CVS

PHYSIOLOGY

Modified NO: 5

كتابة: أحمد المطارنة و شذى

تدقيق: محمود جرادات

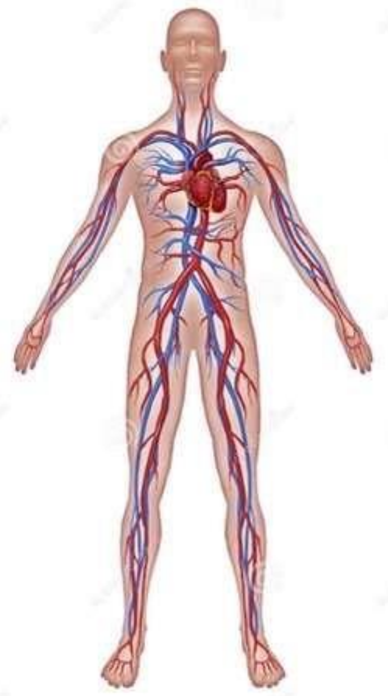
الدكتور: د فاطمة الريالات

Cardiovascular Physiology

Fatima Ryalat, MD, PhD

Assistant Professor, Physiology and Biochemistry Department

School of Medicine, University of Jordan



Color code

■ (black)	Slides
■ (green)	Doctor
■ (blue)	Additional info
■ (red)	Important

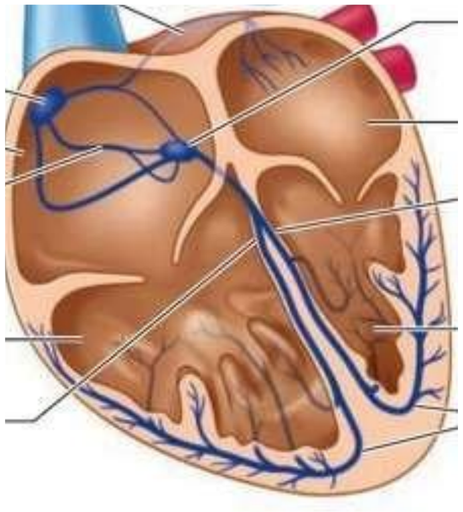
Electrocardiography

- ECGs measure the heart's electrical activity by detecting the summed action potentials of millions of cardiac muscle cells, creating a composite signal that reflects the heart's rhythmic contractions.
- So, we sum up the electrical current in each level through vector that represent summed directional wave, could be left and right, up or down

- Remember!

Movement of current in relation to the electrodes:

- + potential (depolarization) toward + electrode = + deflection
- - potential (repolarization) toward – electrode = + deflection
- - potential toward + electrode = - deflection
- + potential toward – electrode = - deflection on ECG strip.

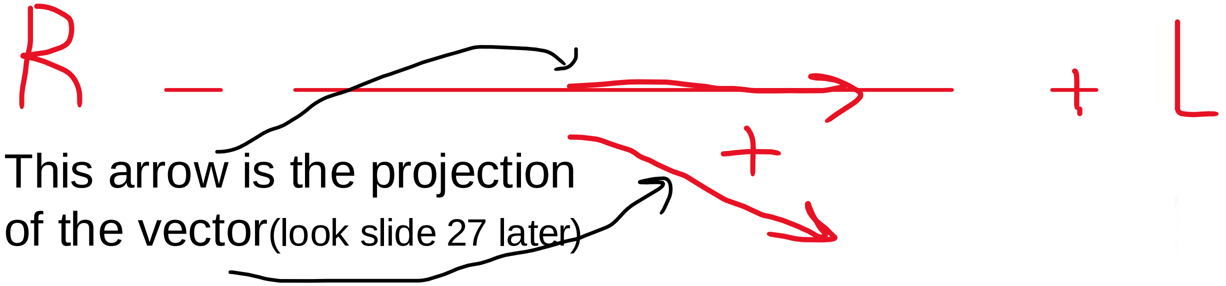


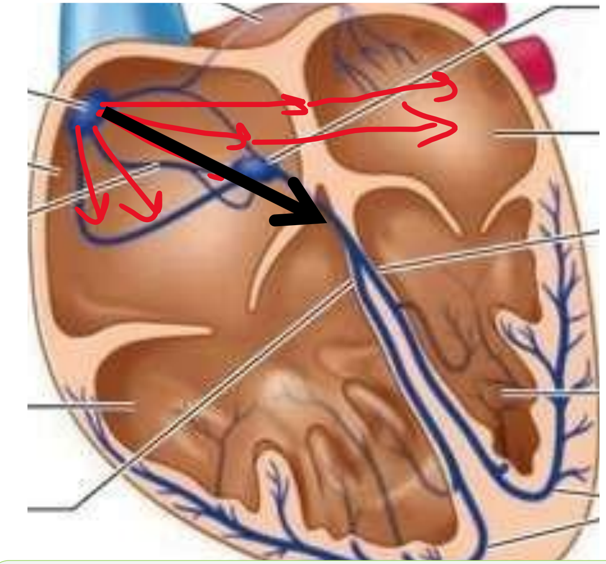
1. the left and right atria depolarization

- The actual potential is start to generate by the depolarization in the SA node and spread throughout the right atria and left atria

The direction of the flow will be (summated vector)→ down and left ⇘⇘⇘

The direction of spread of the electrical flow in red, and the summed vector in black🖤





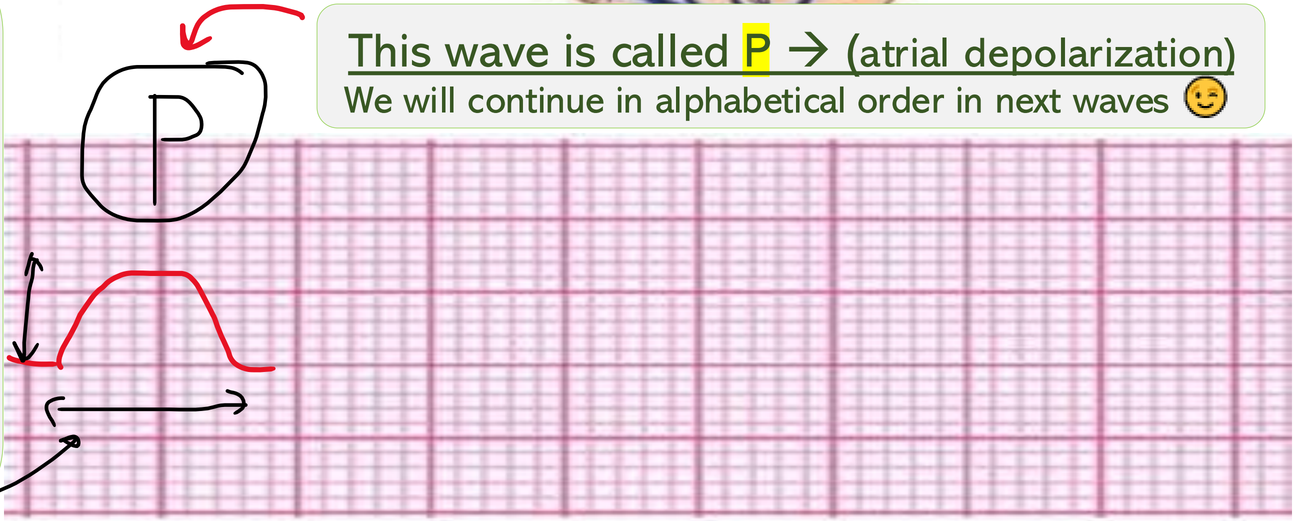
If we use lead I →bipolar lead between left arm (positive side) and right arm (negative side)

- The vector direction here is toward left side of the lead.
- The vector is positive, which represent depolarization (repolarization is negative).

+ potential (depolarization) toward + electrode = + deflection

(the positive deflection is represented in ECG as upward elevation)

- The time needed for the electrical flow and the amplitude is moderate compared to other levels.



This wave is called P → (atrial depolarization)

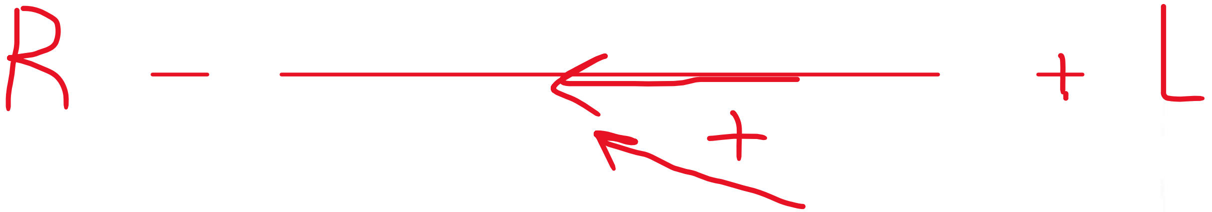
We will continue in alphabetical order in next waves 😉

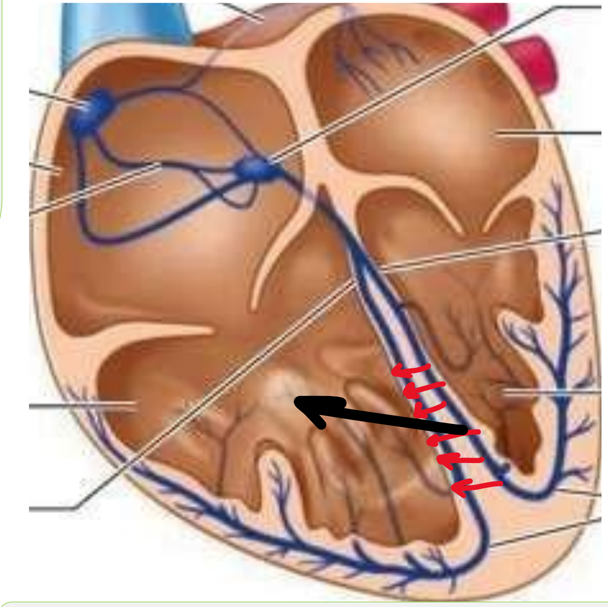
2. septum depolarization

- There will be delay in the AV node after the actual potential reach it (the depolarization in the AV node and SA nodes will not be detected), then to → AV fibers, left and right bundles in the septum (The septum consist of two parts, fibrous and muscular)
- Usually in the lower muscular septum the left bundle branch depolarize the muscles in interventricular septum

