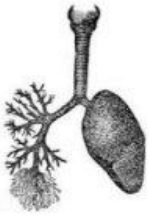
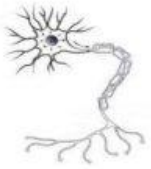



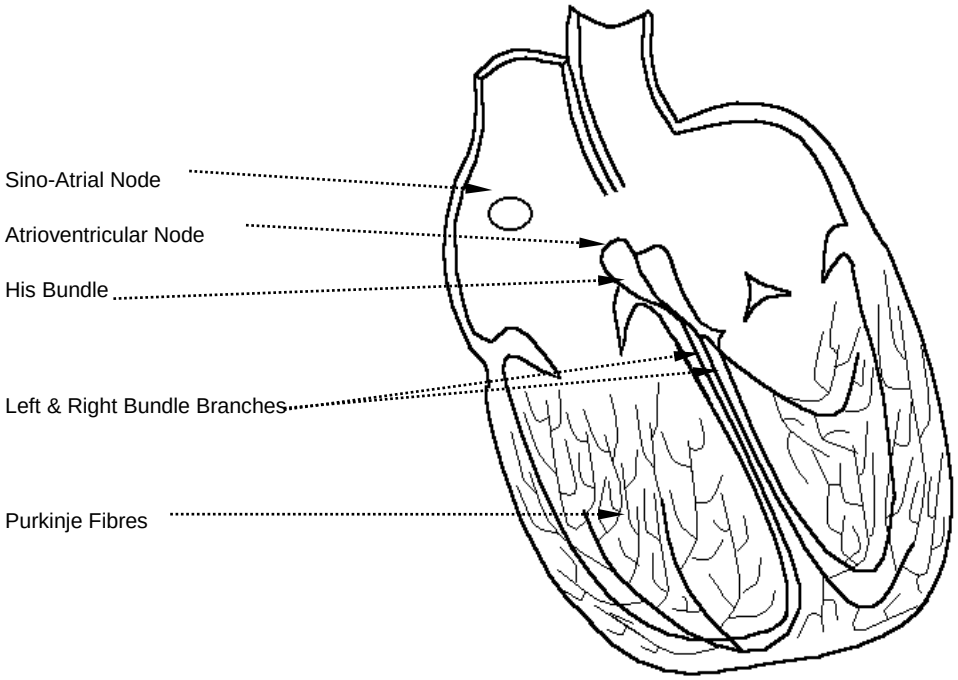
ECG SCREENING COURSE

BY

LEE BOSWELL

THE CONDUCTION SYSTEM

The conducting system of the heart consists of highly specialized neuromuscular tissue. This tissue has the innate ability to produce and propagate impulses that lead to myocardial depolarization and subsequent contraction.



1. Sino-Atrial Node (SA Node)

The Sino-Atrial node is a small cluster of cells situated in the wall of the Right Atrium close to the entrance of the Superior Vena Cava. In the normal heart it assumes the responsibility of pacemaker and rhythmically produces electrical impulses that are propagated through the contractile tissue of both Atria.

The SA node is therefore the usual initiator of the electrical events in the myocardium and the originator of the heart rate. The parasympathetic and sympathetic nerves bring about changes in this base rate. The normal firing frequency of the SA node is around 60-100 per minute.

2. Atrioventricular Node (AV Node)

The AV node is composed of special conducting fibres and is situated on the posterior and lower region of the Atrial Septum. In the normal heart it is the only pathway for electrical impulses to pass from the Atria to the Ventricles because of the fibrous ring separating the two. Atrial impulses generated by the SA node are channelled through the AV node these then pass into the Bundle of His (Common Bundle). The AV node imposes a delay to the passage of the impulse travelling through it, this delay offers a more efficient ventricular filling. In the event of the normal impulse formation of the SA node being affected the AV node can establish itself as a pacemaker. The inherent firing rate of this node is 40-60 per minute approximately

3. Bundle of His (Common Bundle)

The His Bundle is a tract about 1-3mm in width which is formed from fibres from the AV node. These narrow tracts of fibres bridge the Atria and the Ventricles penetrating the fibrous ring that separates them. The His Bundle then divides and forms the Right and Left Bundle Branches that straddle the septum.

