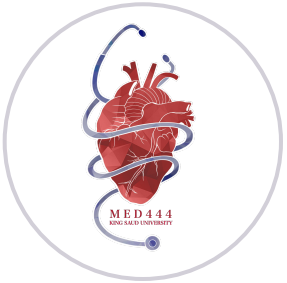
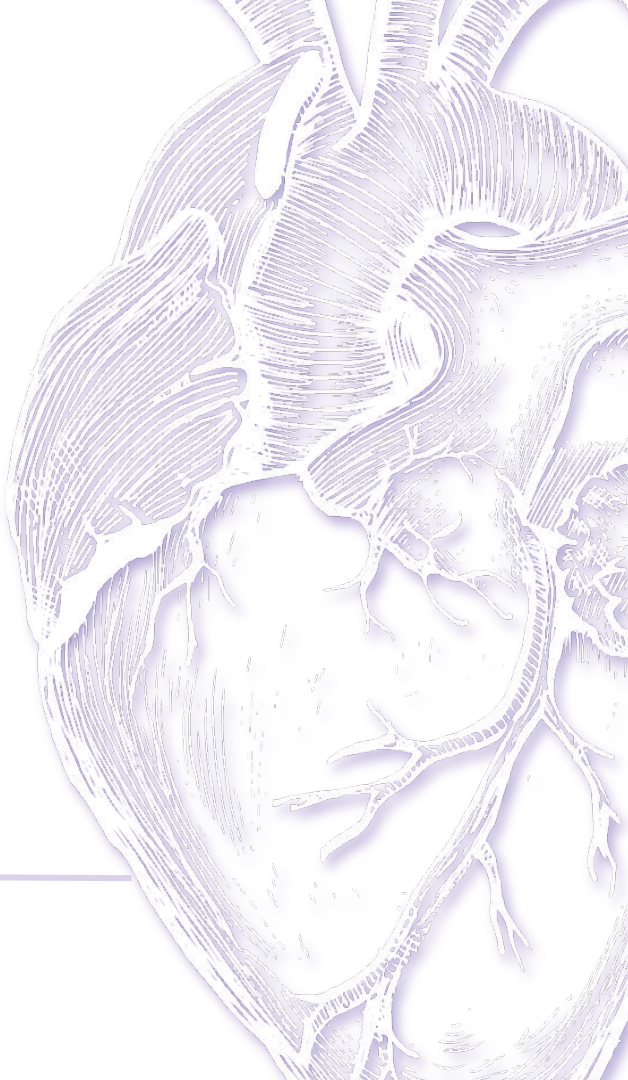






# ECG
# Electrocardiogram

Editing File

Main text Female's slide Male's slide Important text Doctor's note Extra

# Objectives:

We Highly Recommend that you watch this video before study the lecture 🥷

Click here!!!

- Define ECG & list uses of ECG
- Identify waves of ECG and the physiological causes & Understand basic ECG principles
- Define the normal intervals and segments & Recognize ECG waves, Intervals and, segments
- Discuss the bipolar and unipolar leads and their locations & Describe ECG leads and Einthoven's triangle
- Discuss the bipolar limb lead and the cardiac axis
- Calculate the Heart Rate & Determine rate and normal heart rhythm
- ECG changes and body Electrolytes & Have some idea about ECG abnormalities in common clinical conditions

This slide is a mix between male and female slides

# What is ECG (Introduction)

Click here for Noreen video!!!

It is the sum of electrical activity of the heart transmitted to surface of body. The body fluids are good conductors (body is a volume conductor). Fluctuations in electrical potential that represent the algebraic sum of the action potentials of myocardial fibers can be recorded extracellularly

It is a simple and important tool for providing evidence to support a diagnosis, and is sometimes crucial for patient management. The tracing shows waves of different shapes connected to each other by intervening intervals.

It records the electrical activity of the heart by surface electrodes.
The tracing shows waves of different shapes connected to each other by intervening intervals.

A record of the waves (impulses) of electrical excitation in the heart is called ECG and the recording is known as an electrocardiogram.
Electrocardiograph machine record these fluctuations on a moving strip of paper.

# Terminology

ECG: Electrocardiogram refers to the recording of electrical changes that occurs in heart during a cardiac cycle. It may be abbreviated as ECG or EKG.

Electrocardiograph: It is an instrument that picks up the electric currents produced by the heart muscle during a cardiac cycle of contraction and relaxation.

A record of the waves (impulses) of electrical excitation in the heart is called ECG and the recording is known as an electrocardiogram.
EKG is based on the German spelling of electrocardiogram, which is Elektrokardiogram.

# Working principle of ECG

Click here for Nice explanation from Rayan !

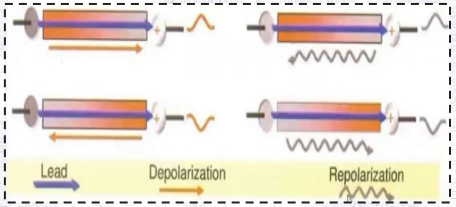
Important slide

Extra slide

Thanks to Layan Al-Ruwaili 443 for this amazing slide!!

To understand **the concept of drawing** the waves (upwards and downwards):

Going to use **lead II** to explain it :
**Base : -**
**Apex:** +




Depolarization: The propagating charge is **positive:**
**Upward** wave: Negative to positive
**Downward** wave: Positive to negative

Repolarization: The propagating charge is **negative:**
**Upward** wave: Positive to negative
**Downward** wave: Negative to positive

ECG waveforms

**3 Waves**
Deflection
- P wave
- QRS complex
- T wave

**3 segments**
Isoelectric record only
- ST segment
- PR segment
- TP segment

**3 time intervals**
Include waves and segments
- PR interval
- QT interval
- RR interval

( ST + TP intervals)

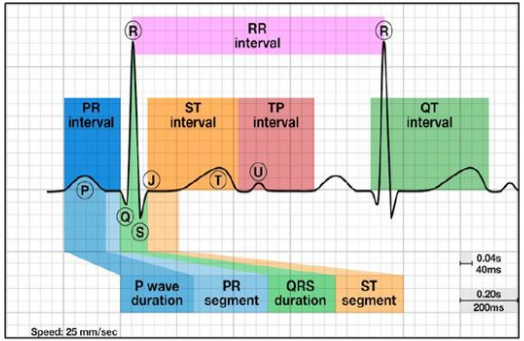



Figure 19. ECG waves and intervals.

Female's slide

# Working principle of ECG

Please don't skip it's for your understanding of upcoming slides

When the depolarization wave spread through heart, electrical currents pass into the surrounding tissue (body fluids are good conductors) and can be recorded from surface electrodes

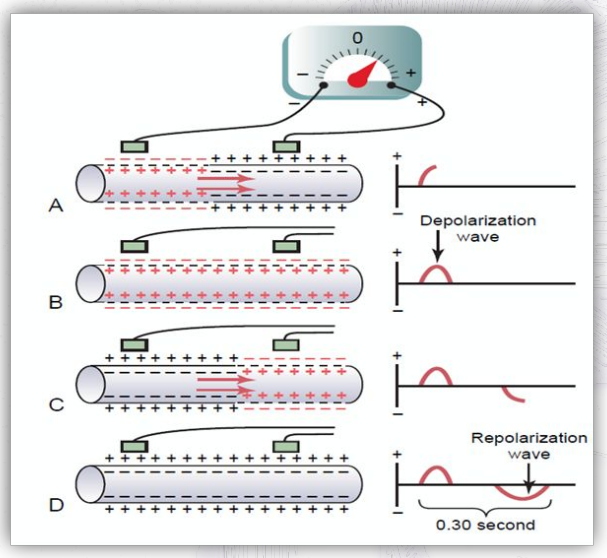
**It's important to notice the direction of the electrons!!**

Thanks to Layan Al-Ruwaili 443!

