

Basic interpretation of ECG

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**M.D (Medicine) F.C.G.P(IND) F.I.A.M.S (Medicine) FICP FICCMD
100 Articles and 16 e-Books on different aspects of ECG to his credit**

National President CCDSI (2020-21)

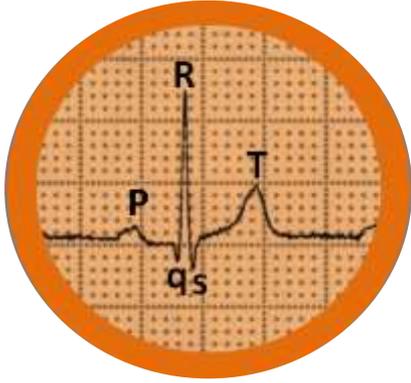
Dean ICCMD (2022-2023)

Awarded Prestigious Master Teacher Award from CCDSI in 2022

National Veteran Academic Excellence Award (IMA,2023)

CME India addressed him as Living Legend in Medicine – The pride of India

Dr. William Einthoven's contribution

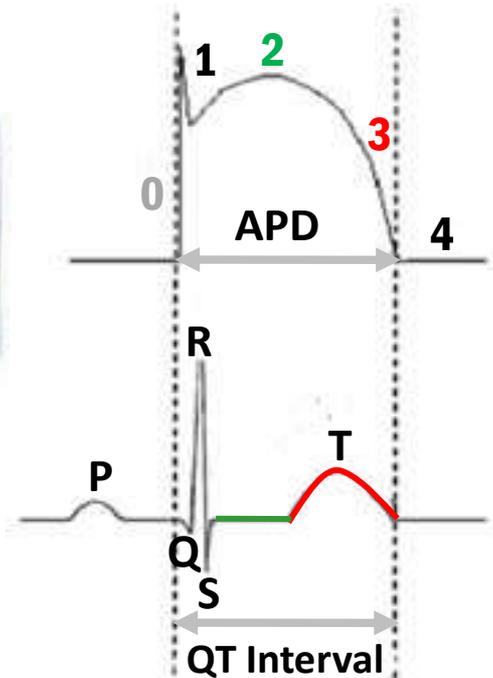
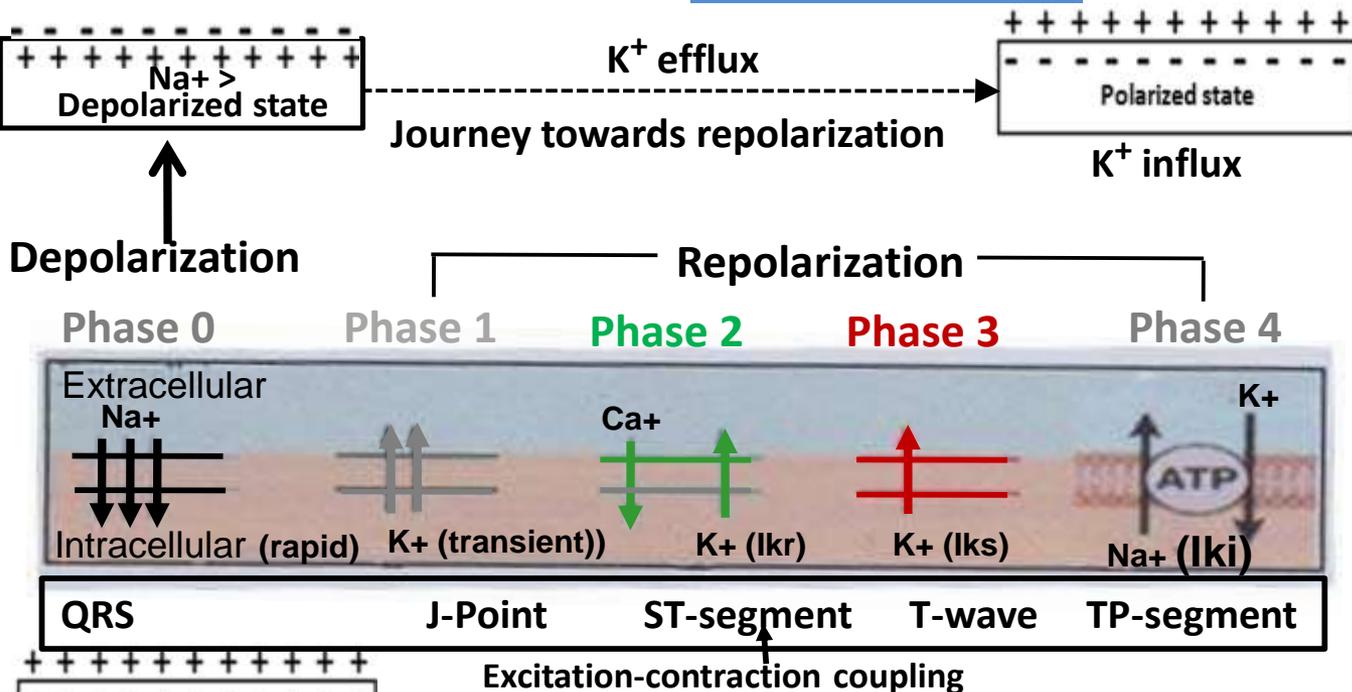


❑ Salutation to Dr. William Einthoven , Dutch physiologist (1860-1927)

- Coined the term Elektrokardiogramm – EKG (transfer the credit to Waller)
 - He built string galvanometer based 3 lead EKG machine (1901) and machine and delineated P-QRS-T-U waves.
 - Famous Einthoven's triangle (With the use of three limb leads)
- ❑ The prediction of Sir Thomas Lewis (British Cardiologist) in the early 1910s that **“the time is at hand, if it has not already come, when an examination of the heart is incomplete if this new method is neglected”**, quickly became a reality
- ❑ There should be no surprise why Einthoven was awarded with **Nobel prize in 1924 ‘for his discovery of the mechanism of the electrocardiogram’**

