



Electrocardiogram

Dr. Thouraya Boutkedjirt

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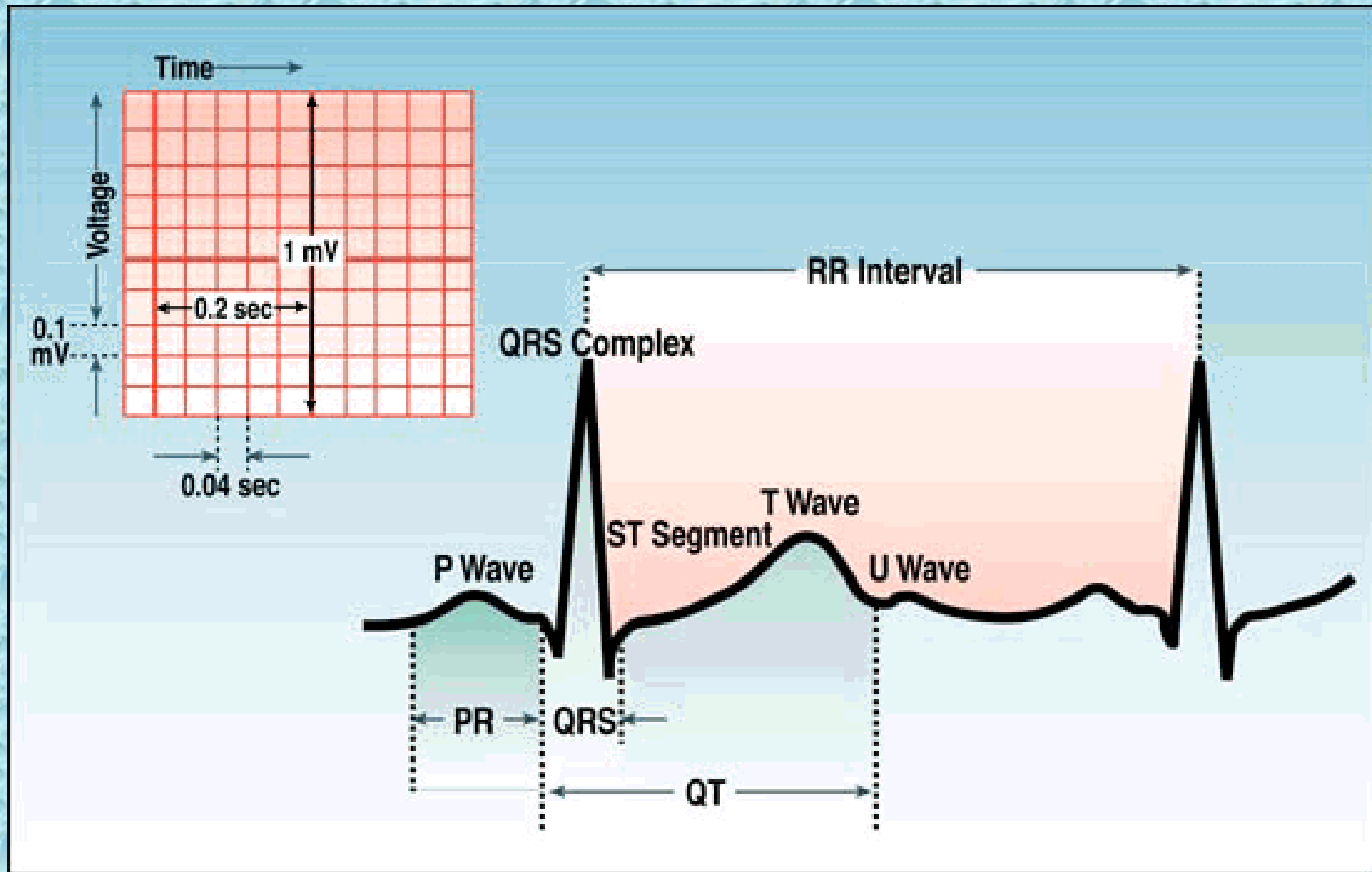
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- ECG records the **electrical changes** (depolarization and repolarization) that take place in the heart/per cycle.
 - These changes can be detected by **electrodes** attached to the surface of the body.
 - Subject supine, relaxed.
 - Temperature of the room : neutral.



ECG Paper

- The ECG is recorded on a graphic paper with standard-sized squares.
- The horizontal axis: **time** measured in seconds.
 - 1mm: 0.04 seconds
 - 1 large square: 0.20 seconds.
 - 5 large squares: 1 second.
- The vertical axis: changes of **voltage**.
 - 10mm = 1cm = 1millivolt.
 - A signal of 1(mV) should move the stylus vertically 1 cm (2 large squares).
- The standard paper speed is 25mm/sec.

ECG Paper



The 12 standard ECG leads

- A *lead* is formed by a *pair of electrodes*.