4. Right and Left Bundle Branches

These branches are formed in the division of the Bundle of His and are the main conducting tracts that convey the impulses to the right and left ventricles. The right branch travels down the right side of the Interventricular Septum, the left branch, which separates into two main divisions, is sited along the left side of the Interventricular Septum.

5. Purkinje Fibres

These fibres are the fine terminals conducting tracts that penetrate and deliver the electrical impulse throughout the ventricular myocardium.

Summary of Normal Impulse Conduction through the Heart

From the generation of the impulse within the SA node, transmission is rapidly spread throughout the Atrial Myocardium causing depolarization of both Right and Left Atria. Following the event of depolarization the Atria contract simultaneously.

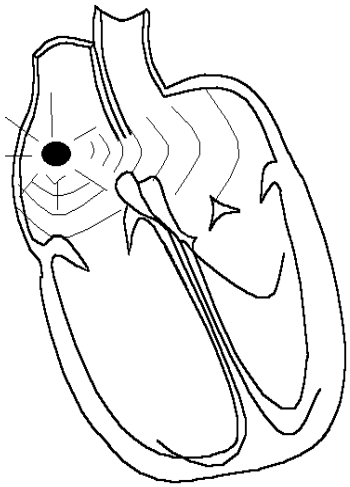
The AV node channels this impulse to the His Bundle, imposing a delay on the impulse on its journey through the AV node. Conduction through the His Bundle is rapid, which then passes the impulse to the Right and Left Bundle Branches. Both Bundle Branches subsequently cause the Interventricular Septum to depolarise. The impulse is then passed to the Purkinje fibres, which branch throughout the ventricles allowing rapid impulse transmission to the myocardium. The Ventricular myocardium depolarises and then contracts.

Following these events repolarisation and relaxation occurs, preparing the heart for the next cycle of events.

ELECTROCARDIOGRAPHIC COMPONENTS OF THE CARDIAC CYCLE

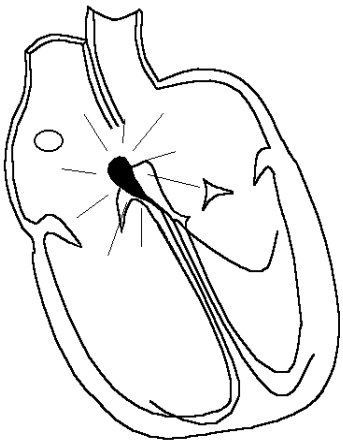
1. P Wave

Under normal conditions the Sino-Atrial node initiates atrial depolarization, which precedes ventricular depolarization. The process of activation begins in the cells within the SA node. This activity is conducted rapidly through the muscle of the right and left atrium causing them to both depolarise. The event of atrial depolarization is recorded as a small rounded and normally positive complex known as the P Wave.



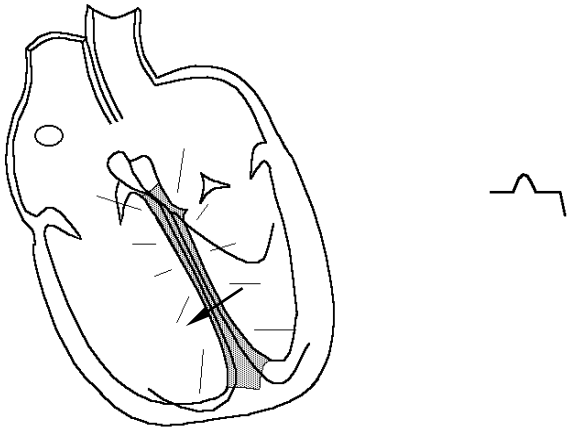
2. P-R Interval

The events of atrial depolarisation cause activation of the Atrioventricular node. Depolarization through this node is slow and a natural delay is imposed to the ongoing activity. The Electrocardiograph writer draws a straight or isoelectric line during this period. The P-R interval includes the time for atrial depolarization and the imposed delay as the impulse passes through the AV node. The P-R segment itself begins after the P wave and ends at the onset of the QRS complex.



