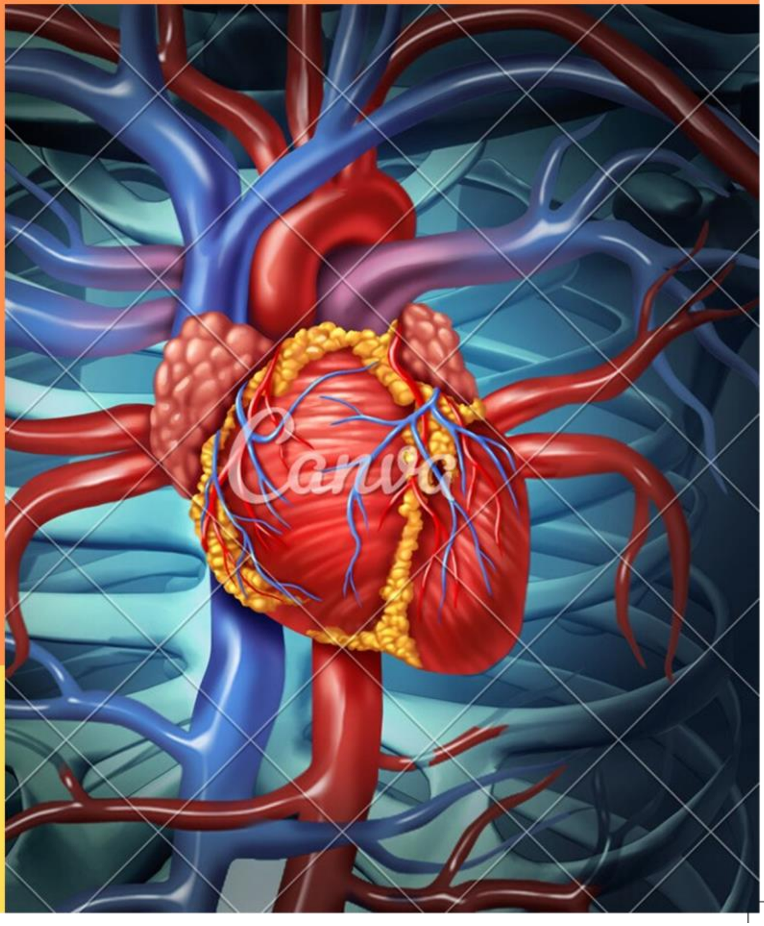
PASSION ACADEMIC TEAM YU - MEDICINE

Cardiovascular System

Sheet #3 Physiology (part 1+2)
Lec. Title: Electrocardiography
Written by: Ahmad AbuHalawa



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Recording of ECG

ECG is recording heart electricity as a whole, How? As action potential spreads from cell to cell through the myocardium of the heart, this current can be transmitted to the body surface, because the body acts as a conductor of electricity, where it can be recorded by putting electrodes on the skin in different areas of the body.

These electrodes are called “leads”.

The recording of these electrical currents is called “electrocardiogram” (ECG), and the machine is called “electrocardiograph”, and the whole process is called “electrocardiography”.

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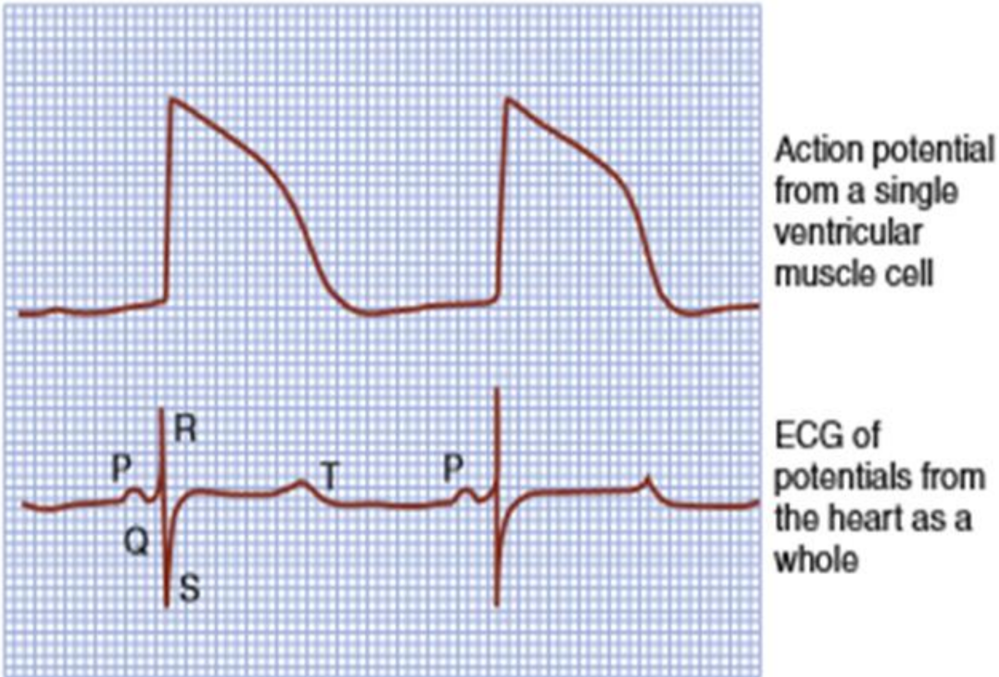
There is a difference in appearance between ECG and action potential, if we take a look at the figures below, we see curves (or waves), the first one represents the action potential, the second one represents the ECG.



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This difference is because that ECG is the sum of all electricity of the heart, while the action potential is the electricity of one cardio myocyte, in ventricle: (initial depolarization-initial repolarization-plateau-repolarization-resting state potential) ➔ 5 phases. It's different in conducting cells (such as SA, AV nodes).

ECG doesn't record the electricity of conducting cells, because action potential of conducting cells is very small and can't be recorded. ECG records the electricity of the myocardium.

