



Electrosurgery

Manual

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GROUP

The company Gebrüder Martin GmbH & Co. KG has been actively engaged in the production of electrosurgical equipment since 1960. The high frequency generators developed and manufactured since that time have established a reputation for Martin as a competent supplier amongst users in all areas of specialist surgery. At Martin, the technological development of equipment has been an ongoing process. Recent examples of this are provided by such procedures as bipolar cutting, electrode detection, or application monitoring by means of a divided rubber neutral electrode. Generator design has undergone far-reaching changes in the decades since 1960. Today, with the dynamic output control of the generator, Martin places a facility in the hands of the operator that, to the greatest possible extent, automates HF generator operation.

This manual is the latest in the illustration series that is available from Martin. You can contact us via our sales representatives.

The manual is organised under the following chapters:

- 1 Electrophysical principles**
- 2 Application techniques**
- 3 Risks**
- 4 Product information**

Something of the history

2800 BC

First reference to the use of heat as a healing medium in the earliest known book on surgery the Edwin Smith papyrus.

Heating the instruments by fire and flammable gases

Middle of the 19th century

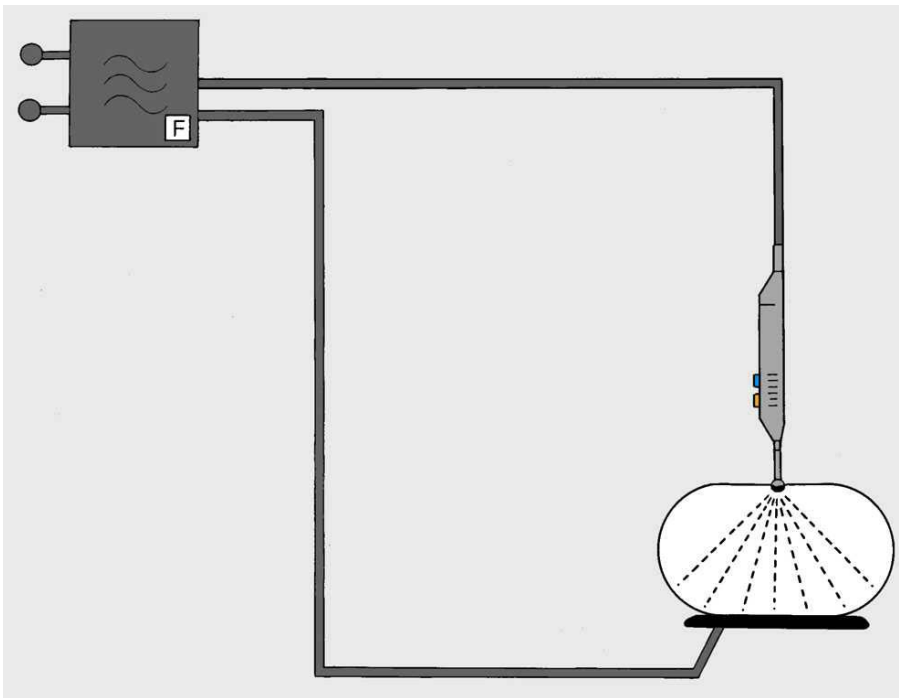
Heating instruments externally superseded by the discovery of the ability of electric current to heat a metallic conductor when flowing through it.

