ECG (ELECTRO CARDIO GRAPH)

Electrocardiograph (ECG) is an instrument which records the electrical activity of the heart. The potential produced in the individual fibers of heart muscle are added to produce the ECG waveform.

The electrocardiogram reflects the rhythmic electrical depolarisation and repolarisation of the myocardium (heart muscle) associated with the contractions of the atria and ventricles.

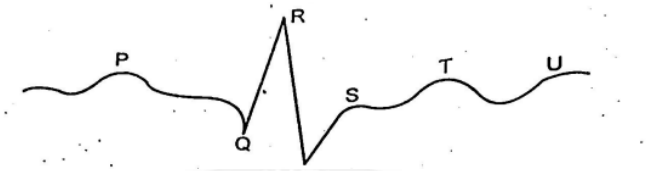

Fig: Electrocardiogram

The basic waveform of normal electrocardiogram is shown above. The shape, time interval and amplitude of the ECG give details of the state of the heart. The change of rhythm can be easily diagnosed using electrocardiogram.

The PQRS and T waves normal values and amplitude, duration of important ECG parameters are shown below.

Description	Origin	Amplitude mV	duration sec
P wave	Artial depolarisation(or) contraction	0.25	0.12to 0.22 (P-R interval)
R wave (QRS Complex)	Repolarisation of the atria and the depolarisation of the verticles.	1.60	0.07 to 0.1
T Wave	Ventricular repolarisation (Relaxation of myocardium)	0.1 to 0.5	0.05 to 0.15 (S-T interval)
S-T interval	Ventricular Contraction	-	-
U Wave	Slow repolarisation of the intra ventricular system	< 0.1	0.2 (T-U interval)

ECG Electrodes:

To record an electrocardiogram, a number of electrodes are affixed to the body of the patient. The electrodes are connected to the ECG machines by the same number of electrical wires. Usually surface electrodes are used with jelly as electrolyte between the skin and electrodes.

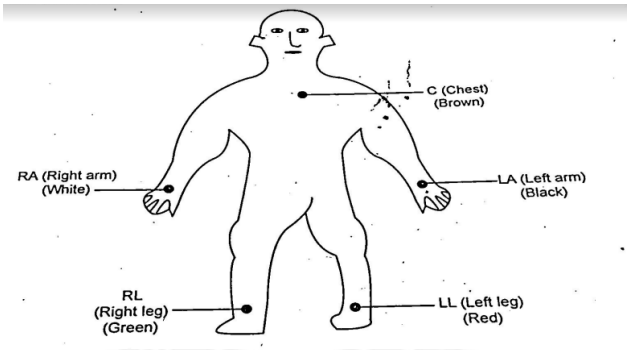

Fig: Color codes used for ECG electrodes

The potentials generated in the heart are conducted to the body surface. The potential distribution changes in a regular and complex manner during each cardiac cycle. Therefore, to record electrocardiogram we must choose electrodes in a standard position.

Each electrode has separate colour, it used to identify the placement of electrodes the above figure shows that. The early electrocardiograph machine employed with three electrodes, of which only two were used at one time.

ECG Lead System:

The tracing of voltage difference at any two sides due to electrical activity of the heart is called Lead. There are four types of lead systems used in electrocardiograms. Types of leads

- Bipolar limb leads or standard leads
- Augmented unipolar limb leads
- Modified chest leads or Unipolar chest leads
- Frank lead system or corrected orthogonal leads

Bipolar Limb Leads:

Bipolar limb leads are also called as standard leads bipolar limb lead system is first introduced by “Einthoven”. In this lead system the potentials are trapped from Four locations of our body, they are right arm, left arm, right leg and left leg.

Usually Right leg electrode is acting as ground reference electrode the following shows the position and standard limb leads of Bipolar limbs.

Lead I – Left Arm (LA) and Right Arm (RA)

Lead II – Left leg (LL) and Right Arm (RA)

Lead III – Left Leg (LL) and Left Arm (LA)

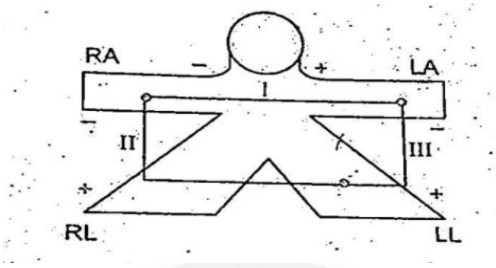

Fig: Recommended position for electrodes

These three leads are called "bipolar" because the electrode diagram is recorded from two electrodes and the third electrode is not connected. Because selection made among the available active electrodes.

