second after onset of depolarization, the heart vector is becoming shorter and the recorded electrocardiographic voltages are lower because the outside of the heart apex is now electronegative, neutralizing much of the positivity on the other epicardial surfaces of the heart. Also, the axis of the vector is beginning to shift toward the left side of the

chest because the left ventricle is slightly slower to depolarize than is the right ventricle. Therefore, the ratio of the voltage in lead I to that in lead III is increasing.

- D, about 0.05 second after onset of depolarization, the heart vector points toward the base of the left ventricle, and it is short because only a minute portion of the ventricular muscle is still polarized positive. Because of the direction of the vector at this time, the voltages recorded in leads II and III are both negative—that is, below the line—whereas the voltage of lead I is still positive.
- E, about 0.06 second after onset of depolarization, the entire ventricular muscle mass is depolarized so that no current flows around the heart and no electrical potential is generated. The vector becomes zero, and the voltages in all leads become zero.

➢ *Remember: In ECG strips, there are large and small squares which is used for the calculation of time and voltage.*

- Each small square represents 0.04 secs horizontally and 0.1 mV vertically.
- Each large square consists of 5 small squares, hence, represents 0.2 secs and 0.5 mV.

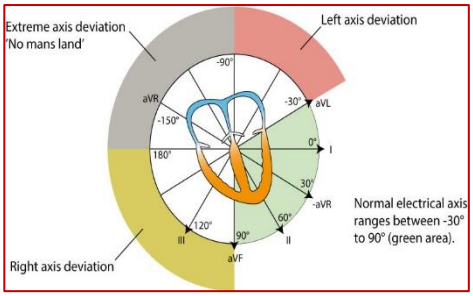
➢ You can refer to the lec (I put you the exact timestamp)!

➢ *Extra note: The electrical axis (cardiac axis or mean QRS axis) reflects the average direction of ventricular depolarization during ventricular contraction. The direction of the depolarization (and thus the electrical axis) is generally alongside the heart's longitudinal axis (to the left and downwards).*

➢ If the electrical axis of the ventricle lies in:

- The left inferior quadrant (0-90^{o}), it is considered normal.
- The left superior quadrant, it is LAD (left axis deviation) which may indicate left ventricular hypertrophy.

- The right inferior quadrant, it is RAD (right axis deviation).
- The right superior quadrant, it is severe RAD.



- There's a difference between cardiologists and physiologists in determining the normal electrical axis of the ventricle, therefore, from 0 to -30° is considered physiological LAD, while from -30° to -90° is the pathological one.

  - Now, try to find out if this ECG indicates normal cardiac axis.

- You can notice that all 12 leads are printed.
- The last words mentioned by the DR, to calculate the cardiac axis we need to calculate the number of small squares of QR (the resultant of it), it should be towards positive to indicate normal cardiac axis.
- I'm not sure if this calculation is required in our exam so you may check on other sources.
- Dr Nagi is a perfect source!

اللهمّ يا من لا يهزم جنده ولا يخلف وعده، ولا إله غيره، كُن لأهلنا في فلسطين وجميع بلاد المسلمين عونًا ونصيرًا ومعينًا وظهيرًا.

V2

Extra explanations were added, re-organized some points, it’s recommended to have this version instead.