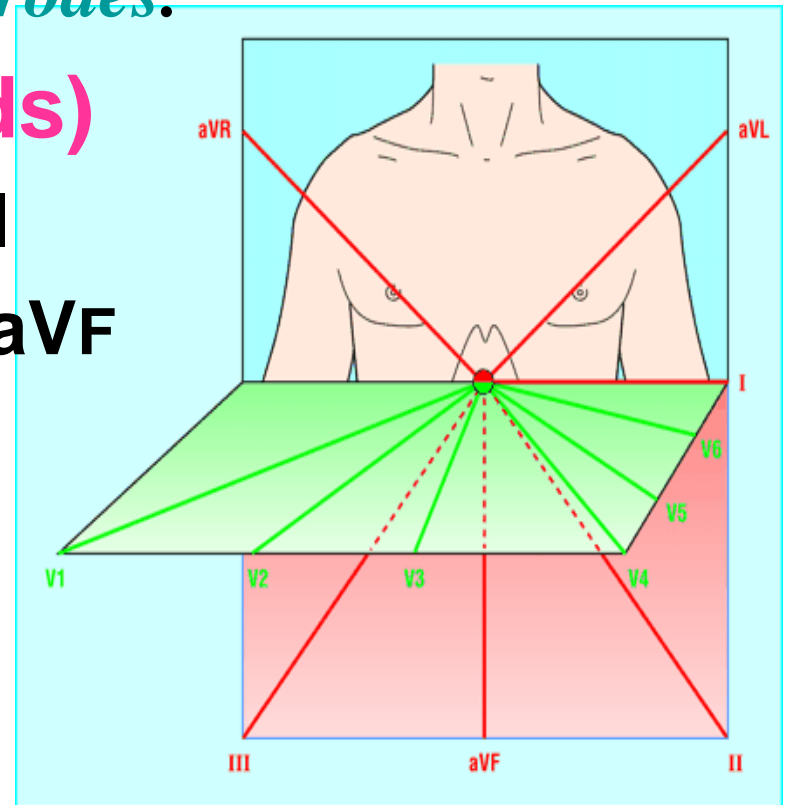
- **Frontal Plane (6 limb leads)**

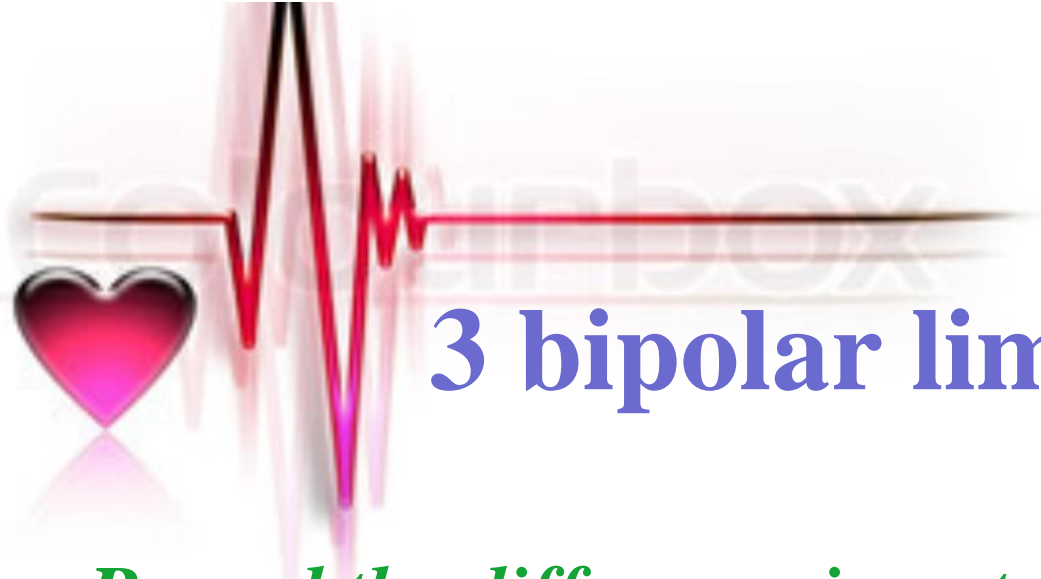
Bipolar Leads: I , II , and III

Unipolar leads: **aVR**, **aVL**, **aVF**

- **Transverse Plane:**

Unipolar chest leads: **V1** to **V6**





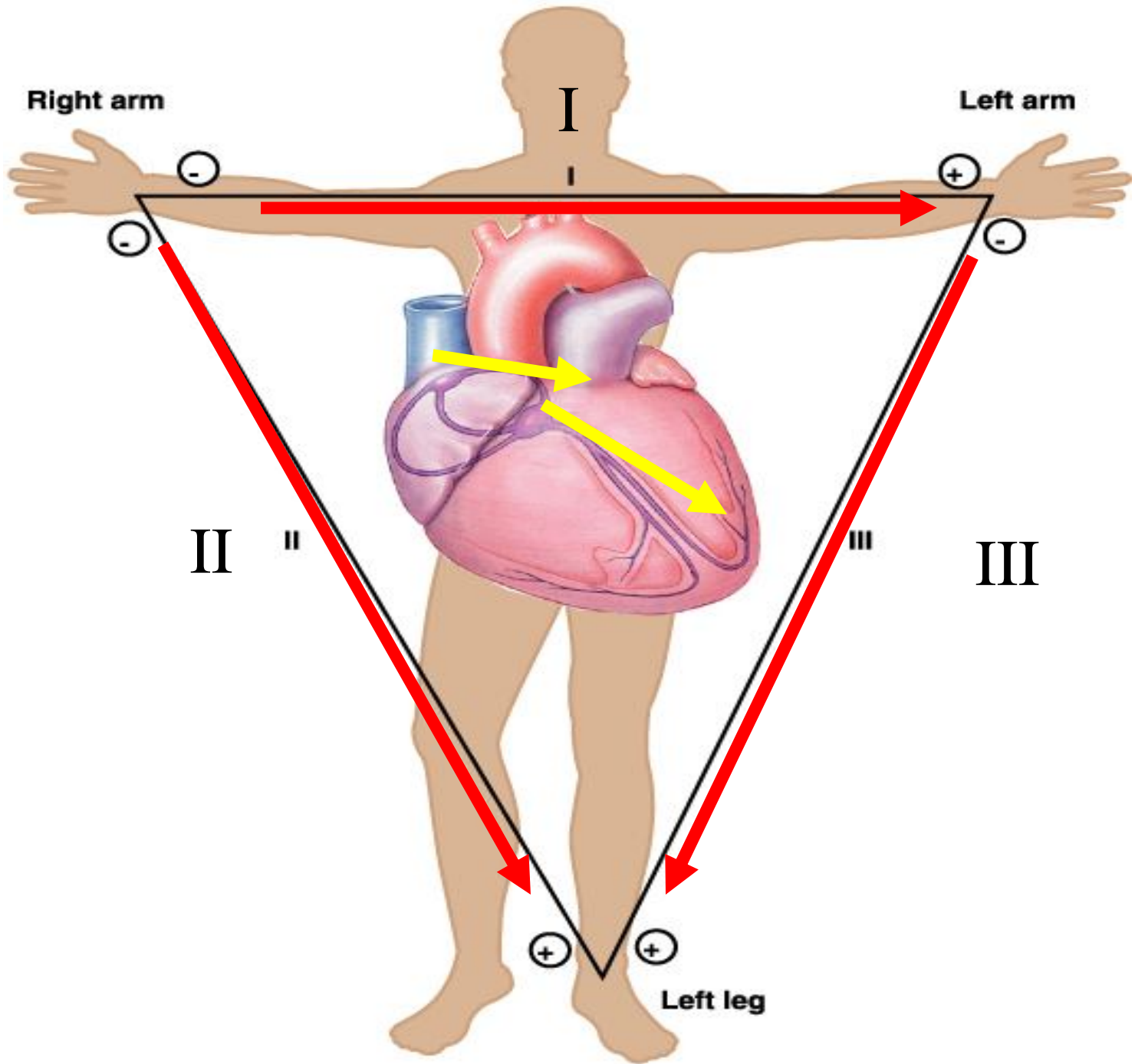
3 bipolar limb leads: I, II, III

- *Record the difference in potential between 2 limbs.*
- *ECG was first recorded by placing electrodes on 3 places: **Right** and **Left** arms and **Left** leg*
- *(Recording +ve Ede) (-ve reference Ede)*

- *Depolarization moving towards a +ve Ede produces a +ve deflection.*
- *Depolarization moving in the opposite direction produces a -ve deflection.*

- **Lead I:** Left arm Ede is +ve, the other is -ve.
- **Lead II:** Edes on the right arm and the left leg with the leg +ve.
- **Lead III:** Ede of the left arm is -ve, Ede of the left leg is +ve.
- The 3 leads arranged as a triangle are known as **Einthoven's triangle.**

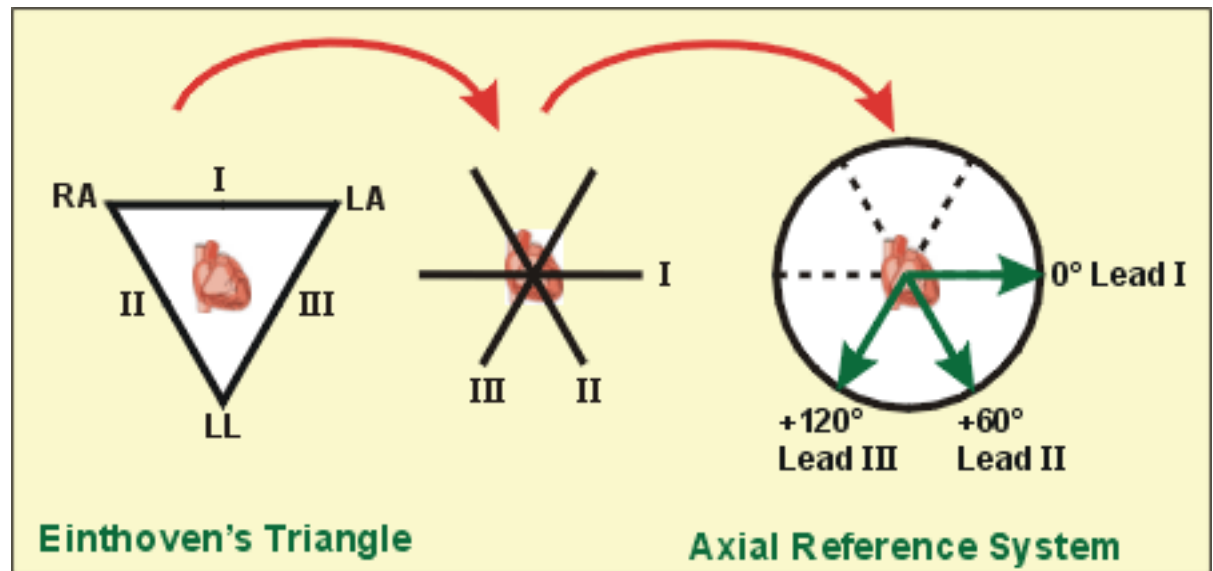




Formation of the triaxial system & assignment of degrees to leads I, II, III

- By bringing the sides of the triangle to the common center.
- The axes are 60° apart.
- *Axis of a lead: direction from the negative to the positive electrode*

- Lead I (+) is at 0°
- Lead II (+) is at $+60^\circ$
- Lead III (+) is at $+120^\circ$

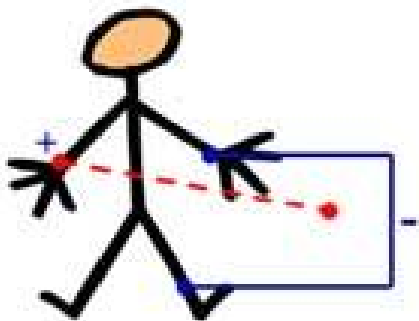


Augmented unipolar limb leads aVR, aVL, and aVF

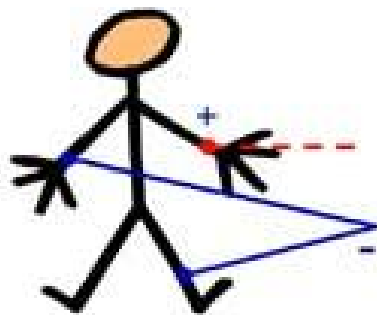
Are recordings between 1 limb and the other 2 limbs.

- Lead **aVR** (augmented, Voltage, Right arm)
- **aVL**: uses left arm as +ve.
- **aVF**: uses left leg as +ve.