The direction of the flow will be (summated vector)→ up and right ⇖⇖

- The direction of spread of the electrical flow in red, and the summed vector in black🖤





This wave is called Q → (septal depolarization)

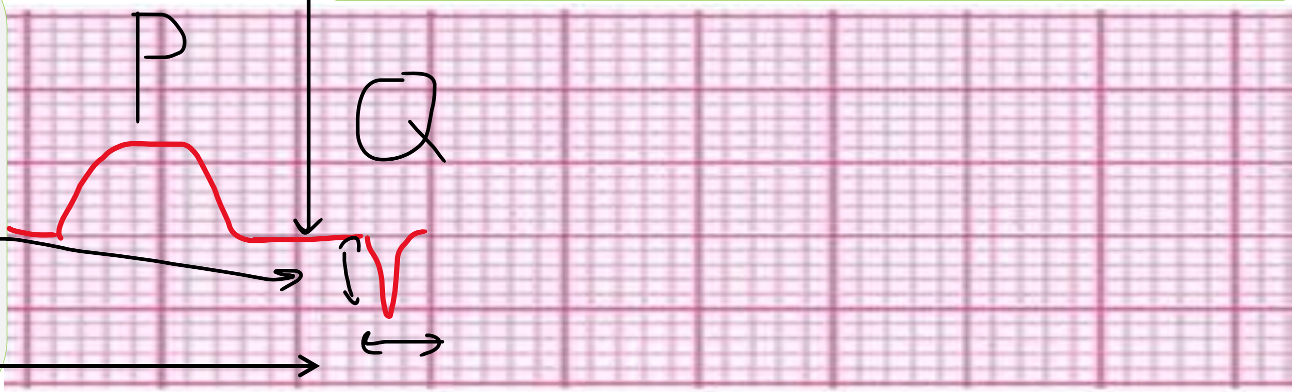
If we use lead I:

The vector direction here → right side of the lead.

- The vector is positive which represent depolarization
  + potential (depolarization) toward - electrode = - deflection

(the negative deflection is represented in ECG as downward depression)

- The time needed for the electrical flow is short and the amplitude is small (small muscles in the septum) compared to other levels.

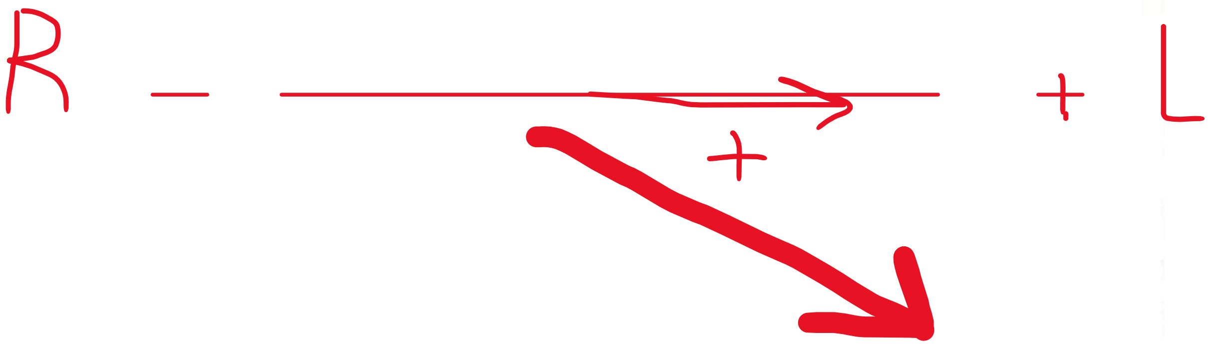


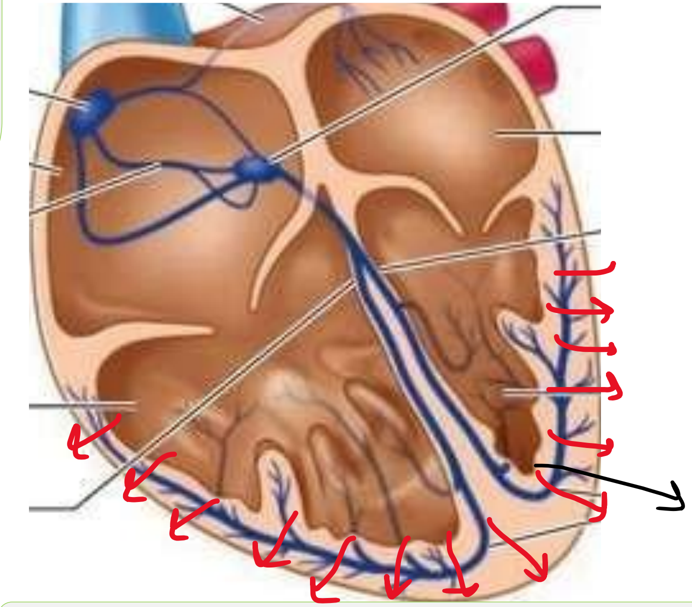
3. ventricular depolarization (in purkinje fibers)

- The waves will be transmitted from the endocardial side to the epicardial side
- The muscle of left side is more so the vector is left 👈

The direction of the flow will be (summated vector)→ down and left ⇘⇘⇘

The direction of spread of the electrical flow in red, and the summed vector in black🖤





This wave is called R →(ventricular depolarization)

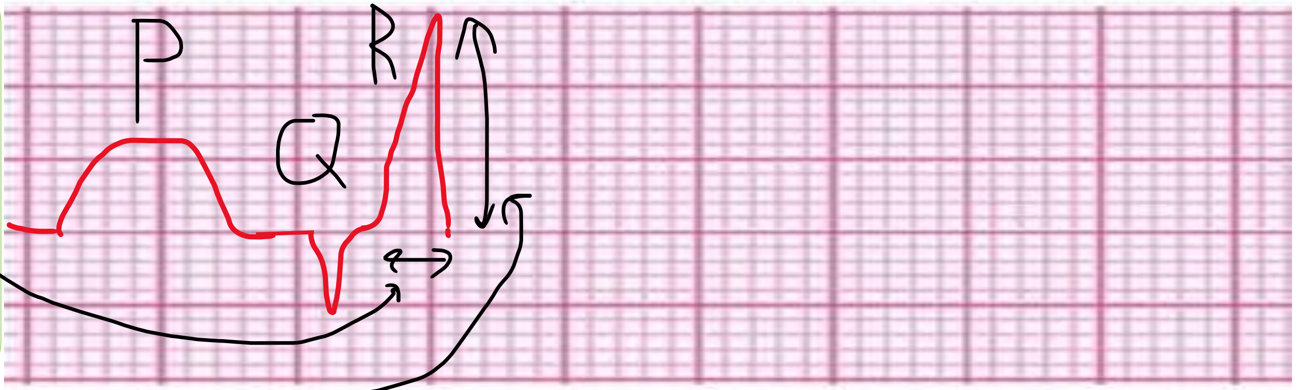
If we use lead I:

The vector direction here → left side of the lead.

•The vector is positive which represent depolarization

+ potential (depolarization) toward + electrode = + deflection

•The time needed for the electrical flow is short and the amplitude is high (large muscles in the ventricles) compared to other levels.

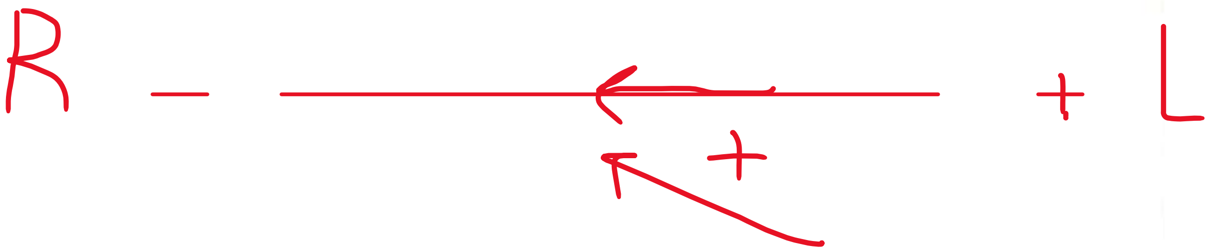


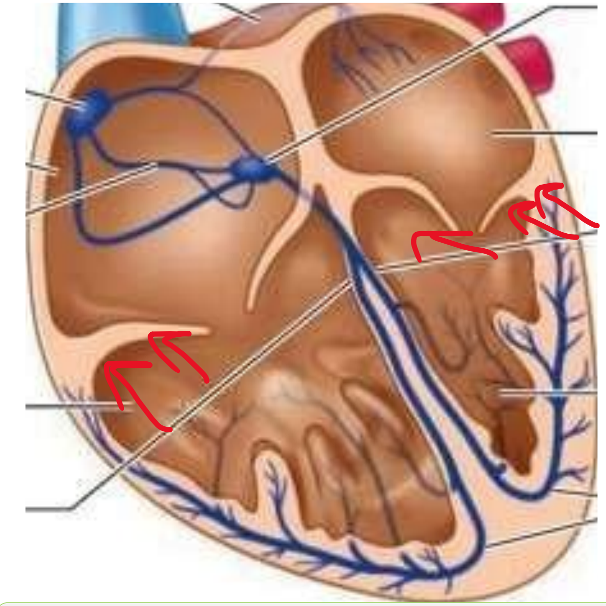
4. Base depolarization

The direction of the flow will be (summated vector)→ up and right⇖⇖⇖

The direction of spread of the electrical flow in red

- <u>QRS complex</u> (Q, R and S waves) → represent total ventricular depolarization





