CVS
PHYSIOLOGY

Modified NO: 4

كتابة: أحمد المطارنة و زين مالك

تدقيق: ميس قشّوع

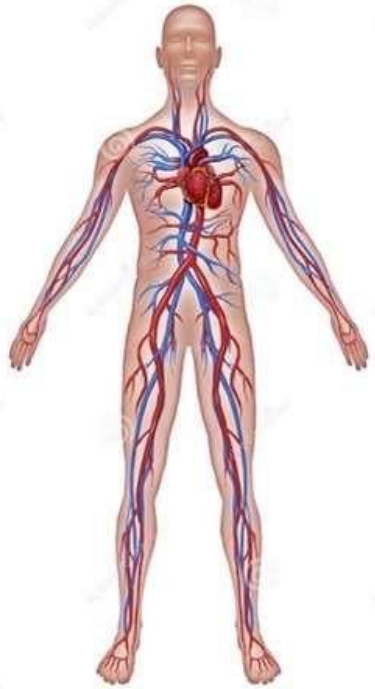
الدكتور: فاطمة الريالات

Cardiovascular Physiology

Fatima Ryalat, MD, PhD

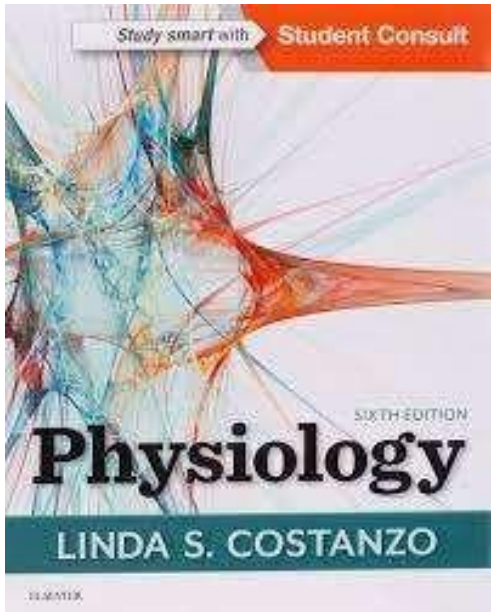
Assistant Professor, Physiology and Biochemistry Department

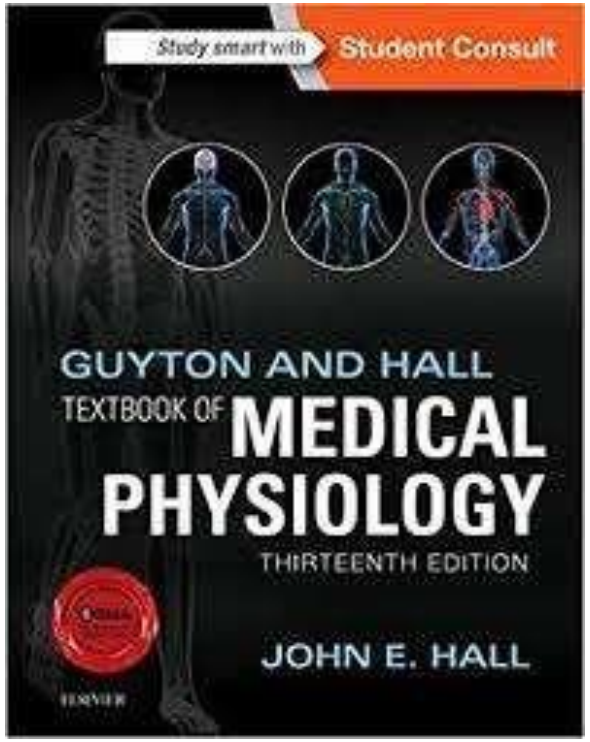
School of Medicine, University of Jordan

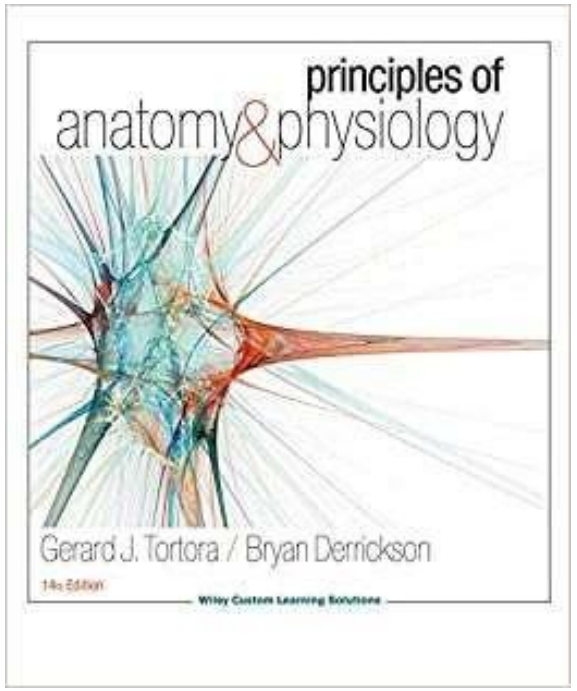


Color code
Slides
Doctor
Additional info
Important

References


Study smart with
Student Consult
SIXTH EDITION
Physiology
LINDA S. COSTANZO


Study smart with
Student Consult
GUYTON AND HALL
TEXTBOOK OF MEDICAL
PHYSIOLOGY
THIRTEENTH EDITION
JOHN E. HALL


principles of
anatomy&physiology
Gerard J. Tortora / Bryan Derrickson


Human Physiology
From Cells to Systems
Lauralee Sherwood
CENGAGE Learning

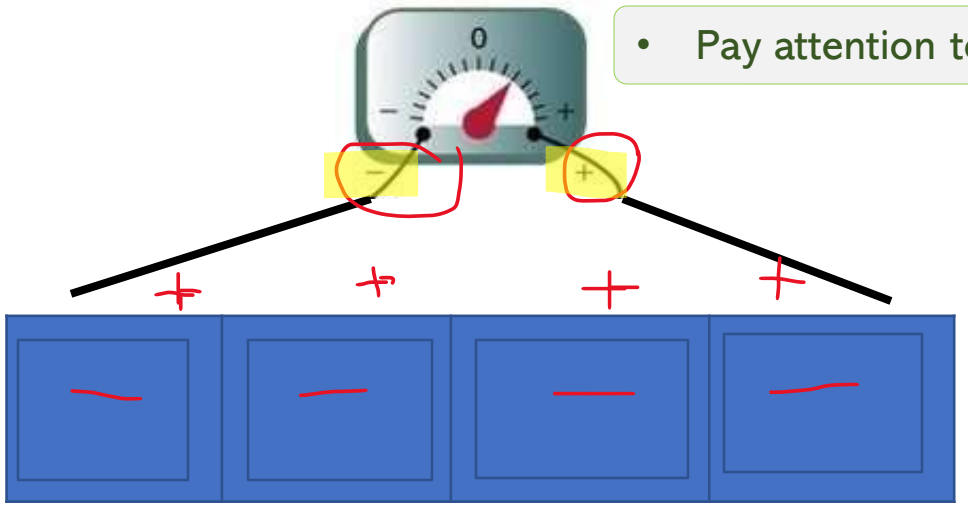
Electrocardiography

a graphical representation of the electrical activity of the heart, a very important diagnostic tool, why; because its sensitive, specific, non-invasive, non-time consuming, easily used ,easily interrupted and its cheap.

