MEDICINE
KING SAUD UNIVERSITY

Physiology Team 436

Revised by
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The Electrocardiogram (ECG)

CVS BLOCK

Red: very important.
Green: Doctor's notes.
Pink: formulas.
Yellow: numbers.
Gray: notes and explanation.

Physiology Team 436 – Cardiovascular Block Lecture 5

Lecture: If work is intended for initial studying.
Review: If work is intended for revision.

Objectives

Study Smart: focus on mutual topics.

From the students' guide:

- Identify waves of ECG and the physiological cause of each.
- Define the normal intervals and segments.
- Discuss the bipolar and unipolar leads and their locations.
- Discuss the bipolar limb lead and the cardiac axis (Quick method).

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The Electrocardiogram (ECG/EKG)

- If a recording electrode is applied on any point on the surface of the trunk, it will detect electrical waves reflecting the electrical activity in the heart. These electrical waves may be as small as 1 mv and are amplified, recorded on ECG paper / monitor / computer and stored.

- When there are no propagating potentials, no waves are recorded and the recording needle will be on the line of zero potential, which is called the isoelectric line.

For recording an ECG, two electrodes are required.	
the active electrode (also called searching electrode or exploring electrode)	reference electrode
applied to a recoding point on the surface of the body.	serves a reference to the active electrode.

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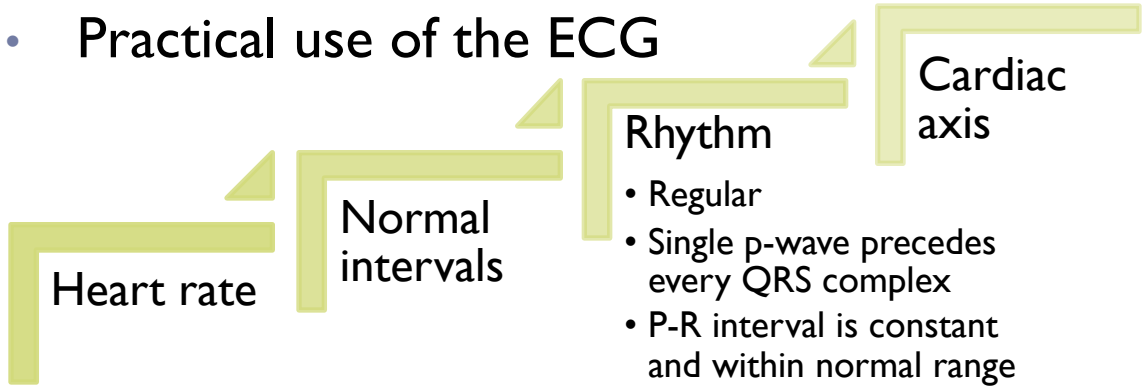
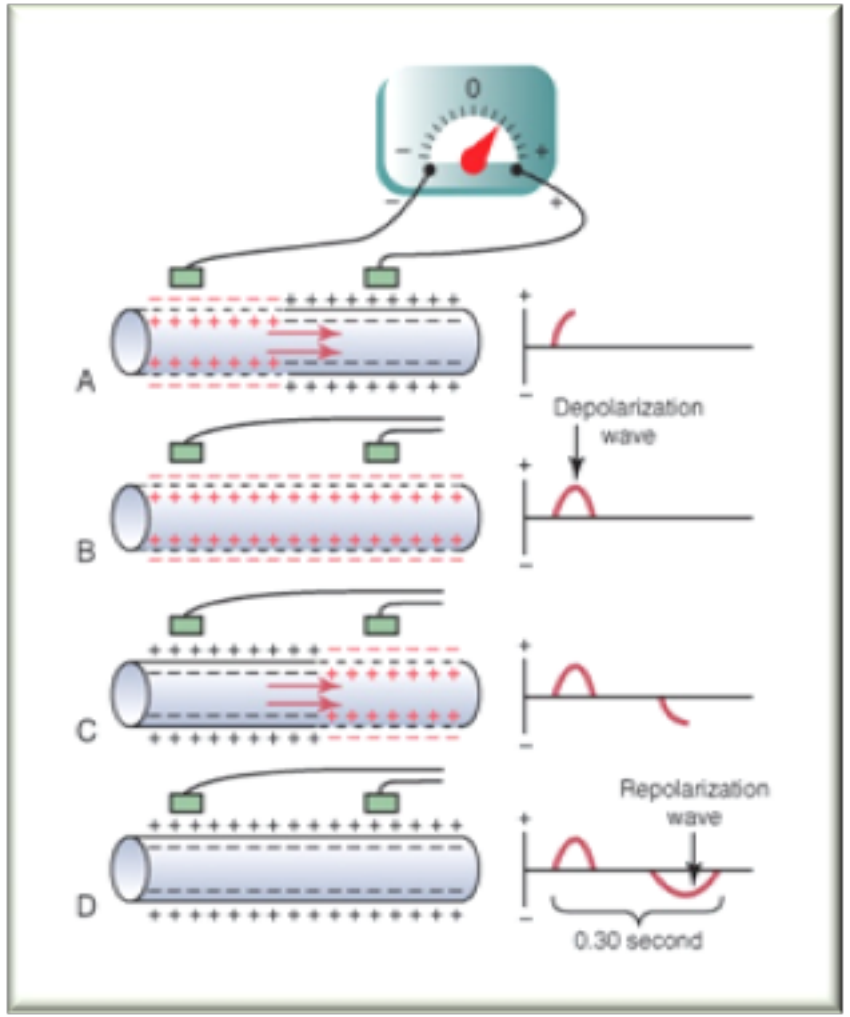
- Practical use of the ECG



