Electrosurgery

ESCHMANN

Introduction

Electrosurgery refers to the passage of high frequency (h.f) electrical current through the body to achieve a desired surgical effect. This effect can be achieved in one of three ways, cutting, coagulating or fulgurating.

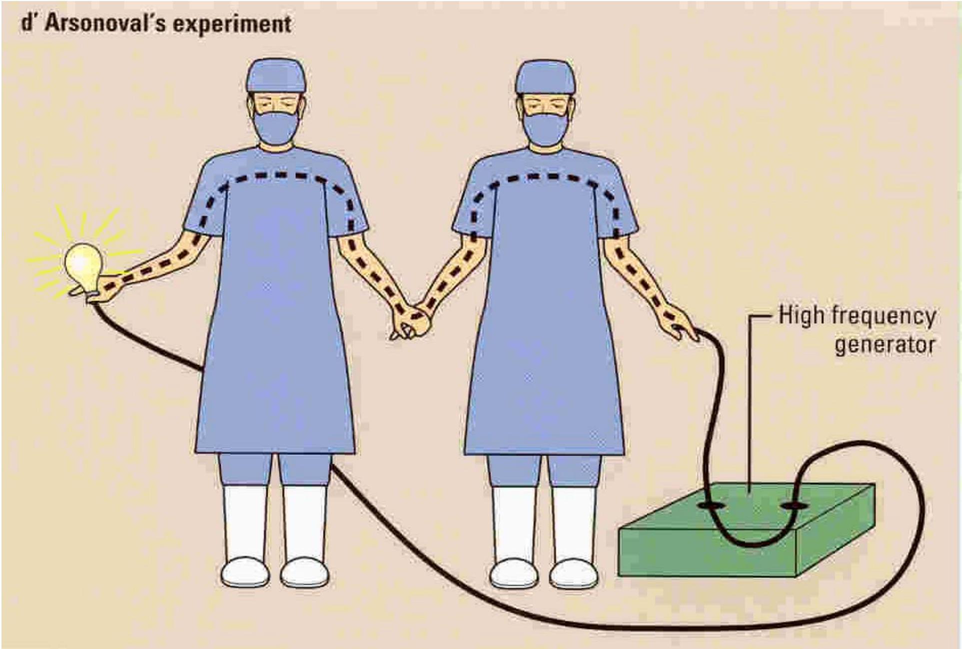
History

The techniques of electrosurgery used today were developed in the early part of the 20th Century, although the history of the technique goes back as far as the early 19th Century, when the French Physicist Becquerel, first demonstrated electrocautery, using electricity to heat a wire needle. The principle of cauterising wounds to stop bleeding was known to Hippocrates and the early Greeks (circa 460 – 370 BC).

One important event in the development of electrosurgery was when, in 1891 d'Arsonoval discovered high frequency alternating electrical current could be passed through the body without causing electrical shock. At a frequency of 20kHz and higher, alternating electrical current passing through the body simply generates heat within tissues and does not create muscle stimulation. In 1909 Nagelschmidt discovered the heating effect of high frequency current could be used for therapeutic purposes and coined the phrase 'diathermy', based on the Greek meaning 'heating through'. A year later Czerny described the use of 'diathermy' for cutting tissue.

In 1909 an Italian surgeon, Pozzi described the process of tissue destruction by electrical sparking, and called it 'fulguration'. In the same year, Doyen introduced the technique of 'electrocoagulation' to stop bleeding. These techniques are still used today although the equipment used to carry them out has been dramatically improved.

Early electrosurgery units were fairly crude, but the development of electronic components enabled rapid progress to be made. By the late 1920s two Americans, Bovie and Cushing had developed a more sophisticated type of electrosurgery unit. This newer type was safe (by the standards at that time), effective and reliable enough to encourage the use of the technique.



These newer designs were based on spark gap oscillators of the type used in wireless telegraphy transmitters and were used for coagulating. The next significant improvement in the design of electrosurgery units was the use of thermionic valve oscillators in the late 1930s. These valve type generators were capable of producing a continuous wave output at higher power levels and were therefore good for cutting. Further advances in electronics resulted in electrosurgery units featuring both valve and spark gap generators, allowing surgeons to mix or blend the output to suit specific surgical procedures by providing cutting, coagulation or a combination of both.

With the 1960s came the advent of solid state electronics with transistors and printed circuit boards. This improved technology, combined with the advances in surgical techniques and increased demands for safety and performance, contributed to the rapid development of electrosurgery units. These are similar to the types of electrosurgery units seen today.

Electricity

In order to understand how electrosurgery works, it is essential to have an understanding of electricity. Electricity exists due to electrons, protons and neutrons, which together create atoms. Atoms, which have the same number of protons as electrons, have a neutral charge. Atoms with more protons than electrons have a positive charge and are called positive ions. Atoms with more electrons than protons have a negative charge and are called negative ions. Should electrons leave their base atom and move to another, the charge on the base atom changes. During these changes unlike charges attract each other and like charges repel. When charged particles flow through a conductor an electrical current is formed.

The flow of electricity is called the **current** and is measured in amps. There are two types of electrical current, alternating current (a.c.), which alternates the flow of the electricity back and forth, and direct current (d.c.), where the electricity flows in one direction only. The **frequency** of this flow is measured in hertz (Hz) where one hertz is one cycle per second

Batteries have direct currents (d.c.) and therefore have a frequency of zero Hz, (the current flows in one direction only). Most household mains supplies have alternating currents (a.c.). In Europe the frequency is 50Hz and in USA the frequency is 60Hz. The pathway around which the current flows, is called the circuit.

