Manual of Surgical Equipment







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JAYPEE

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2 Electrosurgery (Diathermy)

Diathermy – is a Greek word. *Dia* means through, *thermo* means heat. Electrocautery—involves the applications of direct current flowing in one direction. Electrocautery is a closed circuit DC device in which current is passed through an exposed wire offering resistance to the current. In surgical diathermy a high frequency alternating current is passed through the body tissue (Figs 2.1 and 2.2).

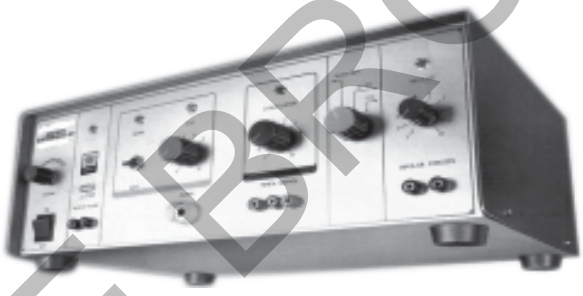

Fig. 2.1: Electrosurgery machine



Fig. 2.2: Accessories of diathermy

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Thus term 'electrocautery' should not be used to described electrosurgery.

The electrosurgical circuit consists of four primary parts:

i. Electrosurgical generators,
ii. Active electrode,
iii. Patient and
iv. Return electrode.

PRINCIPLES OF ELECTRICITY

An electric circuit is any pathway that allows the uninterrupted flow of electrons. Electrical current is the flow of electricity in a given circuit over a constant period of time and is measured in amperes (A) current can be supplied either as direct current (DC) with constant positive and negative terminals or as alternating current (AC) with constantly reversing poles. Voltage is a measurement of the force that propels the current and is related to the difference in potential energy between two terminals. The resistance is the tendency of any component to DC circuit. The equipment of this tendency in AC circuit is known as impedance.

Tissue Effects by Electrosurgery

1. ***Cutting:*** Cutting current has a low voltage. This is achieved with a constant waveform of low voltage. Once the current is applied the current is actively flowing during the entire application. In this technique, the tip of electrode is held just slightly off the surface of the tissue. It produces an intense heat, vaporizing water, exploding the cells in the immediate vicinity of the current. Thus cutting occurs with minimum coagulation production and minimum hemostasis. A combination of coagulation and cutting can be produced by setting the electrosurgical generators, to blend. Blended current is used for (i) TUR of prostate, bladder tumor, bladder neck (ii) excision of neoplastic tissue anywhere.
2. ***Coagulation:*** Coagulation current do not produce a constant waveform. Enough heat is produced to disrupt the normal cellular architecture because cells are not constantly vaporized, heat produced is enough to denature the cellular protein. This accounts for the formation of a coagulation that allows sealing of smaller blood cells and control of local bleeding.
3. ***Fulguration:*** Tissue is coagulated and charred over wide area. This is achieved by an intermittent waveform of high voltage producing less heat. This results in the disruption of normal cellular protein to form a coagulum and char the tissue forming a black

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eschar at the site of operation. The benefit of using this cutting current is for less voltage is needed, an important during laproscopic surgery.

4. ***Desiccation:*** This occurs when the electrode is in direct contact with tissue. Less heat is generated and no cutting action occurs. A relatively low power setting is used, resulting in limited area of tissue ablation with coagulation. Desiccation is achieved most efficiently with the cutting current. The cells dry out and form a coagulation rather than vaporize and explode.

Variables Affecting Tissue Effect

Power setting and the waveform effect, the results of the current application. Any change in the circuit that influence the impedance of the system with influence the tissue affect. These include

i. The size of the electrode
ii. Position of the electrode
iii. Type of tissue
iv. The formation of eschar and
v. Time

The smaller the electrode, higher the current concentration. The longer the generator is activated the more heat is produced. The greater the heat, it will travel to adjust tissue, i.e. thermal spread. Eschar is high in resistant to current. Electrodes should be kept clean and free of eschar.

Types of Circuit

There are two types of circuit:

1. ***Monopolar circuit:*** The active electrode is the surgical site. The patient return electrode is on the patient's body (the plate). This current passes through the patient as it completes the circuit from the active to the patient return electrode. If the patient were not to connected in some way either to a negative terminal or to ground, no current would flow as there would be no way to complete the circuit (Fig 2.3A).
2. ***Bipolar circuit:*** In this the two blades of the forcep perform two functions, i.e. active and return electrodes, thus only the tissue grasped is included in the electrical circuit. No patient return electrode is needed (Fig. 2.3B).