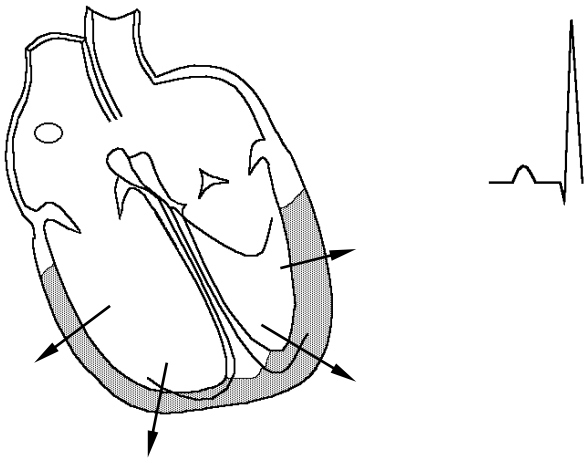
3. Q Wave

The Q wave represents the depolarization of the intraventricular septum as the impulse travels down the His Bundle and the Right and Left bundle branches. Under normal circumstances this depolarization occurs from left to right. The Q wave is represented by a small negative deflection that follows the P-R interval and precedes the R wave.



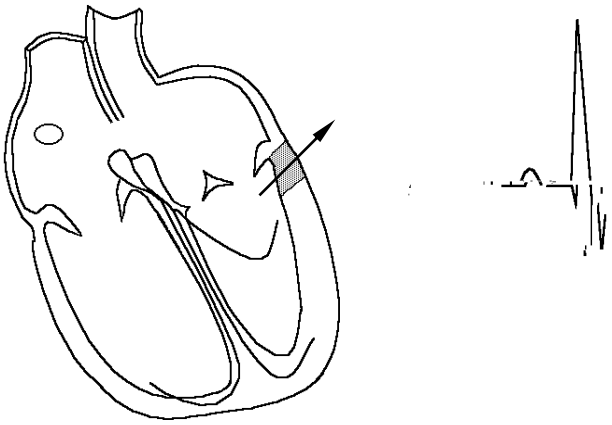
4. R Wave

From the right and left bundle branches the Purkinje fibres penetrate and distribute the impulse to the ventricular myocardium. The ensuing myocardial depolarization occurs from the endocardial (inner) surface to the epicardial (outer) surface. This activity is recorded as a large, usually sharply angled, positive deflection, called the R Once all the myocardium has depolarised the writer will return to the isoelectric baseline.



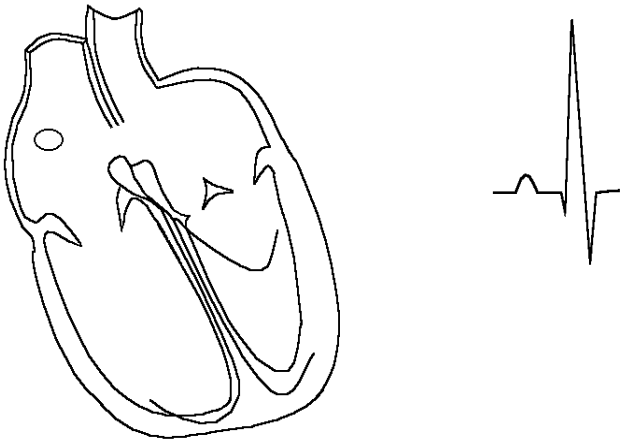
5. S Wave

The S wave represents the depolarization of the posterior-basal regions of the left ventricle. The S wave is the first negative deflection that follows the R wave. The writer then returns to the isoelectric line.



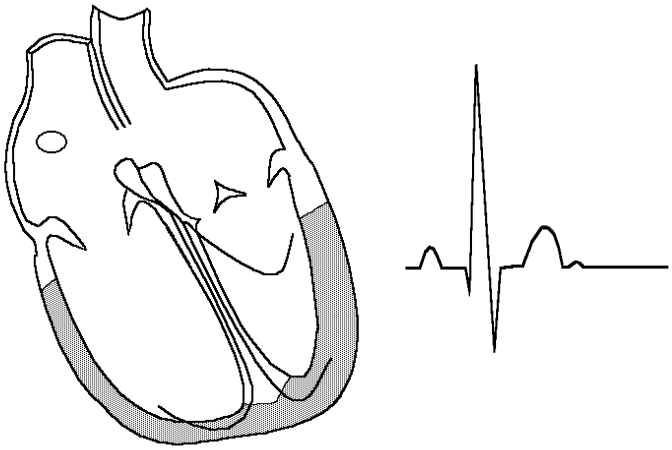
6. ST Segment

The ST segment immediately follows the QRS complex. Little electrical activity occurs during this period so the segment is therefore usually isoelectric or may have a very slightly upward sloping nature.



