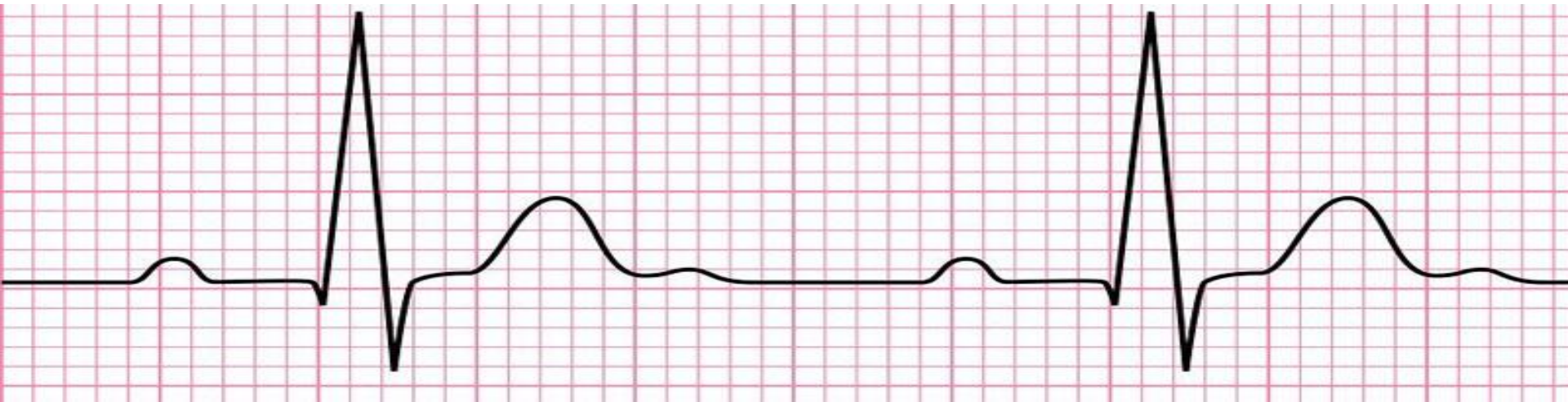
THE ECG

Dr. Tamara Alqudah



References

Guyton and Hall Textbook of Medical Physiology 13th edition

The ECG Made Easy 8th edition

Goldberger's Clinical Electrocardiography A Simplified Approach 8th edition

The electrocardiogram (ECG)

- The ECG is a special graph that represents the electrical activity of the heart from one instant to the next.
- It provides a time-voltage chart of the heartbeat.
- When the cardiac impulse passes through the heart, electrical current also spreads into the adjacent tissues all the way to the surface of the body.

- The device used to obtain and display the ECG is called the electrocardiograph, or ECG machine.
- It records cardiac electrical currents (voltages or potentials) by means of conductive electrodes selectively positioned on the surface of the body.
- A simple & non-invasive diagnostic test. It is a key component of clinical diagnosis and management in both inpatient and outpatient settings.

Depolarization & Repolarization

- The resting heart muscle cell is polarized; that is, it carries an electrical charge, with the outside of the cell positively charged and the inside negatively charged

- When a heart muscle cell is stimulated, it depolarizes. As a result the outside of the cell, in the area where the stimulation has occurred, becomes negative and the inside of the cell becomes positive. This produces a difference in electrical voltage on the outside surface of the cell between the stimulated depolarized area and the unstimulated polarized area. Consequently, a small electrical current is formed.

- Stimulation and depolarization occur until the entire cell is depolarized
- After a time the fully stimulated and depolarized cell begins to return to the resting state. This is known as repolarization.
- A small area on the outside of the cell becomes positive again and the repolarization spreads along the length of the cell until the entire cell is once again fully repolarized.

- The ECG machine records the electrical activity of a large mass of atrial and ventricular cells, not that of just a single cell.

