SNS COLLEGE OF ALLIED HEALTH SCIENCES

SNS Kalvi Nagar, Coimbatore - 35

Affiliated to Dr MGR Medical University, Chennai

DEPARTMENT OF CARDIAC TECHNOLOGY- I YEAR

PAPER III- Basic Electrocardiography

UNIT II : CARDIAC ELECTRIC FIELD GENERATION AND HEXAXIAL REFERENCE

ELECTROCARDIOGRAM

1. Introduction
2. History
3. Technical Aspects
4. Normal Electrocardiogram
5. Physiological Basis
6. Systematic Interpretation
7. Clinical Applications

Introduction

- Definition:

Electrocardiogram is the graphic record of electrical activities of the heart obtained by placing electrodes on the surface of the body that records the voltage differences generated by the heart.

- Electrocardiography
- Electrocardiograph
- Electrocardiogram

History

- Word Electrocardiogram is derived from Greek meaning:

  Electro- related to electrical activity

  Cardio(kardio)- heart

  Graph- to write

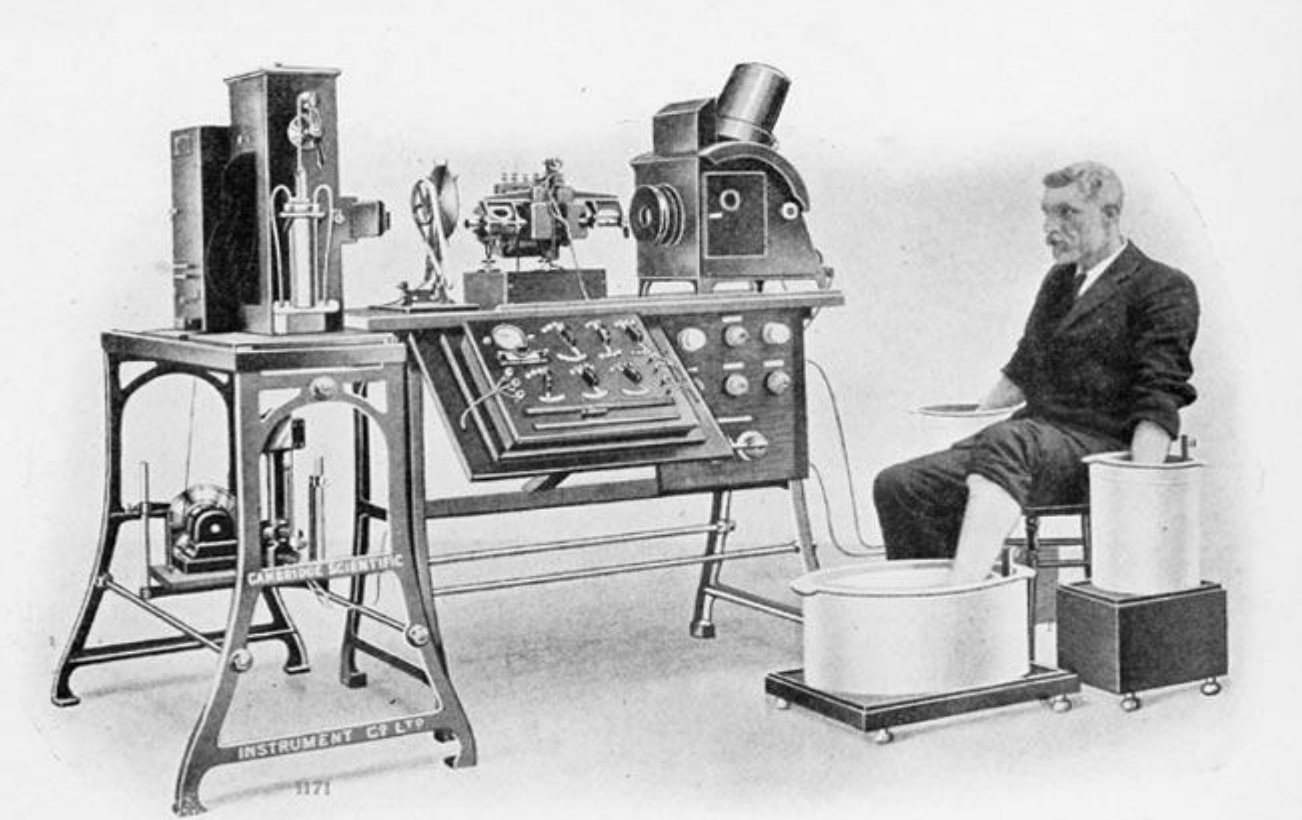
Augustus Desiré Waller (1856 –1922)

- First to record electrical potential associated with beating heart from the human body surface (1887-1888).

Willem Einthoven (1860-1927)

- Invented string galvanometer in 1901.
- In 1924, he was awarded Nobel prize for inventing the first practical system of electrocardiography.

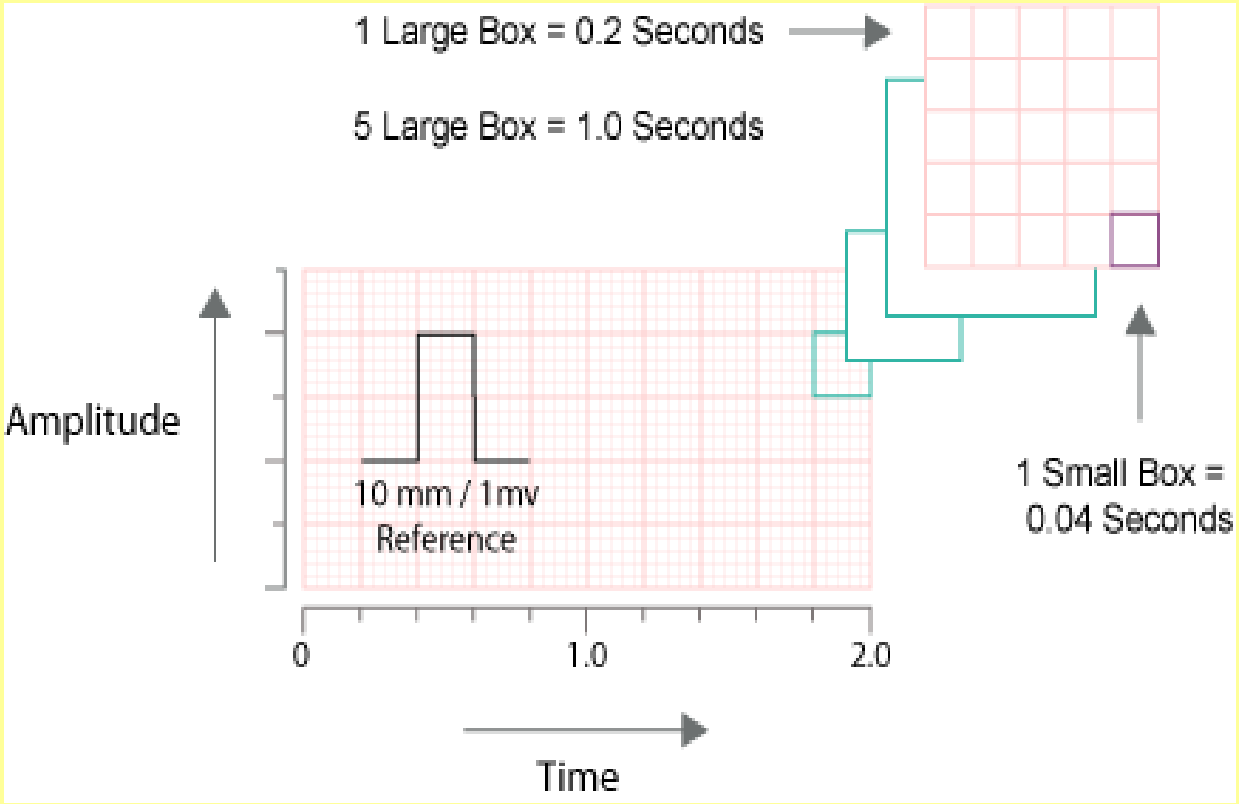
An early ECG device



PHOTOGRAPH OF A COMPLETE ELECTROCARDIOGRAPH, SHOWING THE MANNER IN WHICH THE ELECTRODES ARE ATTACHED TO THE PATIENT, IN THIS CASE THE HANDS AND ONE FOOT BEING IMMERSED IN JARS OF SALT SOLUTION

Technical Aspects

ECG paper


1 Large Box = 0.2 Seconds
5 Large Box = 1.0 Seconds
Amplitude
10 mm / 1mv
Reference
1 Small Box =
0.04 Seconds
0
1.0
2.0
Time

ECG leads

- Direct leads
- Indirect leads
  - Limb leads
  - Chest leads
  - Esophageal leads