7. T Wave

The T wave is usually the last component of the ECG and it represents repolarisation of the ventricles. Occasionally there is another wave after the T Wave and is called the U wave.



THE 12 LEAD ELECTROCARDIOGRAM

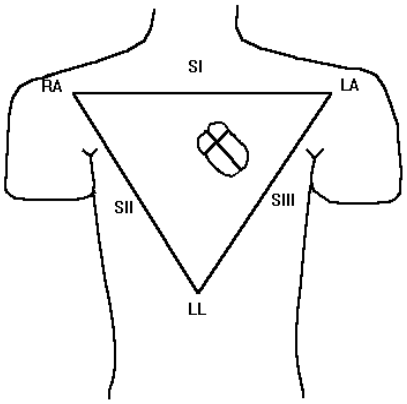
The electrocardiogram (ECG) is a graphical representation of the myocardial depolarization and repolarisation recorded from electrodes placed on the surface of the skin. The instrument used to record such activity is known as an electrocardiograph. The 12 lead ECG is a procedure whereby such cardiac activity is recorded from several designated positions in the frontal and horizontal planes.

1. Standard (or Bipolar) Limb Leads

These leads are designated SI, SII and SIII; the prefix 'S' indicates Standard. These leads are derived from electrodes placed on the limbs, with the exception of the right leg electrode, which is an earth and does not contribute to the actual recording of physiological cardiac activity. Limb electrodes, for convenience, are placed on the arms and legs but actually record electrical potentials from the left shoulder, right shoulder and the symphysis pubis.

a. The limb electrodes may be placed anywhere on the designated arm or leg, they are routinely placed on the forearm and calves for convenience.
b. Changing the position on the designated limb will not affect the recording.
c. Do not attach a limb lead to any other limb but the one to which it is designated.
d. If the limb is not available, due to amputation, dressings, etc., choose the following sites:
    i. For an arm, the shoulder on that side
    ii. For a leg, on the lower abdomen on the same side

Einthovens Triangle



Each Standard Lead (SI, SII & SIII) will record the difference in electrical potential between the two electrodes that it utilises.

Therefore:

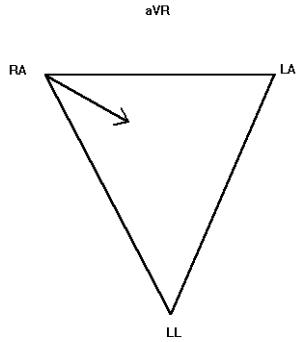
SI = difference between right and left arm

SII = difference between right arm and left leg

SIII = difference between left arm and left leg

2. Augmented (or Unipolar) Limb Leads

These leads are designated aVR, aVL and aVF. The prefix ‘a’ indicating Augmented. Effectively these leads record a boosted signal from one electrode, the other two making up the opposite side of the triangle being reduced to zero.



aVR records from the right shoulder

aVL records from the left shoulder

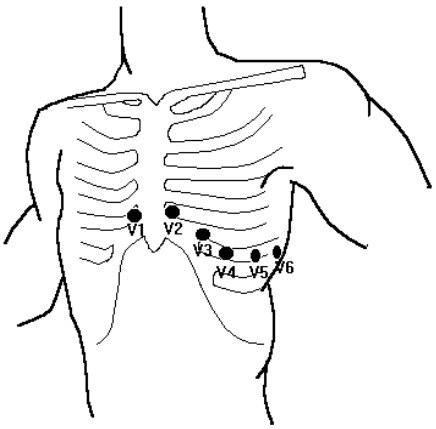
aVF records from the left leg

Example of an Augmented lead - aVR

3. Precordial (or Unipolar) Chest Leads

These leads make up the remainder of the 12-lead system; they are recorded from set positions on the chest wall. They are designated V1, V2, V3, V4, V5 and V6. The prefix ‘V’ indicates Ventral. The positions allocated to the chest leads are as follows:

V1 - Fourth intercostal space, right sternal border
V2 - Fourth intercostal space, left sternal border
V3 - Midway and in line with V2 and V4
V4 - Fifth intercostal space in a midclavicular line
V5 - Anterior axillary line and level with V4
V6 - midaxillary line and level with V4 and V5



RECORDING THE 12 LEAD ELECTROCARDIOGRAM

Depending upon the type and make of ECG recorder these are only general guidelines

1. Machine Check

a. Check the mains connections, power switch and battery condition.
b. Check the writing pen/stylus for damage.
c. Ensure there is adequate paper.
d. Check the recording leads for damage and that they connect to the machine.
e. Check electrodes/clips for cleanliness or corrosion.