The Active and Reference Electrodes

- A positive wave is recorded when depolarization is propagating towards the electrode or when repolarization is propagating away from the electrode.
- A negative wave is recorded when depolarization is propagating away from the electrode or when repolarization is propagating towards the electrode.



شرح الرسمة:

Active electrode is attached to positive end of galvanometer. Reference electrode attached to negative end of galvanometer

(A/B) Depolarization (intracellular +) is propagating towards Active Electrode → positive wave (above isoelectric line)

C/D Repolarization (intracellular -) propagating towards active electrode → negative wave

The Normal Electrocardiogram (ECG)

- The Electrocardiogram (ECG) is a recording of the electrical activity of the heart

The depolarization wave spreads through the heart → electrical currents pass (from bass to apex) into the surrounding tissue → part of the current reaches the surface of the body

- The electrical potentials generated by these currents can be recorded from electrodes placed on the skin opposite the heart
- This is possible as the body tissues function as electrical conductors because they contain electrolytes.

- Methods for Recording Electrocardiograms

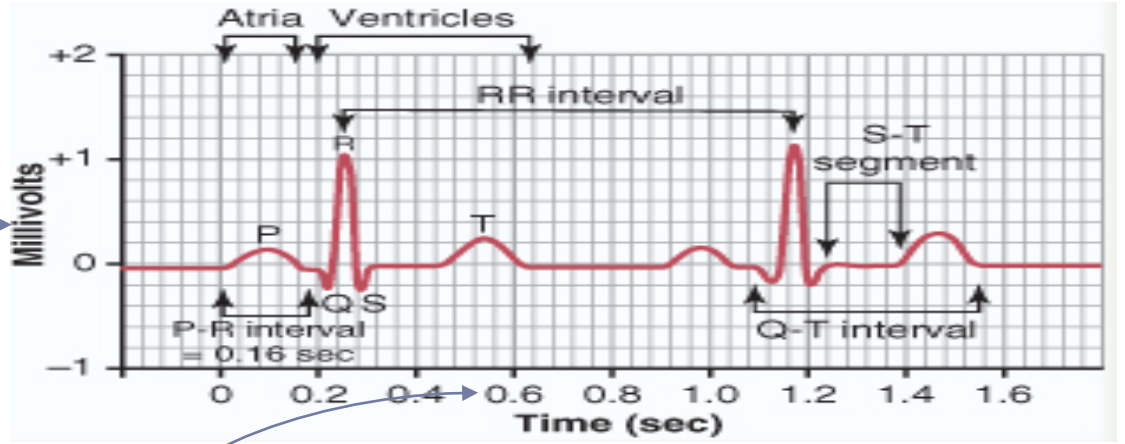
Computer-based and electronic display

Pen recorder and a moving sheet

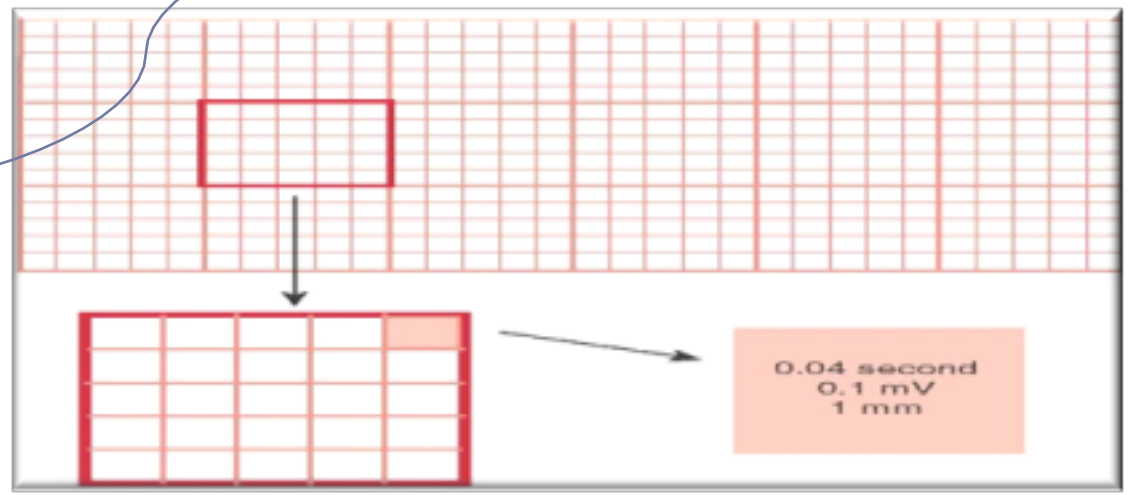
The electrical waves start from the base of the heart (SA node) then move to AV node and spread to the apex.

