PHYSIOLOGY TEAM 432

LECTURE : 5

ECG

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Objectives

1. Identify waves of the normal ECG and the physiological cause of each

2. Define the normal intervals in the ECG trace

3.Determine the bipolar, unipolar and chest leads.

MIND MAP

Normal ECG pattern

- P wave
- QRS complex
- T wave

Voltage and calibration of ECG

- 1 mm horizontally = 0.04 s
- 1mm vertically = 0.1

ECG leads (3 bipolar and 9 unipolar)

- 3 standard (bipolar) limb leads
- 3 augmented limb leads
- 6 precordial (chest) leads

Heart Rate

- Normal range (60-100) bpm
- Determining HR (rule of 300, 10 second rule)

The Normal Electrocardiogram (ECG)

The depolarization wave spread through the heart

↓

electrical currents pass 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 (الأقطاب الكهربائية) placed on the skin opposite the heart**

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

NORMAL IMPULSE CONDUCTION

Sinoatrial node

↓

AV node

↓

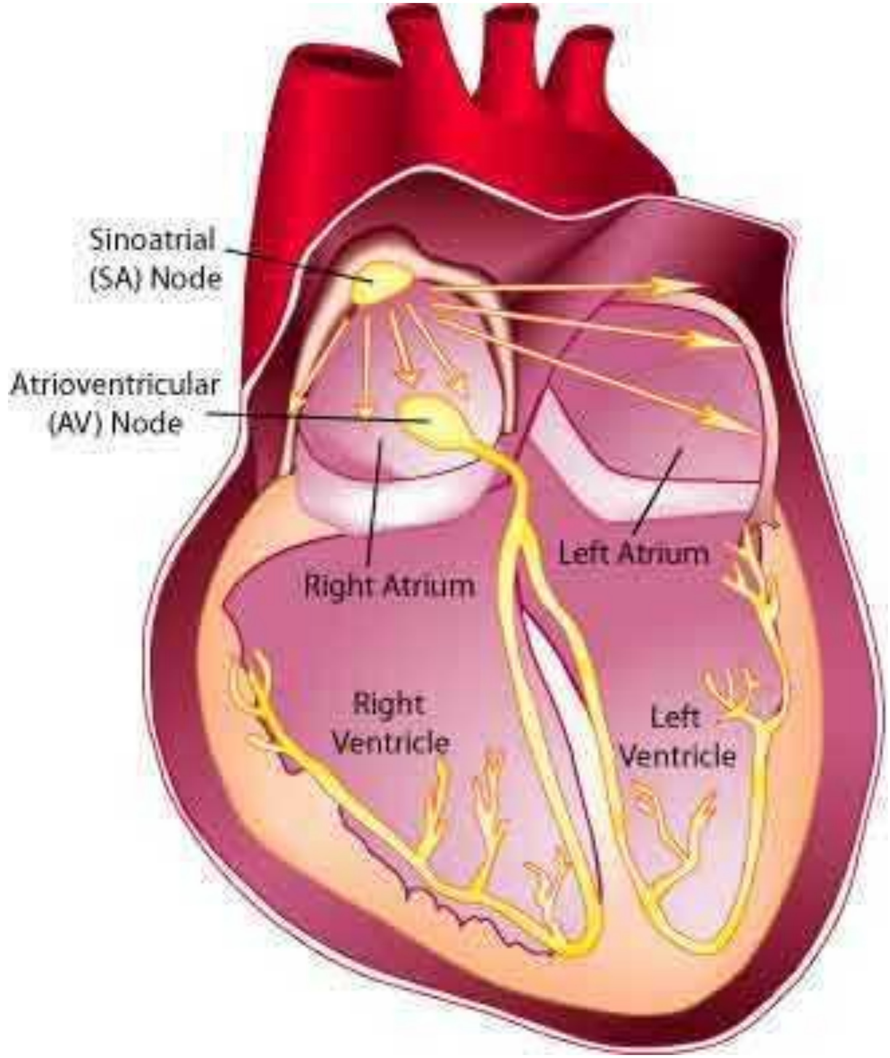
