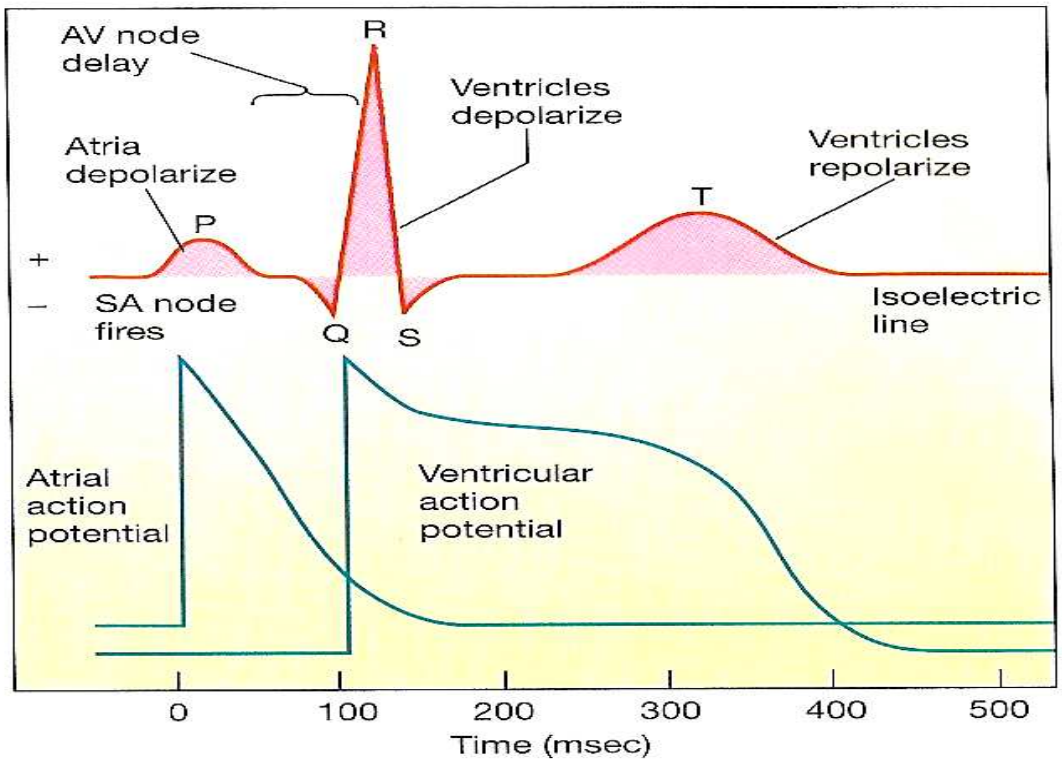
CARDIOVASCULAR PHYSIOLOGY-OUTLINES

The Cardiac Cycle - Electrical Events of the Heart:

Electrocardiogram is a diagnostic tool that record electrical activity (action potential) generated by the heart & conducted from the body surface by electrodes, per unit time.

- **By the end of this lecture, you will be able to:**
  1. Understand the 12 lead ECG.
  2. Perform an ECG recording.
  3. Identify & lable the ECG waves.
  4. Measure the durations & intervals.
  5. Calculate the heart rate.
  6. Determine the normal sinus rhythm.
  7. Calculate the cardiac axis.
  8. Report normal ECG.

- ECG is recorded as waves or deflections onto a graph paper.
- **One heartbeat is normally recorded as:**
  - ♥ a group of 3 waves called: **P wave, QRS complex, & T wave**
    - 3 positive waves (P, R, & T) … (away from electrode)
    - 2 negative waves (Q, & S) … (towards electrode)
  - ♥ 2 intervals between waves: **PR & QT wave**
  - ♥ 1 segment: **ST segment**