ECG leads

- Limb leads: Bipolar & Unipolar Leads
  - ❖Lie in frontal plane

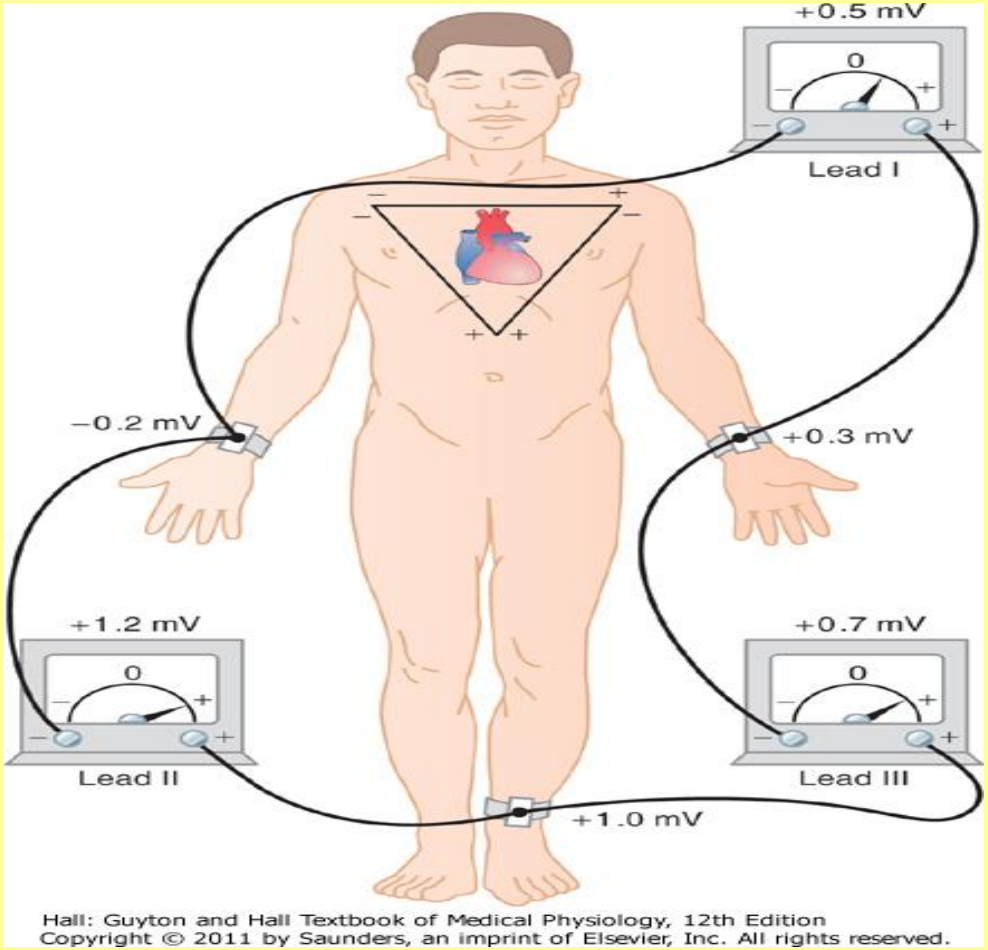
Bipolar leads

Lead I- between right arm(-ve) and left arm(+ve)

Lead II- between right arm(-ve) and left leg(+ve)

Lead III- between left arm(-ve) and left leg (+ve)

Einthoven Triangle



Einthoven's Law

- If the electrical potentials of any two of the three bipolar limb electrocardiographic leads are known at any given instant, the third one can be determined mathematically by summing the first two.
- The positive and negative signs of the different leads must be observed when making this summation.

- According to Kirchoff's law:

  L I+L II+L III=0

- Einthoven deliberately reversed lead II to get positive QRS deflections in all three leads.
- With Einthoven's system Kirchoff's law becomes

  L I-L II+L III=0 (or)

  L I+L III=L II

Unipolar Leads

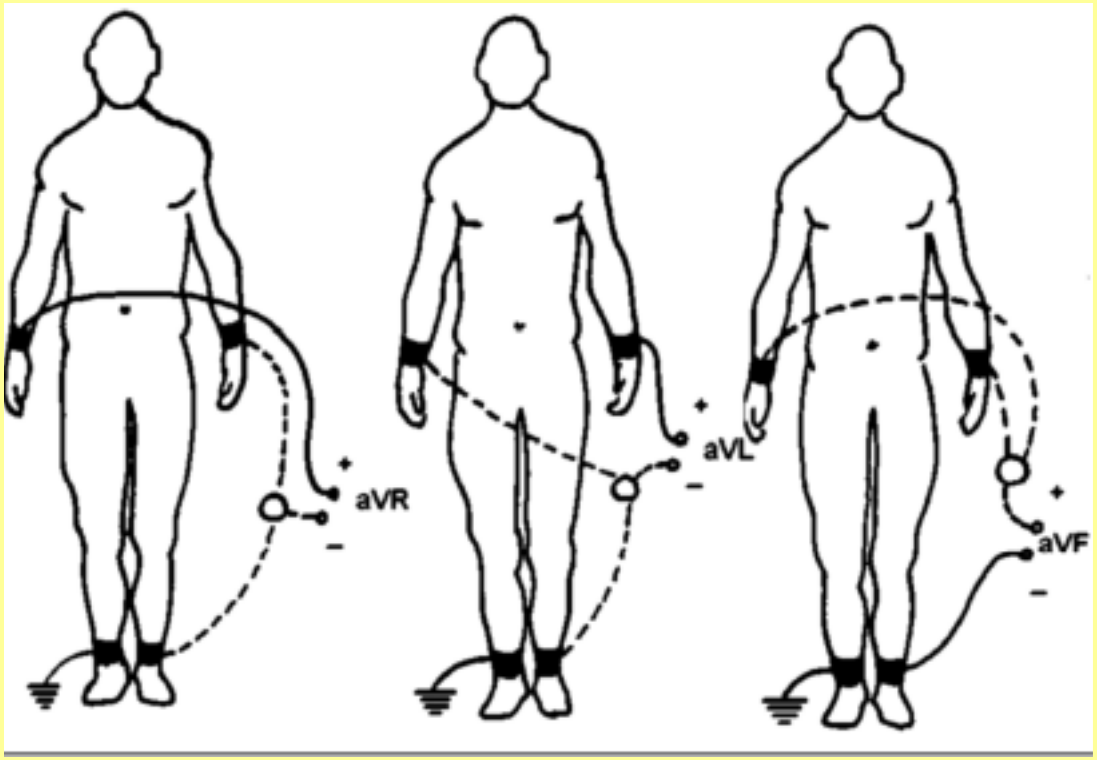
- Unipolar limb leads (Wilson leads)
  - VR,VL,VF
- Augmented limb leads
- Unipolar chest leads

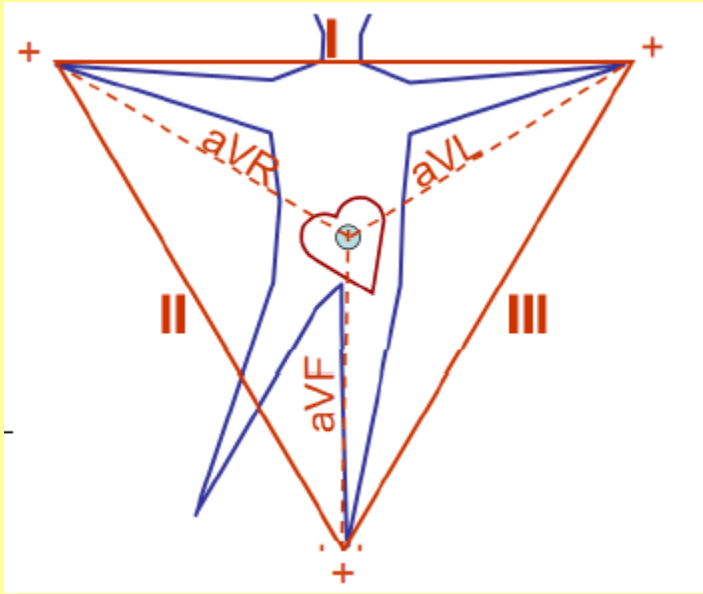
Augmented Limb Leads

- aVR, aVL and aVF

Active electrode	Indifferent electrode	Lead
RA	LA & LF	aVR
LA	RA & LF	aVL
LF	RA & LA	aVF

Augmented Limb Leads





Unipolar Chest Leads (Precordial leads)

- Lie in transverse plane or horizontal plane

❑ Usually six standard chest leads are recorded:

V1: 4th intercostal space to the right of the sternum

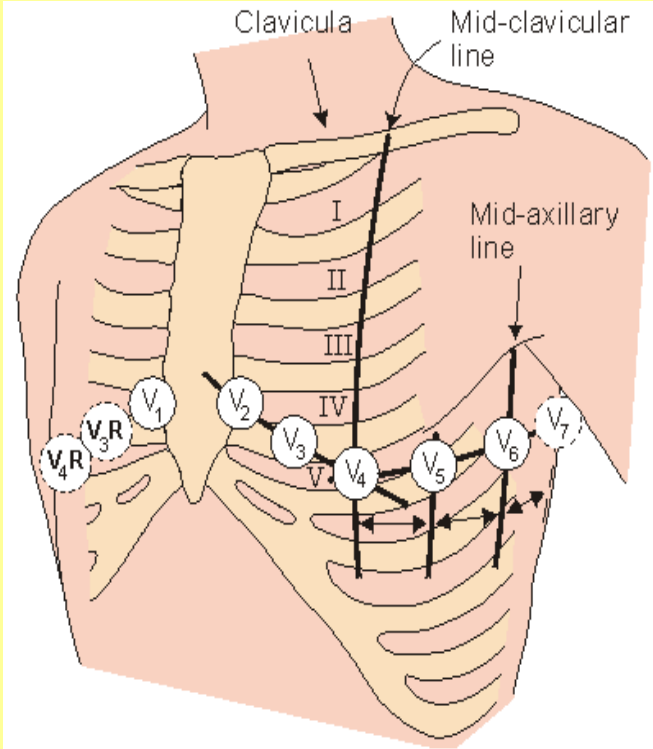
V2: 4th intercostal space to the left of the sternum

V3: halfway between V2 and V4

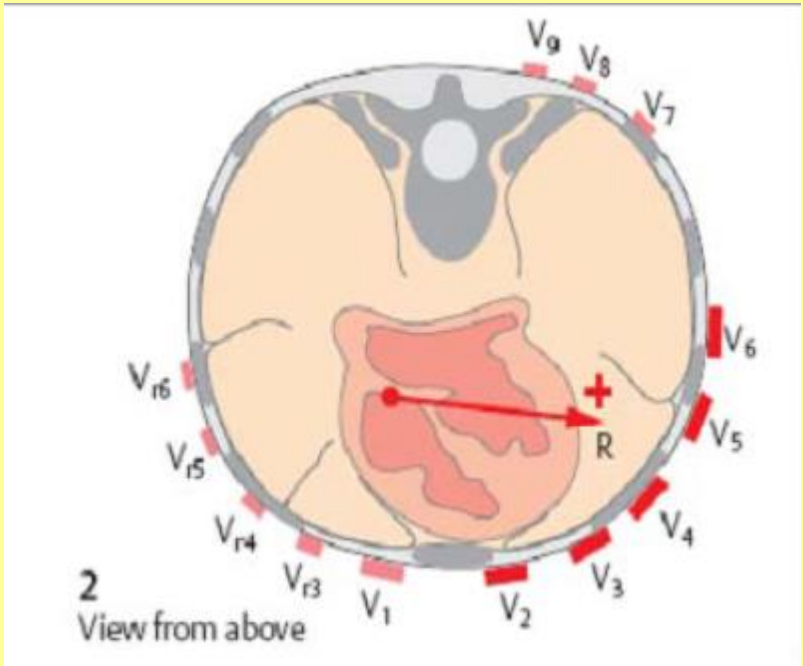
V4: 5th intercostal space at the midclavicular line

