Electrocardiogram (ECG):

The ECG is the recording of the electrical potential of the heart that extend to the body surface. By placing the electrodes of an ECG instrument on the skin surface.

The Aim

ECG is use to detect a previous heart attack (a heart attack in emergency situations), blocked or narrowed heart arteries, heart valve problems, heart defects, and arrhythmias, record the waves of depolarization and repolarization that are generated by the cardiac muscle

Requirements

Electrocardiograph, ECG leads (electrodes), ECG paper, straps and ECG jelly

A standard ECG consists12 leads of:

- 3Bipolar standard limb leads (I, II, III).
- 3unipolar limb leads (aVR, aVL, aVF).
- 6unipolar chest leads.

Bipolar standard limb leads (I, II, III):

These leads record the differences between the potentials in 2 limbs, by applying electrodes usually at the wrist and ankle.

The 3 standard bipolar limb leads include:

- Lead I: This records the difference between the potential in the left arm (LA) and that in the right arm (RA).
- Lead 11: This records the difference between the potential in the right arm (RA) and that in the left leg (LL).
- Lead III: This records the difference between the potential in the left leg (LL) and that in the left arm (LA).

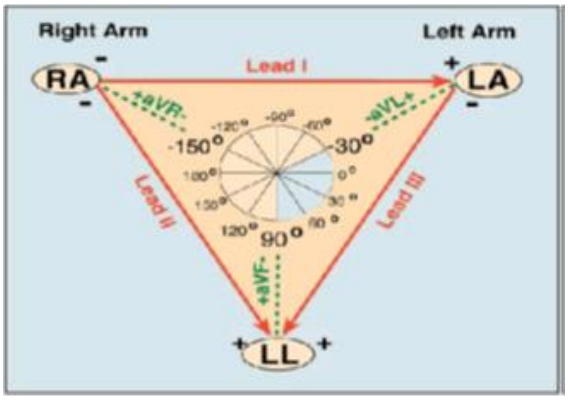
Unipolar limb leads (aVR, aVL, aVF):

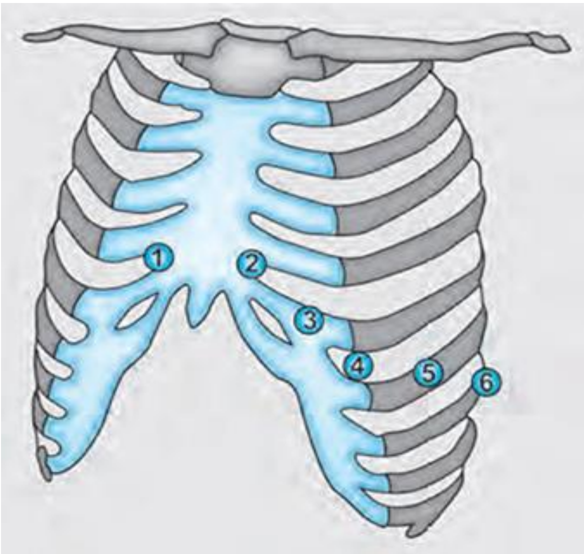
- **Unipolar chest leads** (precordial or chest leads) record the absolute potential at 6 standard points on the anterior chest wall designated as V1 to V6, the locations of which are as follows:

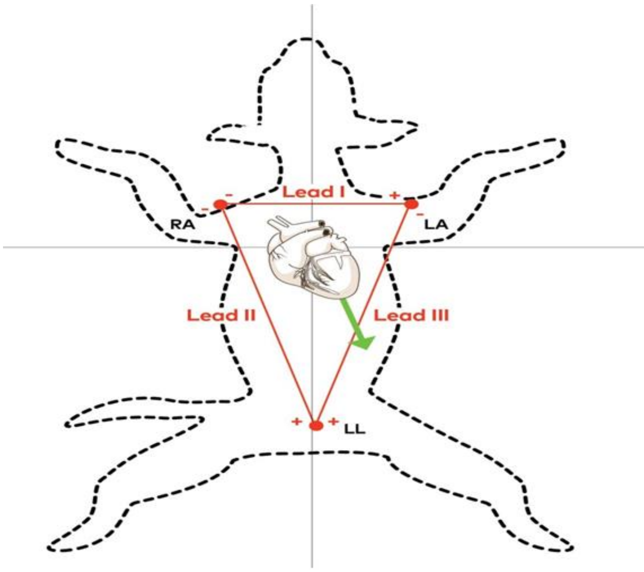
V1: At the right margin of the sternum in the 4th right intercostal space.
V2: At the left margin of the sternum in the 4th left intercostal space.
V3: Midway between V2 and V4.
V4: At the left midclavicular line in the 5th intercostal space.
V5: At the left anterior axillary line in the 5th intercostalspace.
V6: At the left midaxillary line in the 5th intercostal space.