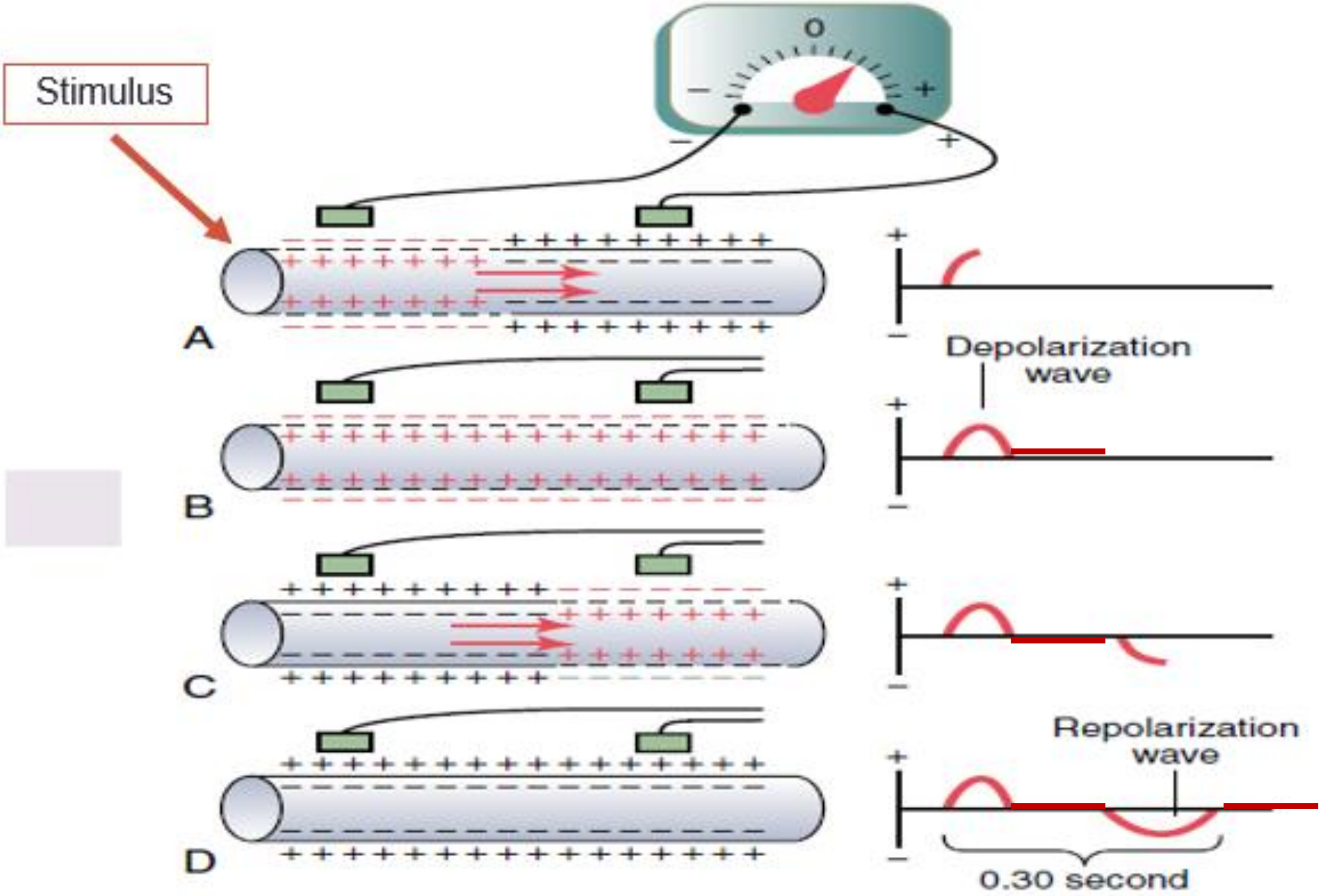
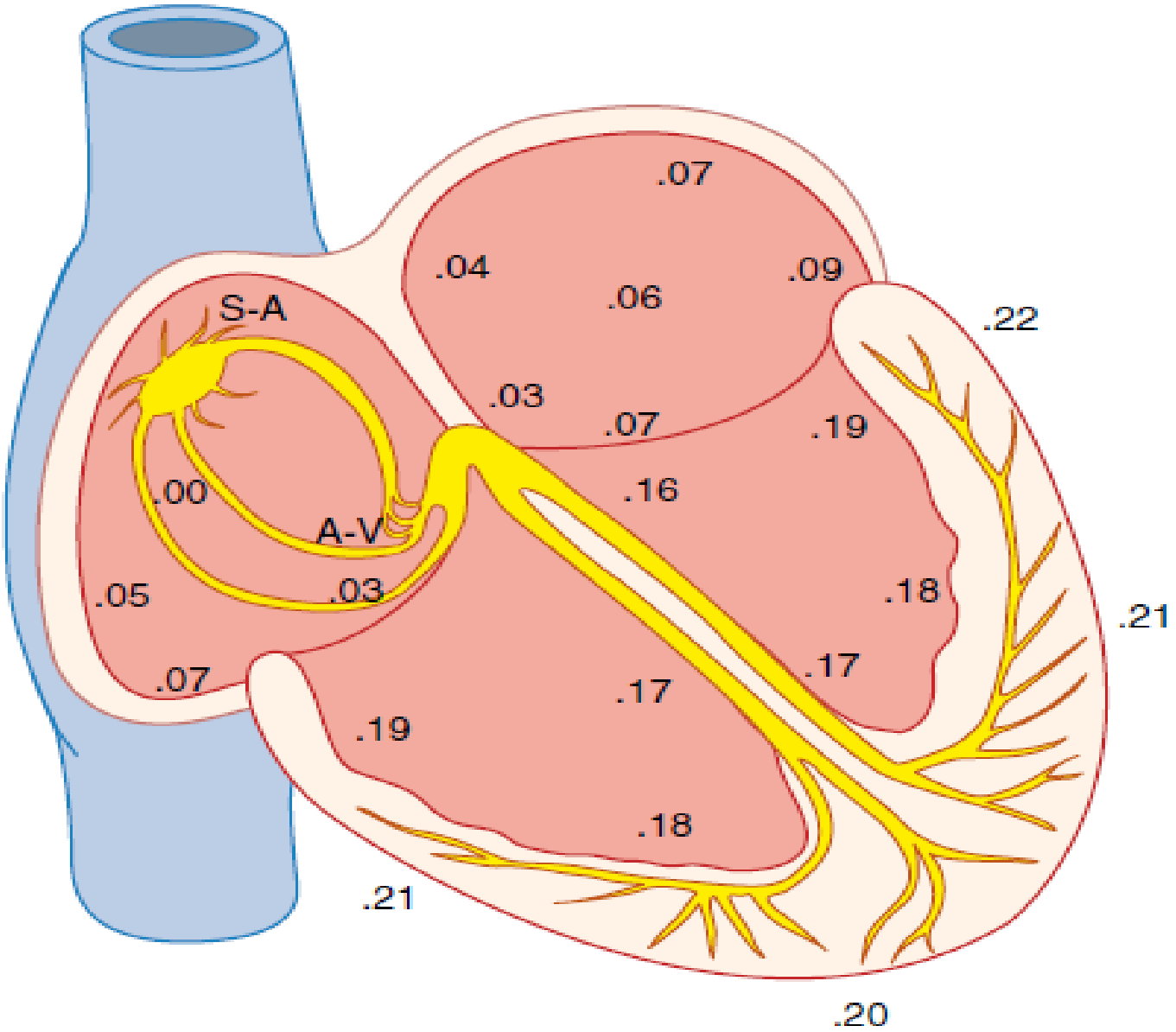
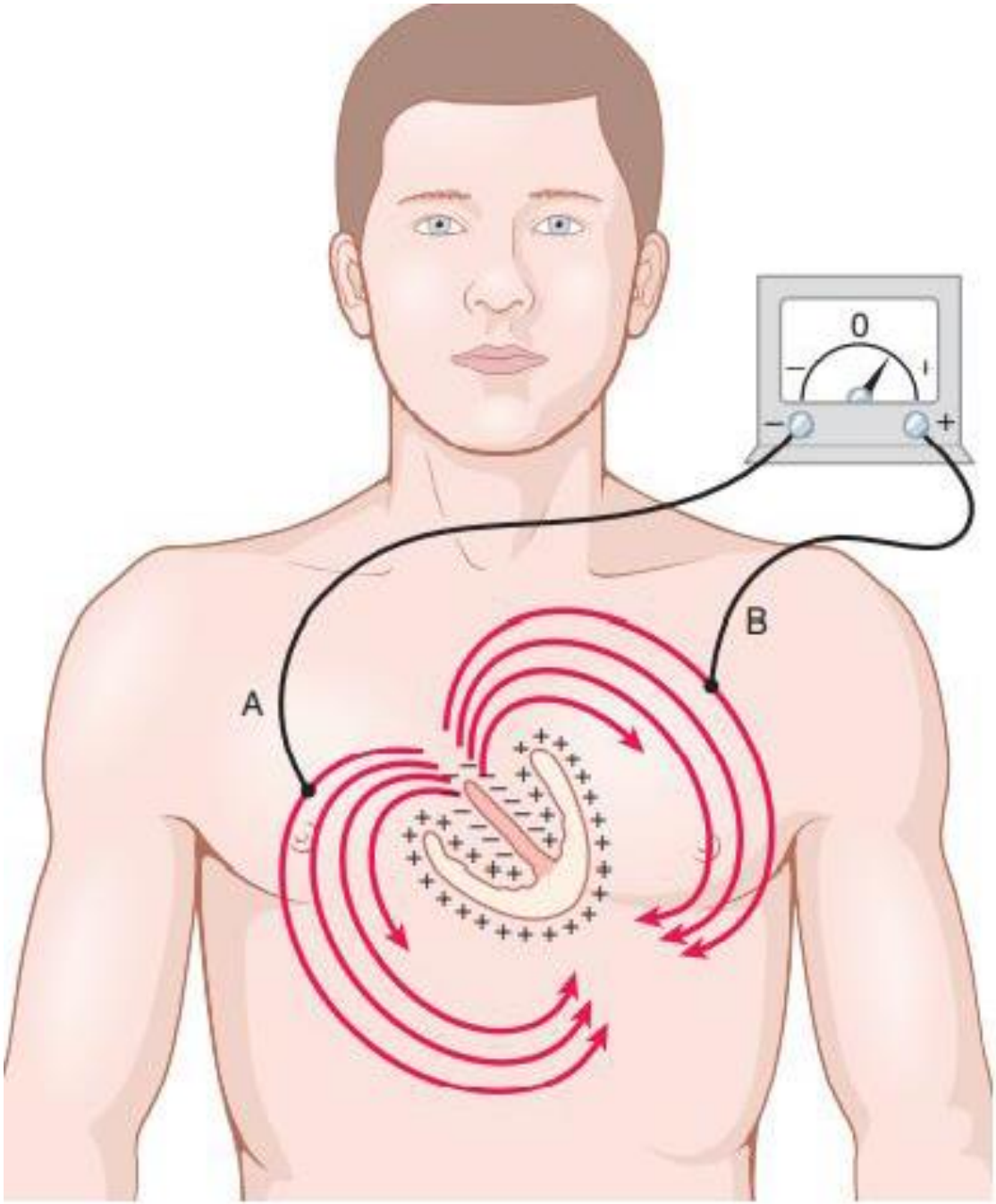


Figure 11-2 Recording the depolarization wave (*A* and *B*) and the repolarization wave (*C* and *D*) from a cardiac muscle fiber.

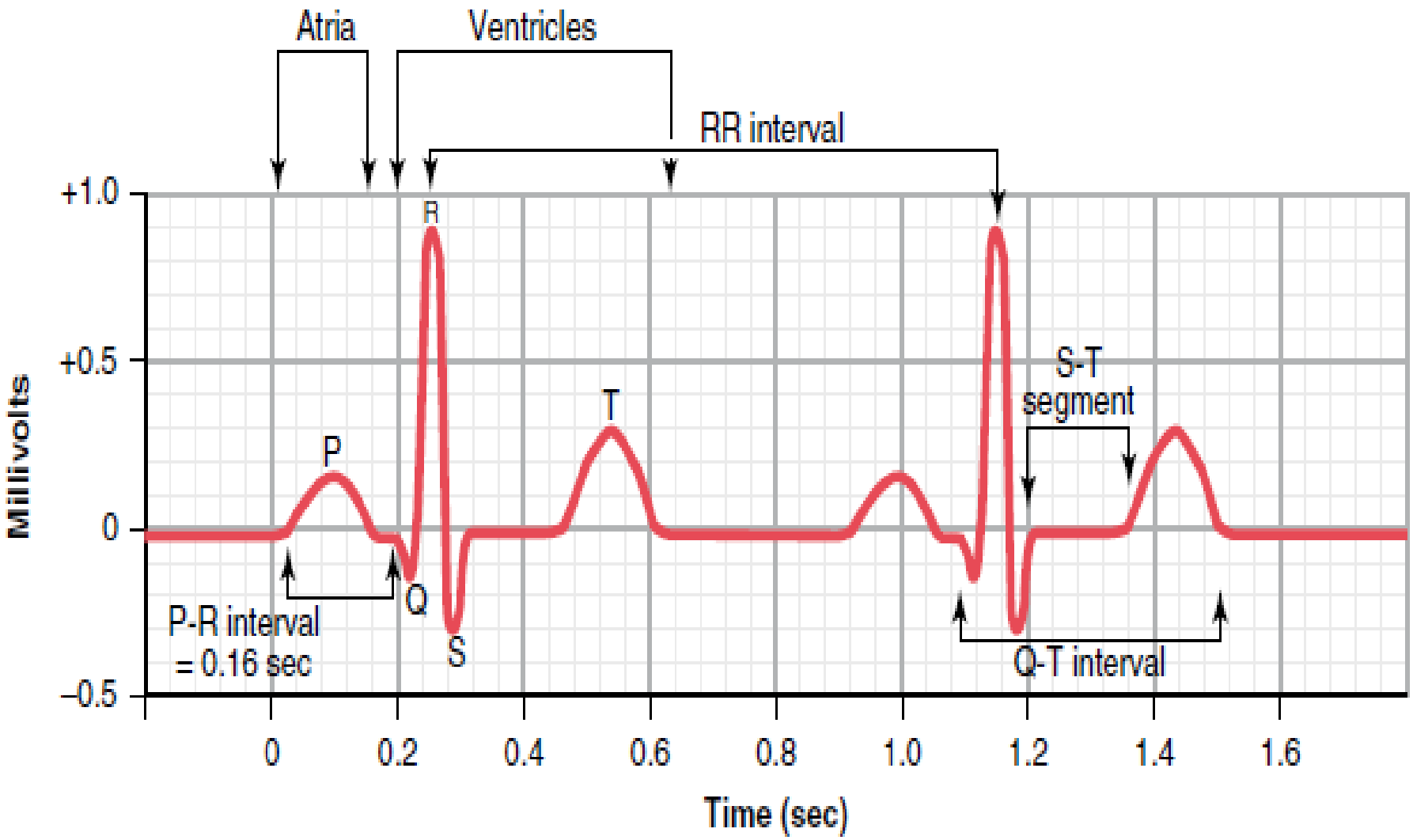
Transmission of cardiac impulse





When one portion of the heart depolarizes and therefore becomes electronegative with respect to the remainder, electrical current flows from the depolarized area to the polarized area in large circuitous routes.