V5: halfway between V4 and V6

V6: 5th intercostal space at the midaxillary line



Special Leads



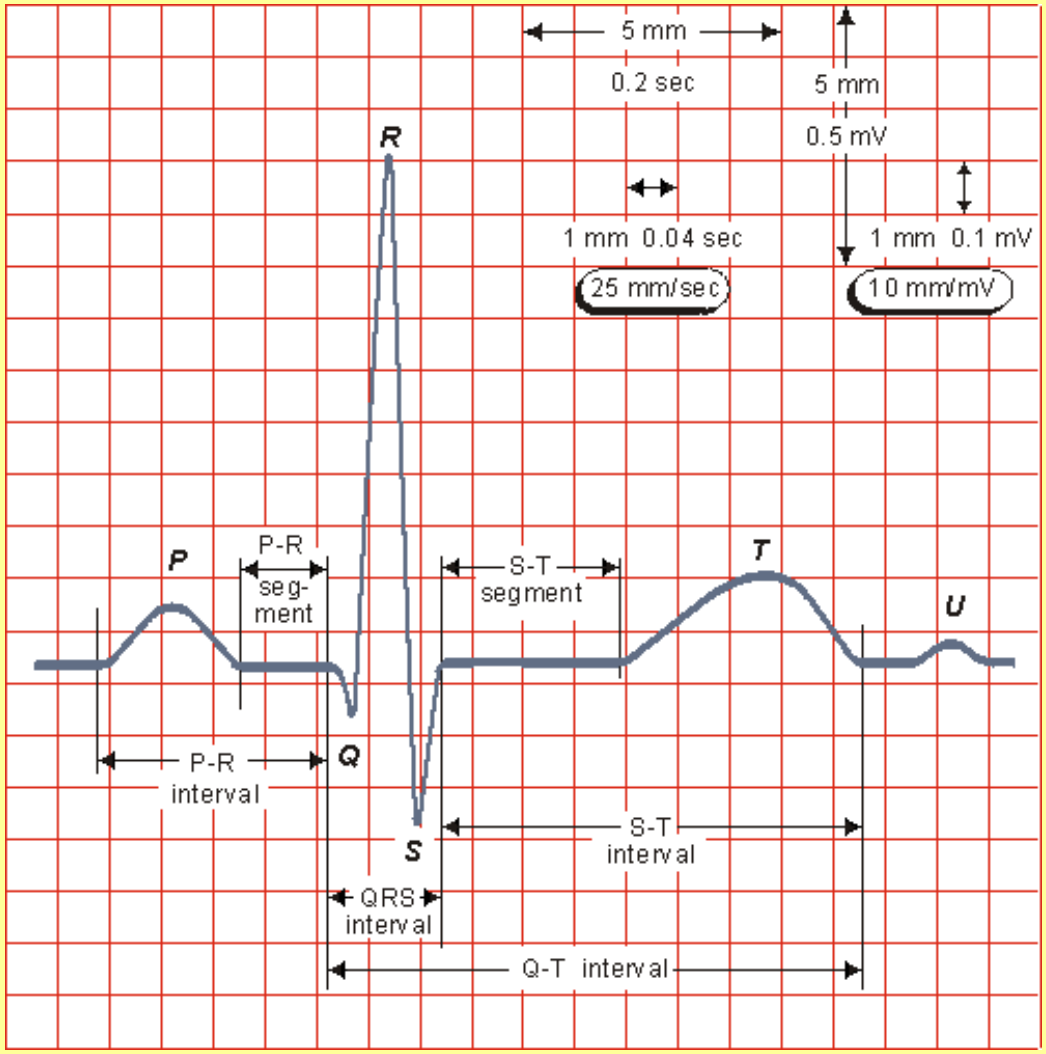
- V7- left 5th intercostal space on the posterior axillary line.
- V8- left 5th intercostal space on the posterior scapular line
- V9- left 5th intercostal space on the back at the left border of spine
- Right sided ECG: V2 and V1 remain in the same place.
- V3R to V6R placed on the same place as V3 to V6 but on the right side of chest.
- Intracardiac leads (Endocardiac leads)

Esophageal leads

- E15-25 : Record the activity of right atrium
- E25-35 : Record the activity from AV groove region
- E40-50 : Record the activity from posterior surface of left ventricle

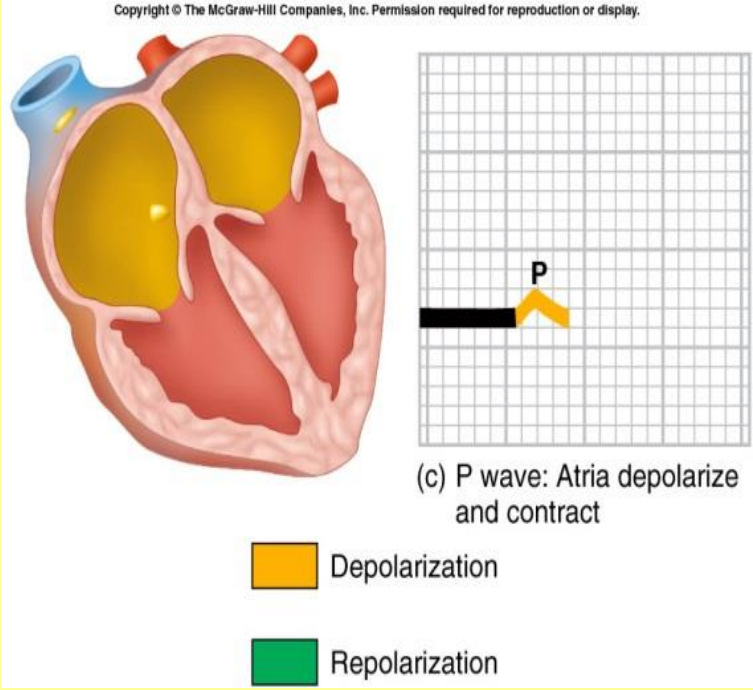
Normal electrocardiogram

Normal electrocardiogram



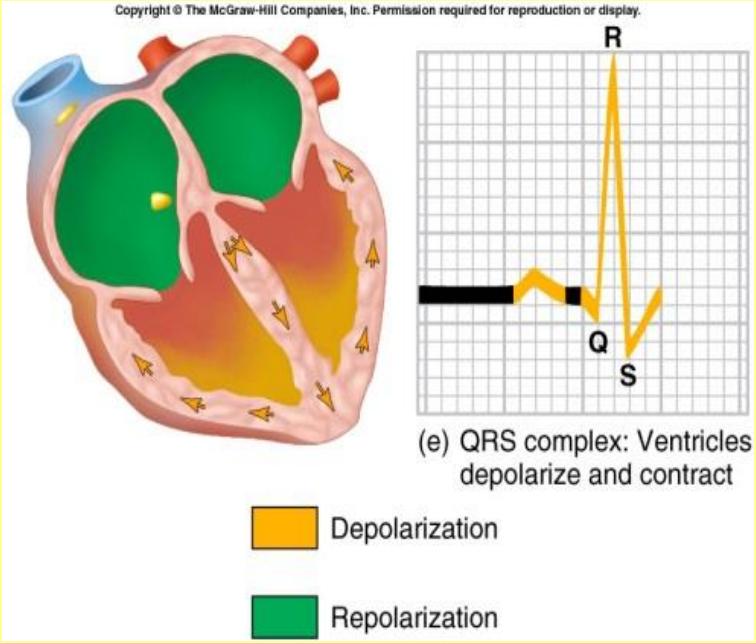
P Wave

- First positive deflection
- Represents atrial depolarization
- Normal duration 0.08- 0.12sec
- Amplitude: 0.1- 0.3mV
- Less height & dome shaped



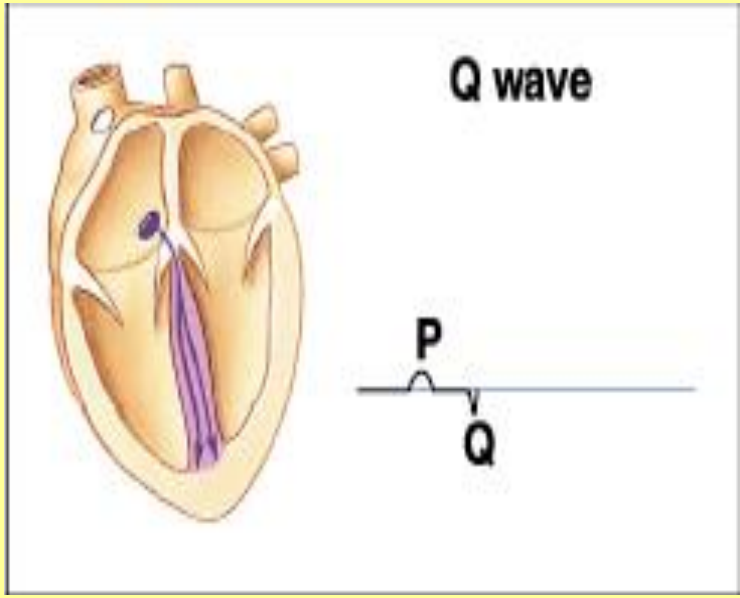
QRS Complex

- Consists of 3 waves: Q, R and S
- Represents ventricular depolarization
- Normal duration:0.08- 0.12sec
- Amplitude: 0.7- 4mV