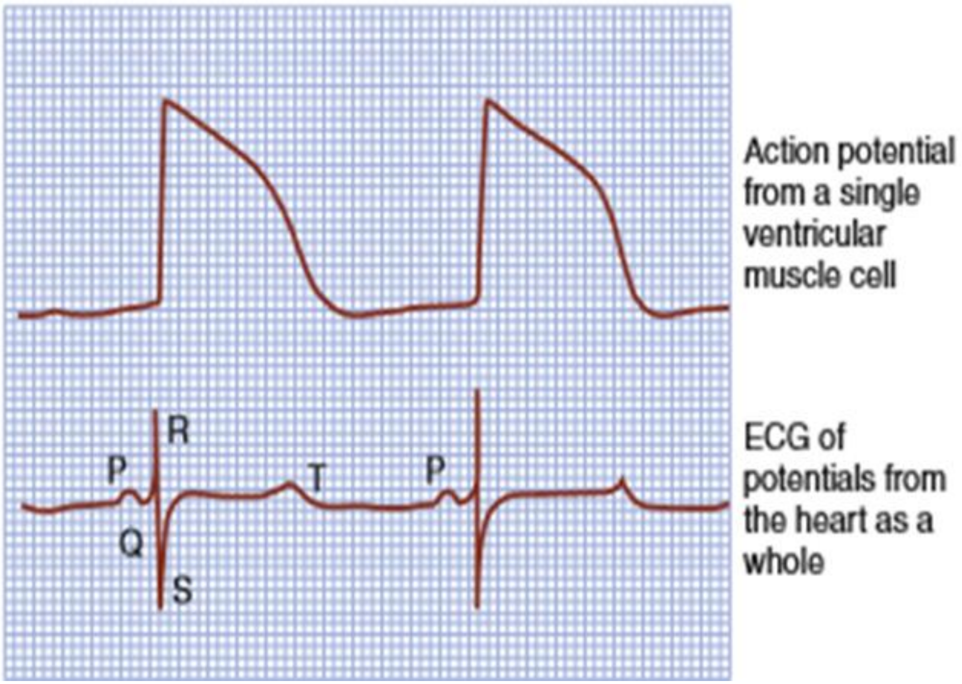
cont.

From the Figure, you can see the waves of ECG:

-P represents the atria.

-QRS represents the ventricles during depolarization.

-T represents the ventricles during repolarization.



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ECG evaluates the cardiac electrical events which greatly helps in the diagnosis of many cardiac diseases:

1. Heart rate
2. Heart rhythm (bradycardia, tachycardia).
3. Abnormal electrical conduction
4. Poor blood flow to heart muscle

(ischemia).

5. Heart attack 6. Coronary artery disease 7. Hypertrophy of heart chambers

Electrocardiographic grid

Electrocardiographic grid is the marking of the lines on ECG paper, so the lines on ECG paper are called "grids", some of these lines are horizontal, while others are vertical. If we take a look at the fig below, we can see a zoomed ECG, with a small squares inside of a large one, ECG paper has horizonal and vertical lines at regular intervals of 1mm, each small square is 1mm, so the large square is 5mm horizontally and 5mm vertically.

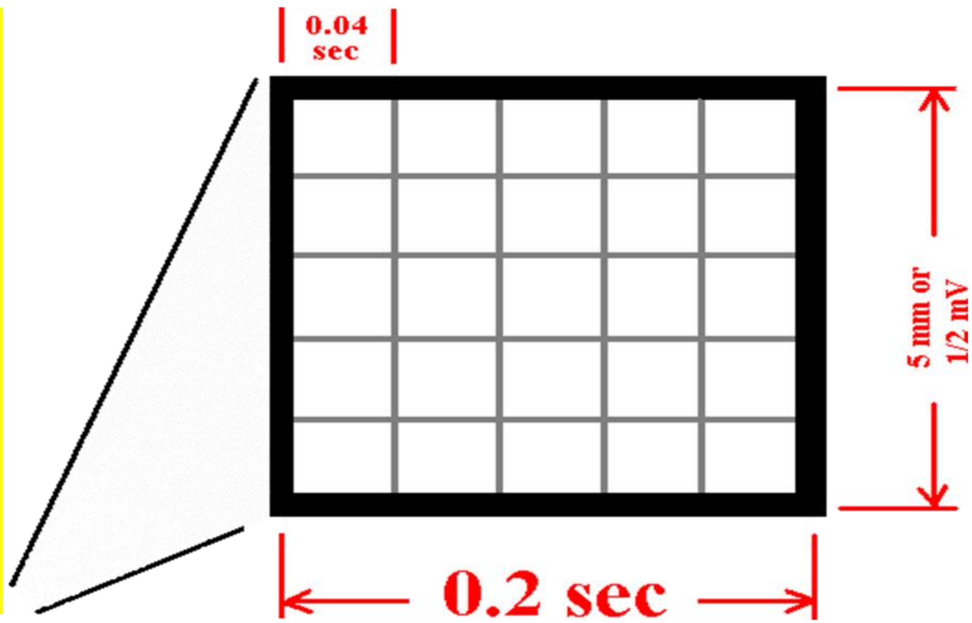
The horizontal line is the duration of ECG waves, each 1mm= 0.04 seconds. So the large square is 5x0.4= 0.2 sec.

Cont.