The Normal ECG



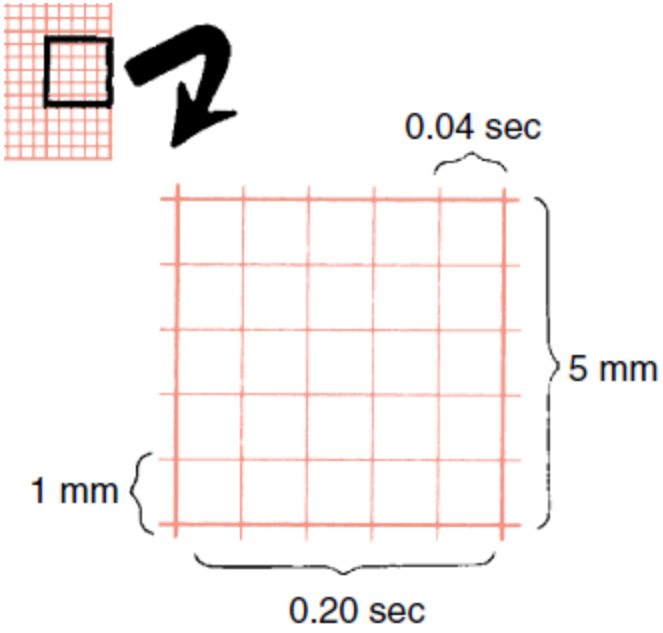
- ECG is a plot of voltage on the vertical axis against time on the horizontal axis

- The ECG waves are recorded on a special graph paper that is divided into standard-sized squares. Each large square is 5 mm long and each small square is 1 mm long.

- ECG is recorded at a speed of 25mm/sec, So:
  - Each large square on the horizontal axis represents =0.2 sec (200ms)
  - Each small square on the horizontal axis represents =0.04 sec (40ms)

- Vertically, the ECG graph measures the height (amplitude) of a given wave or deflection,10 mm (10 small squares) equals 1 mV with standard calibration.

- Paper speed and voltage are usually printed at the bottom of the ECG paper strip.



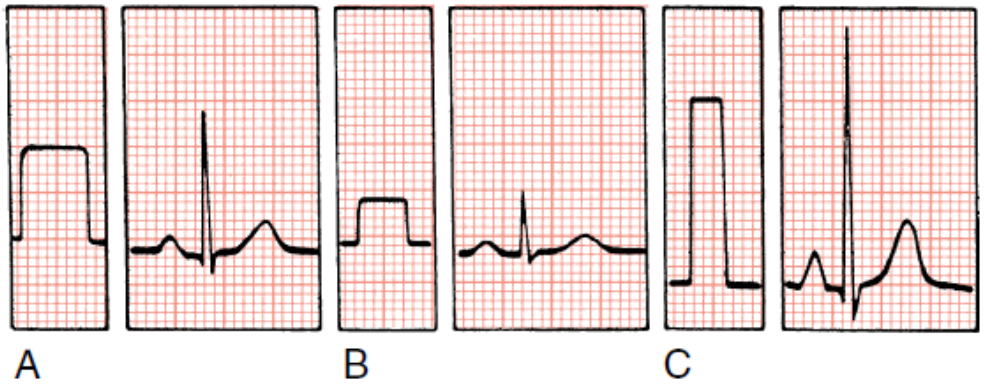


Figure 2-5. Before taking an ECG, the operator must check to see that the machine is properly calibrated, so that the 1-mV standardization mark is 10 mm tall. **A,** Electrocardiograph set at normal standardization. **B,** One-half standardization. **C,** Two times normal standardization.

Main Components of ECG

- The ECG is made of: Depolarization and repolarization waves, Intervals, and Segments
- The **P wave** is caused by electrical potentials generated when the atria depolarize.
- The **QRS complex** is caused by potentials generated when the ventricles depolarize. The first downward deflection is called a Q wave. An upward deflection is called an R wave. Any downward deflection following an R wave is called an S wave
- The **T wave** is caused by potentials generated as the ventricles repolarize.
- The repolarization wave of the atria occurs at the same time as the QRS complex that's why it's not seen on the ECG record **normally**.

- PR interval
- From the beginning of the P wave till the beginning of the QRS complex.

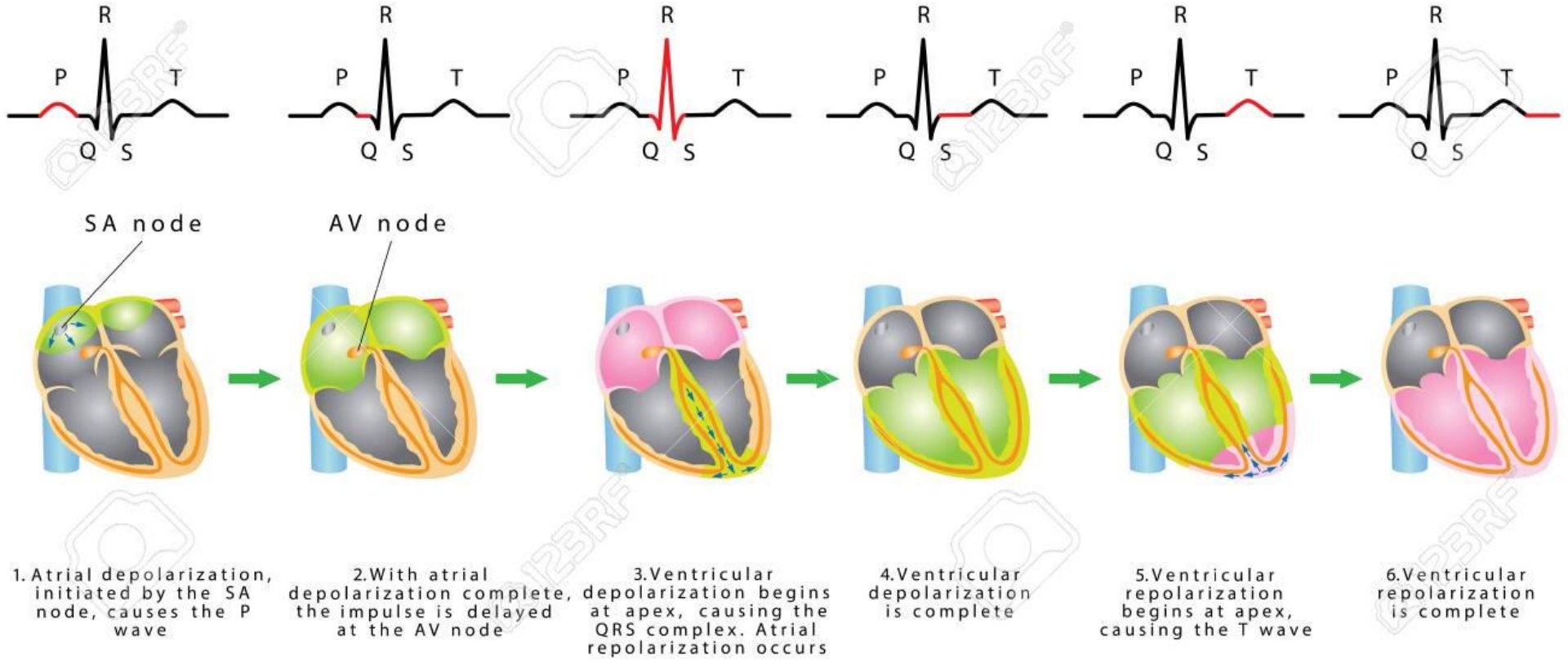
- QT interval
- From the beginning of the QRS complex to the end of the T wave (ventricular depolarization & repolarization).

- R-R interval
- Represents one cardiac cycle & is essential in calculating the heart rate.

- PR segment
- Extends from the end of P wave to the beginning of QRS complex. It should be isoelectric.

- ST segment
- Extends from the end of QRS complex to the beginning of T wave. It should be isoelectric.

- T-P segment
- Extends from the end of T to the beginning of P. It should be isoelectric



THE CARDIAC CYCLE

Electrocardiograph Machine

The ECG machine

- This machine compares, amplifies and filters the electrical potential differences recorded by the ELECTRODES and presents the results as LEADS

- Electrode is a conductive pad which is attached to the skin and allows recording of electrical currents
- The electrodes placed on the surface of the body record only the currents that are transmitted to the area of electrode placement.