Bundle of His

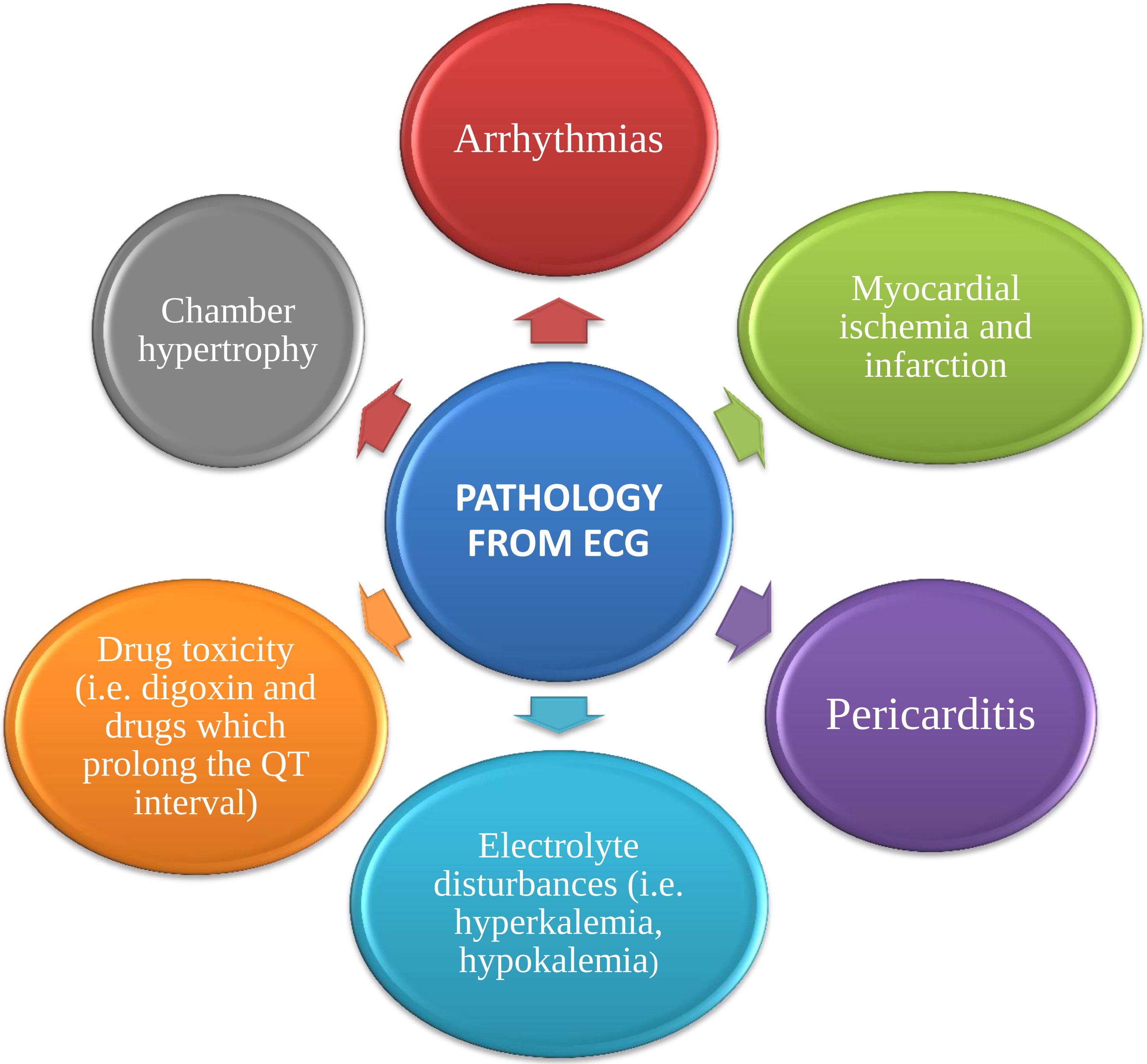
↓

Bundle Branches

↓

Purkinje fibers




Arrhythmias
Chamber hypertrophy
Myocardial ischemia and infarction
PATHOLOGY FROM ECG
Drug toxicity (i.e. digoxin and drugs which prolong the QT interval)
Pericarditis
Electrolyte disturbances (i.e. hyperkalemia, hypokalemia)

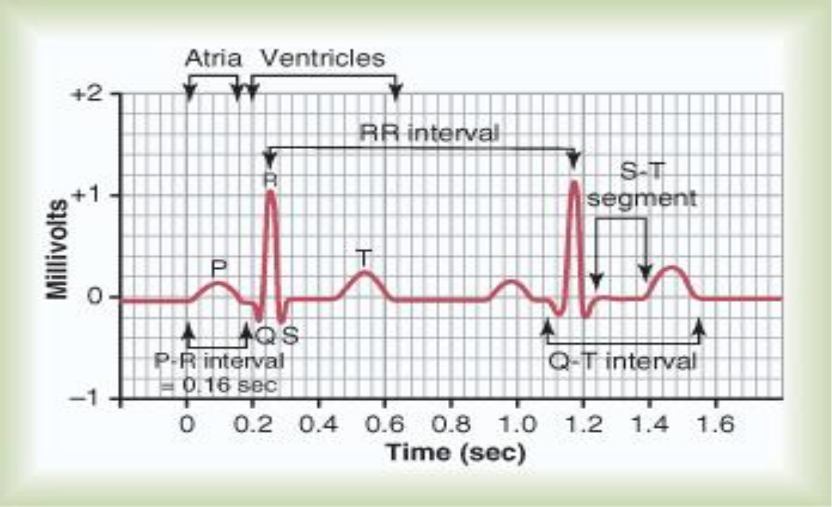
The Normal Electrocardiogram (ECG)

Depolarization=contraction=systol
Repolarization=relaxation=diastol

- **P wave** **(completed in 0.1 s):** is caused by **atrial depolarization** before atrial contraction begins(when atria contract they'll make the P wave)

- **QRS complex** **(0.08-0.12s)**: is caused by **depolarization of the ventricles** before contraction (when ventricles contract they'll make the QRS wave)

- **T wave:** **repolarization of the ventricles** 0.25 to 0.35 seconds after depolarizing (when ventricles eject the blood then relax)



It's important to memorize the waves and what is the cause of each.