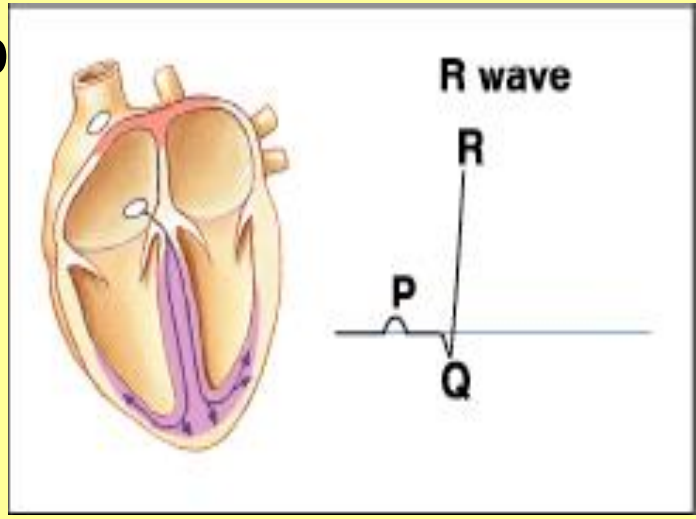
Q Wave

- Initial negative deflection
- Represents septal depolarization
- Small downward sharp wave
- Absent in right ventricular leads
- Present in all bipolar leads



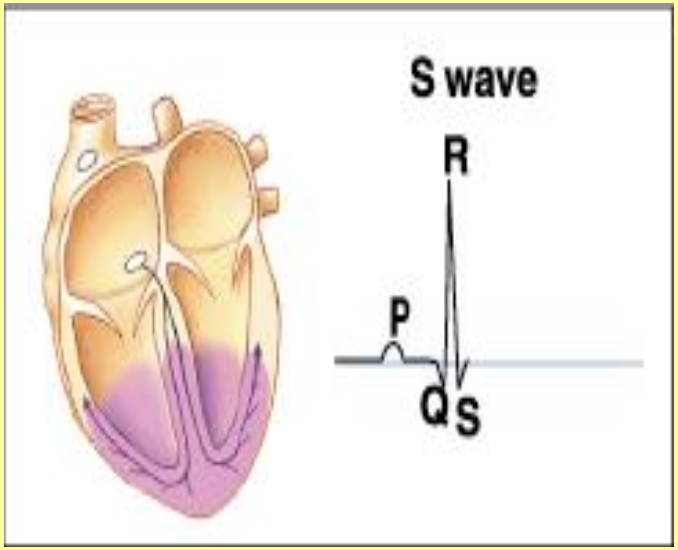
R Wave

- Is the positive deflection in QRS comp
- It is due to potential travelling to the apex of the ventricle
- Is an upward bigger sharp wave
- Peak of R wave is the safest period as ventricle is in absolute refractory period



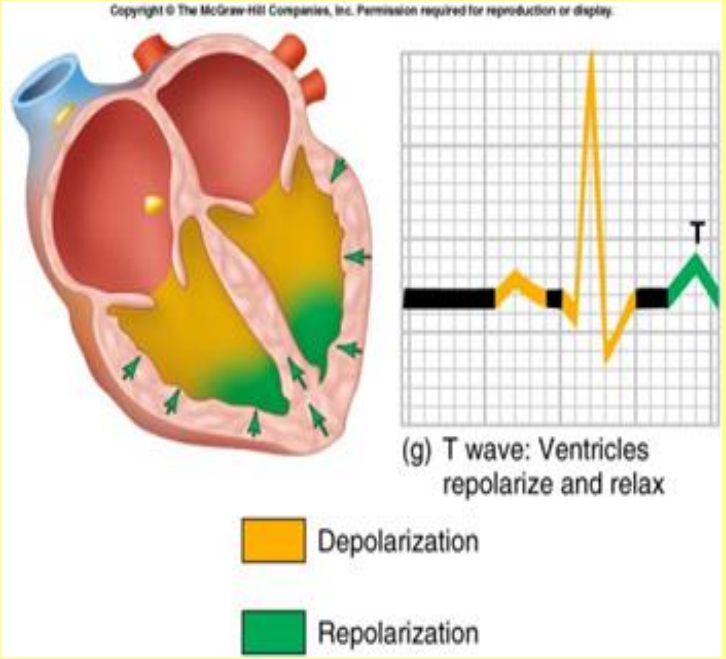
S Wave

- Is the second negative deflection in QRS complex
- It is due to potential travelling to the base of the ventricles
- Is a small negative sharp wave

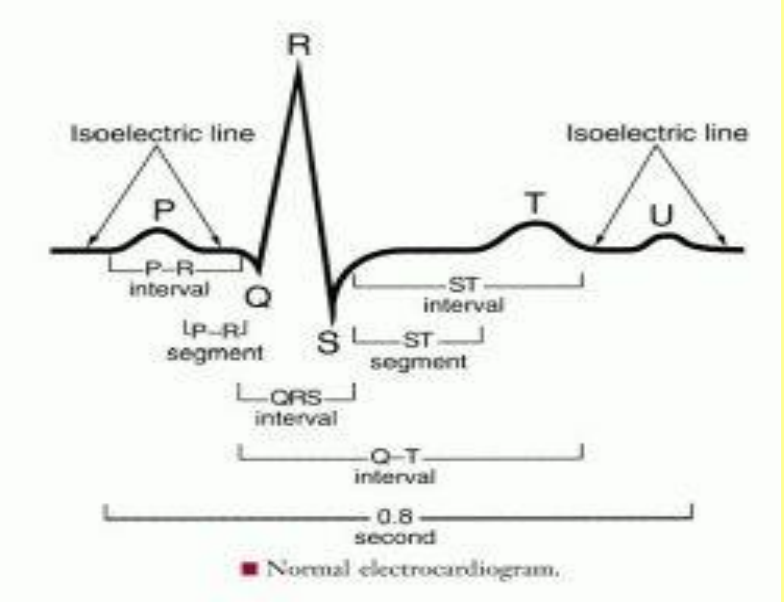


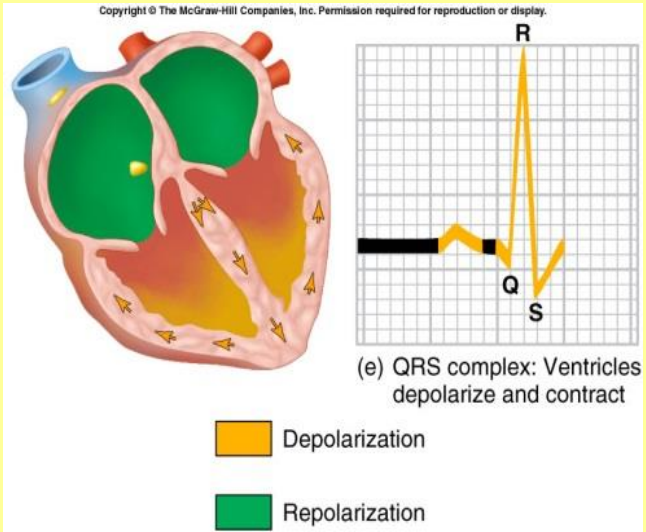
T wave

- Is the positive wave following S wave
- Represents ventricular repolarization
- Is a dome shape positive wave of longer duration
- Normal duration: 0.27sec
- Amplitude is 0.15- 0.5 mV



- Isoelectric period
- U wave
  - Is the final positive deflection
  - Is due to slow repolarization of papillary muscle
- Atrial repolarization

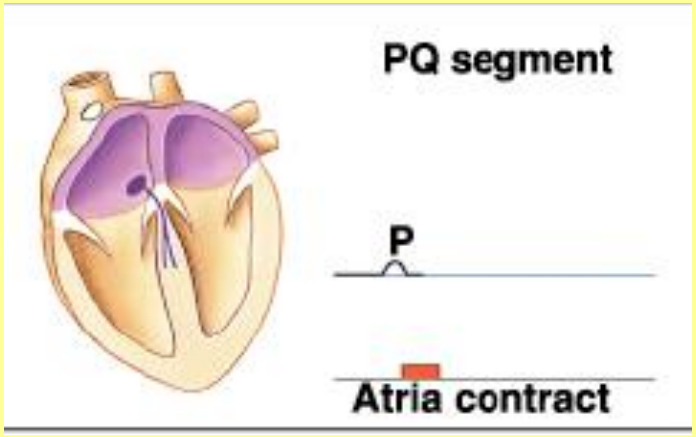




ECG Segments

- PR segment

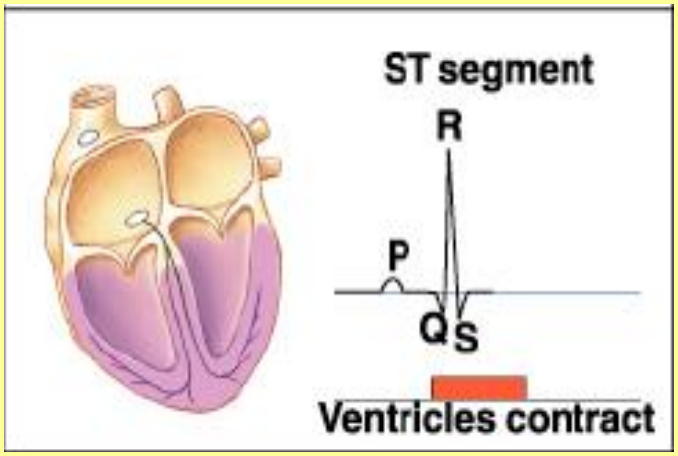
It denotes the time interval between completion of atrial depolarization and beginning of ventricular depolarization