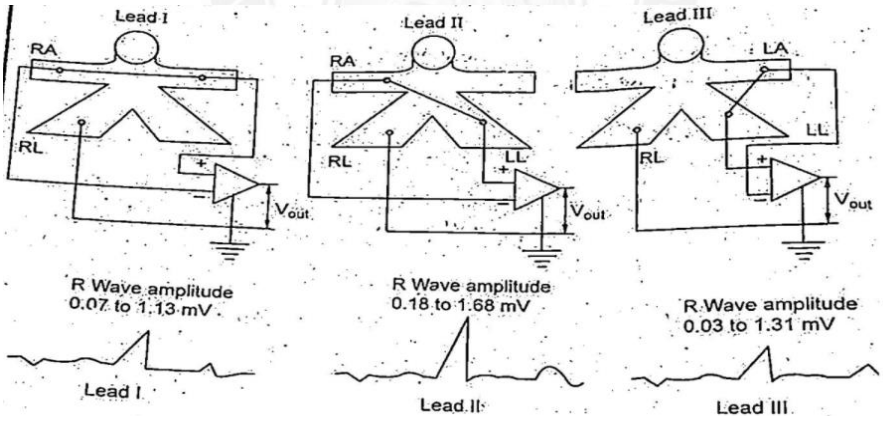

Fig: Standard bipolar limb leads and its corresponding ECG waveform

Einthoven Triangle:

The closed path RA to LA to LL and back to RA is called Einthoven triangle. It also made the assumption that the heart is near to the center of a "equilateral triangle". The sides of the triangle represent the lines along which are three projections of the ECG vector to measured.

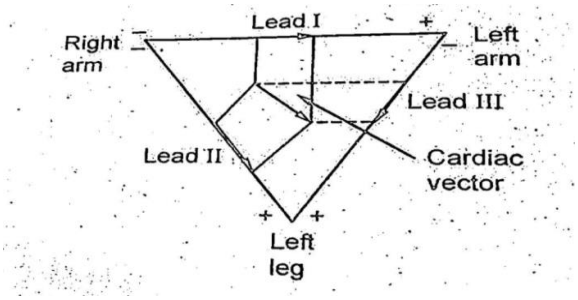

Fig: Einthoven Triangle

Augmented Unipolar Limb Leads:

- Unipolar type leads are introduced by Wilson, in this leads the electrocardiogram is recorded between a single exploratory electrode and the central terminal.
- Unipolar limb leads, one of the limb electrodes is used as an exploaratory electrode as well as central terminal.
- Augmented Unipolar Limb Leads, the limb electrodes use exploratory electrode but not central terminal.
- The following figure shows the augmented lead connections and positions.
    - Augmented Voltage Right arm (aV_R)
    - Augmented Voltage left arm (aV_L)
    - Augmented voltage foot (aV_F)