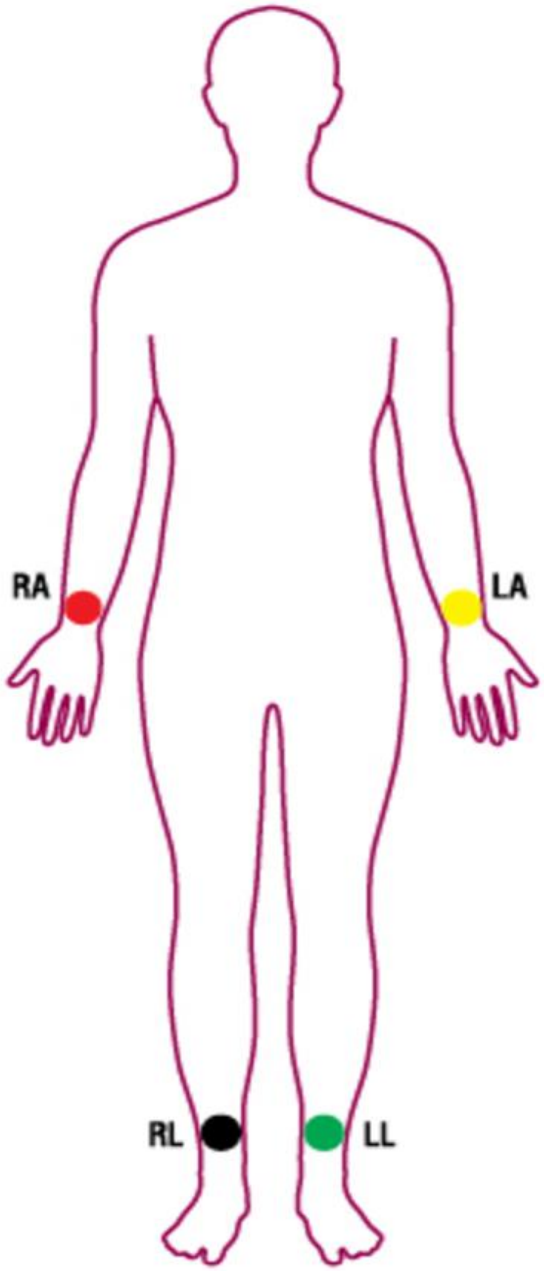
- An ECG lead is a graphical description of the electrical activity of the heart from a particular angle across the body. It is created by analysing the data obtained from two or more electrodes

12-Lead ECG

- 12-lead ECG is generated from 10 electrodes.
- These 10 electrodes allow the electrical activity of the heart to be looked at from 12 different positions. There are 4 limb electrodes and 6 chest electrodes.

- Limb electrodes:
  - LA – Left arm
  - RA – Right arm
  - LL – Left leg
  - RL – Right leg

✓ RL is a neutral lead and is solely present to complete the electrical circuit. It plays no role in the formation of the ECG leads



Limb Electrodes

Clamp Electrodes

Disposable, adhesive

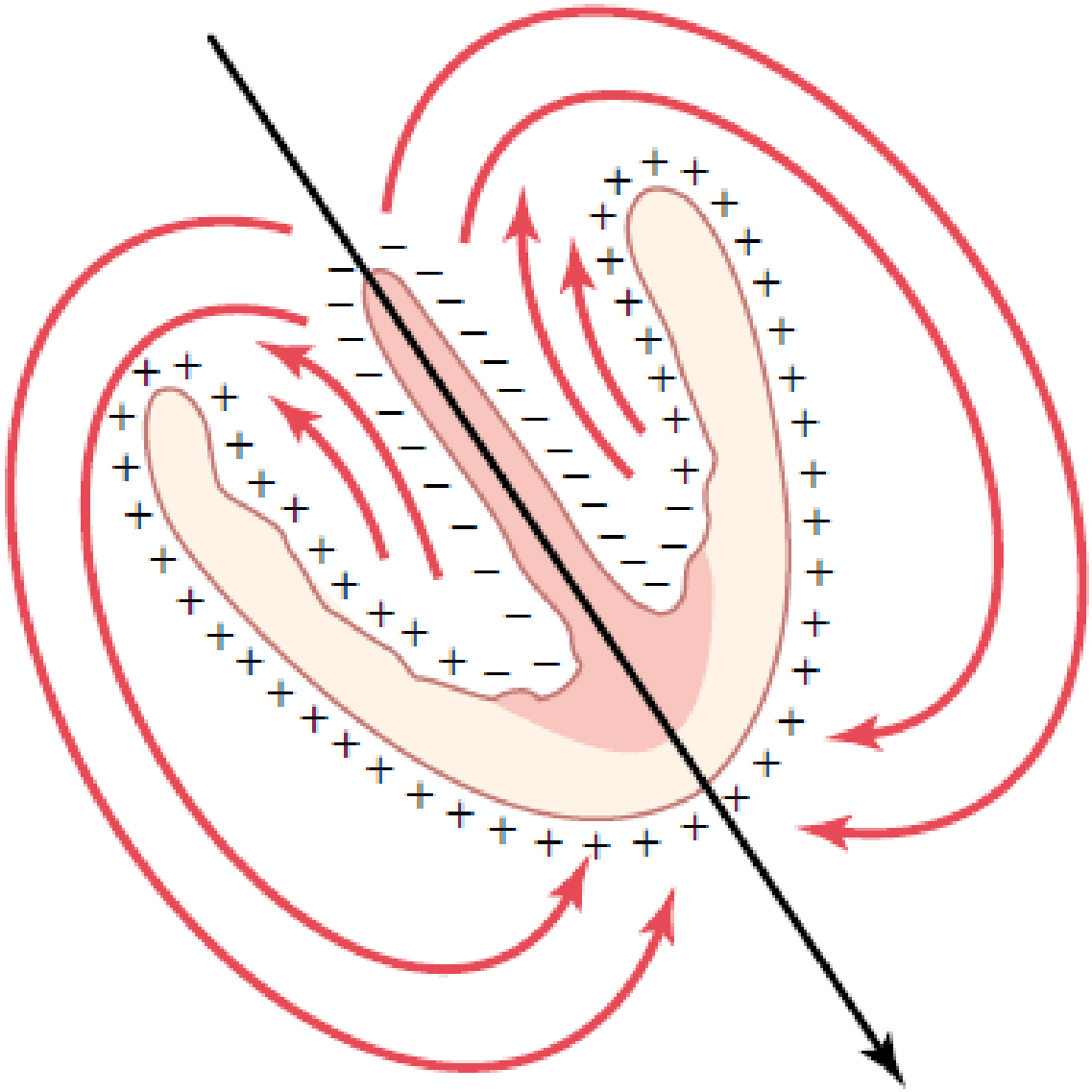
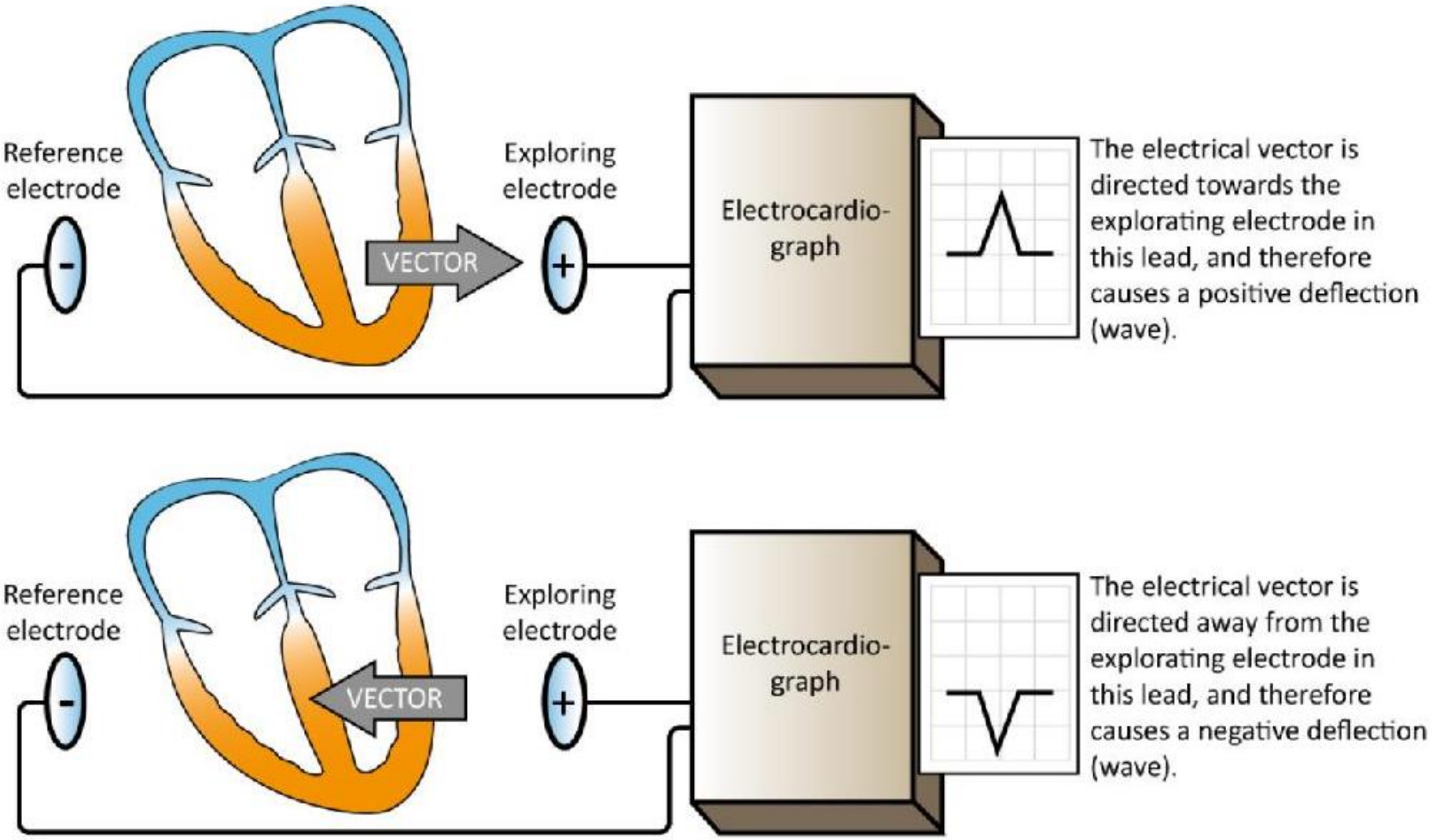


Figure 12-1 Mean vector through the partially depolarized ventricles.