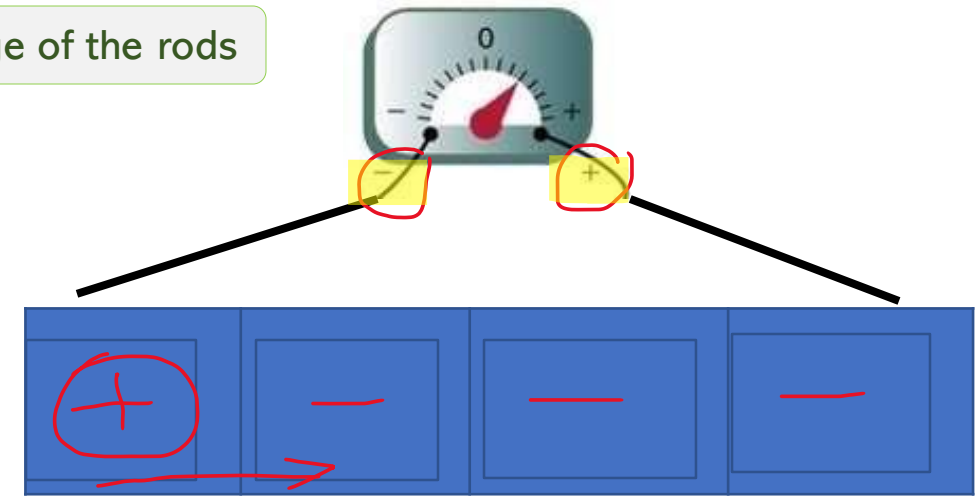
- We measure in ECG (Electrocardiography) the electrical activity of the heart from the body surface, because our body surface are highly conductive to electricity, we measure the electricity by the Galvanometer

- The Galvanometer has two rods, one is positive, and the other is negative, attached to different body surfaces

- The electricity we measure is the → action potential



- Pay attention to the charge of the rods



Considering these blocks as cardiac cells

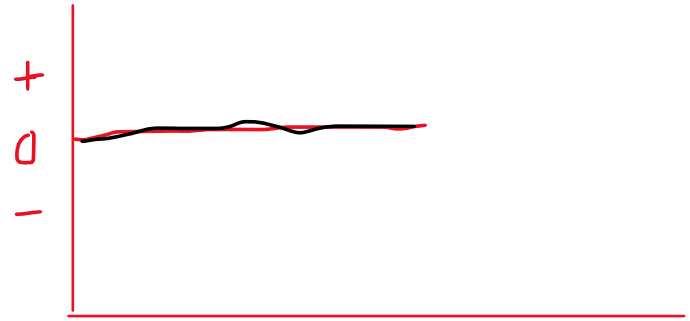
1. Resting cells (resting membrane potential)

The resting potential is negative for all muscle cells

In SA node is about (-60 /-55) and in ventricular cells (-90 /-85)

- The measurement by Galvanometer will be **Zero**

(no difference in potential between each rod)



In ECG, there will be straight line → **isoelectric line**

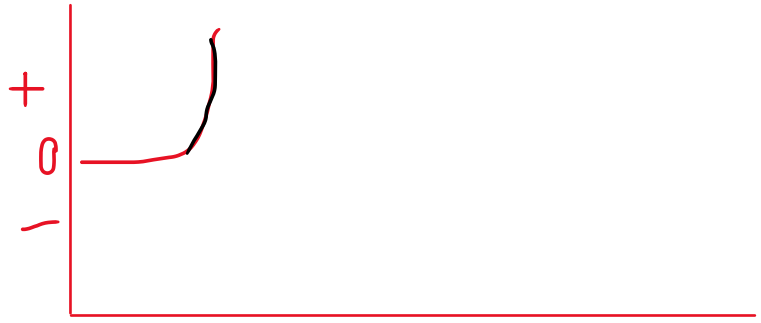
"Resting cells, no action potential"

2. Stimulated cell (the beginning of depolarization)

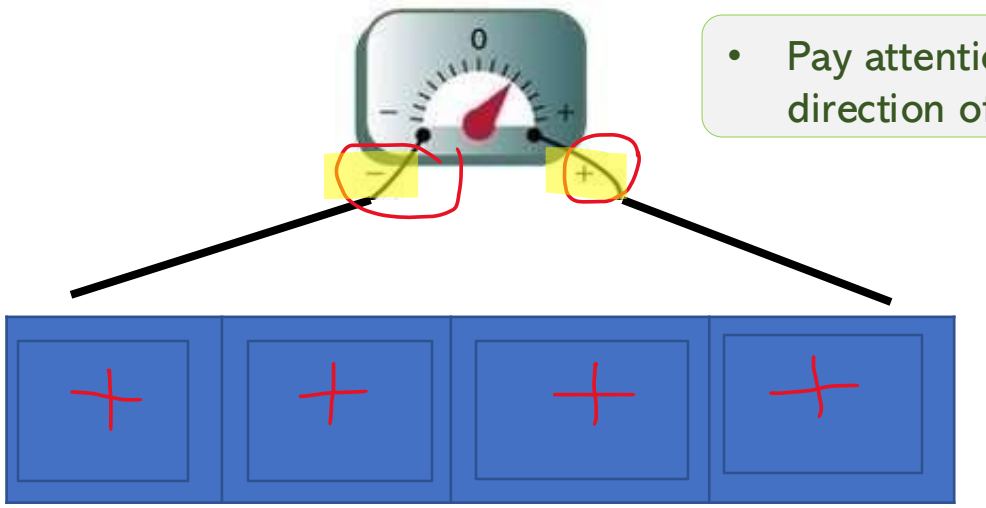
The left side is stimulated here, but the right side is still resting, which will make a difference between the two rods detected by the Galvanometer