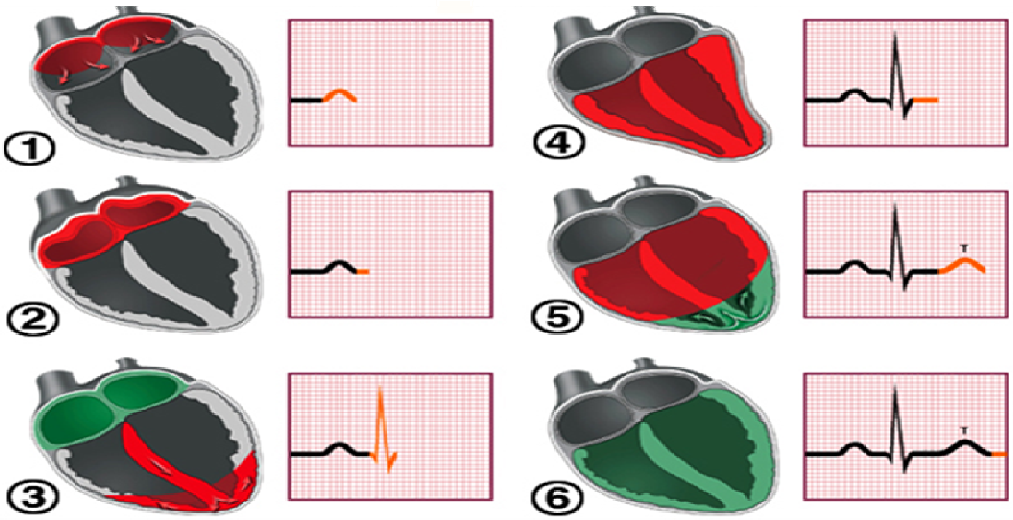
Causes of ECG waves:

	P-wave	QRS-complex	T-wave
Cause	Atrial depolarization	Ventricular depolarization	Ventricular repolarization
Represent	- Time of electrical impulse from SA node to spread through atrial ms - Precedes atrial contraction ≈ 0.02 sec.	- Measured from beginning of Q wave till end of S wave. - Consists of 3 waves: **Q-wave:** 1st –ve deflection, produced by depolarization of interventricular septum. **R-wave:** 1ST +ve deflection, produced by depolarization of ventricular wall. **S-wave:** -ve deflection after R, produced by depolarization of the base of the heart. - Precedes ventricular contraction ≈ 0.02 sec. - Occurs ≈ 0.12-0.2 sec after P-wave; i.e. PR interval, which represents conduction from SA-node to AV-node	- Occurs during latter part of systole, before the onset of diastole
Character	+ve wave - **Height:** not > 2-2.5mm - **Duration:** not > 0.06-0.11sec - **Shape:** curved because conduction through atrial ms is slow	- **Height:** not > 25mm - **Duration:** 0.08-0.1sec **(If prolonged, ∴ block in conductive system)**	+ve wave - **Height:** ≤ 5mm in lead I,II, & III; ≤ 10 mm in leads V1-V6 - **Shape:** curved because repolarization through ventricular ms is slow

* **N.B.** Atrial repolarization occurs at the same time with ventricular depolarization. But, since ventricular depolarization wave is giant, it masks the atrial repolarization wave.

* **U - wave** is caused by repolarization of Purkinje system.

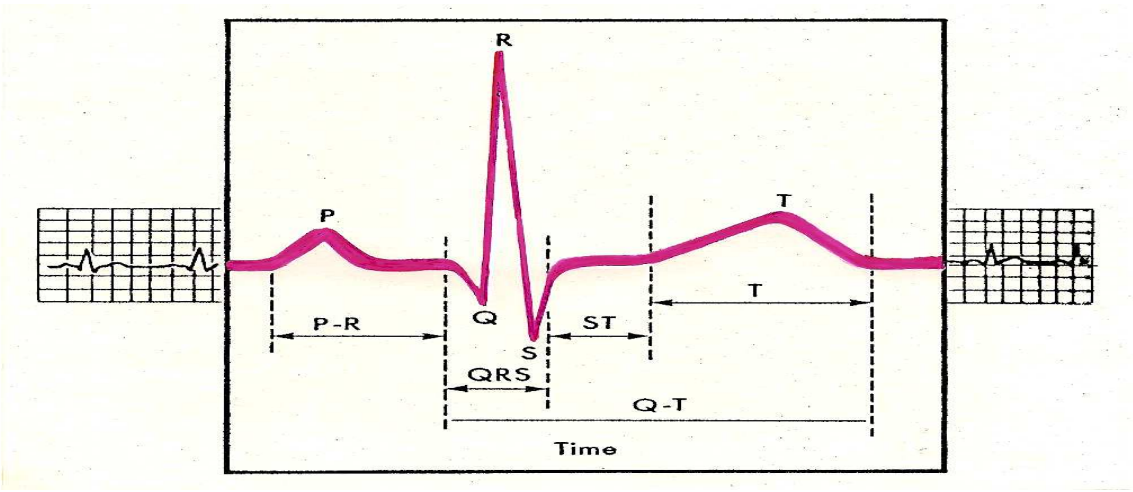
Electrical Activity of Myocardium:



1) atria begin to **depolarize**
2) atria **depolarize**
3) ventricles begin to **depolarize** at apex; atria **repolarize**
4) ventricles **depolarize**
5) ventricles begin to **repolarize** at apex
6) ventricles **repolarize**

Normal duration of ECG Waves and Intervals:

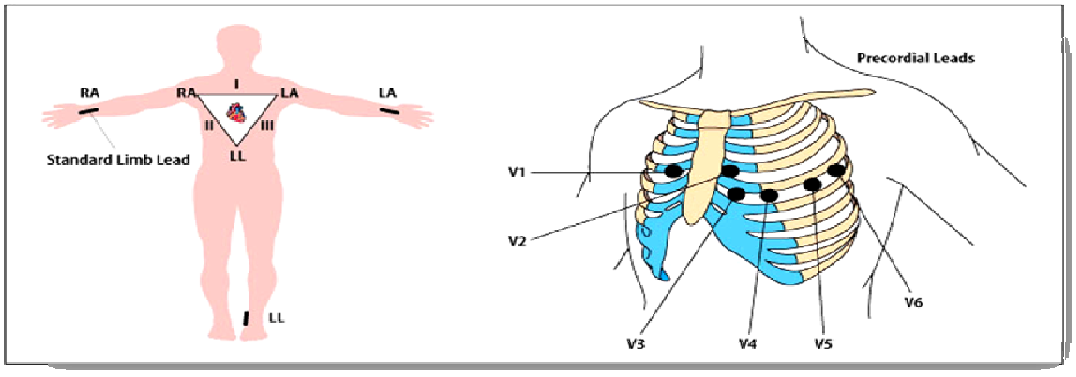
1. P-R (P-Q) interval.
2. QRS duration.
3. Q-T interval.
4. S-T segment.



- **PR - Interval: (0.12 - 0.2 sec):**
  - Extend from beginning of P wave & beginning of QRS complex.
  - Represents conduction (spread of excitation) from SA node to AV node.
  - Shortens as HR ↑.
  - If prolonged, ∴ defect in conductive system.
- **QRS duration: (0.08 - 0.1 sec):**
  - Measured from beginning of Q wave to end S wave.
  - Represents ventricular depolarization.
  - If prolonged, ∴ block in conductive system.
- **QT - Interval: (to 0.4 sec):**
  - Extend from beginning of Q wave & end of T wave.
  - Represents the duration of ventricular depolarization & repolarization.
  - Varies with heart rate.
  - To estimate QT-interval: a QT > half of RR interval, is probably prolonged.
- **ST- segment: (0.3 - 0.32 sec):**
  - Should be iso-electric.
  - Extend from end of S wave to beginning of T wave.
  - Represents period between ventricular depolarization & repolarization (early phase of ventricular repolarization).

Recording of ECG:

- ECG is recorded indirectly by applying electrodes on the surface of the body (skin).
- **ECG is composed of 12 standard leads, which views ventricular surfaces from 12 different angles:**
  - Bipolar & Unipolar limb leads look at vertical views.
  - Unipolar Chest leads look at horizontal views.



- **Bipolar Leads (standard limb leads):**
  - Record voltage b/w electrodes placed on wrists & legs.
  - Rt leg is ground.

- Record voltage between 2 limbs at a time.
- Called Bipolar leads, because one limb carries +ve electrode & other limb carries –ve electrode
- 3 standard limb leads.
    1. Lead I … [LA +ve, RA –ve]
    2. Lead II … [LL +ve, RA –ve]
    3. Lead III … [LL +ve, LA –ve]