On X-axis: Time
1 mm = 0.04 second
5 mm =0.20 second

On Y-axis: Amplitude
1 mm = 0.1 mV
5 mm = 0.5 mV

SPEED OF THE PAPER:
25mm/sec, or
50mm/sec

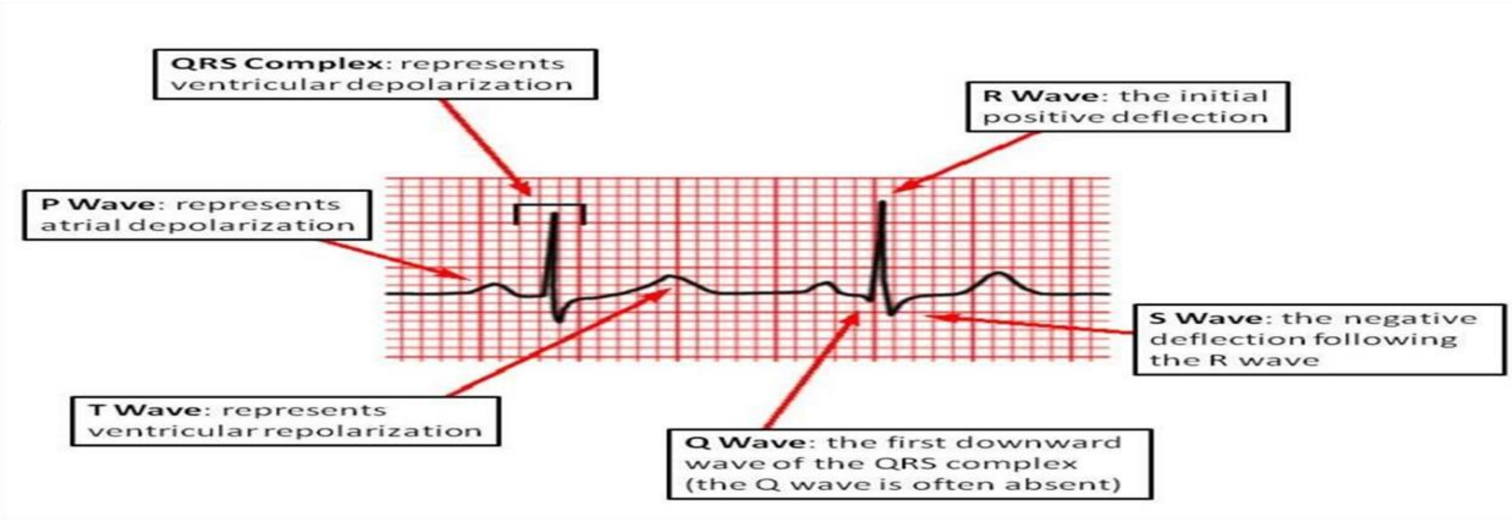


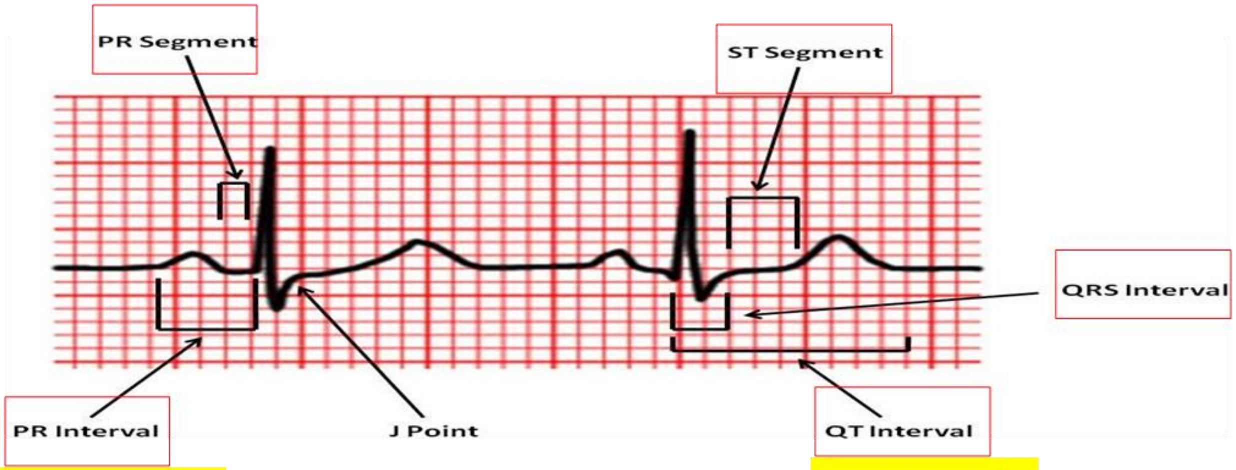
Cont.

The vertical lines represent the amplitude of ECG waves, each 1mm = 0.1 mV, so the large square is 0.1x5= 0.5mV.

Usually, speed of the paper is fixed at 25mm\sec. but if there is an increase in the heart rate, we can increase the speed to 50 mm\sec.

THE NORMAL ELECTROCARDIOGRAM (ECG)





0.12 to 0.21s

0.3- 0.4 s

Cont.

Normally, ECG consists of 5 main waves: P,Q,R,S,T. Q,R,S waves form a complex called QRS. Q,S waves, which have negative deviation, mostly are not clear in some leads, especially Q.

P represents atrial depolarization . QRS represents ventricular depolarization. T represents ventricular repolarization.

In addition to these waves, ECG also has intervals and segments (in lower part of previous slide).

Cont.

PR interval is from the start of P wave to the start of QRS complex, and it represents the time taken for depolarization to spread from SA node to ventricular muscle.

How does parasympathetic innervation (vagus nerves) affect the PR interval?

PR segment is from end of P wave to the start of QRS, and it represents the conduction time of atrioventricular (AV) node. During this segment, depolarization occurs in the conducting system, however, it's silent; means it contains no waves, without upward or downward deviation.

Cont.

Why there is no waves in PR segment ?

Because the depolarized tissue (conductive system) is way too small to generate electricity that can be recorded.

QT interval is from the start of QRS to end of T wave, it represents for the ventricles to depolarize and then repolarize.

ST segment is from end of QRS to the start of T wave, during this segment all ventricular fibers are depolarized, so this segment is silent; it contains no waves, so any deviation in this segment indicates myocardial injury or damage.

Cont.

Why is atrial repolarization not recorded?

Because atrial repolarization happens in the same time of ventricular depolarization, so it's merged within the QRS complex, therefore it's not recorded as a separate wave.