- The measurement by Galvanometer will be **positive**

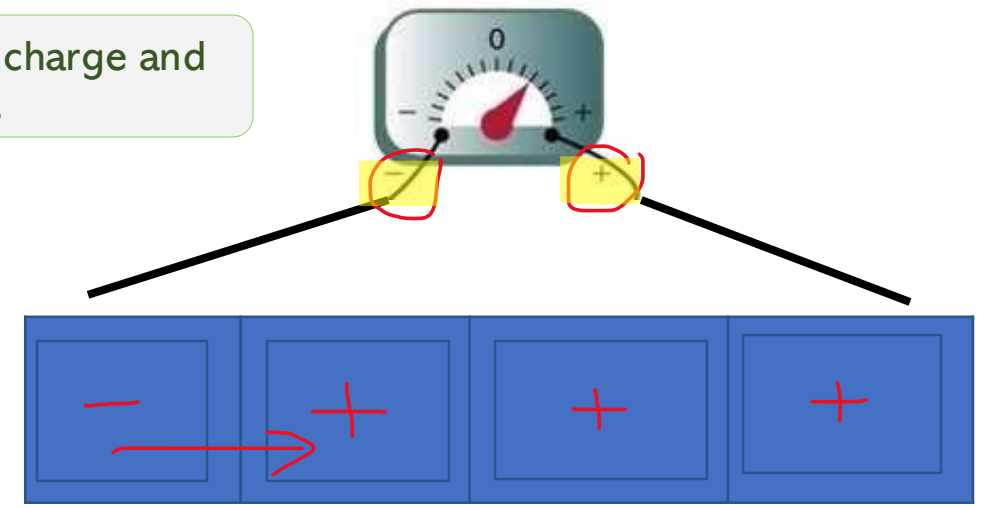
(+ potential (depolarization) because the flow of the current is toward + electrode = **+ deflection**)



positive deflection



- Pay attention to the charge and direction of the rods



3. Completely depolarized cells

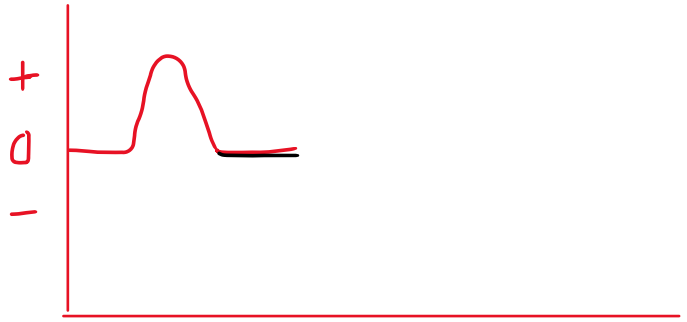
the actual potential will be transmitted by gap junctions, all cells here have positive charge

- The measurement by Galvanometer will be **zero**
  (no difference in potential between each rod)

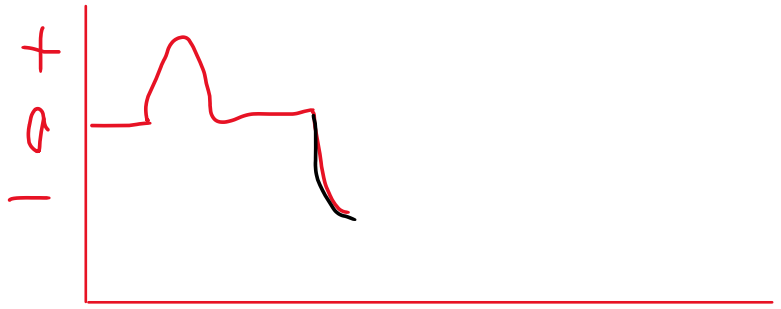
4. The start of repolarization

The left side is repolarized here, but the right side is still depolarized, which will make a difference between the two rods detected by the Galvanometer

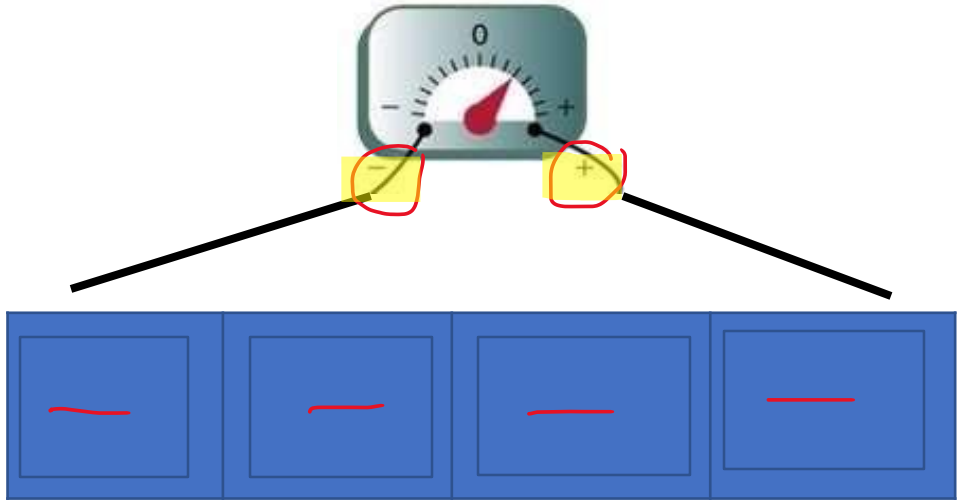
- The measurement by Galvanometer will be **negative**
  (-) potential toward (+) electrode = **- deflection**



isoelectric line



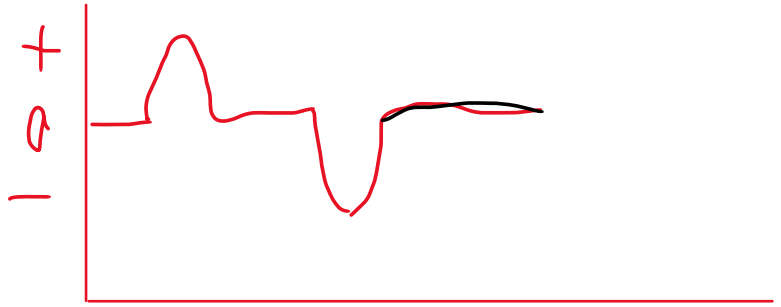
Negative deflection



5. Complete repolarization

Returned to resting potential

- The measurement by Galvanometer will be **zero** (no difference in potential between each rod)



isoelectric line

ECG basics

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.

- The same charge +/+ or -/- → positive deflection
- Different charges +/- → negative deflection

ECG basics

- Galvanometer measures potential difference between myocardial cells, i.e. if there is no flow of ions, there will be no deflection (straight line on ECG).

- no potential is recorded in the ECG when the ventricular muscle is either completely polarized or completely depolarized.

- Only when the muscle is partly polarized and partly depolarized does current flow from one part of the ventricles to another part

ECG basics

- Changes in membrane potential in small parts of the heart such as SA node will not be detected by ECG.

