جامعة الملك سعود
King Saud University

MED438
KING SAUD UNIVERSITY

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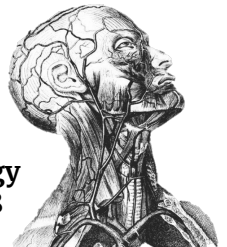
Lecture 5
ECG

- Red: important
- Black: in male / female slides
- Pink: in female slides only
- Blue: in male slides only
- Gray: extra information

Editing file



Physiology
MED438

The Electrocardiogram (ECG)

Definition

ECG is the record of the algebraic sum of electrical activity i.e. action potentials generated by the heart during cardiac cycle.

Principle

When the depolarization wave spreads through heart, electrical currents pass into the surrounding tissue (body fluids are good conductors) and can be recorded from electrodes placed on the skin opposite to the heart.

Methods

- ➔ Computer based & electronic display.
- ➔ Pen recorder & a moving sheet.

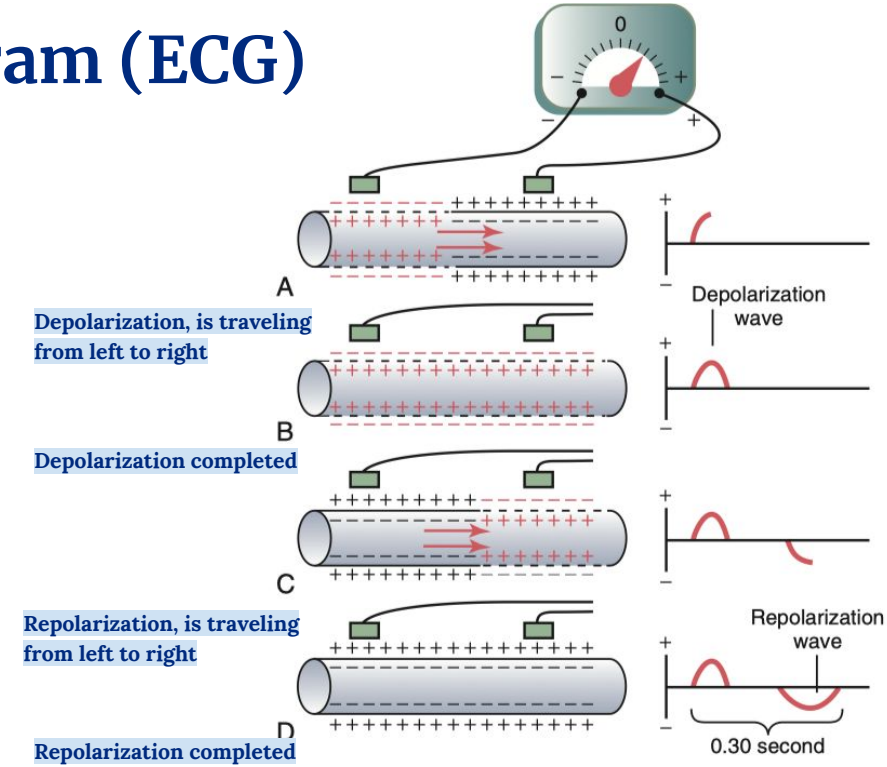
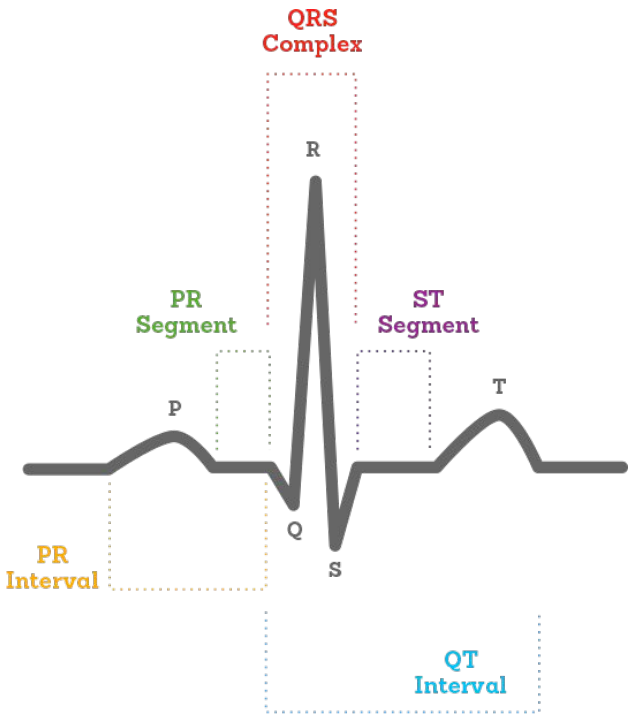