Precautions

Following precautions should be taken while diathermy is used:

1. All OT staff must know whole about the diathermy.

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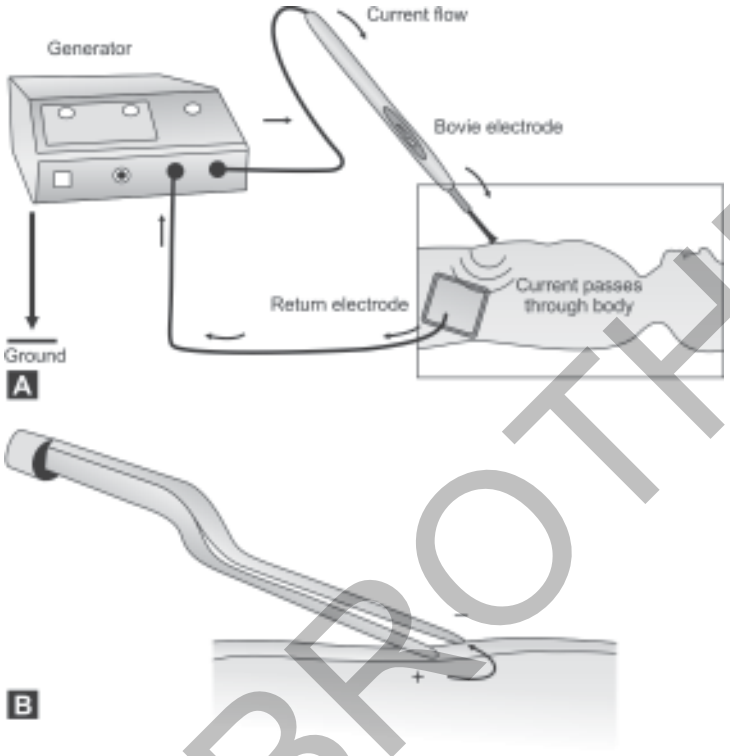

Figs 2.3A and B: A. Monopolar and B. Bipolar circuit

2. The alarm system, generator and equipment should be checked regularly.
3. It should never be used in the presence of ether or cyclopropane and it should be kept atleast 50 cm from the anesthetic machine.
4. Surgical spirit must be dried before diathermy is used.
5. Do not use the top of the generator as a table. Fluids can enter in the generator.

CAUSES OF DIATHERMY INJURY

1. Incorrect application of patients plate.
2. Careless technique.
3. The patient touching earth, metal objects, part of OT table, IV stand, etc.

Safety Measures

1. Diathermy machine and all its accessories must be checked and need to be serviced regularly.

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2. The foot plates should be checked, it should be completely sealed.
3. Monopolar or bipolar should be selected prior to use and correct setting should be checked because when monopolar diathermy is used cutting and fulguration involve higher power current than coagulation, these are not applicable to bipolar. That's why coagulation and cutting levels are correctly set before its use.
4. Insulation of the instruments should be checked regularly.
5. Patient should be protected from metal like OT table metal, OT table accessories, IV stand, etc.
6. Patients' plate should be in proper position and it should not touch any metal point.
7. Skin should be checked after removal of the plate.
8. Live electrode is always placed in the quiver and never on the drapes or on the tray.
9. Always place ECG electrodes as far as away from the site of surgery as possible.

If Diathermy is not Working Look For

1. Its all connections.
2. Loose active electrodes.
3. Poor contact of plate.
4. Faulty or disconnected cable.
5. Setting of electric generator.
6. Plugs, sockets and power supply.

Patient Plate Electrode

The patient plate electrode is also known as return electrode or simply patient plate. It should be fully in contact with the patient over the entire plate area. Conductive jellies help in maintaining this condition. However this condition is necessary to be fulfilled during the entire operative procedure.

Patient plate covered with wet cloth is not recommended for surgical procedure more than 30 minutes time period. The cloth gets dry after this time and creates resistive path for current to flow, which can lead to the burn under the plate.

Avoid any contact of the plate with grounded objects like OT table, IV stand, etc.

Placement of Plate

Certain body sites are generally considered unsuitable for placing the patients plate, e.g. bony protuberances, hairy areas, limbs with

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restricted blood flow, scar tissue. It should be placed under the buttocks, thigh, shoulders or anywhere that can ensure an adequate contact area. Patients plate should be placed near to the site of surgery. It should have maximum contact with the patient's body. The connecting cord must be securely connected towards the instrument end. This cord should never be pulled either during the use or during storage. Lift the patient and place or remove the plate.

Foot Switch (Fig. 2.4)

There are two types of foot switch one is monopolar and another is bipolar foot switch. Connect the monopolar foot switch to perform monopolar cutting and coagulation functions by foot switch. If bipolar electrosurgery is required then connect bipolar function. It should be under the control of operating surgeon. These foot switch must be covered by plastic transparent cover to keep it dry and clean and to prevent any spillage of fluids or blood during operations. Foot switch is provided with two paddles. Yellow for cutting or blend current and blue for coagulation current. Hand switch is also provided with cutting/blend and coagulation current to be switched by yellow and blue button on it.