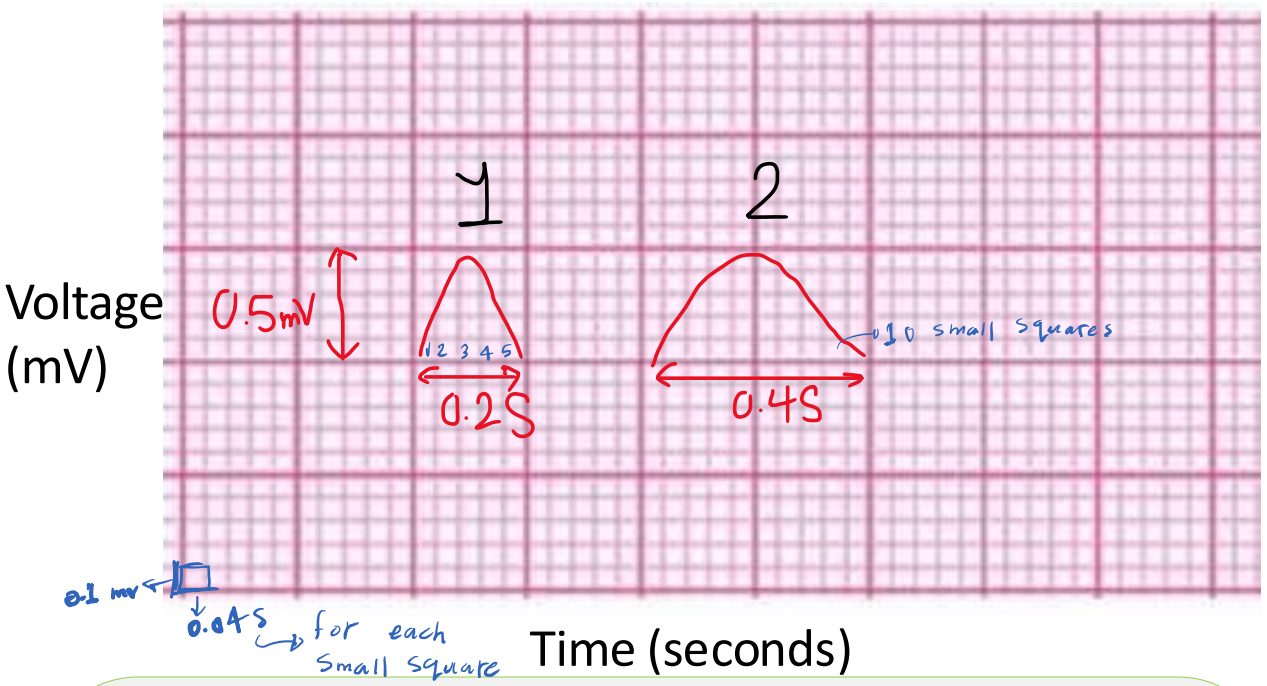
  - We use the ECG to detect the electrical activity of the atria or the ventricles (different ECG between the atria and ventricle)
  - The ECG cannot detect the changes of the SA node and other parts of the hearts; because the tissue mass the SA node or AV node have is much less than arial and ventricular tissue mass.

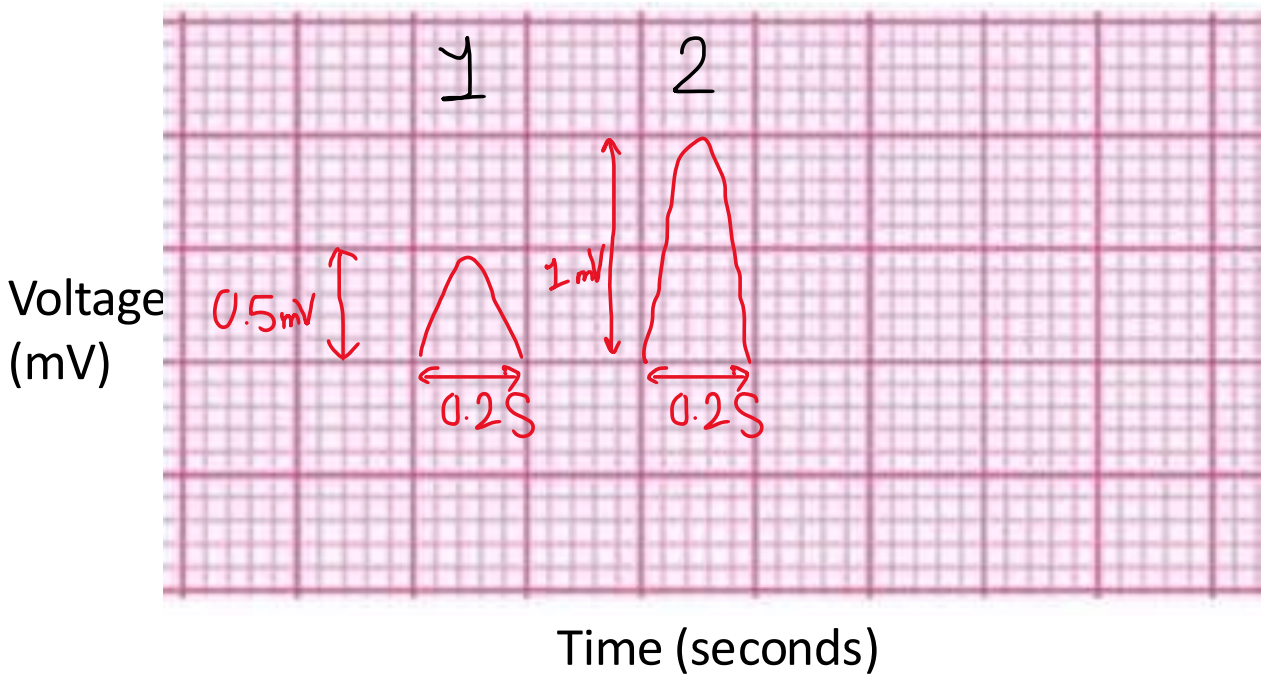
- The amplitude of the deflection is determined by the tissue mass; the larger the mass (ventricle vs atrium), the larger the amplitude (voltage).(represented in the Y axis in ECG)

- The speed of deflection is determined by the speed of conduction; faster in ventricular depolarization than atrial depolarization. (represented in the X axis in ECG)

  - The amplitude and the time, the two factors the differ between the ECG of atria and ventricles

A standard ECG has large squares, each containing 25 small squares





Wave 1 take less time (faster) than wave 2 because of :

1. Anatomical or physiological : different fibers and different conductive tissue affect the conductive velocity. In purkinje fibers the velocity reach about 1.5-4 m/s, while other part only to about 0.3-1 m/s, lead to shorter duration in purkinji and shorter wave
2. Pathological : for example, if purkinje fibers affected causing lower velocity than normal

Wave 1 has same conduction as wave 2
Wave 2 have a higher amplitude than wave 2 because of :

1. Anatomical or physiological : larger mass (more cells), as in ventricles have more muscles than atria
2. Pathological : hypertrophy

ECG calibration

- the horizontal calibration lines are arranged so that 10 of the small line divisions upward or downward in the standard ECG represent 1 millivolt (each small horizontal line will be about 0.1mV), with positivity in the upward direction and negativity in the downward direction.
- The vertical lines on the ECG are time calibration lines. A typical ECG is run at a speed of 25 millimeters per second, although faster speeds are sometimes used.