■ **<u>Unipolar Leads</u>:**

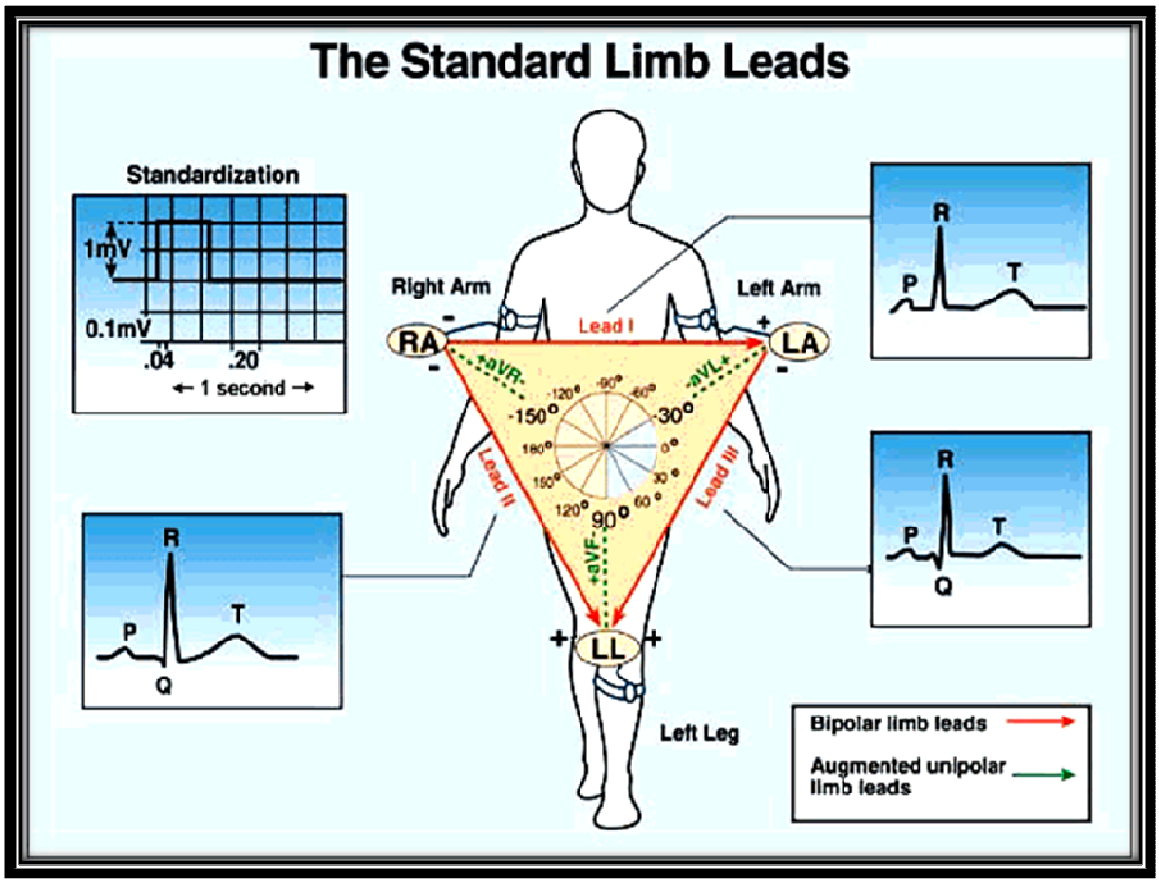
- Voltage is recorded b/w a single "exploratory electrode" placed on body & an electrode built into the electrocardiograph.
- Placed on Rt arm, Lt arm, Lt leg, & chest.
    - Allow to view changing pattern of electrical activity from different perspectives.
- of (2 types):

a. Unipolar limb leads: (Augmented Leads)