First you need to understand that the **apex** of the heart has **positive** charge , and the **base** has the **negative** charge.
We know previously that depolarization would make the charge inside the cell positive in respect to outside which will be negative, now I need you to focus at the charge outside since our leads will detect the charge of extracellular fluid at the drawn graph, so:

**The Depolarization:**
Normally outside positive , but in depolarization the inside will be positive as ions diffuse in(Na-Ca) ,so at outside the potential differences will move the new negative charge over the positive one wave will be drawn as **upward** wave (A: halfway depolarization)
When the outside is fully negative as depolarization completed will be drawn as **downward** wave (B: complete depolarization)

**The Repolarization:**
Same principle vica versa , when the outside is negative after depolarization the k ions will go out the cell for repolarization , potential differences will have outflow of the new positive charge to the negative one , will be drawn as **downward** wave (C: halfway repolarization)
As the outside is fully positive it will be drawn as **upward** wave (D: complete repolarization)




**Cardiac muscle fiber:**
A: halfway depolarization
B: complete depolarization
C: halfway repolarization
D: complete repolarization

Male's slide

# Wiring of the heart

## NORMAL TRANSMISSION OF CONDUCTING IMPULSE

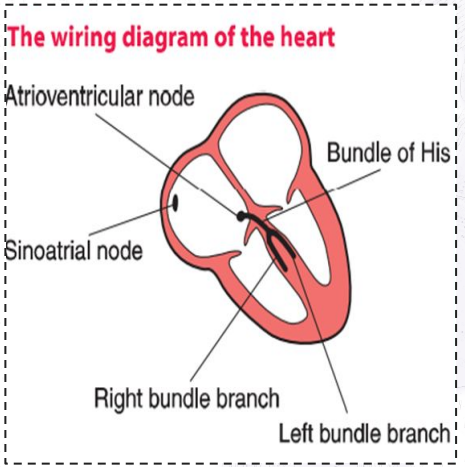
1. Sinoatrial node
2. AV node
3. Bundle of His
4. Bundle Branches
5. Purkinje

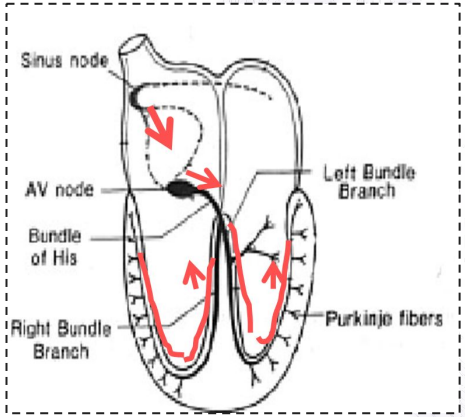
Thanks to 443 team!

An electrocardiogram (ECG) reflects the electrical activity of the heart as it beats. The ECG records the electrical signals produced by the heart as it contracts and relaxes. The ECG is made up of several waves, each of which corresponds to a specific phase of the cardiac cycle.

The P wave represents the electrical activity associated with atrial depolarization (contraction). The QRS complex represents the electrical activity associated with ventricular depolarization (contraction), and the T wave represents the electrical activity associated with ventricular repolarization (relaxation).

The ECG can also provide information about the timing and duration of the electrical impulses, which can help diagnose various heart conditions such as arrhythmias, conduction blocks, and ischemia (lack of blood flow to the heart). Abnormalities in the ECG can indicate problems with the electrical conduction system of the heart, which may require further investigation and treatment.



# Principles of Vectorial Analysis of Electrocardiograms

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.(apex)

Direction of a Vector Is Denoted in Terms of Degrees
And length of the arrow is proportional to the voltage of the potential.

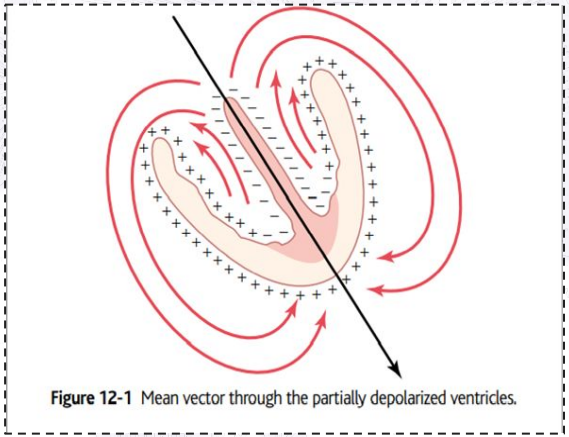


**Figure 12-1** Mean vector through the partially depolarized ventricles.

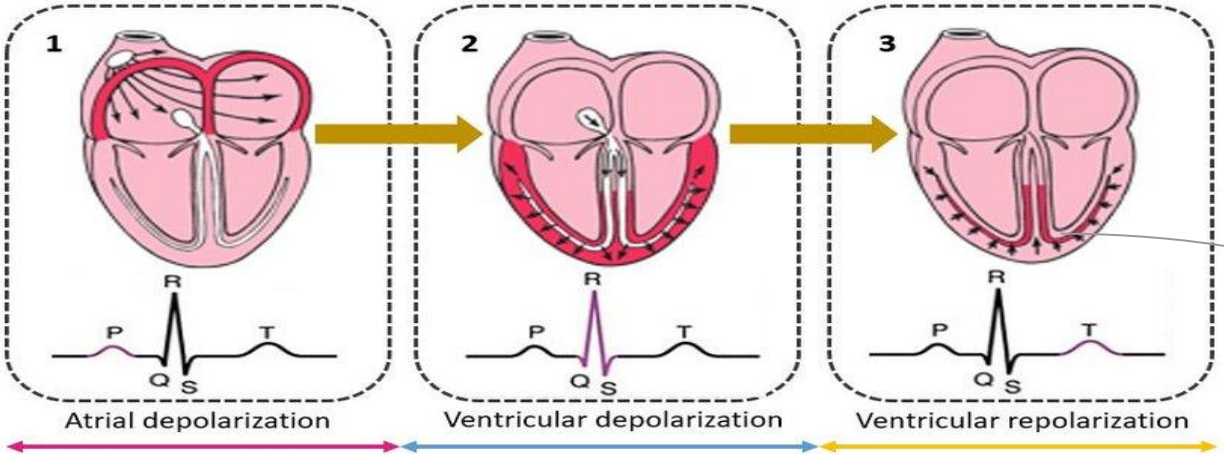
In a normal heart, the average direction of the vector during spread of the depolarization QRS wave through the ventricles is called the mean QRS vector, and is about +59 degrees

Physiological Heart Axis: -30 to +90 degrees

# The pattern of spreading of depolarization and repolarization

Important slide

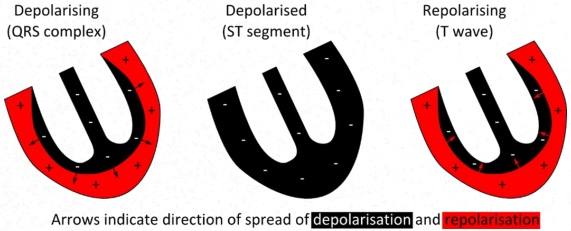
Female's slide




- Resting
- Polarized (negative)

- contracts
- Depolarized (less negative)

- Relax
- Repolarized (go back to negative state)