Opposition to the flow of alternating current is called **impedance**. Impedance is the sum of two quantities called resistance and reactance. Reactance depends upon frequency, whereas resistance is independent of frequency. Only the resistive part of impedance can dissipate power and hence produce heat. Resistance is measured in ohms. The ‘pressure’, which forces current to flow through impedance, is called **voltage**. This is measured in volts. The energy produced per second by a current flowing through a resistance is called **power** and is measured in watts. Power dissipated in a resistance produces heat.

Diathermy versus Electrosurgery

The term diathermy was originally applied to the therapeutic heating effect of passing high frequency electrical current through the body and was later used to describe cutting tissue. The term diathermy is still used today but the term electrosurgery has a more accurate meaning and should be used in preference. The word diathermy covers both medical diathermy, which is a therapeutic technique and surgical diathermy, which is equivalent to electrosurgery. The heating effect in the tissue is produced by the passage of current through the body/tissue.

This heating effect depends on 4 factors:

Factor 1 - The current density (current divided by area)

- The greater the current through a particular area, the greater the heating effect.
- The smaller the area through which a particular current flows, the greater the heating effect.

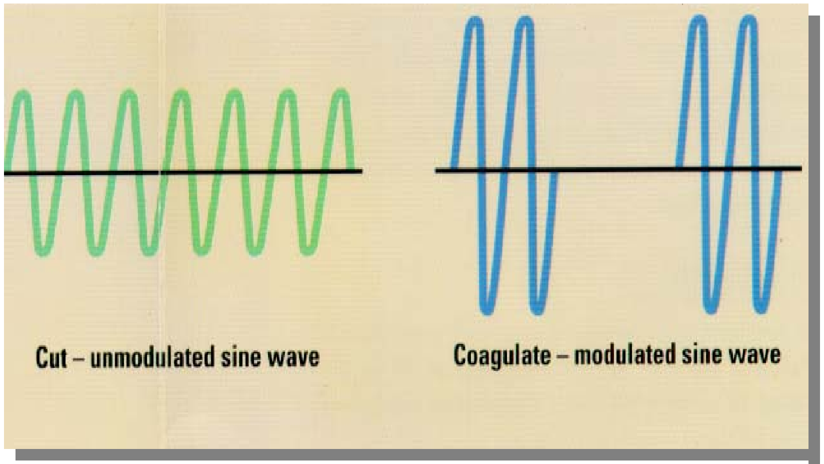
When using identical power settings identical tissue with identical resistance and identical conductivity, the heating effect will be greater with the needle electrode than with the ball electrode. This is due to the needle electrode having a smaller surface area in contact with the tissue than the ball electrode. The heating effect will therefore be more concentrated.

Factor 2 - The conductivity of the tissue

- Different types of tissue have different electrical resistances. Fat is a poor conductor (with a relatively high resistance) and muscle is a good conductor (with a relatively low resistance).

Factor 3 - The type of current used

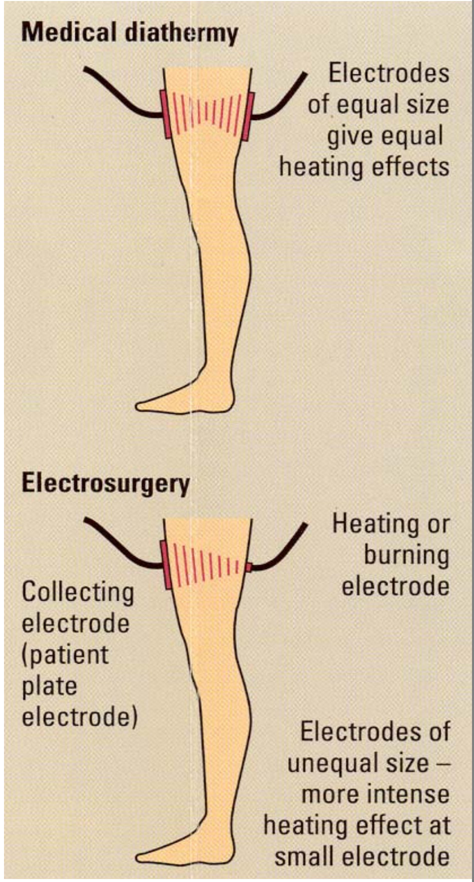
- There are distinct differences in the waveforms of currents produced by electrosurgery units and these currents produce different effects in the tissues. For example cut has a continuous waveform as opposed to the coagulation waveform, which is not continuous (see the picture right).



Factor 4 - The size of the electrode

- If the electrodes used are flat plates of equal size, the heating effect produced at both electrodes will be of equal intensity. Maximum heat intensity will be at a depth of approximately 1 cm from the skin surface.
  This is the type of effect produced by medical diathermy used in physiotherapy departments.

- Should one of the electrodes be reduced in size, the current at both electrodes will be almost equal but the current density will increase at the smaller electrode and the heating effect produced by that electrode, will be concentrated. Eventually, if the size is reduced even further, the heat will become intense enough to produce a burn. This is the type of effect produced by surgical diathermy otherwise known as electrosurgery. It follows therefore, that if both electrodes were reduced in size, a burn would result from both electrodes. In monopolar electrosurgery, one small electrode is used to produce the heating effect and one large electrode (the patient plate electrode) to 'collect' the current and return it safely to the electrosurgery unit.



Isolated and Earth Referenced Electrosurgery Units

Earth referenced electrosurgery units are not commonly used in surgery today. The patient plate electrode from these units, (which provides a circuit for the current to return to the electrosurgery unit) have low impedance to earth, therefore it is easy for the current to choose an alternate pathway, should one exist. This is known as current division. Should this occur, wherever the current leaves the patient's body a burn could arise. It is possible for the full current generated by the electrosurgery unit to choose this pathway resulting in a severe alternate site burn.