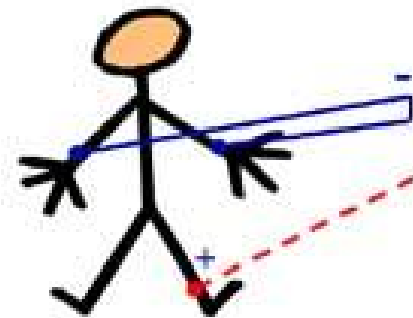
AVR: Augmented voltage right arm



AVL: Augmented voltage left arm

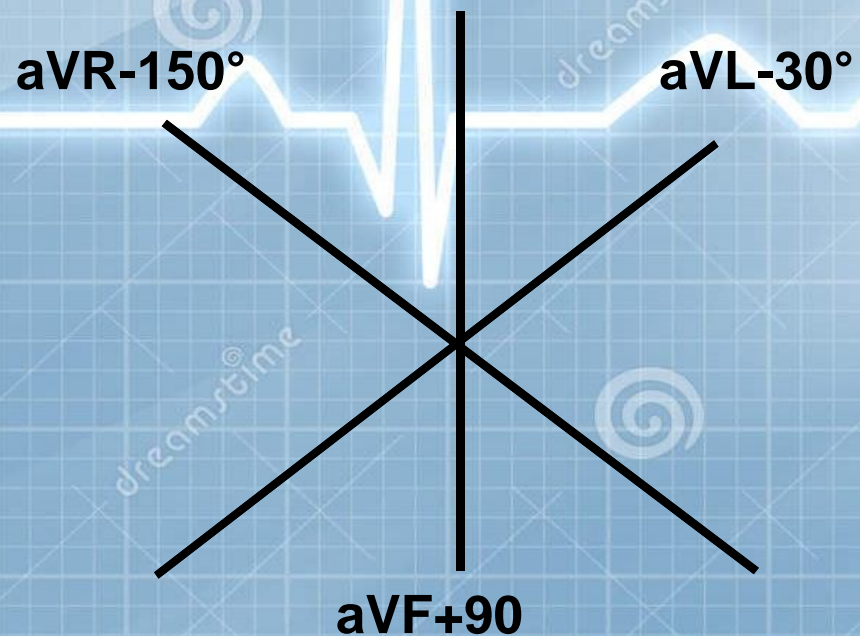
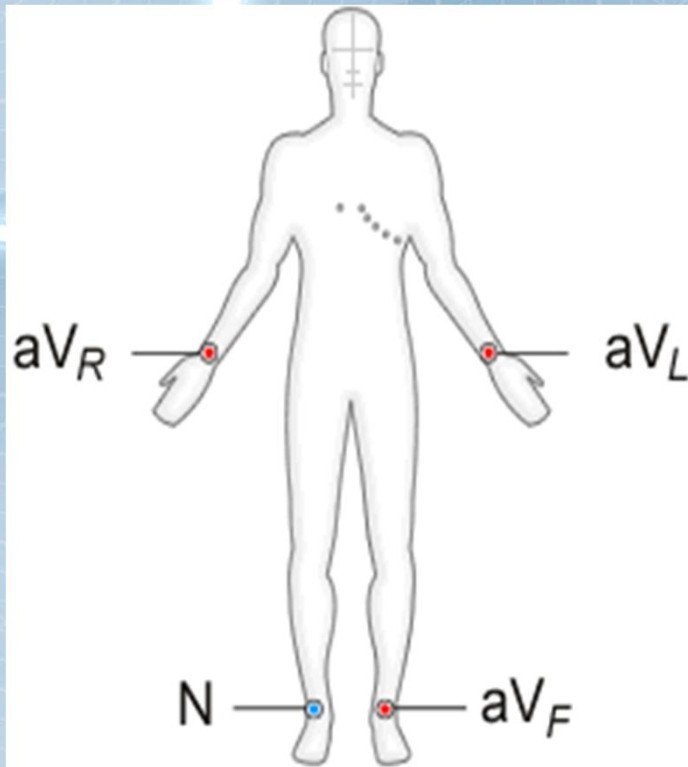


AVF: Augmented voltage left foot



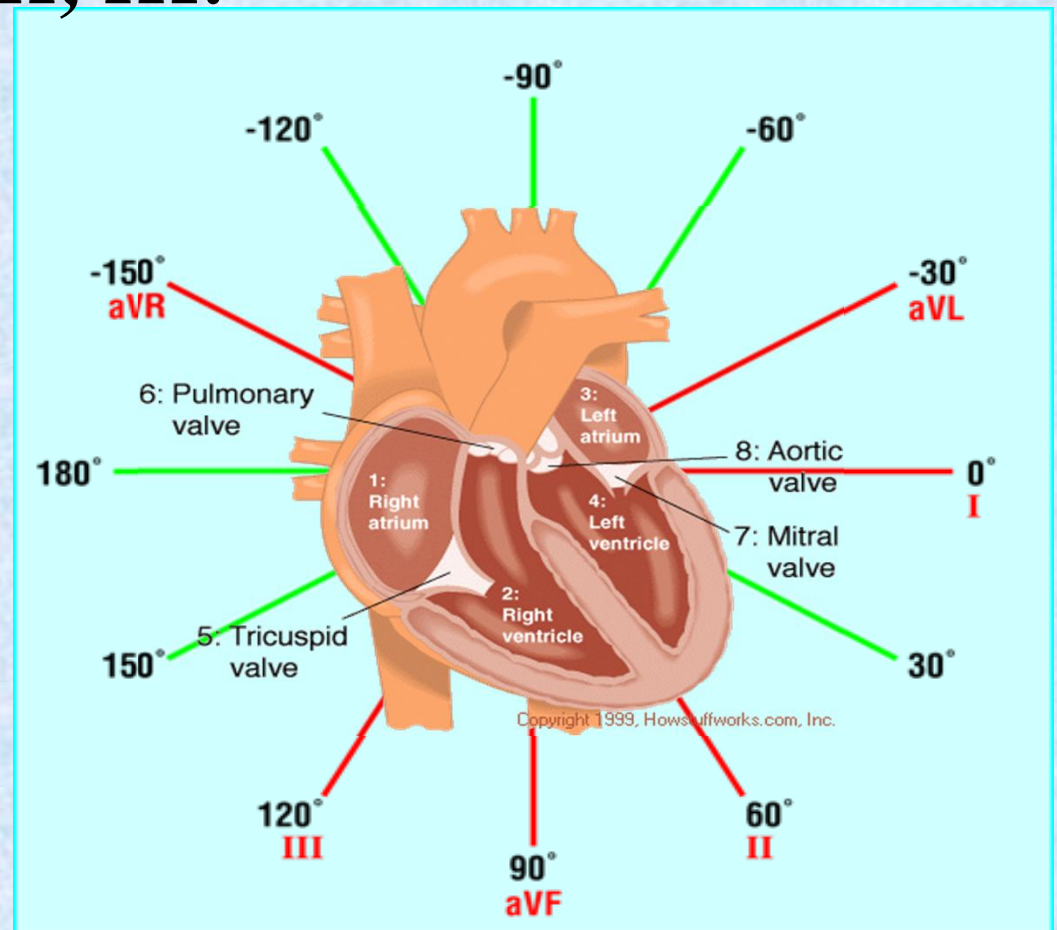


- Leads aVR, aVL, aVF cross at # angles and produce an intersection of 3 other lines.
- Angles of 60° like for lead I, II, III.



Formation of hexaxial system

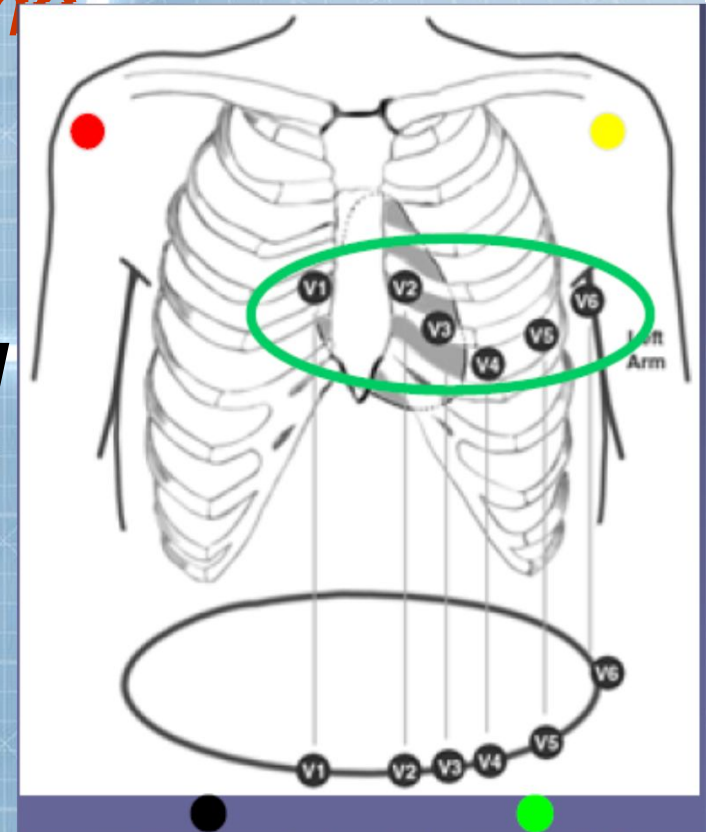
- *Leads aVR, aVF, aVL divide the angles formed by lead I, II, III.*
- *The leads cross precisely at 30°.*





B: 6 standard “**chest leads**” depict electrical events in the **horizontal plane**