The Normal Electrocardiogram (ECG)

- The vertical calibration lines: Voltage(millivolt)
- 1 small square in the vertical calibration = 1 mm = 0.1 mv.
- 5 small lines (large square) = 0.5 mV (IN MALES' SLIDES) 1mV (IN FEMALES' SLIDES)



- The horizontal calibration lines:Time (seconds)
- 1 inch(25 small lines) = 1 second
- Each inch is divided by 5 dark vertical lines
- The interval between the dark lines (large squares 5mm)= 0.2 second
- thin line (small squares 1mm)= 0.04 second
  Because 1 / 25 = 0.04



5 small lines (squares) = 1 large square

Video of (Understanding ECG)
Duration: (4)mins

The Normal Electrocardiogram(ECG)

1-Wave	Caused by (represents)	How To Know it's Normal	Notes
P wave	atrial depolarization It is a small positive deflection caused by systoli or contraction of atria.	Amplitude ≤ 2.5 mm Duration ≤ 0.12 sec	.Why is it small? Because the atria's walls is thinner and its contraction is weaker than the ventricles
QRS complex	depolarization of the ventricles		(ventricular contraction/systole Where's the atrial repolarization? It's hidden and masked by the QRS complex.
T wave	repolarization of the ventricles	Polarity of P wave = polarity of T wave	

1- Waves (voltage + time)
2- Intervals (time only)
3- Segments (part of an interval)

In ventricles:
First part that gets depolarized is septum (by left bundle branch)
Then Depolarization of LV & RV
Last part of ventricles to depolarize is pulmonary conus

- Q wave is due to depolarization of septum by left bundle branch
- S wave is due to depolarization of pulmonary conus

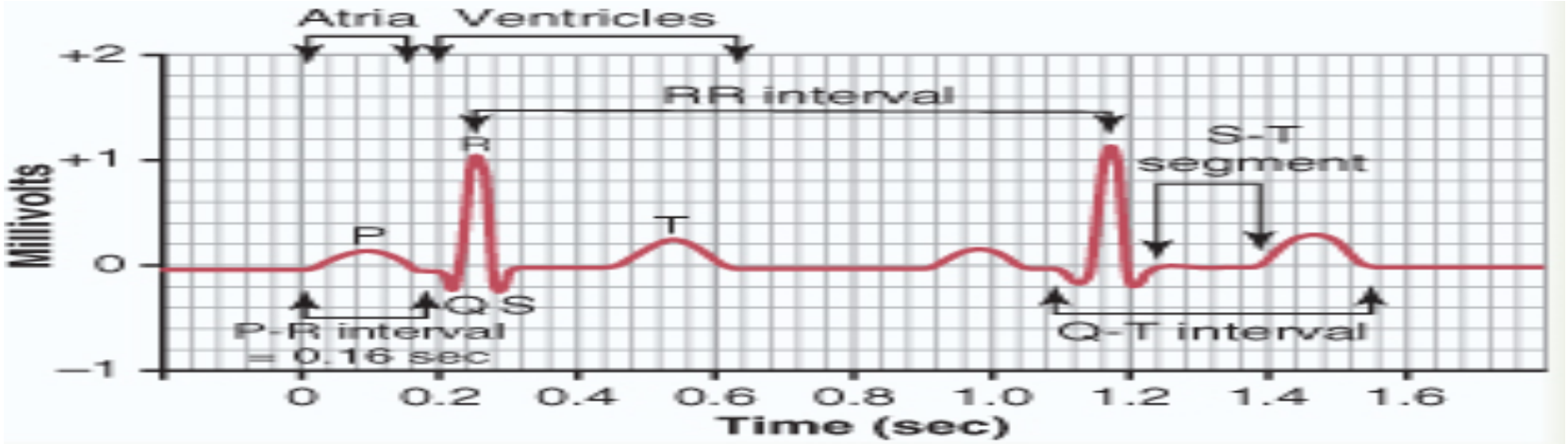
(depolarization is from epicardium to pericardium while repolarization is from pericardium to epicardium)

The Normal Electrocardiogram (ECG)