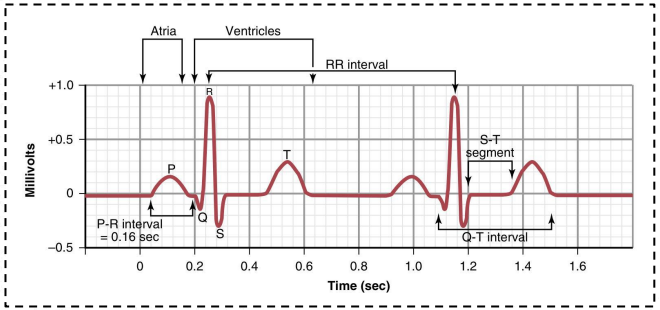

# Normal ECG

**The normal ECG is composed of:**

- **P wave**
- **QRS complex**
- **T wave**

## How does a 12-lead ECG work?

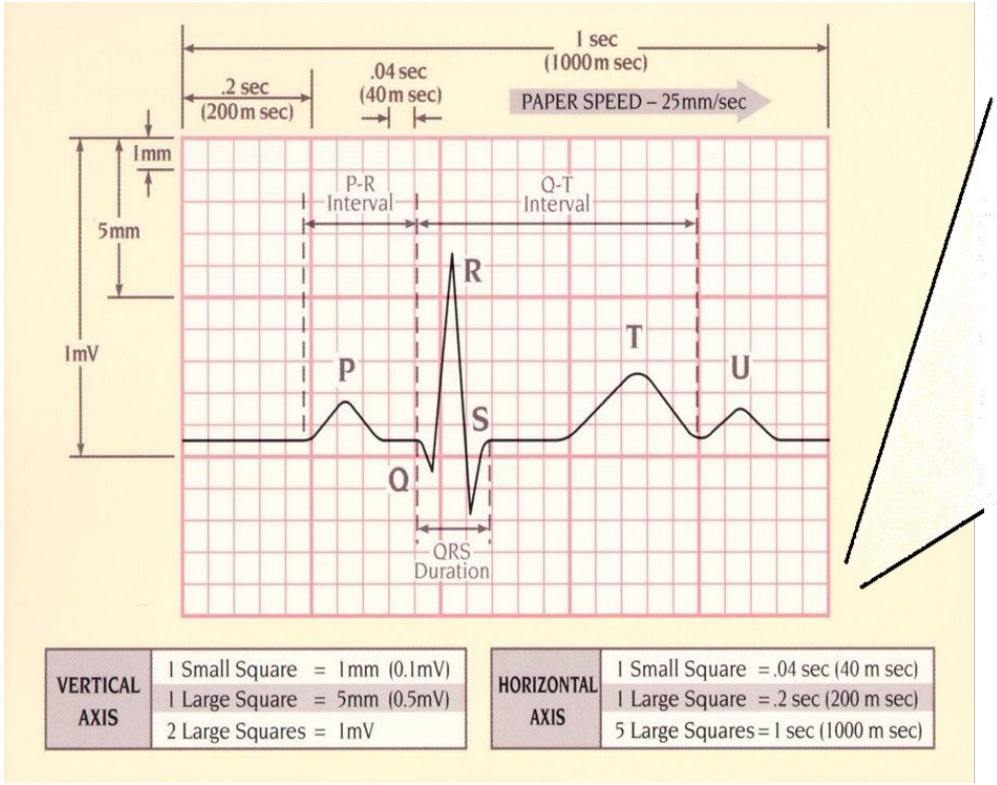
- The ECG is a graphical representation of the heart's electrical activity, plotting its voltage on a vertical axis against time on a horizontal axis.

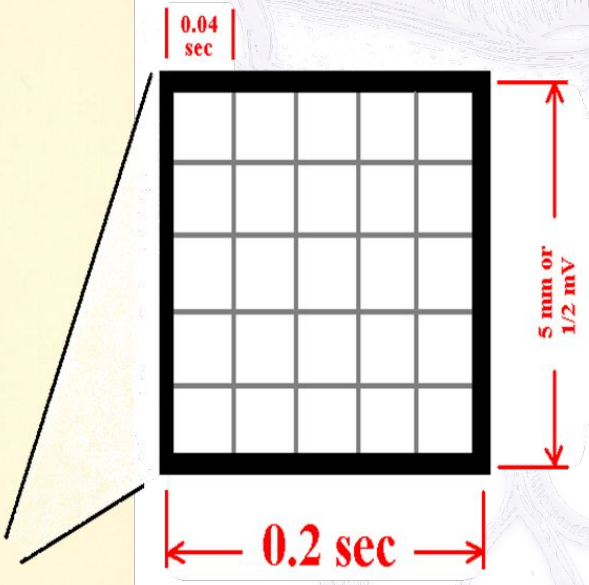



| P Wave |
| --- |
| Atria **depolarize** before atrial contraction begins |
| **QRS Complex** |
| Ventricles **depolarize** before contraction |
| **T Wave** |
| Ventricles recover from the state of depolarization<br>This process normally occurs in ventricular muscle 0.25 to 0.35 second after depolarization and the T wave is known as a repolarization wave |

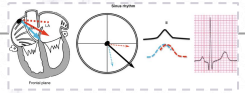
# ECG Sheet

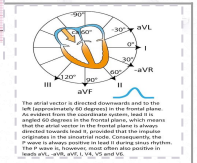
To read the ECG, you need to understand the measurements of the paper and the units which you can see in the photo below



# Waves of ECG





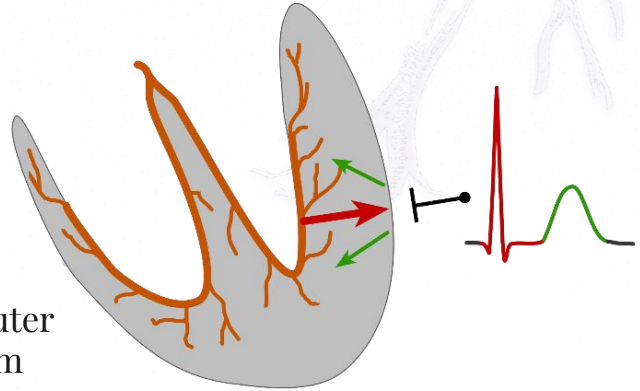

| | | | |
|---|---|---|---|
| waves | P wave | • Atrial depolarization. (Completed in 0.1 seconds).<br>• Irregular shape or absent P waves may indicate arrhythmia or atrial problems.<br>• Duration: 0.08–1.00 seconds<br>• The single P wave represents two overlapping waves of depolarization – one for each atrium. | |
| | QRS complex | Q wave | Ventricular Septal Depolarization (depolarization of the septum from the left to the right.) |
| | | R wave | major ventricular muscle depolarization.(ventricular wall) |
| | | S Wave | Basal Ventricular depolarization. |
| | | The beginning of the QRS complex is the start of ventricular systole and that goes until the end of the T wave. Ventricular<br>diastole starts when the T wave ends.<br>• Ventricular depolarization<br>• Duration: equal 0.08/0.06-0.12/0.10 sec (max 0.1 seconds)<br>• Very wide and deep Q waves may indicate myocardial infarction. | |
| | T wave | Ventricular repolarization(more info in next slide) | |
| | U wave | • Sometimes the electrical activity of the ventricular papillary muscle is out of phase with the rest of the ventricles and will record as a “U” wave that shows after the T wave. ( in general it’s not present in all people)<br>Could find it in pregnant woman | |

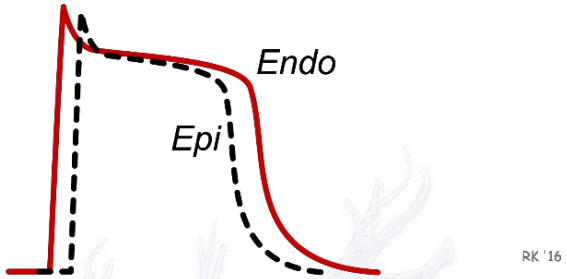
# T wave ( more info)

1. represents ventricular repolarization.

2. why is the T wave upright, if it represents repolarization, not depolarization? Shouldn't the deflection be downwards if the opposite electrical event is occurring?
Answer: Because, repolarization of the ventricles begins in the outer subepicardium, whereas you might expect it to start in the septum and spread outwards, as is the case for depolarization.

3. The consequence of this is that the distribution of positive and negative charges is similar during depolarization and repolarization of the ventricles, so both appear as positive deflections





# Sequence of Ventricular Depolarization-QRS complex

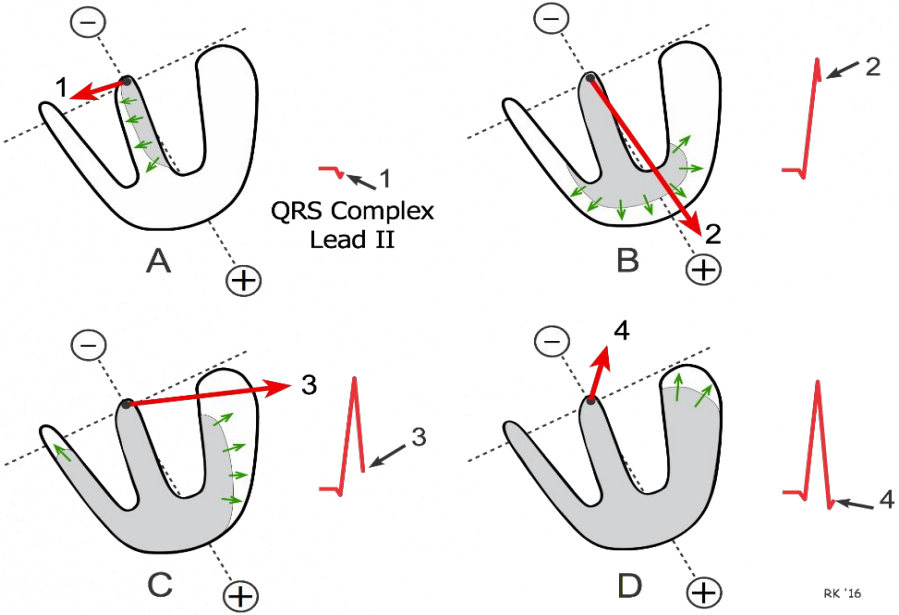
QRS complex appears in ECG leads that look at the heart from the left (**I, II, aVL, V3 and V6**).
the positive electrode is the exploring electrode (looking at the heart from different angles).