The type of electrosurgery unit commonly used in surgery today is known as floating or isolated. In contrast to the earth referenced units, the patient plate electrode from these are isolated from earth, at high frequency and have high impedance to earth. This means that the current is forced to return safely to the electrosurgery unit via the patient plate electrode. Unfortunately, there is still potential for alternate site burns caused by 'leakage' or 'stray' currents (see Note: Leakage or stray currents).

With floating units it is possible for the full output voltage of the electrosurgery unit to appear on the patient plate electrode, should the active become earthed. Having the full output voltage on the patient plate electrode means that the full output voltage will also be on the patient's body, if the patient plate electrode is in normal contact with the patient. This greatly increases the risk of an alternate site burn. Also, if somebody touches the patient when the full output voltage of the electrosurgery unit is on the patient's body, (e.g. electrosurgery unit energized), both the patient and the person touching the patient could get an electrosurgery burn.

It is possible for the active output to become earthed by an insulation fault inside the electrosurgery unit or by an active cable with damaged insulation being draped over an earthed object. With an earth referenced electrosurgery unit the full output voltage of the unit cannot appear on the plate. If the active output becomes earthed for any reason then the output of the electrosurgery unit is short-circuited and a relatively small voltage will appear on the plate.

The Eschmann series of electrosurgery units offer Plate Voltage Monitors (PVM) and Patient Earth Monitors (PEM). These reduce the risks associated with high voltages on the patient and alternate pathways.

Note: Leakage or stray currents

A natural phenomenon of electricity is that high frequency alternating current can pass from a conductive material (e.g. an electrode) through an insulator (e.g. the insulation of the electrode) to another conductive material (e.g. a metal cannula). This is known as a capacitor. These capacitors pass 'leakage' or 'stray' currents.

Another example of a capacitor is an active cable draped along the floor of an operating theatre. Here a capacitor is formed between the metal core of the cable, the cable insulation, and earth. Should another earthed object touch the patient, the leakage currents will pass from the active cable through the insulation to earth, flow back up the earthed object through the patient and back to the electrosurgery unit. If the contact area where the earthed object touches the patient is sufficiently small, a burn will be created.

The effects of electricity on tissue

At low frequencies alternating current (a.c.) causes a dangerous shock but with frequencies above 20kHz, muscular contraction stops, pain stops and the only detectable effect, is heat generation within the tissue. In practice, frequencies of 250kHz or higher are used in electrosurgery units to avoid 'arc rectification' which is low frequency current caused by sparking. This 'arc rectification' is avoided by including a suitable value of capacitance in series with the output.
The simplest way to get sufficient power delivered to the patient via this capacitance is to use frequencies of 250kHz or above.

Note: A capacitor will pass high frequency electrical current but not low frequency electrical current. It is the low frequency electrical current that causes muscle stimulation. Should arc rectification occur, low frequencies will also be generated through sparking. These low frequencies will cause muscle stimulation if they are not blocked by suitable capacitors.

The intensity and spread of heat through the tissue can be altered in various ways to provide the coagulating or cutting power needed in electrosurgery. The objective of electrosurgery is to deliver the optimum power (watts) into a specified electrical resistance as safely and effectively as possible.

The most common range of electrical resistance into which a surgeon operates is between 100 and 1,000 ohms. Different tissues have different ranges of resistance, due to their differing conductivity. Also the total resistance between the active electrode and patient plate electrode depends to a large extent on the size, shape and contact pressure of the active electrode and the distance between the two.

Examples of resistivity and conductivity of tissue

Tissue Type	Resistance **(ohms (Ω))**	Conductance **(siemens (S))**	Conductance **(millisiemens (mS))**
Muscle	110	0.00909	9.090
Kidney	126	0.00794	7.940
Heart	132	0.00758	7.580
Spleen	256	0.00391	3.910
Skin	289	0.00346	3.460
Liver	298	0.00336	3.360
Fat	2,180	0.000459	0.459

These resistances and conductances were measured in a conductivity cell.

(Reference: Mitchell, Lumb and Dobbie, A handbook of surgical diathermy (1978). Bristol: J Wright & Sons.

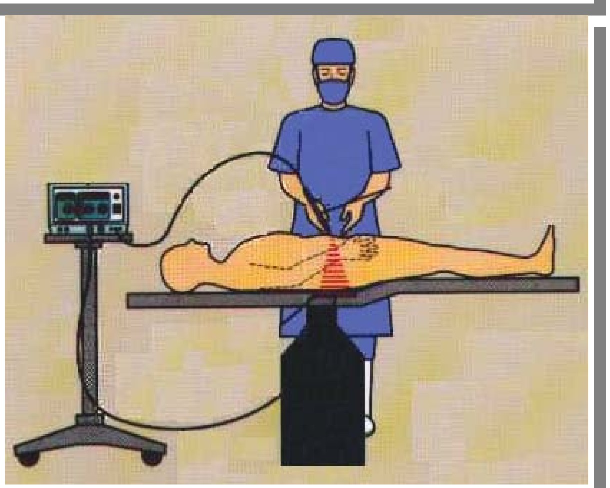
Note:

- The resistivity of a particular type of tissue is the resistance of the sample of tissue in the conductivity cell multiplied by the cross-sectional area of the conductivity cell and divided by the length of the conductivity cell.
- Resistivity is normally expressed in "ohm centimetres" (W cm) or "ohm metres" (W m).
- The conductivity of a particular type of tissue is the conductance of the sample of tissue in the conductivity cell multiplied by the length of the conductivity cell and divided by the cross-sectional area of the conductivity cell.
- Conductivity is normally expressed in "siemens per centimetre" (S/cm) or "siemens per metre" (S/m).
- Resistance is voltage divided by current. Conductance is current divided by voltage.
- Conductance is, therefore, the reciprocal of resistance.