Electrophysiology : Ionic flow across the cardiac membrane

Basis of ECG



FUNDAMENTAL LAW – Cardiac discipline

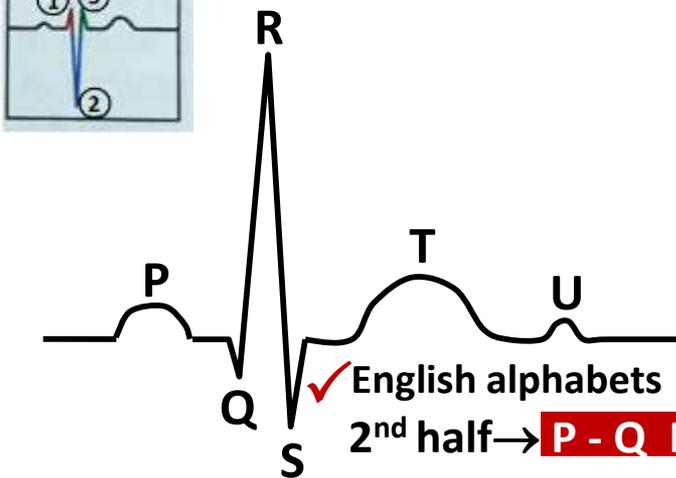
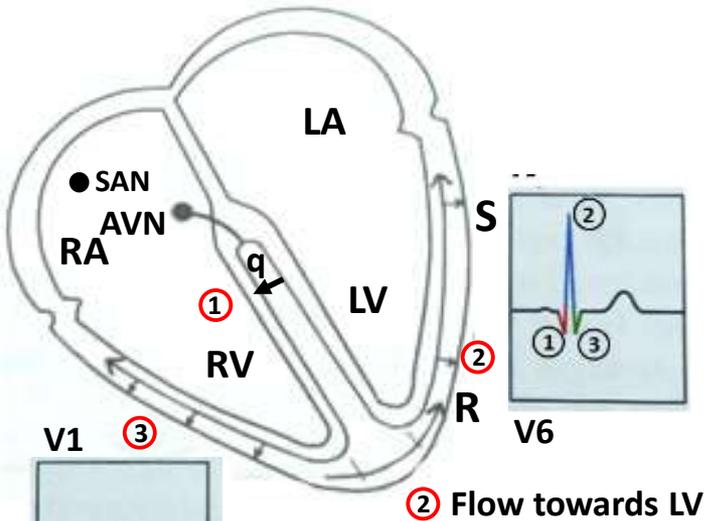
- ❑ The flow of current from positive ionic state towards negative ionic state
- ❑ Waves display as per voltage gradient (R, T wave)
- ❑ No voltage gradient : no wave (isoelectric ST-TP segment) TP segment always kept isoelectric by ECG machine

Polarized state ($K^+ >$)

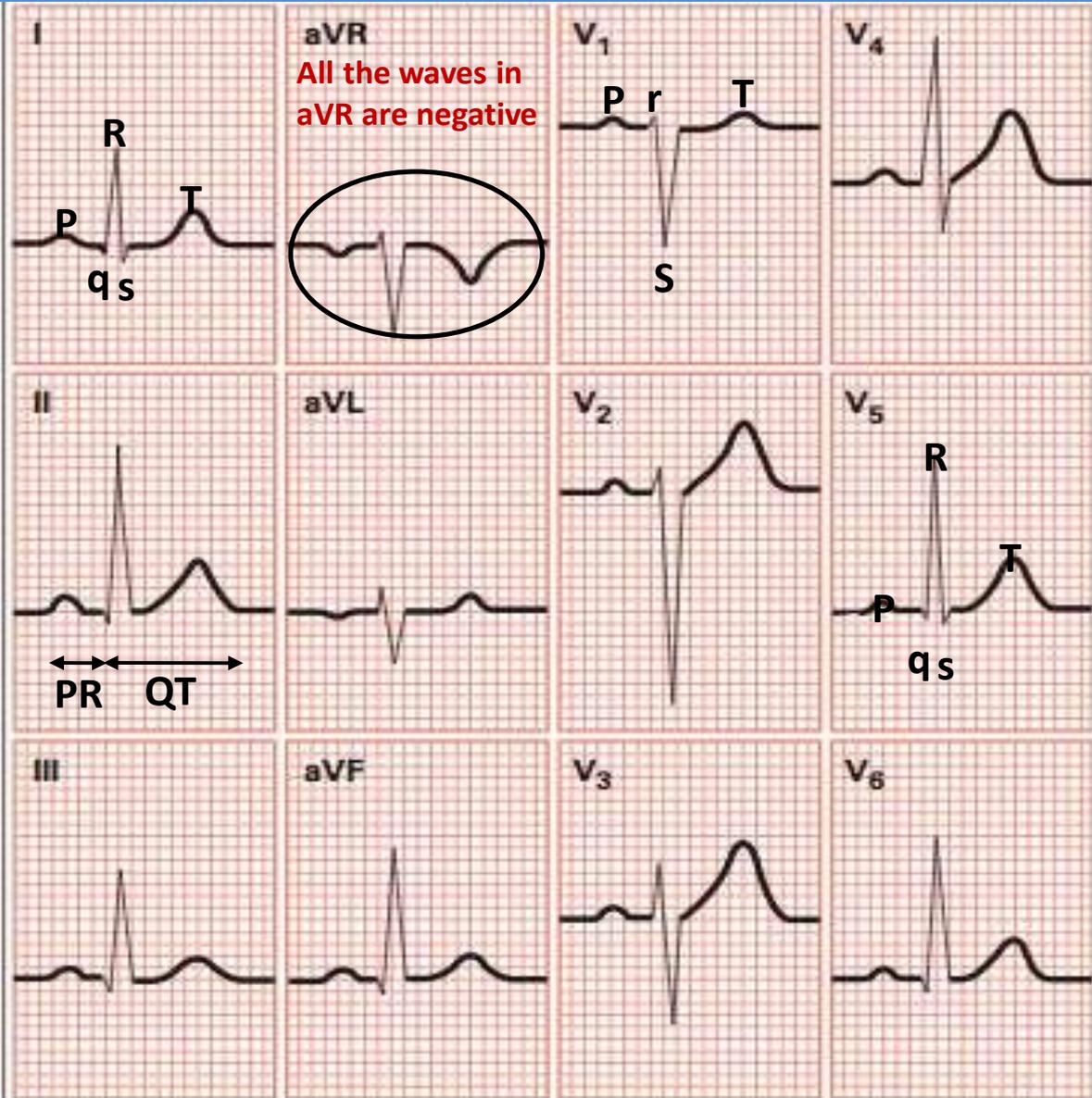
✓ outside $3Na^+$
inside $2K^+$

Basics : Normal ECG

- Positive wave towards the flow of current
- Negative wave away from the flow of current