2- Interval	Represents	How to Know it's Normal	Notes
P-R interval	• It is the time between the beginning of the P wave and the beginning of the QRS complex • interval between the beginning of electrical excitation of the atria and the beginning of excitation of the ventricles.	The P-R interval is about 0.16 second	(from SA node to ventricle) between the beginning of the atrial contraction and the ventricular contraction) # of small lines multiplied by 0.04
Q-T interval (Ventricular changes only)	• is the time from the beginning of the *Q wave* to the end of the *T wave* • The QT interval represents electrical depolarization and repolarization of the ventricles (contraction of the ventricles)	Q-T interval is about 0.35 second	• Contraction of the ventricles last from the beginning of the Q wave to the end of the T wave. • QT interval roughly approximates the period of ventricular systole. • Relaxation hasn't begun but **repolarization** has # of small lines multiplied by 0.04

The Normal Electrocardiogram (ECG)

3- Segment	Represents	Notes
S-T segment	No electrical potentials are measured on the body surface; ventricular muscle cells are in the plateau phase of their action potentials	T wave represents ventricular repolarization (phase 3) , ST segment is before T wave → so it happens in phase 2 (plateau



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heart rate:

- The heart rate is the repetition of the time interval between two successive heartbeats
- If the interval between 2 beats is 1 second , the heart rate is 60 beats per minute.
- It is the RR interval = 0.8 seconds
- 0.8 / 60 = BPM

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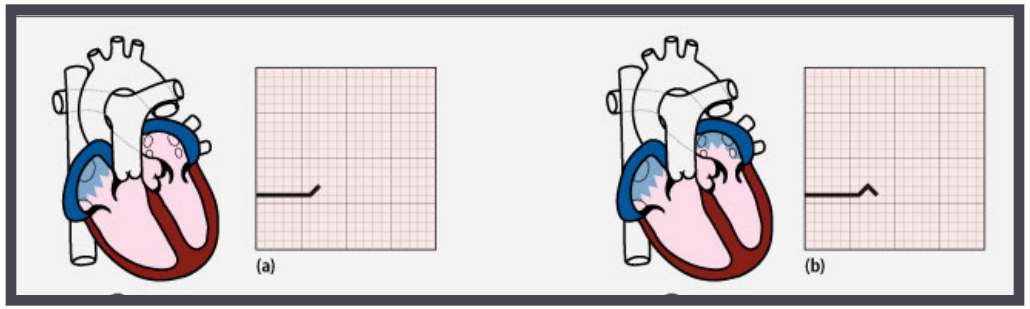
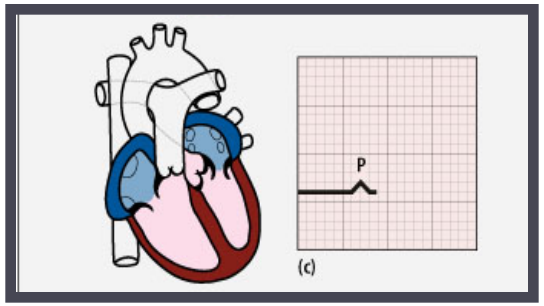
Video of (ECG Interpretation - Cardiac Electrical Activity) Duration (7min)

ECG Waves

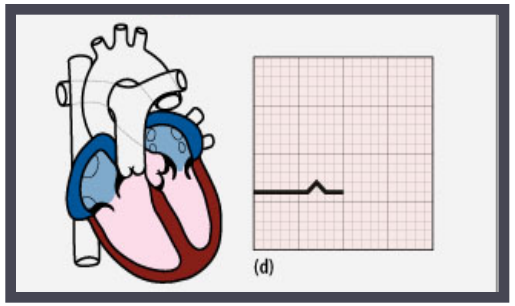
The impulse originates at the SA node and spreads to the atria.



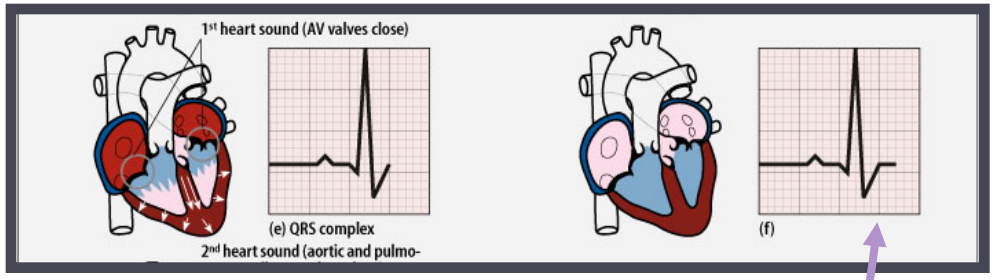
Atrial depolarisation generates a '**P wave**' on the ECG.



The impulse is delayed at the AV node.