First application of electric current in surgical techniques

Use of galvano-cautery: a red hot platinum wire

Technical forerunner of the HF unit

The working principle of electrosurgery



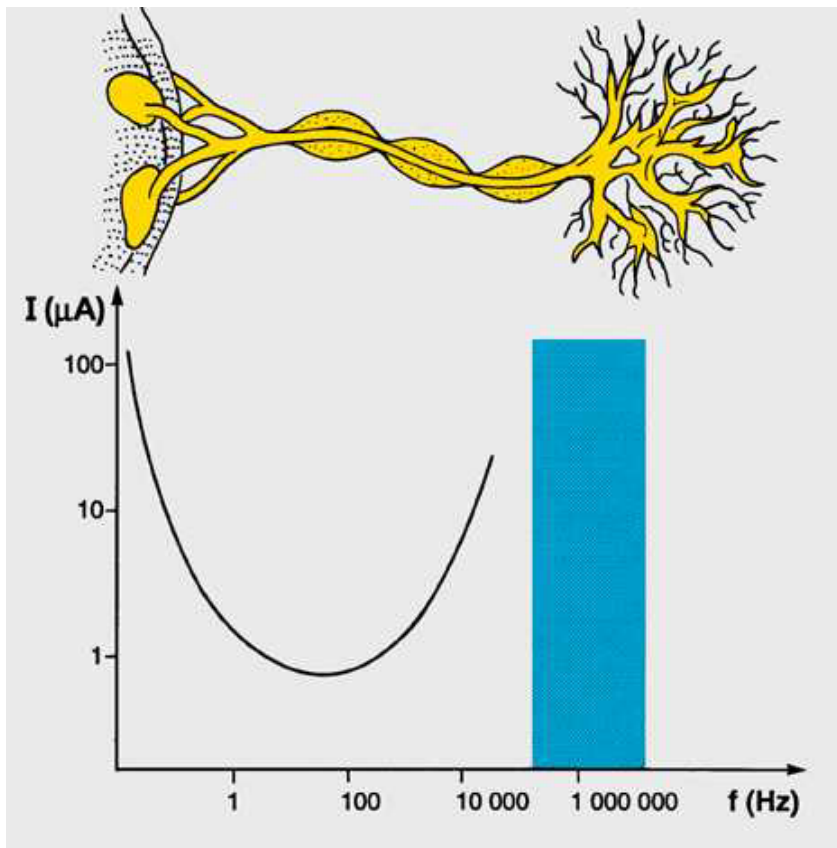
The diagram shows the principle of the construction of an electrosurgical unit. The electrosurgical generator is the module in which electrical energy drawn from the mains supply is converted to a high frequency current. This high frequency current is passed through a supply cable and a handle to an active **spot** electrode. At the point of application, this electrode builds up a highly concentrated field in the tissue surrounding the contact point. The concentration of energy within a small area produces the desired electrosurgical effect in the region around the active electrode. As the energy is conducted through the patient to a neutral electrode, in contact with a large surface, the current concentration is reduced. Thus, in the vicinity of the neutral electrode, there is, as is intended, no thermal effect. The electrical circuit is completed by the neutral electrode's connecting cable.

The HF generator can be activated either by a footswitch or a finger switch on the surgical handle.

It must be pointed out that there is a risk of unwanted cauterisation if the neutral electrode is not placed so that its whole surface makes full contact with the patient, because the current density is increased where only part of the electrode makes contact with the patient.

The principle described above applies in the first instance to the function of generators of the so-called monopolar design. The distinguishing feature of the bipolar instrument is that it applies the functions of the active and neutral electrodes to a pair of insulated forceps. Further details are given in the Chapter "Bipolar Technique".

Stimulus effect



Pulsating electrical current e.g. d.c. pulses or low-frequency currents (including mains supply frequencies) have a stimulating effect on nerve and muscle cells. The origin lies in a stimulation of the standard ion exchange in the human body that is responsible for the physiological transmission of stimulus. Stimulation of this kind leads to a spasm in the muscle that can extend to extra-systole and ventricular fibrillation.

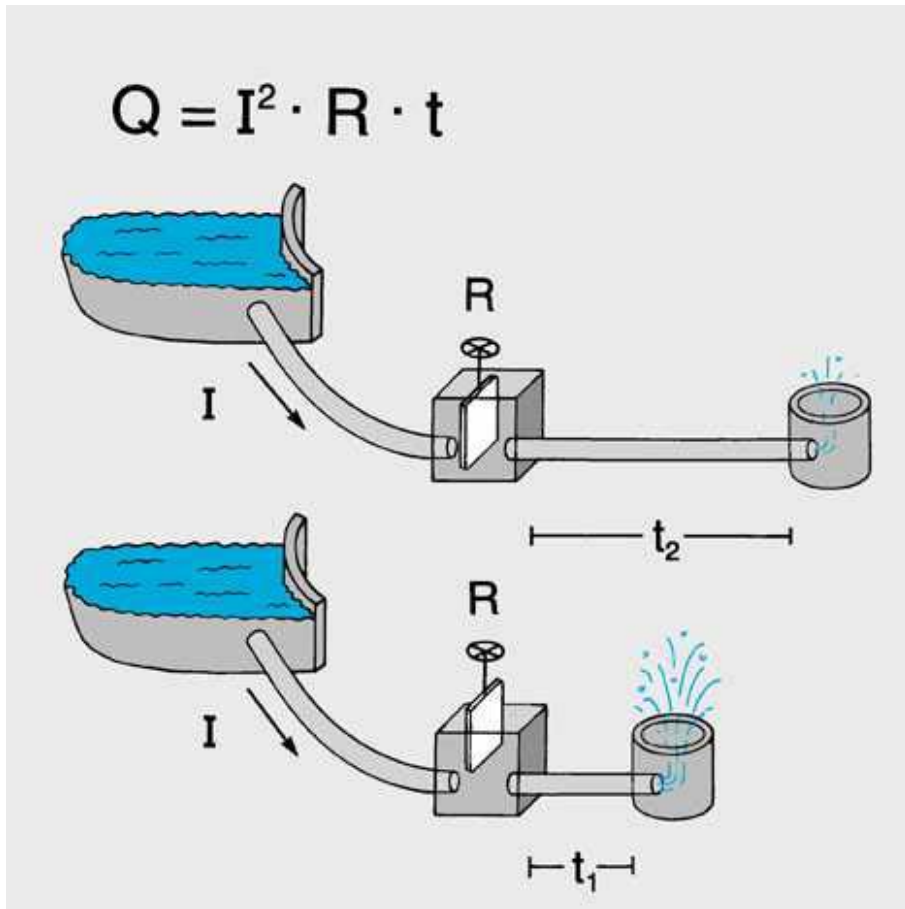
The effect of the stimulus, also known as the faradic effect, is expressed by the formula