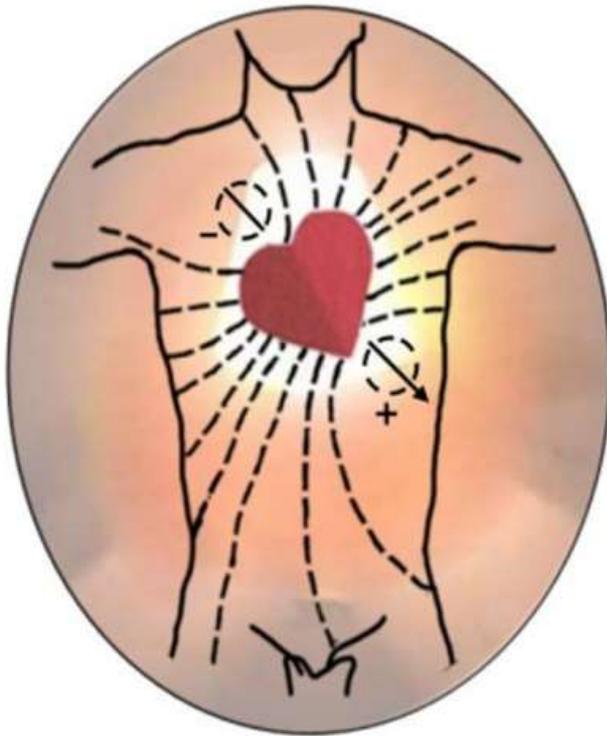
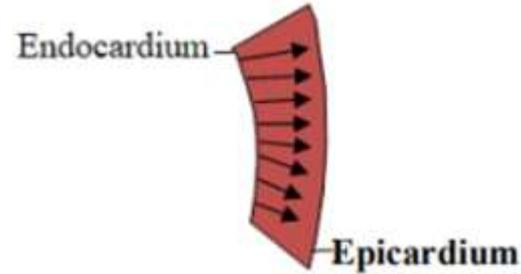
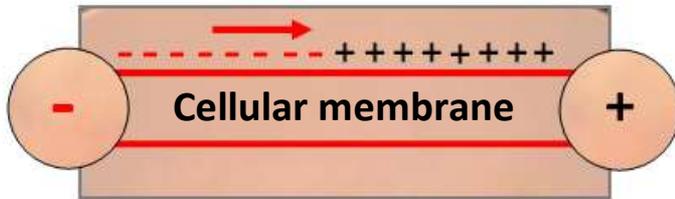


Normal 12-ECG

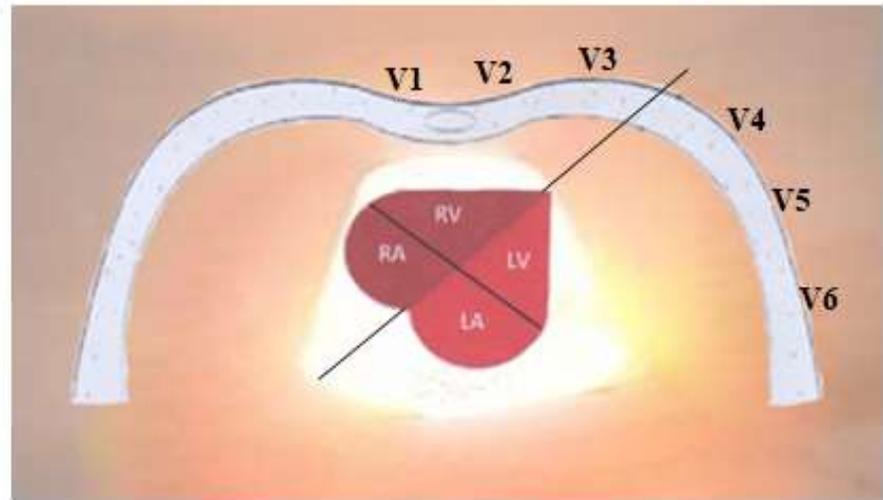


Cardiac electrical field

The flow of ions (positively and negatively charged) constitutes a field of electrical current around the heart (60 times more intense than that of brain electrical activity)