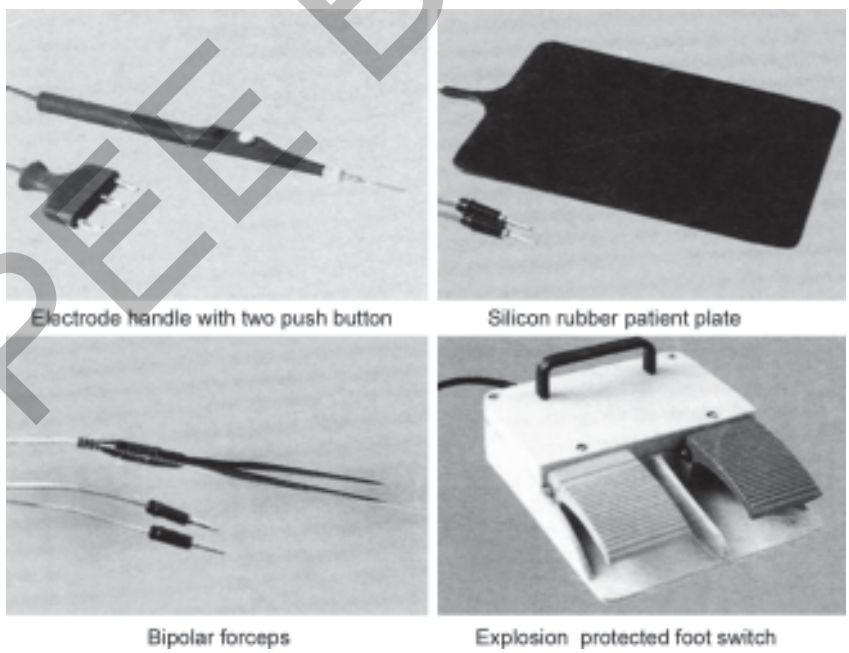

Fig. 2.4: Parts of diathermy

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Different Modes of Current

1. Coagulation current is divided in two types. Fulguration is used where arcing of the coagulation current is required from a distance in operations like TURP and bladder resection where fulguration plays an important role.
2. Cutting is provided with three types of current. Pure, Blend 1 and blend 2.
   a. Pure cutting gives sharp cutting. A knife in a butter effect is usually loved by Urosurgeons.
   b. Blend 1, a modulated waveform type current is used where cutting with controlled bleeding is used.
   c. Blend 2, current with additional percentage of coagulation when used for cutting purpose gives absolutely bloodless cutting.
3. Monopolar accessories are provided with specially electrodes like straight knife, ball and needle.
   a. Straight knife electrode is used both for cutting and coagulation by changing the face of blade.
   b. Ball electrode is used for desiccation, i.e. contact coagulation normally used in gynecology.
   c. Needle electrode is used for sharp cutting. Cutting with needle electrode requires less setting compare to straight knife electrode.
4. Bipolar activation is provided with independent bipolar activator. In bipolar, tissue is grasped in between the bipolar forcep and cauterized the tissue.

Patient with Pacemaker

Diathermy may affect the pacemaker. Modern pacemaker are also sensitive to possible interference during electrosurgery but have an inbuilt safeguard so that any interference is in building rather stimulating.

It is always safer to use a bipolar circuit when possible.

Metallic Prosthesis

With a monopolar circuit, patient plate should be sited well away from the prosthesis, e.g. in orthopedic surgery where generally prosthesis are used.

Safe Use of Diathermy in Minimal Invasive Surgery

Several safety concerns are unique to MIS, have a limited and tight environment in which operations occur. One danger is that of direct

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coupling between the electrode and other conductive instruments, which lead to tissue damage. When coagulation is used with high voltage current ,there is risk of breakdown in the insulation resulting into tissue damage of adjacent tissue. This damage can be reduced by using low voltage current. A capacitor may be created between the active surgical instrument electrode and the metal cannula. A capacitor by a dielectric. The conductive electrode separated from either a metal cannula or the abdominal wall can induce capacitance in either of these structures.

The electric field between these two conductors allows a current to be induced in the second conductor (metal cannula). It is reduced but not eliminated by the use of plastic cannula. Safety measures—

1. Check insulation thoroughly and regularly.
2. Use a low power setting.
3. Use a low voltage when possible.
4. Use intermittent rather than continuous.
5. Do not activate when the electrode is in contact with other metallic instrument.

ARGON BEAM COAGULATION

Argon is an inert gas that is easily ionized by the application of an electric current. The current arcs along the pathway of ionized gas, which is heavier than both oxygen and nitrogen and thereby displaces air. Once the current arrives at the tissue, it produces its coagulating effect in the same manner as conventional diathermy. Argon beam coagulation devices can operate only in two modes (i) pinpoint coagulation and (ii) spray coagulation.