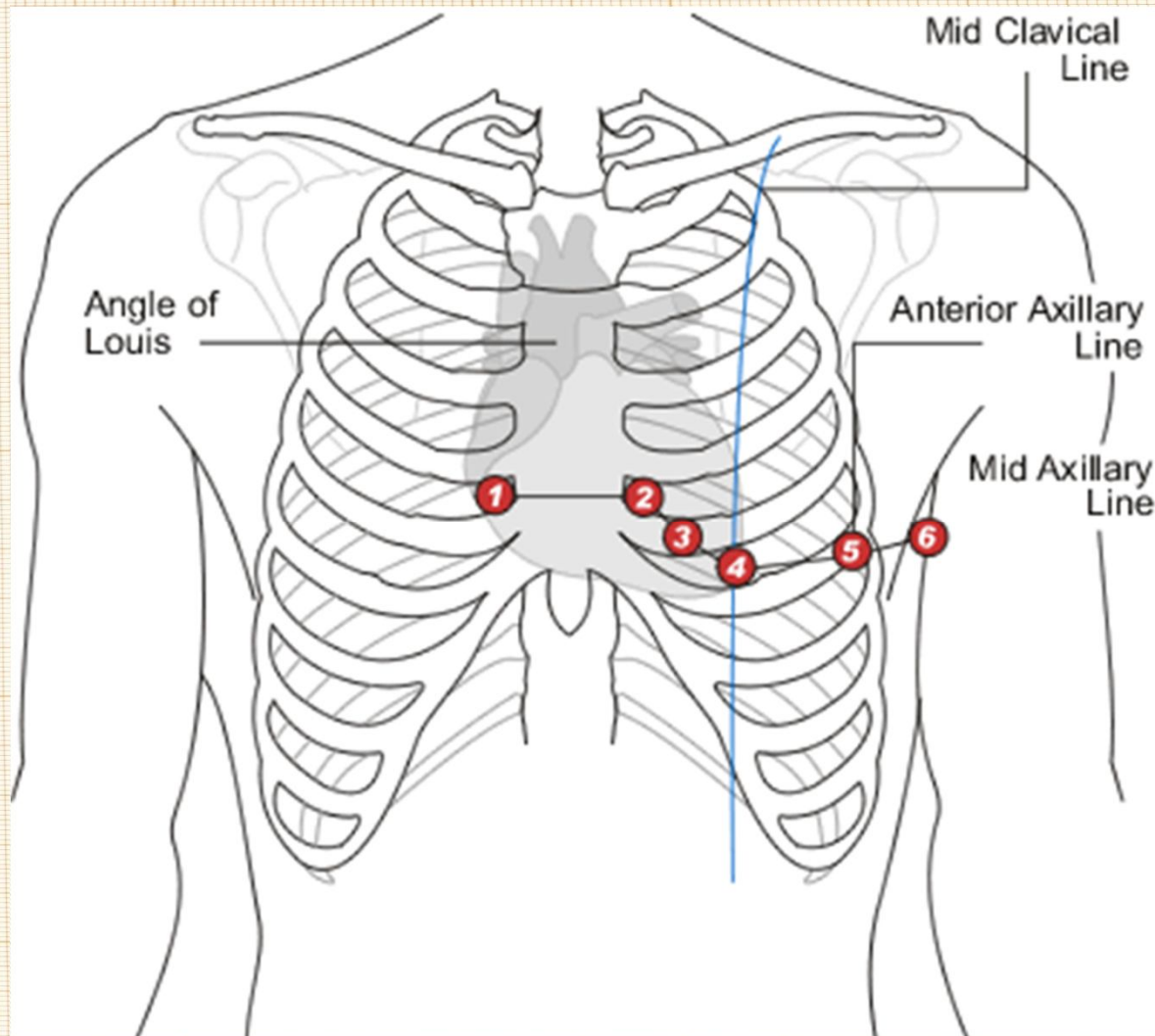
- One **+ve Ede** is placed on 6 different positions around the chest.
- The **reference -ve Ede** is a combined limb lead.



Chest leads:

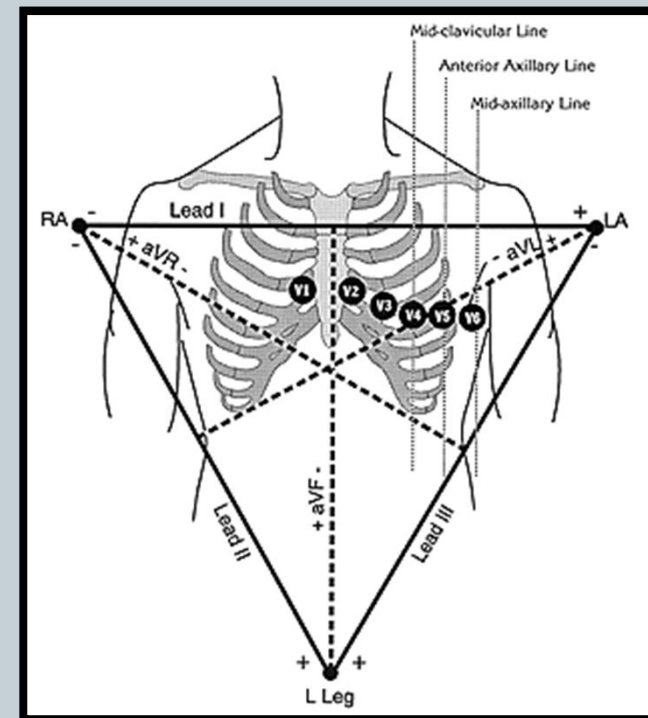
- **V1** – Right sternal border, 4th ICS.
- **V2** – Left sternal border, 4th ICS.
- **V3** – Halfway between leads V2 & V4.
- **V4** – Left mid- clavicular line, 5th ICS.
- **V5** – Anterior axillary line, 5th ICS.
- **V6** – Mid axillary line, 5th ICS.