Figure 11-2. Recording the depolarization wave (**A** and **B**) and the repolarization wave (**C** and **D**) from a cardiac muscle fiber.

The depolarization wave can either be upward or downward depending on the direction of depolarization with respect to the positive electrode (same direction is upward)

ECG detections

- Electrolyte disturbances
- Conduction defects
- Heart rate, axis, rhythm
- Myopathies
- Carditis
- Chamber hypertrophy
- Myocardial Ischemia
- Drug toxicity (Digoxin)



3 Waves

(De/repolarize)
- **P** wave
- **QRS** complex
- **T** wave

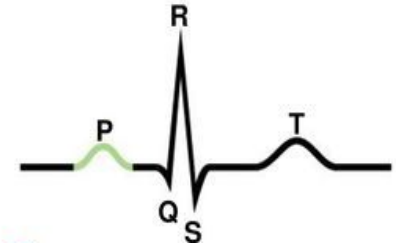
3 Time intervals

(Include Waves)
- **PR-** interval
- **QT-** interval
- **RR-** interval

3 Segments

(Isoelectric, No waves included)
- **PR-** segment
- **ST-** segment
- **TP-** segment

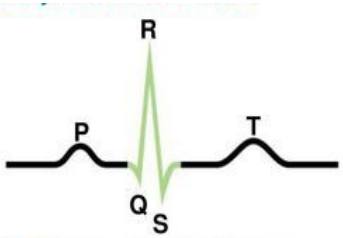
Analysis of normal ECG “Wave”



P wave

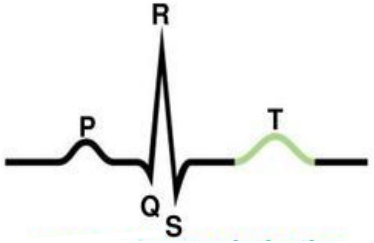
- Caused by atrial depolarization
- Duration: 0.06-0.11 sec
- Precedes atrial systole by 0.01-0.02 sec
- Represents time of electrical impulse from SA node to spread through atrial muscle.

Notice how atrial repolarization is missing in the ECG. that’s because it occurs simultaneously with ventricular depolarization, which hides it.



QRS complex

- Caused by ventricular depolarization
- **Q wave:** depolarization of interventricular septum
- **R wave:** depolarization of ventricle wall
- **S wave:** depolarization of base of heart.
- Precedes ventricular systole by 0.02 sec
- Duration : ≤ 0.1 sec

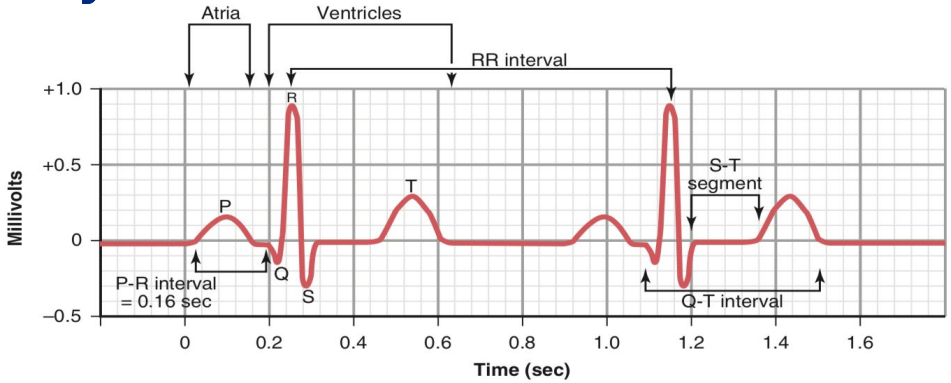


T wave

- Caused by ventricular repolarization
- Duration : 0.27 sec
- Precedes Ventricular diastole