It does not cut even the most delicate tissue.

Advantages

1. It allows use of the coagulation mode without contact of the electrode. This prevents buildup of eschar, which diminishes electrode efficiency, on the electrode tip.
2. There is decreased smoke and thus odor is also reduced.
3. There is decreased tissue loss and reduced tissue damage.
4. There is less danger of ignition by instrument as argon gas is delivered at room temperature.
5. Beam coagulation improves coagulation and reduces blood loss and the risk of rebleeding.

Disadvantages

1. It cannot be used to produce a cutting effect in the same manner as other types of diathermy.

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2. Its nozzle for gas delivery can become clogged, which reduces its efficiency.
3. If it is used for a prolonged period of time it may overheat and may cause inadvertent damage.

Use

It is especially useful for procedures in which the surgeon needs to rapidly and efficiently coagulate a wide area of tissue. It is especially suitable to dissecting very vascular tissue and organs, e.g. liver.

ULTRASONIC DEVICES (FIG. 2.5)

These are totally different from electrosurgery (diathermy). By this there are two most prominent devices which produces ultrasonic vibrations in which mechanical energy is converted into energy for surgery.

These are:

i. Ultrasonic scalpels and clamps
ii. Cavitational ultrasonic surgical aspiration (CUSA).

Ultrasonic Scalpels and Clamps

In these instruments electric energy from a power source is transformed into ultrasonic vibrations by a transducer. This transducer expands and contracts in response to electrical current at a frequency of upto 55,500 cycles/second. The blade tip vibrates through an amplitude of around 200 micrometer. As the blade tip vibrates, it produces cellular friction and denatures proteins. These denatured proteins form a coagulation, which allows sealing of blood



Fig. 2.5: Ultrasonic devices (Harmonic scalpel)

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vessels. By this way temperatures reaches between 50°C to 100°C. In conventional diathermy temperature reaches between 150°C to 400°C. Thus using this device, tissue can be dissected without burning or oxidizing tissues and eschar. When it is used for clamp, energy is transferred to the tissue through the active blade under applied force, which minimizes the lateral spread. The monitor of the blades induces cavitation along the cell surfaces, whereby low pressure causes cell fluids to vaporize and rupture.

Advantages

1. It can be used while operating deep and tight spaces with least damage to adjacent structures. This makes such instruments especially suitable for MIS.
2. There is no risk of current inadvertently arcing to adjacent structures.
3. There is no neuromuscular stimulation, since no current passes through the patient.
4. Coagulation occurs at much lower temperature than conventional diathermy.
5. Lateral thermal tissue damage is negligible.
6. There is no eschar formation on the blade and less smoke is produced.
7. It can be safely used in patient having pacemaker.

Disadvantages

1. It is quite expensive instrument.
2. Maintenance is also expensive.
3. Electrosurgery can be applied throughout an operation, while ultrasonic scalpels are typically used for more controlled dissection around the site of interest.

CUSA

It works on almost same principle as ultrasonic scalpels. In this there is a handpiece in which current passes through a coil and induces a magnetic field which in turn results in a vibration. These vibrations are magnified over the length of the handpiece. The oscillating tip, when brought into contact with tissue, causes fragmentation of tissue leading to cellular disruption. This high-frequency vibration produces heat, which is reduced via a closed, recalculating cooling water system. This maintains the temperature of the tip around 40°C.

There is an another function of this system is suction (aspiration as its name implied). As tissue is fragmented, debris is carried away by

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aspiration. For irrigation sterilized water or saline is fed through tubing to the handpiece, where it irrigates the surgical site, which is removed by the vacuum pump (which is attached in the same system). Suction pulls irrigation fluid, fragmented tissue and debris through the distal tip of handpiece.

Uses

1. CUSA system have their primary application in situations where fragmentation emulsification and aspiration debris or other tissue are desirable.
2. In general surgery its primary application is in liver resection where it can disrupt only parenchyma and leaves major vasculature and biliary ducts intact.

Limitations CUSA

Since it provides minimum hemostasis thus it is not versatile in general surgery as diathermy or ultrasonic scalpel.

LASERS

It is very sophisticated instrument. It should be used in designated OT by fully trained staff. Protective eye wear is must at all times of its use. Care with the direction of the Laser beam is critical to safe use. There should be no reflective or inflammable fixtures or furnishings must be present in the OT. With all these it has many more limitations. It is not useful in general surgical practice. It is more useful in dermatology and ophthalmology practice.

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Manual of Surgical Equipment

Salient Features

- A unique book on the subject
- Presents a ready source of information about surgical equipment
- Covers all the instruments related to every branch of surgery
- Arranges the chapters in order to understand the subject clearly
- Serves as a ready reference text to the students and teachers of surgery, paramedical staff, practising surgeons and all the medical-surgical fraternity.

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