The Electrocardiography (ECG) II

Dr. Waleed R. Ezzat

Lecture Objectives:

1. Describe methods of recording ECG.
2. Explain the differences in QRST configuration in various leads.
3. State the right and left deviations of the electrical axis of the heart.

The leads:

The electrical connections between electrodes placed on certain points on the patient's body and electrocardiograph for recording electrocardiograms.

Standard bipolar limb leads:

They are lead I, II, and III. Each records the differences in potential between two limbs. This means that the electrocardiogram represents a record of a potential difference between two locations on different sides of the heart.

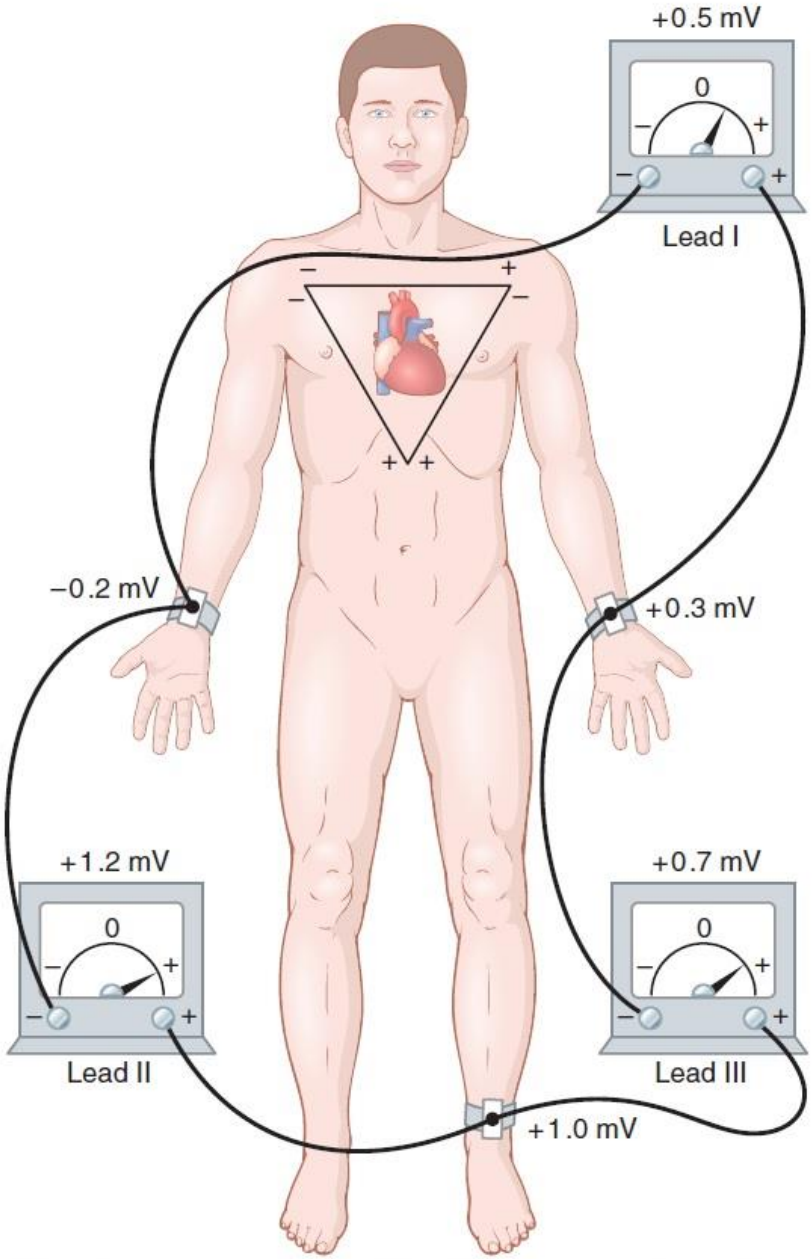
Lead I → Rt. arm (-ve) and left arm (+ve)
Lead II → Rt. arm (-ve) and left leg (+ve)
Lead III → left arm (-ve) and left leg (+ve)

Einthoven's triangle

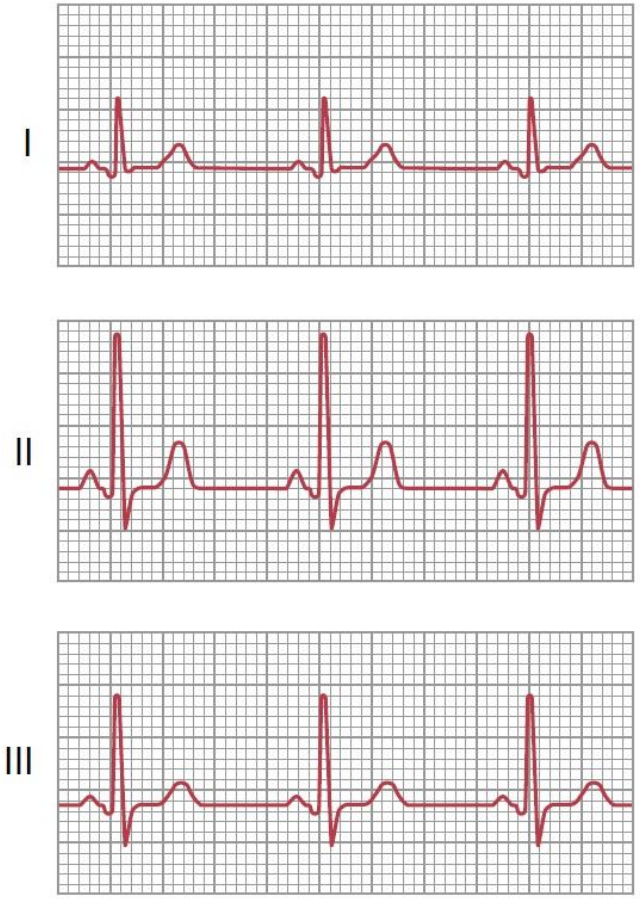
A diagrammatic equilateral triangle surrounding the heart in which the base of the triangle is directed upward and the head is down. The upper two apices of the triangle represent the electrical connection of the two arms (Lead I). The lower apex is the point at which the left leg connects.