Analyzing ECG tracings

Questions to ask when analyzing ECG tracings:

1. What is the rate? Is it within the normal range of 60-100 beats per minute?

2. Is the rhythm regular?

3. Are all normal waves present in recognizable form?

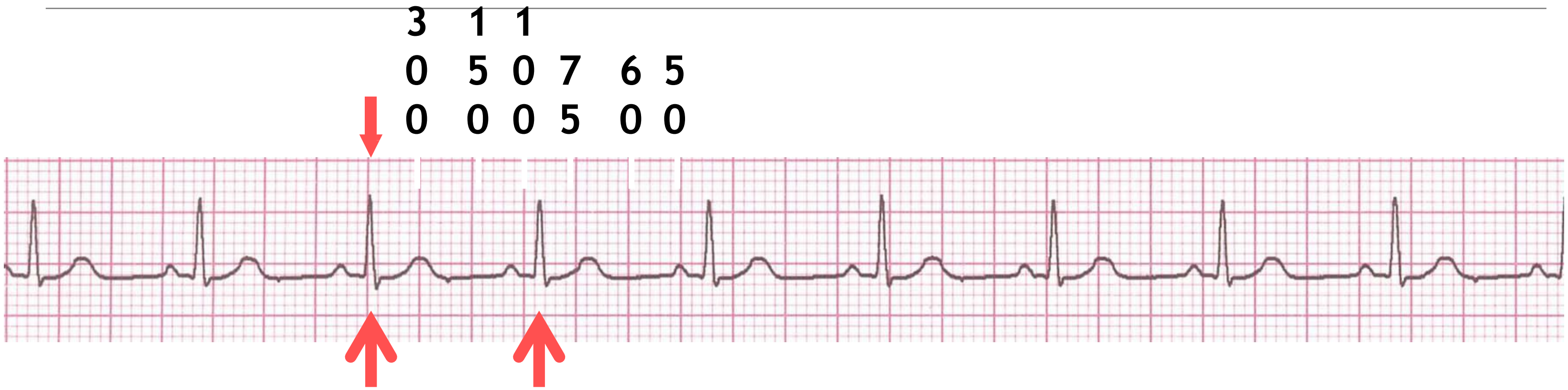
4. Is there one QRS complex for each P wave?
   If yes, is the P-R segment constant in length?

How to calculate heart rate in regular rhythm ?

- Option 1
  - A quick method is measuring the number of large boxes that form the R-R interval (between R peaks), and then, Rate = 300/(number of large boxes)

Interpretation?
Approx. 3 large squares
300/3= 100 bpm (bpm= beat per minute), (heart rate)

Cont.



- Option 2
  - Find a R wave that lands on a bold line (vertical line of a large box)
  - Count the number of large boxes to the next R wave. If the second R wave is 1 large box away the rate is 300, 2 boxes - 150, 3 boxes - 100, 4 boxes - 75, etc. (cont)

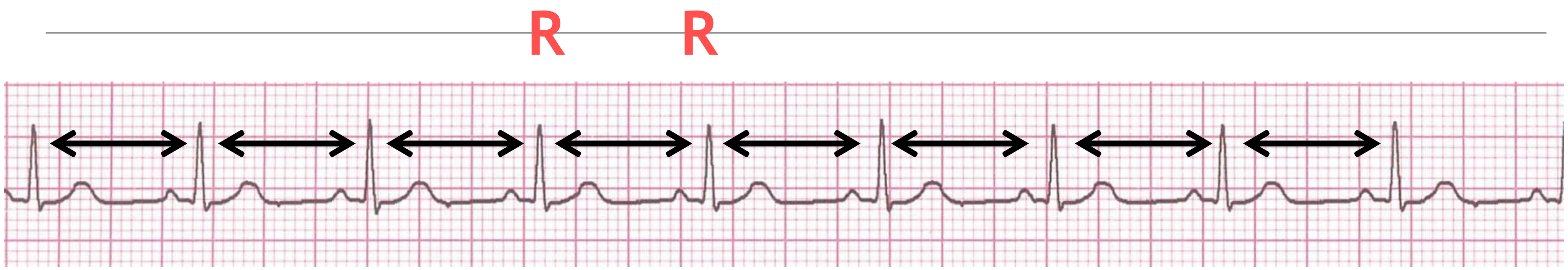
Interpretation? In the example above: Approx. 1 small box less than 100 = 95 bpm (because next R wave isn't exactly on the bold line)

Cont.

NOTE:

To calculate the heart rate in irregular rhythm, count the number of R waves in a 6 second strip (30 large boxes) **and multiply by 10.**

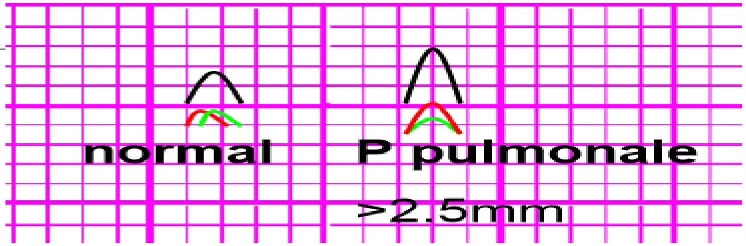
Determine regularity

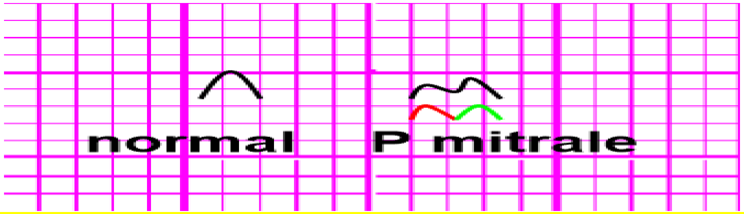


- Look at the R-R distances (using a caliper or markings on apaper), R-R distances should be equal in a regular rhythm.
- Regular (If they equidistant apart).

Interpretation? Regular

Asses the P waves





Are there P waves?
Do the P waves all look alike?
Do the P waves occur at a regular rate?
Is there one P wave before each QRS?