$$R = \frac{I}{\sqrt{f}}$$

The physiological stimulus transmission system in the tissue follows a stimulus threshold curve as a result of which low frequency or pulsed currents generate an aggressive stimulation impulse. With high frequency alternating currents (> 200 kHz), the physiological system can no longer follow the stimulation impulse. An insensitivity to stimulus develops.

As a result, HF electrosurgical instruments are operated at a base frequency of > 300 kHz.

Joule's 5th Law


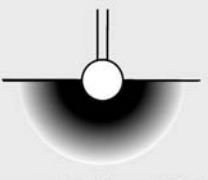

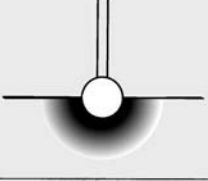
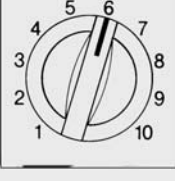
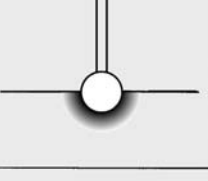


Electrosurgical instruments are based on the principle of converting electrical energy into heat. The basic principle is laid down in Joule's* law of thermodynamics in which the relationship of the amount of heat to the electric current (I), the ohmic resistance (R) and the duration (t) is expressed:

$$H = I^2 \times R \times t$$

* Joule, James Prescott, 1819 - 1889, English physicist, determined a value for the coefficient of mechanical thermal equivalence.

The effect of Joule's Law

	$40\text{W} \times 6\text{s} = 240\text{Ws}$	
	$80\text{W} \times 2\text{s} = 160\text{Ws}$	
	$120\text{W} \times 1\text{s} = 120\text{Ws}$	

Here, the effects of the basic principles of Joule's thermodynamic law on the operation of an HF instrument are illustrated diagrammatically. The amount of heat generated is determined by:

- the square of the current
- the setting of the power splitter
- the ohmic resistance of the physical tissue as a total of the resistance of the area in contact with the active electrode (e.g. blood, muscle or fatty tissue)
- the resistance in the total area between active and neutral electrode

The duration (t) is the time during which the HF current is activated by the finger switch on the handle or the foot pedal.

It should be noted as well that the amount of heat dissipated (blood flow) can reduce the temperature generated at the active electrode.

On the later designs of generators, the regulating curve at the HF generator output is, under certain circumstances, not linear i.e. the power splitter is not in the centre of the adjustment range at 50% output power. This has the distinct advantage that adjustment of the HF power in the lower ranges is especially fine for difficult operations. As more power is required, corresponding power reserves are then available.

Regulating the thermal effect

Regulating the thermal effect through:

1. Current and output power
2. Modulation level
3. Shape of electrode
4. Condition of active electrode
5. Cutting speed and duration of action
6. Tissue properties

- Current and output power

- Modulation level

This is understood to mean the wave form of the high frequency current produced by a particular generator design and instrument setting. There is a number of different designs on the market resulting from the difference in the specific data gathered by the various companies. The modulation level can for example be a parameter for the aggressiveness of an electrical incision, but it can also be for the depth of penetration in a coagulation procedure.