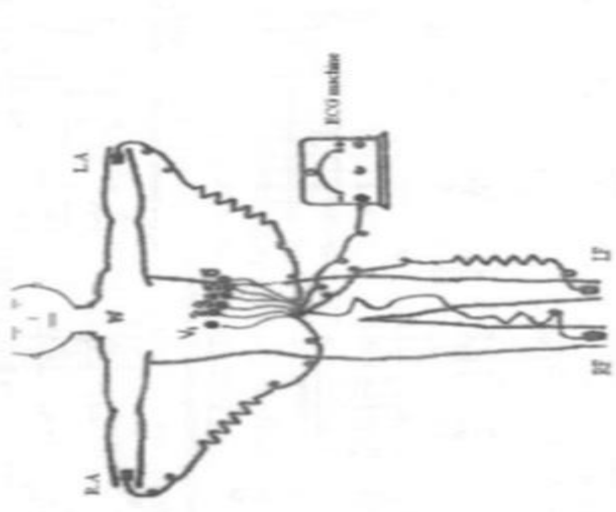
The precordial leads look at the heart in a horizontal plane from the front & left sides. Leads **V1 & V2 look at the right ventricle** and reflect its activity, **V3 & V4 look at the interventricular septum** and reflect its activity, while leads **V5 & V6 look at the left ventricle** and reflect its activity.

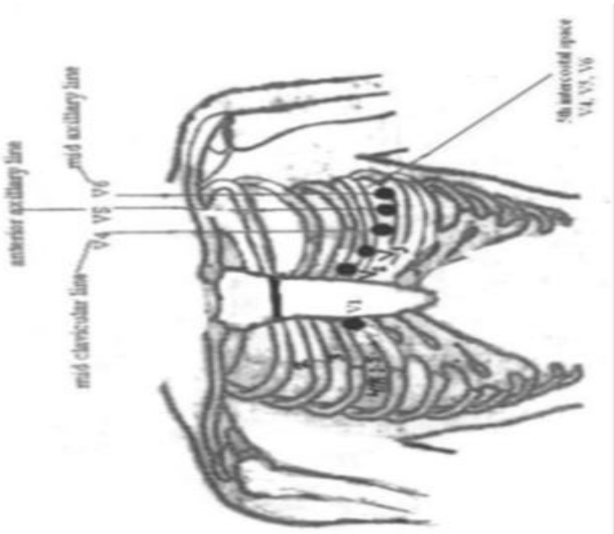
Einthoven's triangle: This is an equilateral triangle, the sides of which represent the 3 bipolar standard limb leads while the heart lies at its centre.