The U wave represents repolarization of papillary muscles but is rarely seen. It becomes prominent in cases of hypokalemia, hypercalcemia, thyrotoxicosis

Analysis of normal ECG “Intervals”



P-R interval

- From **P wave** (atrial depolarization) → **QRS complex** (ventricular depolarization)
- 0.12 - 0.2 sec
- Includes P wave (which denotes atrial depolarization) & PR segment (which denotes AV delay)
- An increase in conduction velocity through AV node will decrease P-R interval (sympathetic stimulation) & vice versa.

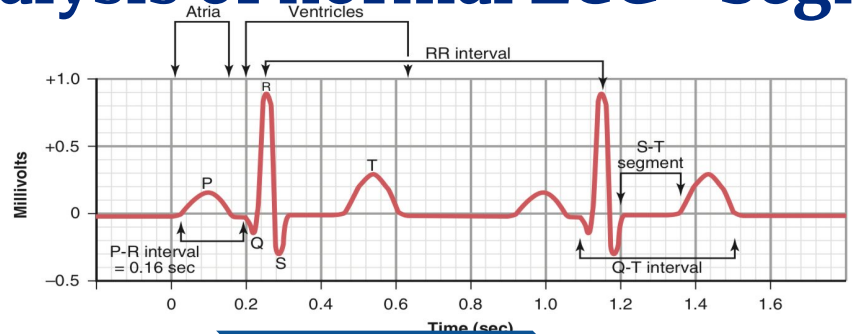
Q-T interval

- From the beginning of **Q wave** (ventricular depolarization) → end of the **T wave** (ventricular repolarization)
- 0.35 – 0.45 sec
- QRS complex, ST segment & T- wave.

R-R interval

- Between two successive R-waves
- Used to measure Heart rate & cardiac cycle length.
- **Heart rate:** the repetition of the time interval between two successive heart beats.
  can be measured by counting the number of R-waves per minute.
- If the interval between 2 beats is 1 second , the heart rate is 60 beats per minute.

Analysis of normal ECG "Segments"



P-R segment

Represents A-V nodal delay

(Between atrial depolarization and ventricular depolarization)

S-T segment

- ➔ Represents **complete depolarization** of all ventricular muscles i.e. no potential difference between areas of myocardium at this stage.
- ➔ It roughly **corresponds to the plateau** phase of the ventricular action potential.
- ➔ A normal S-T segment is on isoelectric line.
- ➔ If it is deviated up or down, it indicates diseased fibers.

One ECG diagnostic change for acute **myocardial infarction** is ST segment elevation and inverted T wave.

T-P segment

- ➔ Represents **ventricular filling** (between repolarization and depolarization).
- ➔ Calculated from **end of T-wave to beginning of P-wave.**
- ➔ Time interval from ventricular repolarization till next atrial depolarization.

Cardiac Vectors

Definition

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.**

Principle

- The length of the arrow is **proportional** to the voltage of the potential.
- Electrical forces can be represented in the form of vectors.