- Electrode shape

The designed shape of the active electrode is the final determinant for the field concentration at the point of application. It enables the temperature in the immediate vicinity, and with it the resulting effect, to be regulated. Thin, point-shaped electrodes create a high current density and therefore a high temperature. The result is an electric cutting effect. Larger surface electrodes create a lower current density and thus a lower temperature and produce a coagulation effect.

- Condition of the electrode

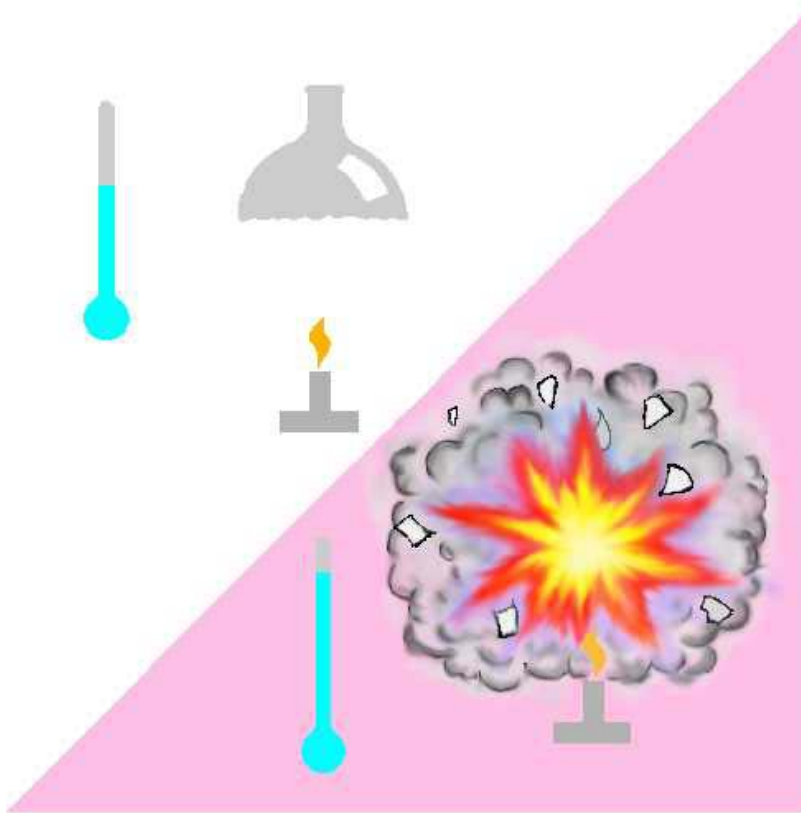
According to Joule's law of thermodynamics, the effects are proportional to resistance. In addition to the physical resistance already described, the electrode contact resistance, i.e. an electrode on which coagulate has already formed, increases the resistance of the system enormously. With an unchanged instrument setting and unchanged time, the resulting effect will therefore be considerably reduced. This being so, a contaminated electrode must always be cleaned during the course of the procedure.

- Tissue properties

As has already been mentioned, physiological tissue varies in its resistance properties. These properties are expressed physically by the specific resistance R_0 .

Biological tissue (in the 0.3 to 1 MHz range)		Metal	
blood	0.16×10^3	silver	0.16×10^{-5}
muscle, kidney, heart	0.2×10^3	copper	0.17×10^{-5}
liver, spleen	0.3×10^3	gold	0.22×10^{-5}
brain	0.7×10^3	aluminium	0.29×10^{-5}
lungs	1.0×10^3		
fat	3.3×10^3		

The effect of the current



Temperatures above 45°C cause a breakdown in the structure of living tissue and disruption of the function of protein molecules. The process is referred to as denaturation. The origin is a thermal effect. Depending upon the type of temperature range and the wave form employed, we differentiate between two types of HF current effect.

- Coagulation

Temperatures of 60 – 70°C in the area around the active electrode lead to a slow boiling of the intra-cellular fluid through the cell membrane. As a result of this effect, the cell shrinks and several cells link up to form chains. A "welding effect" is initiated which stops the bleeding.