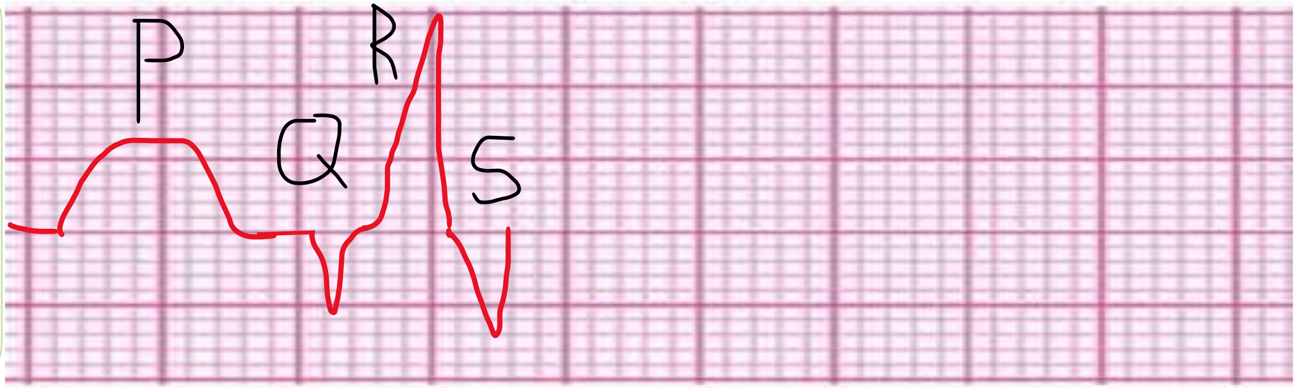
This wave is called S →(base depolarization)

If we use lead I:

The vector direction here → right side of the lead.

- The vector is positive which represent depolarization
  + potential (depolarization) toward - electrode = - deflection

- The time needed for the electrical flow is moderate and the amplitude is small compared to other levels.



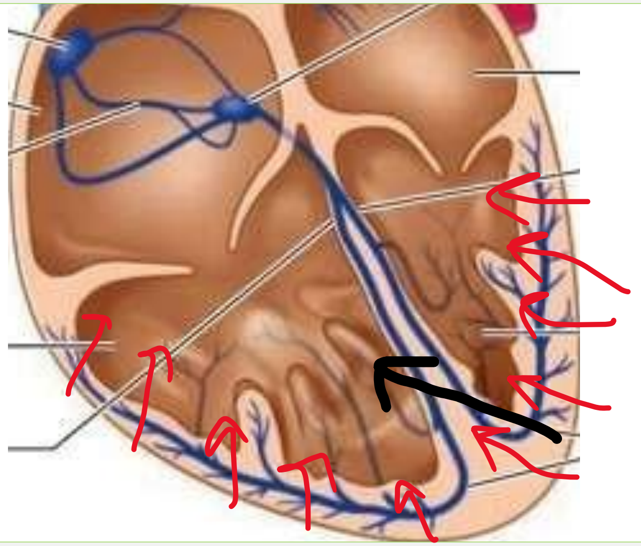
5. ventricular repolarization

- After complete depolarization (represented as isoelectric line after the QRS complex), repolarization start at epicardial toward the endocardial layer (the last cells to depolarize is the first to repolarize), this is caused by : after depolarization, the muscles will contract increasing the tension and pressure on the endocardial side, this will impair the blood supply for the endocardial muscles, which decrease oxygen, metabolic rate, which impair the movement of the ions resulting in slowing repolarization. also, the epicardial part has shorter repolarization phase

- The repolarization is slower than depolarization, causing all the ventricle cells to repolarize together with longer duration.

The direction of the flow will be (summated vector)→ up and right ⇖⇖⇖

The direction of spread of the electrical flow in red, and the summed vector in black



If we use lead I:

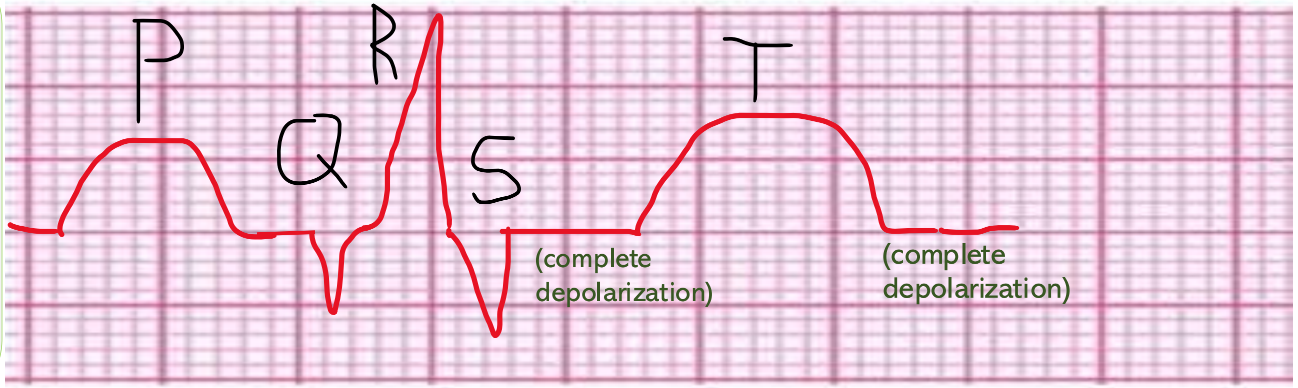
The vector direction here → right side of the lead.

- The vector is <u>negative</u> which represent <u>repolarization</u>

<u>- potential (depolarization) toward - electrode = + deflection</u>

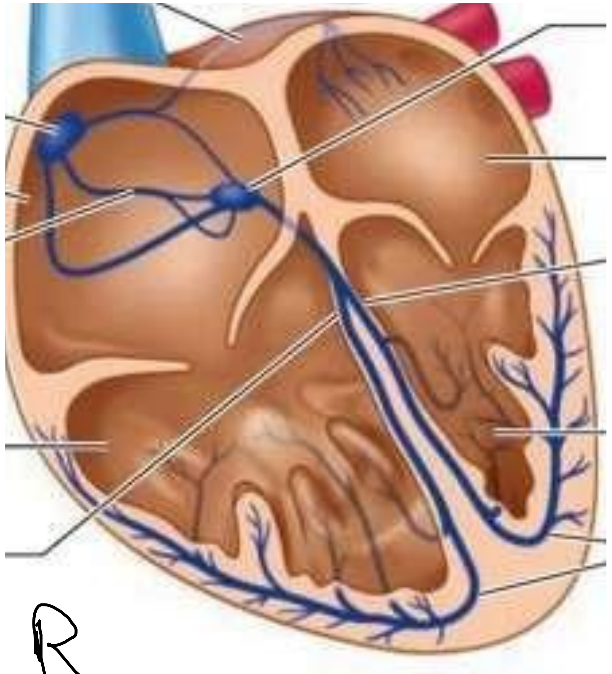
- The time needed for the electrical flow is <u>long</u> and the amplitude is <u>moderate</u> compared to other levels.

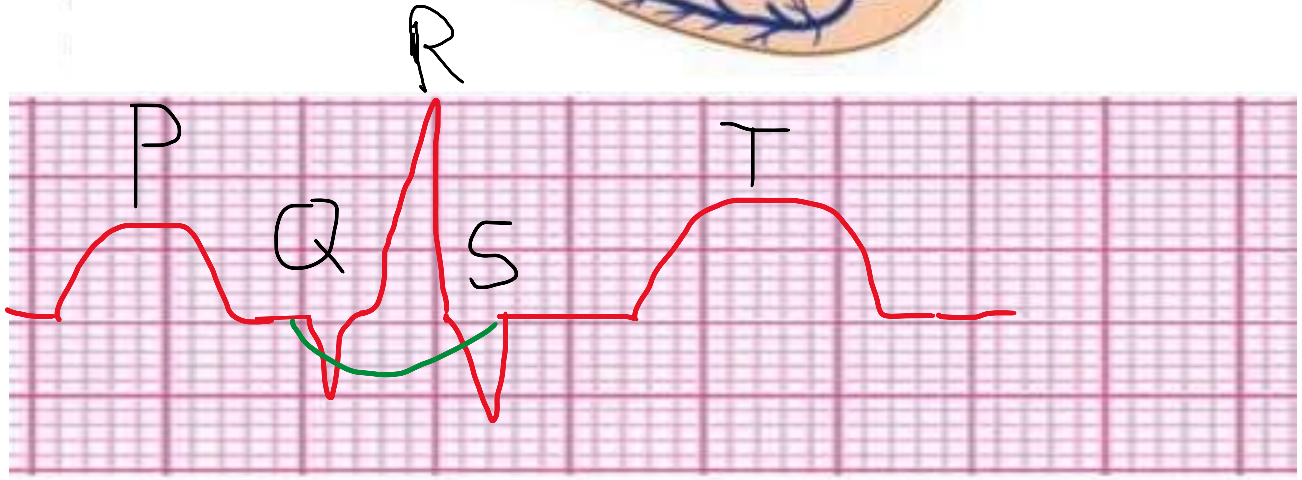
<u>This wave is called T →(ventricular repolarization)</u>