Recording a wave of depolarization



Limb leads (Frontal Plane)

- **Bipolar Limb Leads**
  - Lead I: RA (-) to LA (+)
  - Lead II: RA (-) to LL (+)
  - Lead III: LA (-) to LL (+)

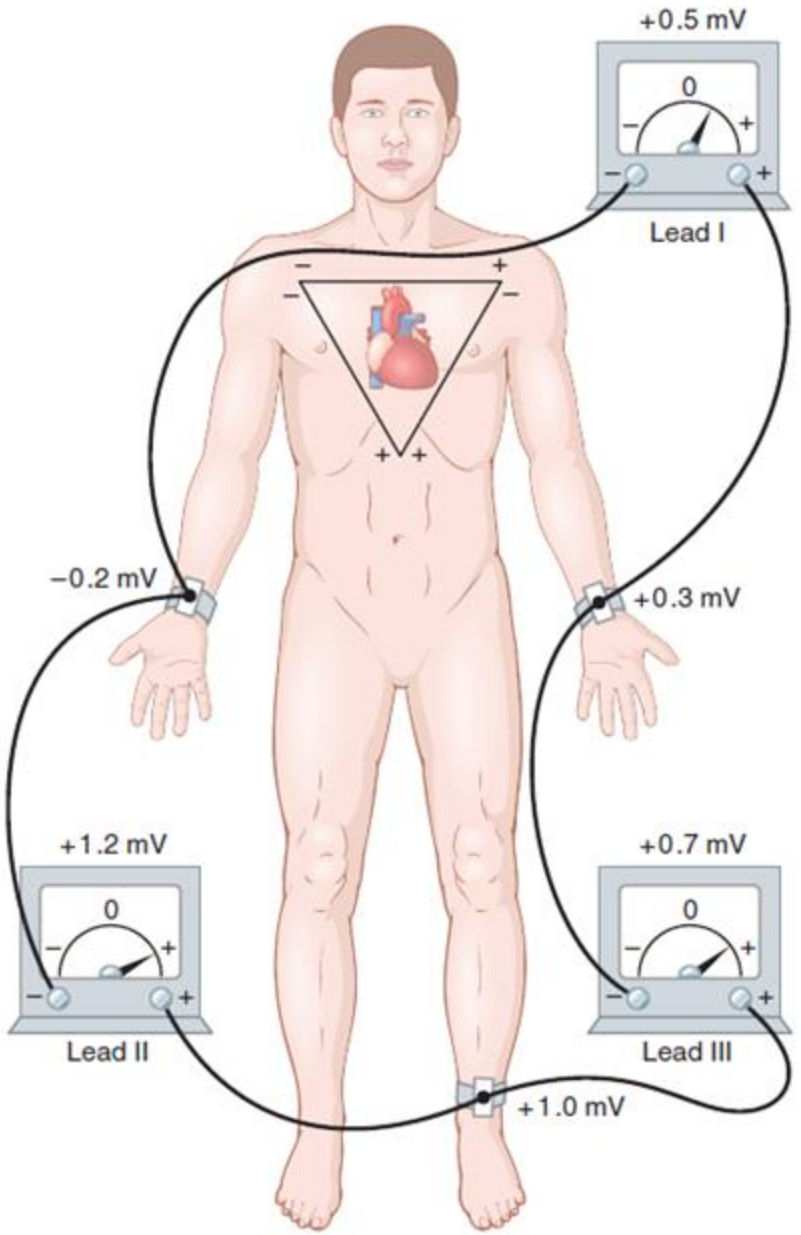
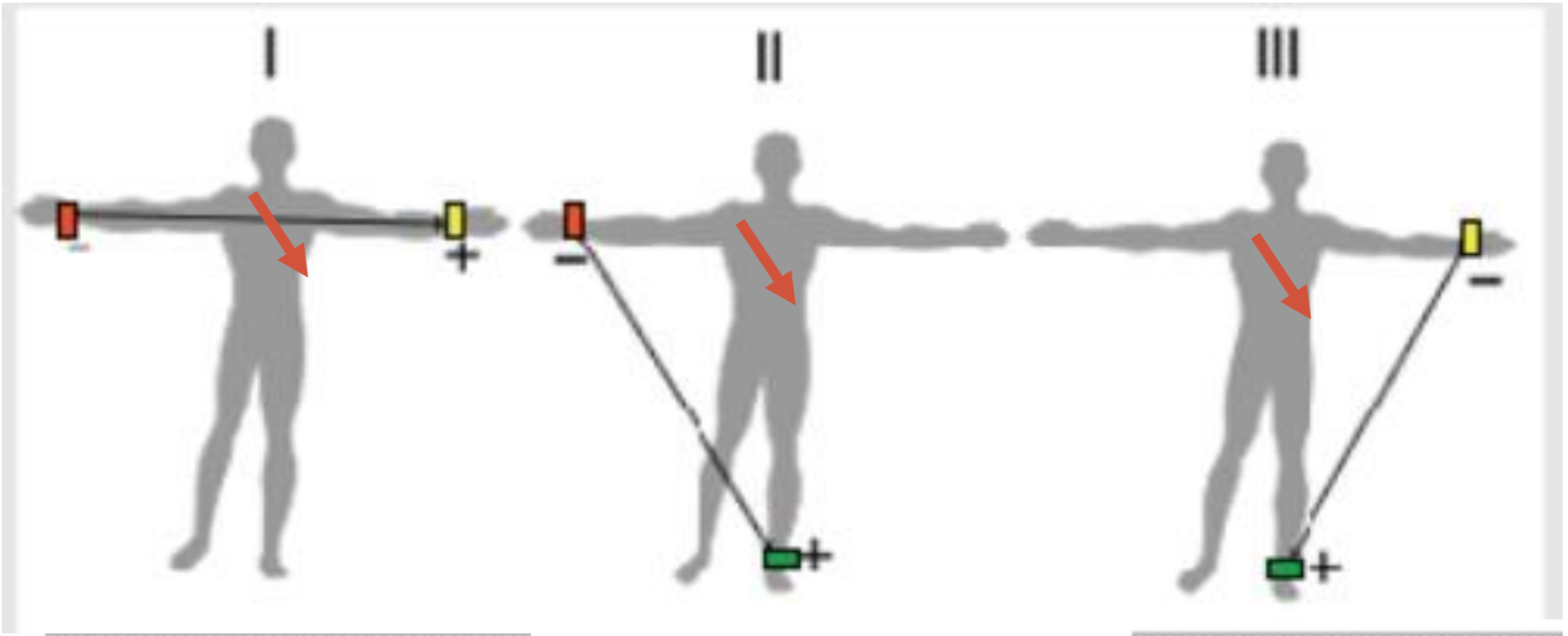
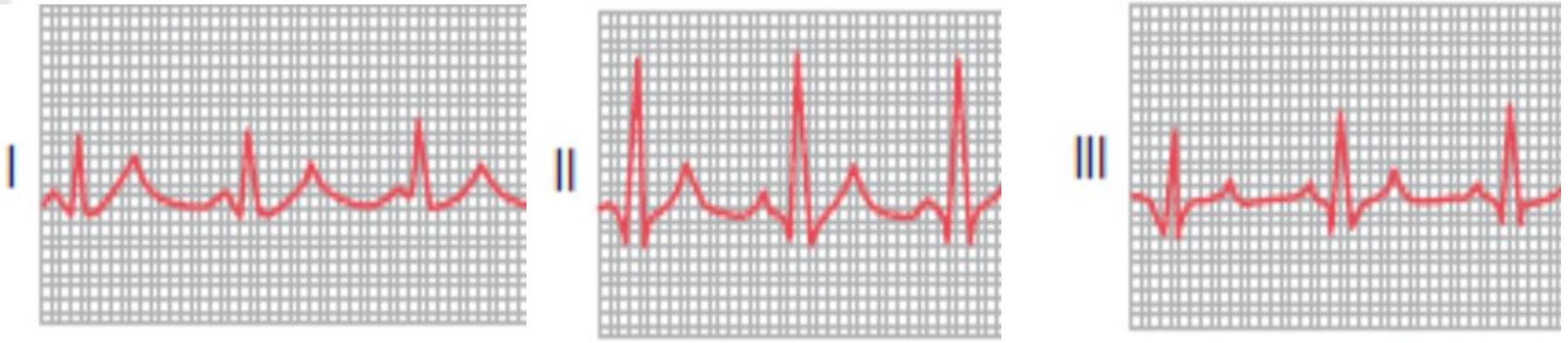


Figure 11-6. Conventional arrangement of electrodes for recording the standard electrocardiographic leads. Einthoven's triangle is superimposed on the chest.