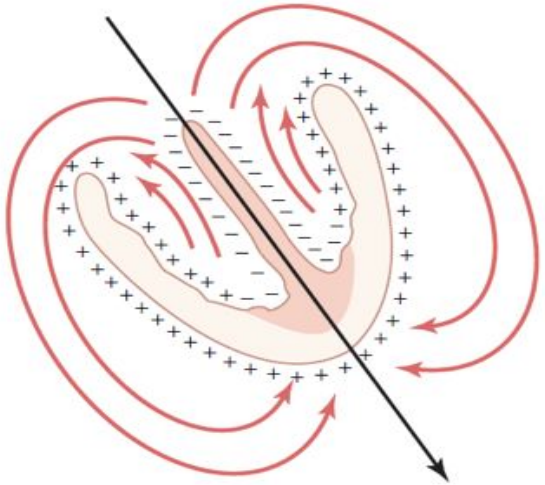


Figure 12–1

Mean vector through the partially depolarized ventricles.

Electrical events in cardiac cycle

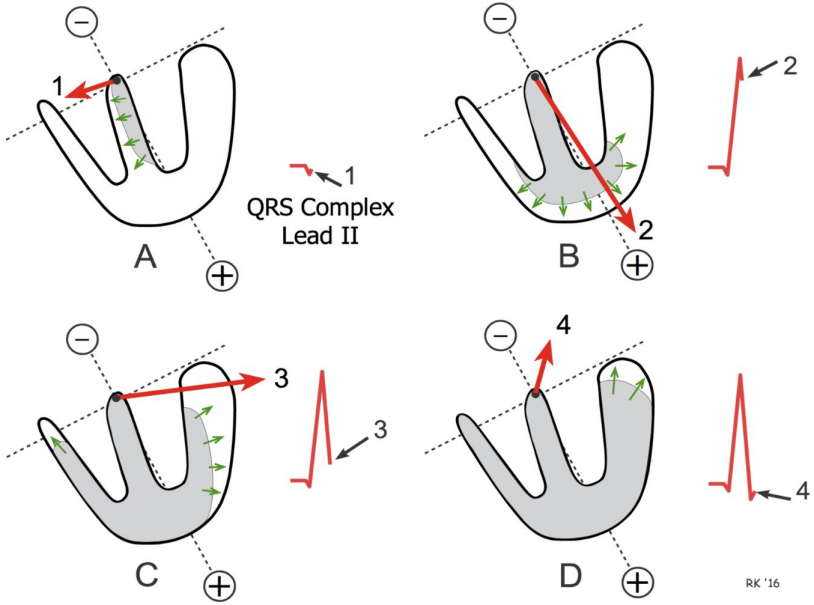
The atrium follows the rule of first depolarized first repolarized, while the ventricles go with first depolarized last repolarized.

Depolarization of the ATRIA - The P-wave

- First area to become repolarized is the sinus nodal region (first depolarized) Therefore, the atrial repolarization vector is backward to the vector of depolarization.

Excitation of ventricles - QRS complex

- The first area depolarized is the left endocardial surface of the septum, while the last is the left side of the Apex.
- The left depolarization of the septum before the right creates a weak left-to-right vector (shown as Q wave in ECG) for a fraction of a second before the normal vector occurs.



Remember that the Q wave is represented as a small dip in the ECG.

Repolarization of ventricle – The T-wave

The greatest portion of ventricular muscle mass to repolarize first is the entire outer surface, near the apex of the heart.

The septum has a longer contraction period than the external surfaces of the heart **so** endocardial areas, conversely, normally repolarize last.

Therefore, the **positive** end of the overall ventricular vector during repolarization is toward the apex of the heart.

As a result, the normal T wave in all three bipolar limb leads is **positive**, which is also the polarity of most of the normal QRS complex.

ECG paper calibration

01

ECG

Is displayed on a graph paper as waves.