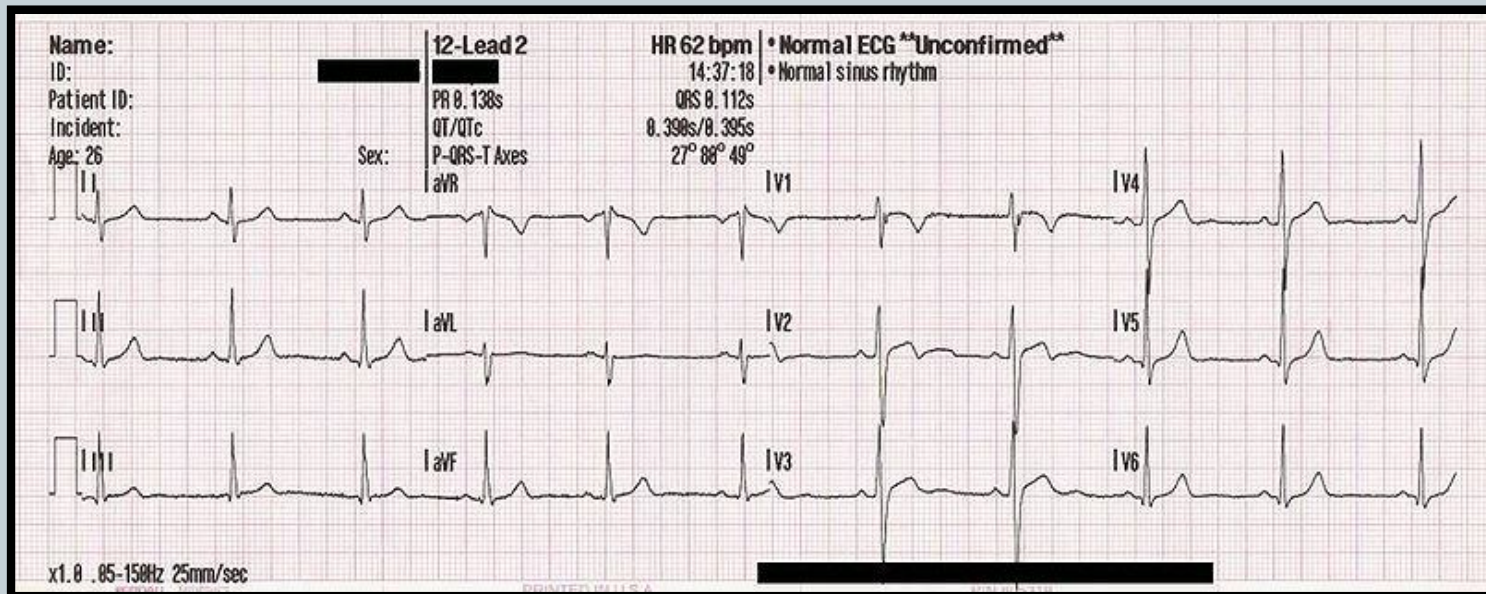


The standard 12-lead ECG

- How many electrodes?
 - 10 electrodes
- How many leads?
 - 12 leads



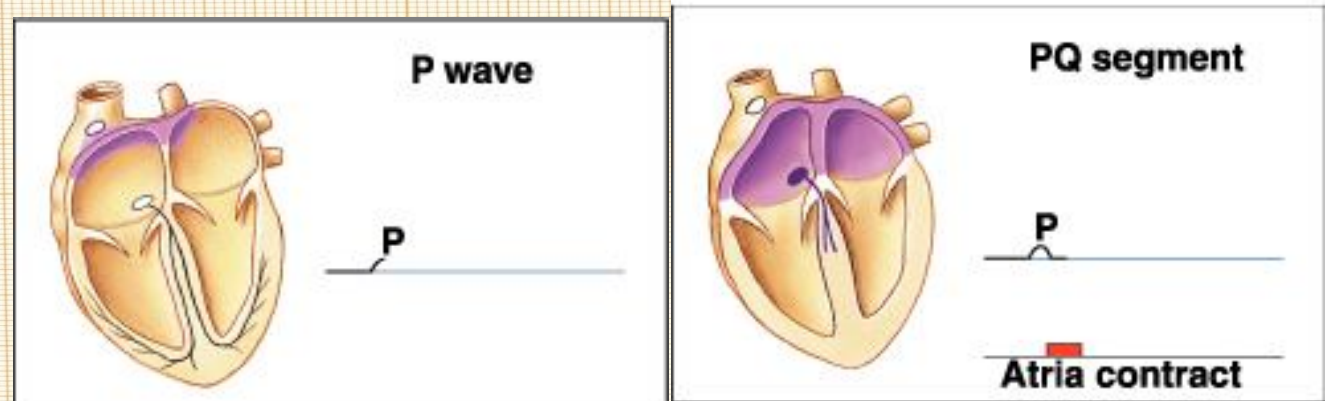
The 12-lead ECG



Interpretation of the normal ECG

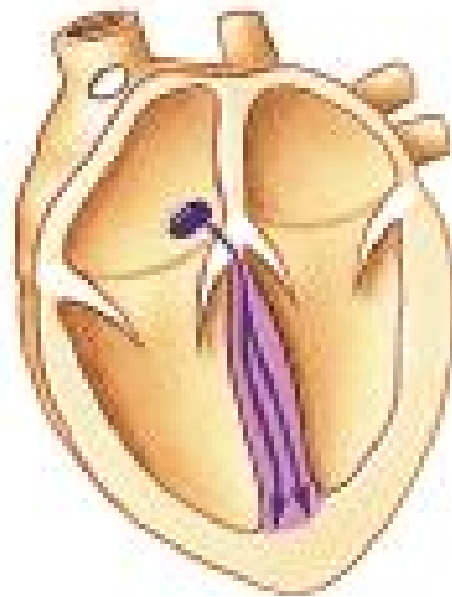
Atrial activation:

- The impulse originates at SA node, spreads through the atria.
- This causes positive upward deflection.
- The **P wave** represents the **depolarization of both atria**.
- Pw: <0.12 sec
< 2.5 mm

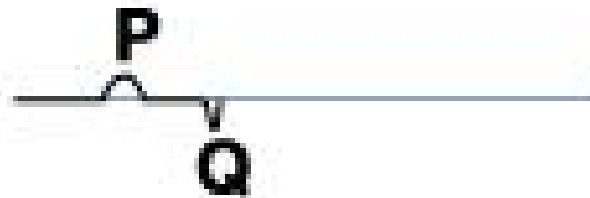


Septal Activation:


- The impulse spreads to the AV node, common bundle of His and R and L bundle branches then enters the IV septum.
- This occurs during **PR segment**.

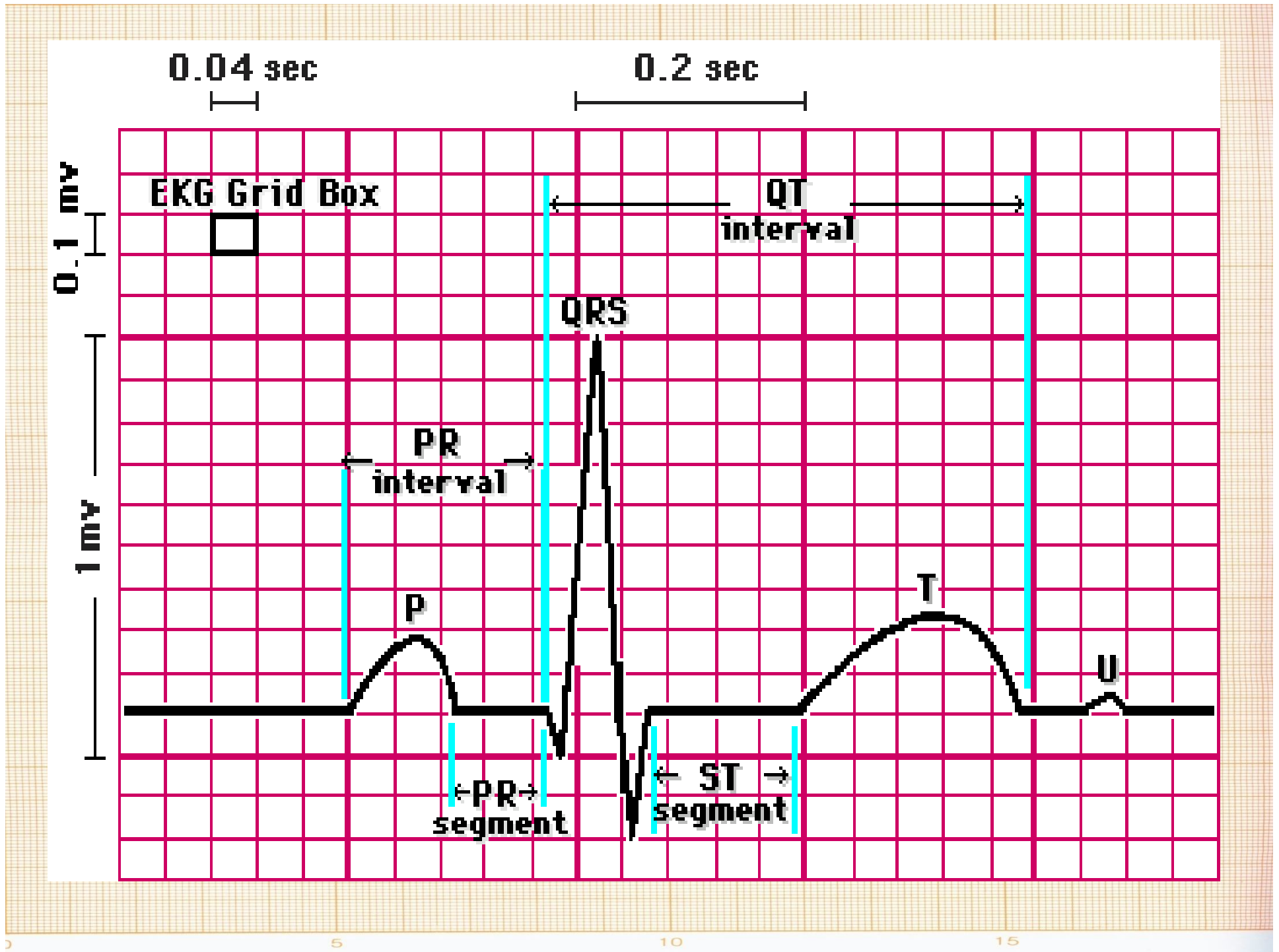


Q wave



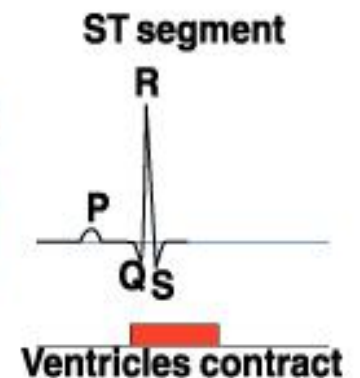
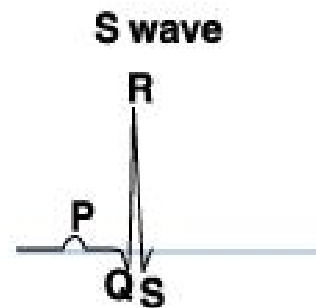
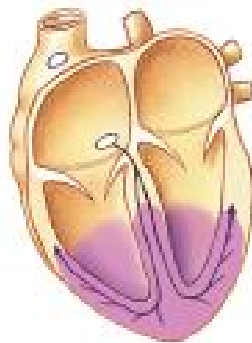
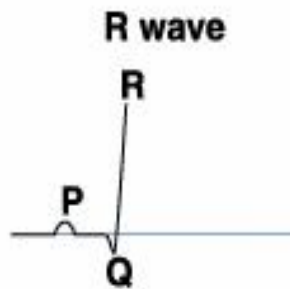


- ***PR interval: P wave + PR segment.***
- ***Time of transmission of electrical impulse from the beginning of atrial depolarization to the beginning of ventricular depolarization.***
- ***PR: 0.12 - 0.20 seconds (less than 1 large square).***
- ***Block AV: PR prolonged > 0.20 seconds.***
An ECG strip showing a regular rhythm with a prolonged PR interval, characteristic of AV block. The strip is on a pink grid and shows several cardiac cycles with a noticeably long interval between the P wave and the QRS complex.
PR shortens as heart rate increases.