Einthoven's law:

voltage in Lead I + Lead III= voltage in Lead II



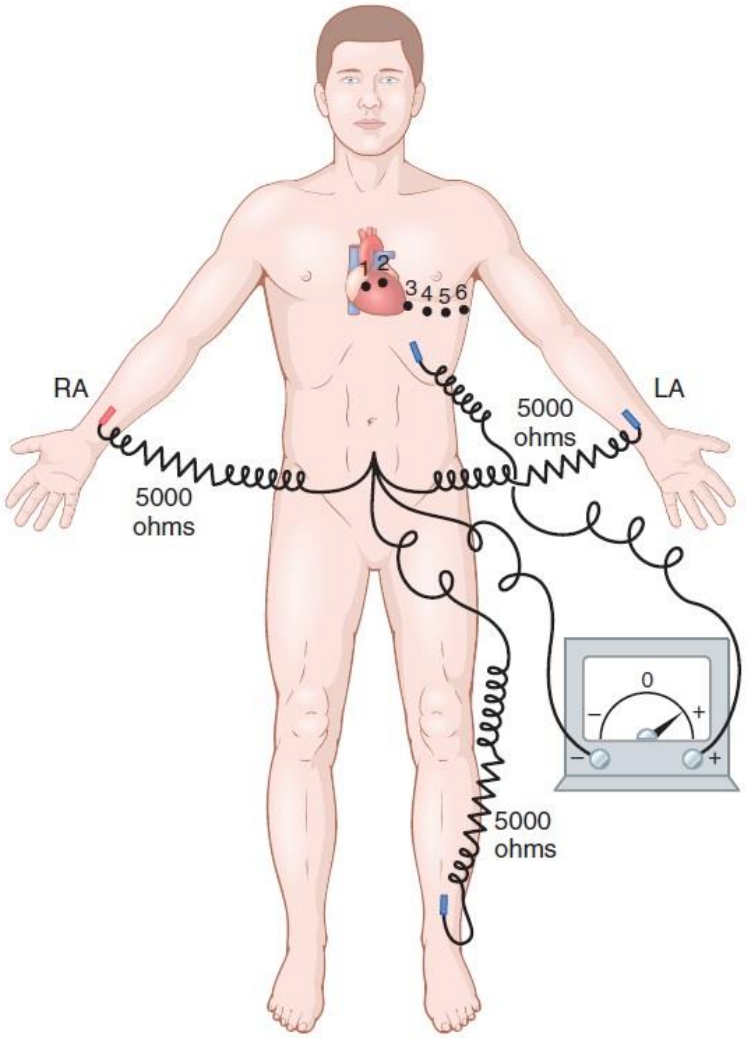
Conventional arrangement of electrodes for recording the standard electrocardiographic leads. Einthoven's triangle is superimposed on the chest.



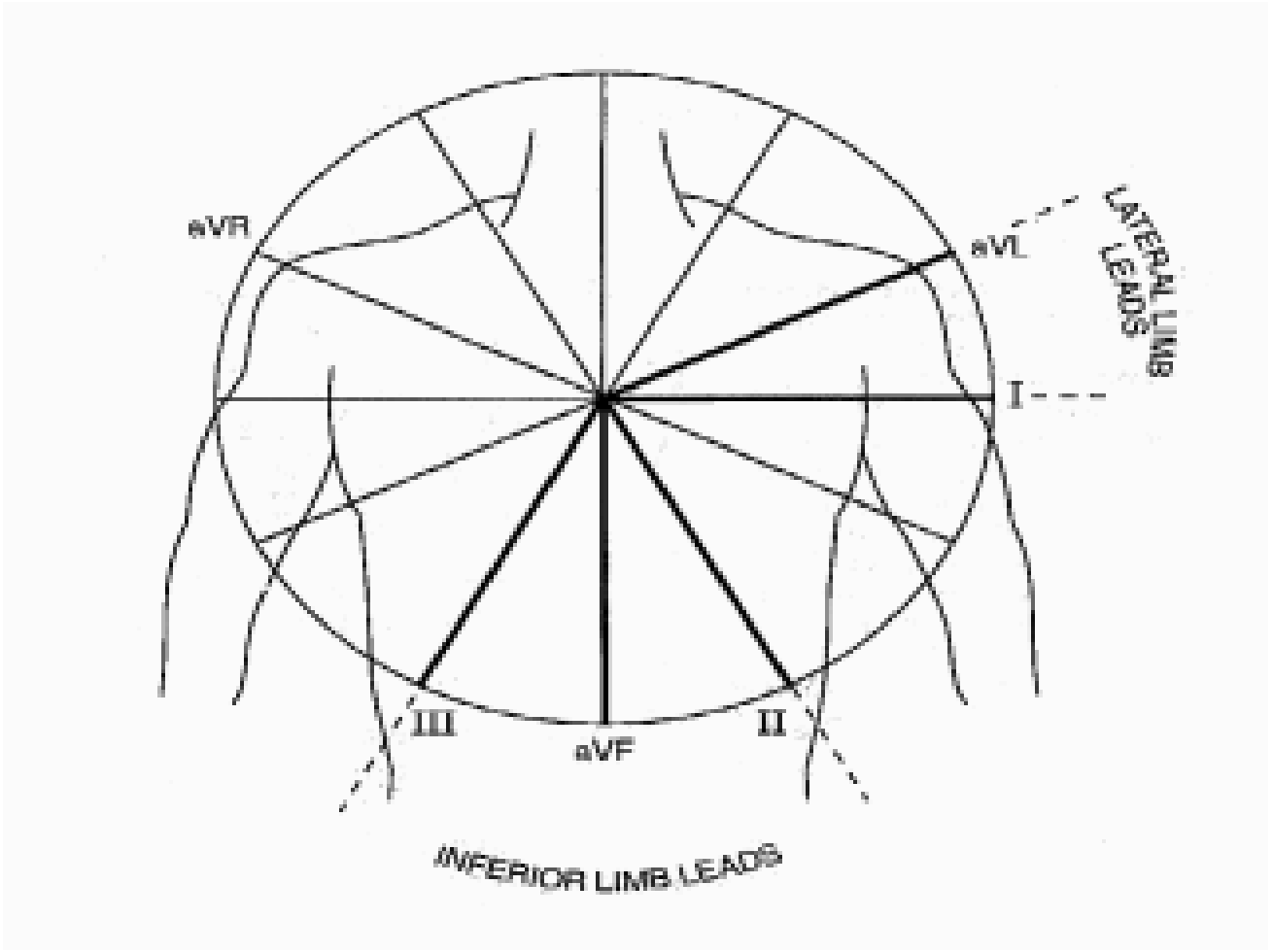
Normal electrocardiograms recorded from the three standard electrocardiographic leads (I–III).