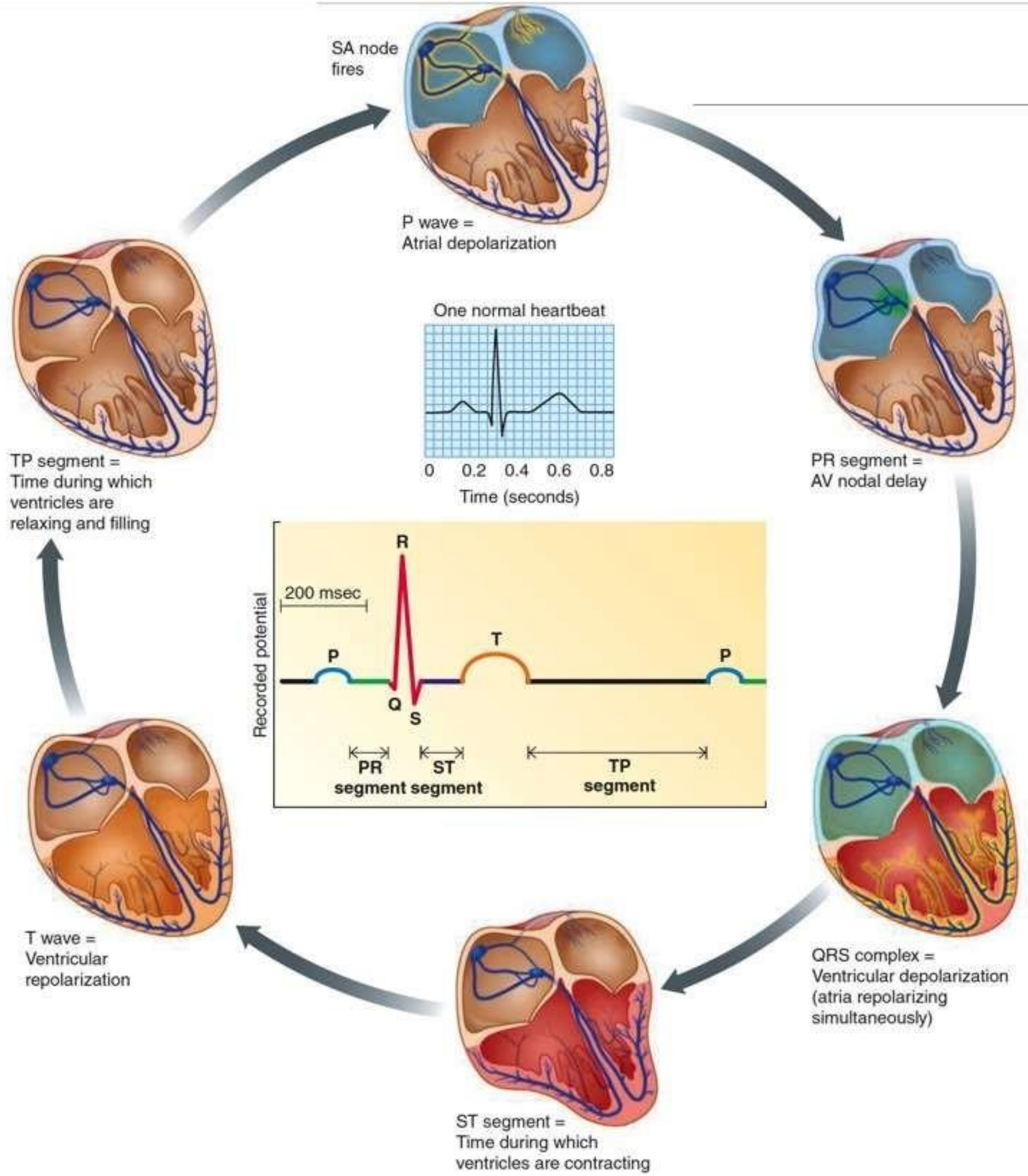


Did we forget something?🤔

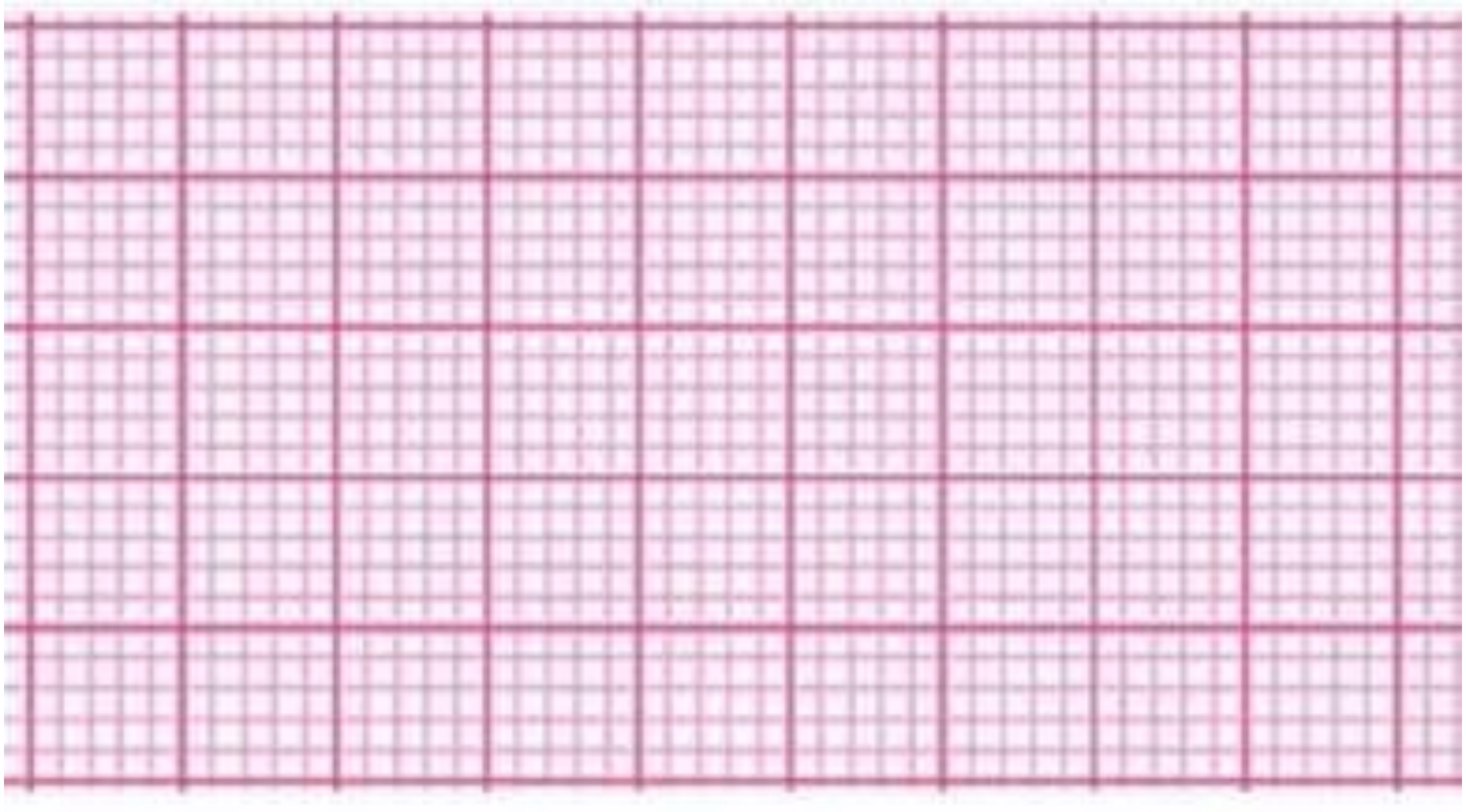
- That's right! it's the atrial repolarization (as represented in the green line), but well, it's masked anyway by the QRS complex.






SA node
fires
P wave =
Atrial depolarization
PR segment =
AV nodal delay
QRS complex =
Ventricular depolarization
(atria repolarizing
simultaneously)
ST segment =
Time during which
ventricles are contracting
T wave =
Ventricular
repolarization
TP segment =
Time during which
ventricles are
relaxing and filling
One normal heartbeat
0 0.2 0.4 0.6 0.8
Time (seconds)
R
200 msec
Recorded potential
P
T
P
Q
S
PR
segment
ST
segment
TP
segment

Voltage
(mV)



Time (seconds)

Projected vectors

- To determine how much of the voltage in a vector will be recorded in a lead, a line perpendicular to the axis of the lead is drawn from the tip of the vector to the lead axis, and a so-called projected vector is drawn along the lead axis.

- The arrow of the projected vector points toward the positive or the negative end of the lead axis.

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Vectorial analysis of ECG

- when the vector in the heart is in a direction almost perpendicular to the axis of the lead, the voltage recorded in the ECG of this lead is very low.

- when the heart vector has almost exactly the same axis as the lead axis, essentially the entire voltage of the vector will be recorded.

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Vectorial analysis of ECG

- heart current flows in a particular direction in the heart at a given instant during the cardiac cycle.
- A vector is an arrow that points in the direction of the electrical potential generated by the current flow, ~~with the arrowhead in the positive direction.~~
- Also, by convention, the length of the arrow is drawn proportional to the voltage of the potential.
- ~~the summated vector of the generated potential at any particular instant, called the instantaneous mean vector~~.