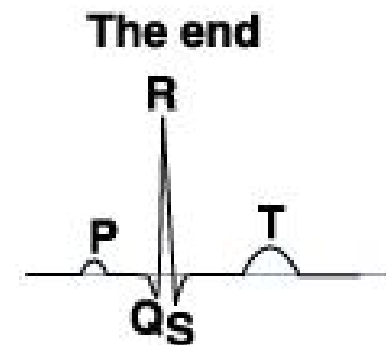
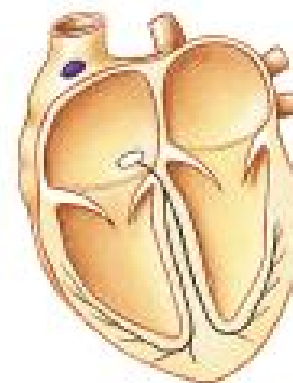
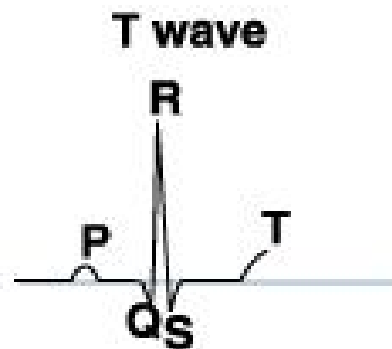
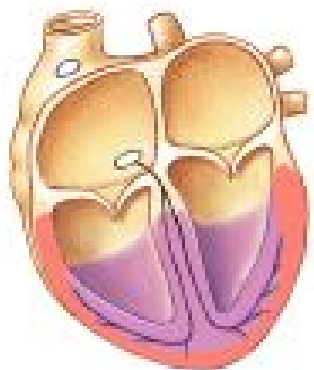
Ventricular depolarization

- The wave of depolarization spreads in the Purkinje fibers to all parts of the ventricles.
- The initial negative deflection is **Q wave**.
- The first positive deflection is **R wave**.
- The negative deflection after R wave is : **S wave**.
- **QRS duration: < 0.10 sec.**



Ventricular repolarization: T wave

- **Ventricular repolarization represented by ST segment and T wave.**
- **ST segment:** period between the end of QRS and the start of T wave.
- **QT interval:** from beginning of Q wave to end of T wave (ventricular dep and rep) **< 0.43 sec.**
- **ST interval:** **QT-QRS = 0.32 sec.**

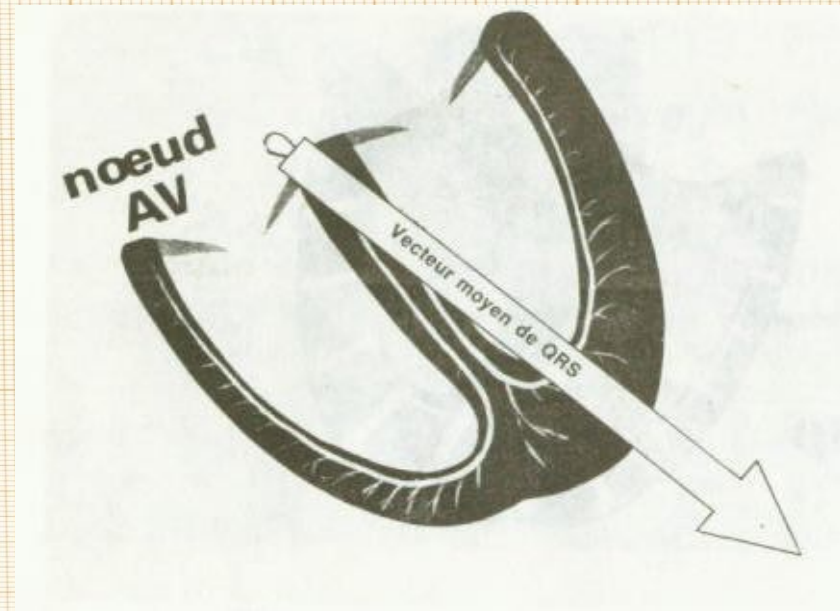
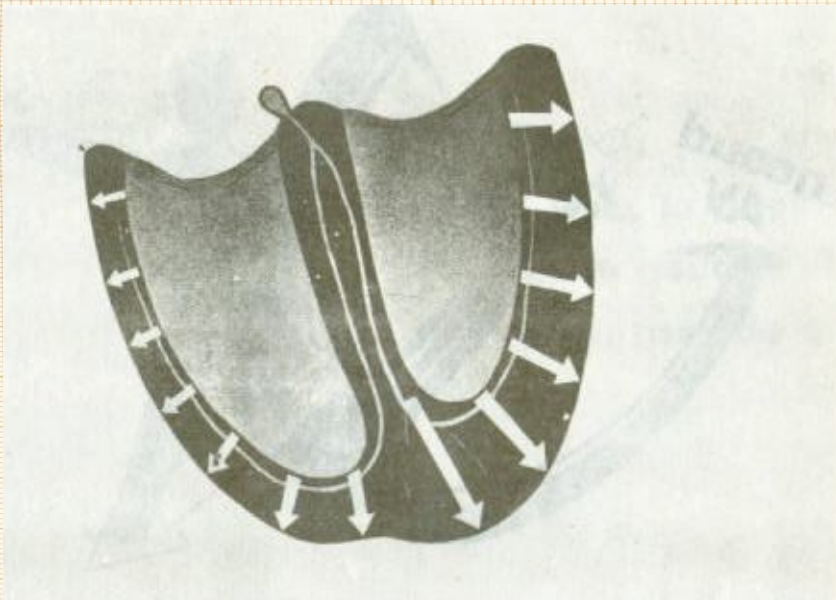