- ST segment

Indicates completion of depolarization of the ventricle

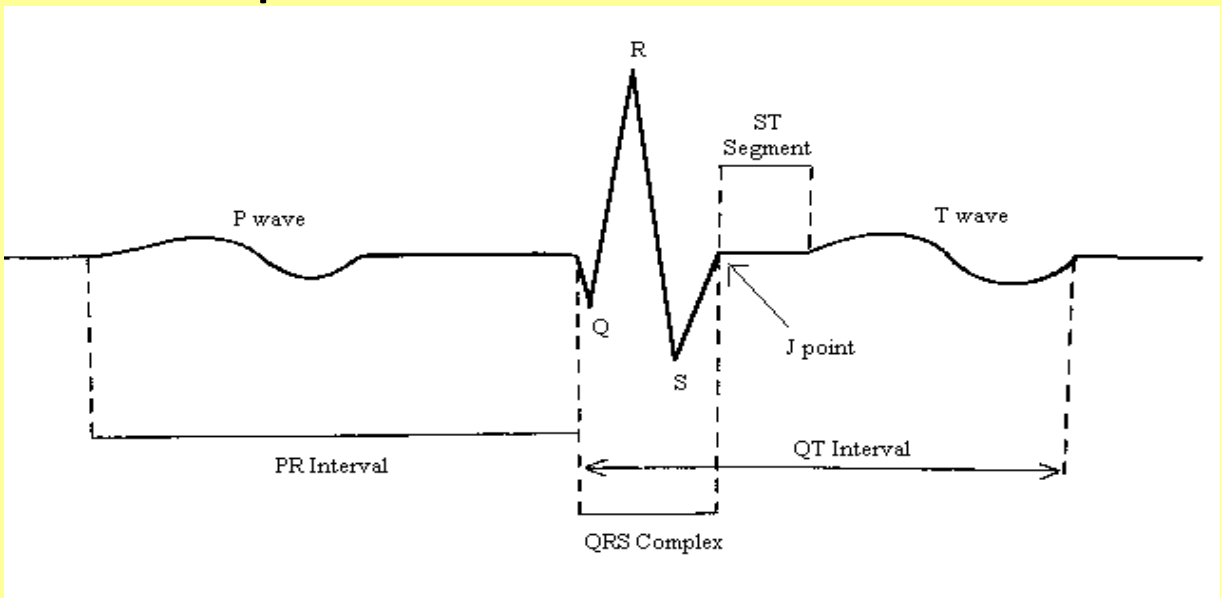
Average duration is 0.05sec



J point

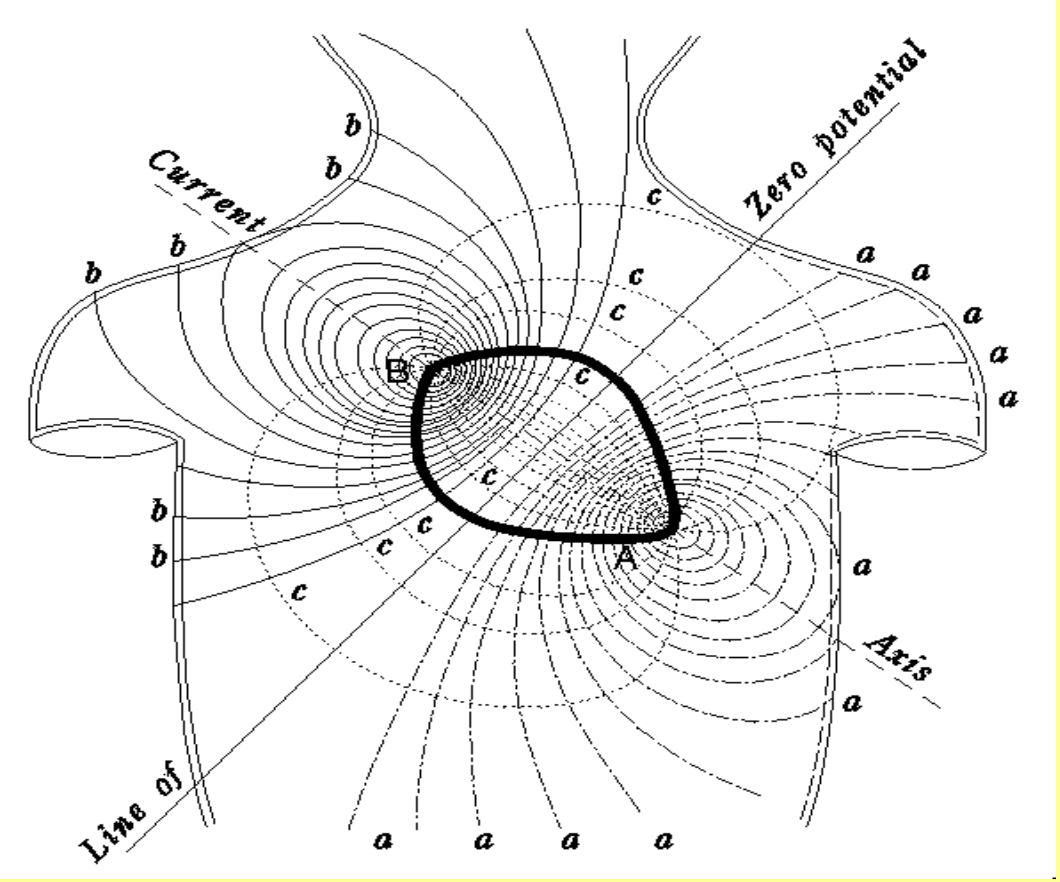
Is the point at which

- The S wave ends and the ST segment begins
- Ventricular depolarization ends and all parts of the ventricle are in depolarization



Physiological Basis

Electric field of the heart on the surface of the thorax, recorded by Augustus Waller (1887).



The curves (a) and (b) represent the recorded positive and negative isopotential lines, respectively.

These indicate that the heart is a dipolar source having the positive and negative poles at (A) and (B), respectively.

The curves (c) represent the assumed current flow lines..

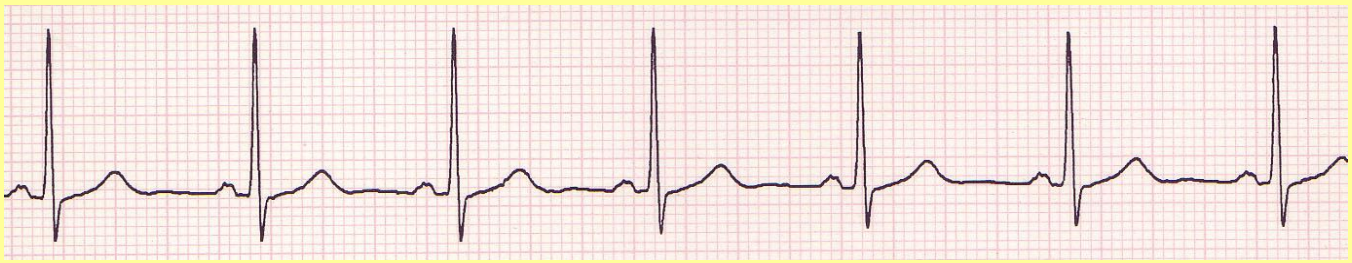
Systematic interpretation

Heart Rate

- If the heart rate is regular
  - Rate = 300/No. of large squares in RR interval
  - Rate = 1500/No. of small squares in RR interval

Cardiac rhythm

- Normal rhythm is regular



Waves and Intervals

- P wave
  - Does not exceed 0.10s in duration or 2.5mm in height
  - Abnormal in atrial enlargement (tall peaked P wave) and intra-atrial conduction abnormalities

Waves and Intervals

- PR Interval

  Normal PR interval is 0.12 to 0.20secs

QRS Complex

- Amplitude

  In limb leads should be 5mm or more

  In chest leads should be 10mm or more

- Low amplitude
  - ✓ Marked emphysema
  - ✓ Pericardial effusion
  - ✓ Cardiomyopathy
- High amplitude
  - ✓ Ventricular hypertrophy

Q wave

- Small in L I, aVL, V5, V6
- Deep in lead III
- Pathological Q waves
  - ✓Acute or old MI
  - ✓Unstable angina
  - ✓Dilated cardiomyopathy
  - ✓Hypertrophic cardiomyopathy

ST Segment

- Normal ST segment is isoelectric
- ST elevation is upto 1mm in limb leads & V5 & V6 and 2mm in V1- V4 is normal
- ST depression < 0.5mm is not abnormal
- ST elevation
  - ✓Acute MI
  - ✓Acute pericarditis
- ST depression
  - ✓Myocardial ischemia

T Wave

- Upright in L I, II, V4- V6; inverted in aVR
- Upright, inverted or biphasic in L III, aVL, aVF, V1- V3
- Tall T Wave
  - ✓ Hyperkalemia
  - ✓ Acute MI
- Inverted T Wave

Physiological	*Pathological*
✓ Young Children	Ventricular Hypertrophy
✓ Deep Inspiration(sometimes)	Bundle Branch Block
✓ After Heavy Meals	Digitalis Effect
	Myocardial Ischemia