I
II
III
+
−
−
+
−
+


I
II
III

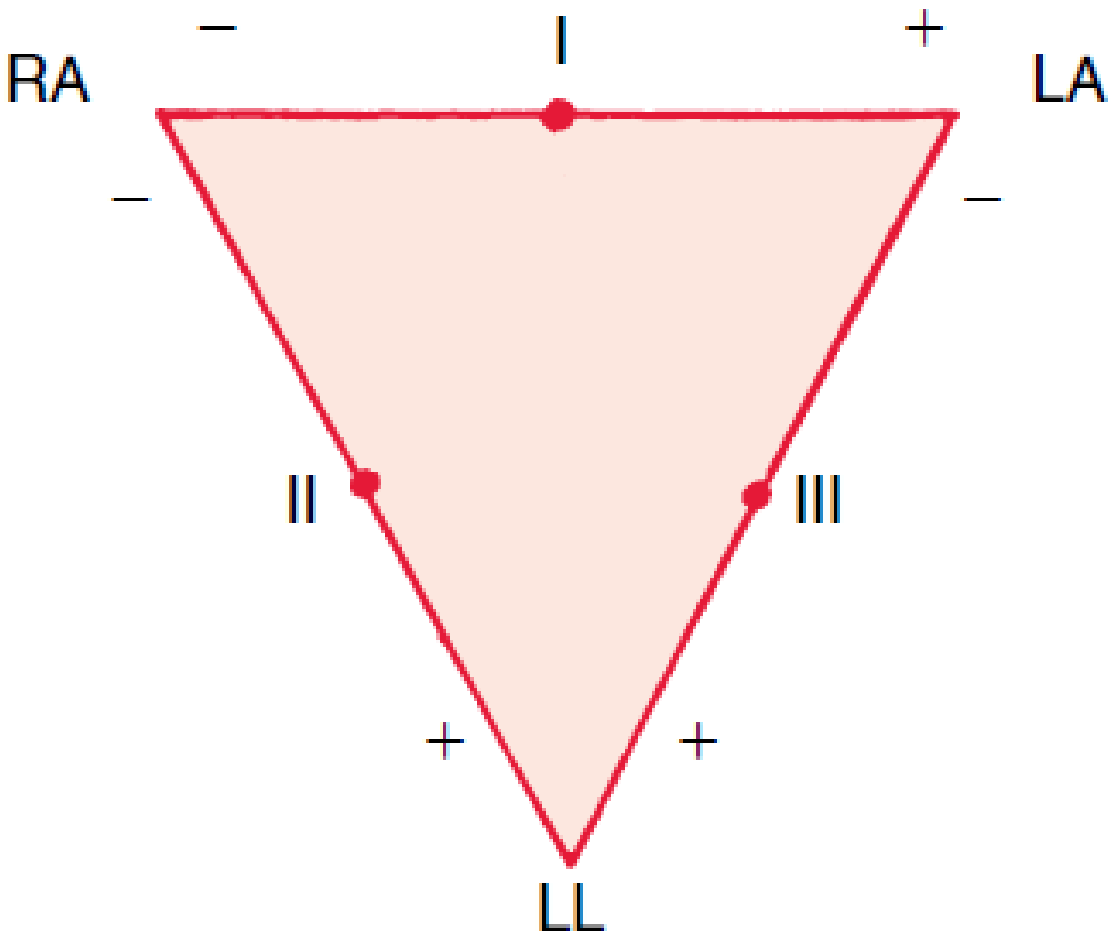
Einthoven's Triangle & Law

- Einthoven's triangle, the two arms and the left leg form apices of a triangle surrounding the heart.

- Einthoven's law states that if the electrical potentials of any two of the three bipolar limb leads are known at any given instant, the third one can be determined mathematically. Because:

- The sum of the voltages in leads I and III equals the voltage in lead II

Einthoven's Triangle

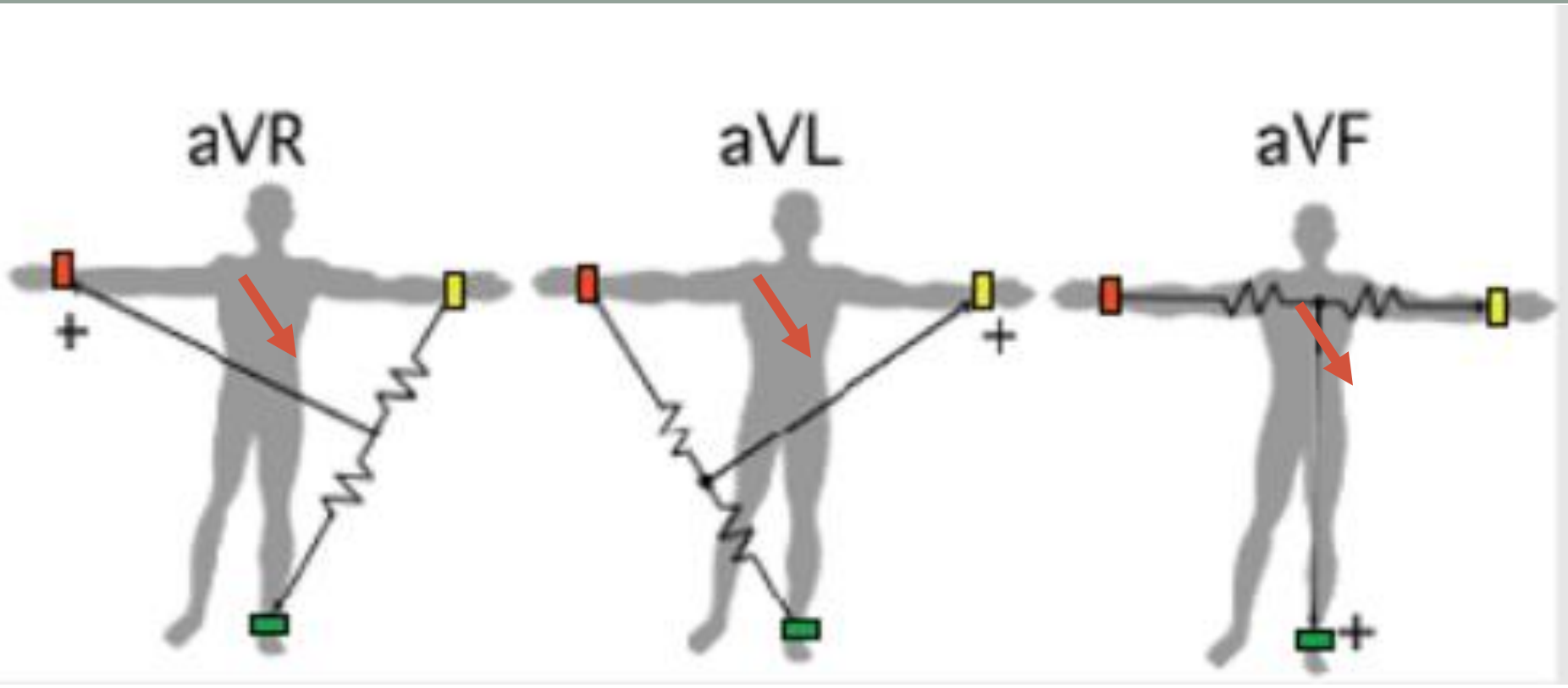


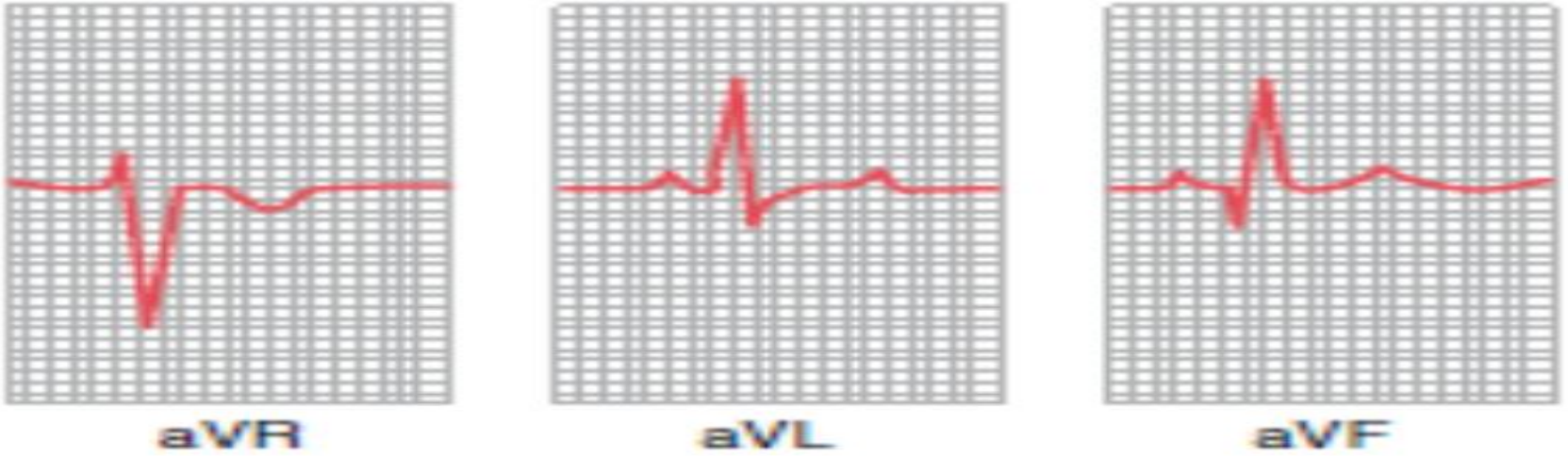
Limb leads (Frontal Plane)

- **Augmented Unipolar Limb Leads**
- Connect two limbs to the negative (reference) electrode through very high resistance (the recorded voltage will be almost zero). The third limb is connected to the positive(exploring) electrode and its voltage is thus recorded.