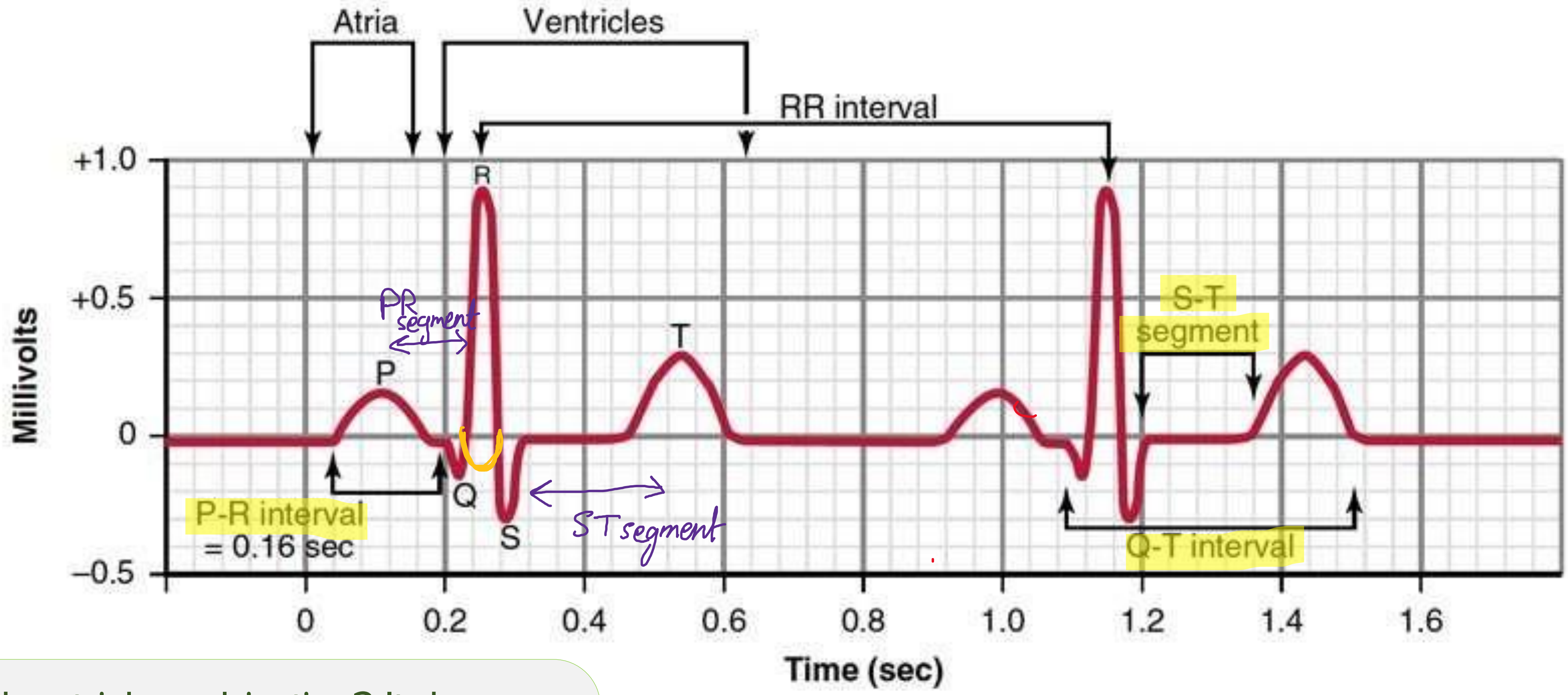
ECG waves

- Depolarization waves:
- Atria (P wave)
- Ventricle (QRS complex)

- Repolarization waves:
- Atria (not shown on ECG because occur simultaneously with QRS)
- ~~The atria repolarize about 0.15 to 0.20 second after termination of the P wave, which is also approximately when the QRS complex is being recorded in the ECG. Therefore, the atrial repolarization wave, known as the atrial T wave, is usually obscured by the much larger QRS complex. For this reason, an atrial T wave is seldom observed on the ECG.~~
- Ventricles (T wave)

ECG segments and intervals

- <u>**Segment represent isoelectric line between two waves**</u>
- P-R segment: between P wave and QRS complex, named P-R because normally it's difficult to see Q wave
- S-T segment: between the QRS complex and T wave, this segment is important when we talk about MI (myocardial infarction)
- <u>**In Interval there is at least one wave and one segment**</u>
- P-R interval: consist of 1) P wave and 2) P-R segment (the Q wave is not included)
- Q-T interval: consist of 1) QRS complex, 2) S-T segment and 3) T wave



- where the atrial repolrization? It does happen here at the same time of ventricular depolrization but it will be masked by the QRS complex's bcz. It's larger more voltage more amplitude

- As we see the ECG , it showed waves , segments which is represent the line, and intervals
- The segment between P wave and QRS complex is called PR more common or PQ , but we usually don't see the Q on the ECG , we see R wave directly , but make sure that it is line so Q doesn't include in it ,,, also we have ST segment between QRS and T wave

- Intervals means that we have at least one wave and one segment , we have the **PR interval** ➡️ P wave and PR segments.
- Another **interval QT** includes QRS complex, T segments and T wave.
- We talk about it more in the next lecture

ADDED •

Atrial depolarization and repolarization

- Spread of depolarization through the atrial muscle is much slower than in the ventricles because the atria have no Purkinje system.
- the area in the atria that also becomes repolarized first is the sinus nodal region, the area that had originally become depolarized first (atrial T wave).
- Therefore, the atrial repolarization vector is backward to the vector of depolarization.

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Ventricular depolarization

- When the cardiac impulse enters the ventricles through the atrioventricular bundle, the first part of the ventricles to become depolarized is the left endocardial surface of the septum.
- Then, depolarization spreads rapidly to involve both endocardial surfaces of the septum

ADDED •

Ventricular repolarization

- Because the septum and endocardial areas of the ventricular muscle depolarize first, it seems logical that these areas should repolarize first as well.
- However, this is not the usual case, because the septum and other endocardial areas have a longer period of contraction than most of the external surfaces of the heart.

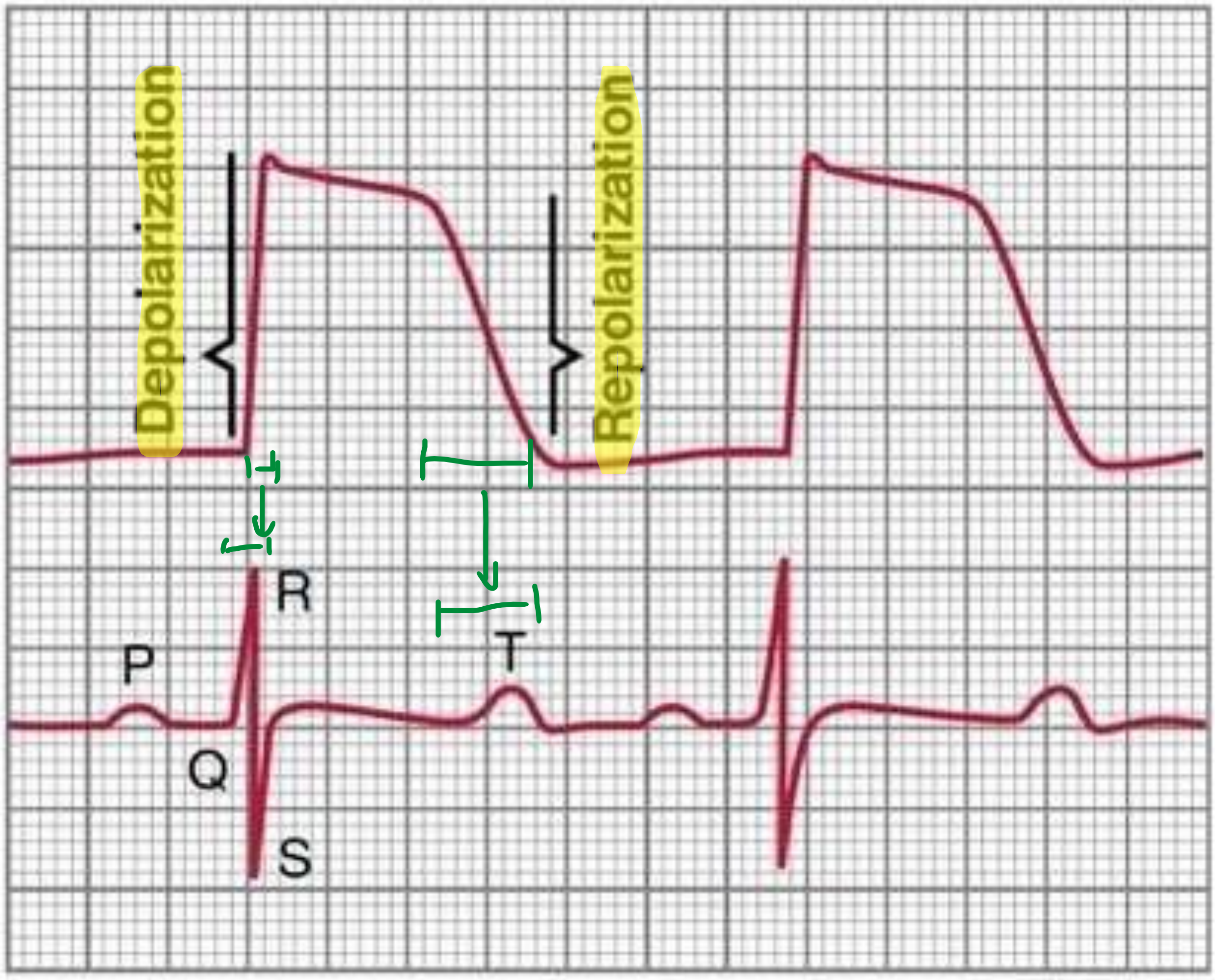
- Therefore, the greatest portion of ventricular muscle mass to repolarize first is the entire outer surface of the ventricles, especially near the apex of the heart.
- The endocardial areas, conversely, normally repolarize last.
- This sequence of repolarization is postulated to be caused by the high blood pressure inside the ventricles during contraction, which greatly reduces coronary blood flow to the endocardium, thereby slowing repolarization in the endocardial areas.