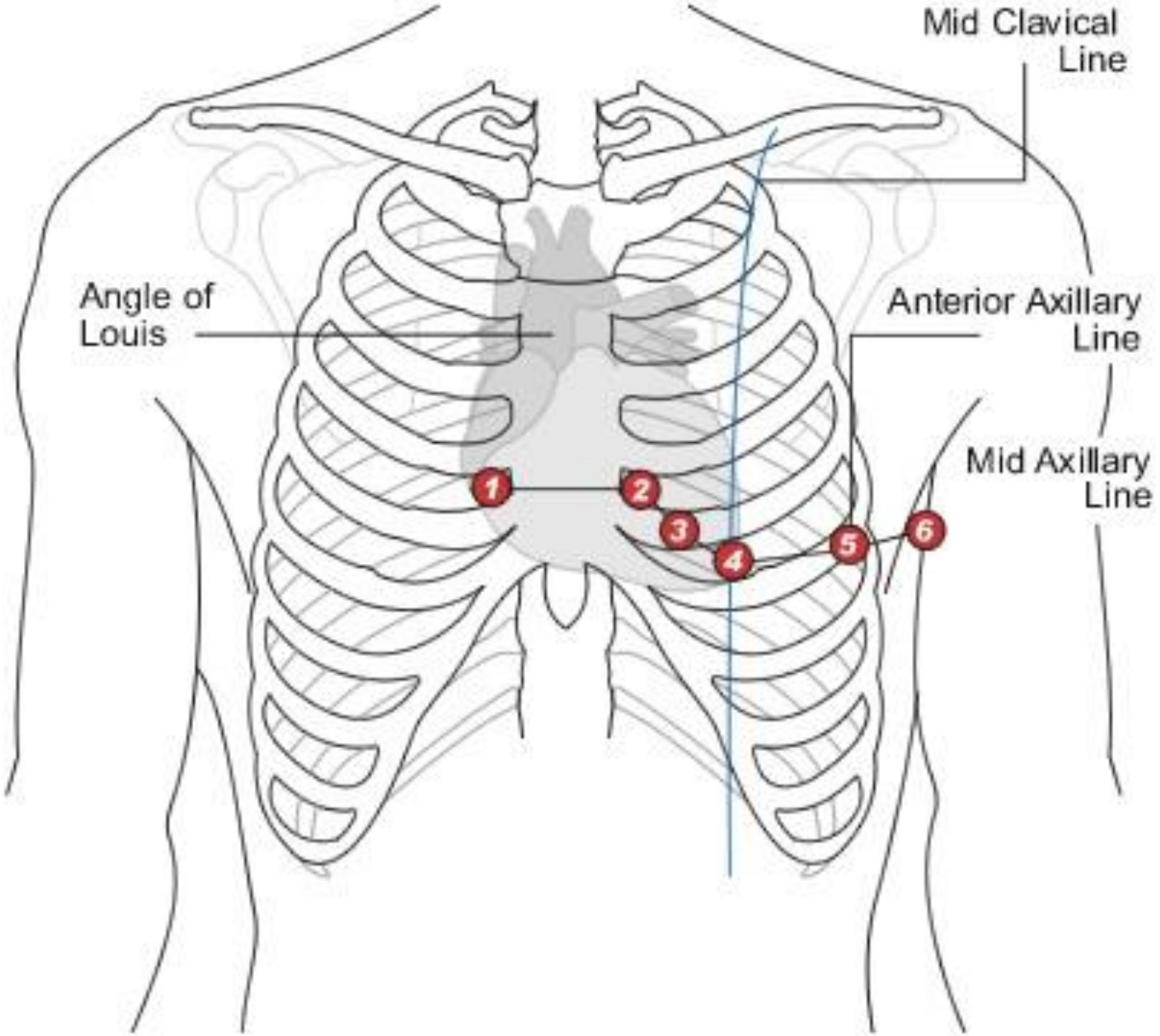
The Unipolar (V) leads

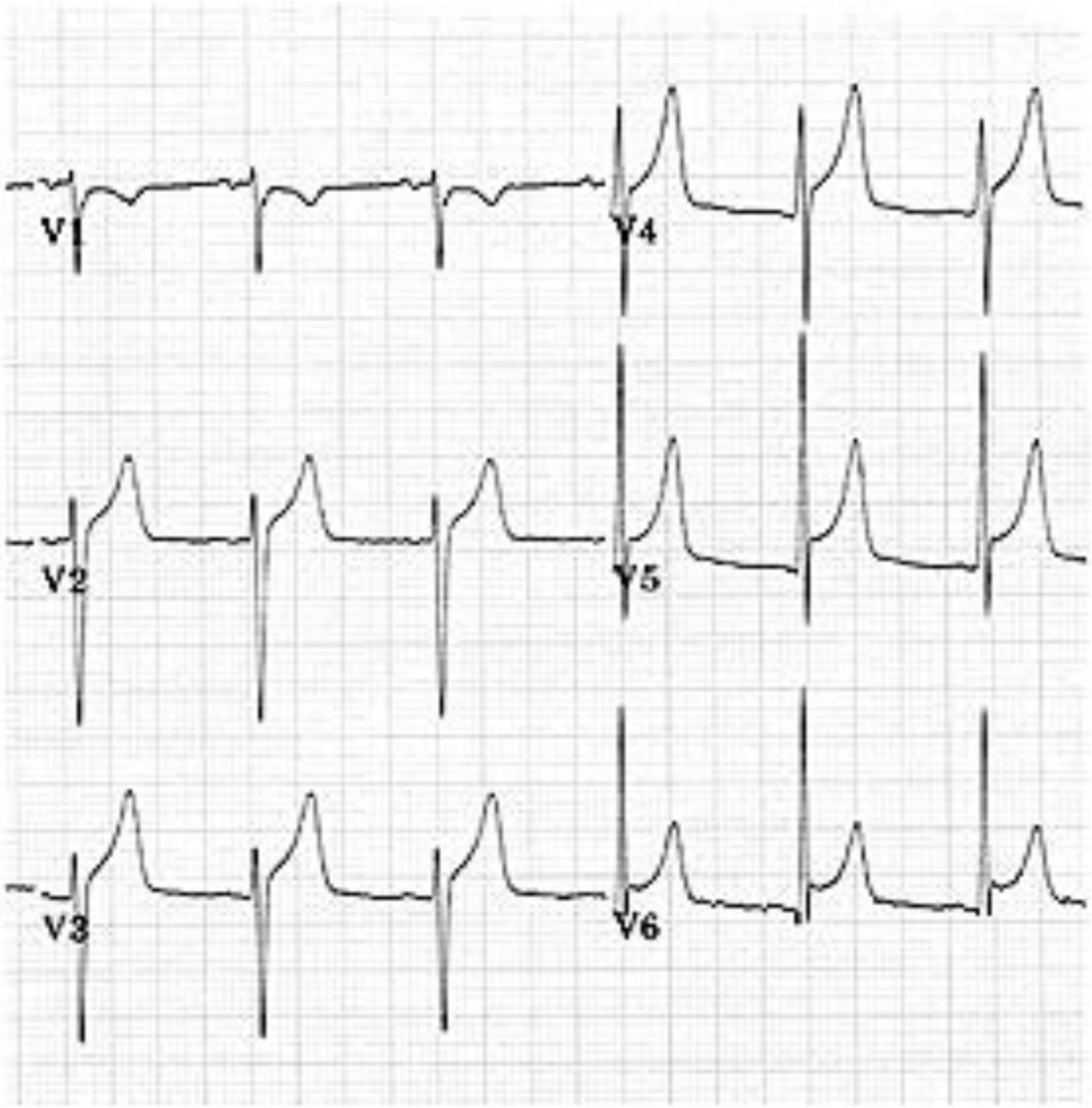
- The unipolar lead records the potential difference between an exploring (+ve) electrode and an indifferent (-ve) electrode.
- They are nine leads, six unipolar chest leads (precordial leads) designated V1-V6 and three unipolar limb leads; VR, VL, and VF.
- Some special unipolar leads are also used in medical practice. (Note that; VR+VL+VF= O).



Connections of the body with the electrocardiograph for recording chest leads. LA, left arm; RA, right arm.


aVR
aVL
LATERAL LIMB LEADS
I
III
aVF
II
INFERIOR LIMB LEADS


Mid Clavical Line
Angle of Louis
Anterior Axillary Line
Mid Axillary Line
1
2
3
4
5
6