Monopolar and bipolar electrosurgery

Monopolar and bipolar electrosurgery are two distinct methods of electrosurgery. The fundamental difference between the two is how the electrical circuit is completed.

MONOPOLAR ELECTROSURGERY



With monopolar electrosurgery the patient forms a major part of the electrical circuit. An active cable from the electrosurgery unit carries current to the active monopolar electrode. Current then spreads through the tissue to be collected and returned to the electrosurgery unit by a 'patient plate electrode' attached to the patient. There are no intended thermal tissue effects at the plate electrode, since the current is less concentrated. (The patient plate electrode is also known as dispersive, neutral, passive or return electrode).

Monopolar active electrodes have a single active pole delivering the current. This current then returns through the patient's body to the patient plate electrode.

Monopolar electrodes are available in an assortment of tips:

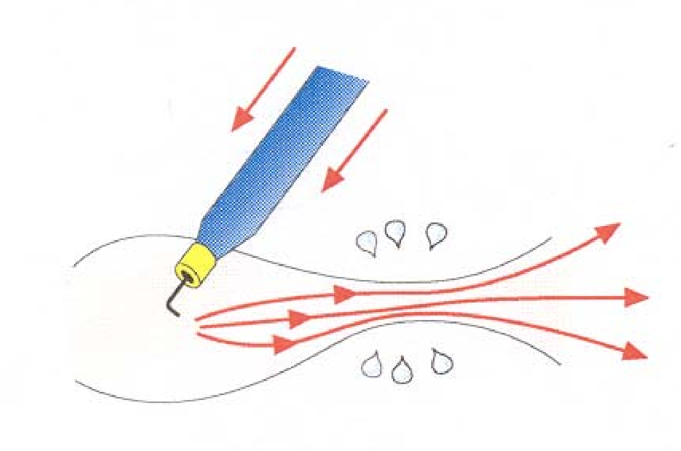
- Loops to cut and fulgurate

- Ball electrodes for desiccation (contact coagulation) and fulguration (non contact coagulation)

- Needles to cut and coagulate

- Blades to cut and coagulate

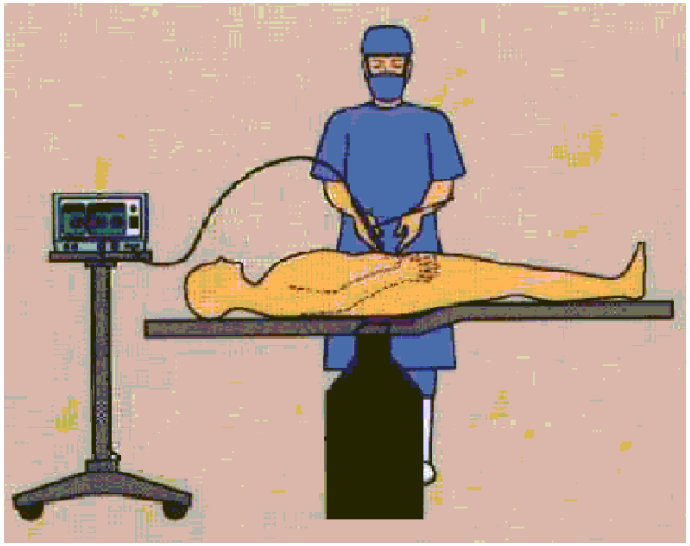
Monopolar electrosurgery should not be used in areas where the target tissue is connected to adjoining tissue via small delicate structures. Should monopolar electrosurgery be used in this situation, the electrical current can pass through these structures which, if sufficiently small and the current sufficiently concentrated will heat this structure to the extent that tissue damage can occur, resulting in partial or total occlusion of the vessel lumen. This effect is known as 'channelling' or the 'pedicle effect' (illustrated right)



When using monopolar electrosurgery, the active electrode which delivers power to the surgical site can either be hand or foot activated.

Bipolar Electrosurgery

Unlike monopolar electrosurgery where the patient's body forms a major part of the electrical circuit, with bipolar electrosurgery only the tissue grasped between the tips of a pair of bipolar forceps forms part of the electrical circuit. These bipolar forceps incorporate two active electrodes, which also return the current, the same as a patient plate electrode in monopolar electrosurgery. Both electrodes are isolated in respect of earth and are routed directly to the site of the operation. Bipolar electrosurgery typically uses a frequency between 250 kHz and 1 MHz. When using bipolar electrosurgery, the active electrodes delivering power to the surgical site, can either be hand or foot activated.



The advantages of bipolar electrosurgery are as follows:

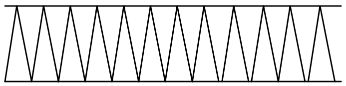
- Reduced risk to the patient
  - The intended current does not pass through the body of the patient, only through the tissue grasped between the tips of the forceps.
- Reduced damage to surrounding tissue
  - Bipolar electrosurgery has a localised effect on tissue, which is precise. It suits delicate surgery such as ophthalmic, maxillofacial, neurosurgery, vascular and tubal surgery in gynaecology. It is also widely used in orthopaedics where nerves of digits are involved and is particularly suited to paediatric surgery e.g. tonsillectomy and circumcisions.
- Greater efficiency
  - The pressure exerted on a blood vessel by forceps increases heat dissipation and desiccation, causing a 'spot welding' effect that improves coagulation efficiency.