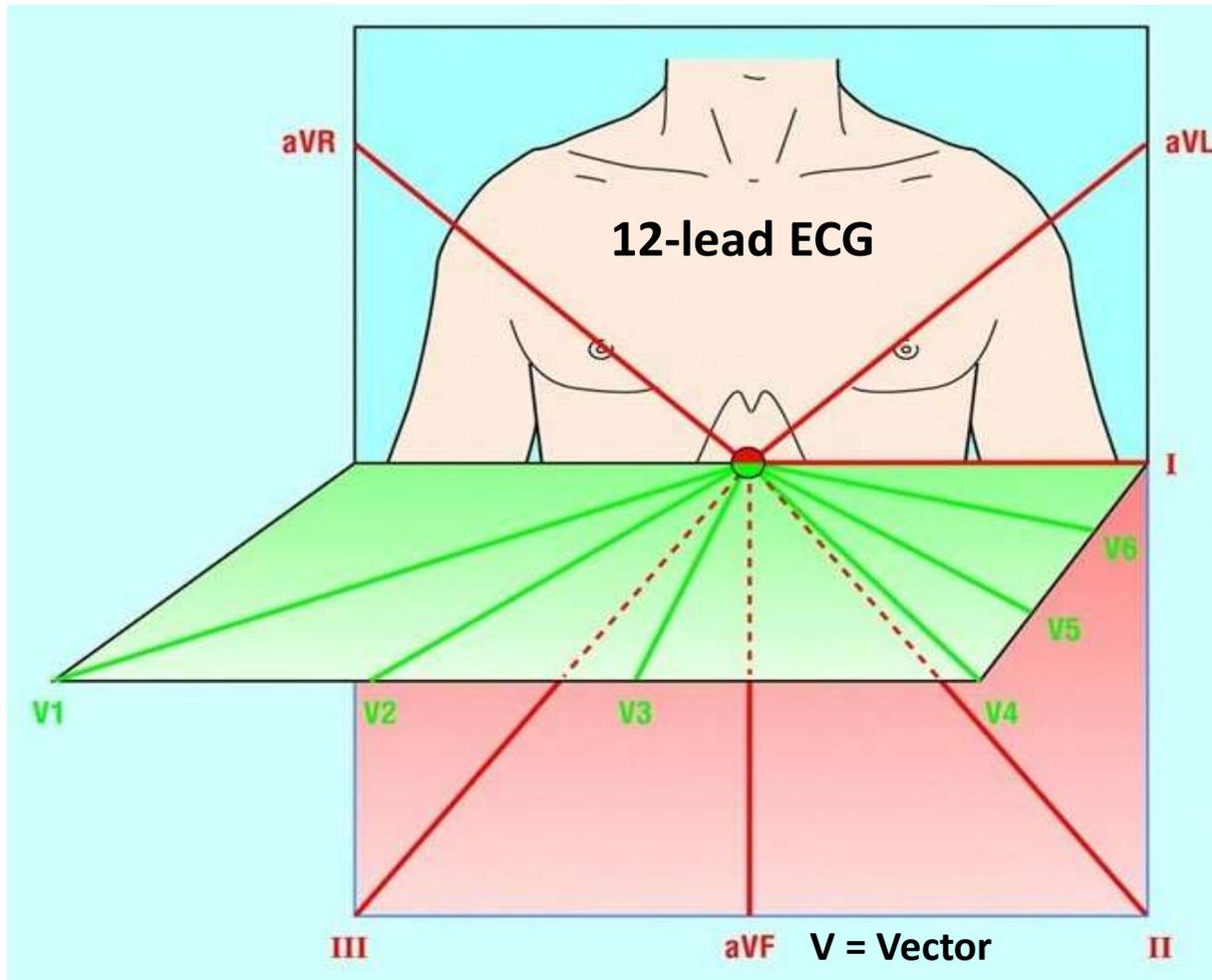


Vertical plane



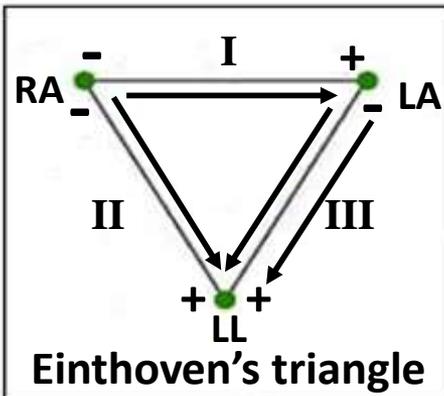
Horizontal plane

Frontal and horizontal planes of ECG recording



- ❑ **Frontal plane** Three bipolar limb leads I , II , III
PLUS unipolar limb leads aVR , aVL , aVF (Here, 'V' stands for vector)
- ❑ **Horizontal plane** six points over the chest : V1-V6
('V' stands for voltage)

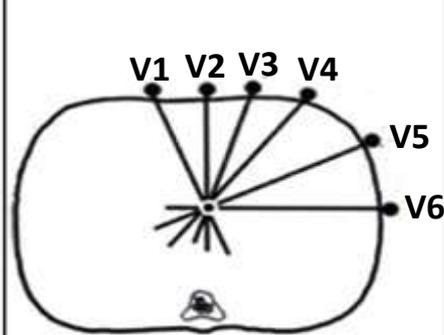
The Standard 12-lead ECG



Precordial



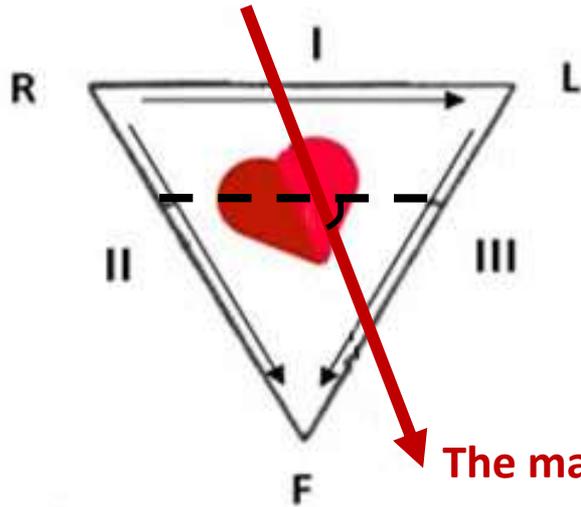
V1 V2 V3 V4 V5 V6



Leads		Negative Electrode	Positive Electrode
Bipolar	I	Right Arm	Left Arm
	II	Right Arm	Left Leg
	III	Left Arm	Left Leg
Unipolar	aVR	Central Terminal	Right Arm
	aVL		Left Arm
	aVF		Left Leg
Precordial	V1	Central Terminal	4th Right intercostal space parasternal
	V2		4 th left intercostal space parasternal
	V3		Midway between V2 and V4
	V4		5 th intercostal space at left midclavicular line
	V5		Level with V4 at left anterior axillary line
	V6		Level with V5 at left mid axillary line