**1.** The Q wave represents depolarization of the septum from the left to the right.

**2.** The R wave represents depolarization of the ventricular wall.

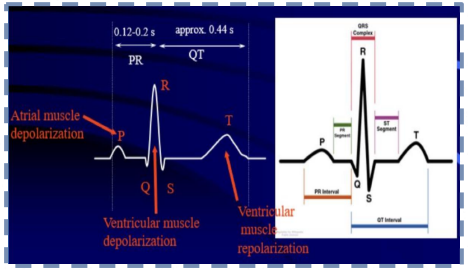
**3.** R wave has come to an end and the wave is going to the base line

**4.** The S wave represents depolarization of the ventricular base.



# Cont..., Segments

Female's slide



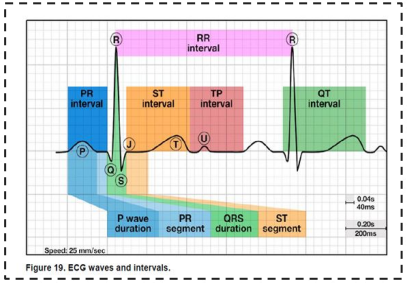



Figure 19. ECG waves and intervals.

Relaxation of the autrum is not recorded or not shown in the graph

Because the atria have relatively little mass, the slower and less well synchronised process of repolarization doesn't appear on the ECG
The repolarization of the atria occur at the same time with ventricular depolarization, so it will be masked by it.

Segment is the region between two waves (elevation or depression or progression)

| | | |
|---|---|---|
| Segments | PR segment | •Conduction depolarization of the AV node and A-V bundle. It's a flat line because the wave is not strong enough to be recorded on the voltmeter. |
| | ST segment | • During the ST segment, all the ventricular myocardium is depolarized. All have positive charges. So there is no potential difference to be recorded by the voltmeter (ECG machine). So there is a flat line.<br>• Important for detection of myocardial infarction |

Important slide

# Intervals

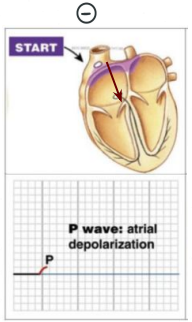
Interval is a duration of time that includes one segment and one or more waves.

| | | |
|---|---|---|
| Intervals | PR interval | - Wave goes over the atrium and through the AV node and ends just before it activates the ventricles to depolarize.<br>- Atrial depolarization & conductive time (the AV nodal delay),Measured from the P wave and Through the AV node to the beginning of QRS complex<br>- 0.18 seconds (N.R. 0.12 to 0.2s) ( P wave+PR segment) |
| | ST interval | - the initial, slow phase of ventricular repolarization (0.28s-0.36s)<br>- (QT - QRS) (equal 0.32 seconds) |
| | TP interval | It represents the time when the heart muscle cells are electrically silent |
| | QT interval | - Important because it captures the beginning of ventricular depolarization through the plateau phase to the ventricular repolarization. It covers the entire ventricular activity.<br>- Ventricular depolarization & repolarization ( equal 0.4 seconds) ( 0.35s-0.45s) |
| | RR interval | the duration between each cardiac cycle (0.6s-1.2s)<br>Used to determine heart rate because it depends on the heart rate |

Important slide

Female's slide

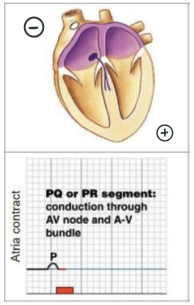
# Electrical events of the cardiac cycle



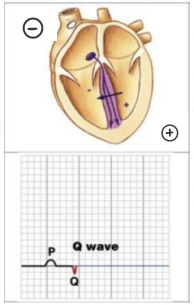

When SA node fires up to depolarize the atria, many different vectors (charges) will go in different directions and the mean of these directions is shown in the pic.

A the positive charges are directed toward the positive electrode which mean an upward deflection is seen on the paper

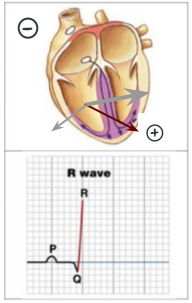
Start here



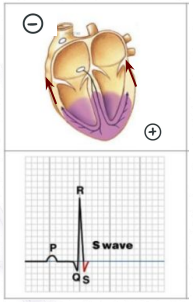

An isoelectric line is seen because AV node wave is not strong enough to be detected by the electrodes. (there is no net movement )




When bundle of His branches, the left bundle branch is the one that will actually conduct the electrical impulse to interventricular septum and it's vector is going away form the positive electrode meaning a downward deflection is seen ( Q wave )

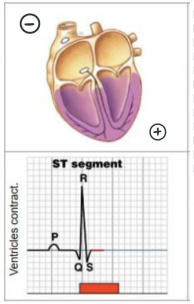



Impulses propagate to both ventricles, making two vectors that can be summed into a mean vector (black arrow ). The arrow is going to the positive electrode making an upward deflection (R wave)

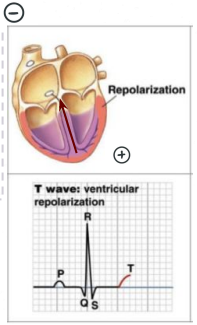



Impulses started to go upward toward the base of the ventricles making the mean vector to upward and toward the negative electrode.

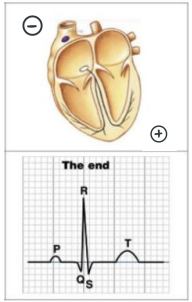
A positive charge that is going to a negative electrode will cause the deflection to be downward ( S wave ).




An isoelectric point is seen after S wave, because all parts of the ventricle have depolarized and not net movement is seen. ( rapid ejection phase )




Repolarization starts from the apex of the ventricle to its base, making a mean vector with NEGATIVE charges toward an negative electrode and an upward deflection is seen ( T wave )




An isoelectric line is seen after T wave is caused by rapid inflow and reduced inflow from atria which do not require any electrical activity .

Note: there is no recording of atrial **repolarization on ECG**

Important slide

# ECG waves , segments , intervals durations

| Intervals/waves | Normal Duration (sec) | Event in the heart during interval |
|---|---|---|
| P-R interval | Range: 0.12-0.2(3-5 small boxes = 0.12s-0.2s)<br>Average:0.18 | Atrial depolarization and conduction through AV node |
| Q-T interval | Range : 0.35-0.45/0.43<br>Average : 0.40<br>(it changes based on heart rate and there is a complex formula that cardiologists use to calculate normal levels, so we don't think its important to memorize this number, **know importantly it should not be more than halfway through RR interval**) | Ventricular depolarization plus ventricular repolarization |
| S-T interval<br>(QT minus QRS) | Range : 0.28 - 0.36<br>Average : 0.32 | Ventricular repolarization and period between depolarizartion and repolarization |
| QRS complex | Range : 0.06- 0.10<br>Average:0.08(less than 3 small boxes = <0.12s) | Ventricular depolarization and atrial repolarization |
| P wave | Range : 0.08 - 0.1 | atrial depolarization |
| T wave | Range : 0.30-0.35 | ventricular repolarization |
| R-R | Range : 0.6 - 1.20 | The duration of the R-R interval depends on the heart rate |

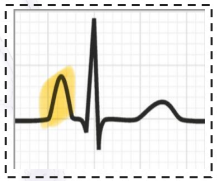
Female's slide

# Waves abnormalities

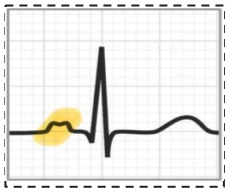
Dr: We may mention the abnormality and ask you about the cause

## P waves

- Anything that causes the right atrium to become hypertrophied (such as tricuspid valve stenosis or pulmonary hypertension) causes the P wave to become peaked.
- Left atrial hypertrophy (usually due to mitral stenosis) causes a broad and bifid P wave.