The disadvantages of bipolar electrosurgery are as follows:

- Electrode adherence
  - The close contact between the forceps and tissue can cause adherence in "dry tissue", often caused by squeezing the tips of the forceps too tightly on the tissue. This can also result in the loss of current flow.
- Low cutting power
  - The low bipolar output of typical electrosurgery units makes them less effective as cutting devices. Also, bipolar cutting instruments need special design in order to cut and not coagulate.
- Slower
  - Because of its precise nature, each vessel has to be grasped and coagulated separately (the size of the blood vessel will also have a bearing on power needed).

Electrosurgery modes

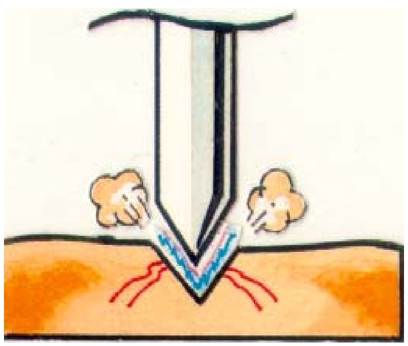
CUTTING (PURE & SPECIALIST)



This is a diagram of a cutting current which has a continuous waveform. Because the delivery of the current is continuous, much lower voltages are required to achieve tissue vaporisation.

The Pure cut mode is suitable for a wide range of operations where a scalpel would otherwise be used.

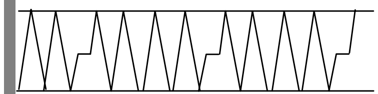
With the cutting modes, the electrode is held over the tissue and a small



continuous arc is formed between the electrode and the tissue. This in turn causes rapid cell destruction followed by the complete explosion of the cell. It 'blows away' cell debris achieving a clean cut. Should the electrode be placed directly on the tissue and the cut waveform used, some coagulation will be achieved, this effect is called desiccation. Desiccation can be more effective when using the relevant coagulation mode.

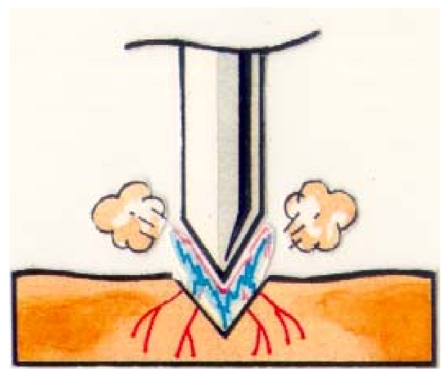
The Specialist cut mode is specifically designed for operations in wet fields (fluid) which have increased levels of conductivity due to the wet environment. This mode delivers more power into higher resistances and is particularly suitable for urology and gynaecology.

BLEND



This is a diagram of a blend current which is not a continuous waveform. Because the delivery of the current is not continuous, higher voltages are required to achieve some coagulation.

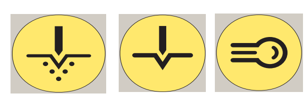
The Blend mode is a function of the cut mode and provides coagulation at the same time as cutting.



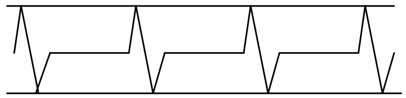
Because the waveform is not continuous, (needed to enable some coagulation to occur), it employs higher voltages than the other cutting modes, which are designed to cut only.

All electrosurgery cut modes are colour coded yellow. This requirement is in accordance with IEC 60601-2-2:1998

Blend Pure Specialist

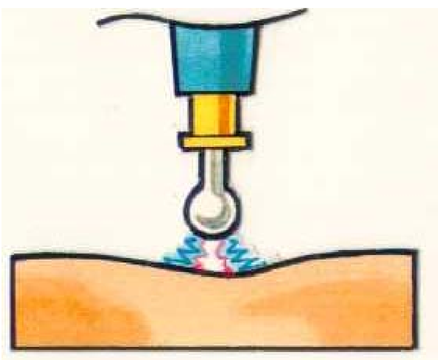


COAGULATION MODES

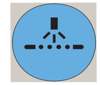
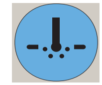


This is a diagram of a coagulation current which does not have a continuous waveform. Because the delivery of the current is not continuous and is 'off' for longer periods of time than it is 'on', much higher voltages are required to achieve tissue coagulation.

Desiccation (otherwise known as pinpoint coagulation or contact coagulation) creates rapid localised heat at the end of the blood vessel causing contraction with eventual occlusion of the lumen. This creates precise coagulation of the tissue.



Spray coagulation mode (otherwise known as fulguration) employs higher voltages. This is because the waveform is off for longer periods of time than any other mode, and because the electrode is not in contact with the tissue (held approximately 2 - 4mm away). This therefore, creates an air gap across which the current must jump. The spray coagulation mode creates a more widespread coagulation than the other coagulation modes and due to the higher voltages employed, should not be used in laparoscopic or endoscopic surgery, where the voltages could break down the insulation of the instruments used.

Spray Pinpoint

All electrosurgery coagulation modes are colour coded blue. This requirement is in accordance with IEC 60601-2-2:1998.

The use of two electrosurgery units

In certain procedures it is convenient or even essential that two independent monopolar outputs are used on one patient at the same time. Eschmann Equipment recommends that electrosurgery units specifically designed for this type of surgery should be used.

The use of two independent electrosurgery units on one patient should be avoided for the following reasons. If the current from the first electrosurgery unit and the current from the second crossover, there is a possibility that low frequency ("beat") currents can be generated if the frequencies of the two electrosurgery units are not exactly the same. These "beats" could cause an effect similar to an electric shock. If the currents from both electrosurgery units cross whilst passing through the patient to return to the patient plate, there is a potential for abnormally high temperatures to be created by current passing through the same tissue. This could lead to unwanted tissue damage.