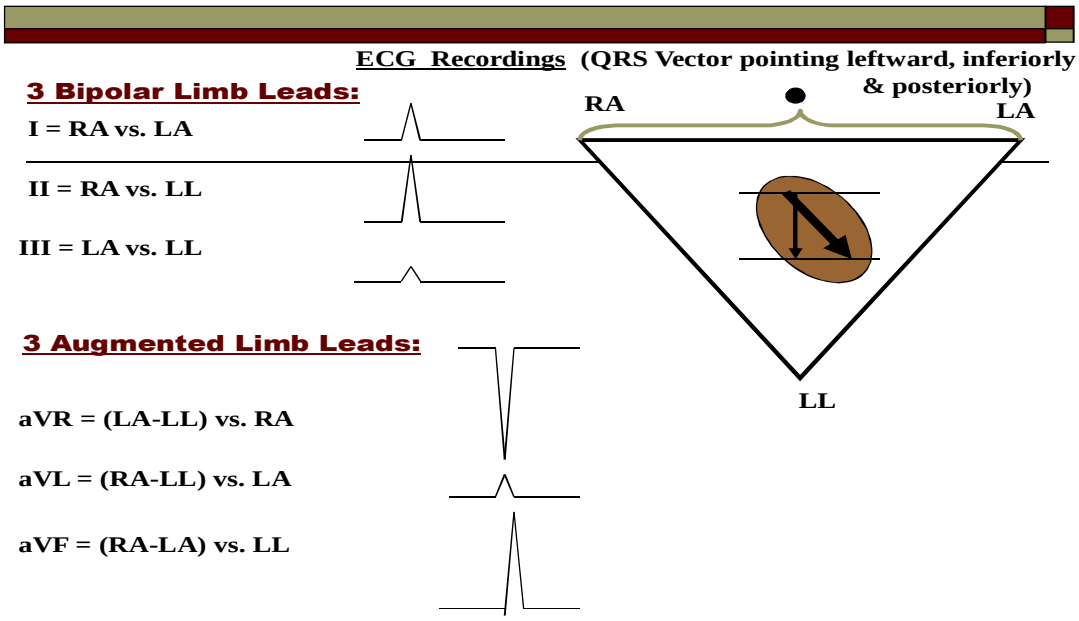
1. aVR … (RA)
2. aVL … (LA)
3. aVF … (LL)

b. Unipolar chest leads (Precordial leads):

V1, V2, V3, V4, V5, V6.

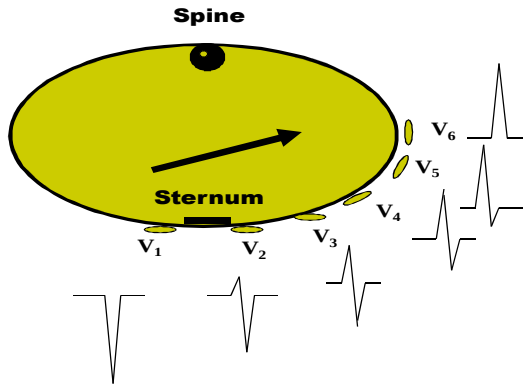


The +ve deflection of the leads represents the position of the lead in relation to the direction of the cardiac axis.



- Normal cardiac axis is downward & to the left, i.e. the wave of depolarisation travels from RA towards LV.
- When an electrical impulse travels towards a positive electrode, there will be a positive deflection on the ECG.
- if the impulse travels away from the positive electrode, a negative deflection will be seen.
- Lead II record shows the tallest R-wave.
- AVR lead shows upside down wave pattern.

6 PRECORDIAL (CHEST) LEADS



Calculating the Heart Rate:

- **Measured in beats per minute (bpm).**

Heart Rate = 1500/no. mm b/w R-R interval

- 1500 = length in mm/minute,
  when the ECG paper speed of is 25mm/sec. (60 X 25)
- R-R interval = distance b/w 2 R waves in mm.

Determining the Rhythm:

- Sinus.
- Regular / Irregular.
- Any change during inspiration / expiration?(sinus arrhythmia)

Normal Sinus Rhythm:

- Implies normal sequence of conduction, originating in the sinus node & proceeding to the ventricles via the AV node & His-Purkinje system.

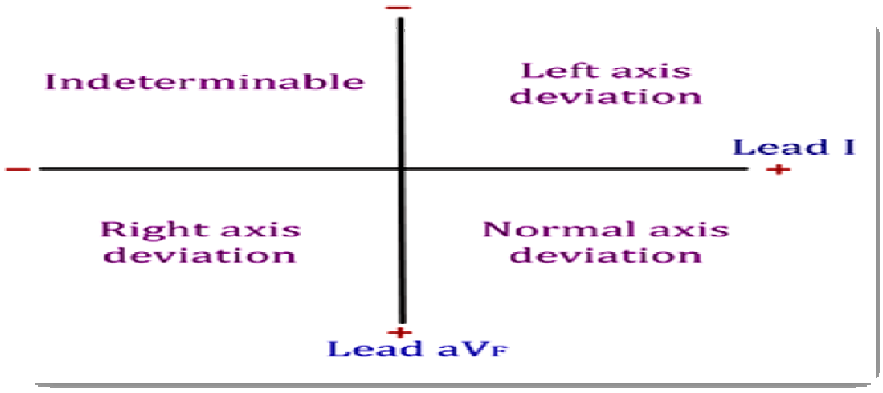
- **ECG Characteristics:** Regular rhythm
  Rate 60-100 bpm
  Each QRS complex is proceeded by a P wave
  P wave is upright in lead II & down going in lead aVR

The Cardiac Axis:

- Normally, anatomical axis nearly coincides w electric axis.

