Electrical safety in medical envir onment

- Electrical Safety is one of the basic protection mechanisms for patient, operator, and third persons.

- Medical technology has improved health care in ALL medical specialties, with rising complexity
- Hospitals are confronted with the difficult problem of creating a safe electric environment for the care and comfort of the patients.

- The purpose of safety testing medical electronic equipment is to ensure that a device is safe from electrical hazards to patients, maintenance personnel's and users

Electric safety in hospital is a shared responsibility between several parties,physician, including:
• The nurses
• All engineers (electrical, biomedical, facility, etc)
• Manufacturersin addition to the

Electrical Safety – Critical points to be checked
• The electrical installation, no matter how safe, is only part of the safety requirements.
• Plugs and cords must be checked and rejected if defective.
• Electrical compatibility of the entire electrical system must be tested regularly.
• Patients leads must be attached and connected properly.
• Radio-frequency devices (including mobile telephones) must be excluded

Basic safety should be performed on line powered before installation and after every repair are:
- Ground wire integrity (Resistance)
- Ground wire leakage
- The basic electrical characteristic usually causes the most leakage currents in modern equipment is Capacitive Reactance Coupling in power cord.

Electric Shock Hazards

It is a common experience that hazards due to electric shock are also associated with equipment other than that, used in hospitals.
The equipment's used in medical practice have tooperate in special environments, which differ in certain respects from the others. Suchspecial situations are as follows:

(i) A patient may not be usually able to react in the normal way. He is either ill, unconscious,anaesthetized or strapped on the operating table. He may not be able to withdraw him-self from the electrified object, when feeling a tingling in his skin, before any danger ofelectrocution occurs.

(ii) The patient or the operator may not realize that a potential hazard exists. This is becausepotential differences are small and high frequency and ionizing radiations are notdirectly indicated.

(iii) A considerable natural protection and barrier to electric current is provided by humanskin. In certain applications of electromedical equipment, the natural resistance of theskin may be by-passed. Such situations arise when the tests are carried out on the subjectwith a catheter in his heart or on large blood vessels.

(iv) Electromedical equipment, e.g., pacemakers may be used either temporarily or permanentlyto support or replace functions of some organs of the human body. An interruptionin the power supply or failure of the equipment may give rise to hazards, whichmay cause permanent injuries or may even prove fatal for the patient.

(v) Medical instruments are quite often used in conjunction with several other instrumentsand equipment.

These combinations are often ad-hoc. Several times there are combinationsof high-power equipment and extremely sensitive low signal equipment. Each ofthese devices may be safe in itself, but can become dangerous when used in conjunctionwith others.

(vi) The environmental conditions in the hospitals, particularly in the operating theatres,cause an explosion or fire hazards due to the presence of anaesthetic agents, humidityand cleaning agents, etc.there are two situations which account for hazards from electric shock.

It is also obvious that an optimum level of safety can only be achieved when efforts are made to include safety measures in the equipment, in the installation as well as in the application.
There are two situations which account for hazards from electric shock:
(i) gross shock and
(ii) micro-current shock.
In the case of gross shock, the current flowsthrough the body of the subject, e.g. as from arm to arm. The other case is that of micro-currentshock in which the current passes directly through the heart wall. This is the case when cardiaccatheters may be present in the heart chambers. Here, even verysmall amounts of currents canproduce fatal results.

Gross Shock

- Gross shock is experienced by the subject by an accidental contact with the electric wiring at any point on the surface of the body.
- The majority of electric accidents involve a current pathway- through the victim from oneupper limb to the feet or to the opposite upper limb and they generally occur through intact skin surfaces.
- In all these cases, the body acts as a volume conductor at the mains frequency. For a physiological effect to take place, body must become part or an electric circuit. Current must enter the body at one point and leave at some other point. In this process, three phenomenacan occur. These are:
  (i) Electrical stimulation of the excitable tissues nerves and muscles
  (ii) Resistive heating of tissue
  (iii) Electro-chemical burns and tissue damage for direct current and very high voltages. The value of electric current, flowing in the body, which causes a given degree of

  stimulation, varies from individual to individual. Typical threshold values of current produce certain responses where the current flows into the body from external contacts(e.g. hand to hand) and these have been investigated. For a given voltage present on the surface of the body, the value of current passing through it would depend upon the contact impedance. Besides this, it depends on many other factors such usage, sex, condition ofskin (dry or wet, smooth or rough, etc.), frequency of current. Duration of current and the applied voltage.