If the current from the active of the first electrosurgery unit flows to the patient plate of the second electrosurgery unit or vice versa, this patient plate may have to pass more current than would otherwise be expected. This could lead to abnormally high temperatures under the patient plate, which is passing abnormally high current. This could lead to a patient plate burn.

Electrosurgery Burns

As stated in the Introduction, 'electrosurgery refers to the passage of high frequency (h.f) electrical current through the body to achieve a desired surgical effect'. The result of this 'surgical effect' is the damage of, or the destruction of tissue. It follows therefore, that if some or all of this current is concentrated in an area other than the intended site, unwanted thermal damage to tissue (commonly known as burns) can occur. There are three classifications of thermal damage associated with electrosurgery, endogenous, exogenous and pseudo burns.

Endogenous burns

These are burns that are created from within the tissue and can be the result of problems with the patient plate (e.g. too small, poorly applied) or through alternate sites. Even though modern day electrosurgery units are isolated from earth, alternate site burns can occur through leakage currents as detailed earlier. These leakage currents cannot be completely eliminated and are a natural phenomenon of electricity, when utilising alternating current (a.c.). Alternate site burns can occur where a part of the patient's body makes a relatively small contact area with an electrically conductive object, which has low impedance to earth. Some examples of situations where alternate site burns can occur are:

- If a patient's arm makes a small area contact with a metal drip stand which has antistatic tyres, on an antistatic operating theatre floor.
- Where a metal earring in contact with the patient's body is held or accidentally touched by a member of theatre staff during the activation of the electrosurgery unit. In this scenario, both the patient and member of theatre staff could receive a burn.
- Concentration of high frequency (h.f.) current by a metal prosthesis in the current path between the active site and the plate site.

Picture above shows an example of a Patient Plate burn

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Pseudo Burns

These burns are created by external damage to the tissue. For example, chemical skin burns (e.g. spirit or skin preparation) or pressure sores.

Exogenous Burns

These burns are created by external heating of the tissue. For example, faulty warming blankets, ignition of flammable or explosive substances or gases, sparks from the active electrode of the electrosurgery unit.

Hazards associated with Minimal Access Surgery

Minimal access surgery has certain hazards associated with its use. As long as these hazards are avoided, electrosurgery can be used in minimal access surgery

Inadvertent activation of electrodes

In open surgery any unused electrodes should be stored in an insulated quiver so that they are isolated from the patient. With minimal access surgery, these electrodes often remain in situ and cannot be placed in a quiver. If these electrodes are in contact with the patient and are accidentally activated, unintentional burns can occur. To ensure this situation does not occur, when not in use, remove or disconnect the active electrode's cable from the electrosurgery unit. If this is not practical, ensure the electrode when not in use does not touch any part of the patient's tissue. Ensure, at all times, the footpedal is operated only by the surgeon using the active electrode.

Insulation Failure:

Insulation failure is when the coating applied to an electrode for insulation is compromised. Should this happen the current can either activate another metal instrument or inadvertently directly burn tissue.

Direct coupling

Direct coupling is where the electrode touches another instrument, which in turn is touching tissue. The first electrode can activate the other instrument and create an unintentional burn on the tissue it is touching. In laparoscopic surgery never activate the electrosurgery unit unless the uninsulated part of the active electrode is in full view.

Electrode Temperature

After prolonged activation, the tip of the electrode may remain hot for some time after de-activation. If this comes into contact with tissue, unintentional burns can also be created.

Capacitive coupling

A natural phenomenon of electricity is that high frequency alternating current (a.c.) can pass from a conductive material (e.g. an electrode) through an insulator (the electrodes insulation) to another conductive material (e.g. a metal cannula). The electrode, the insulator and the cannula form what is known as a capacitor. The current can, therefore, pass from the active electrode to the cannula and onto any tissue in contact with the cannula. Should the metal cannula be of sufficient size and making good contact with the abdominal wall, the current will safely be dissipated and no burn will result. However, should the cannula not make good contact, a burn could result. Because of this, plastic anchors should not be used to secure the cannula; these will isolate the current from the abdominal wall. In this situation the current can no longer safely dissipate through the abdominal wall. Should tissue within the abdomen touch the electrode's insulation or indeed the metal cannula, a capacitor will be formed and a burn could be created.

Location and Site Preparation.

- Choose a muscular site well supplied with blood vessels and adjacent to the surgical field, e.g. thigh, buttocks or upper arm. In some situations the trunk of the body may be preferable.
- Always shave the area onto which the patient plate electrode will be sited.
- Site the patient plate electrode on the patient with the longest edge facing towards the surgical site.
- Ensure all the conductive area of the patient plate electrode is in contact with the patient’s skin (small areas can cause burns).
- Ensure the surface under the patient plate electrode is clean and resilient.
- **Do Not Apply:**

1. Over bony protuberances
2. Over metal implants
3. Over folds of skin
4. Over scar tissue
5. Over hairy areas
6. Over any form of skin discoloration
7. Over an injury or to limbs with a restricted blood supply
8. Adjacent to ECG electrodes

Application

- Open patient plate electrode pack as indicated immediately prior to use. Withdraw the patient plate electrode and peel off backing sheet, avoiding unnecessary contact with the adhesive surface. Apply one edge to the patient and firmly press the rest of the patient plate electrode into position, ensuring overall contact of adhesive surface with the skin.
- Check the condition of the patient plate electrode cable. Attach the connector to the patient plate electrode tab and connect the cable plug to the electrosurgery unit.
- Reset the electrosurgery unit so that monopolar is active.
- Most modern electrosurgery units include a contact quality monitor (for use with divided plates). This system measures the quality of the contact between the patient’s skin and patient plate electrode. If the plate becomes dislodged or there is a high resistance between the patient plate electrode and the patient’s skin, the unit will sound an alarm and the power will be disabled. Please note that if a standard patient plate electrode is used (not a divided patient plate electrode) irrespective of whether the electrosurgery unit in use has a contact quality monitor, the alarm will not sound. A divided patient plate electrode must be used to activate this type of monitoring system.