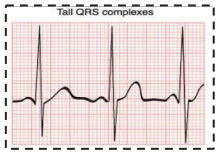
(peaked p wave)



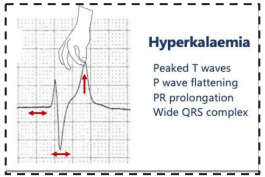
Bifid P wave

## QRS complex

—Broad QRS complex > 100ms(the normal 60ms-100ms) (lead to increased width indicates that depolarization has spread through ventricles by an abnormal and therefore slow pathway).
Ex: Hyperkalemia.
-Increased height (An increase of muscle mass in either ventricle will lead to increased electrical activity).
Ex. ventricular hypertrophy



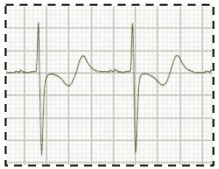

Tall QRS




Broad QRS and peaked T wave

## T wave

-Peaked T waves: hyperkalemia
-Inverted T waves: ischemia
-Biphasic T waves: due to hypokalemia



Biphasic T waves


Inverted T wave

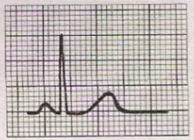
Male's slide

Important slide

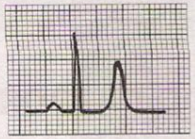
# Clinical Significance of different waves & segments of ECG

| | | | | | |
|---|---|---|---|---|---|
| **ST Elevation** | Acute MI or Angina MI = myocardial infarction | **T wave inversions and non-specific ST changes** | in normal cases and in many diseases, therefore not useful for diagnosis. | **U waves** | Hypokalemia ( "Hump" at the end of T wave ) |
| **ST depression >1 mm** | Ischemia / angina (flat), digoxin (sloping) | **Tall P waves** | Right atrial hypertrophy | **Prolonged QT interval** | Hypocalcemia |
| **Q waves in 2 or more leads** | Previous MI ( Transmural ) | **Broad (and often bifid) P waves** | Left atrial hypertrophy | **Shortened QT interval** | Hypercalcemia |
| **Diffuse ST elevation with PR depression** | Pericarditis | **Peaked T waves or loss of P wave** | Hyperkalemia | **Peaked T waves or loss of P wave** | Hyperkalemia |

# ECG abnormalities

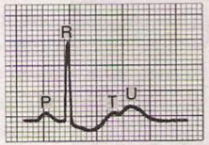


**Normal tracing (plasma $K^+$ 4–5.5 meq/L).** PR interval = 0.16 s; QRS interval = 0.06 s; QT interval = 0.4 s (normal for an assumed heart rate of 60).

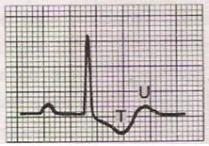


**Hyperkalemia (plasma $K^+$ ±7.0 meq/L).** The PR and QRS intervals are within normal limits. Very tall, slender peaked T waves are now present.

**Hyperkalemia (plasma $K^+$ ±8.5 meq/L).** There is no evidence of atrial activity; the QRS complex is broad and slurred and the QRS interval has widened to 0.2 s. The T waves remain tall and slender. Further elevation of the plasma $K^+$ level may result in ventricular tachycardia and ventricular fibrillation.




**Hypokalemia (plasma $K^+$ ±3.5 meq/L).** PR interval = 0.2 s; QRS interval = 0.06 s; ST segment depression. A prominent U wave is now present immediately following the T. The actual QT interval remains 0.4 s. If the U wave is erroneously considered a part of the T, a falsely prolonged QT interval of 0.6 s will be measured.




**Hypokalemia (plasma $K^+$ ±2.5 meq/L).** The PR interval is lengthened to 0.32 s; the ST segment is depressed; the T wave is inverted; a prominent U wave is seen. The true QT interval remains normal.

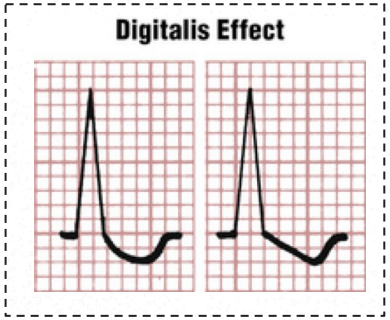
Hyperkalemia : higher than normal potassium level in your bloodstream.
Hypokalemia :lower than normal potassium level in your bloodstream.

Hypocalcemia :lower than normal calcium level in your bloodstream.
Hypercalcemia higher than normal calcium level in your bloodstream.

# ECG abnormalities

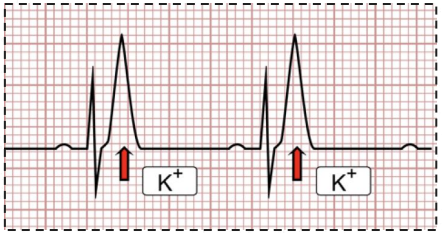
**ECG -Drug effects**

scooping of the ST-T complex produced by digitalis

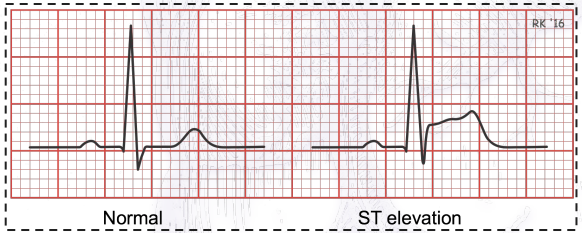



ECG in Electrolyte imbalance (hyperkalemia)

**Peak T wave**




ECG in Presence of ischemia



# The information that can you obtain from ECG reading

1. Rate and Rhythm of the heart
2. Heart's orientation
3. Size of the chambers
4. Presence of ischemia or infection in the heart along with its location and extent .
5. Electrolyte imbalance
6. Drug effects

Important slide

# The 12- Lead ECG

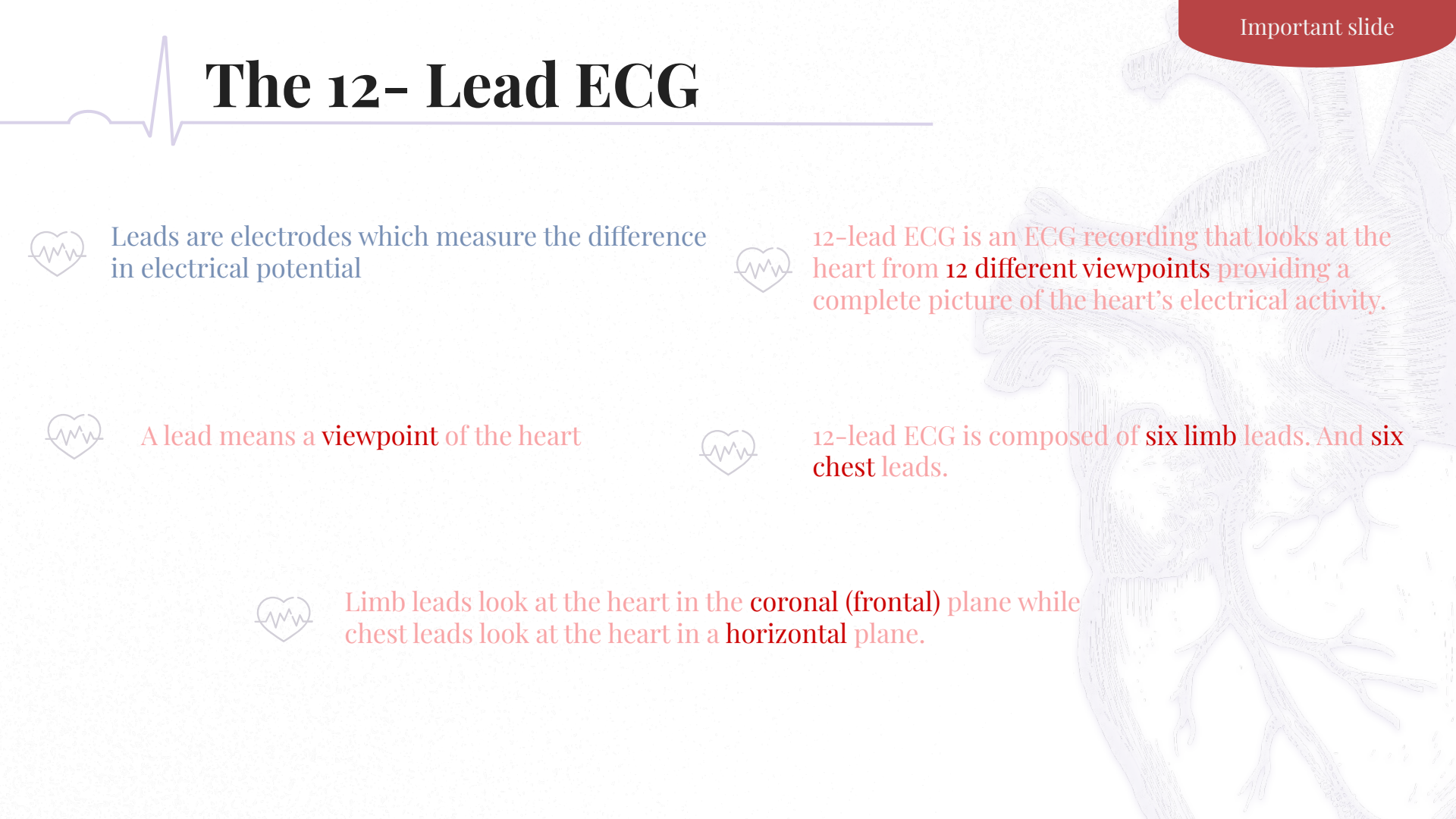
Leads are electrodes which measure the difference in electrical potential

12-lead ECG is an ECG recording that looks at the heart from 12 different viewpoints providing a complete picture of the heart's electrical activity.