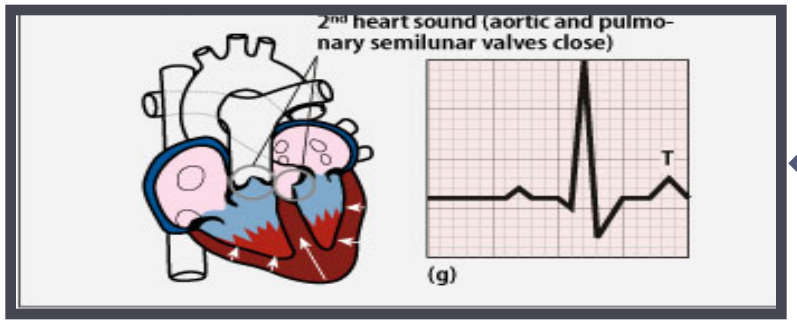


The impulse then spreads to ventricles generating a **QRS complex.**



Ventricles uniformly depolarised - ST segment

Ventricles repolarize forming a **T wave.**



Question :

Why atrial repolarization does not appear in ECG?

Because atrial repolarization happens at the same time of ventricle depolarization,and ventricle depolarization is stronger so it will appear instead of atrial repolarization in the ECG.

Normal Rate and Rhythm; Sinus Rhythm

- ✓ Impulses originate in the SA node regularly at a rate of 60-100 beats per minute in adults.
- ✓ P waves upright, uniform in size and contour from beat to beat.
- ✓ Each P is followed by a QRS complex with a resulting P:QRS ratio 1:1.
- ✓ All complexes are evenly spaced.
- ✓ PR interval is constant and within normal range.

Abnormalities in ECG

What defines a normal QRS complex?

- Duration: 0.08 – 0.10 sec
- Increased width of the complex is characteristic of defects in the branch bundles or Purkinje fibres, i.e., bundle branch block.

What defines a normal PR interval?

- 0.12 – 0.21 sec
- What is defined by an increased PR interval?
  →Primary AV block
- What is the significance of decreased PR interval?
  →Accessory pathway (impulse passes from atria to ventricles without passing into AV node)

Flow of Electrical Current in the Heart

- In normal ventricles , current flows:

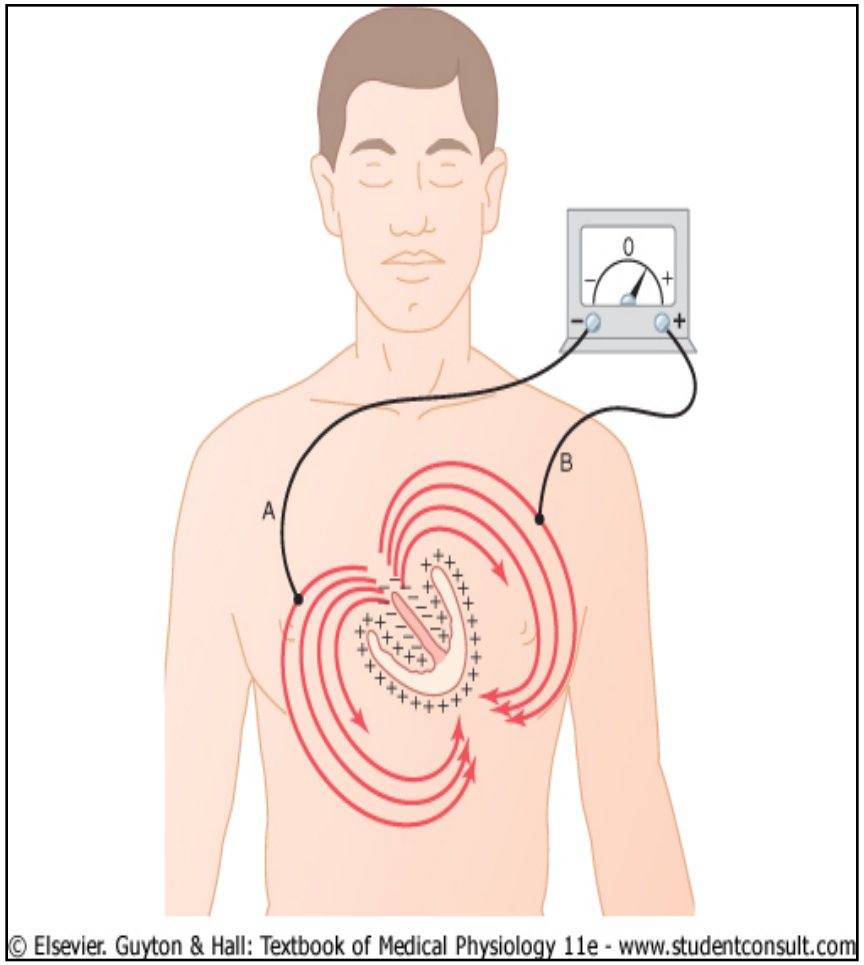
From *negative* → *positive*

From the *base* toward → the *apex*

From *electronegative inner surface* → *electropositive outer surface*

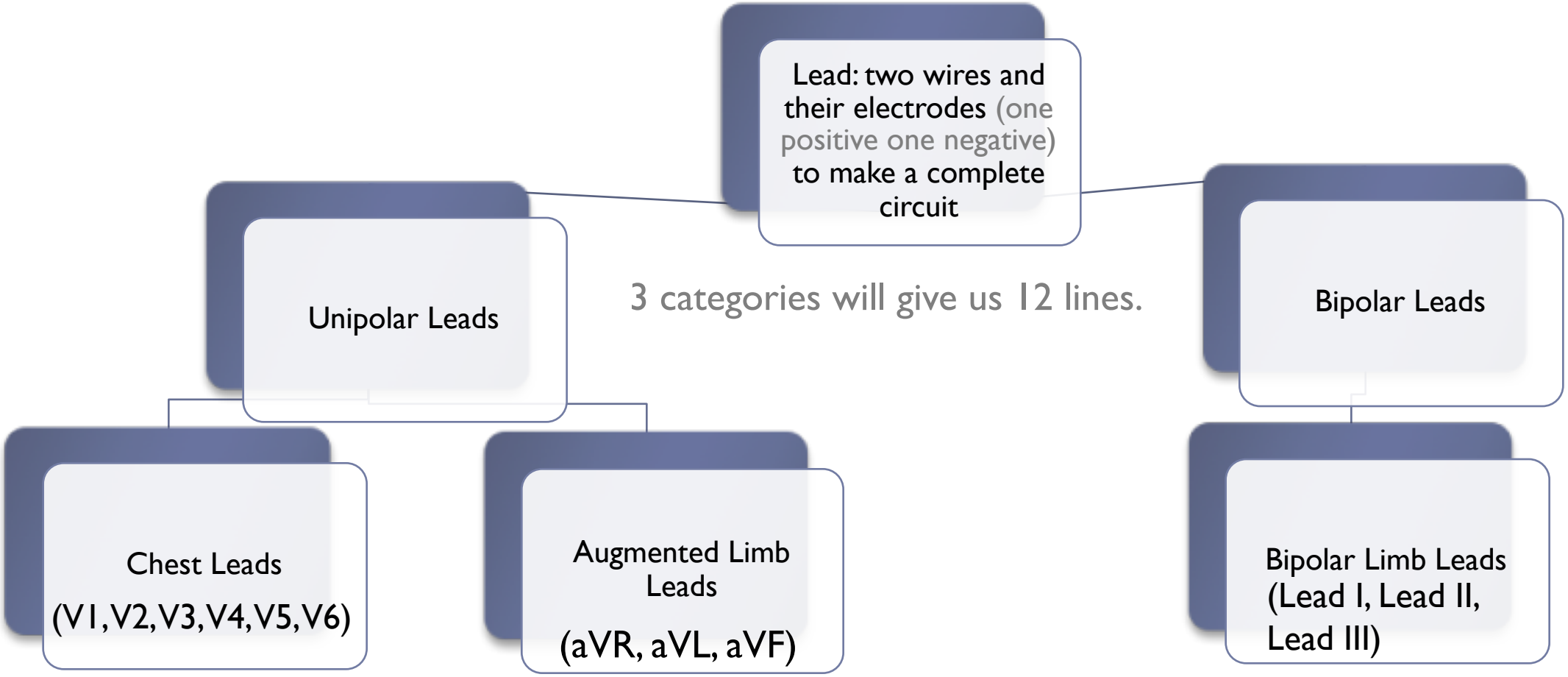
- An electrode placed near the base of the heart is electronegative, and near the apex is electropositive

- The first area that depolarizes is the ***ventricular septum***



The ECG Leads

Video of (ECG leads) Duration: (3)mins



An ECG lead is the ECG record obtained when the recording electrodes are placed at specific points on the body.

Unipolar and Bipolar leads

Unipolar ECG leads

- These are the ECG records obtained when the reference electrode is at zero potential. The active electrode is applied to the recording points on the body surface.
- There are six standard unipolar chest leads recorded from the six standard chest points and designated as V1, V2, V3, V4, V5 and V6.
- There are other three standard unipolar limb leads recorded from the standard limb points and designated as aVL, aVR, aVF.