ECG calibration

- Therefore, each 25 millimeters in the horizontal direction is 1 second, and each 5-millimeter segment, indicated by the dark vertical lines, represents 0.20 second.

- The 0.20-second intervals are then broken into five smaller intervals by thin lines, each of which represents 0.04 second.

- Each small vertical line is about 0.04 s → each large or thick vertical line is about 0.2 s. 5 large vertical lines = 25 small vertical lines → 1s
- Don't get confused!

1. Horizontal line → represent voltage
2. Horizontal direction → represent time direction

Removed

Wave voltage

- The recorded voltages of the waves in the normal ECG depend on the manner in which the electrodes are applied to the surface of the body and how close the electrodes are to the heart.

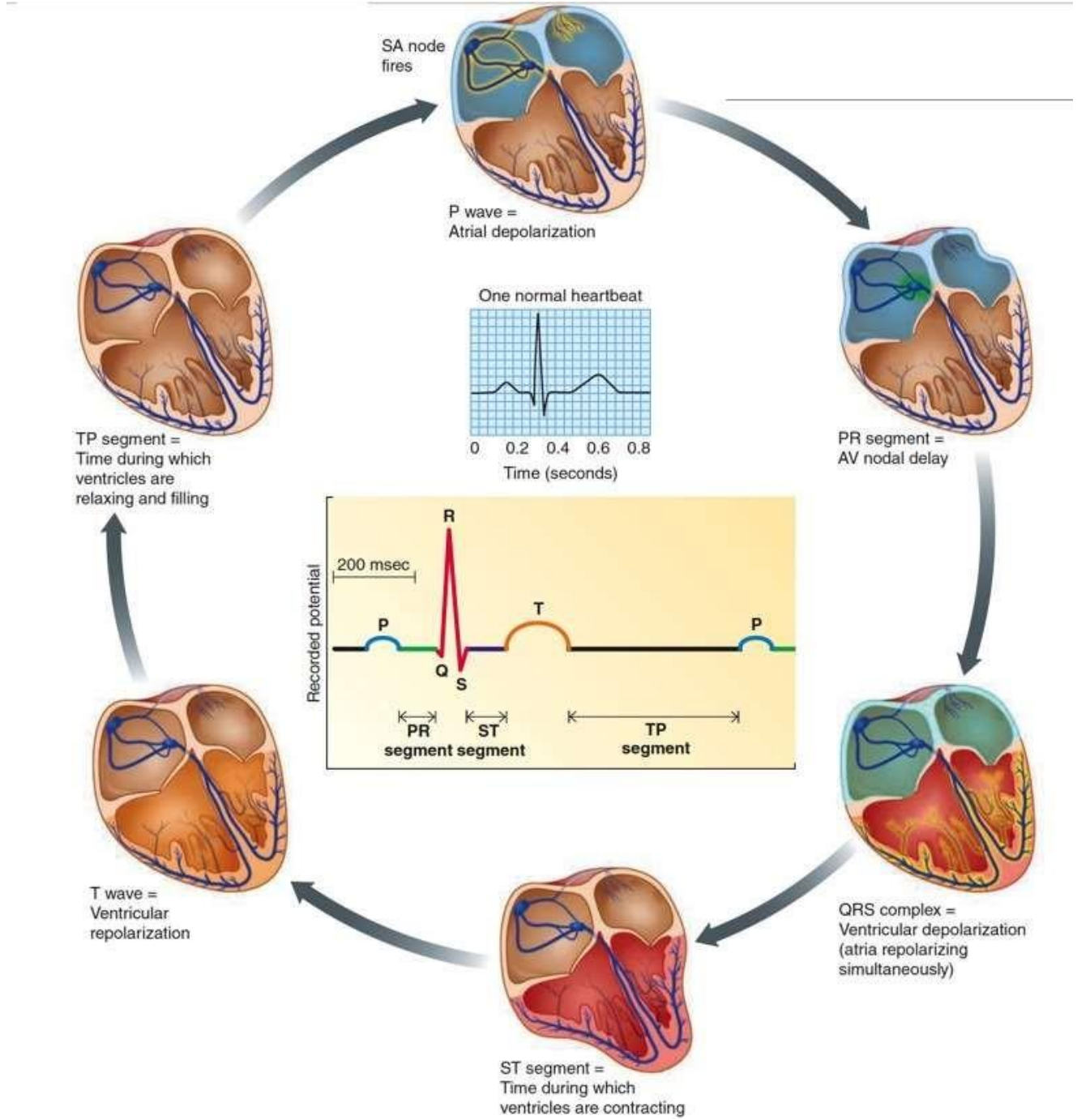
- When one electrode is placed directly over the ventricles, and a second electrode is placed elsewhere on the body remote from the heart, the voltage of the QRS complex may be as high as 3 to 4 millivolts.

Removed

Wave voltage

- Even this voltage is small in comparison with the monophasic action potential of 110 millivolts recorded directly at the heart muscle membrane.

- When ECGs are recorded from electrodes on the two arms or on one arm and one leg, the voltage of the QRS complex usually is 1.0 to 1.5 millivolts from the top of the R wave to the bottom of the S wave, the voltage of the P wave is between 0.1 and 0.3 millivolts, and the voltage of the T wave is between 0.2 and 0.3 millivolts.


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)
Recorded potential
200 msec
R
P
T
P
Q
S
PR segment
ST segment
TP segment

Removed

Ventricular depolarization

- in normal heart ventricles, current flows from negative to positive primarily in the direction from the base of the heart toward the apex during almost the entire cycle of depolarization, except at the very end.