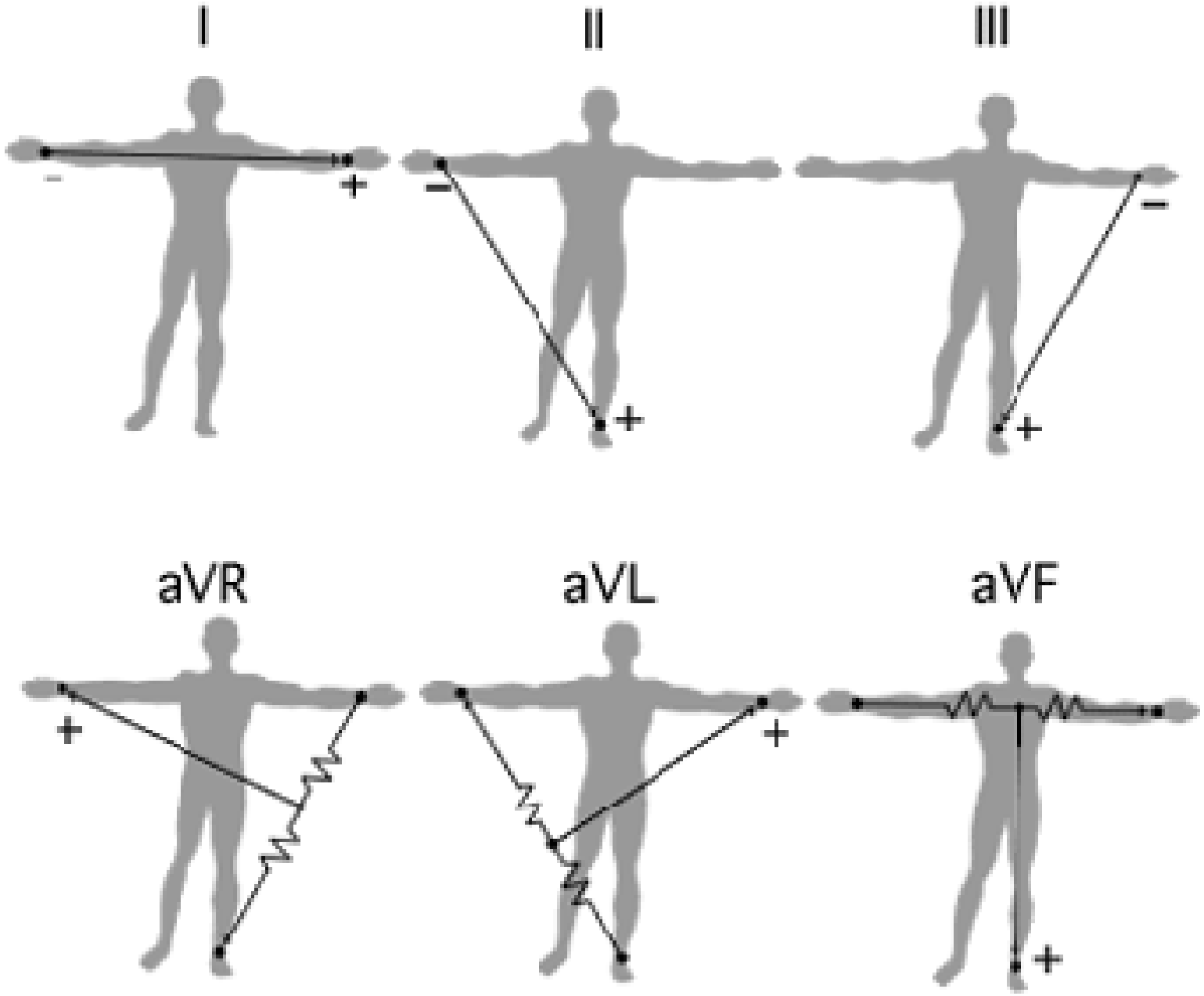

V1
V4
V2
V5
V3
V6

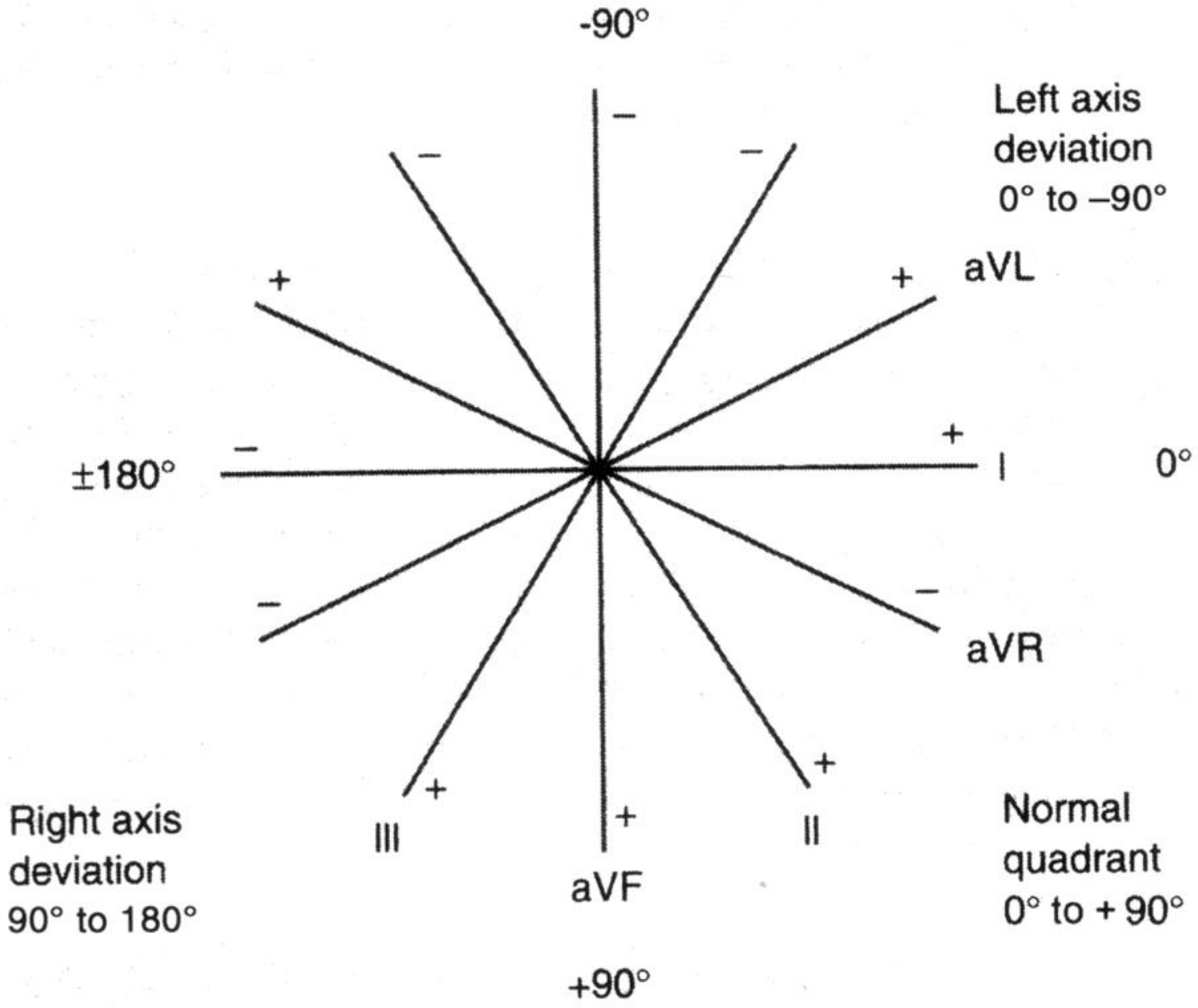
Augmented limb leads

They are aVR, aVL, and aVF. The augmented limb lead records the potential difference between one apex and the other two apices of Einthoven's triangle. Such connection increases the size of potentials by 50% without any change in configuration from the non-augmented record.

Note:

1. Any lead can be used to diagnose cardiac arrhythmias