Picture left shows single and divided patient plates

REMOVAL

- Place the electrosurgery unit into monopolar standby, or alternatively turn the unit off by the mains switch.
- Disconnect the cable from the patient plate electrode and the electrosurgery unit.
- Gently lift one corner of the patient plate electrode and peel off very slowly. Discard the patient plate electrode.

PAEDIATRIC USE

- With babies and small children the patient plate electrode should always be applied to the trunk section of the body. It is unsatisfactory to attach a patient plate electrode to small limbs where overlap of the plate can occur.

General notes and warnings

- If the desired surgical effect is not achieved using normal power settings, do not increase the power setting until the following checks have been made. This is particularly relevant if the electrosurgery unit has been working satisfactory and its performance has suddenly deteriorated.

  – Check the patient plate electrode is in complete contact with the patient's skin. Failure to achieve this could result in an electrosurgery burn or poor performance.
  – Check the plate cable is intact and correctly connected to the electrosurgery unit.
  – Check the active handle or fingerswitch is correctly connected and in good condition.

- Adhesive patient plate electrodes must not be relocated after initial application. Should the patient be repositioned, check patient plate electrode contact and electrical connections.
- Do not use contact gels.
- No not cut or modify the patient plate electrode in anyway whatsoever.
- Do not reuse single use patient plate electrodes.

Notes on general electrosurgery safety

Instructions for Use:

Do

1. 'Instructions for Use' are provided with the electrosurgery unit and should be read and understood before operating the equipment.

Electrosurgery Cables:

Do

1. Ensure electrosurgery cables are rated above the corresponding maximum peak output voltage of the electrosurgery unit (these voltages can be found in the 'Instructions for Use').
2. Check all cables and accessories routinely before use for possible damage to insulation or breaks in continuity.
3. Ensure monopolar cables are only plugged into the correct monopolar sockets and bipolar cables into the correct bipolar sockets.

Don't

1. Do not allow electrosurgery cables to drape across or contact the patient's body.
2. Do not allow electrosurgery cables to contact the cables or leads of other equipment.
3. Do not use hook type active cables.
4. Do not coil cables.
5. Do not fasten cables to drapes with metal clips, (these could make contact with the patient's skin and cause a burn). They could also damage the insulation of the cable.

Patient Plate Electrode:

Do

1. Ensure the entire area of the patient plate electrode is reliably attached to the patient's body and as close to the operative site as possible.
2. Should the patient be repositioned, do ensure the patient plate electrode and cable are checked to ensure good contact is maintained. If this is compromised, the patient plate electrode should be discarded and a new one applied.

Don't

1. Do not reuse disposable patient plate electrodes.
2. Do not reposition adhesive patient plate electrodes. Should this be necessary, discard the original patient plate electrode and apply a new one.

Active Electrodes:

Do

1. Store temporarily unused active electrodes such that they are isolated from the patient (e.g. use a quiver).
2. Frequently clean electrodes during surgical procedures with a sterile damp swab or specifically designed pads.

Don't

1. Do not scrape active electrodes clean or use abrasive pads. These can damage the surface of the active electrode and shorten its life.

Notes on general electrosurgery safety

Bipolar Techniques:

Do

1. Use bipolar techniques in preference to monopolar whenever possible. For surgical procedures on parts of the body that have relatively small cross-sectional areas, the use of bipolar techniques is desirable to avoid unwanted coagulation.

Implanted Pacemakers:

Do

1. Seek approved qualified advice (e.g. cardiology department) before using electrosurgery on patients with implanted pacemakers or other active implants, to avoid interference or damage to the implant.
2. Monitor patients carefully.

Power Settings:

Do

1. Before use, set power output controls to the minimum power setting to achieve the desired surgical effect.

Monitoring Electrodes:

Do

1. Ensure the ECG electrodes are positioned as far away from the operative site as possible.

Don't

1. Do not use needle ECG monitoring electrodes.

Flammable Spirits:

Do

1. Ensure that flammable spirits, if used on the patient's skin for cleaning or preparation prior to surgery, have evaporated completely before using an electrosurgery unit.

Body Piercing/Jewellery:

Do

1. Remove from the patient any body piercing/jewellery. If this is not practical, ensure the body piercing/jewellery is insulated using several layers of surgical tape.

Notes on general electrosurgery safety

Patient:

DON'T

1. Do not allow the patient's body to touch conductive objects. The patient should not come into contact with metal parts which are earthed or which have an appreciable capacitance to earth, e.g. operation table, uninsulated table accessories, surgical retractors attached to the side bars of operation tables, etc. The use of antistatic sheeting is recommended for this purpose.
2. Do not allow 'skin to skin' contact (e.g. between the arms and body of the patient), this can be avoided, for example by the insertion of adequate dry gauze.
3. Do not touch the patient with an area of less than 10 cm^2 when the electrosurgery output is energised.

Uninsulated Forceps:

DON'T

1. Do not use uninsulated forceps in combination with electrosurgery.
2. Do not rely solely on surgical gloves to provide insulation when using electrosurgery.