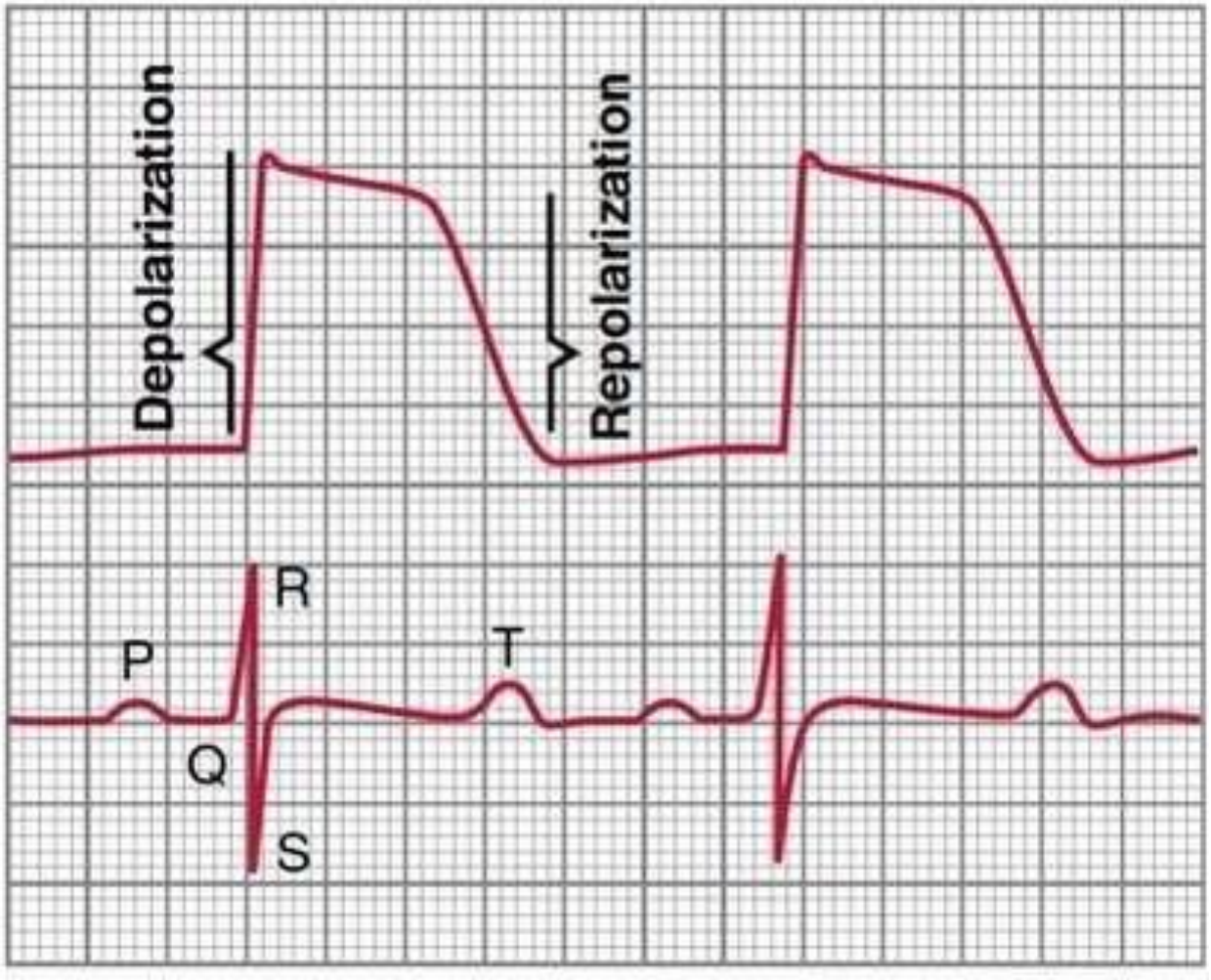
Removed

Principles of ECG

- Before contraction of muscle can occur, depolarization must spread through the muscle to initiate the processes of contraction.

- The P wave occurs at the beginning of contraction of the atria, and the QRS complex of waves occurs at the beginning of contraction of the ventricles.
- The ventricles remain contracted until after repolarization has occurred—that is, until after the end of the T wave.

Removed



T wave compared to QRS

Removed

Atrial repolarization

- 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.

Removed

ECG

- Ordinarily, ventricular muscle begins to repolarize in some fibers about 0.20 second after the beginning of the depolarization wave (the QRS complex), but in many other fibers, it takes as long as 0.35 second.

- Thus, 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 a prolonged wave, but the voltage of the T wave is considerably less than the voltage of the QRS complex, partly because of its prolonged length.

ECG leads

- How we can measure the electricity of heart of the ECG machine? We use leads

- <u>Standared:12 leads</u> other ECG machines can attach to 6 leads or 3 leads, but the standared is 12 12 sihT)leads consis of 6 limb leads –right arm, left arm and left foot. And 6 chest leads –chest wall .

- Bipolar limb leads(3)
- Augmented unipolar leads(3)
- Chest leads(6)

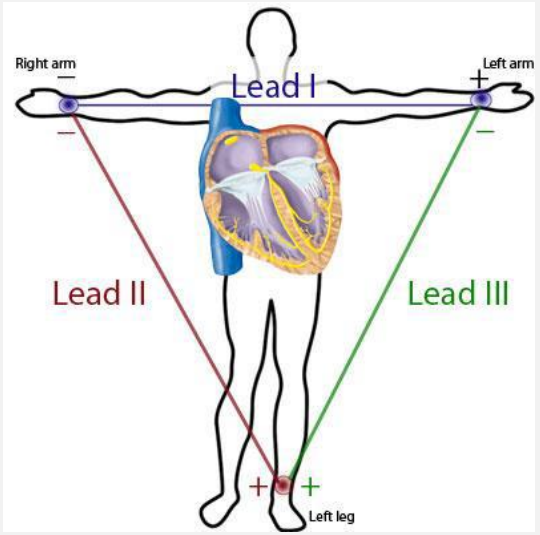
- Limb leads are ventrical plane(axis)
- Chest leads are horizental plane (axis)

- The idea of ECG leads distribution is that you can see the heart from different angles or directions as a vertical axis in the limb leads and a horizontal axis in the chest lead (this point will be more clear in the next lecture).

ECG limb leads Consist of: 3bipolar leads and 3agumented unipolar leads

- bipolar means that the ECG is recorded from two electrodes located on different sides of the heart—in this case, on the limbs.

Extra image as the drawn image:



Bipolar limb leads:

Lead I= positive left arm and negative right arm
Lead II= negative right arm and positive left foot/leg
Lead III= positive left foot/leg and negative left arm