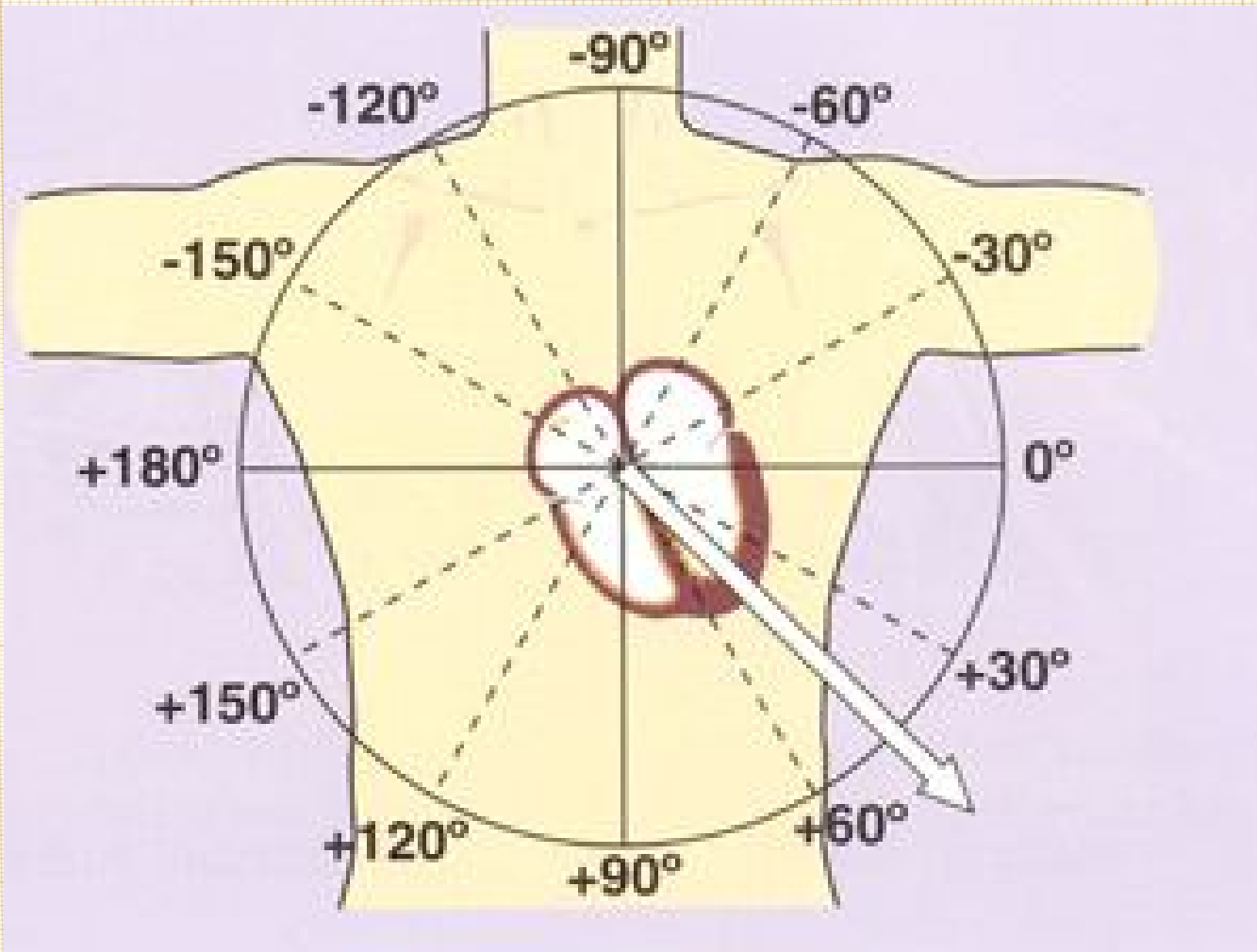
ECG intervals

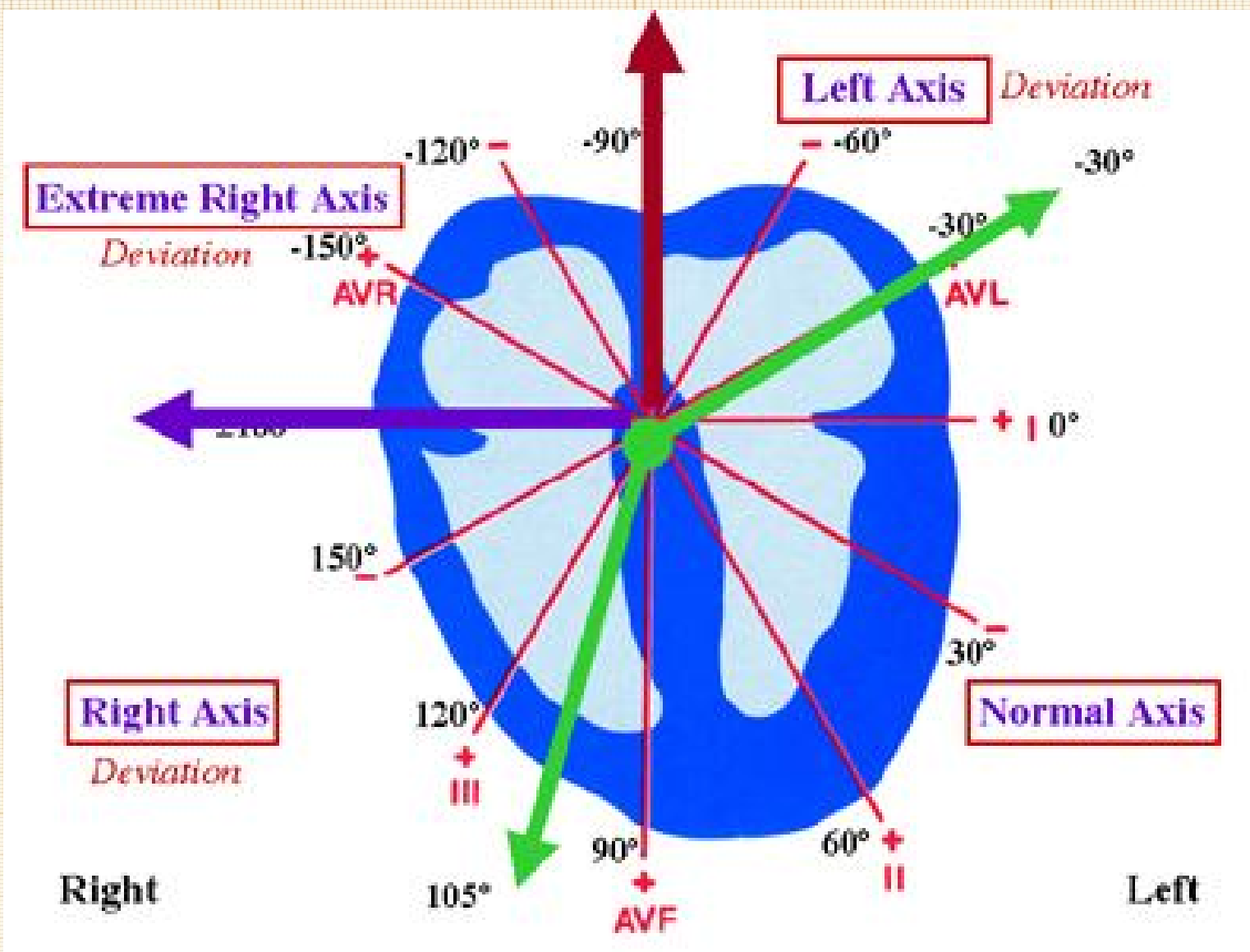
Intervals	Normal Duration(s)		Events in the Heart During Interval
	Average	Range	
PR interval Pw + PR segment.	0.18	0.12-0.20 < 1 large square	Atrial depolarization and conduction through AV node
QRS duration	0.08	To 0.10	Ventricular depolarization and atrial repolarization
QT interval	0.40	To 0.43	Ventricular depolarization plus ventricular repolarization
ST interval (QT minus QRS)	0.32	...	Ventricular repolarization

Cardiac axis

- *The mean QRS vector is the preponderant direction of the potential during depolarization.*
- *The mean electrical axis of the ventricles is 59° .*

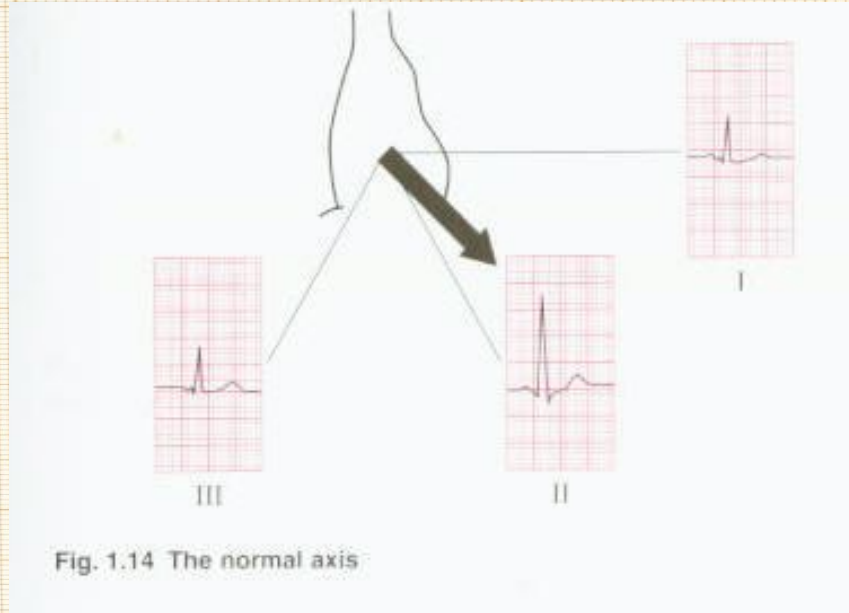




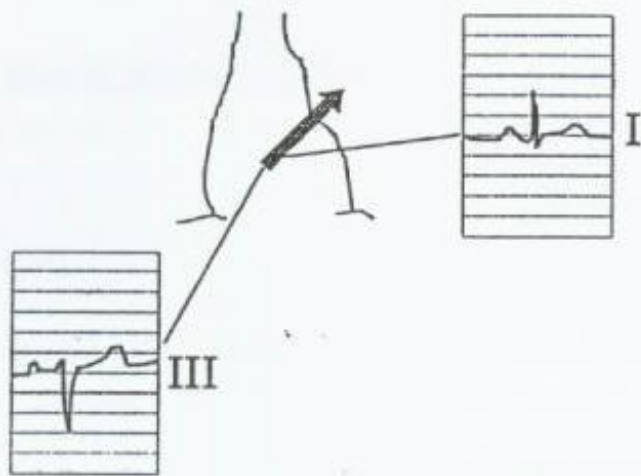


Normal Axis:	from 0 ° to +90 °
Left Axis Deviation: Obese (normal) L V hypertrophy	from 0 ° to -90 °
Right Axis Deviation: Thin tall (normal) R V hypertrophy R B B B	from + 90° to ± 180 °
Extreme Right Axis Deviation:	from -90 ° to ± 180°