ADDED •

Ventricular repolarization

- The process of ventricular repolarization extends over a long period, about 0.15 second.

- For this reason, the T wave in the normal ECG is:
- prolonged wave,
- the voltage of the T wave is less than the voltage of the QRS complex.



T wave compared to QRS

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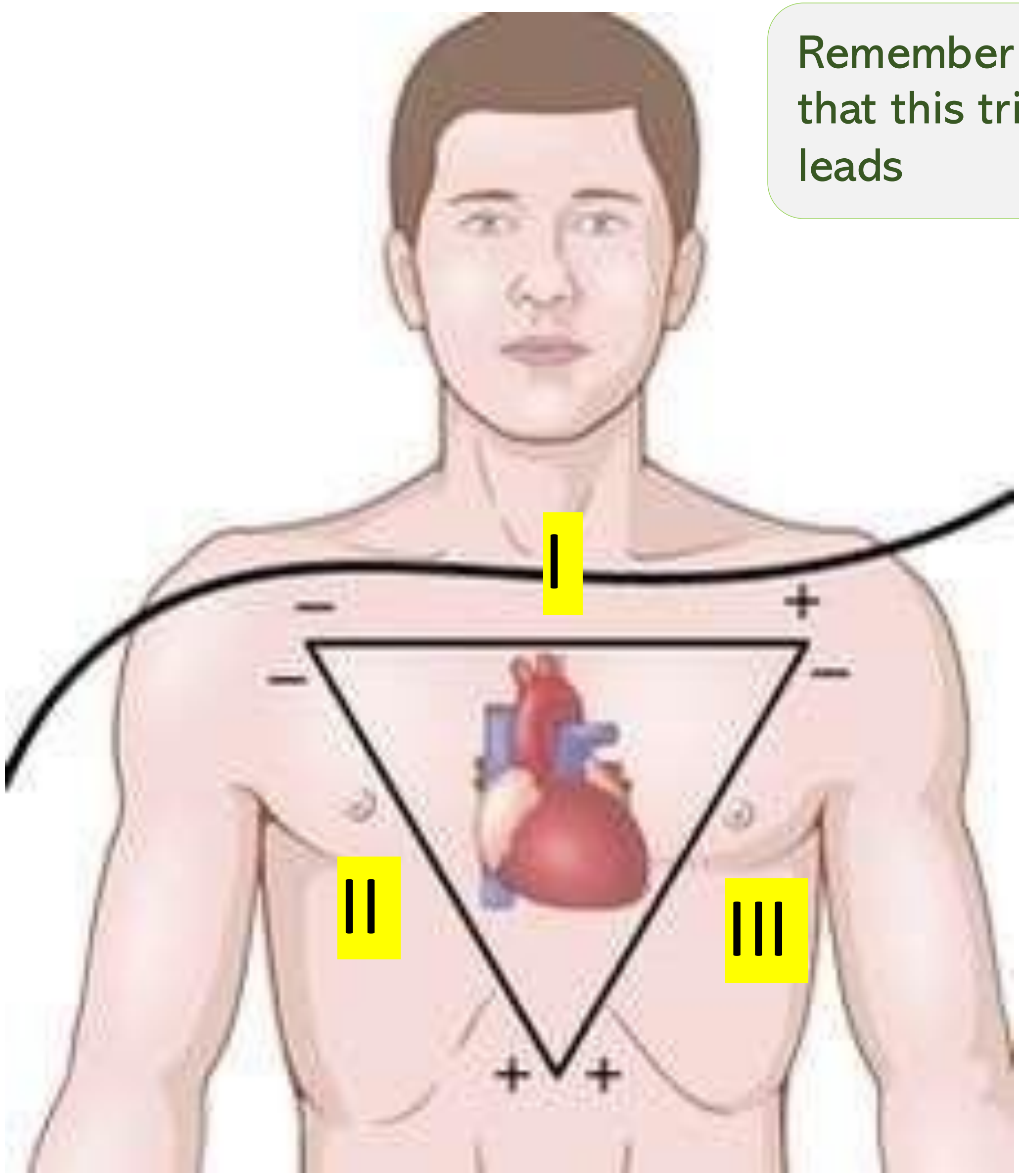
This is showing why the ventricular depolrization faster compered to single base action potential
Look to the depolrization is steep and faster, while T wave represents repolrization which has a longer duration than depolrization **in addition to factors that we said**
I will mention it here to memories (about T wave) :
However the amplitude depends on the muscles mass , and the same muscles that have depolrization have repolrization, but the amplitude should be less in ventricular repolrization.Why? Bcz. The same muscles mass distributed on longer time , so the amplitude appears less . **Remember students and doors example** 🤓😉😔 that is why the amplitude in R wave in depolrization high than the repolrization bcz. It distributed in longer duration

Einthoven's triangle



Remember from the previous lecture, that this triangle consists of 3 bipolar leads

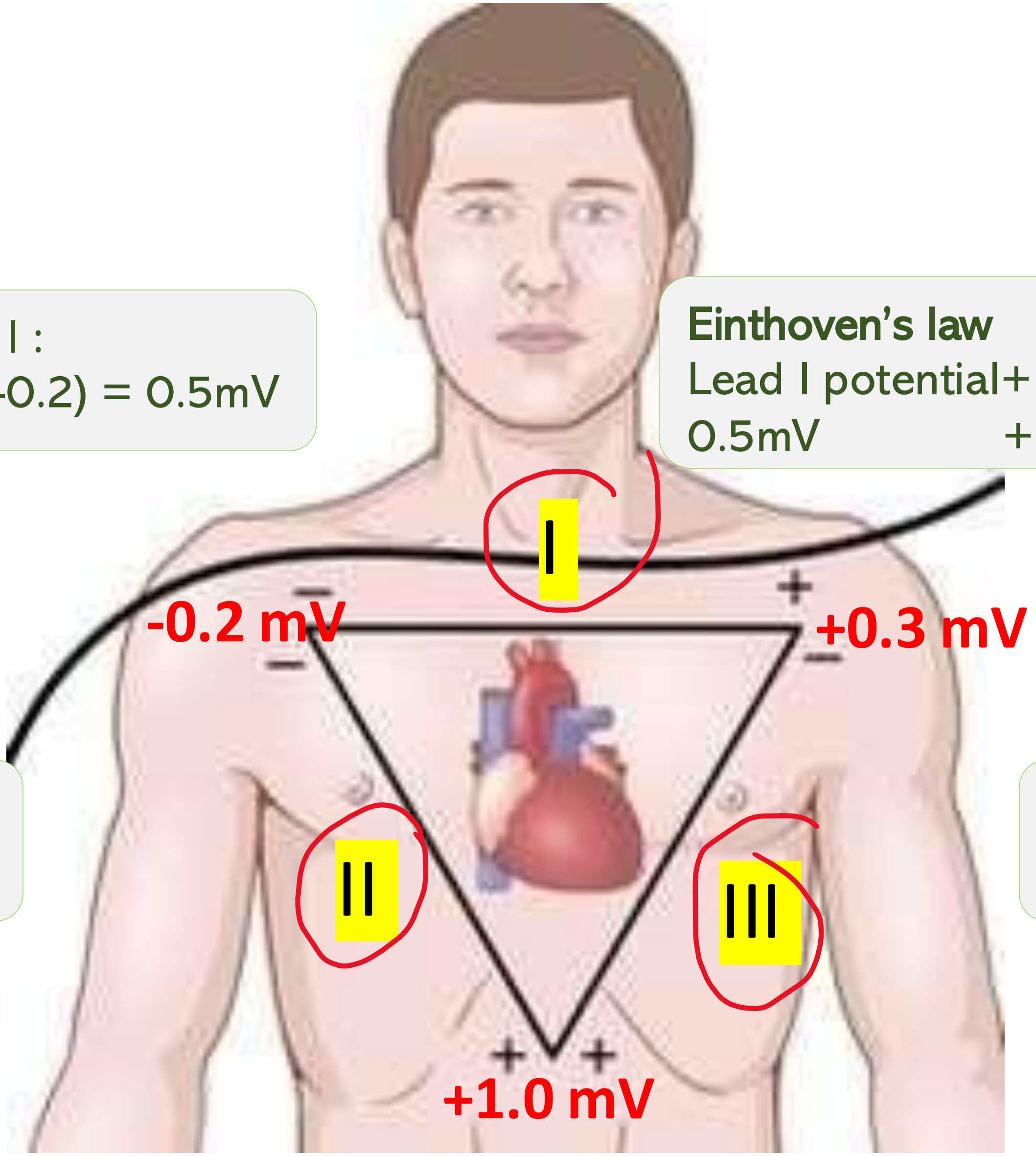
Einthoven’s law

- if the ECGs are recorded simultaneously with the three limb leads, the sum of the potentials recorded in leads I and III will equal the potential in lead II:
- Lead I potential+ Lead III potential = Lead II potential
- Mathematically, this principle, called Einthoven’s law, holds true at any given instant while the three “standard” bipolar ECGs are being recorded.
- Do not forget the signs (negative or positive).