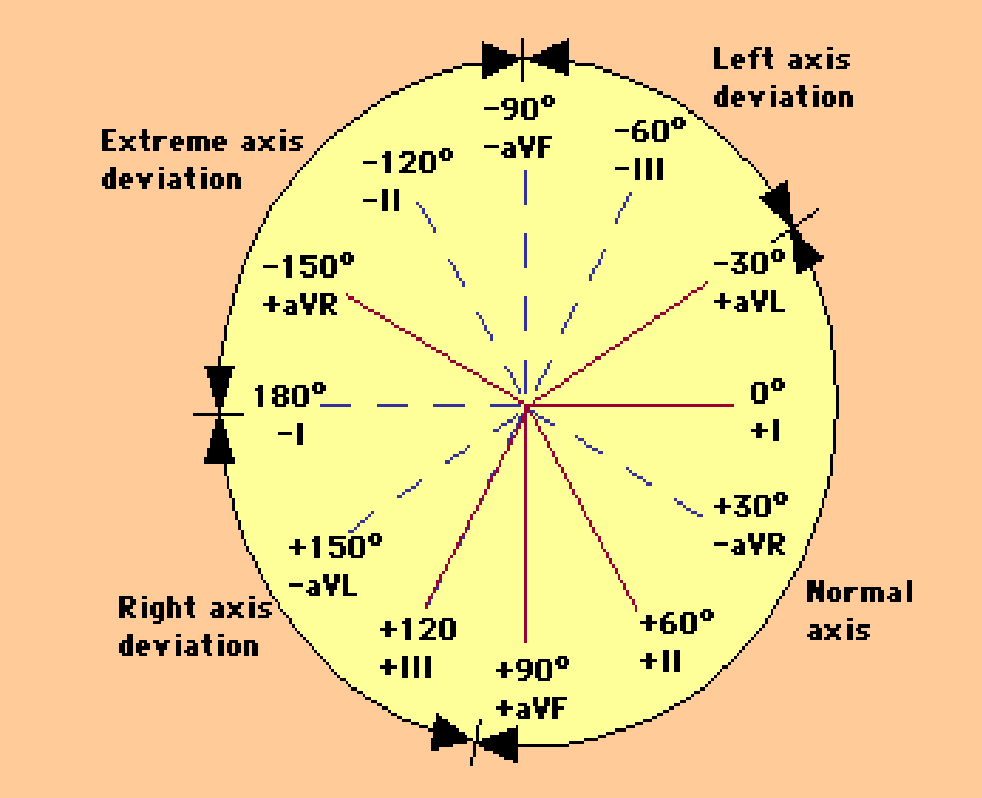
Mean QRS Axis

- Is the magnitude and direction of mean cardiac dipole (vector)
- Normal mean cardiac vector ranges between -30^0 to $+110^0$
- Less than -30^0 indicates left axis deviation and more than $+110^0$ indicates right axis deviation

Factors affecting mean cardiac vector

- ✓ Position of heart
- ✓ Properties of conducting system
- ✓ Electrical properties of ventricular myocardium
- ✓ Muscle mass of each ventricle

Mean QRS Axis



Abnormal Axis Deviations

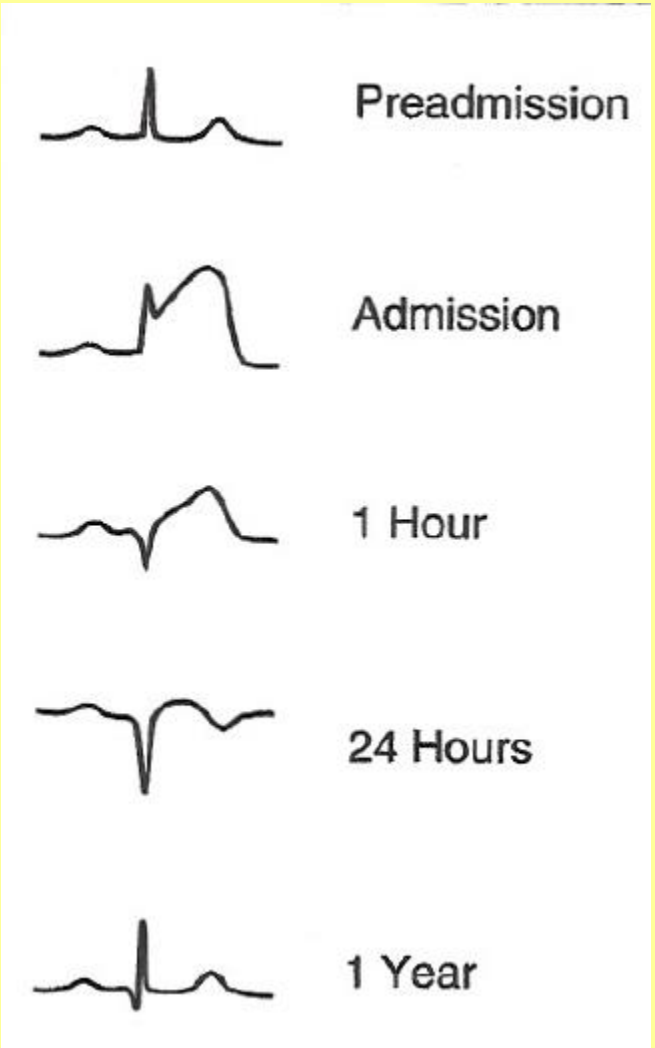
- Right axis deviation
  - ✓ Right ventricular hypertrophy
  - ✓ Left posterior hemiblock
  - ✓ WPW syndrome
  - ✓ Dextrocardia
- Left axis deviation
  - ✓ Left ventricular hypertrophy
  - ✓ Left anterior hemiblock
  - ✓ WPW syndrome
  - ✓ Inferior MI
  - ✓ Obstructive airway disease

Clinical applications

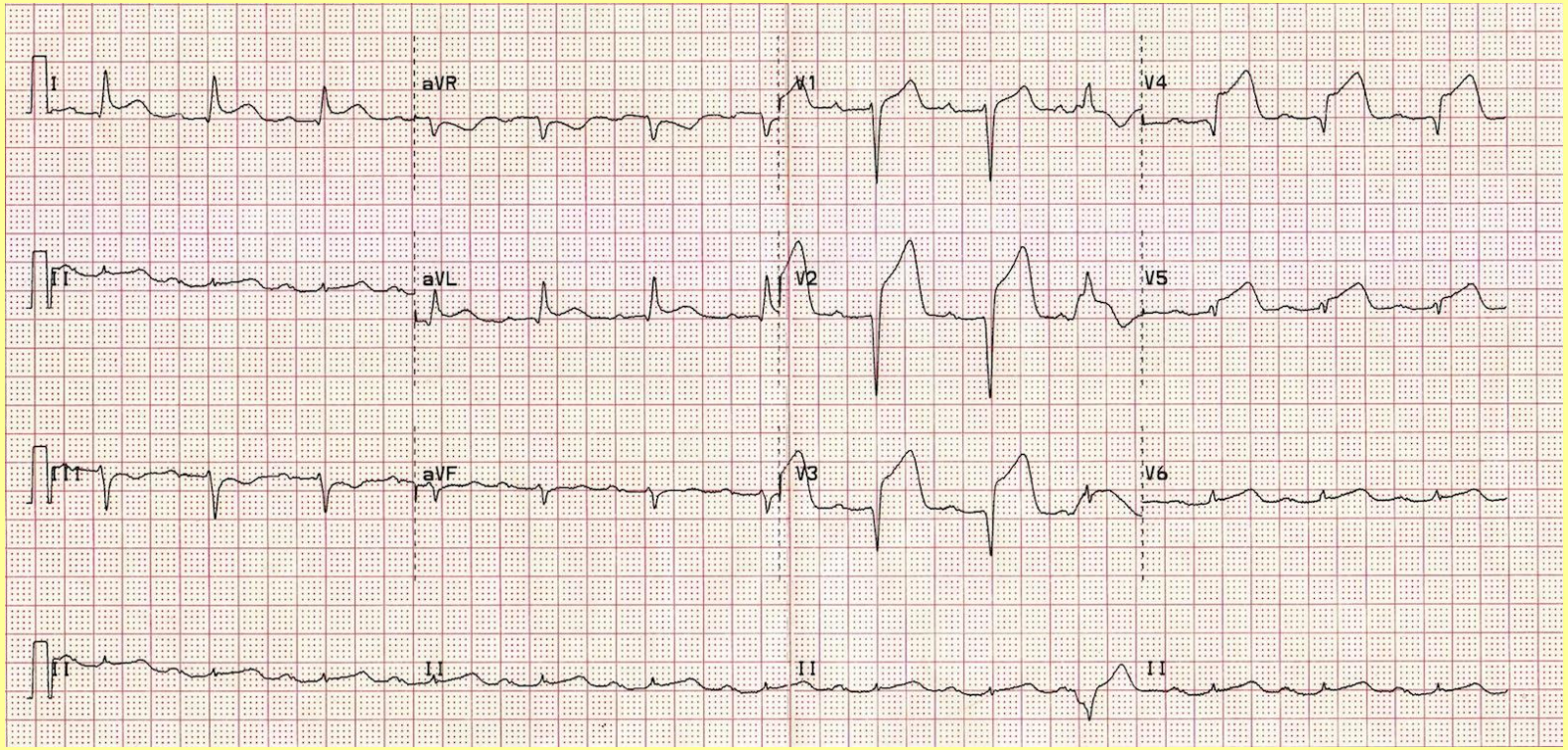
- ECG is useful in diagnosis, assessment of prognosis and management of the following conditions
  - ✓ Cardiac arrhythmias
  - ✓ Abnormalities of myocardium
  - ✓ Anatomical orientation of the heart
  - ✓ Electrolyte imbalance
  - ✓ Assessment of toxic effects of drugs acting on the heart
  - ✓ Conduction defects
  - ✓ Chamber hypertrophy
  - ✓ Myocarditis and cardiomyopathies
  - ✓ Cardiac involvement secondary to other diseases