There is a hidden wave (not clear because other waves QRS and T are greater than it) which is **atrial relaxation .**

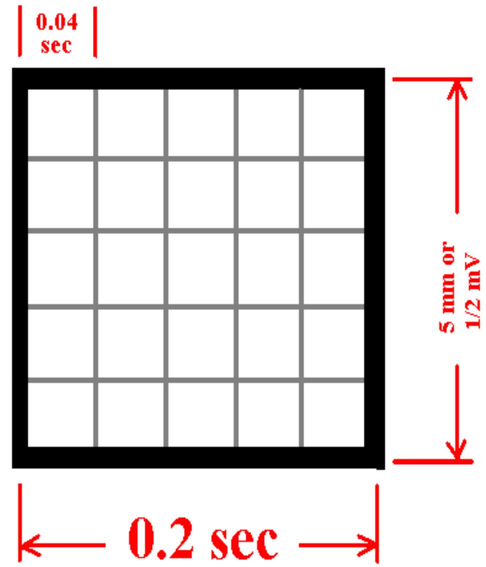
Continue

- ***Irregular or absent P waves may indicate arrhythmia.***
- ***The shape of the P waves may indicate atrial problems.***
- **Very wide and deep Q waves indicate myocardial infarction**

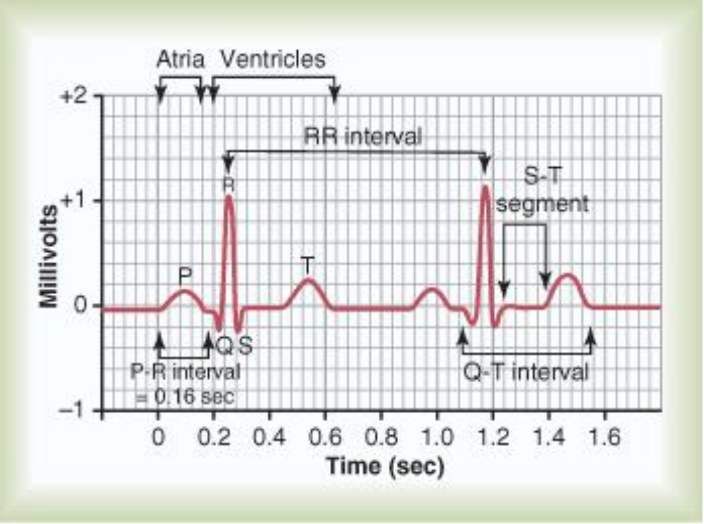
- **Irregular P waves means that the P wave present in different periods of time.**

Important things you should know before viewing the next slides

- 1 inch=25 millimeters
- The ECG paper is divided into small squares which has a length of 1 mm.
- Each small square represent 0.04 s horizontally and 0.1 millivolt vertically.
- a big square has a length of 5 mm (0.2 inch) which 25 small squares.



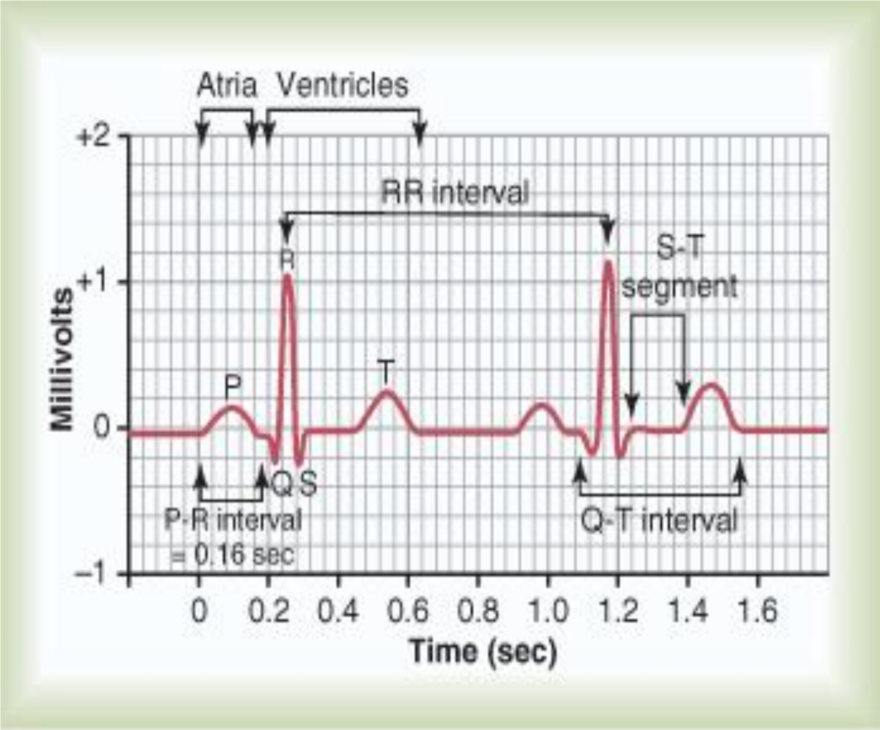
- Note that this picture represent small rectangles (2mmx1mm) rather than small squares; which make each 1millivolt = 5 small lines