Interpretation?
Normal P waves with 1 P wave for every QRS

This wave is produced as a result of atrial depolarization:

- Its amplitude is about 0.1 mV.
- Its duration does not exceed 0.1s
- It is normally positive in all leads except aVR.

Abnormalities of the P wave:

- In left atrial hypertrophy (e.g. due to mitral stenosis), the P waves enlarge and become notched (= P mitrale).
- In right atrial hypertrophy (e.g. due to tricuspid stenosis), the P waves become tall.
- the P waves disappear in atrial fibrillation

Cont.

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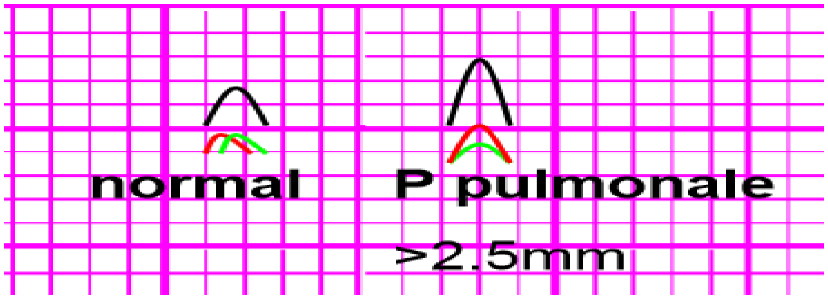
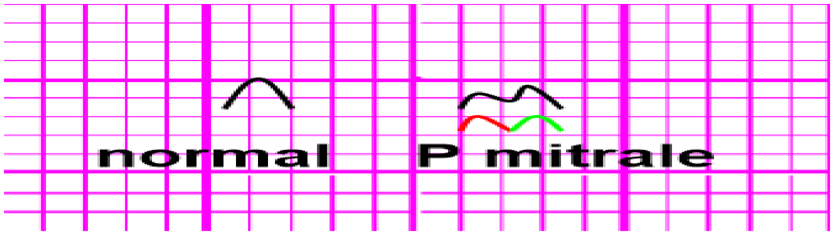
- the P waves disappear in atrial fibrillation





Determine PR interval

- Normal: 0.12 - 0.20 seconds.
  (3 - 5 small boxes)

Interpretation?

0.12 seconds

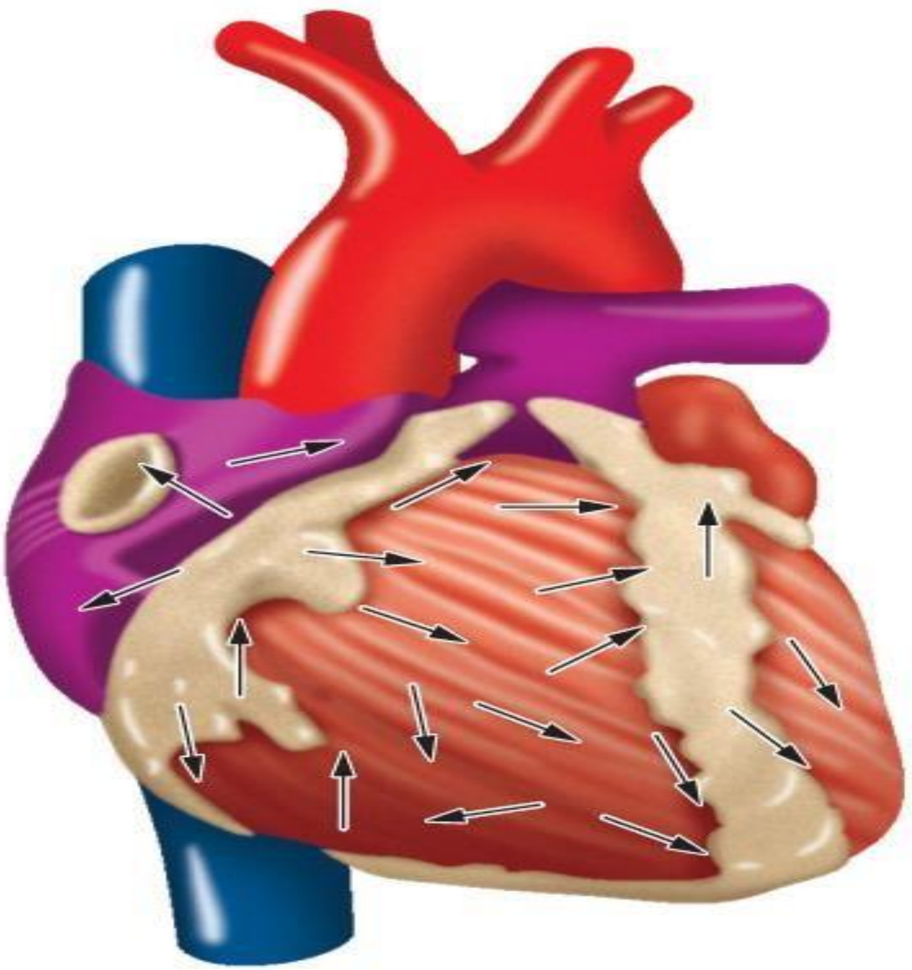
If PR interval is short and less than 0.12 sec (3 boxes), it may indicate an accessory electrical pathway between atria and ventricles, so electricity is not conducted normally (through the AV node), so ventricles depolarize early.
Accessory pathways such as: bundle of Kent, leading to a syndrome called wolf Parkinson white syndrome.