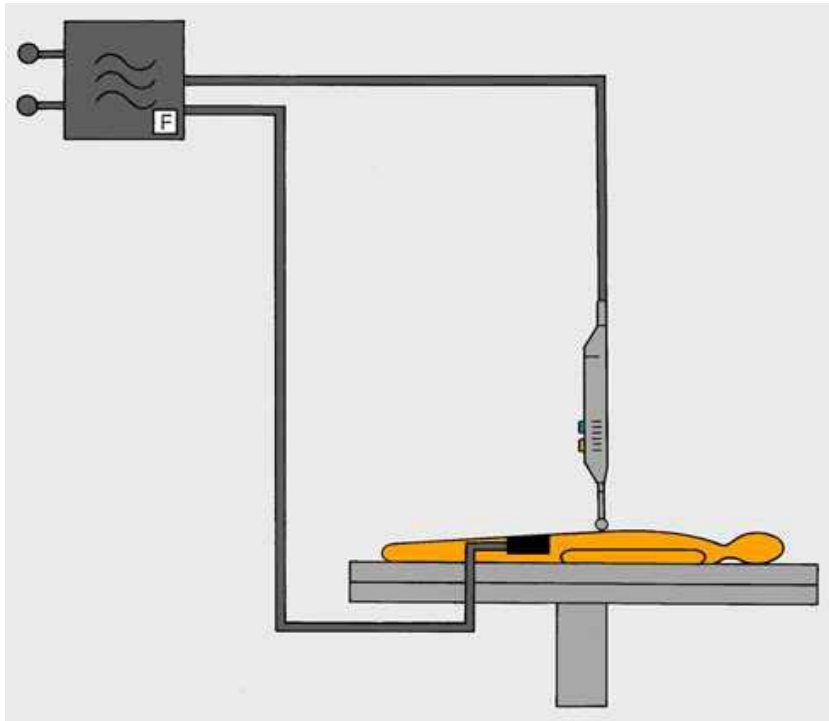
- Electrotomy

Temperatures of above 100°C in the region around the active electrode lead to the rapid evaporation of the fluid within the cell membrane. As a result, the cell membrane ruptures forming vapour around the electrode which in turn involves other cells lying in the path of the electrode as it moves. Electrotomy thus cannot be compared to a mechanical cutting process.

- Mixed currents

The basic effects of coagulation and electrotomy can now be combined into so-called mixed currents, that have different characteristics. The instrument thus provides such facilities as reduced haemorrhage incision, or cutting with intense scab formation. These facilities can be selected with function keys on the control panel of the instrument.

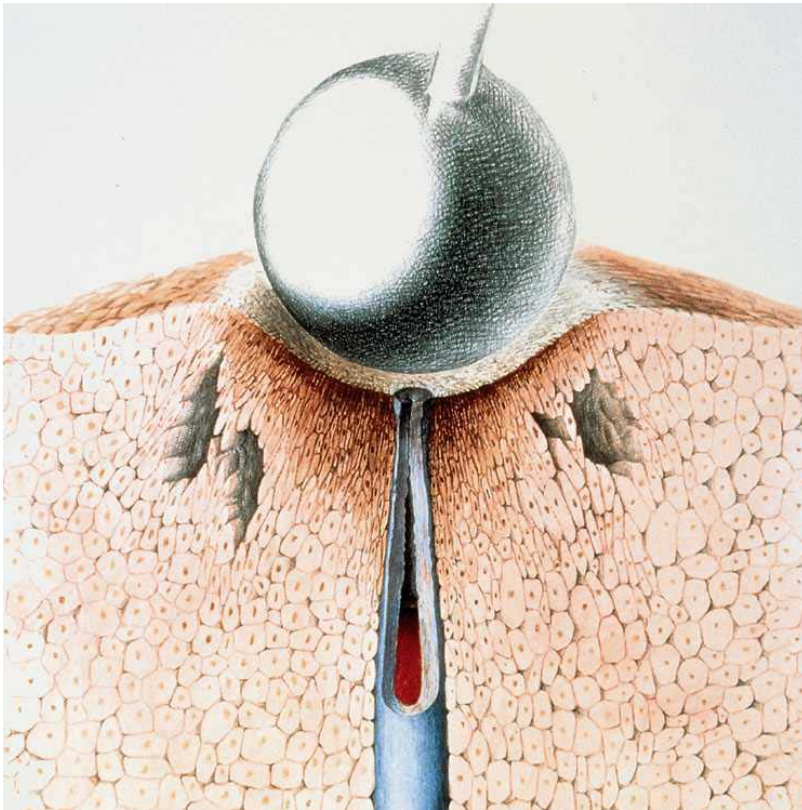
Operating principle of the monopolar technique



With the monopolar application technique, current flows from the active electrode through the biological tissue to the neutral electrode. The power is supplied by the HF generator producing a high frequency current. The electrical circuit is completed by the supply cable to the surgical handle, the active electrode and patient, and the neutral electrode and its connection cable.