A lead means a viewpoint of the heart

12-lead ECG is composed of six limb leads. And six chest leads.

Limb leads look at the heart in the coronal (frontal) plane while chest leads look at the heart in a horizontal plane.



Important slide

# The 12- Lead ECG

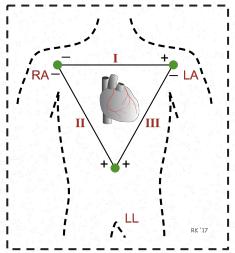
## Types of 12 lead ECG

### Bipolar

Lead records the potential difference between two electrodes.

two different points on the body

Examples \Limb lead I, II and III (Standard limb leads)



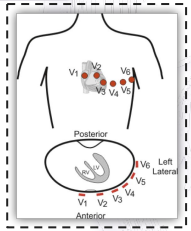

Limb leads I-II-III (standard limb leads)

### Unipolar

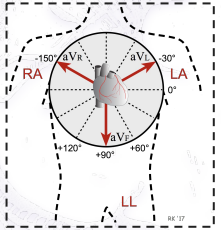
Lead records the potential of one electrode

one point on the body and a virtual reference point with zero electrical potential, located in the center of the heart

Examples\ Limb leads aVR, aVL and aVF (augmented limb leads) as well as chest leads (V1-V6 precordial leads) are unipolar.

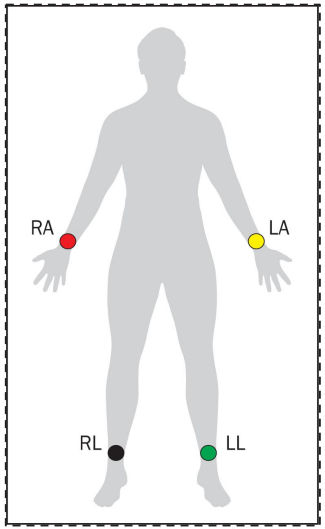



Chest leads v1-v6



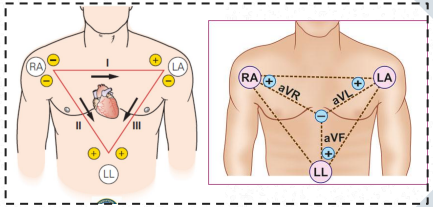

Limb leads AVR-AVF-AVL (Augmented limb leads)

# Limb leads

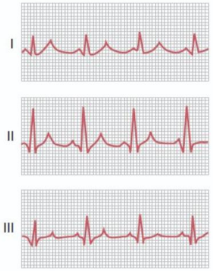



4 electrodes placed on :
- Left arm (LA)
- Right arm (RA)
- left leg (LL)
- Right leg (RL)- earth

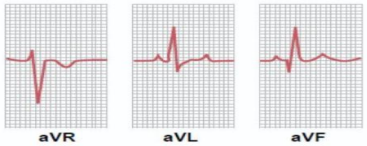
4 electrodes will record six leads (views) of the heart in the coronal plane, namely: Lead I, lead II, lead III, aVR, aVL and aVF.



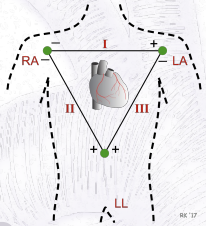

Each lead is a pair of electrodes connected to the body on opposite sides of the heart, & the direction from negative electrode to positive electrode is called the "axis" of the lead.




Normal ECG recorded from the three standard ECG leads.

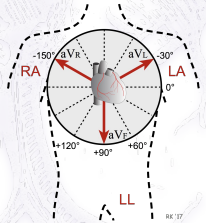



Normal electrocardiograms recorded from the three augmented unipolar limb leads.




**Bipolar Lead**

have a - & + pole. Electrical potential differences are measured between the poles




**Unipolar Lead**

No negative lead, heart is the negative pole. Electrical potential difference is measured between the lead & the heart.

Important slide

Extra slide

# Vectorial analysis in leads

## How can I determine if it will go upward or downward ?

The cardiac electrical vectors are constant in any heart ,so the direction of the wave depend on the electrode place

### Depolarization (+):

if the positive cardiac electrical vector is going to the positive electrode=upward deflection

if the positive cardiac electrical vector is going away from positive electrode = downward deflection

### Repolarization(-):

if the negative cardiac electrical vector is going to the negative electrode=upward deflection

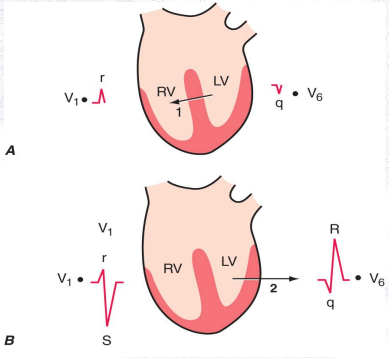
if the negative cardiac electrical vector is going away from the negative electrode=downward deflection

## Why the height of the wave will be different in each lead?

the more parallel the cardiac vector is to the lead axis, the higher the deflection is

### Example:

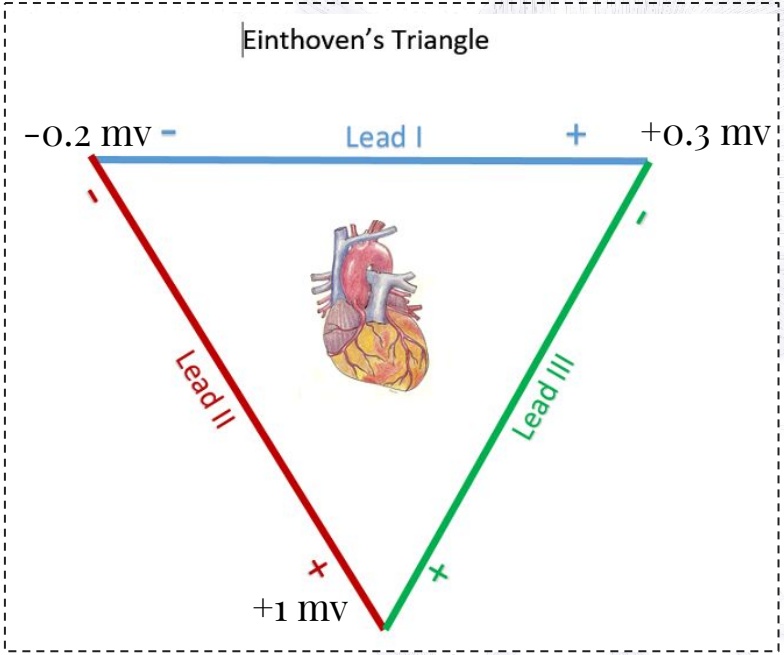
Look at the difference in the direction of waves depending on the location of the electrode



# Einthoven's triangle & Law on bipolar leads

sum of the potentials recorded in leads I and III = the potential in lead II.

Lead I + Lead III= Lead II




Extra note from 443 teamwork

This law is applied even with certain abnormalities, it's a law..

The ECG detect the potential difference between two electrodes.

ex. if the voltage at the right corner is -0.2 mv, the left corner is +0.3 mv and the apex is +1 mv. Calculate lead II ?
Answer:
Lead I = +0.3 mv - (- 0.2 mv ) = +0.5 mv
Lead III = + 1 mv - (+ 0.3 ) = +0.7 mv
Lead II = +1 mv - ( -0.2 mv ) = 1.2 mv
Law = Lead I + Lead III = lead II

Important slide

Female's slide

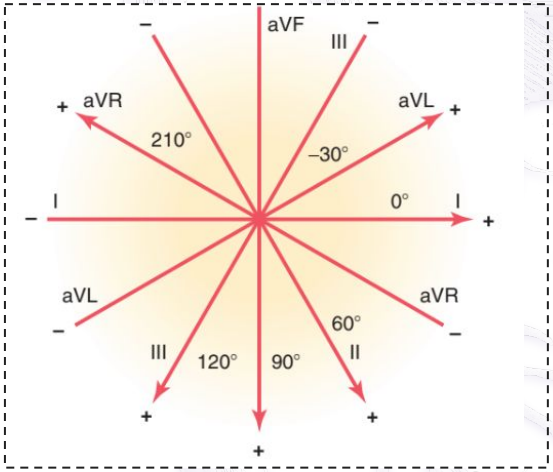
# hexagonal reference system

Each lead is actually a pair of electrodes connected to the body on opposite sides of the heart, and the direction from negative electrode to positive electrode is called the "axis" of the lead.