2. Diagnoses of damage in the ventricular or atrial muscle, or in the Purkinje conducting system requires to decide which lead is involved, since some leads can record the abnormalities in conduction while others may not be affected.


I
II
III
aVR
aVL
aVF

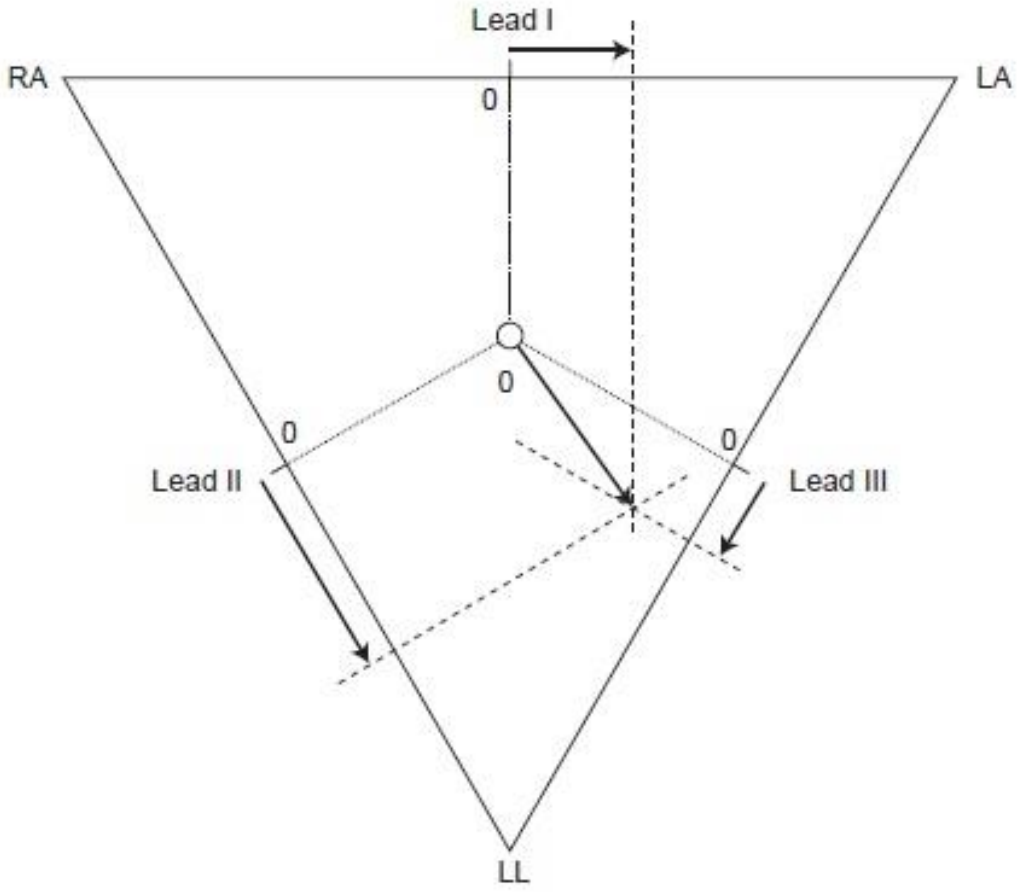

-90°
Left axis deviation
0° to –90°
aVL
I
0°
aVR
II
aVF
III
±180°
Right axis deviation
90° to 180°
Normal quadrant
0° to + 90°
+90°