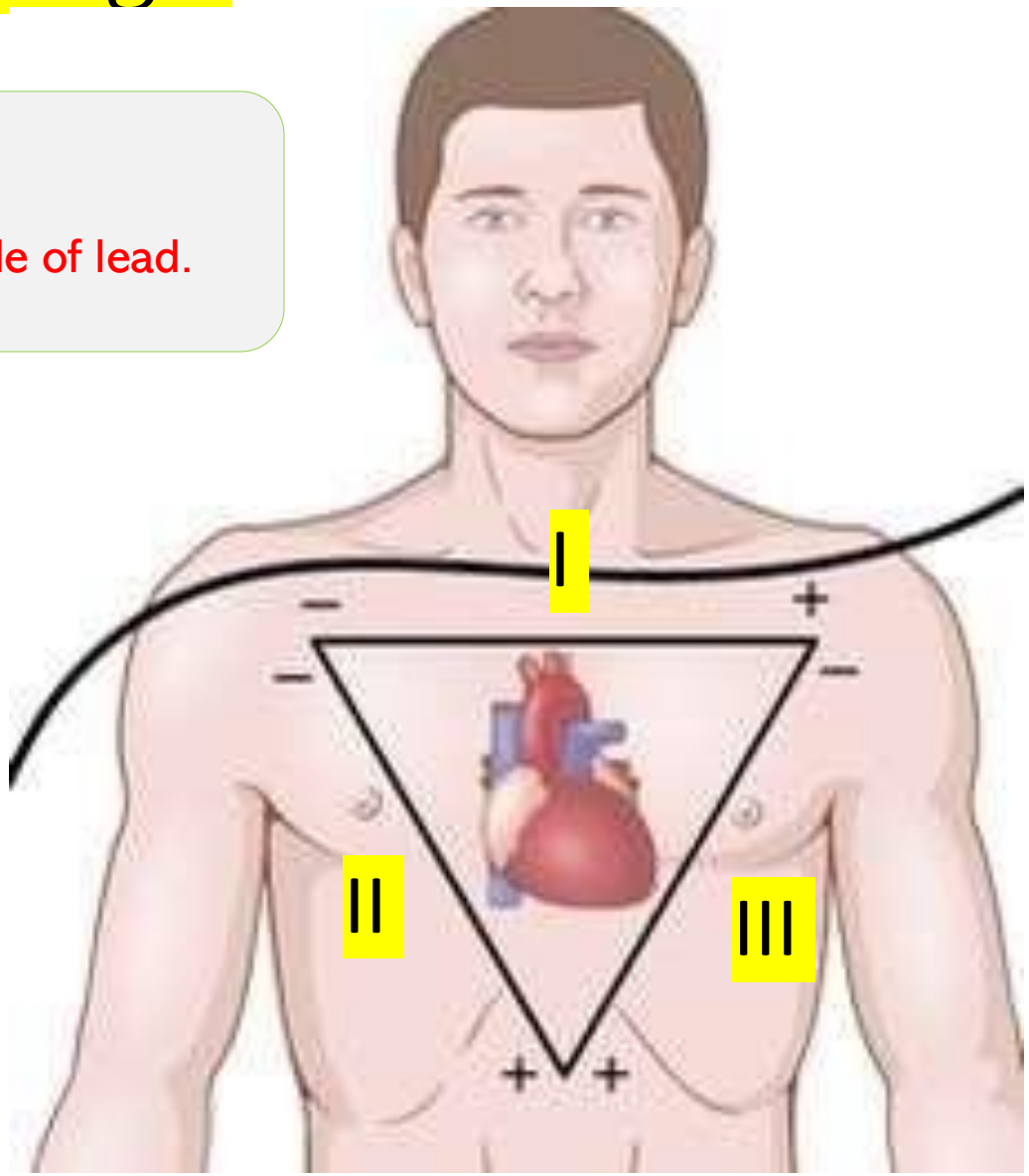
NOTE : right arm is always negative and left foot is always positive.

]These bipolar limb leads are represent as triangle called :

Einthoven’s triangle

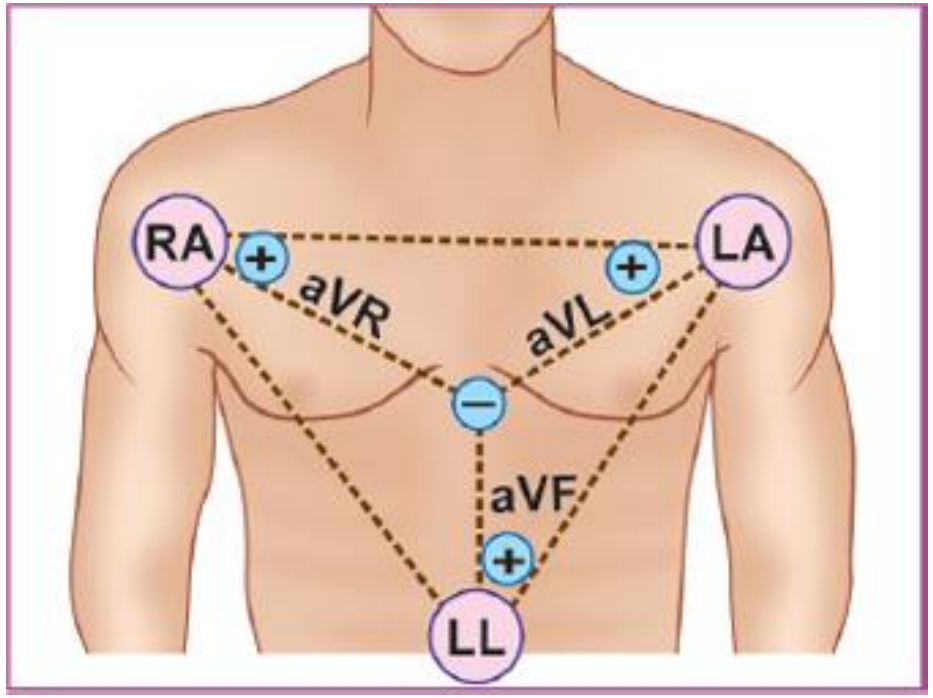
We have to know:

- Anatomical position
- The charge of each electrode of lead.
- The axis.



The doctor shows this slide in the lecture, but it is not in the original file.

Augmented unipolar limb leads



We consider the heart a negative electrode and RA, LA, and LL positive electrodes.

aVL between the LA and the heart
aVR between the RA and the heart
aVF between the LF/LL and the heart

aV means agumented Vector.

Extra: المعزّز

- The augmented limb leads (aVR, aVL, aVF) are calculated using signals from the other limb leads (I, II, and III) but with a higher resistance.
- the high resistance in augmented leads is a design choice in ECG machines that helps provide more accurate, clear readings of the heart's electrical activity from various angles.

Removed

Bipolar limb leads

- Because the recordings from all the bipolar limb leads are similar to one another, it does not matter greatly which lead is recorded when one wants to diagnose different cardiac arrhythmias, because diagnosis of arrhythmias depends mainly on the time relationships between the different waves of the cardiac cycle.
- However, when one wants to diagnose damage in the ventricular or atrial muscle or in the Purkinje conducting system, it matters greatly which leads are recorded, because abnormalities of cardiac muscle contraction or cardiac impulse conduction change the patterns of the ECGs markedly in some leads yet may not affect other leads.