  - Lead aVR: RA (+) to [LA & LL] (-)
  - Lead aVL: LA (+) to [RA & LL] (-)
  - Lead aVF: LL (+) to [RA & LA] (-)

- a refers to augmented; V to voltage; and R to right arm, L left arm, and F left foot (leg).

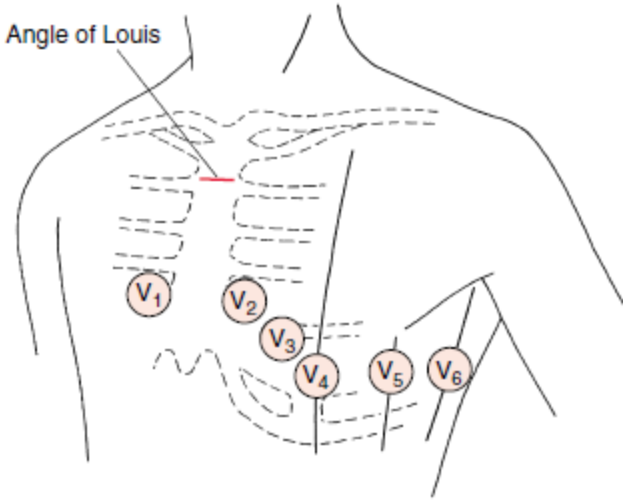

aVR
aVL
aVF
+
+
+


aVR
aVL
aVF

Chest electrodes

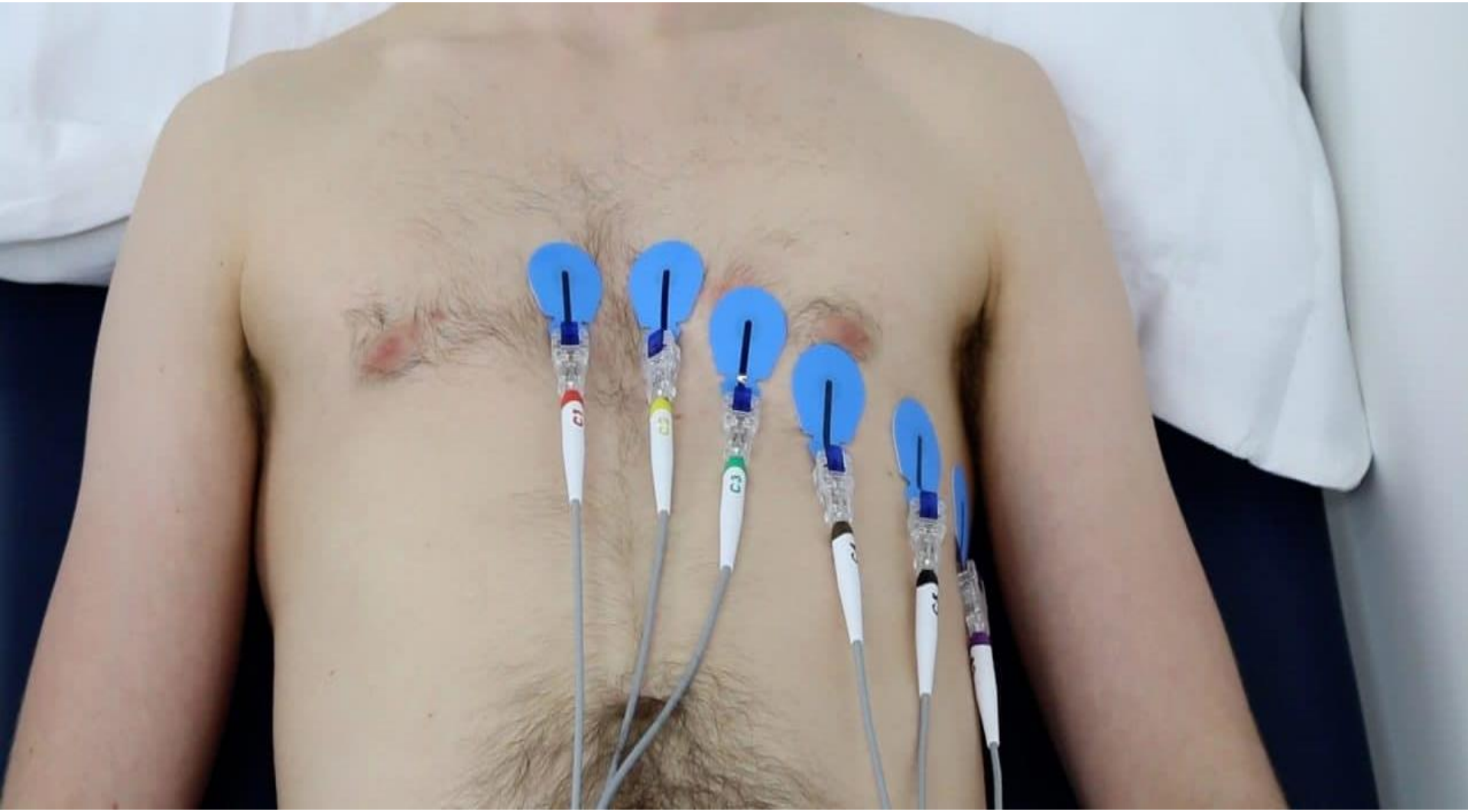
Position of the chest electrodes:

- V1: Right sternal edge, 4th intercostal space
- V2: Left sternal edge, 4th intercostal space
- V3: Midway between V2 and V4
- V4: Left mid-clavicular line, 5th intercostal space
- V5: Left anterior axillary line, 5th intercostal space
- V6: Left mid-axillary line, 5th intercostal space