Lead I is recorded from two electrodes placed respectively on the two arms. Because the electrodes lie exactly in the horizontal direction, with the positive electrode to the left, the axis of lead I is 0 degrees.

In recording lead II, electrodes are placed on the right arm and left leg. The right arm connects to the torso in the upper right-hand corner, and the left leg connects in the lower left-hand corner. Therefore, the direction of this lead is about +60 degrees.

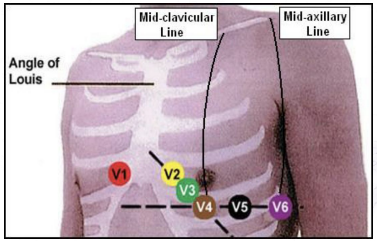
By similar analysis, it can be seen that lead III has an axis of about +120 degrees; lead aVR, +210 degrees; aVF, +90 degrees; and aVL, −30 degrees.

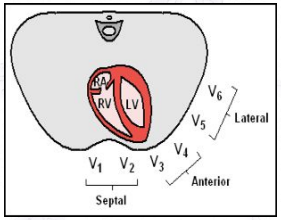


Important slide

# Precordial (chest Wilsons) leads

Dr: V.important !!! It may come as a MCQ or SAQ




V1: 4th intercostal space (ICS), right sternal border.
V2: 4th ICS, left sternal border.
V3: midway between V2 and V4.
V4: 5th ICS, mid-clavicular line
V5: 5th ICS (horizontal to V4), anterior axillary line.
V6: 5th ICS (horizontal to V4), mid-axillary line.

We take the potential difference between that center (zero) and the positive electrode (V1, V2...) which seems like it's unipolar

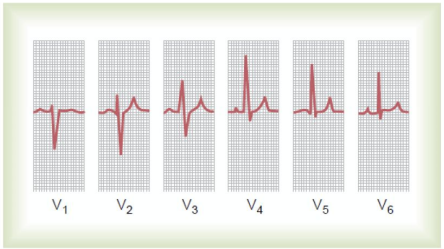
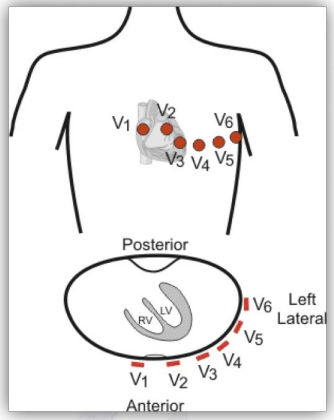



**Figure 11–9**

Normal electrocardiograms recorded from the six standard chest leads.



# Leads view of the heart

**Inferior** → II,III,aVF

**Lateral** → I, aVR, aVL, V5,V6

**Anterior** → V3.V4

aVR = None

**Septal** → V1,V2

## ARRANGEMENT OF LEADS ON THE ECG paper

| | | | |
|---|---|---|---|
| I | aVR | $V_1$ | $V_4$ |
| II | aVL | $V_2$ | $V_5$ |
| III | aVF | $V_3$ | $V_6$ |

| | | | |
|---|---|---|---|
| I lateral | aVR None | V1 septal | V4 anterior |
| II inferior | aVL lateral | V2 septal | V5 lateral |
| III inferior | aVF inferior | V3 anterior | V6 lateral |

# Calculation of The Cardiac Axis

1. The electrical axis is the average direction of the current flow in the heart during a cardiac cycle.

2. The cardiac axis refers to the general direction in which the heart depolarizes.

3. The cardiac axis is expressed as an angle and is measured in degrees.

4. The depolarization wave normally spreads through the ventricles in a direction from base of the heart to its apex.

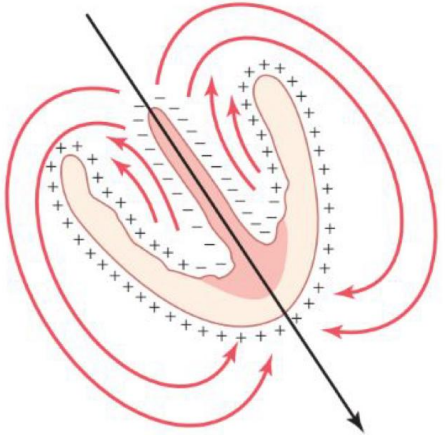


**Figure 12-1.** Mean vector through the partially depolarized ventricles.

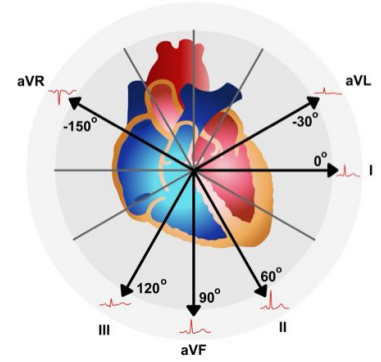
# Calculation of The Cardiac Axis

1. Lead I will be looking at the heart from the left at an angle of 0 degrees.

2. Any deviation below that line is expressed as a 2 positive number whereas deviations above the line are expressed as negative numbers.

3. Lead II is considered to be looking at the heart at an angle of +60.

4. Lead III looks at the heart at +120.



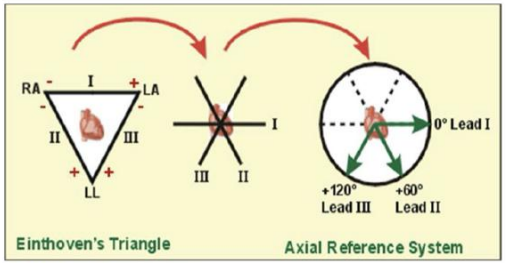
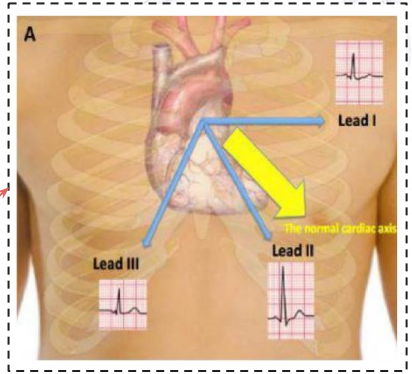




Figure 21. The axial reference system.

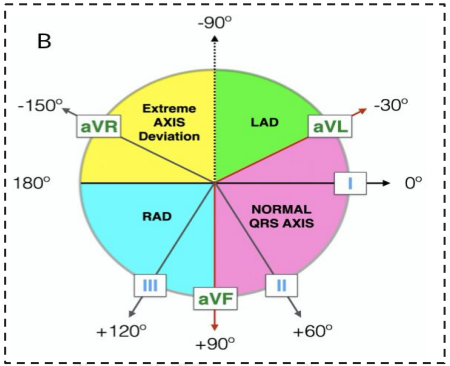
# Normal cardiac Axis

1. The QRS axis represents the net overall direction of the heart's electrical activity

2. (A) In the normal heart Normal cardiac/QRS axis, the average current flow occurs primarily in the direction from base to apex with negativity at the base and positivity towards the apex of the heart at an angle between (-30 to +90).




3. (B) shows the range in which the cardiac axis /QRS axis is considered :**normal** (-30 to +90),
-Left axis deviation **LAD** (-30 to -90),
-right axis deviation **RAD** (+90 to +180) and
**extreme axis deviation** (+180 to -90).

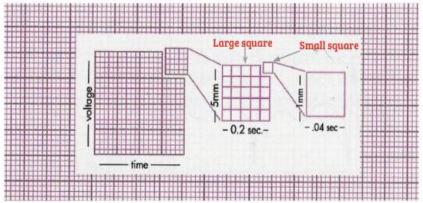



4. Abnormalities of axis can hint at:
- Ventricular enlargement
- Conduction blocks (i.e hemiblocks)

# ECG paper & Interpretation

## Paper

- The ECG is recorded on graph paper.
- The paper runs at a standard speed of 25mm/sec.
- The horizontal axis denotes time while the vertical axis denotes voltage.
- The graph paper is divided into large and small squares.
- Each large square contains 5 small squares of 1 mm length. it's seconds 0.2sec, 0.5mv
- Given that the paper runs at a rate of 25 mm/sec, horizontally, one small square of 1 mm length represents 0.04 sec + 0.1mv




## Interpretation

- The ECG paper
- ECG waves and intervals
- Heart rhythm determination
- Heart rate calculation
- Calculation of the cardiac axis

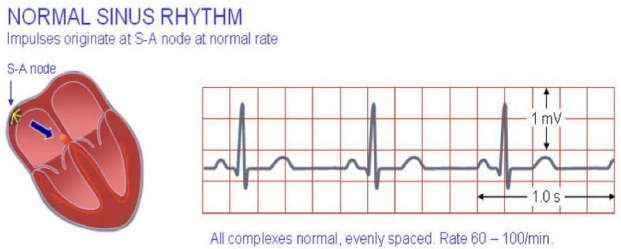
# Heart rhythm determination

The heart rhythm refers to the regularity of heart beat.