Einthoven's triangle

For lead I :
+0.3 – (-0.2) = 0.5mV

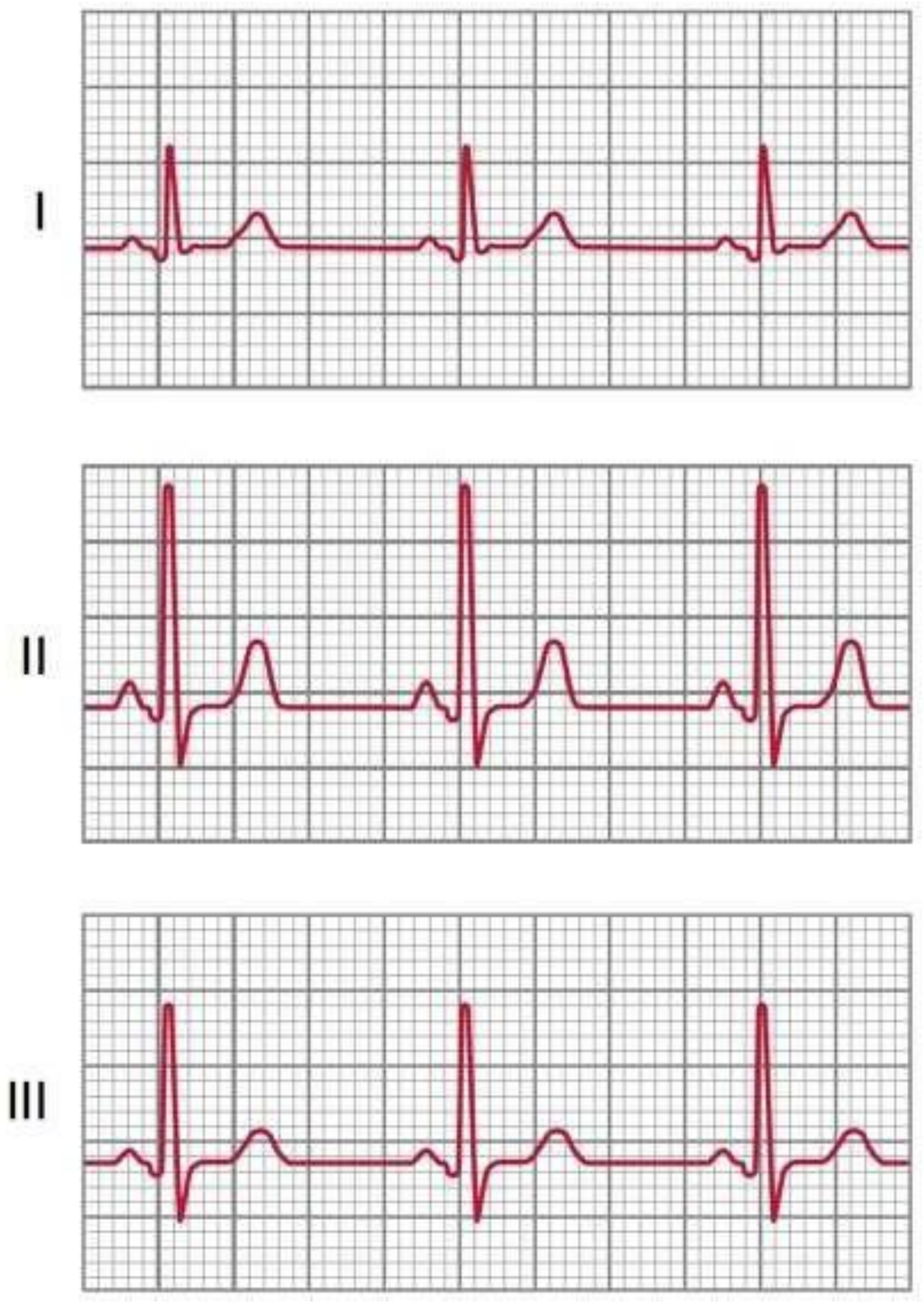
Einthoven's law
Lead I potential+ Lead III potential = Lead II potential
0.5mV + 0.7 mV = 1.2 mV



For lead II :
+1.0 – (-0.2) = 1.2mV

For lead III :
+1.0 – (+0.3) = 0.7mV

- In the ECG, if we want to measure the potential we use the QRS complex, in the QRS complex we have positive and negative deflection, so we take the net for the three wave in the complex (the difference between the positive and negative deflection)
- In lead I, the wave ascends up nearly 7 squares and down 2 square (1 Q and 1 S in waves) = 0.5 mV (each small square = 0.1mV)
- In lead II, the wave ascends up nearly 15 squares and down 3 square = 1.2 mV
- In lead III, the wave ascends up nearly 10 squares and down 3 square = 0.7 mV
- The number of squares is not very specific here, just a reference for how we measure in the ECG and the numbers here are changeable the only thing that we use constantly is the Einthoven's triangle.

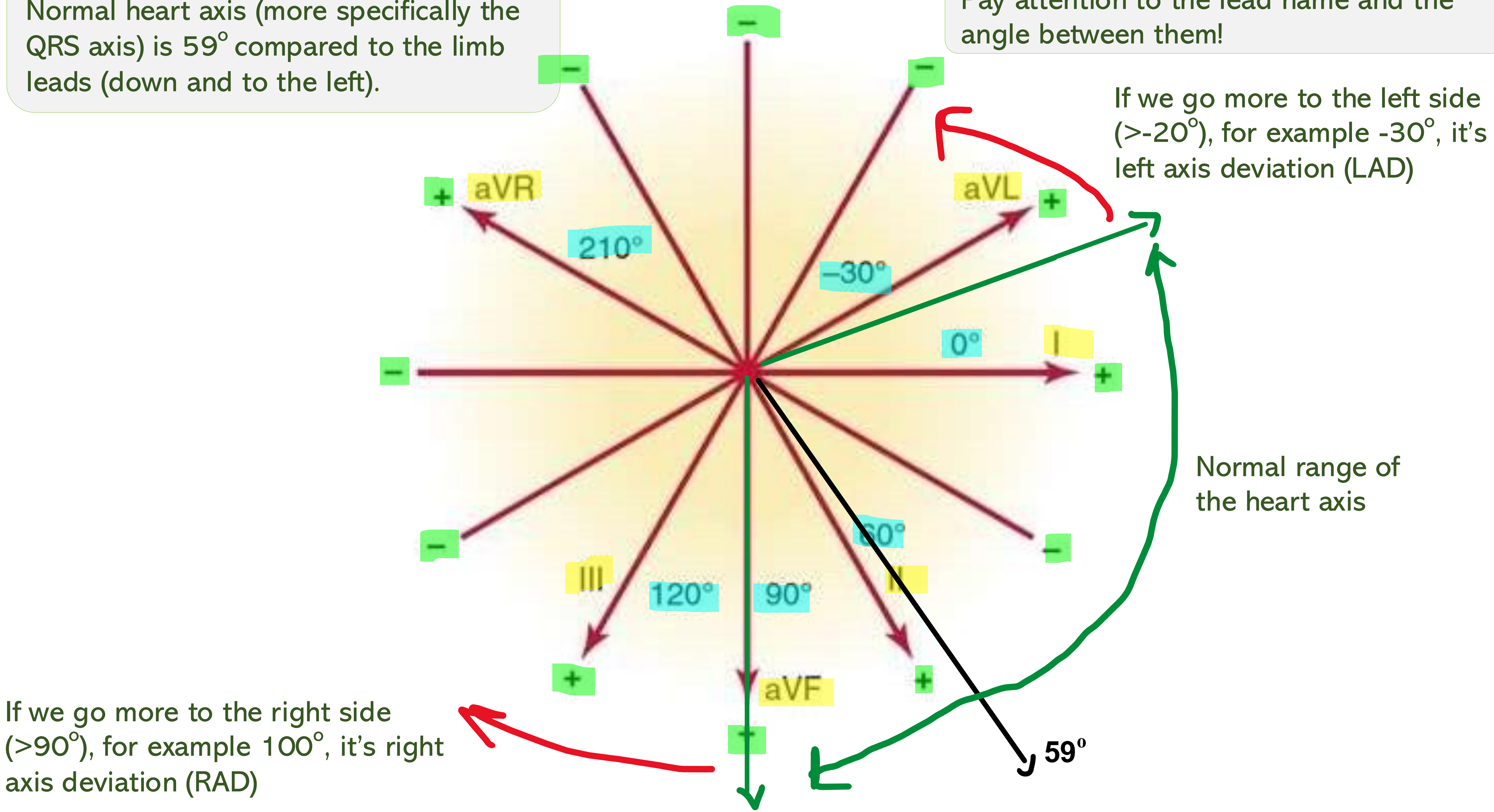


Axes of limb leads

The heart axis depends on the limb leads (not the chest)
The 3 bipolar and the 3 unipolar

clockwise is the positive angle direction! Normal heart axis (more specifically the QRS axis) is 59° compared to the limb leads (down and to the left).

Pay attention to the lead name and the angle between them!



ADDED •

Electrical Axis of QRS

- The approximate average potential generated by the ventricles during depolarization is represented by the length of this mean QRS vector, and the mean electrical axis is represented by the direction of the mean vector.

- Thus, the orientation of the mean electrical axis of the normal ventricles is 59 degrees

ADDED •

Normal electrical axis of QRS

- Although the mean electrical axis of the ventricles averages about 59 degrees, this axis can swing, even in a normal heart, from about - 20 degrees to about +100 degrees (in other references -30 to +90).
- The causes of the normal variations are mainly anatomical differences in the Purkinje distribution system or in the musculature itself of different hearts.

Removed •

Vectorial analysis of ECG

- In a normal heart, the average direction of the vector during spread of the depolarization wave through the ventricles, called the mean QRS vector, is about +59 degrees
- In normal situation, the heart axis is usually between (-20° to +90°)

Vectorial analysis of ECG

- the direction from negative electrode to positive electrode is called the axis of the lead.

- To determine how much of the voltage in a vector will be recorded in a lead, a line perpendicular to the axis of the lead is drawn from the tip of the vector to the lead axis, and a so-called projected vector.