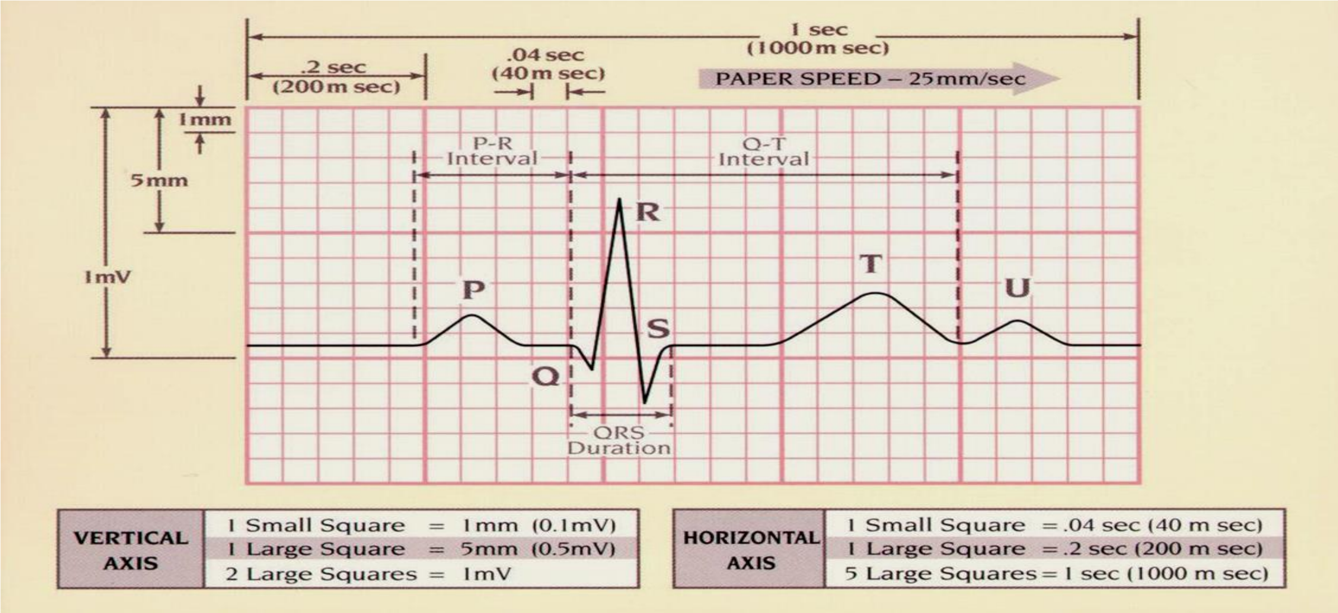












Calibration of the electrocardiograph:

The electrocardiograph is calibrated so that a change of 1 Mv upward or downward produces a deflection of 10 mm amplitude (10 small squares; 2 large squares), thus each mm between the horizontal lines (voltage calibration lines) equals 0.1 mV. In other words, the thin horizontal lines calibrated at 1 mm interval and the thick horizontal lines at 5 mm intervals. The vertical lines are time calibration lines in which duration of each mm (small square) equals 0.04 second, each inch (2.5cm) is 1 second, divided into 5 large squares, each large square (5 small squares) represents 0.20 second as each small square = 0.04 second.

Calculation of heart rate from ECG paper:

If the heart rhythm is regular, the heart rate (HR) ran be counted by dividing the number of large squares between two consecutive R waves into 300 or small squares into 1500. If the rhythm is irregular, one can multiply the number of complexes in 6 seconds by 10.

ECG waves:

ECG (Electrocardiograph) is an indirect recording of electrical potential of the heart. Normal ECG consists of the following waves:

P wave caused by the depolarization process of the atria; i.e., correspond to atrial depolarization just before contraction (i.e., not atrial contraction).

QRS complex of waves caused by the depolarization process of the ventricles; again before ventricular contraction (i.e., not ventricular contraction).

T wave caused by the repolarization of the ventricles; the ventricles recover from the state of depolarization.

<u>**Duration and intervals:**</u>

P wave, duration; 0.07-0.14 seconds and not higher than 3 mm.

PR interval, This is measured from the beginning of the P wave to the beginning of the **QRS complex**; to the onset of the Q wave if there is one and to the onset of the R wave if there is no Q wave. This interval corresponds to the time taken for the impulse to travel from the sinus node to the ventricular muscle. It ranges normally between 0.12- 0.21 seconds. Abnormal PR interval is either long as in first degree heart block or short as in WPW syndrome.

QRS complex, duration; 0.06 – 0.10 seconds. Abnormal wide QRS indicate bundle branch block.

T wave, duration; 0.25 -0.35 seconds and not taller than 10mm in chest leads.

QT interval, it represents the total time from the onset of ventricular depolarization to the completion of repolarization. It indicates the duration of ventricular systole i.e. contraction of the ventricle lasts from the beginning of the Q wave to the end of the T wave. Normally it is about 0.35 seconds; range 0.28 – 0.44 seconds

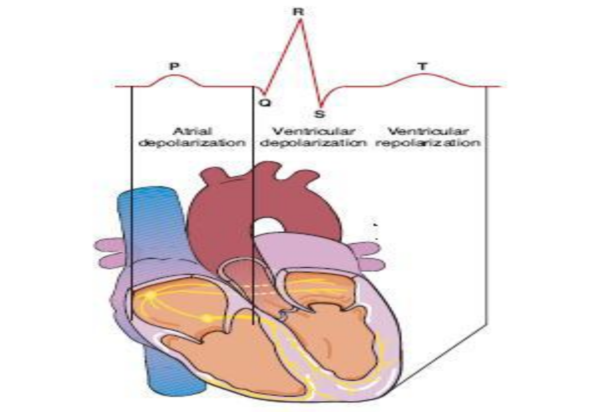


Figure 2.1 ■ Correlation of depolarization and repolarization with the ECG.