SA node is the pacemaker of the heart and it generates impulses at regular intervals.

Heart rhythm can be determined by observing R-R intervals on ECG

If R-R intervals are the same duration, the rhythm is said to be regular (sinus rhythm), whereas if R-R intervals are variable in length the rhythm is said to be irregular (arrhythmia).



Female's slide

# Heart rate

**Normal heart rate**
**60-100 beats/minute**

**Tachycardia**

**Higher** than 100 beats/ minute

All complexes normal, evenly spaced. Rate > 100/min

**Bradycardia**

**Less** than 60 beats/ minute

All complexes normal, evenly spaced. Rate < 60/min

# Heart rate calculation

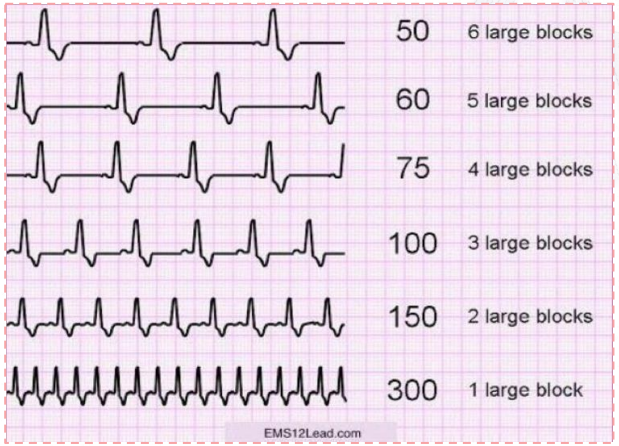
## 1-Regular heart rhythm

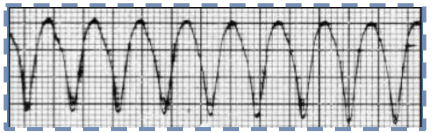
- The heart rate can be calculated from the ECG using one of the following formulas: (when the rhythm is normal)

$$\text{Heart rate} = \frac{1500}{\text{Number of small squares in one R - R interval}}$$

$$\text{Heart rate} = \frac{300}{\text{Number of large squares in one R - R interval}}$$

E.g. 300/6=50 beats per minute (bradycardia)



(300/1.5)=200 bpm

(300/4)=75 bpm

(300/6)=50 bpm

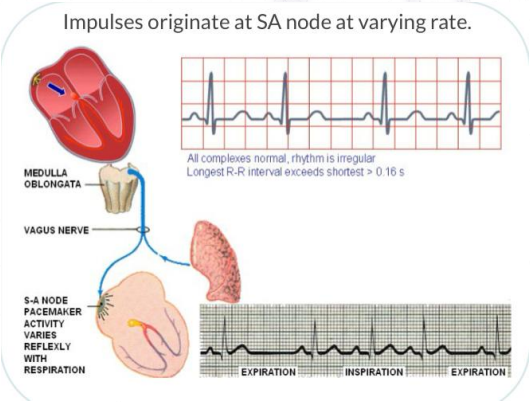
# Sinus Arrhythmia

The heart usually beats faster during inspiration and slower during expiration, showing unequal R-R intervals on ECG strip.

This pattern of arrhythmia is physiologic and is due to the different firing rate of SA node during inspiration & expiration.

The R-R intervals are shorter during inspiration & wider during expiration. Inspiration ↑ heart rate by ↓ vagal tone.

10 second rule, most ECGs record 10 seconds of rhythm per page, one can simply count the number of beats present on the ECG and multiply it by 6 to get the number of beats per 60 seconds.

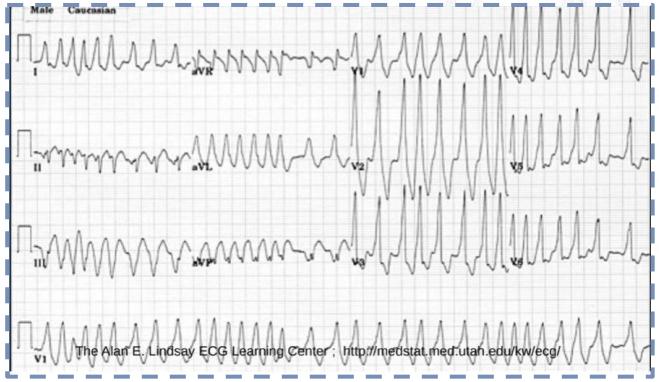


# Heart rate calculation

## 2-Irregular heart rhythm

- Count the number of QRS complexes in 30 large squares (which equals the number of QRS complexes in 6 seconds).

- Then multiply the number of QRS complexes counted in 6 seconds by 10 to get the number of QRS complexes in one minute, i.e. the heart rate.




**33 x 6 = 198 bpm**

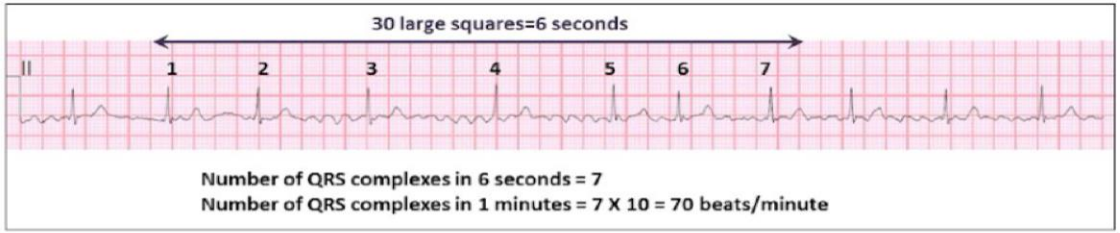



Figure 20. Calculating the heart rate when the rhythm is irregular.

10 seconds rule works well for irregular rhythm

## The ECG 'Rule of Fours'

- Four initial features (history, rate, rhythm, axis).
- Four waves (P, QRS, T, U).
- Four intervals (PR, QRS, ST, QT).
- What is the diagnosis?

## The ECG trace analysis

- Patients details, Calculate the heart rate.
- Comment on the rhythm of the heart.
- Name the waves and intervals and calculate their duration.
- Determine the cardiac axis.

# Check here for our summary
# Highly recommended !!!!!

Sorry but if you will not cheack it راحت عليك المليون

# MCQs:

Answers

For more question check our summary file!

1/A
2/B
3/C

**1** How many seconds does a big square have in ECG?

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| A | 0.2 sec | B | 0.4 sec | C | 0.6 sec | D | 0.8 sec |

**2** Which of the following is unipolar limb lead ?

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| A | Lead I | B | Lead aVR | C | Lead V2 | D | All are correct |

**3** Calculate the heart rate in ECG from a patient with normal rhythm if 5 big boxes are between the R-R intervals

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| A | 75 beats/min | B | 100 beats/min | C | 60 beats/min | D | 135 beats/min |

# MCQs:

Answers

For more question check our summary file!

4/A
5/D

**4** Which of the following indicates left axis deviation?

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| A | (-30 to -90) | B | (-30 to 90) | C | (90 to 180) | D | (180 to -90) |

**5** What do peak T waves indicate ?

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| A | ischemia | B | hypokalemia | C | atrium hypertrophy | D | hyperkalemia |

# SAQ

| | |
|---|---|
| Why atrial repolarization is not available in ECG | Because it is weak and ventricular depolarization occur in the same time |
| What leads are represented by the lateral view of the heart? | I , aVL , V5 , V6 |
| What are the physiological importance of P-R Interval ? | Denotes atrial depolarization & AV delay. |
| Why is S-T segment Isoelectric ? | Because the heart has completely depolarized, and repolarization has not started yet. |

**Finally you have arrived , we have been waiting for you !!**

# Meet our team !

## Team leaders

Rimaz Alhammad

Noreen Almaraba

Rayan Alshehri

Omar Albaqami

Aljoharah Alyahya

## Heroes of the lecture :

Joud Alahmri

Abdulaziz Alanazi

Khalid Alkanhal

Did you like the lecture ? we mean our work :)

Contact with us! physiology.444ksu@gmail.com