Guiding words on Hexaxial lead system



Bipolar Limb Electrodes

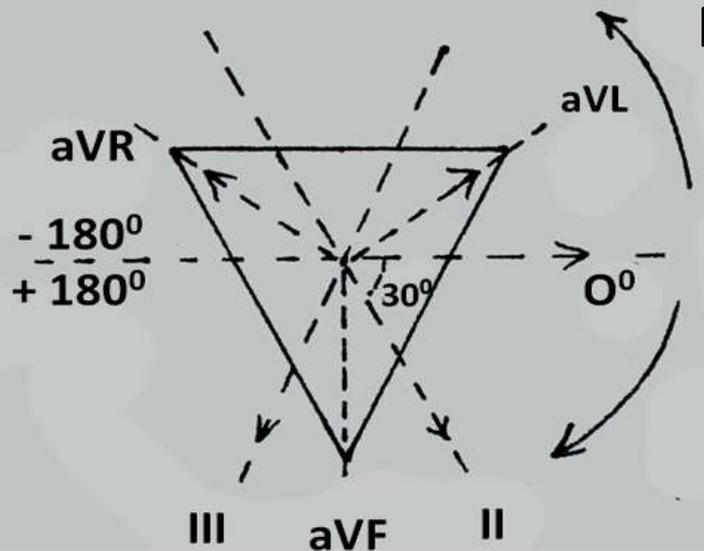
R - L = Lead I

R - F = Lead II

L - F = Lead III

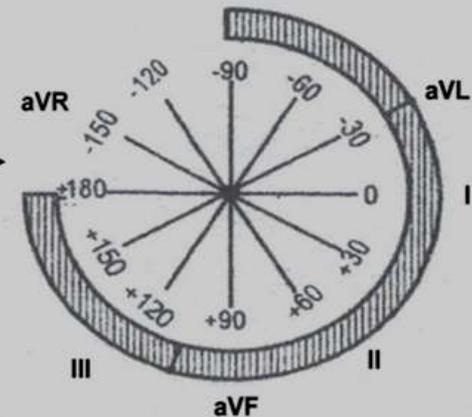
Einthoven's triangle

The manifest potential difference in the heart



Einthoven + E. Goldberger contribution

Rule of 15 cm

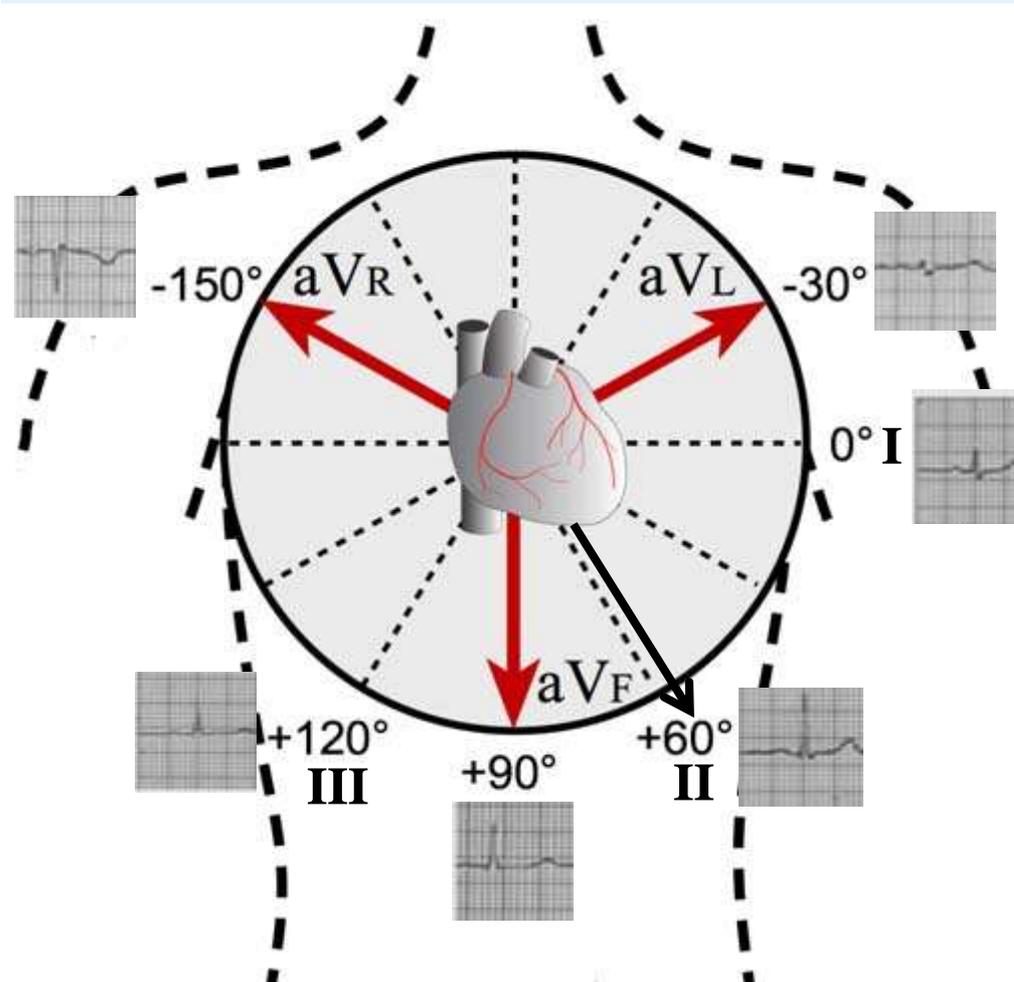


Hexaxial Lead System

The hexaxial system for graphing the electrical axis

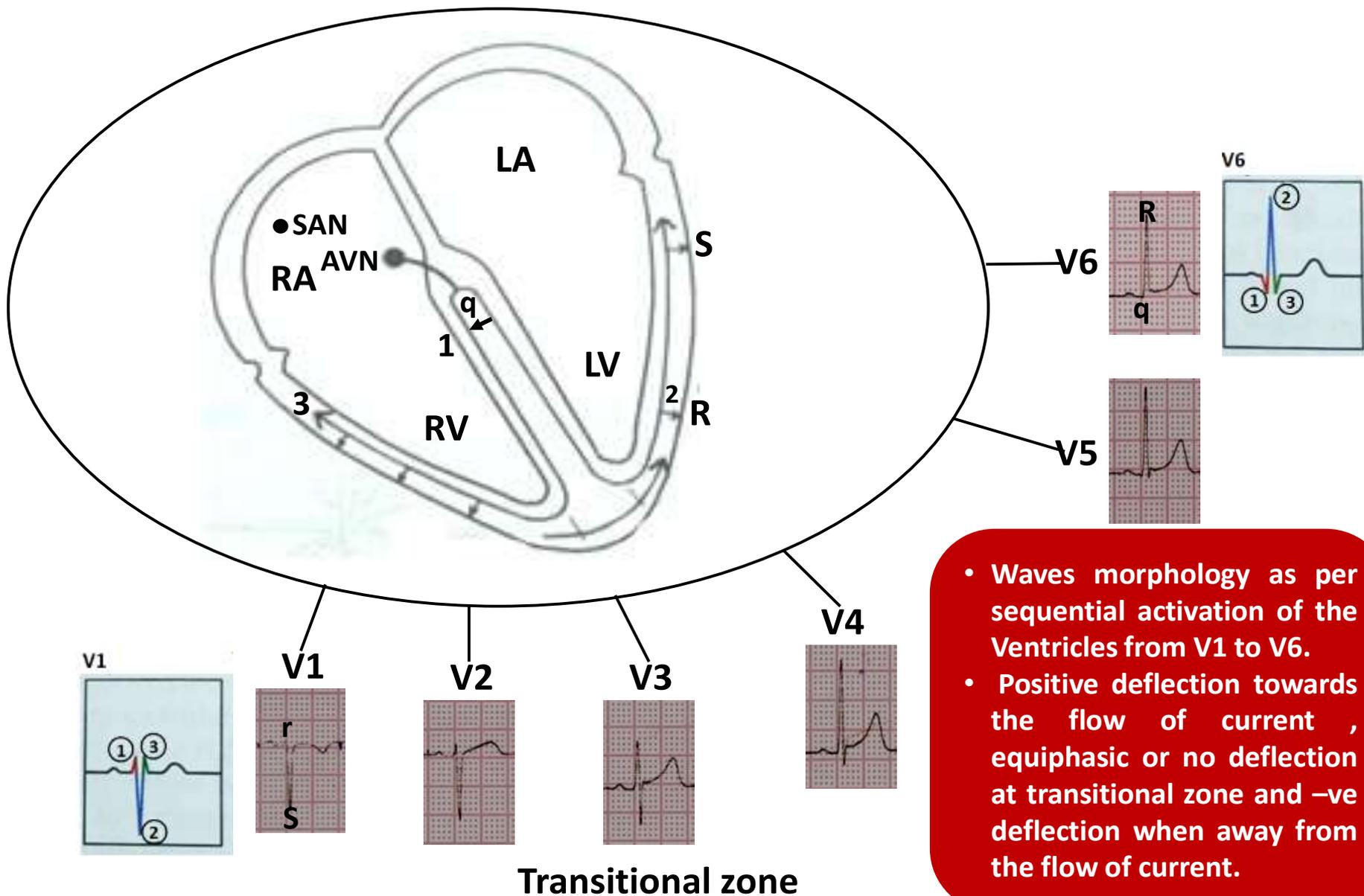
FUNDAMENTAL LAW

Any exploring lead placed within a range of 90° in respect to cardiac axis records positive current, at 90° equiphasic deflection or no deflection or beyond 90° negative deflection.