Cardiac Axis Values:

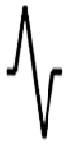
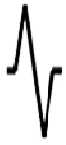
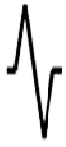
- Normal axis = 0° to 90°
- Right axis deviation = 90° to 180°
- Left axis deviation = 0° to - 90°



Calculating the Cardiac Axis:

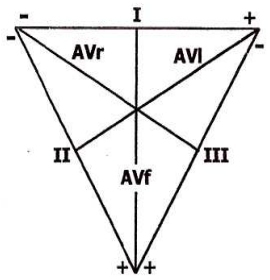
- Many ways, but 2 methods will be considered to determined the axis.
  - **Method # 1: Quick method**
    Look at direction of major deflection in lead I & III

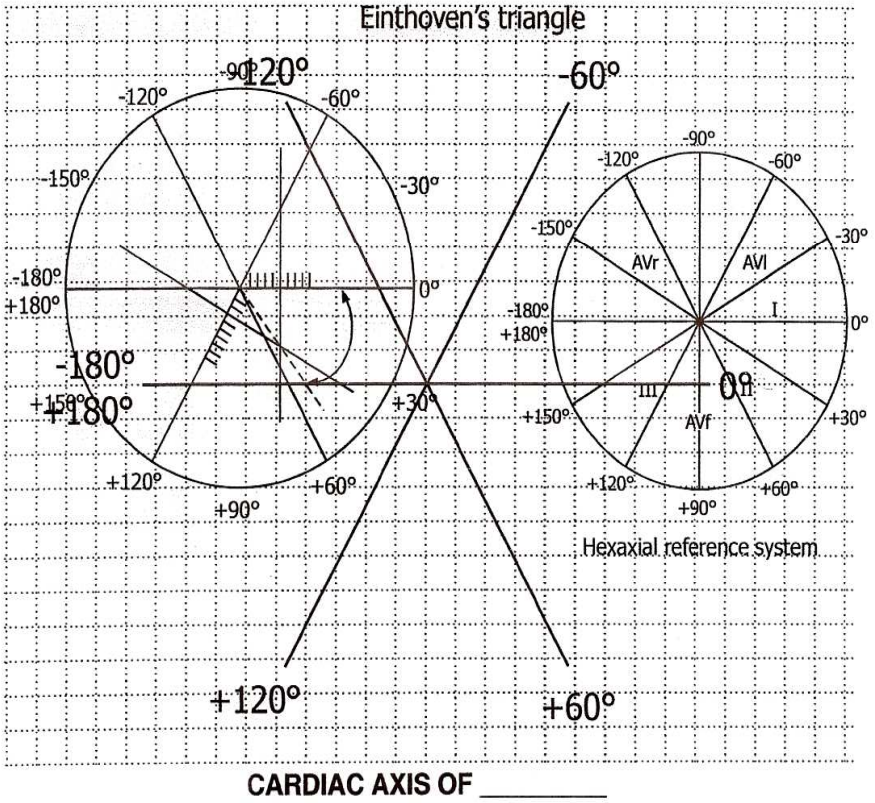
Same direction (upwards)	**Normal Axis**
Opposite direction (away)	**Lt. Axis deviation**
Towards one another (meeting)	**Rt. Axis deviation**

	Normal Axis 0 to 90	Left Axis Physiological 0 to -30	Left Axis Pathological -30 to -90	Right Axis 90 to 180	Extreme Axis -90 to 180	Indeterminate Axis ?
Lead I						
Lead II						
Lead III						