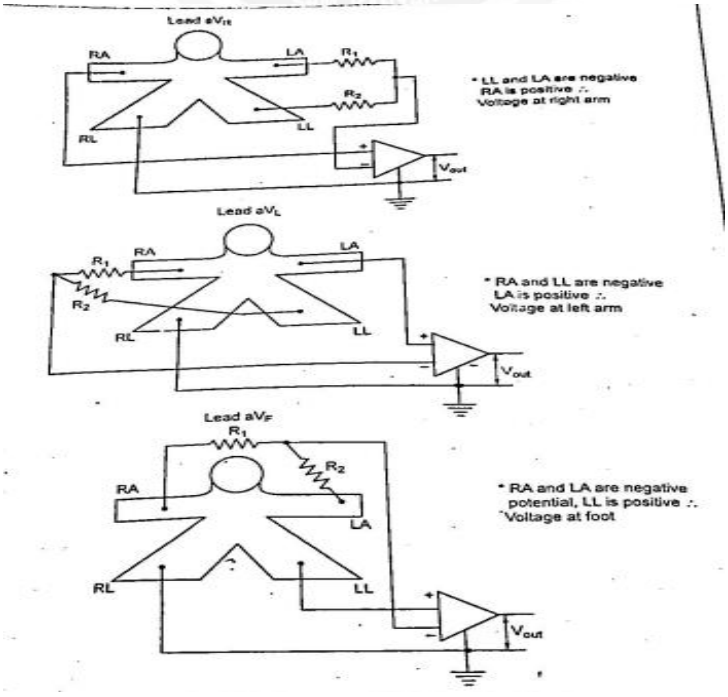

Fig: Augmented Unipolar Limb Leads

Modified Chest Leads (Unipolar Chest Leads)

A single chest electrode is placed sequentially on each of the six predesignated points on the chest. These chest positions are called the pre-cordial unipolar leads and are designated V_1 through V_6. The following figure shows the unipolar chest leads and lead configuration.

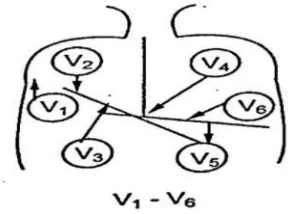

Fig: Unipolar chest leads

V_1 – Fourth intercostals space, at right sternal margin

V_2 - Fourth intercostals space, at left sternal margin

V_3 – Midway between V_2 and V_4

V_4 – Fifth intercostals space, at mid-clavicular line

V_5 – Same level as V_4, on interior axillary line

V_6 – Same level as V_4, on mid axillary line

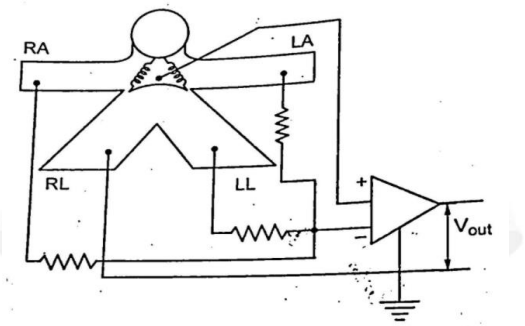

Fig: ECG chest lead configuration

Frank Lead System:

Frank lead system or corrected orthogonal leads system. It is used in vector cardiography. The electrocardiograms are recorded from these 12 lead selections such as

- 3 standard bipolar leads
- 3 Augmented unipolar leads and
- 6 chest leads

ECG Recording Unit:

The block diagram of ECG recording unit consist of the following blocks, defibrillator protection circuit, lead selector, power supply unit, Amplifier unit and Output unit. Connecting leads to the patient electrodes originate at the end of a patient cable and the other end plugs into the ECG recorder.

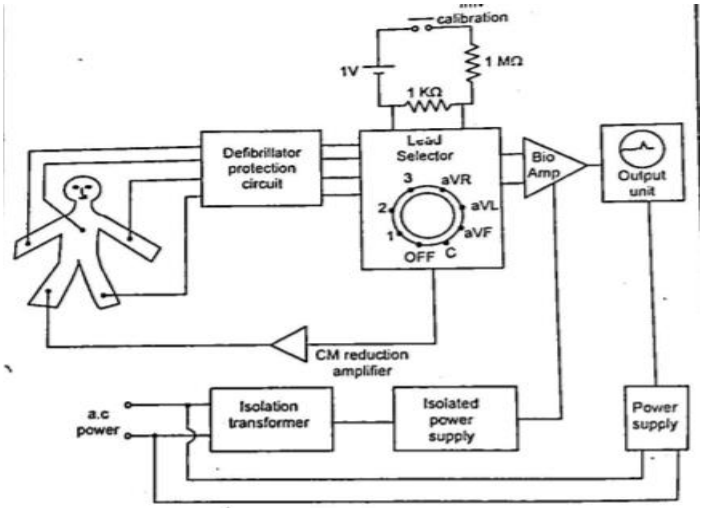

Fig: ECG Recording Unit (set up)

Patient cable:

The patient cable connects different leads from the limbs and chest to the defibrillator protection circuits.