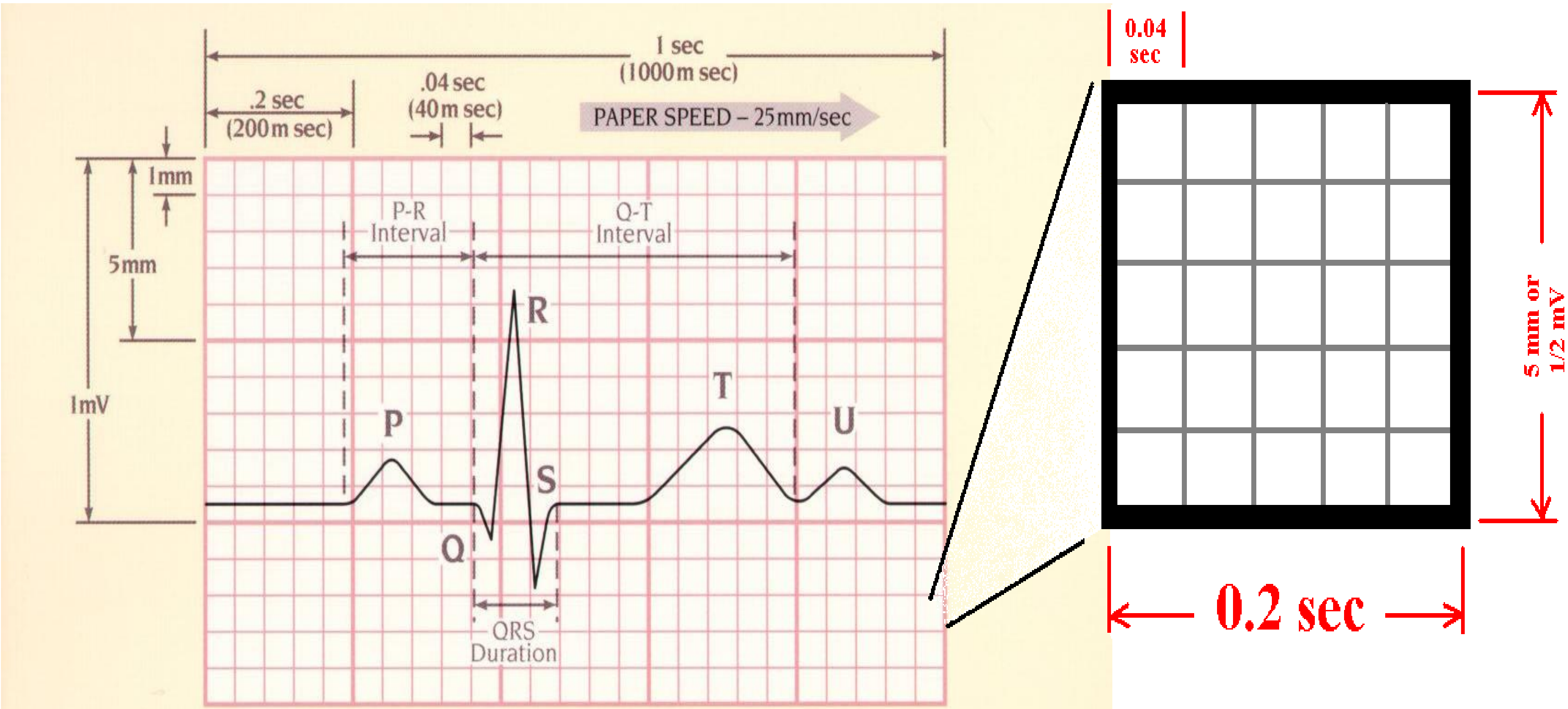
Voltage and Calibration of the ECG

هذا السلايد بس يعلمنا كم معايير القياس بالرسمة

- The vertical calibration lines: **Voltage(millivolt)**
  - 5 small lines = 1 mV
- 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= 0.2 second
  - thin line =0.04 second