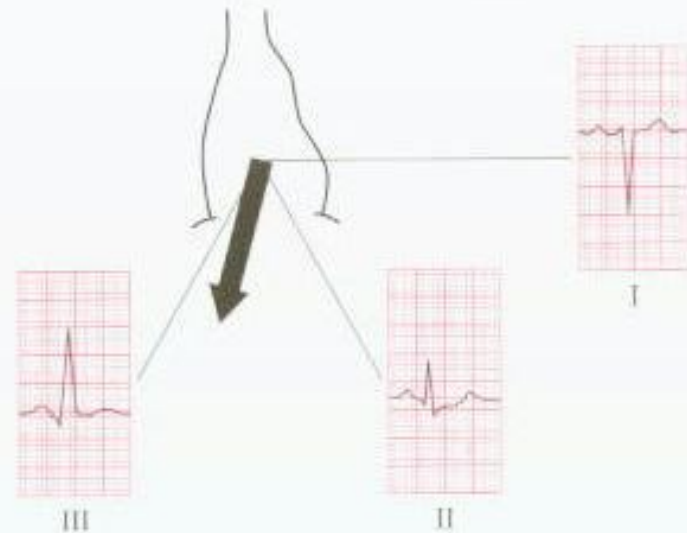
Inspection method

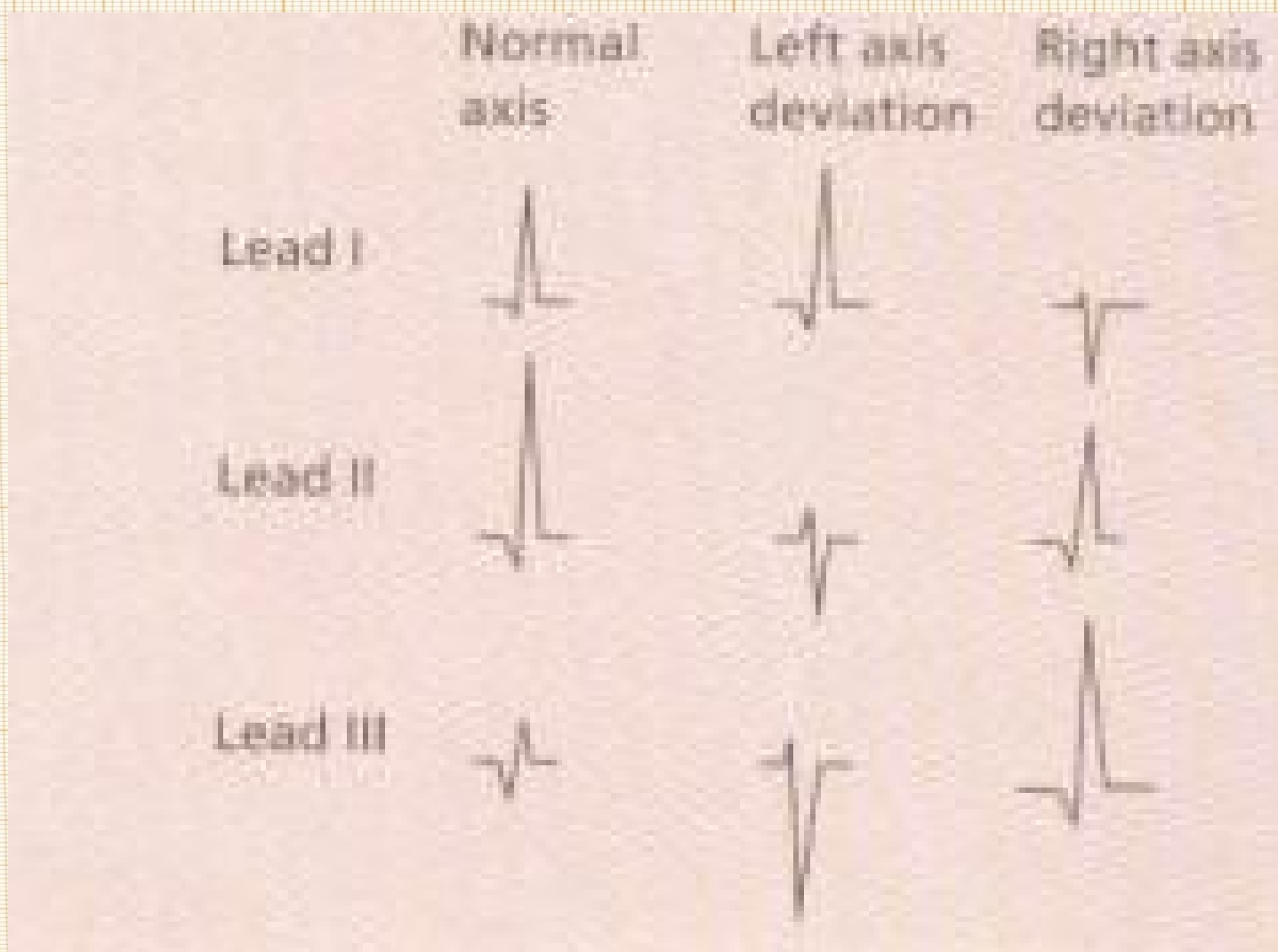


LEFT AXIS DEVIATION



RIGHT AXIS DEVIATION



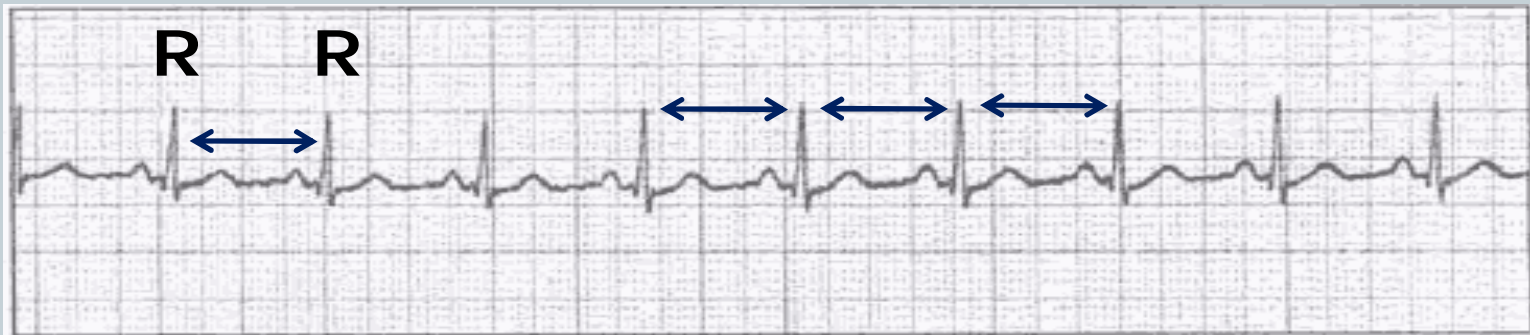


Calculating the direction of the cardiac vector

Rythm

Sinus rhythm: P wave before every QRS: Impulse from SA node

Sinus Regular : distance between R-R: constant



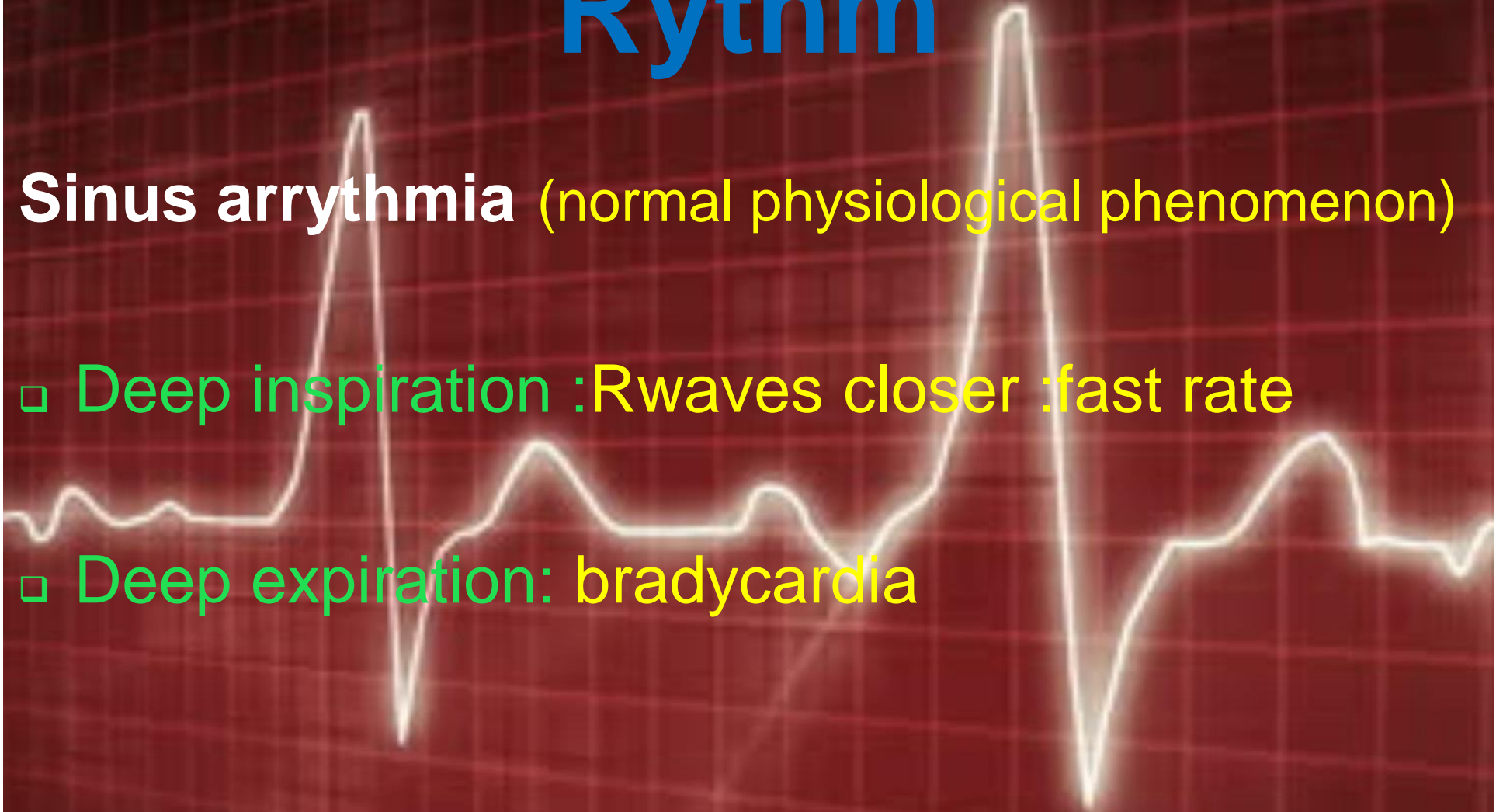
Irregular : Unequal R-R intervals

Rythm

Sinus arrythmia (normal physiological phenomenon)

□ Deep inspiration :Rwaves closer :fast rate

□ Deep expiration: bradycardia



Heart rate



Examine the distance between QRS complexes.

If the distances are regular, use one of these two formulas:



300

Big squares between R-R



Or:

1500

Small squares between R-R



To obtain the heart rate in beats per minute.



1 complex every 1 major division = 300/min



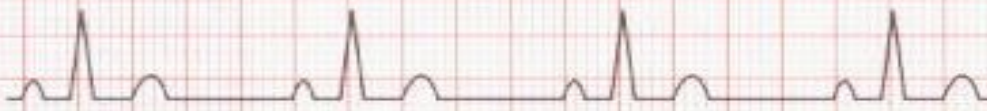
1 complex every 2 major divisions = 150/min



1 complex every 3 major divisions = 100/min



1 complex every 4 major divisions = 75/min



1 complex every 5 major divisions = 60/min



1 complex every 6 major divisions = 50/min