Disposable, adhesive

Suction bulb electrodes


C1
C3

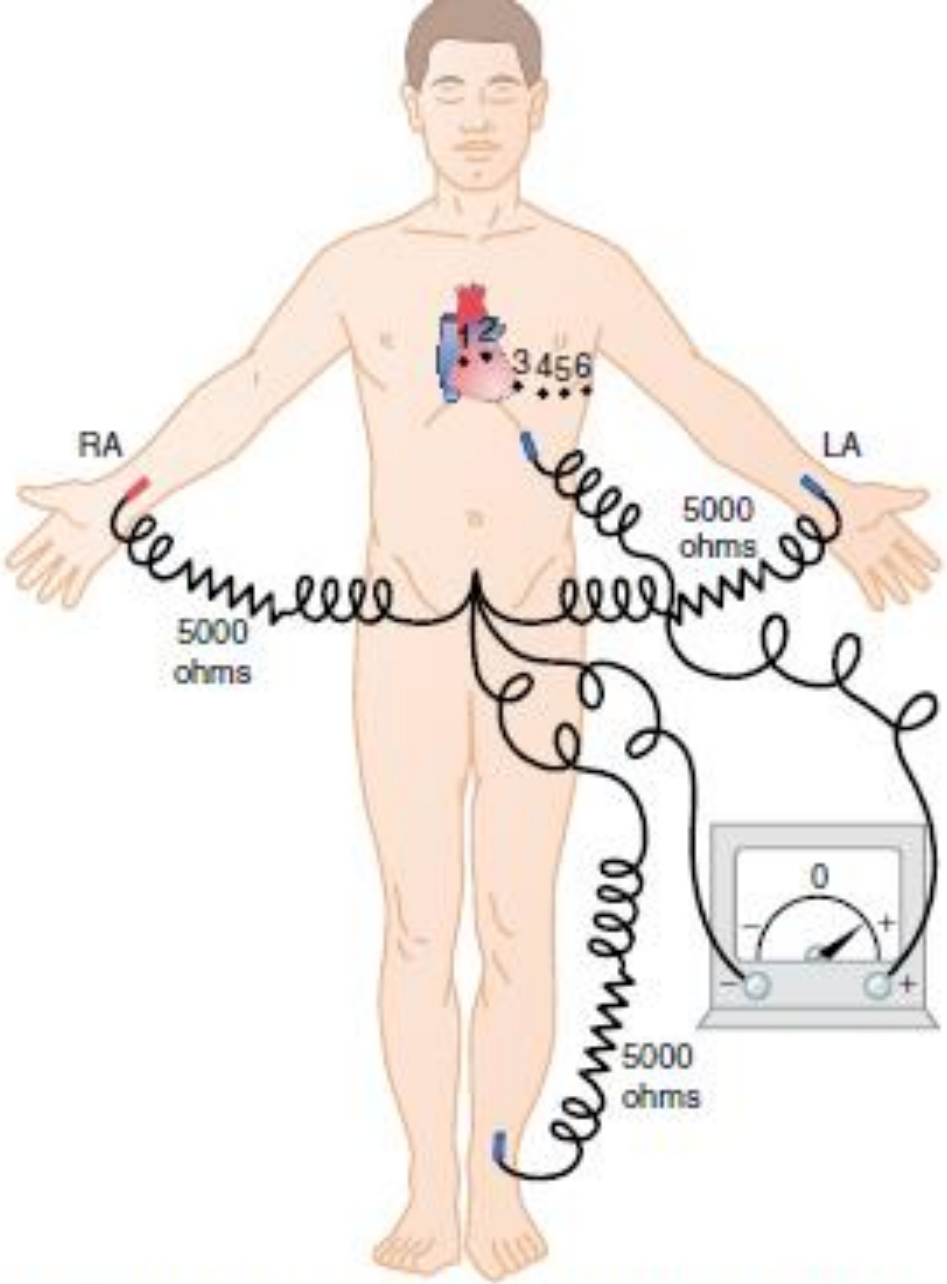
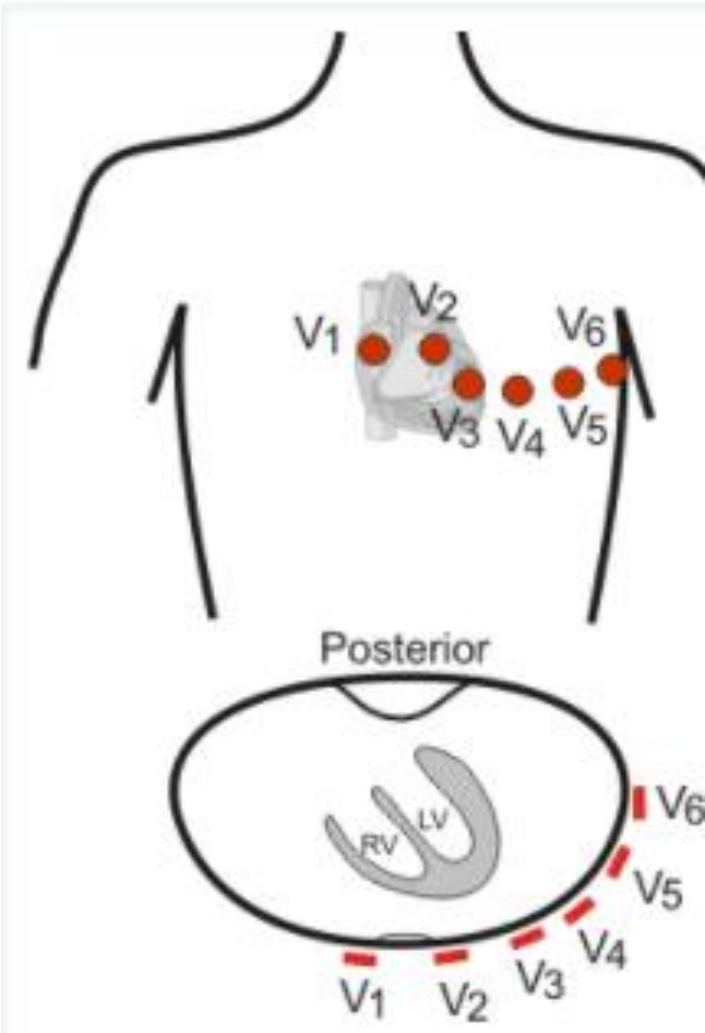
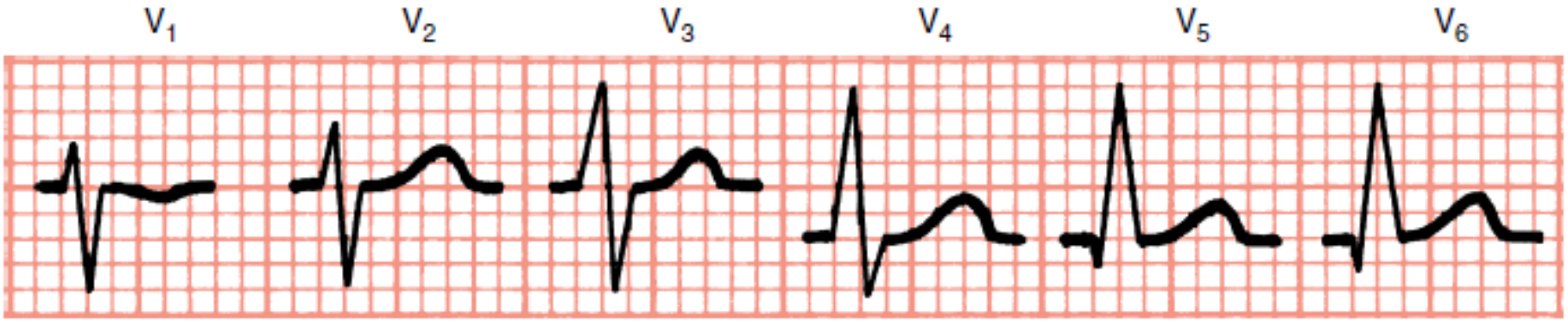


Figure 11-8 Connections of the body with the electrocardiograph for recording chest leads. LA, left arm; RA, right arm.



Chest Leads (Horizontal plane)

- These are unipolar leads.
- The positive (exploring) electrode is placed on the anterior surface of the heart and the negative (reference) electrode is attached to the three limbs through very high resistance



QRS complex progression in chest leads

- The QRS complex in the chest leads shows a progression from lead V1, where it is predominantly negatively deflected, to lead V6, where it is predominantly positively deflected.

- The ‘transition point’, where the R and S waves are equal, indicates the anatomical position of the interventricular septum. It is normally seen in leads V3 or V4.

What we need to perform a 12 lead ECG

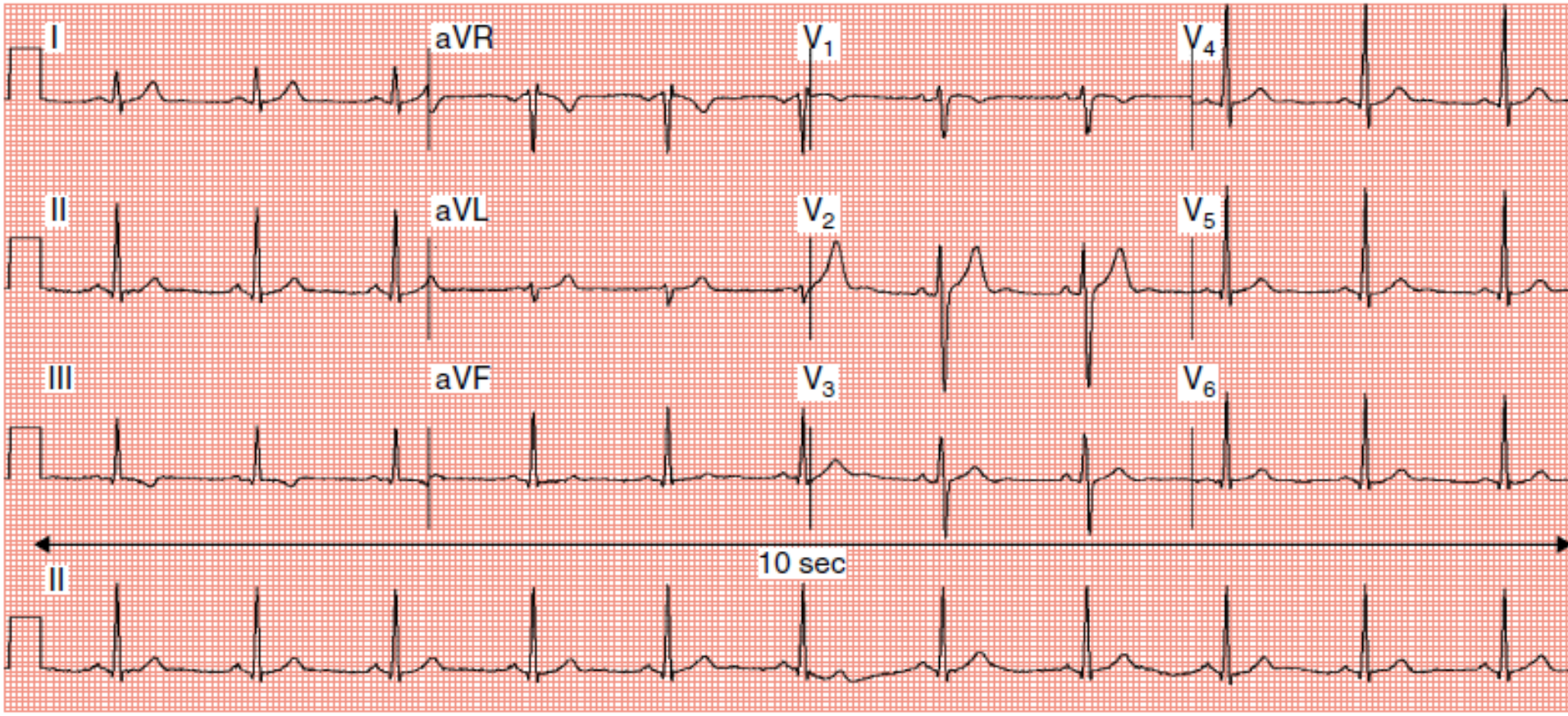
- ECG machine
- 4 limb electrodes
- 6 chest electrodes
- Razors and skin cleansing wipes (alcohol swabs)
- Conducting gel

MAKING A RECORDING – PRACTICAL POINTS

- Fully explain the procedure to the patient
- Make sure the patient is relaxed, warm and lying in a Semi-recumbent position comfortably
- Ask the patient to take off any jewellery, belts and clothes with metallic parts and to turn off the cell phone.
- Shaving might be necessary since hair is a bad conductor of electrical activity.
- Make sure the skin is clean and dry
- The electrodes should be accurately positioned.
- Apply the gel in sufficient quantities.
- Ensure good contact between the electrodes and the skin.
- Make sure the patient isn't moving or talking while making the record
- Check the calibration & speed settings on the machine.

- You can watch this video for further clarification
- //www.youtube.com/watch?v=1k4B_fIX_t0


45°



A good record of a normal ECG

Note

- The upper three traces show the six limb leads (I, II, III, VR, VL, VF) and then the six chest leads
- The bottom trace is a 'rhythm strip', entirely recorded from lead II (i.e. no lead changes)
- The trace is clear, with P waves, QRS complexes and T waves visible in all leads