Hallmark of Infarction

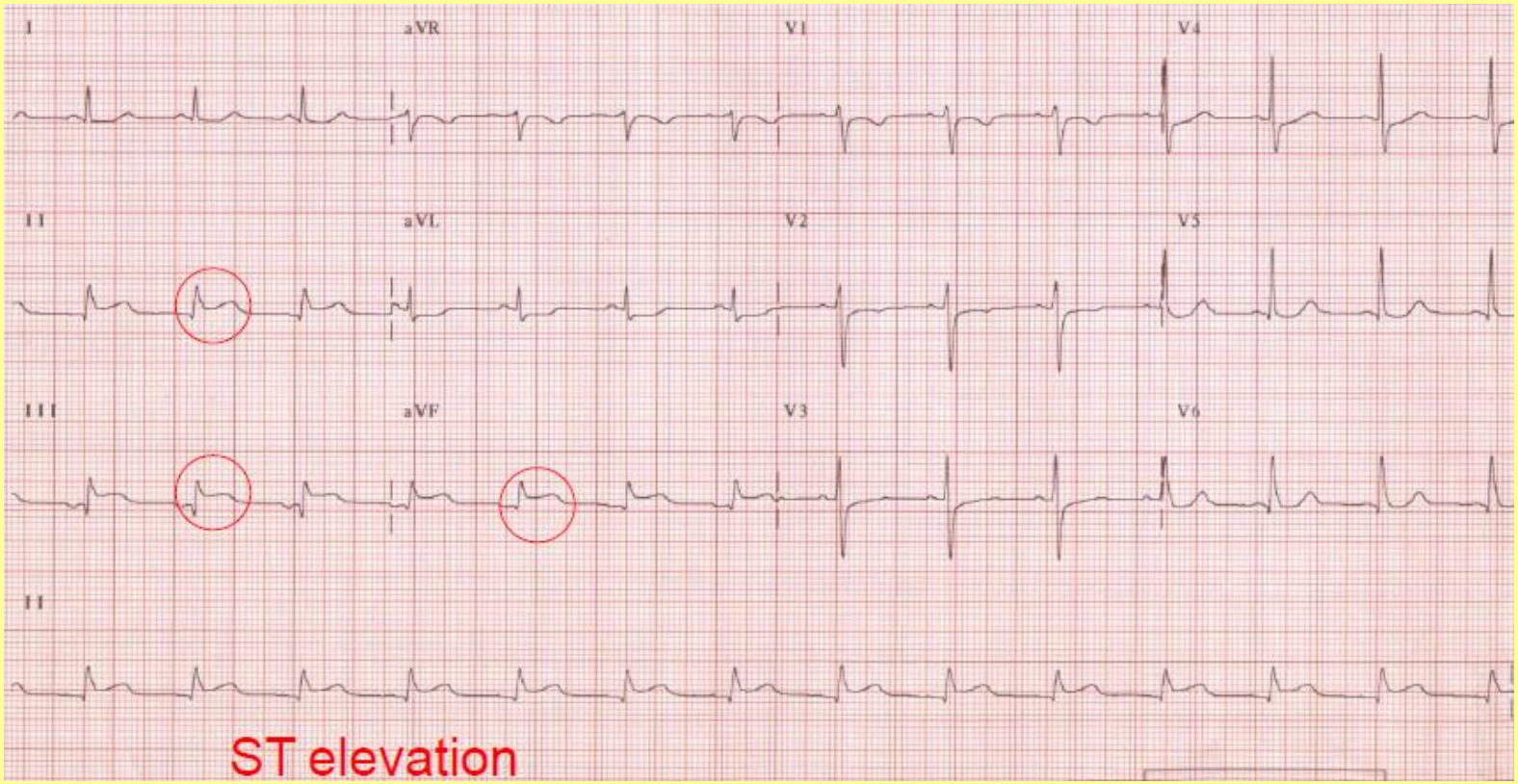
- ST elevation
- T wave inversion
- Q wave formation



Anterior wall MI

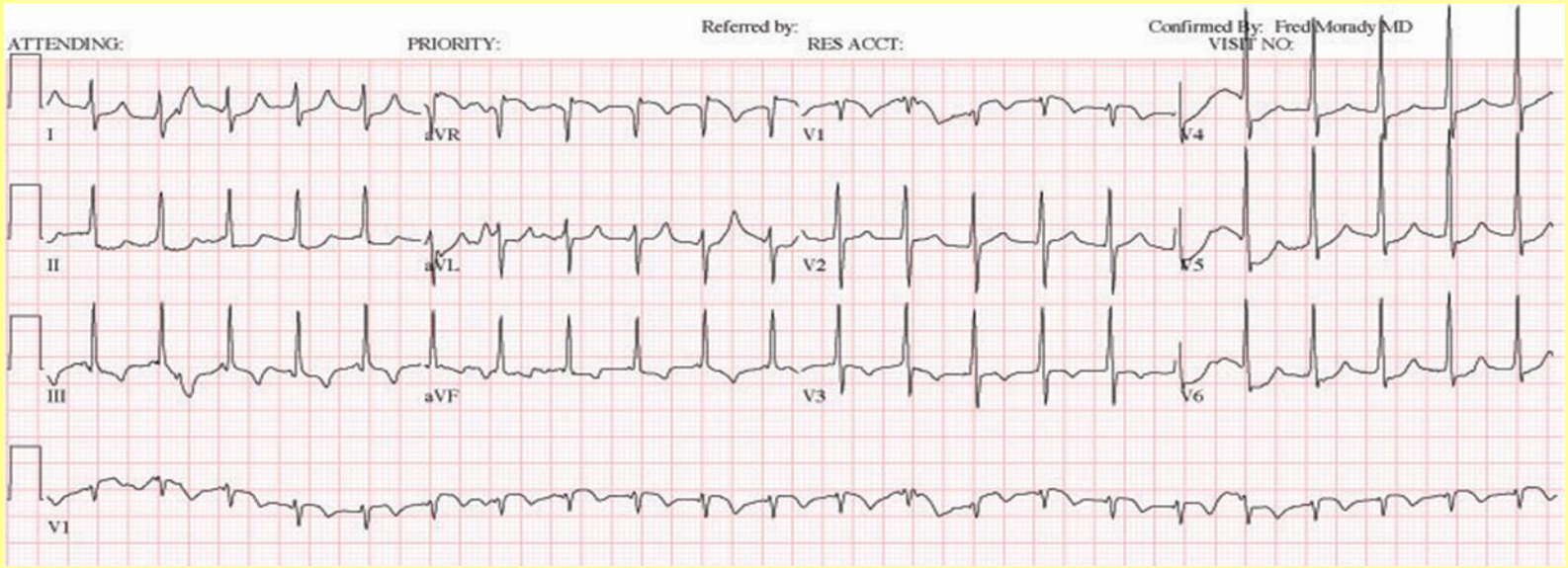


Inferior wall MI



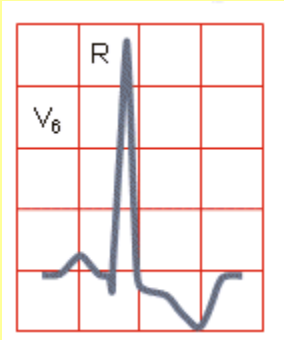
Ventricular Hypertrophy

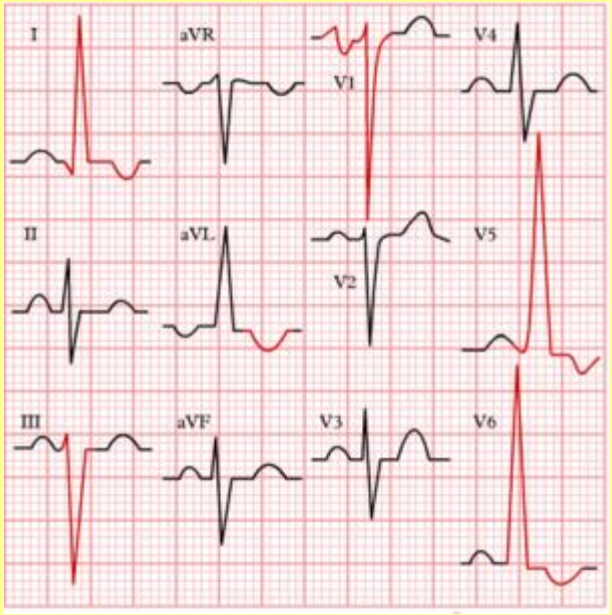
- Right ventricular hypertrophy
  - ✓ Mean QRS vector deviates to right
  - ✓ R waves is high in amplitude in V1(5mm more than normal)

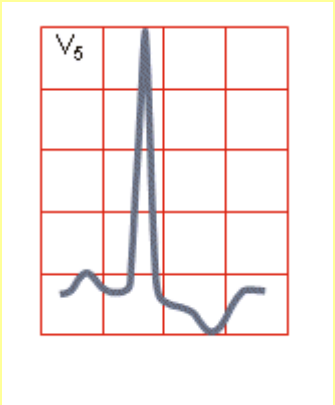


Ventricular Hypertrophy

- Left ventricular hypertrophy
  - ✓ Mean QRS deviates to left
  - ✓ R wave is high in amplitude in V5 & V6(25mm more than normal)