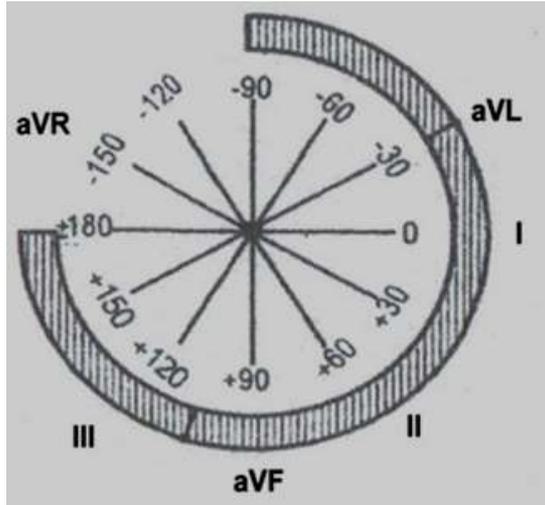
- Normal Axis = -30° to $+90^{\circ}$
- Right Axis Deviation (RAD) = $+90^{\circ}$ to $+180^{\circ}$
- Left Axis Deviation (LAD) = -30° to -90°
- North-West Deviation (NWD) = -90° to -180°

Horizontal plane of ECG recording



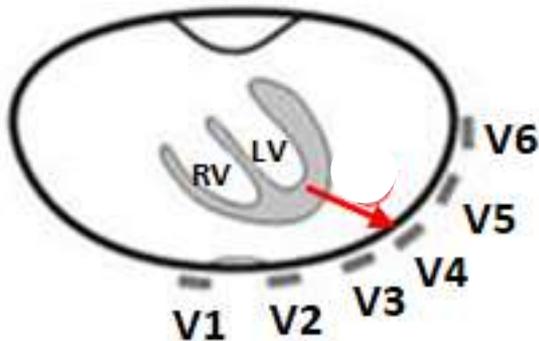
Frontal and horizontal planes combined together 12 lead ECG

(1942 : Dr. Emanuel Goldberger Cardiologist of Lincoln hospital New york unipolar limbs system)