Bipolar ECG leads

- means that the ECG is recorded from two electrodes
- These are the ECG records obtained when the active electrode is applied to a recording point and the reference electrode is applied to another recording point.
- The ECG will be a record of the changes in electrical potential at the active electrode relative to the reference electrode.
- There are 3 bipolar leads: Lead I, Lead II and Lead III

Unipolar Chest Points

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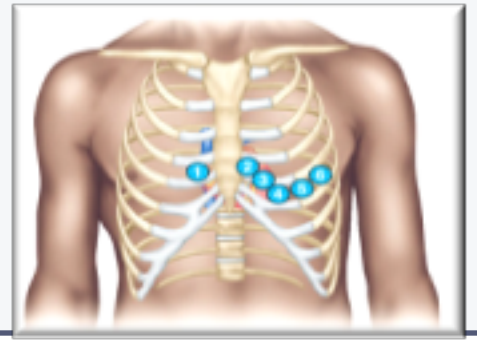
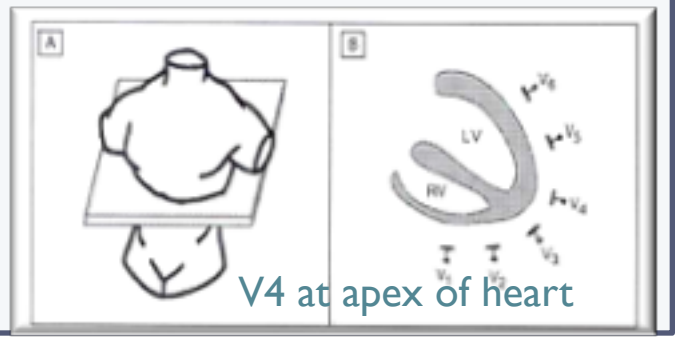
- V_1: at the right fourth intercostals space near the sternum.
- V_2: at the left fourth intercostals space near the sternum.
- V_3: midway between V_2 and V_4.
- V_4: at the left fifth intercostals space at the midcalvicular line.
- V_5: at the left fifth intercostals space at the anterior axillary line.
- V_6: at the left fifth intercostals space at the midaxillary line.





V4 at apex of heart

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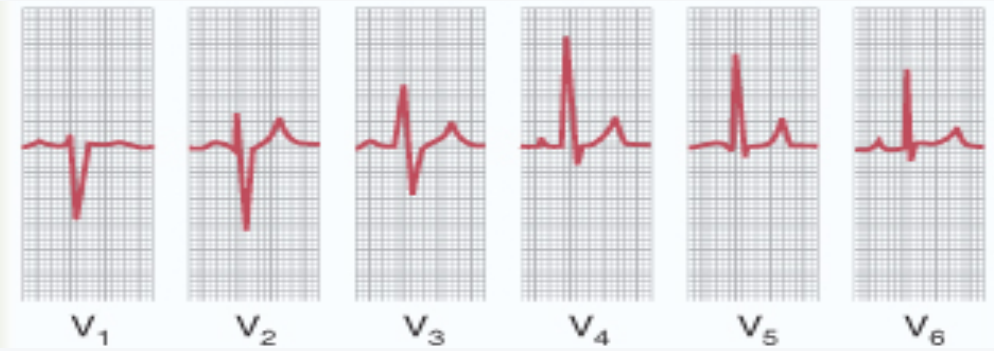
- Recorded from the anterior surface of the chest (V1,V2,V3,V4,V5,V6)
- Positive electrode on the chest
- The *indifferent electrode* is the negative electrode connected to the right arm, left arm, and left leg
- V1 and V2: QRS are mainly negative because the chest leads are nearer to the base of the heart
- V3,V4 and V6 are mainly positive because the chest electrode are nearer to the apex



Unipolar Augmented Limb Leads

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- aVL: at the junction of the left arm with the trunk. Any point on the left upper limb has the same potential.
- aVR: at the junction of the right arm with the trunk. Any point on the right upper limb has the same potential.
- aVF: at the junction of the left lower limb with the trunk. Any point on the left or right lower limbs has the same potential.

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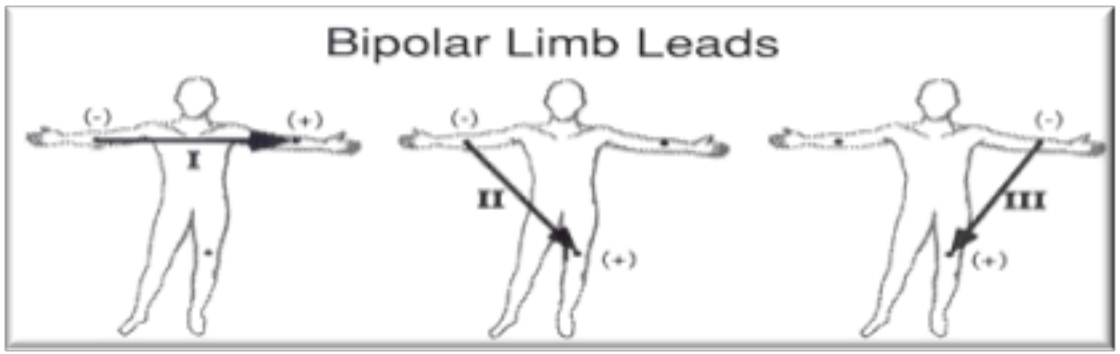
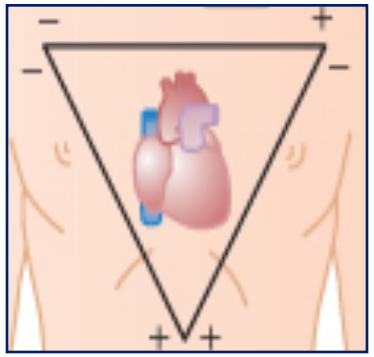
- The two limbs are connected to the negative terminal of the ECG, but only one is recording. and the third limb is connected to the positive
- When the positive terminal is on:
  - The right arm (aVR): inverted
  - The left arm (aVL)
  - The left leg (aVF)
- All are similar to the standard limb leads