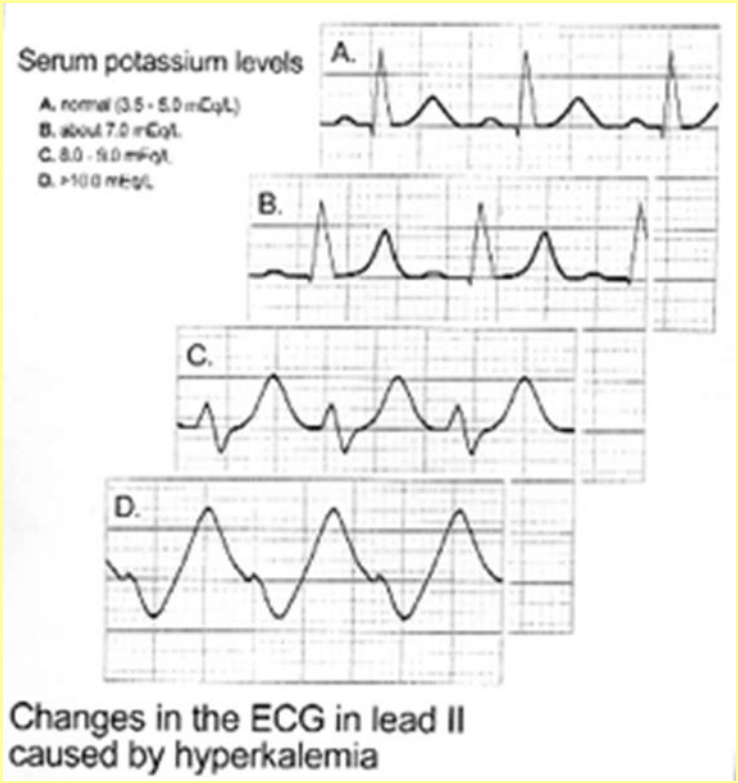


Electrolyte Imbalance Hyperkalemia

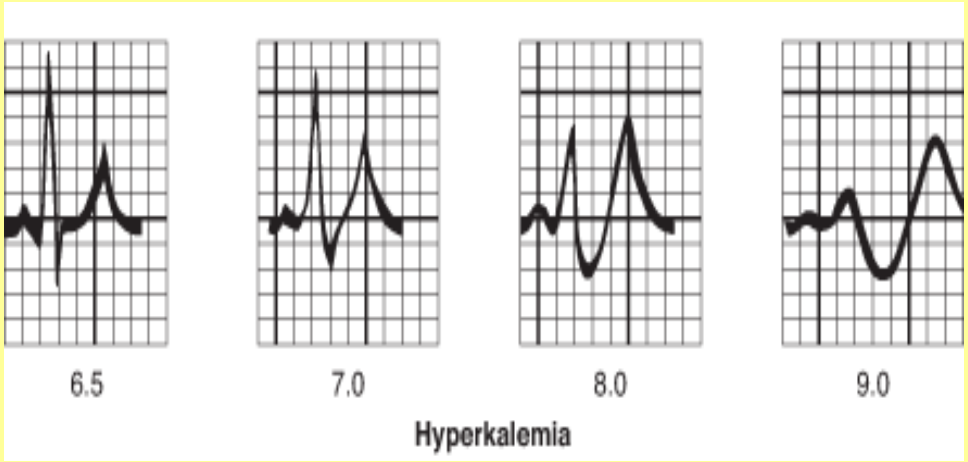
- Plasma K+ at about 7 meq/l
  - ✓Tall, peaked T wave
- Plasma K+ at about 8.5 meq/l
  - ✓Broadening & slurring of QRS complex
  - ✓Tall & slender T waves
- Plasma K+ more than 9 meq/l
  - ✓Ventricular tachycardia and ventricular fibrillation

Electrolyte Imbalance

- Hyperkalemia



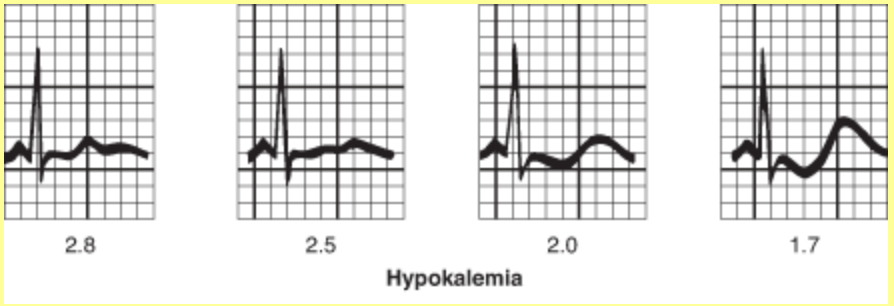
Changes in the ECG in lead II caused by hyperkalemia

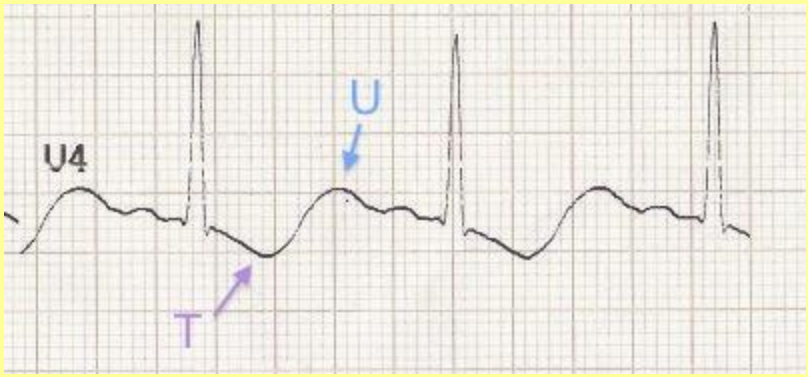


Hyperkalemia

Hypokalemia

- Plasma K+ at about 3 meq/l
  - ✓ ST depression
  - ✓ Appearance of prominent U wave
- Plasma K+ at about 2 meq/l
  - ✓ Prolongation of PR interval
  - ✓ ST segment depression
  - ✓ T wave inversion
  - ✓ Prominent U wave

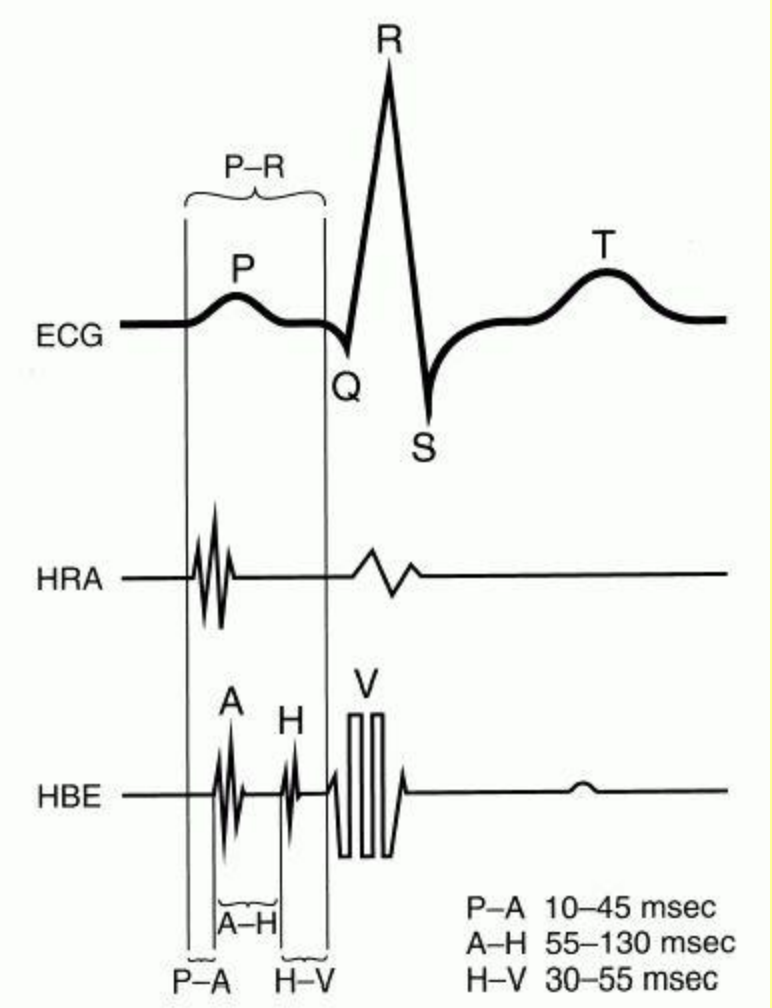




- Alteration in plasma Ca++
  - ✓ Hypercalcemia- QT interval shortened
  - ✓ Hypocalcemia –prolongation of ST segment, lengthening of QT interval
- Alteration in plasma Na+
  - ✓Hypernatremia- high voltage ECG complexes
  - ✓Hyponatremia – low voltage ECG complexes

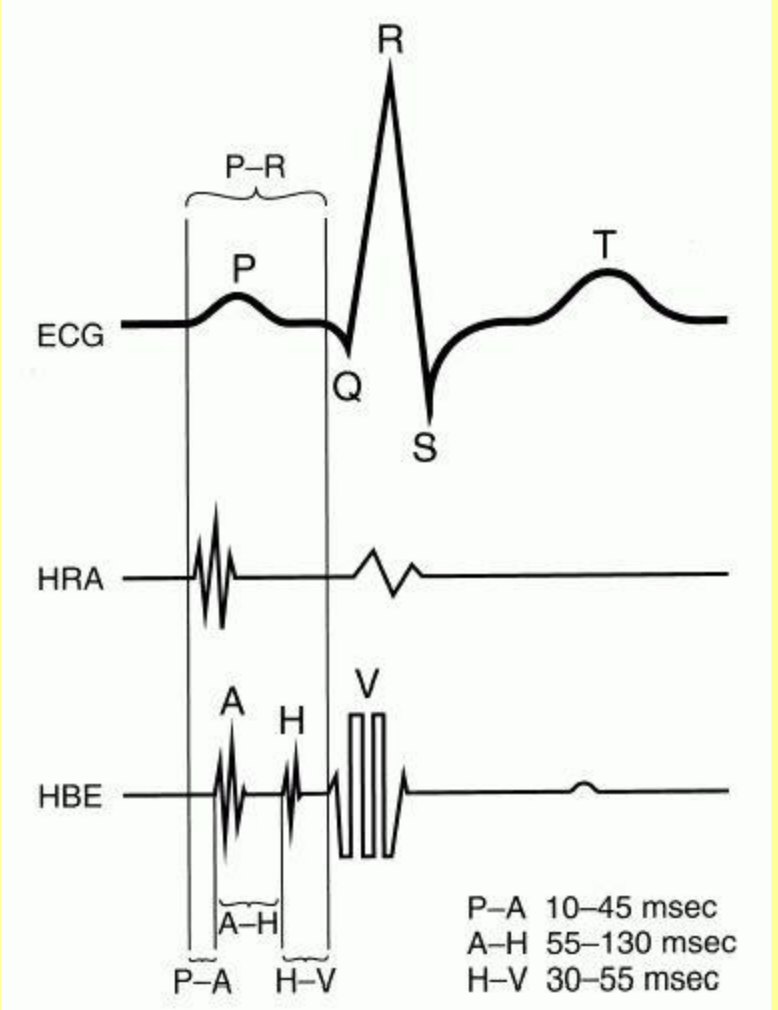
His Bundle Electrogram

- Has following deflections:
  - ✓ A deflection- Activation of AV node
  - ✓ H deflection- Transmission of impulse through His bundle
  - ✓ V deflection- Ventricular depolarization



His Bundle Electrogram

- Has three intervals:
  - ✓ *PA interval* - Time of conduction of impulse from SA node to AV node
  - ✓ *AH interval* - Time of conduction through AV node
  - ✓ *HV interval* - Time of conduction through His bundle and bundle branches



Ambulatory 24 Hr ECG Recording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THANK YOU