02

Speed

ECG machine runs at
25 mm/sec

03

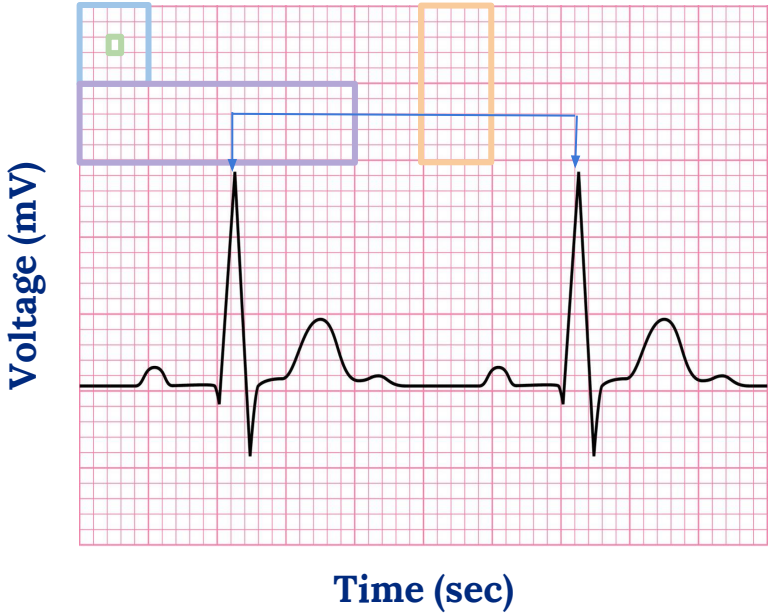
Time (X-axis)

1mm square = 0.04 sec
5 small squares = 0.2 sec
25 small squares = 1 sec

04

Voltage (y-axis)

1mm square = 0.1 mV
10 small lines = 1mV



Heart Rate Calculation From ECG:

1- Reciprocal of time interval between <u>two R peaks.</u>
If time is 0.83, then heart rate is 60/0.83=72 bpm
2- 1500/number of small squares between <u>two R peaks</u>
1 second has 25 small squares, thus 1 min has 1500
3- 300/number of big squares between two R peaks

Flow of Electrical current in the heart

In normal ventricles:

Current Flows from the electronegative inner surface of the heart to the electropositive outer surface
(From the Base to the apex)

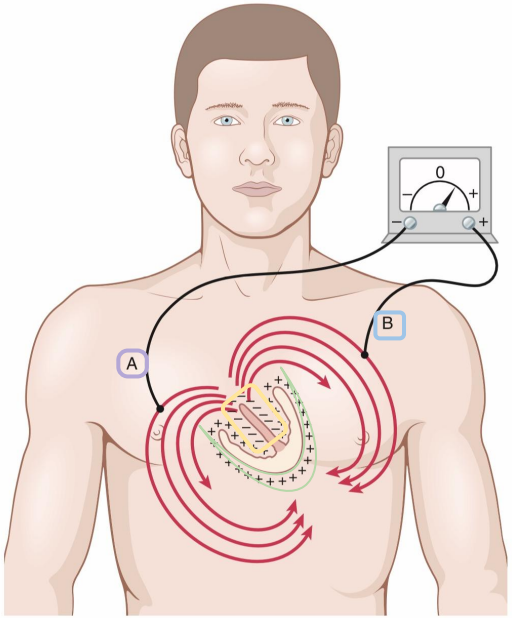
Electrode placements:

- The electronegative electrode is placed near the base of the heart.
- The electropositive electrode is placed near the apex of the heart.

Why is this arrangement important? So the recording meter will show positive recording in the ECG

The first area to depolarize is the *ventricular septum*

Followed by the rest of the ventricle



Note: Remember that the base of the heart is the posterior surface of it, not the inferior.

Electrocardiographic Leads

Definition

An ECG lead is a pair of electrodes and their wires, which are applied to particular parts of the body in order to complete a circuit.

1- Bipolar (standard) Limb Leads

Bipolar: means that the ECG is recorded from two electrodes located on different sides of the heart.