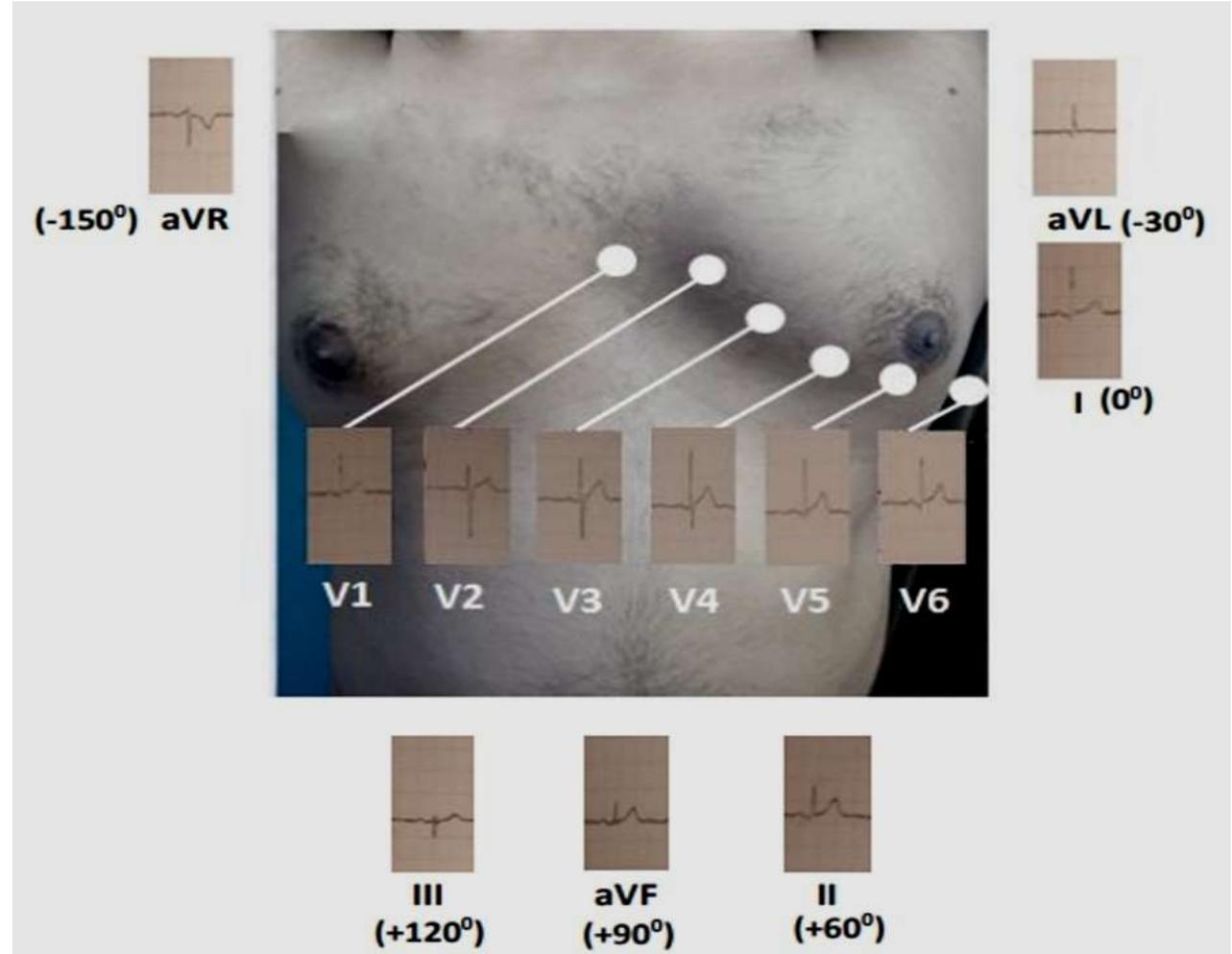


VERTICAL PLANE

Back



HORIZONTAL PLANE



A Bird's Eye View

✓ Paper Speed = 25 mm/sec

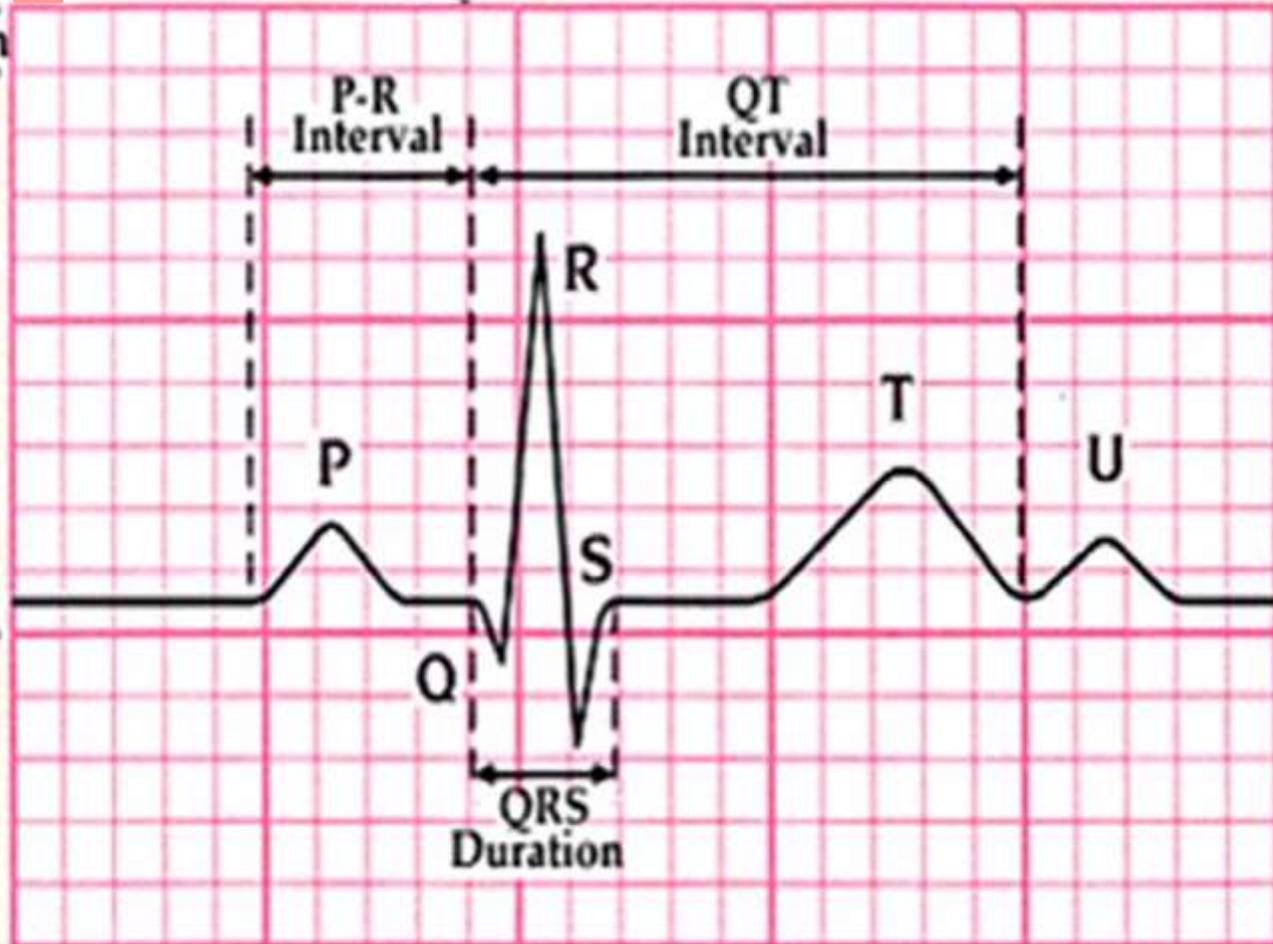
1 mm width = 0.04 sec (small square)

1 mm

0.5 mV

1 mV

✓ standardization
1 mV = 10 mm ht



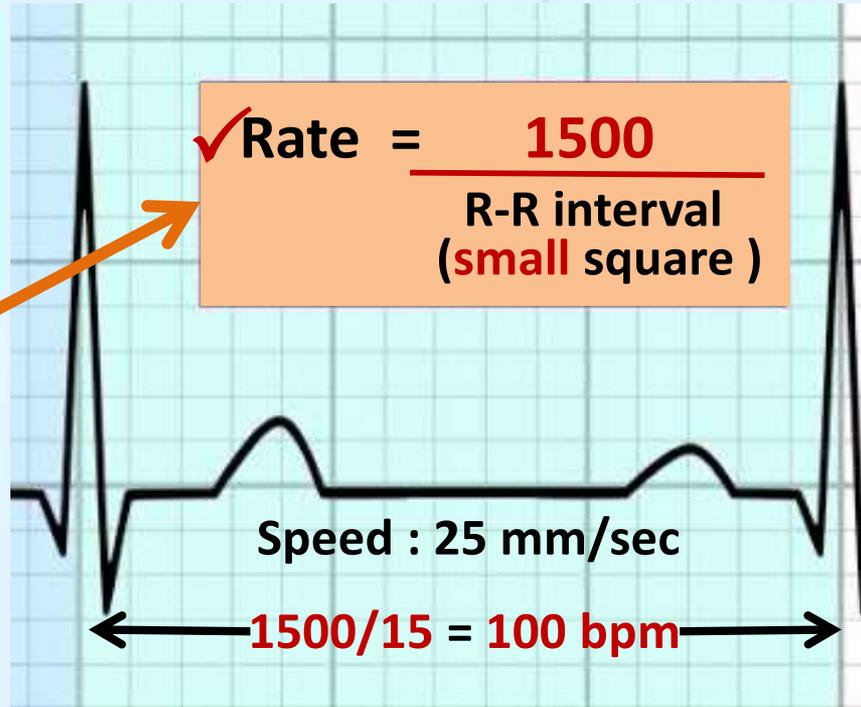
PR interval also includes the conduction through AV node

Heart rate (A rate – V rate)

1 sec = 25 small sq
60 sec (1 min) =
25x60 = **1500** small sq

When the rhythm
is regular

A



Number of small squares in between two corresponding RR

✓ A practical approach

- < 3 big squares = Tachycardia
- >5 big squares = Bradycardia
- Accurate rate calculation by the given formula

- ✓ **B** when rhythm is irregular (e.g., atrial fibrillation) :
Rhythm irregularity is commonly obvious , determine maximum RR interval / minimal RR interval and say , rapidly / slowly conducted