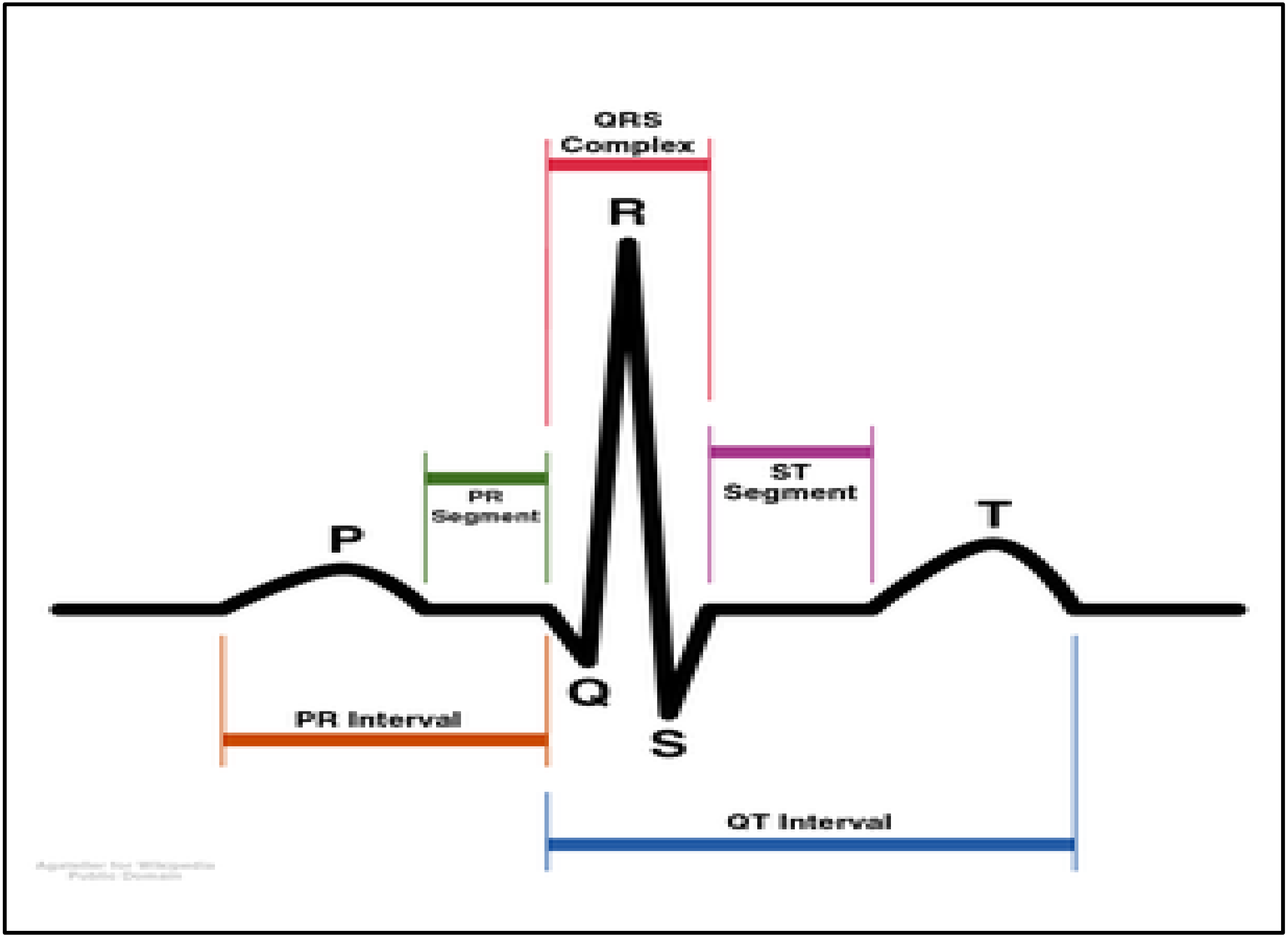


The ECG paper

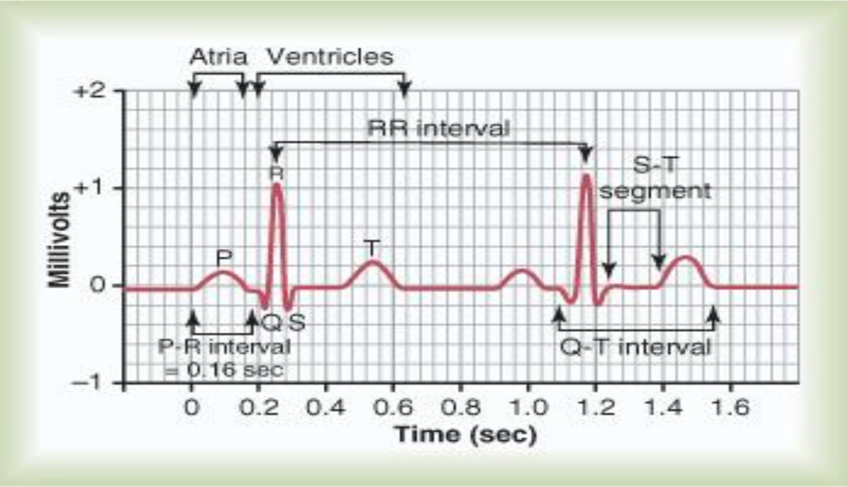


VERTICAL AXIS	
	1 Small Square = 1mm (0.1mV)
	1 Large Square = 5mm (0.5mV)
	2 Large Squares = 1mV