A special form of the monopolar technique is mono-terminal application. This method is used primarily on surgical equipment in dental practices. As a rule, no neutral electrode is applied. This function is taken over by the capacitive coupling between patient and the dental chair. This is another means of completing a high frequency circuit.

The principle of coagulation

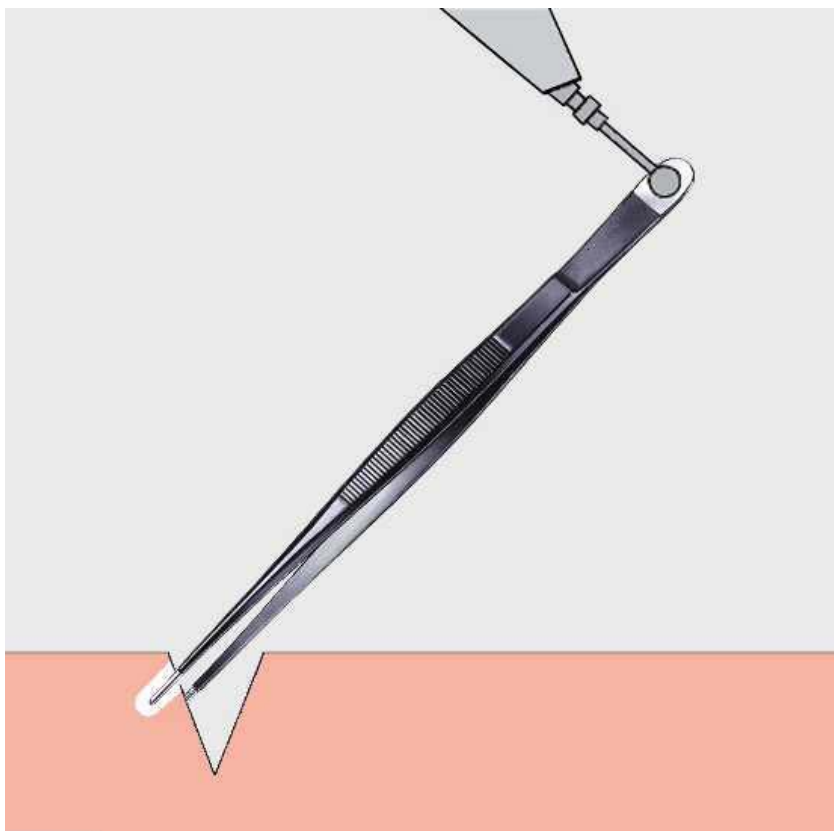


Where the thermal effect of protein clotting is caused by the heat generated in the area surrounding the active electrode, the process is termed coagulation. Here, the range of the temperature generated and the size of the contact area of the coagulation electrode, along with the current strength selected on the generator, determine the coagulating effect. The tissue around the active electrode is denoted as the actual coagulation zone depending upon the effect of the current. In the adjacent tissue areas, the effects of so-called denaturation can still occur. The procedure is such that there should be no thermal effect in the area of tissue beyond this in the direction of the neutral electrode.

In a bleeding vessel, the effect described causes the blood to retreat. The vessel walls near the electrode are fused together by the protein clotting caused by the heat. Coagulation takes place and the flow of blood is stopped.

Suitable electrodes for contact coagulation are e.g. ball electrodes, plate electrodes or the side faces of cutting electrodes.