Miscellaneous:

DON'T

1. Do not store items especially liquids on top of the electrosurgery unit.
2. Do not use flammable anaesthetics, flammable solvents or oxidising gases such as nitrous oxide (N_2O) or oxygen if the surgical procedure is carried out in the region of the thorax or head, unless these agents are sucked away.
3. Do not disconnect cables by pulling cable, always grasp the connector.

Glossary

ACTIVE ELECTRODE[1]:

Electrode intended to produce certain physical effects required in electrosurgery, for example cutting and coagulation.

ALTERNATING CURRENT

Electrical current flowing back and forth.

AMPERE (AMP)[2]

Unit of electric current. The amp is defined by the magnetic force between two conductors both carrying an amp. Note: one amp equals one coulomb per second flowing past a fixed point in a circuit.

BIPOLAR ELECTRODE[1]:

Assembly of two active electrodes on the same support so constructed that, when energized, the h.f. current flows mainly between these two electrodes.

BIPOLAR ELECTROSURGERY

The passage of high frequency alternating electric current through the tissue typically grasped between the tips of bipolar forceps.

BLEND

Electrosurgery monopolar cutting mode which provides cutting with coagulation.

CAPACITIVE COUPLING

The capacitive effect of high frequency alternating current (a.c.) passing from a conductive material (e.g. an electrode) through an insulator (e.g. the electrodes insulation) to another conductive material (e.g. a metal cannula).

CAUTERY

The sealing of small blood vessels or body tissues by the heating of a wire.

CHANNELLING

The effect generated by the use of monopolar electrosurgery on tissue connected to adjoining tissue via small structures. Where the current pathway passes through the small structures and heats these to the extent that partial or total occlusion of the vessel can occur. This effect is also known as the 'pedicle effect'.

CIRCUIT

Pathway for the flow of electricity (current).

COAGULATION[1]:

Sealing of small blood vessels or of body tissue caused by the passage of high frequency current at the active electrode(s).

COULOMB

Unit of electric charge (defined by the amp). One amp equals one coulomb per second flowing past a fixed point in a circuit.

CURRENT DENSITY

The total current divided by area through which that current is flowing. The smaller this area, the greater the effect.

CUTTING[1]:

Resection or dissection of body tissue caused by the passage of high frequency current of high current density at the active electrode(s).

CURRENT

Flow of electricity.

DESICCATION

Also known as pinpoint and contact coagulation. An electrosurgery monopolar coagulation mode which provides contact coagulation.

Glossary Cont'd

DIATHERMY

Another name for electrosurgery but includes medical diathermy.

DIRECT COUPLING

When the active electrode touches another instrument and energizes that instrument.

DIRECT CURRENT

Electrical current flowing only in one direction.

ELECTROCAUTERY

The sealing of small blood vessels or body tissues by the use of electricity to heat a wire.

ELECTROSURGERY

Performance of surgical operations, such as cutting or coagulation of biological tissue by means of high frequency (h.f.) currents.

ELECTROSURGERY UNIT[1]

Unit intended for the performance of surgical operations, such as cutting or coagulation of biological tissue by means of high frequency (h.f.) currents.

ENDOGENOUS BURNS

Electrosurgery related burns created from within the tissue.

EXOGENOUS BURNS

Burns created external of the tissue.

FREQUENCY[2]

The number of repetitions of a regular occurrence in a fixed period of time.

HERTZ[2]

Unit of frequency (The number of repetitions of a regular occurrence in one second).

IMPEDANCE

Opposition to the flow of electric current.

JOULE

Unit of energy equal to one newton-metre.

LEAKAGE CURRENTS

Unintended current (e.g. currents that can pass through stray capacitance and pass back to the electrosurgery unit via an unintended pathway).

MEDICAL DIATHERMY

The use of electrical current to heat tissue to produce a therapeutic heating effect, commonly used in physiotherapy (uses two electrodes of equal size).

MONOPOLAR ELECTROSURGERY

The passage of high frequency alternating electric current through the patient's body to create a desired surgical effect.

NEWTON

Unit of force, equal to the force that causes a mass of one kilogram to have a rate of acceleration of one metre per second squared.

OHMS[2]

Unit of electric resistance, one ohm is one volt per amp.

Glossary Cont'd

PATIENT PLATE ELECTRODE[1]

Electrode of a relatively large area for connection to the body of the patient, intended to provide a return path for the high frequency current with such a low current density in the body tissue that physical effects such as unwanted burns are avoided.

Note: The patient plate electrode is also known as plate, neutral electrode, passive, return or dispersive electrode.

PEDICLE EFFECT

See channelling

POWER

Amount of energy changed in form during fixed period of time. (E.g. amount of electrical energy converted to thermal energy (heat) in joules per second).

PSEUDO BURNS

External damage to the tissue unrelated to electrosurgery.

SIEMENS[2]

Unit of conductance, the reciprocal of the ohm. A body having a resistance of 4 ohms would have a conductance of 0.25 siemens. One siemen is one amp per volt.

SPRAY

Also known as fulguration. An electrosurgery monopolar coagulation mode which provides non contact coagulation.

SURGICAL DIATHERMY

Also known as electrosurgery, see definition of electrosurgery.

VOLT

Unit of electric potential or electromotive force (e.m.f.).

WATTS[2]

Unit of power, equal to one joule per second.

WAVEFORM

The pattern observed on a cathode ray oscilloscope when the probes of the cathode ray oscilloscope are connected to conductors between which a repetitive time varying voltage exists and the cathode ray oscilloscope is adjusted to display one or more cycles of that repetitive time varying voltage.

[1]IEC 60601-2-2 (1998)

[2]Brindley, Radio and Electronics Engineer's Pocket Book (1985). Newnes Technical Books.

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