Electrocardiogram (ECG)

Learning objectives for this lecture

- Describe how to record a 12-lead ECG.
- State the direction from which each of the 12 standard ECG electrodes views the heart.
- Draw a standard ECG: state what events are represented by each wave.
- Describe how electrical activity may be represented as a cardiac vector: state the position of the average vectors for atrial depolarisation, ventricular depolarisation, ventricular repolarisation.

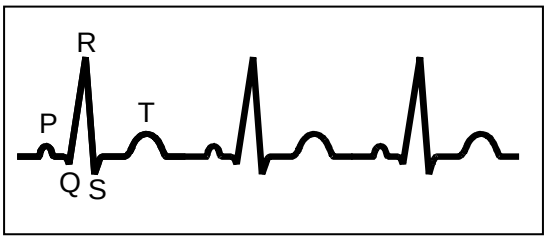
Introduction to ECG

ECG is a recording at the surface of the body of electrical activity originating from the heart. The ECG recording may be:

- bipolar - between 2 points on the body surface (+ and - electrodes)
- unipolar - from 1 point on the body surface (exploring electrode) relative to ground (indifferent electrode)

Events of the ECG

- P wave - atrial depolarisation
- QRS complex - ventricular depolarisation
- T wave - ventricular repolarisation(Q – interventricular septum, R – main body of ventricular muscle, S – upper septum & high posterior walls)



In a standard ECG, a wave of depolarisation moving towards the exploring electrode gives a positive deflection, and depolarisation moving away from the electrode gives a negative deflection.

Similarly, repolarisation moving towards the electrode gives a negative deflection, and repolarisation moving away from the electrode gives a positive deflection.

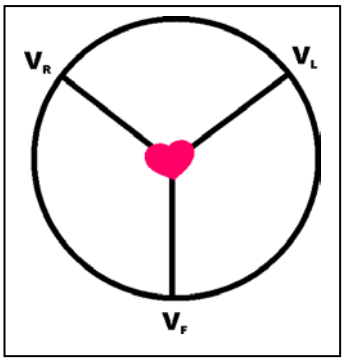
Either depolarisation or repolarisation moving at 90° to the electrode gives no deflection.

12 standard leads

<u>Bipolar leads</u>		<u>-ve</u>	<u>+ve</u>
Standard limb leads	Lead I	right arm	left arm
	Lead II	right arm	left leg
	Lead III	left arm	left leg
<u>Unipolar leads</u>		<u>exploring electrode</u>	
Limb leads	VR	right arm	
	VL	left arm	
	VF	left leg	
Chest (precordial) leads	V_1	4^{th} intercostal space, immediately to R of sternum	
	V_2	4^{th} intercostal space, immediately to L of sternum	
	V_3	halfway between V_2 & V_4	
	V_4	5^{th} intercostal space, left midclavicular (collarbone) line	
	V_5	5^{th} intercostal space, left anterior axillary (armpit) line	
	V_6	5^{th} intercostal space, left midaxillary line	

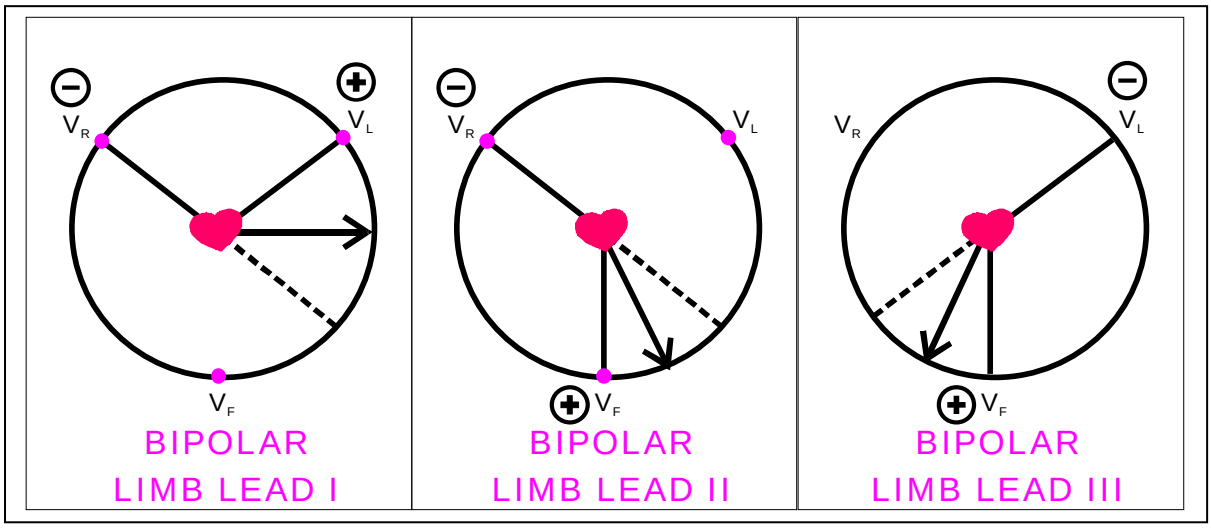
Unipolar limb leads may be "augmented" (aVR, aVL, aVF) by recording between 1 limb and the other 2 limbs. This increases the size of the voltage signal.