ADDED •

BBB

- the lateral walls of the two ventricles depolarize at almost the same instant because both the left and right bundle branches of the Purkinje system transmit the cardiac impulse to the two ventricular walls at almost the same time.
- However, if only one of the major bundle branches is blocked, the cardiac impulse spreads through the normal ventricle before it spreads through the other ventricle. Therefore, depolarization of the two ventricles does not occur, even nearly at the same time, and the depolarization potentials do not neutralize each other. As a result, axis deviation occurs

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Ventricular hypertrophy

- When one ventricle hypertrophies greatly, the axis of the heart shifts toward the hypertrophied ventricle for two reasons.
- First, there is more muscle on the hypertrophied side of the heart than on the other side, which allows for the generation of greater electrical potential on that side.
- Second, more time is required for the depolarization wave to travel.

RAD

(right axis deviation)

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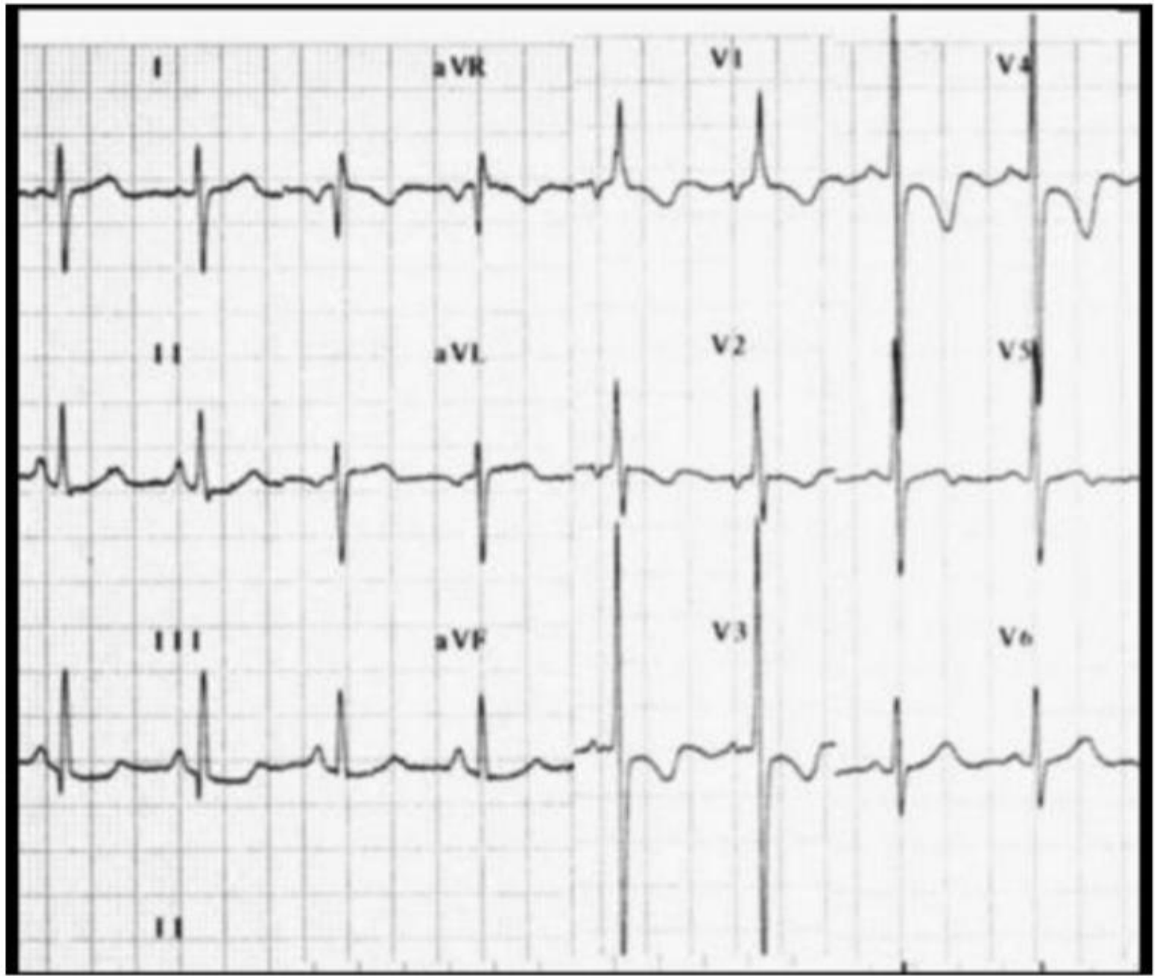
- **Physiological causes of RAD:**
- (1) at the end of deep inspiration,
- (2) when a person stands up,
- (3) normally in tall thin people.

- **Pathological causes of RAD :**
- (4) RVH (right ventricular hypertrophy)
- (5) RBBB (right bundle branch block) : will lead to slower conduction in the right side (the signal can reach the right from the left through gap junctions) → shift to the right in axis

ADDED •



• تغير ترتيب رقمها السابق 31
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LAD (left axis deviation)

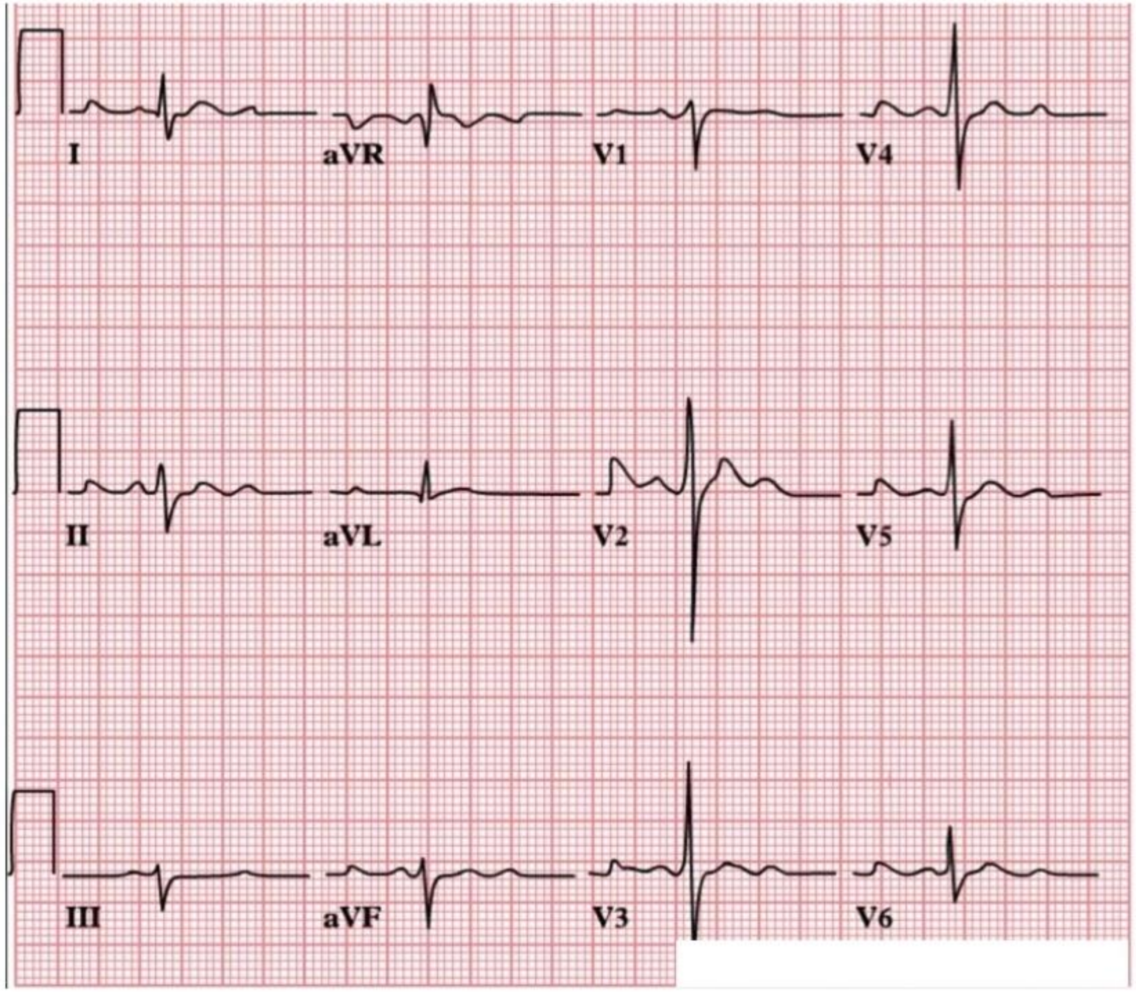
- **Physiological causes of LAD:**
- (1) at the end of deep expiration,
- (2) when a person lies down, because the abdominal contents press upward against the diaphragm,
- (3) quite frequently in obese people, whose diaphragms normally press upward against the heart all the time as a result of increased visceral adiposity.
- (4) in pregnancy because the increased intra-abdominal pressure press upward against the diaphragm
- **Pathological causes of LAD:**
- (5) LVH (left ventricular hypertrophy)
- (6) LBBB (left bundle branch block) : will lead to slower conduction in the left side (the signal can reach the left from the right through gap junctions) → shift to the left in axis

ADDED •

LBBB

- Left axis deviation
- Prolonged QRS
- This extremely prolonged QRS complex differentiates bundle branch block from axis deviation caused by hypertrophy.

ADDED •



VERSIONS	SLIDE #	BEFORE CORRECTION	AFTER CORRECTION
V1→ V2	37**	LAD left	RAD right
V2→V3	V3هذه الأرقام تمثل شرائح الملف 33,34 13,20,22,23,31,32,35,38,40,41 14,15,21,24,36,37,39 16		 Removed ADDED تغيير ترتيبهم داخل الملف تعديل

امسح الرمز و شاركنا بأفكارك لتحسين أدائنا!!