Lead I

Electrodes:

-*ve*: Right arm
+*ve*: Left arm

Lead II

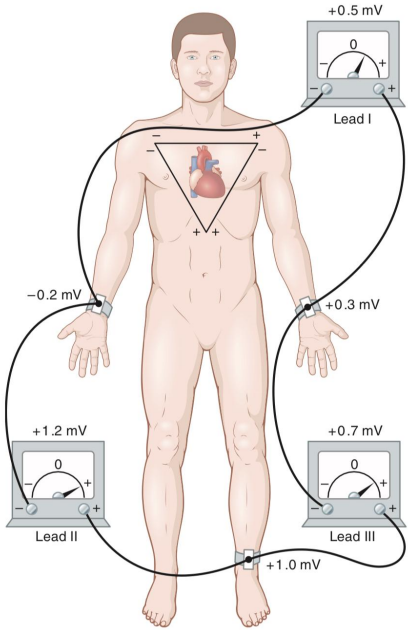
Electrodes:

-*ve*: Right arm
+*ve*: Left leg

Lead III

Electrodes:

-*ve*: Left arm
+*ve*: Left leg



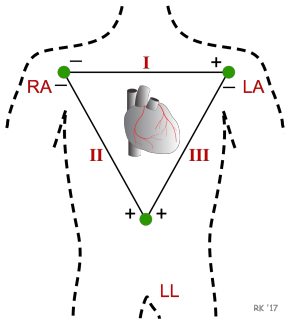
Note: right leg is always used for earthing (grounding).

Electrocardiographic Leads

1- The Bipolar (standard) Limb Leads *(cont.)*

Einthoven's Triangle

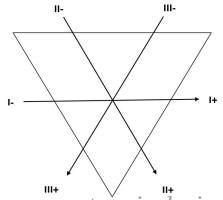
Heart: is the center of the triangle
Upper apices: Two apices representing both arms
Lower apex: represents the left leg



Bipolar leads

Hexagonal reference system

Lead I: At 0°
Lead II: At 60°
Lead III: At 120°



Notice that: The hexagonal reference system is derived from Einthoven's Triangle. How? By joining the three sides on the triangle in one common point of intersection at the center (So the intersection point represents the heart)

Einthoven's Law: States that If the electrical potential of any two of the three bipolar limb leads are known, the third one can be calculated as the sum of Lead I and Lead III is equal to the potential in lead II.

Lead I Potential + Lead III Potential = Lead II Potential

Electrocardiographic Leads

2- Augmented Unipolar leads

Principles:

- Recorded using an active (*Exploring*) electrode connected to an indifferent (*Inactive*) electrode at zero potential.
- Connection of limbs on the ECG terminals:
  - Positive terminal: One limb
  - Negative terminal: Two limbs
- The letter (a) means augmentation: increase in the magnitude of recording **1.5 times**

aVR

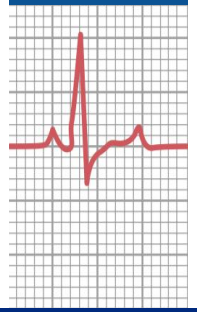
Augmented Voltage of the Right arm

- *Positive terminal:*
  - **Right arm**
- *Negative terminal:*
  - Left arm
  - Left Leg

Note: aVR lead is inverted

aVL

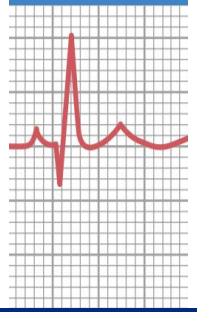
Augmented Voltage of the Left arm



- *Positive terminal:*
  - **Left arm**
- *Negative terminal:*
  - Right arm
  - Left Leg