Limb Leads



Direction of view

Limb leads view the heart in the vertical plane: unipolar leads view the heart from the direction of the exploring electrode, whereas bipolar leads view the heart from a direction halfway between the +ve electrode and the opposite of the -ve electrode.



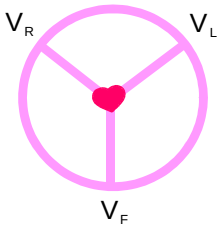
Cardiac vector

The total electrical activity of the heart (sum of all the individual movements of potential waves) can be regarded as a vector, since it has both magnitude & direction.

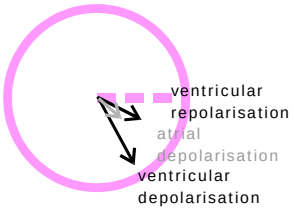
- Atrial depolarisation spreads from the SA node to the AV node (ie downwards & to the left) ⇒ average vector = directed at ~ +45° from the horizontal.
- Majority of ventricular depolarisation = through ventricular muscle from inner to outer surface: L ventricle has greater bulk than R ventricle, ⇒ average vector = directed down & to the L (~ +60° from the horizontal)
- Ventricular repolarisation proceeds from the outer to the inner surface of the myocardium. ⇒ average vector = again directed down & to the L (~ +35° to +40°)

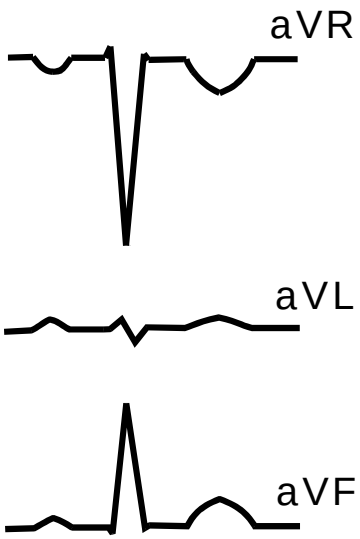
Appearance of the ECG

- If the vector for a depolarisation event has a component which is aligned with the direction from which the electrode views the heart, then a positive deflection will be seen.
- If the vector for a repolarisation event has a component which is aligned with the direction from which the electrode views the heart, then a negative deflection will be seen.

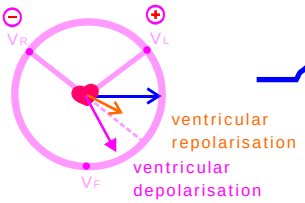


UNIPOLAR
LIMB LEADS



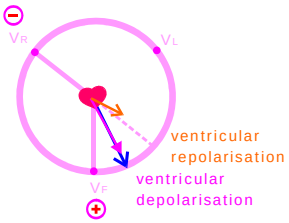


Unipolar Limb Leads



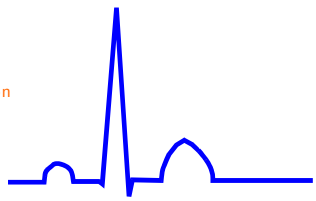
BIPOLAR
LIMB LEAD I

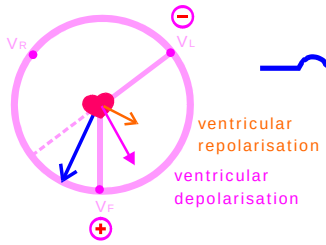
Lead I ECG



BIPOLAR
LIMB LEAD II

Lead II ECG



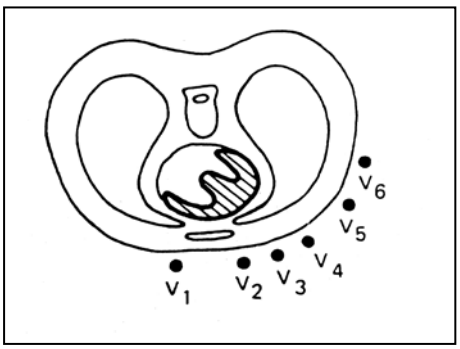


BIPOLAR
LIMB LEAD III

Lead III ECG

Precordial Leads

Precordial leads view the heart in the horizontal plane.



Structures which are located close to the electrode will give a larger deflection.

- V1 & V2 are located over the R ventricle: the S wave is expected to be larger than the R wave
- V5 & V6 are located over the L ventricle: the R wave is expected to be larger than the S wave
- V3 & V4 are located over the inter-ventricular septum: the R and S waves are expected to be equal in magnitude in either V3 or V4

Types of information that can be obtained from the ECG

- Rate
- Rhythm
- Coordination of electrical activity in different regions
- Abnormal pacemaker activity
- Heart block
- Myocardial hypertrophy
- Ischaemia or injury

(Note: you are not required to know pathological changes of the ECG in detail)