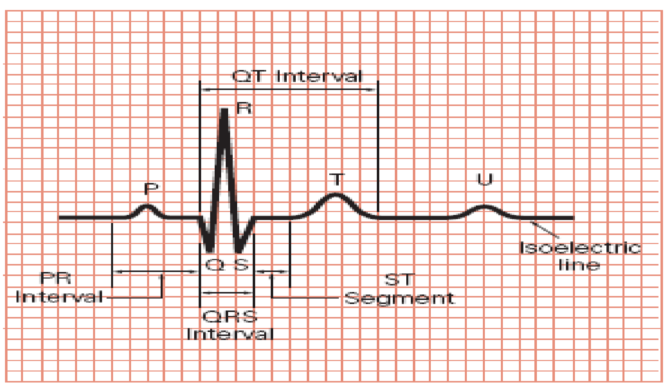


Figure 2.13 ■ The electrical pattern of the cardiac cycle shows waves and intervals.

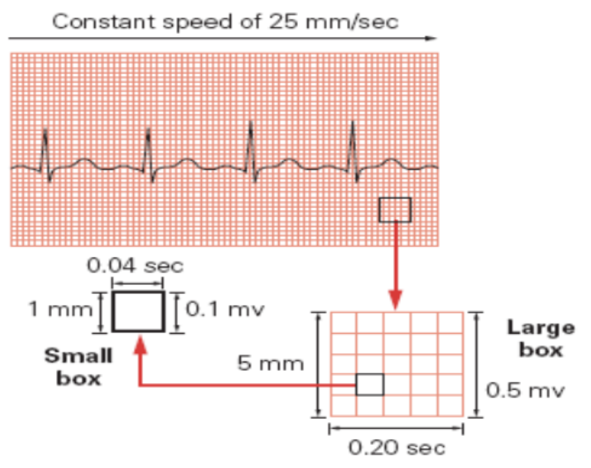


Figure 2.12 ■ ECG graph paper values.