VL faces anterolateral surface, VR faces anterior surface, VF faces inferior surface.

Bipolar ECG Leads

- **Lead I:** records the potential between left arm and right arm. The active electrode is at VL and the reference electrode is at VR.
- **Lead II:** records the potential between left leg and right arm. The active electrode is at VF and the reference electrode is at VR.
- **Lead III:** records the potential between left leg and left arm. The active electrode is at VF and the reference electrode is at VL.





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Lead I:
The right arm : –ve
The left arm: +ve

Lead II:
The right arm: -ve
The left leg: +ve

Lead III:
The left arm: -ve
The left leg: +ve

- Positive is the active electrode.
- Negative is the reference electrode.

Doctor's Notes

Anterior surface of heart → RV
Anterolateral surface → LV
Inferior (diaphragmatic) surface → RV & LV

Surface of the heart	Leads
Anterior surface	V1, V2, aVR
Anteroseptal surface	V3, V4
Anterolateral surface	V5, V6, aVL, Lead I
Inferior Surface	aVF, Lead II, Lead III

If a person has an **inferior** wall myocardial infarction, ECG changes will be in AVF lead 2 and lead 3

Einthoven's Triangle & law

Einthoven's Triangle:

- is drawn around the area of the heart
- The two apices at the upper part of the triangle represent the points at which the two arms connect electrically
- The lower apex is the point at which the left leg connects

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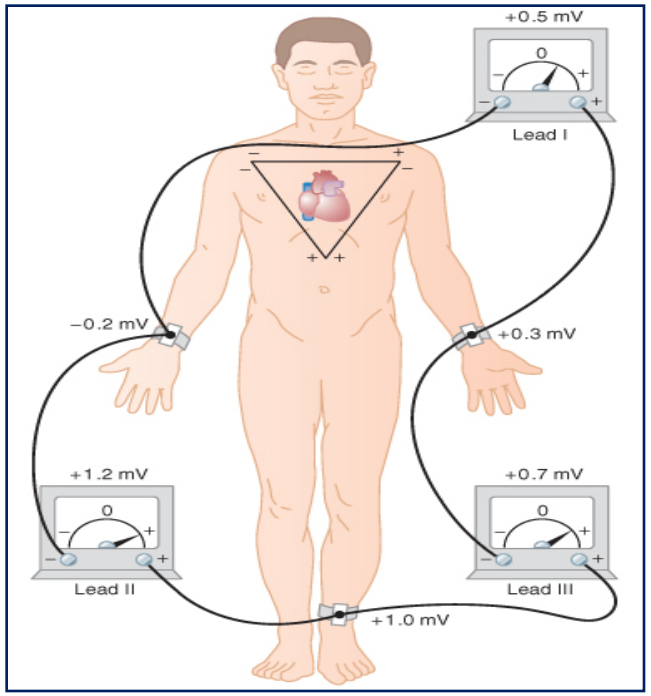
Lead I = E_{LA} - E_{RA}
Lead II = E_{LL} - E_{RA}
Lead III = E_{LL} - E_{LA}



Einthoven's Law:

- if the electrical potential of any two of the three bipolar limb leads are known, the third one can be determined mathematically by summing the first two (note the +ve and -ve signs)
- *The sum of the voltage in Lead I + Lead III= Lead*
- ***Einthoven's*** law: $E_I + E_{III} = E_{II}$

In the ECG, at any given instant, the potential of any wave in lead II is equal to the sum of the potentials in lead I and III.

LA= Left Arm. RA= Right Arm. LL= Left Leg. E= Electrical potential

Quiz

- https://www.onlineexambuilder.com/ecg/exam-137070

Link to Editing File

(Please be sure to check this file frequently for any edits or updates on all of our lectures.)

References:

- Girls' and boys' slides.
- Guyton and Hall Textbook of Medical Physiology (Thirteenth Edition.)

Thank you!

اعمل لترسم بسمة، اعمل لتمسح دمعة، اعمل و أنت تعلم أن الله لا يضيع أجر من أحسن عملا.

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