HORIZONTAL AXIS	
	1 Small Square = .04 sec (40 m sec)
	1 Large Square = .2 sec (200 m sec)
	5 Large Squares = 1 sec (1000 m sec)


QRS
Complex
R
PR
Segment
ST
Segment
P
T
Q
S
PR Interval
QT Interval

If it's not regular then the patient has arrhythmia



P-R interval(P-Q interval)

- It is the time between the beginning of the *P wave* and the beginning of the *QRS complex*
- It is the 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** (normal range: 0.12-0.2s)
- Through the AV node 0.18 seconds

Q-T interval

- Contraction of the ventricles last from the beginning of the Q wave to the end of the T wave
- Q-T interval is the time from the beginning of the *Q wave* to the end of the *T wave*
- Q-T interval is about **0.35** second

Heart Rate (normal 70 – 80)

- 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

We measure how many seconds between 2 heart beats then multiply it with 60 to know the number of beats per minute (this way is easier because we don't have time to measure all the intervals between each 2 heartbeats to know how many beats per minute)

Methods for Recording Electrocardiograms

1. **Computer-based** and electronic display
(common nowadays especially in the ICU)

2. **Pen recorder** and a moving sheet

1

2

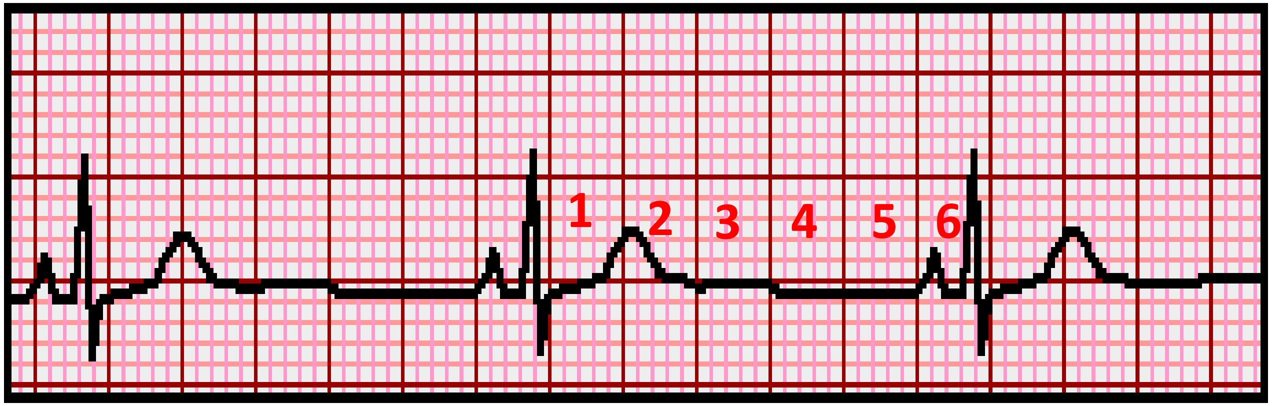
Determining the heart rate:

1- Rule of 300:

Take the number of "big boxes" between neighboring QRS complexes, and divide this into 300. The result will be approximately equal to the heart rate

Although fast, this method only works for regular rhythms.

(300 / 6) = 50 bpm



Determining the heart rate(cont.)

2- 10 Second Rule :

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

This method works well for irregular rhythms.

33 x 6 = 198 bpm

Flow of Electrical current in the Heart

- In normal ventricles, current flows from ***negative*** to ***positive*** from the ***base*** of the heart toward the ***apex***.
- The first area that depolarizes is the ***ventricular septum***

- Current flows from the ***electronegative*** inner surface of the heart to the ***electropositive*** outer surface (from the ***base*** of the heart to the ***apex***)
- An electrode placed near the **base** of the heart is **electronegative**, and near the **apex** is **electropositive**

Any electrical impulses towards the electrode will be **Positive**
Any electrical impulses away from the electrode will be **Negative**

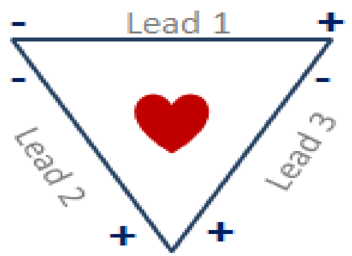
The ECG Leads:

Lead: two wires and their electrodes to make a complete circuit (each lead has 2 pairs of electrodes)

- **The Bipolar Limb Leads: (I, II, III)**
- **Chest Leads: (V1, V2, V3, V4, V5, V6)**
- **Augmented Unipolar Limb Leads (aVR, aVL, aVF)**

* إذا سويناهم للمريض يطلع ١٢ خط وهم عبارة عن كل أنواع الـ Leads الثلاثة مع بعض يعني ما أسوي كل واحد لحاله