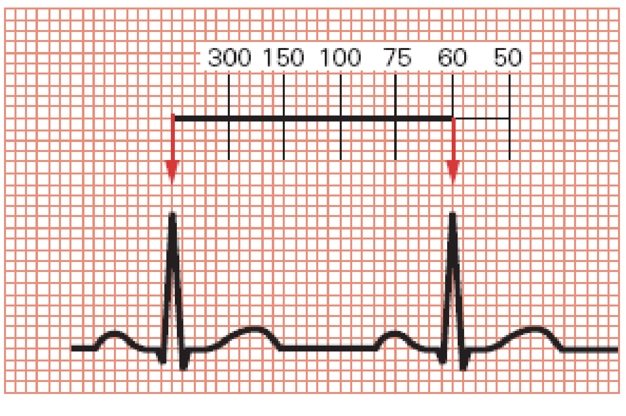
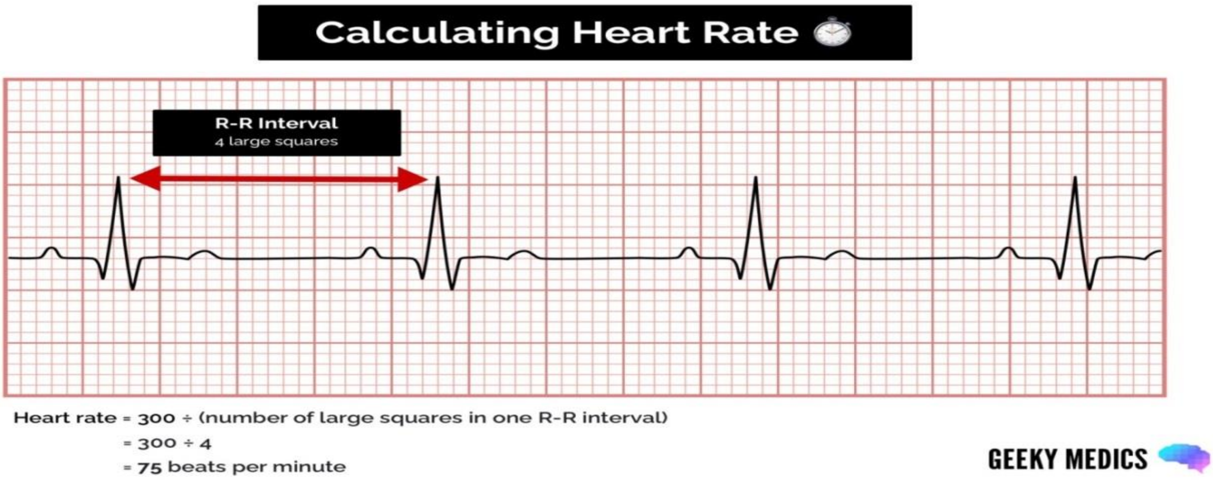
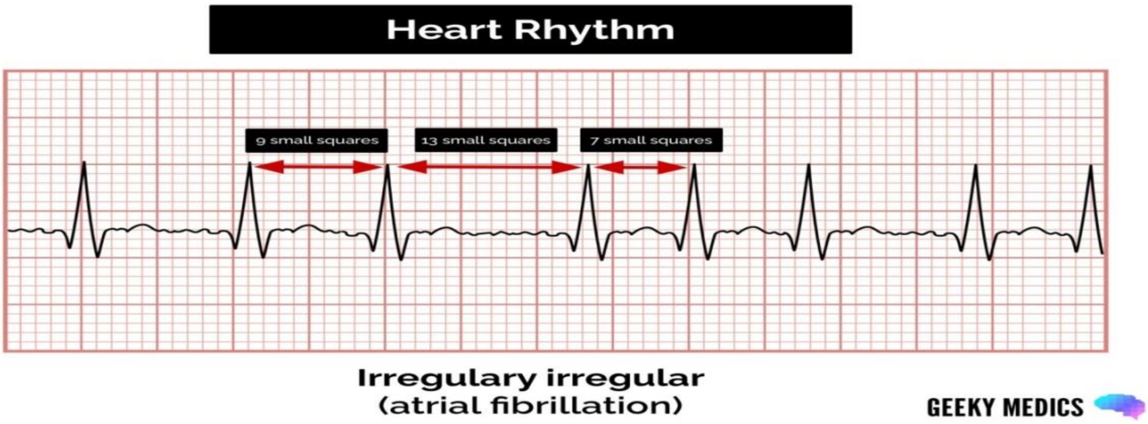
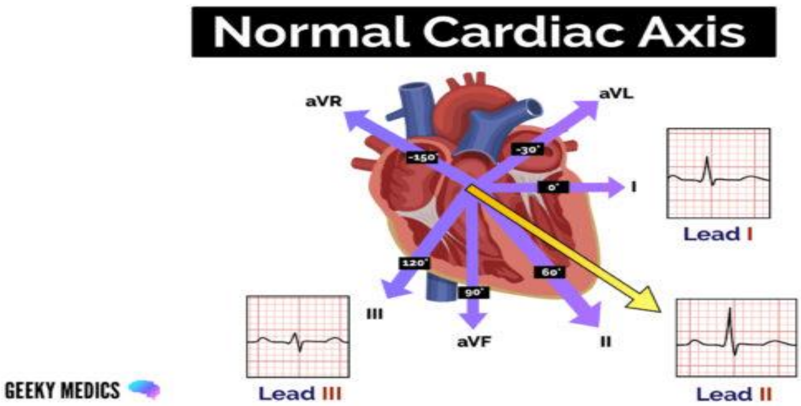


Figure 2.14 ■ Counting large boxes for heart rate. The rate is 60 bpm.


Calculating Heart Rate
R-R Interval
4 large squares
Heart rate = 300 ÷ (number of large squares in one R-R interval)
= 300 ÷ 4
= 75 beats per minute
GEEKY MEDICS


Heart Rhythm
9 small squares
13 small squares
7 small squares
Irregulary irregular
(atrial fibrillation)
GEEKY MEDICS


Normal Cardiac Axis
aVR
aVL
-150°
-30°
0°
I
120°
60°
90°
III
aVF
II
Lead I
Lead III
Lead II
GEEKY MEDICS

When evaluating the heart rhythm on an ECG, using a stepwise approach simplifies the process.