❑ Method # 2: Einthoven's triangle; Hexaxial reference system

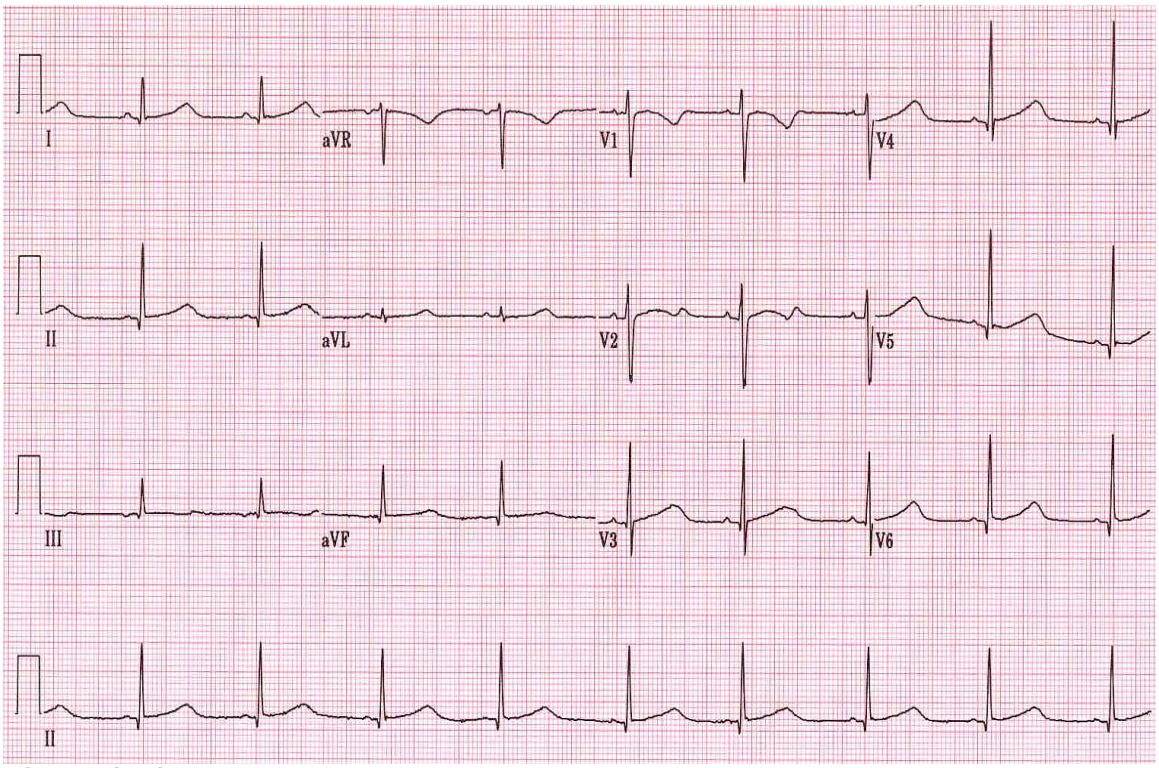
1. Use leads I, II, & III (triaxial reference system).
2. Draw the axis of 60^{o} b/w each.
3. In lead I, measure height of R-wave & depth of S-wave in mm. Calculate R-S.
4. In lead III, measure height of R-wave & depth of S-wave in mm. Calculate R-S.
5. Plot on the triaxial reference & determine the cardiac axis.