aVF

Augmented Voltage of the Left Foot



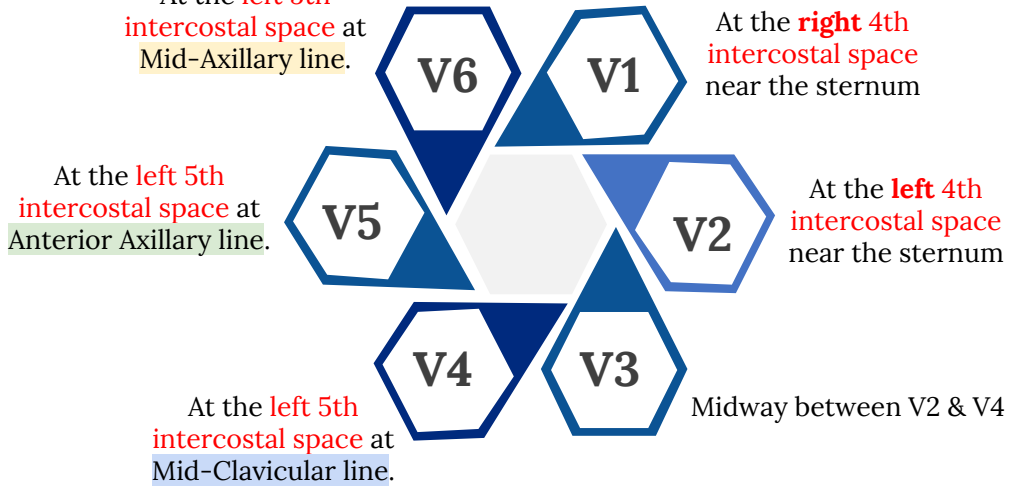
- *Positive terminal:*
  - **Left Foot**
- *Negative terminal:*
  - Right arm
  - Left arm

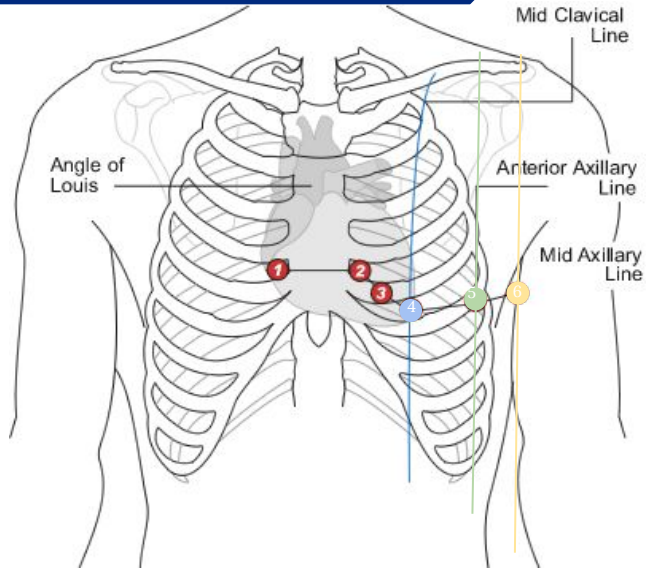
Electrocardiographic Leads

3- Chest leads

Principles:

- Electrodes placements:
  - Positive (Exploring) electrode: Chest. Include V1 to V6
  - Negative (Indifferent) electrode: connected to the 3 limbs: right arm, left arm, and left leg.