1. Count the heart rate and determine if it is normal or abnormal (bradycardia or tachycardia). In cases of AV dissociation, there may be different atrialand ventricular rates.

2. Look at R-R regularity. Rhythms originating from a single site in the ventricles or atria are often regular, whereas rhythms originating from the sinus node are often irregular due to variations in adrenergic activity (Figure 4).

Figure 4. Lead II ECG from a dog (25 mm/sec; 10 mm/mV).

Heart rate: 90 bpm; normal.

R-R regularity: Regularly irregular (the heart speeds up and then slows down gradually in a regular rhythm).

QRS morphology: Narrow, normal-looking QRS shape; supraventricular origin.

P waves: There is a P wave for every QRS complex and a QRS complex for every P wave; P-wave shape looks normal.

Rhythm diagnosis: Sinus arrhythmia.

3. Evaluate the shape or morphology of the QRS complex. Does it appear normal or wide? Causes of wider-than-normal QRS complexes include ventricular origin (Figure 5), electrolyte abnormalities (hyperkalemia), aberrant conduction (bundle branch block), ventricular hypertrophy or certain medications. Is there a P wave for every QRS complex and a QRS complex for every P wave? If so, sinus rhythm is likely. If there are P waves without QRS complexes, AV block is present.

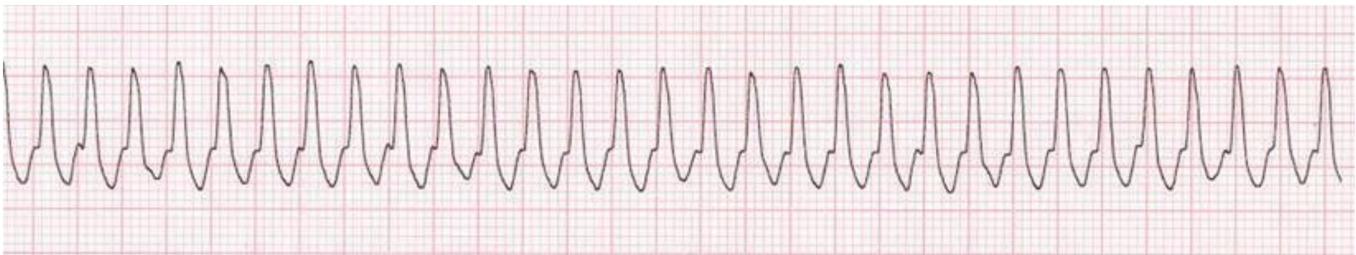


Figure 5. Lead II ECG from a dog (25 mm/sec; 5 mm/mV).

Heart rate: 300 bpm; tachycardia.

R-R regularity: Regular.

QRS morphology: Wide complex; ventricular (always keep in mind other possible causes of wide complex tachycardia, especially if rhythm doesn't respond to therapy as expected).

P waves: Not visible.

Rhythm diagnosis: Ventricular tachycardia, sustained.

4. Determine the degree of AV block. In first-degree AV block, every P wave produces a QRS complex but the AV conduction is slow and the P-R interval is therefore prolonged. If only some P waves block (i.e. do not result in a QRS complex), the rhythm is second-degree AV block (Figure 6). Second-degree AV block is further broken down into Mobitz type 1 (Wenkebach type), in which there is gradual lengthening of the P-R interval until a P wave blocks, or Mobitz type 2, in which the P-R intervals are constant. Complete dissociation (there are P waves and QRS complexes but no connection between them) is present with third-degree or complete heart block

Figure 6. Lead II ECG from a dog (25 mm/sec; 5 mm/mV).

Heart rate: 130 bpm; normal.

R-R regularity: Regularly irregular (the heart speeds up and then slows down gradually in a regular rhythm).

QRS morphology: Narrow, normal-looking QRS shape; supraventricular origin.

P waves: Several P waves occur without a following QRS complex (after the second, sixth and ninth QRS complexes).

Rhythm diagnosis: Second-degree AV block (P-R interval is fixed; therefore, second-degree AV block type 2).