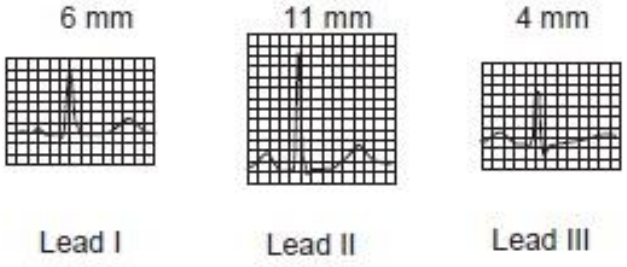
The cardiac vector or axis

- The depolarization wave or current flows from the depolarized toward the still polarized areas. Depolarization starts from the endocardial surface toward the epicardial surface, whereas repolarization runs in the opposite direction. That's why the direction of the T wave is always up (except in aVR).
- The vector is the summated generated potentials. It is represented by an arrow. The mean QRS vector is about +59 degrees, directed from the base of the heart toward the apex, i.e. the apex of the heart remains +ve with respect to the base of the heart. The vector can be drawn by using the hexagonal reference system.
- Normal range: -20° to +100°

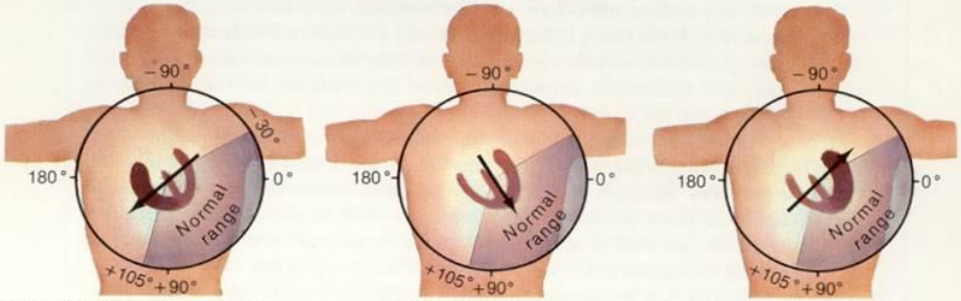
Axis ≤ -30° → left axis deviation (e.g. left bundle branch block and inferior myocardial infarction).

Axis ≥ +110° → Rt. axis deviation (e.g. Rt. vent. Hypertrophy and Rt. bundle branch block).


Lead I
RA
LA
0
0
0
0
Lead II
Lead III
LL


6 mm
11 mm
4 mm
Lead I
Lead II
Lead III

Electrical Axis of Heart



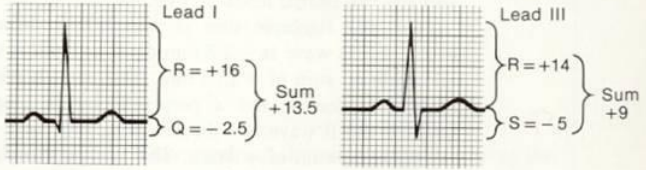
Right axis deviation: ≥ +105°, e.g., chronic obstructive lung disease and pulmonary hypertension

Normal electrical axis: −29° to +105°

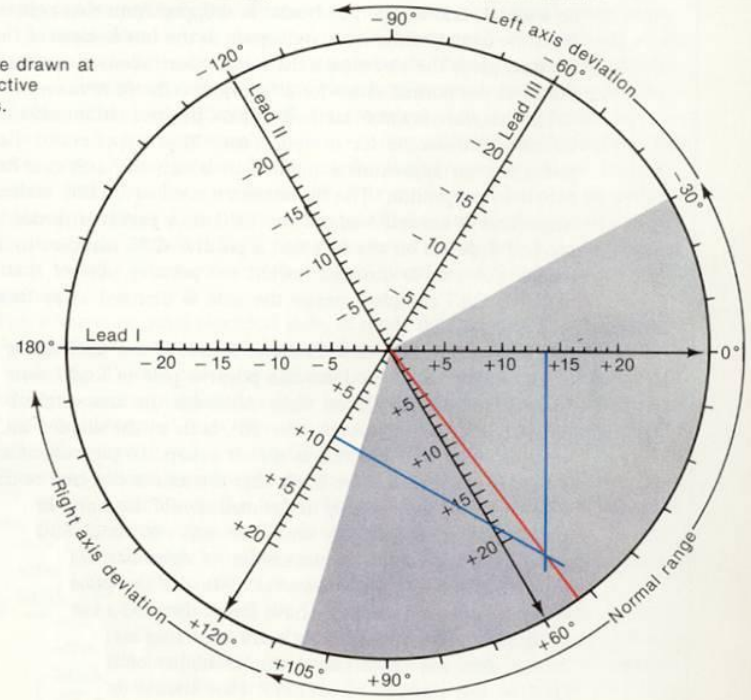
Left axis deviation: ≥ −30° (more negative), e.g., hypertension or aortic stenosis with major left ventricular predominance

Triaxial reference (vectorial) method of axis determination

Sum of QRS in mm in lead I and lead III (or in leads I and II) is determined and plotted on vectorial diagram below

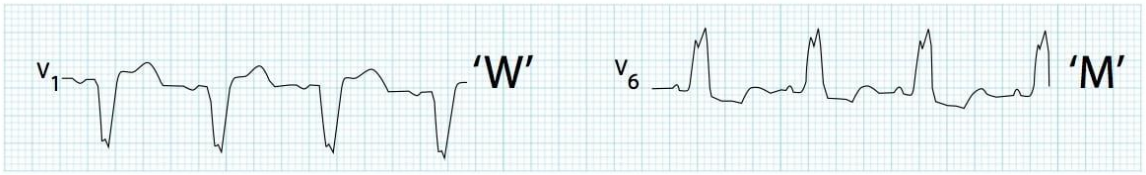


Perpendiculars (blue) are drawn at plotted points on respective vectorial reference lines. Line (red) drawn from central point through intersection of perpendiculars gives electrical axis (in this case about +53°, which is within normal range)