Defibrillator Protection Circuit:

It consists of buffer amplifier and over voltage protection circuit. The leads are connected with the buffer amplifier such that one buffer amplifier for each patient lead (totally 4 leads)

The overvoltage protection circuit is necessary to avoid any damage to the bio amplifiers in recorder. It consists of network of resistors and neon lamps.

Lead selector switch:

It used to feed the input voltage from the appropriate electrode to the preamplifier. It also includes the resistors necessary for the unipolar leads.

Calibrator:

A push button allows the insertion to calibrate the recorder. Modern recorders are stable, and their sensitivity does not change with time. If it changes the setting of the lead selector switch introduces as artifact on the recorded trace.

Bio-Amplifier:

It consists of Pre-amplifier and Power-amplifier.

Pre-amplifier:

The pre-amplifier is a differential amplifier with common mode rejection ratio. The pre-amplifier also provides a switch to set gain or sensitivity. Pre-amplifier also avoid problems with small de voltage from the polarization of the electrodes.

Power Amplifier:

Pre-amplifier is followed by an ac amplifier called “pen amplifier” which provides power to drive the pen motor that records the actual ECG trace. Input of pen amplifier is access separately with a special auxiliary input at the side of ECG recorder.

ECG Recorder:

ECG recorder can be used to record the output of electrocardiograph. A position control on the pen amplifier makes it possible to center the pen on the recording paper.

All modern ECG recorders use heat sensitive paper and the pen is actually an electrically heated stylus. The temperature can be adjusted with a stylus heat control for optional recording trace.

Generally, electrocardiogram is recorded at a power speed of 25 mm/s. But a faster speed of 540 mm/s is provided to allow better resolution.

Buffer Amplifier:

Buffer amplifiers are used to increase the input impedance and reduce the effect of variations in electrode impedance. Buffer amplifier used for each patient lead.

Power switch:

ECG recorder has three positions of power switch.

- On position – Amplifier turned ON, but paper drive not running.
- RUN position – Paper drive starts running.

- OFF position – ECG unit switch off.

Isolated power supply:

- Used to give power to the bio-amplifier.
- Used to increase the electrical safety of patient.

Output unit:

- Output unit is a CRO (Cathode ray oscilloscope)
- In case of paper chart recorder, the power amplifier or pen amplifier supplies the required power to drive pen motor.

Analysis of ECG curves:

The following waveforms show the different ECG signals. If the normal conduction system us disturbed therefore the beat rate will be slower than the normal rate this state is called heart block.

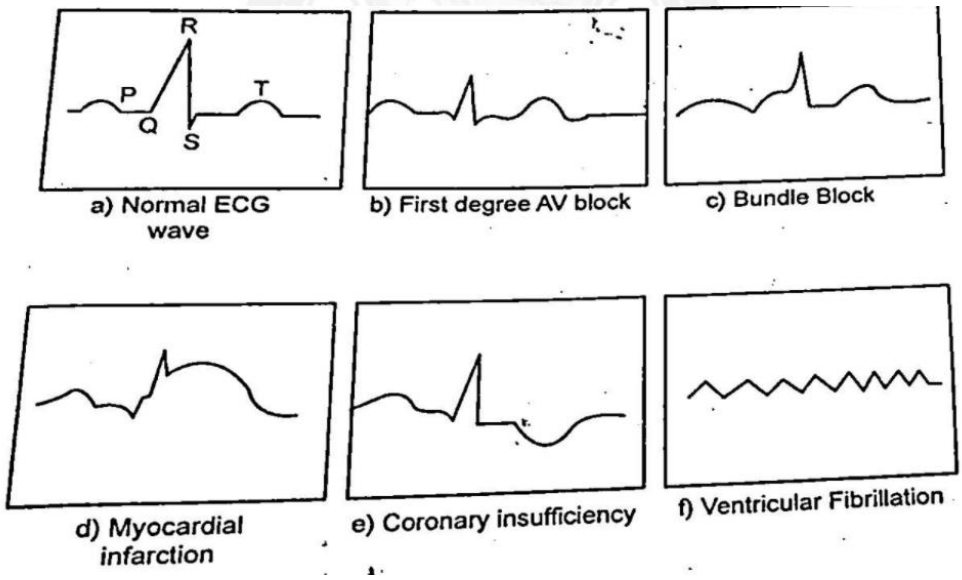

Fig: Analysis of ECG signals