2. Recorder Settings

a. Ensure paper speed is set to 25mm/s (millimetres per second).
b. Ensure sensitivity (gain) is set to 10 mm/mV (millimetres per millivolt).
c. Check that the high frequency filter (50Hz) is off.

3. Explain the Procedure

a. Give a clear and concise explanation of the test to the patient.

4. Patient Details Required

a. Name and initials
b. Date of birth and/or age
c. Date and time of recording
d. Height and weight of patient
e. Clinical information or reason for ECG

5. Prepare the Patient

a. Have the patient remove only that clothing which is necessary to perform test.
b. Settle the patient into a comfortable lying position.
c. Reassure the patient.

6. Application of Electrodes

a. Apply the limb electrodes in the designated positions.
b. Correctly connect the designated limb lead to the appropriate electrode.
c. Accurately find chest positions and apply electrodes.
d. Connect the correct chest leads to the appropriate positions.

7. Record the ECG

a. Power on the machine
b. Press F1 to enter Patient Details
c. Enter the details by inputting relevant information, if you want to leave it blank press return ↵
d. Service/Staff number or leave blank. Press return ↵
e. Last Name, press return ↵
f. First Name, press return ↵
g. Date of birth, press return ↵
h. Height, press return ↵
i. Weight, press return ↵
j. Gender, press return ↵ then select male or female by pressing the 'v' on the circular keypad once or twice. 
k. Press return ↵ to go to the next page and enter the indication, such as Diving Medical, high blood pressure, palpitations, etc.
l. Press return ↵ three times to bypass next few entries if leaving blank
m. Enter initials of person performing ECG (unless you want to remain anonymous), press return ↵
n. Now press F6 to save all the details then press the 'ECG' button. If you're happy with the recording press F4 to continue, if it is artefactual then press F3 to re-acquire a new ECG.
o. To print the ECG press F2, to save it F3, to record a new ECG on a different patient press F1 then F2
p. To turn machine off press and hold the power switch for 2-3 seconds

8. Post ECG Checks

a. Look at the ECG and repeat if necessary
b. Ensure the ECG is free from any artefact
c. If necessary re-record ECG with chest leads set at half gain (5mm/mV)
d. If required record a rhythm strip on SIII
e. If required record the ECG with a deep inspiration

9. Patient Dismissal

a. Check the recorded ECG for quality and labelling.
b. Remove all leads and electrodes from patient.
c. Remove all electrode gel from patient.
d. Allow patient to dress and leave.
e. Clean all electrodes.
f. Return all machine settings to normal.
g. Power down (unless recharging battery)

COMMON ECG ARTEFACTS

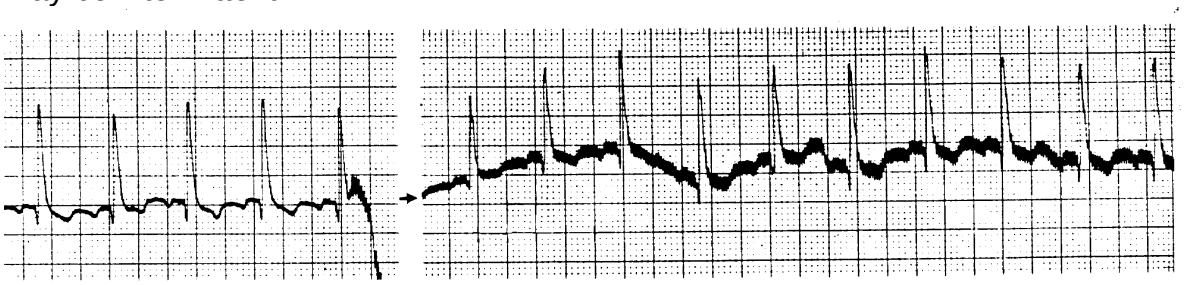
Artefacts contaminating the electrocardiogram can be considered to be any recorded electrical potential that does not originate from the heart.