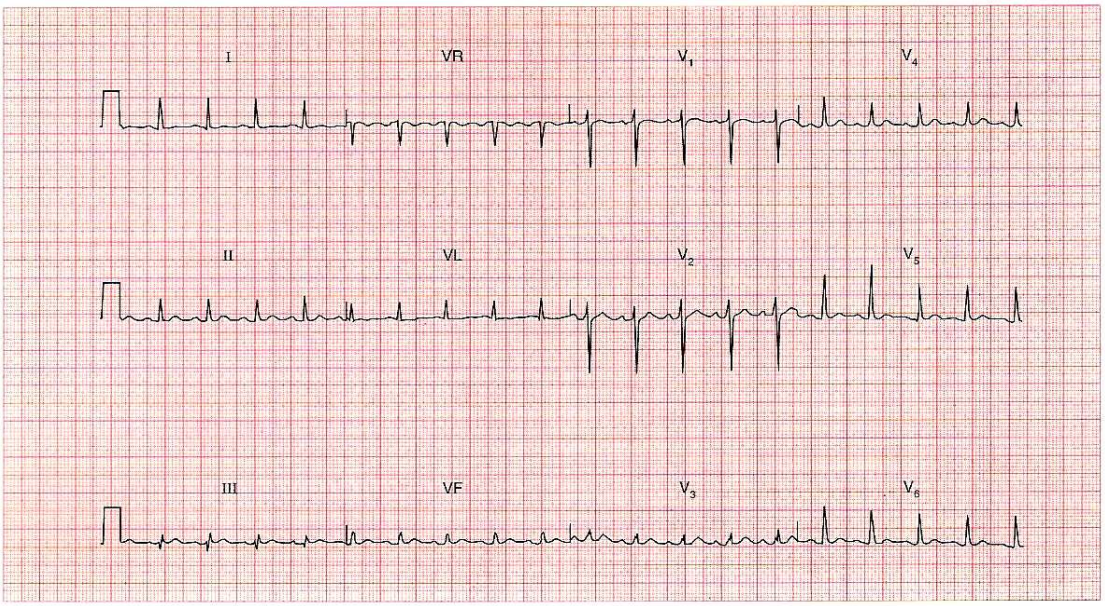


CARDIAC AXIS OF _____

The Standard 12 – Lead ECG:



Sinus Rhythm

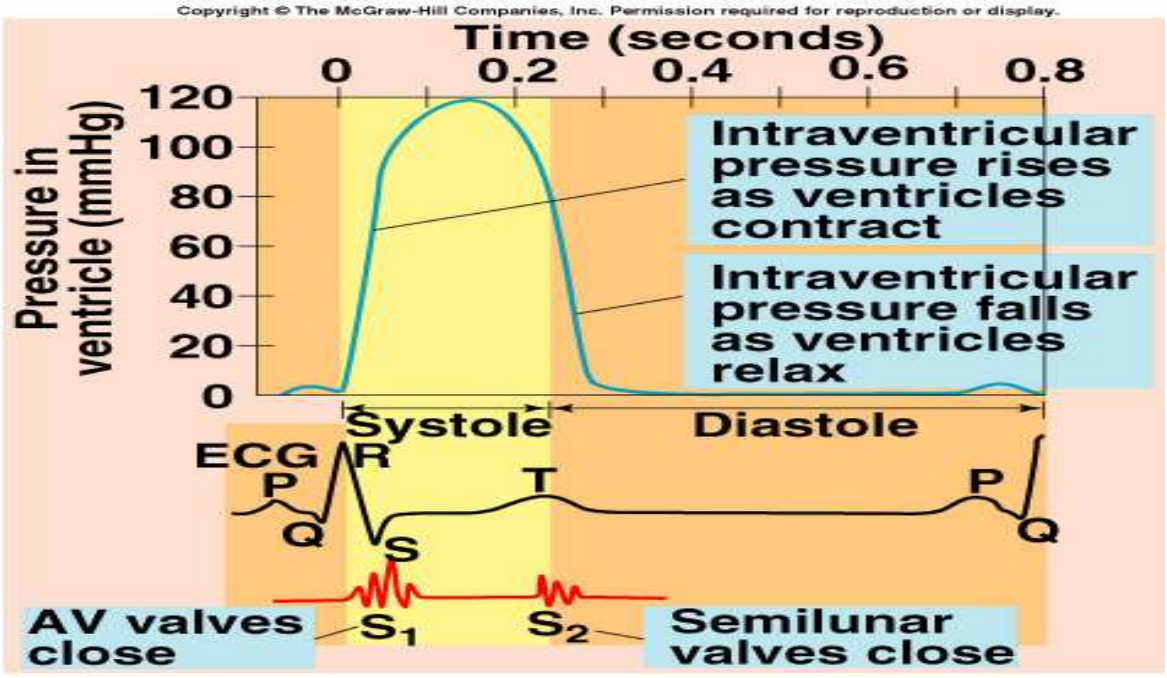


This ECG shows:

- Sinus rhythm, rate 110 per minute
- PR interval normal, at 140 ms
- QRS duration normal, at 120 ms
- Normal cardiac axis
- Normal QRS complexes
- Normal T waves (an inverted T wave in lead VR is normal).

Interpretation: Normal ECG.

Correlation of ECG with Heart Sounds:



Clinical Significant of ECG:

- **Diagnosis of:**
  - chamber enlargement.
  - conduction abnormalities (heart block).
  - dysrhythmias.
  - myocardial infarction.
  - drug effects.
  - electrolyte alterations.
  - coronary artery disease by exercise stress testing.
  - many other abnormalities.