ECG Morphometry

- **P wave** : Normal duration **< 0.12 sec (3 small squares)**
Amplitude **< 2.5 mm in the limb leads**
< 1.5 mm in the precordial leads
- **Q wave** : Pathological Q wave
> 0.04 s wide
> 25% of depth of the QRS complex
Seen in lead V1-3
- **PR interval** : **0.12-0.20 sec**
- **QRS width** : **70-100 ms (sometimes 110 ms)**
- **T wave** :
Amplitude < 5 mm in limb leads , <10 mm in precordial leads
(duration related to QT interval)

Documentation of ECG findings

- **Name / Sex**
 - **Address**
 - **ECG performed on date with timing**
 - **History in brief**
-

Recording of findings as below :

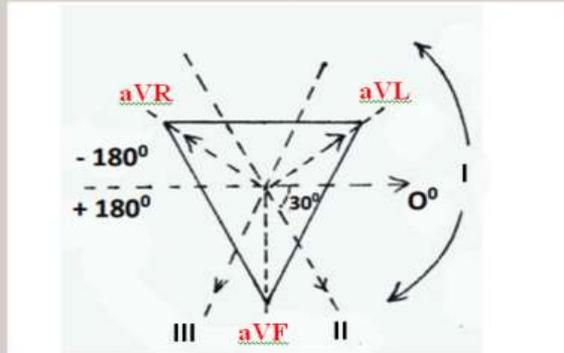
- **Rate**
- **Rhythm**
- **Axis**
- **PR interval**
- **QRS complex**
- **QT interval**
- **ST segment**
- **T wave**

Impression

Doctor's Name with signature

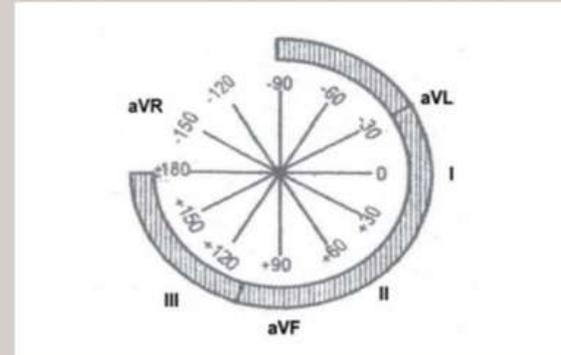
Take Home Message

Einthoven's triangle + Emanuel Augmented Unipolar Leads

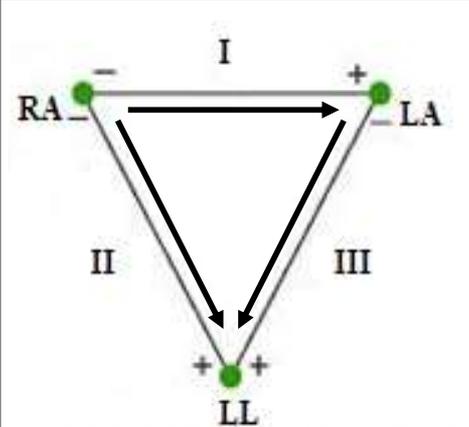


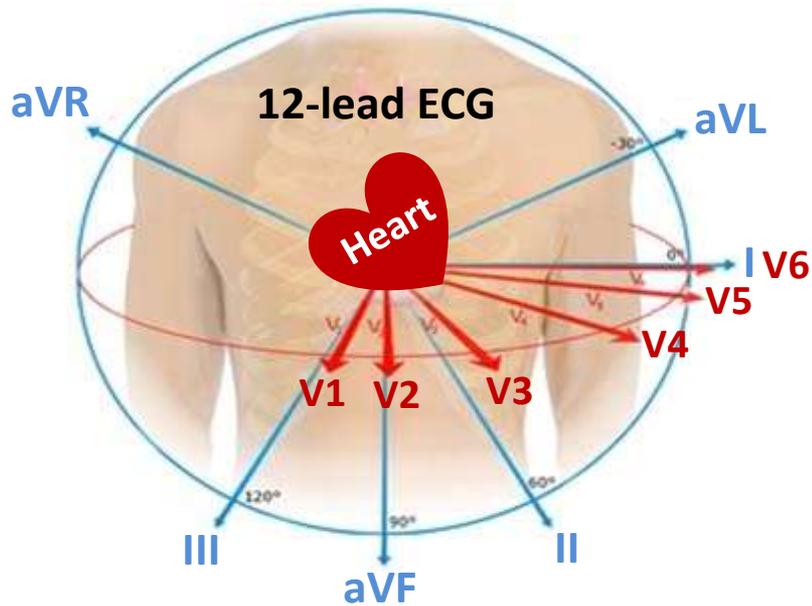
Rule of 15 cm

Hexaxial Lead System



Rule of 90°

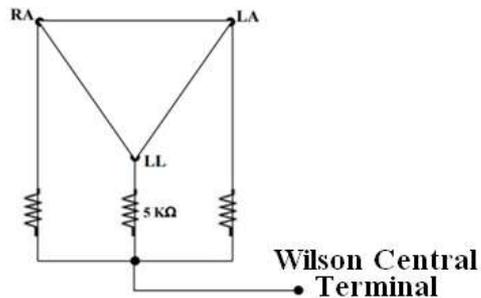
 <p>Einthoven's triangle</p>	Leads	Negative Electrode → Positive Electrode	
	Bipolar I. II. III.	Right Arm Right Arm Left Arm	Left Arm Left Leg Left Leg
Unipolar aVR aVL aVF	Central Terminal	Right Arm Left Arm Left Leg	



Point to be noted

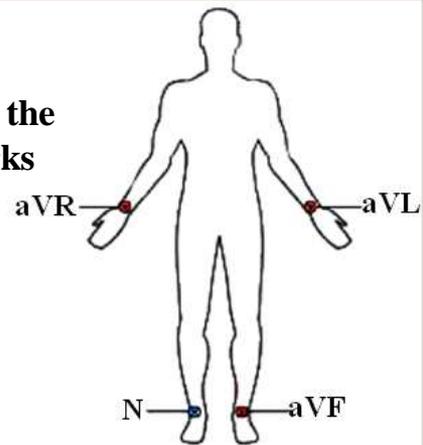
- Flow of current negative to positive pole
- Rule of 90°
- With distances greater than 15 cm from the heart, the decrement in the intensity of the electrical field is hardly noticeable. Consequently, all electrodes placed at a distance greater than 15 cm from the heart may, in an electrical sense, be considered to be equidistant from the heart

Wilson Central Terminal (1932)



Goldberger Central Terminal = Wilson central terminal without 5 K Ω resistance

The lead connected to the right leg works as a neutral lead just to complete the electrical circuit.



Thanks