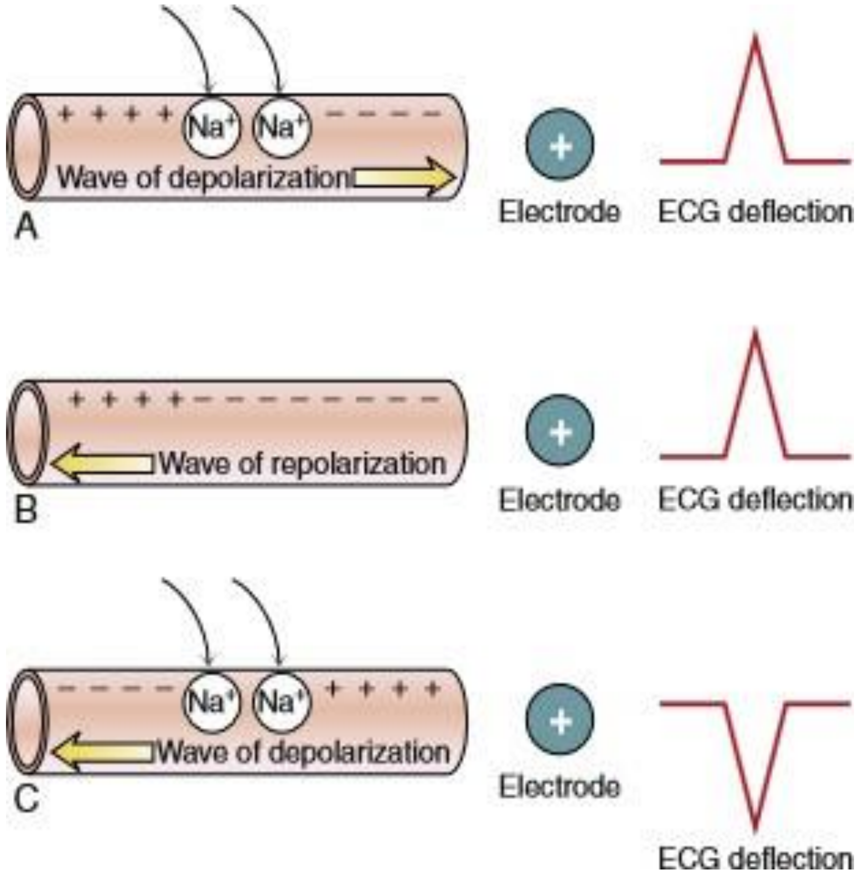
QRS duration

Normal: 0.04 - 0.12 seconds (1 - 3 small boxes)

Interpretation? 0.08seconds

How does the ECG work?





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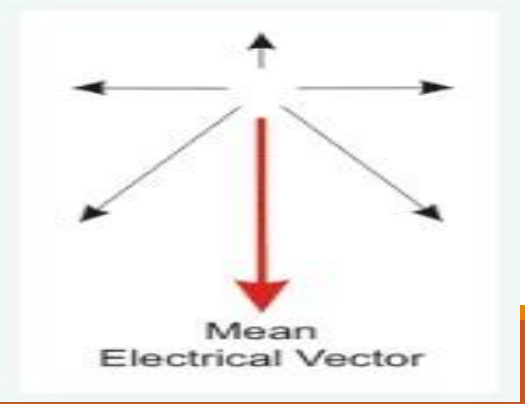
The fig. from the previous slide shows an electrical current travelling in various directions all over the heart. These currents have both a direction and a magnitude, so they can be described as vectors. The sum of instantaneous vectors is called mean electrical vector.

P wave, for example, is the mean electrical vector in the atria, it has a magnitude and a direction (downward to the left).



Cont.

ECG waves have different shapes, why?

Because of the difference in placement of electrodes, and the place where they are put.

From the fig. two slides before:

A) A wave of depolarization moving toward the positive electrode gives an upward deflection.

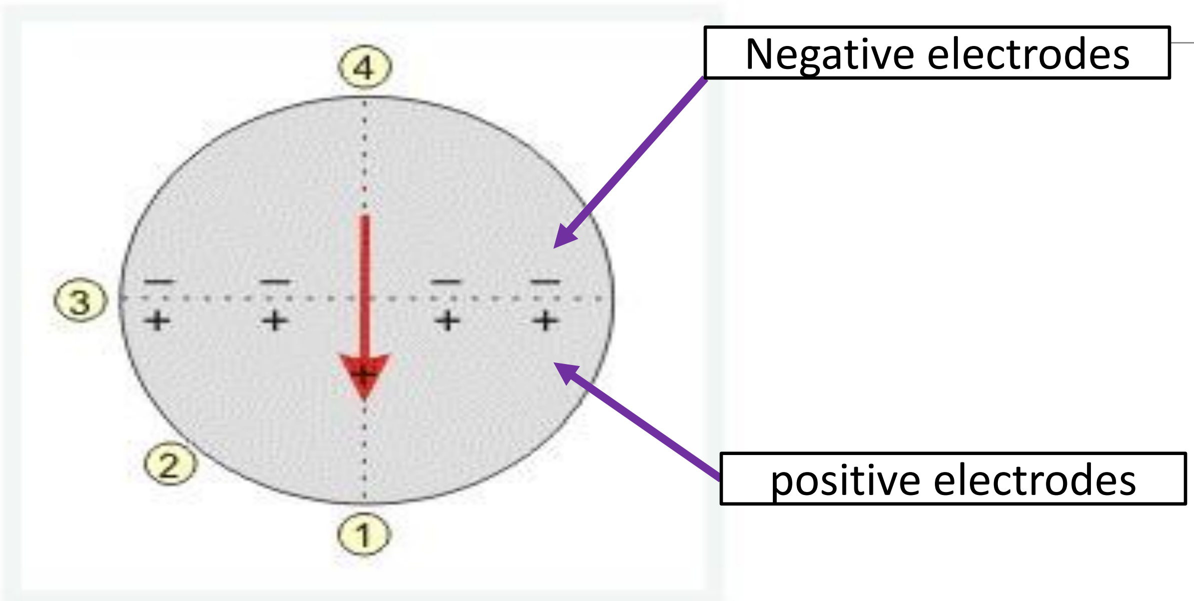
B) A wave of repolarization moving away from the positive electrode gives an upward deflection.