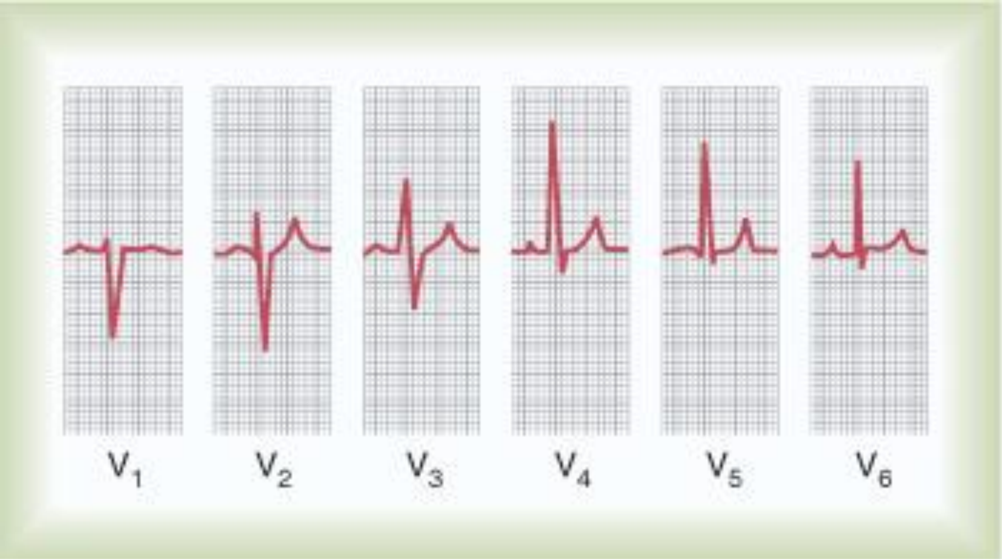
The nurse puts gel before putting the electrodes to allow the conduction of electrical impulses .

Bipolar Limb Leads (standard limb leads)	Chest Leads (precordial leads)	Augmented Unipolar Leads
ECG is recorded from two electrodes located on different side of the heart (Has 3 Leads each 2 electrodes	Recorded from the anterior surface of the chest (V1, V2, V3, V4, V5, V6) (6 leads)	The two limbs are connected to the negative terminal of the ECG, and the third limb is connected to the positive.
 Easy way to memorize what's below	• Positive electrode on the chest • The *indifferent electrode* is the negative electrode connected to the right arm, left arm, and left leg	When the positive terminal is on: • The right arm (aVR) • The left arm (aVL) • The left leg (aVF)
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*	اللي على اليدين والرجل مصفرينهم. لأنه هذا النوع يحسب من electrode واحد والثاني اللي بالـ Lead يصير مصفّر. فكل وحده من اللي بالصدر تحتاج الكترود ثاني مصفّر وهذي هي اللي باليدين والرجل.	• All are similar to the standard limb leads • aVR lead is inverted (رسمتها تصير على تحت) مثلاً اليد اللي بنحسبها اليمين (aVR) هي بس نقيس منها والباقي اللي باليد اليسار والرجل مصفرينهم.

Chest Leads

This slide is not important

- 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



Anatomical presentation

this slide just to understand.
You don't have to memorize it

I Lateral	aVR None	V_1 Septal	V_4 Anterior
II Inferior	aVL Lateral	V_2 Septal	V_5 Lateral
III Inferior	aVF Inferior	V_3 Anterior	V_6 Lateral

Practical use of the ECG

- Heart rate
- Normal intervals
- Rhythm
  - Regular
  - Single p-wave precedes every QRS complex
  - P-R interval is constant and within normal range
- Cardiac axis Axis

Cardiac axis (we know that the apex of the heart normally deviated a little bit to the left).
we can measure the cardiac axis from ECG specifically from Bipolar Leads and if there is :

Left axis deviation :
we think about the causes of it like (tumor) also late stage of pregnancy.

Right axis deviation:
Tumor
Effusion of the ling

The QRS Axis:

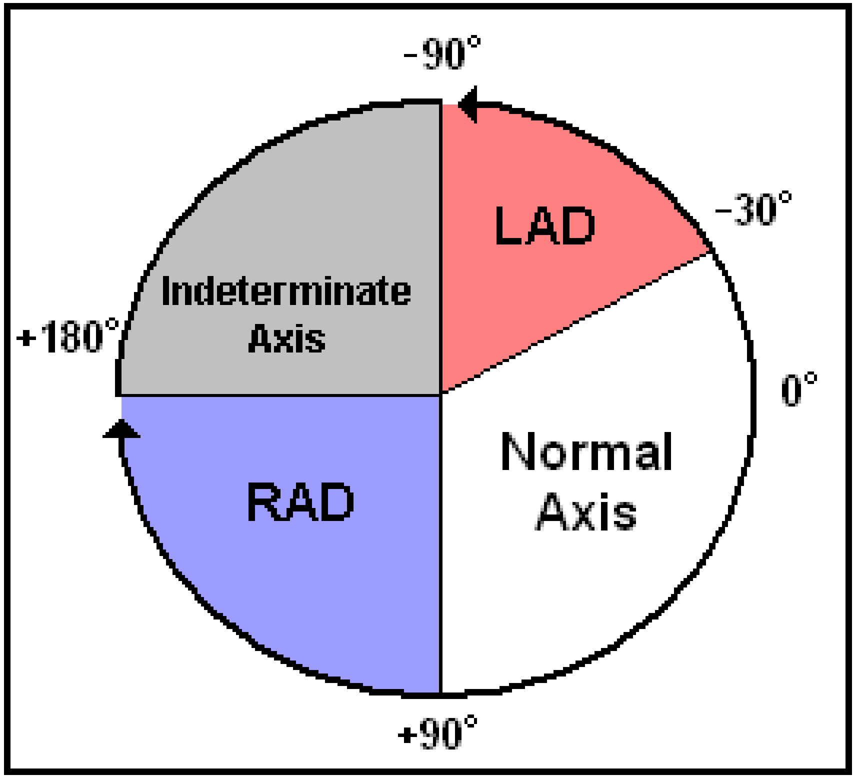
The QRS axis represents the net overall direction of the heart's electrical activity.
Abnormalities of axis can hint at:

- Ventricular enlargement
- Conduction blocks (i.e. hemiblocks)

By near-consensus, the normal QRS axis is defined as ranging from -30° to +90°.

-30° to -90° is referred to as a left axis deviation (LAD)

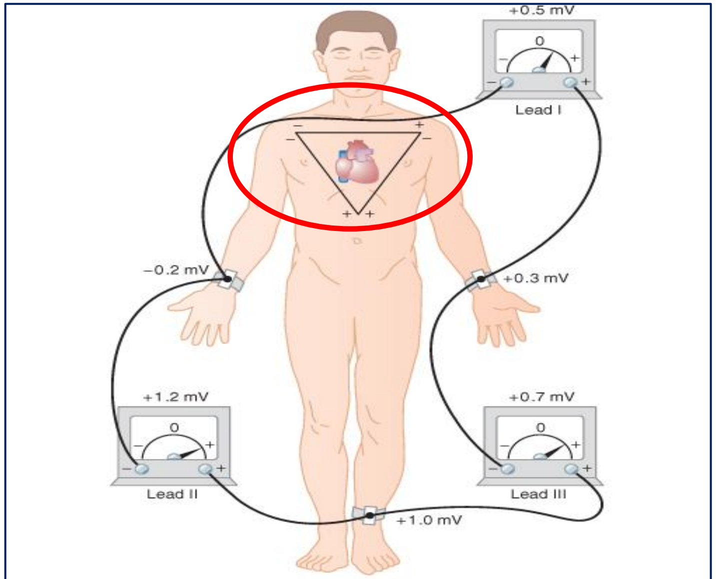
+90° to +180° is referred to as a right axis deviation (RAD)



Einthoven's Triangle

- **Enthoven'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

(نفس الرسمة اللي فوق بالجدول المثلث)



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- **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)

Einthoven's Law

- *The sum of the voltage in*

Lead I + Lead III= Lead II

Einthoven's law

Clinical Significance of different waves and segments of ECG

ST Elevation - Acute MI or Angina

ST depression >1 mm - Ischemia/Angina (flat), digoxin (sloping)

Q waves in 2 or more leads - Previous MI (Transmural)

Diffuse ST elevation with PR depression – Pericarditis

T wave inversions and non-specific ST changes - Can be seen both in normal cases and in many diseases, therefore not useful for diagnosis.

Tall P waves - Right atrial hypertrophy

Broad (and often bifid) P waves - Left atrial hypertrophy

Peaked T waves or loss of P wave – Hyperkalemia

U waves - Hypokalemia ('Hump' at the end of T wave)

Prolonged QT interval – Hypocalcemia

Shortened QT interval - Hypercalcemia

SUMMARY

- *The Electrocardiogram* ***(ECG)*** is a recording of the **electrical activity** of the heart
- P wave and the components of QRS complex are **depolarizing** waves and T wave is a **repolarizing** wave.
- PR segment represents the **delay of the electrical impulse** at the AV node.
- **Mechanical events occur after electrical events.**
- *Irregular or absent P waves may indicate **arrhythmia***
- In one minute, the number of **large squares** passing through the ECG machine is **60/0.2=300**
- Three **bipolar limb leads**: lead I, lead II, and lead III
- **Chest leads**: V1,V2,V3,V4,V5,and V6(6 leads)
- Three **augmented leads**: aVR, aVL, and aVF
- The **P-R** interval is about **0.16 sec** while **Q-T** interval is **0.35 sec.**
- current flows from ***negative*** to ***positive*** from the ***base*** of the heart toward the ***apex***.

THE END

If there are any problems or suggestions
Feel free to contact:

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THANK YOU