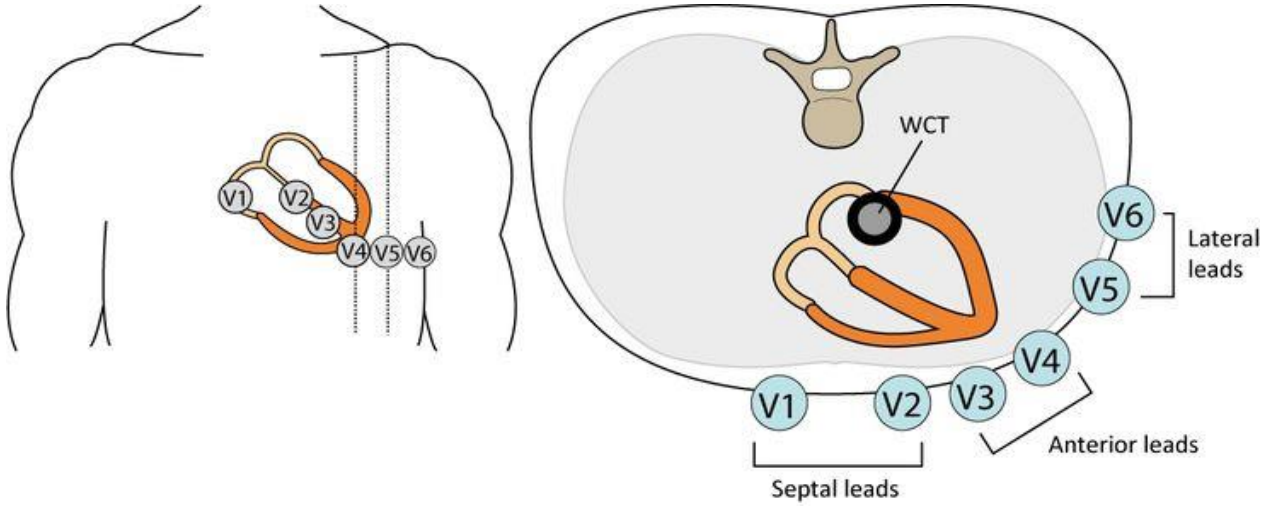
Augmented limb leads

- two of the limbs are connected through electrical resistances to the negative terminal of the electrocardiograph, and the third limb is connected to the positive terminal.

- The recording of the aVR lead is inverted.

The doctor shows this slide in the lecture, but it is not in the original file.

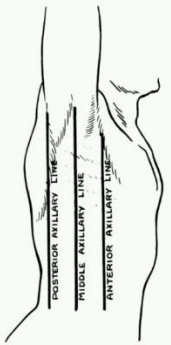
Chest leads



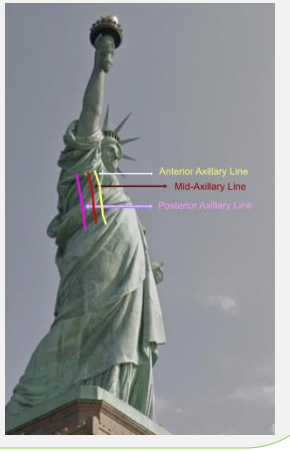
They are arranged in a horizontal plane on the chest wall arround the heart from V1 to V6

The anatomical position of each one:
V1 = right fourth intercostal space
V2 = left fourth intercostal space
V4 = mid clavicular line in left fifth intercostal space
V3= between V2 and V4
V5 = anterior axillary line in left fifth intercostal space
V6 = mid axillary line

Extra:V5 and V6 position



If you like freedom country!



Chest leads

Chest ECG leads give stronger voltage than Limb ECG leads because of shorter distance to the heart.

- Because the heart surfaces are close to the chest wall, each chest lead records mainly the electrical potential of the cardiac musculature immediately beneath the electrode.

- Therefore, relatively minute abnormalities in the ventricles, particularly in the anterior ventricular wall, can cause marked changes in the ECGs recorded from individual chest leads.

Removed

Chest leads

- In leads V1 and V2, the QRS recordings of the normal heart are mainly negative because the chest electrode in these leads is closer to the base of the heart than to the apex, and the base of the heart is the direction of electronegativity during most of the ventricular depolarization process.

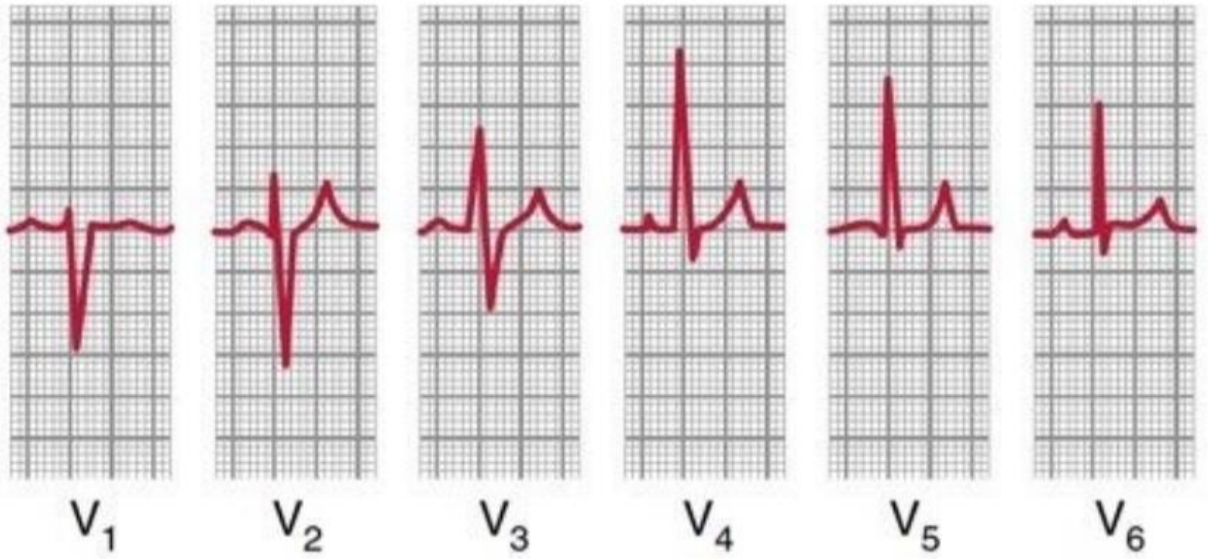
- Conversely, the QRS complexes in leads V4, V5, and V6 are mainly positive because the chest electrode in these leads is closer to the heart apex, which is the direction of electropositivity during most of depolarization.

ADDED

Chest leads

- In leads V1 and V2, the QRS recordings of the normal heart are mainly negative (near the base).

- Conversely, the QRS complexes in leads V4, V5, and V6 are mainly positive (near the apex).



Thank you

" إِنَّ اللَّهَ وَمَلَائِكَتَهُ يُصَلُّونَ عَلَى النَّبِيِّ ۚ يَا أَيُّهَا الَّذِينَ آمَنُوا صَلُّوا عَلَيْهِ وَسَلِّمُوا تَسْلِيمًا "

VERSIONS	SLIDE #	BEFORE CORRECTION	AFTER CORRECTION
V1→ V2	28	كلام معكوس	IN YELLOW
V2→V3	14,15,17,18,19,20,21,26,30 31		REMOVED ADDED

امسح الرمز و شاركنا بأفكارك لتحسين أدائنا!!