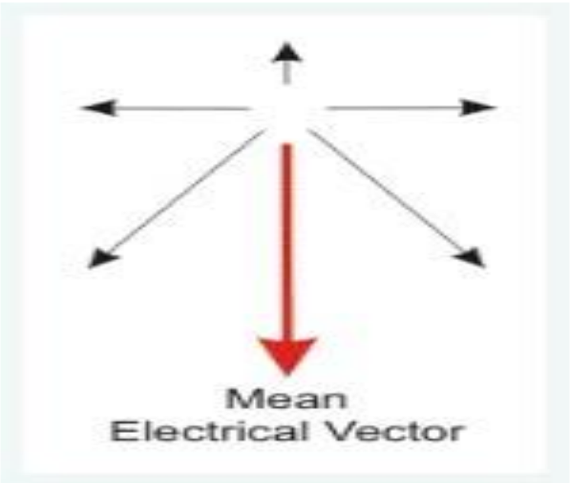
Cont.

C) A wave of depolarization moving away from the positive electrode gives a downward deflection.

Note: A wave of repolarization moving toward the positive electrode gives a downward deflection.

Cont.

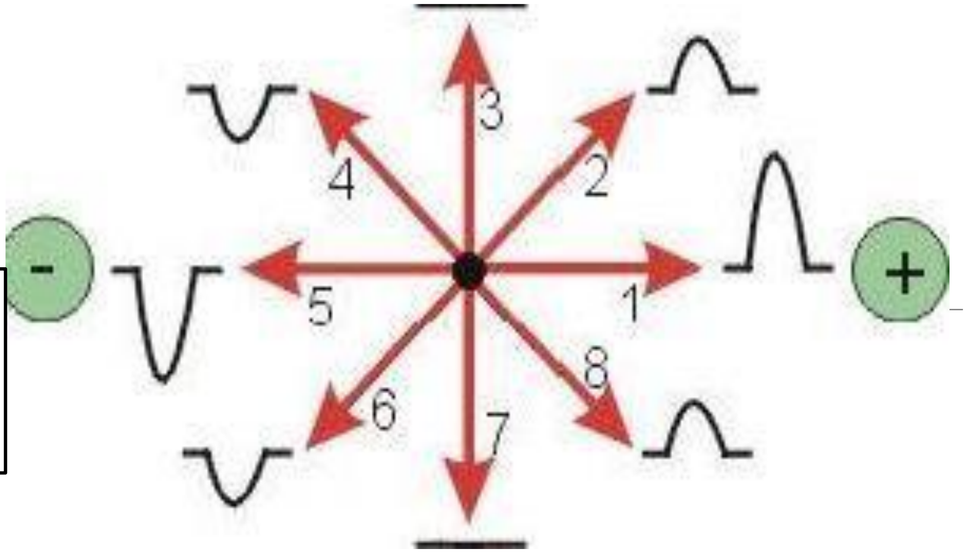




The fig in the next slide shows the mean electrical vector (on the right) plotted on the circle (on the left) with positive and negative electrodes opposite to each other.

Cont.

These "mean electrical vectors" (1-8) are of **depolarization** waves.



*1 and 2 are toward +ve electrode, and therefore give upward (positive) deflection. 1 has the highest deflection, because it's exactly toward the +ve electrode (angle is zero). 2 has an angle, so it has a bit lower upward deflection.

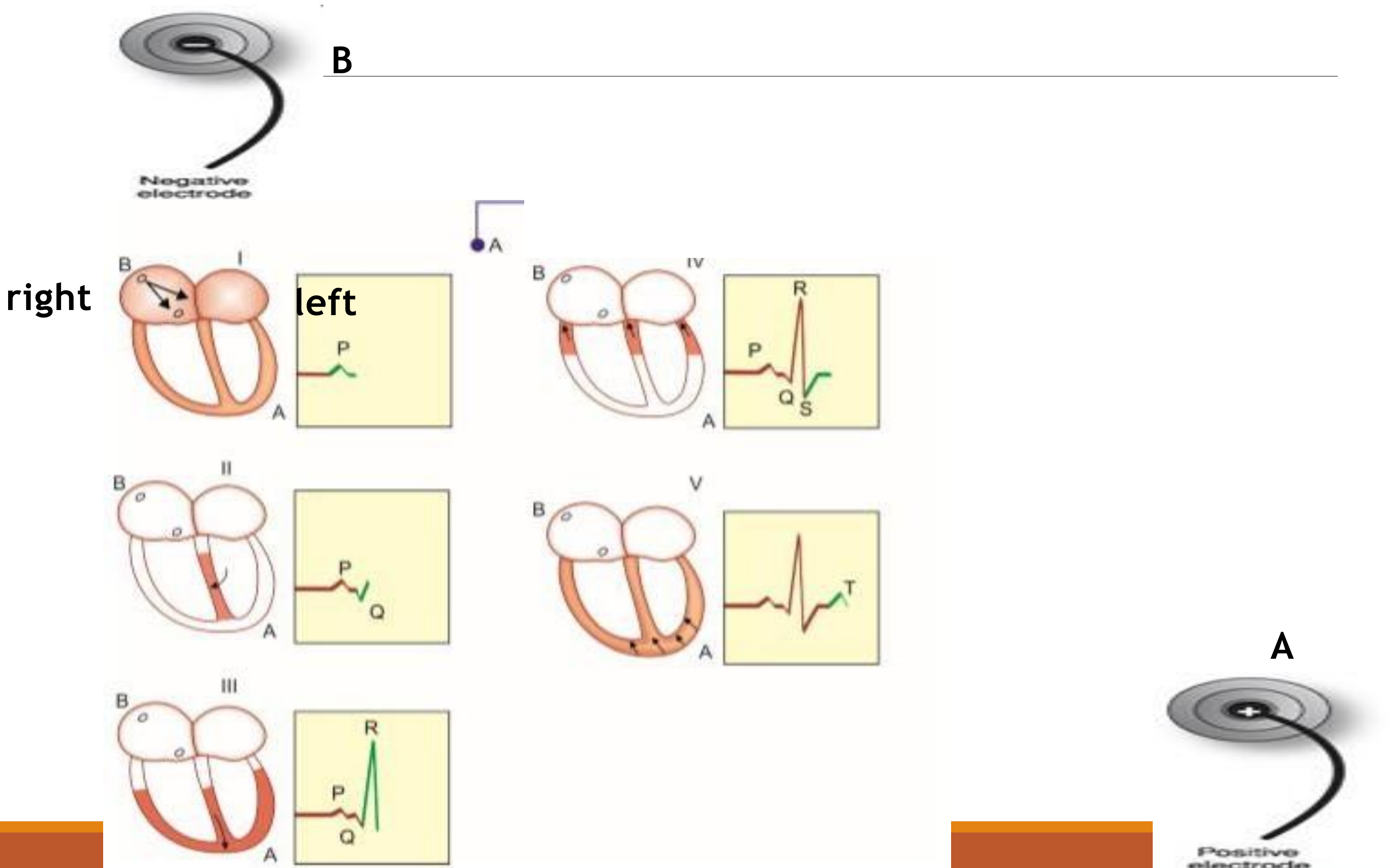
*3 is perpendicular (متعامد) to the positive electrode, so it has no deflection (neutral=flat=upward and downward deflections cancel each other) , because it has zero net voltage.