The main sources of artefact are from:

a. The recording equipment
b. Electrical interference external to either patient or recorder
c. Recording leads and electrodes
d. The patient
e. The operator

1. Mains (50Hz) Interference

This interference appears as a regular, fast waveform with 50 sharp peaks and troughs each second. It may contaminate the whole ECG or individual leads and may be intermittent.



Causes:

a. Unshielded electrical equipment near or adjacent to patient or recorder
b. Poor electrode application
c. Dry electrode - no gel
d. Poor connection between electrode and recording lead
e. Broken/damaged recording lead or faulty insulating cover

Remedy:

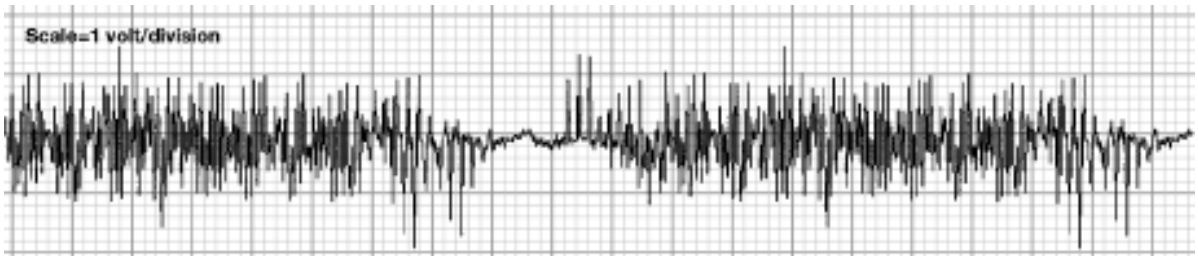
To rectify this type of artefact the cause needs to be isolated and resolved. This may be done by:

a. Check the right leg lead (earth) is properly connected
b. Ensure that the recorder power cable and patient lead cable are not close together and parallel
c. Check all other leads and connections
d. Check electrodes
e. Isolate from mains supply (unplug and use on battery)
f. As a last resort use HF filter on ECG machine

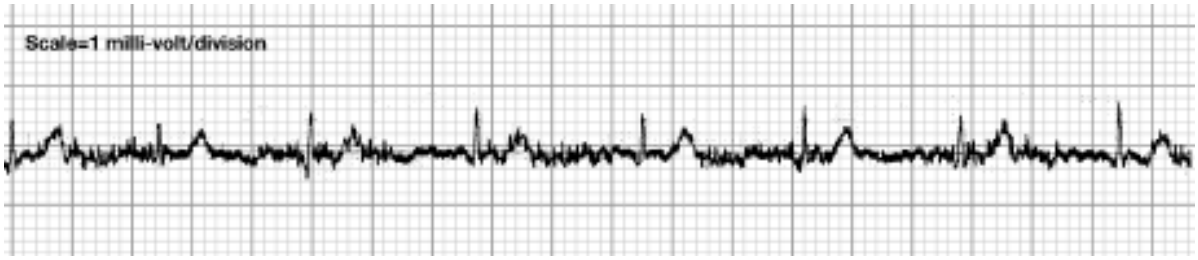
2. Muscle Tremor or (Somatic) Artefact

The amplifiers of an ECG recorder are not selective and will record any electrical potential generated by the patient. Muscle artefact is a fast activity recorded from skeletal muscles. It will contaminate the recording by varying degrees of severity with an irregular fast activity.

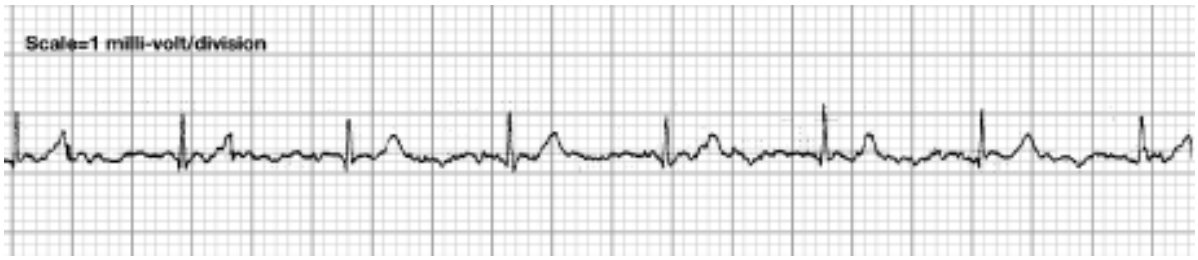
Severe Muscle Artefact



Moderate Muscle Artefact



Filtered Muscle Artefact



Causes:

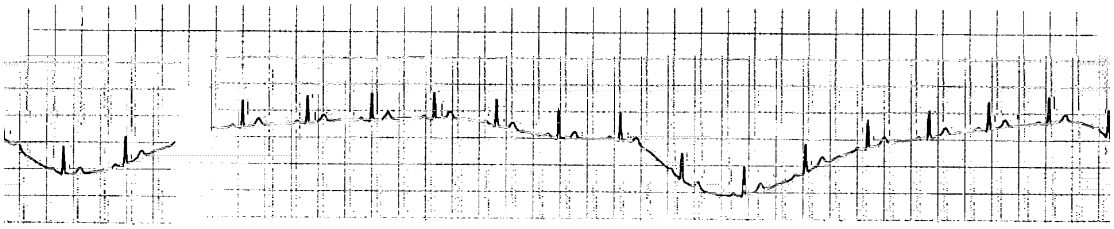
a. A tense patient or one that is not relaxed
b. A patient that is uncomfortable
c. Shivering patient in a cold room
d. Injured limbs causing muscle spasm
e. Neurological conditions producing limb tremors (Parkinson's disease)
f. Elderly or very young patients that are unable to lay still.

Remedy:
Depending upon the causative factor the resolution of muscle artefact will vary.

a. Reassure and relax patient
b. Ensure patient is comfortable and warm
c. Locate limb electrodes higher up, placing on shoulders or lower abdomen
d. Have patient hold item loosely, maintaining limb muscles in a steady state
e. As a last resort us HF filter on ECG machine

3. Baseline Sway

This seen usually with a clear ECG but the baseline wanders in an undulating pattern.



Causes:

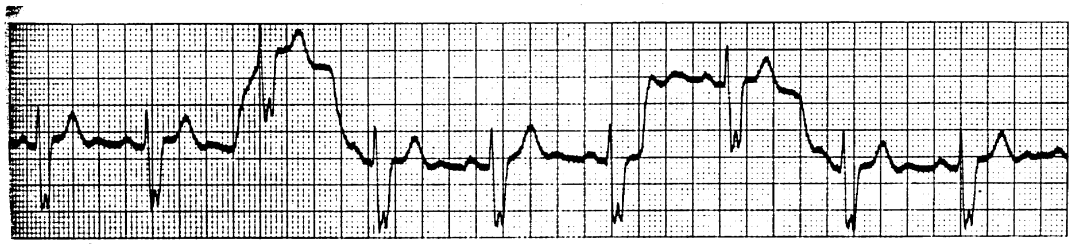
a. Perspiration, this causes changes of electrical resistance at the junction of skin and electrode
b. Respiration, usually seen in the chest electrodes (V1 - V6) caused by movement of the chest during breathing
c. Psycho-galvanic response (PGR). This is commonly recorded from anxious, frightened or embarrassed patients caused by changes in skin electrical resistance

Remedy

a. For perspiration dry the electrode site with gauze/tissue. In severe cases an alcohol swab may be used prior.
b. For respiration simply have the patient stop breathing for a short time whilst recording. Do not let them take a deep breath in and hold.
c. Baseline sway artefact from PGR can be eliminated by reassurance.

4. Other Artefacts

Less common artefacts may include electrostatic interference that causes large electrical changes to the ECG. It usually caused by friction or movement on synthetic fibres. Deliberate limb movements (children), hic coughing, sucking, sneezing and coughing may cause artefact like below.



To resolve these artefacts common sense prevails, eliminate the cause or repeat the recording a little while later.

5. Operator Artefacts

Although not strictly considered artefact operator errors can and do occur resulting in abnormal ECG's. This is usually due to carelessness, lack of attention or poor ECG procedure education.

Common errors include:

a. Transposition of limb leads, left arm lead reversed with right arm, etc.
b. Incorrect chest positioning
c. Unlabelled ECG, no patient details
d. Incorrect date/time