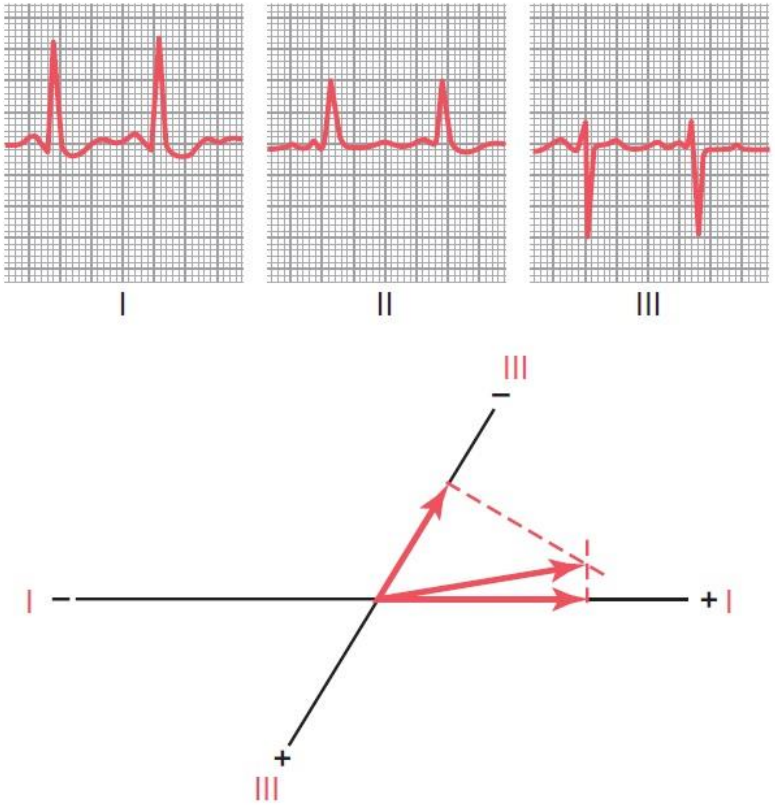


Clinical Significance of axis deviation:

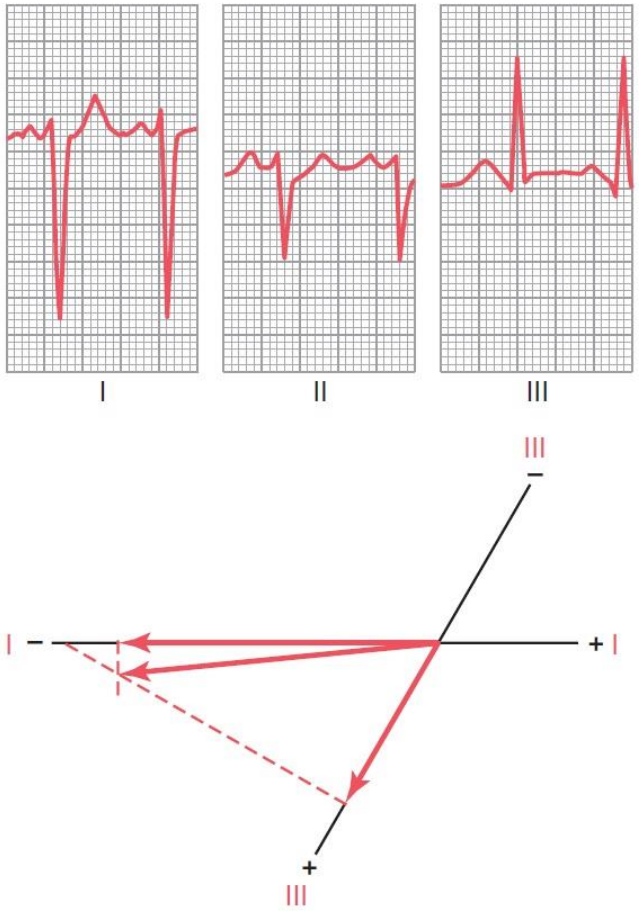
- Changes in the mean electrical axis may occur if the anatomical position of the heart is altered, if the relative mass of the right or left ventricle is enlarged (as it is in certain cardiovascular disturbances), or if there is conduction defects.
- Normally the axis tends to shift toward the left (more horizontal) in short, stocky (obese) individuals
- Normally the axis tends to shift toward the right (more vertical) in tall, thin persons.
- The axis shifts toward the left in left ventricular hypertrophy, left anterior fascicular block (or hemiblock) and in left bundle branch block. This results in 'M'-shaped R wave in the lateral leads (i.e. lead I, V_5, and V_6) with absence of Q waves.



- The axis shifts to the right in right ventricular hypertrophy, in left posterior fascicular block or in right bundle branch block.



Left axis deviation in a *hypertensive heart (hypertrophic left ventricle)*. Note the slightly prolonged QRS complex as well.



A high-voltage electrocardiogram for a person with *congenital pulmonary valve stenosis with right ventricular hypertrophy.* Intense right axis deviation and a slightly prolonged QRS complex also are seen.

Test Question:

Q. The 'T' wave in ECG is above the isoelectric line because of?

A. Depolarization of ventricles

B. Depolarization of bundle of His

C. Repolarization of Purkinje fibers

D. Effect of the AV node on the conduction of the depolarization wave from atria to ventricles

E. The direction of ventricular repolarization wave is opposite to that of depolarization