Electrocardiographic Leads

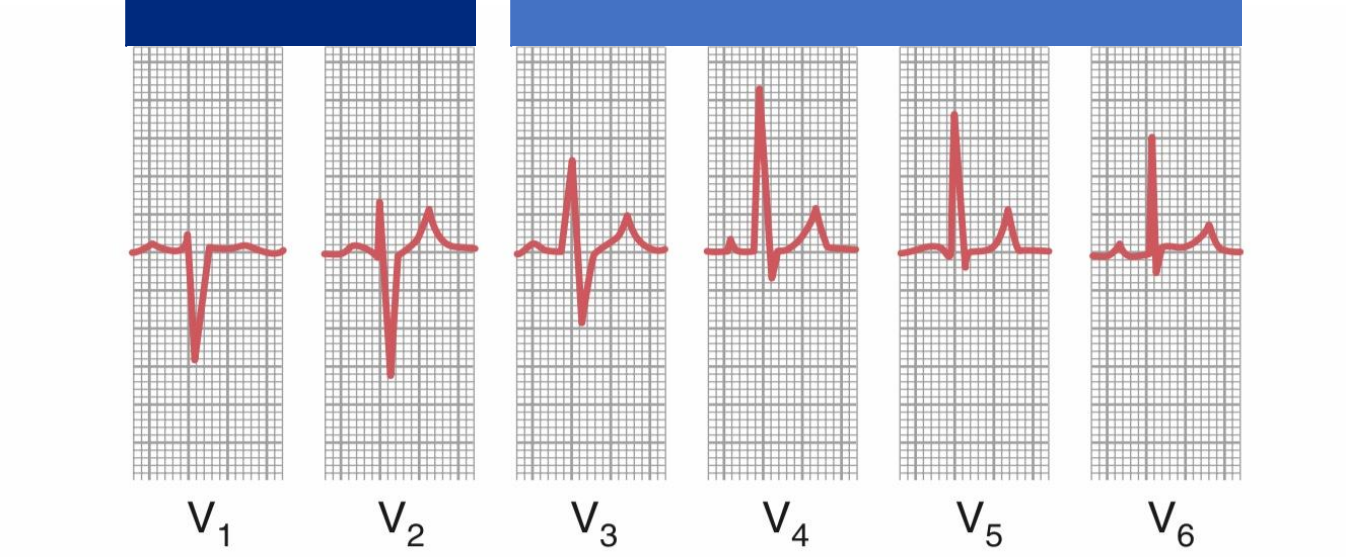
3- Chest leads *(cont.)*

V1 & V2

QRS are mainly **negative**
Why? Because V1 & V2 are nearer to the base of the heart (electronegative)

V3, V4, V5 & V6

QRS are mainly **Positive**
Why? Because these electrodes are nearer to the apex of the heart (electropositive)



ECG and the cardiac cycle

Phase	ECG change
Atrial systole	P- wave starts 0.02 seconds before atrial systole & continues. Q- wave occurs at the end of this phase.
Isovolumetric contraction	Q- wave starts 0.02 sec. before this phase. R & S waves occur during it.
Rapid ejection	T- wave starts at the last part of this phase.
Slow ejection	T- wave continues.
Isovolumetric relaxation	T- wave ends.
Rapid filling	T-P segment.
Slow filling	P- wave of the next cycle starts at the end of this phase.

Quiz

1. Which of the following chest leads is placed at the left 4th intercostal space?

A. V6
B. V1
C. V3
D. V2

2. Which of the following ECG changes corresponds with isovolumetric relaxation?

A. S- wave ends
B. T-wave continues
C. T-wave ends
D. T-P segment

3. A man had an ECG done and his QRS voltage was 0.5 mV in lead I and 1.5 mV in lead III, what is the potential in lead II?

A. 1 mV
B. 2 V
C. 2.5 mV
D. 2 mV

4. When recording lead II on an ECG, the negative electrode is?

A. Right arm
B. Left leg
C. Right leg
D. Left arm

5. Which wave represents depolarization of the base of the heart?

A. T- wave
B. U- wave
C. R- wave
D. S- wave

SAQ:

1- Enumerate 3 things that can be detected with an ECG

Myocardial Ischemia, electrolyte disturbance, carditis etc.

3- enumerate the chest leads and their locations, and explain why some of them are negative.

Answers: D - C - D - A - D

Leaders

Sedra Elsirawani Abdulrahman Alhawas

Members

- Lama AlZamil
- Arwa AlEmam
- Noura AlTurki
- Ghada AlSadhan
- Nouf AlShammari
- Nouf AlHumaidhi
- Taibah AlZaid
- Ajeed AlRashoud
- Reem AlGarni
- **Raghad AlKhashan**
- Leen AlMazroa
- Nouran Arnous
- Maha AlNahdi
- Badr Almuhanna
- **Abdulrahman Almezaini**
- Omar Aldosari
- Omar Alghadir
- Ibrahim Alshaqrawi
- Abdullah Aldawood
- Abdullah Shadid
- Meshari Alzeer
- Mohammed Alhamad
- Abdullah Alassaf
- Khalid Alkhani
- Amjad Albaroudi
- Mohammed Alhuqbani