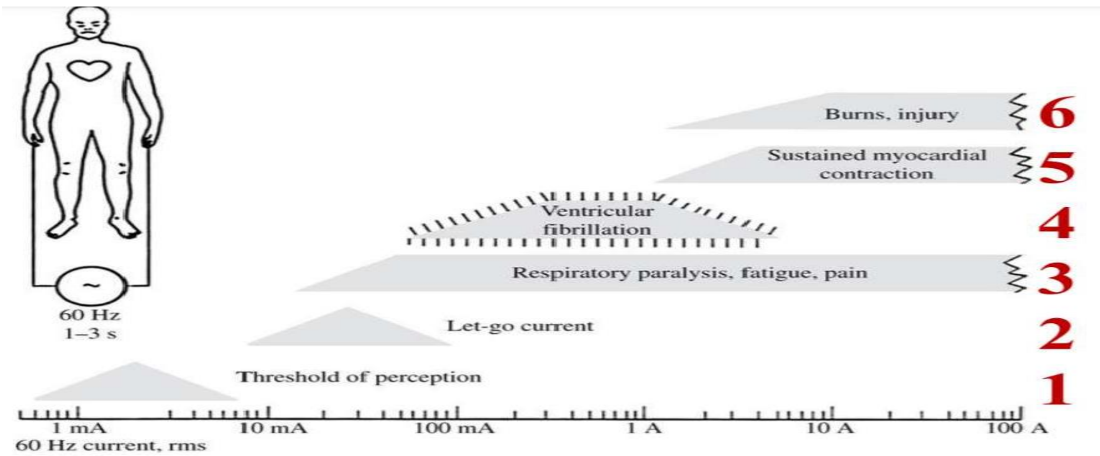
Effects of Electric Current on the Human Body

- Threshold of Perception
- Let-go Current
- Physical Injury and Pain:
- Ventricular Fibrillation:
- Sustained Myocardial Contraction
- Burns and Physical Injury

Micro-current Shock

- The threshold of sensation of electric currents differs widely between currents applied arm to arm and currents applied internally to the body.
- In the latter case, a far greater percentage of the current may flow via the arterial system

directly through the heart, thereby requiring much less current to produce ventricular fibrillation. Such situations arc commonly encountered in hospitals;



Effect of Various Levels of Current on the Human Body

Current	Effect
1 milliampere	Tingling sensation, threshold of perception
5 milliamperes	Slight shock felt, not painful but disturbing
6 to 20 milliamperes	Painful shock, let-go range
50 milliamperes	Extreme pain, respiratory arrest, severe muscular contraction
100 milliamperes	Ventricular fibrillation
>5 amperes	possible burns, sustained myocardial contraction, respiratory paralysis and probable death

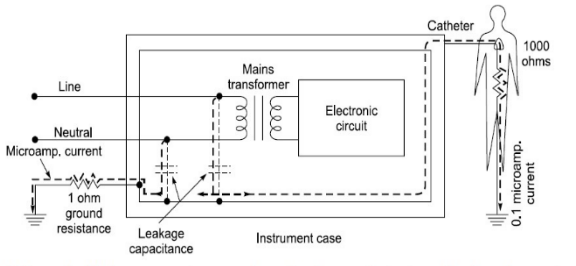
Leakage Currents

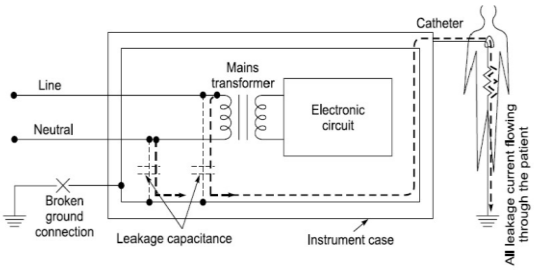
- Currents of extremely small magnitude can be fatal to a patient when a direct, localized electrical path exists to the heart. Accidents of this nature can occur in unpredictable circumstances.
- Accidents can even occur with safe electro medical equipment being properly used if there are defects in the wiring of power outlets.
- **Leakage current** by definition is an inherent flow of non-functional current from thelive electrical parts of an instrument to the accessible metal parts. Leakage currents usually flowthrough the third wire connection to the ground.
- The major source of potentially lethal currents in any instrument or equipment is the leakagecurrent.

- They occur by the presence of a finite amount of insulation impedance, which consists of twoparts: **Capacitance**
  Resistance.
- Leakage currents due to capacitance between any two conductors separated in space. Current flow shall take place if an alternating voltage is applied between them. The magnitude of the leakage current is determined by the value of the capacitance present therein. Leakage currentof this type mostly originates due to capacitive coupling from the power transformer primary to other parts of the transformer or other parts of the instrument.
- The resistive component of leakage current arises because no substance is a perfect insulator andsome small amount of current will always flow through it.
- However, this type of leakage current is usually very small as compared to the capacitive leakage currents and can be safely ignored.

Types of Leakage Current

- **Enclosure Leakage Current**
- **Earth Leakage Current**
- **Patient Leakage Current**





Path of leakage current in a normal case **Path of leakage current in case ofdiscontinuous ground**

Precautions to Minimize Electric Hazards

- In the vicinity of the patient, use only apparatus or appliances with three-wire power cords.
- Provide isolated input circuits on monitoring equipment.
- Have periodic checks of ground wire continuity of all equipment.
- No other apparatus should be put where the patient monitoring equipment is connected.
- Staff should be trained to recognize potentially hazardous conditions.
- Connectors for probes and leads should be standardized so that currents intended for powering transducers are not given to the leads applied to pick up physiologic electric impulses.