Cont.

*4 and 5 have a downward (negative) deflection, because they are moving away from the positive electrode, 5 is lowest, because it's moving exactly away from positive electrode (angle is 180), 4 has a bit higher downward deflection because it has an angle.

*and so on.

Mean Electrical Vector



Cont.

Form the previous fig:

Why is electrode A positive and electrode B negative?

It's easier to study, if we change the electrodes the ECG will be inverted. So it's better that the positive electrode is placed on the lower part and to the left (of the body, not the fig).

In ECG, the P wave is positive, Q is negative, R is positive, S is negative, T is positive. مرة هيك و مرة هيك

In atria, all depolarization vectors summation form the mean electrical vector, the P wave, which has a direction downward and to the left (from SA to AV), so it gives an upward deflection.

Cont.

Ventricular depolarization consists of 3 vectors: septal depolarization (Q wave) and ventricular apex depolarization (R wave) and pace of ventricle depolarization (S wave).

Q wave is negative because current is moving from left to right, away from positive electrode.

R wave is positive because current is moving downward to the left, just toward the positive electrode, with a very small angle, so it gives a high upward deflection.

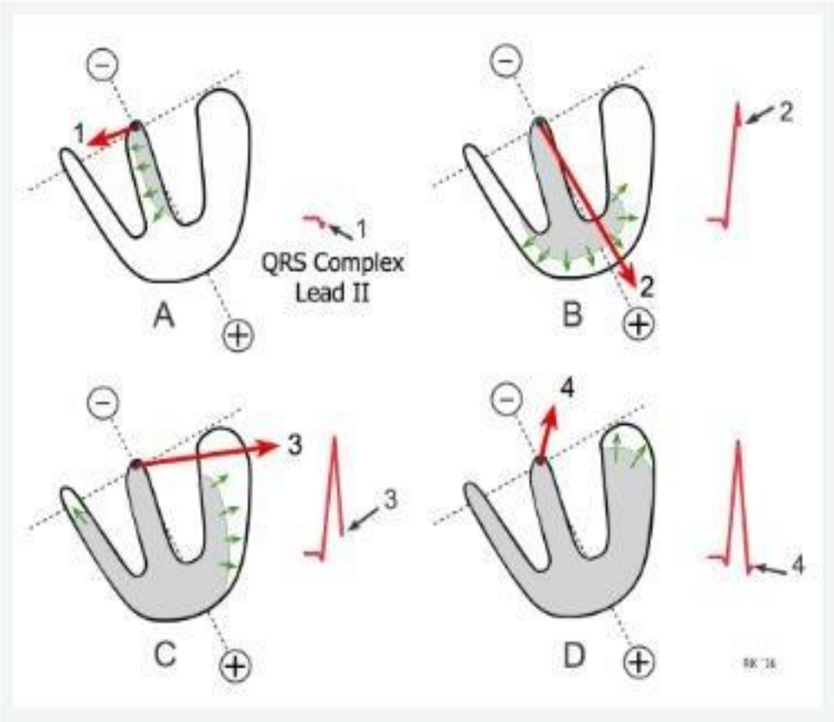
Cont.

S wave is negative because current is moving upward and to the right, away from positive electrode.

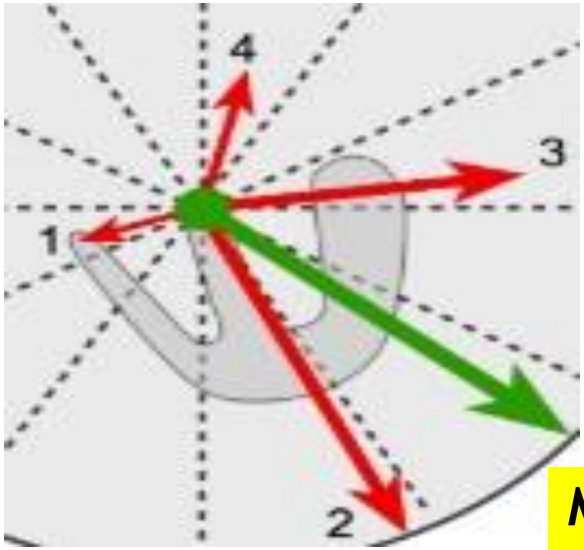
T wave is positive because current is moving upward and to the right, away from positive electrode.

Keep in mind that P,Q,R,S waves represent a depolarization, whereas T wave represents a repolarization.

Ventricular Depolarization and the Mean Electrical Axis



Sequence of Ventricular Depolarization



Mean electrical axis

Cont.

Fig from previous slide shows ventricular depolarization vectors (on the left). The average of these mean electrical vectors is called mean electrical axis (on the right), which has a direction downward and to the left.

The mean electrical vector in atrial depolarization (P), and the mean electrical axis in ventricular depolarization, both are downward and to the left, we put the positive electrode there, so studying ECG becomes easier.