Coagulation at the clamp or forceps



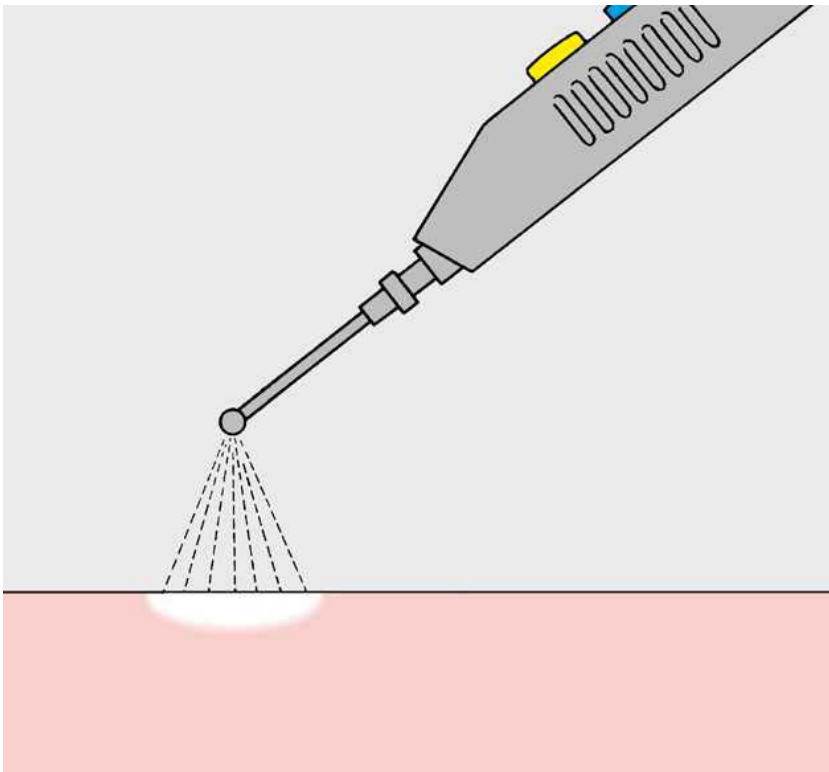
Where electrosurgical instruments are mainly used for coagulation, coagulation at the clamp or the forceps is the most commonly applied technique. Here, the surgeon grips a bleeding vessel with the forceps or the clamp. The application of mechanical pressure stops the flow of blood. Contact with the metal parts of the instrument is made by the active electrode. The HF current is activated. The instrument acts as an extension of the active electrode. The coagulation effect occurs at the point of contact between the instrument and the tissue. Coagulation follows.

In this operating technique, the surgical glove not only has a hygiene function but also provides insulation from the live metal components.

In order to avoid breakdown of the insulating properties of the surgical glove, it is absolutely essential to proceed as follows:

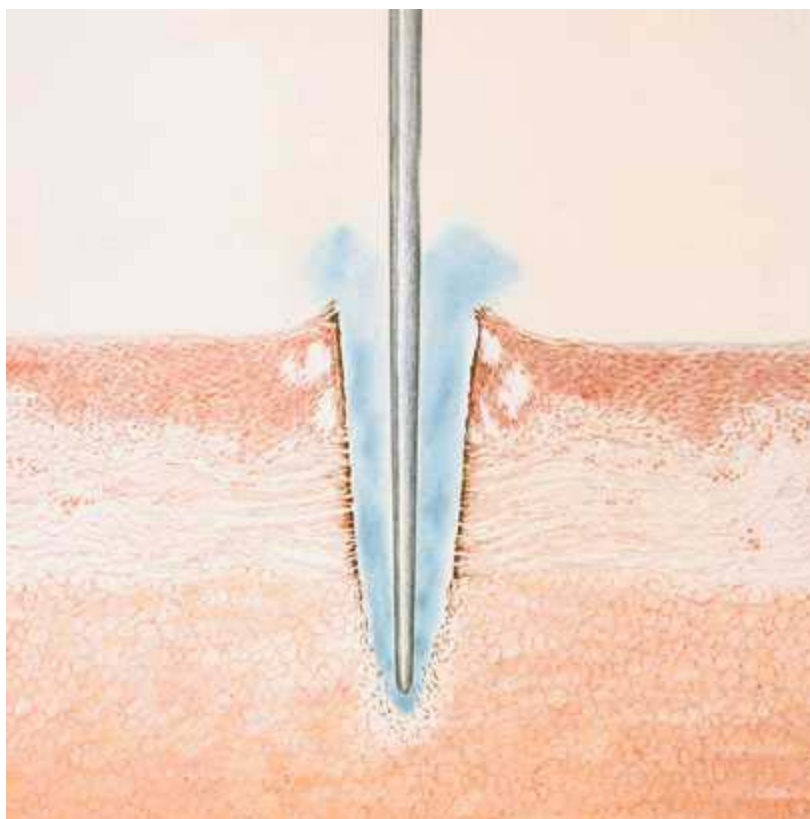
First contact must be made between the active electrode and the surgical instrument and only then should the high frequency be switched on. If, contrary to this, a live electrosurgical handle is moved towards the surgical instrument, there will be a spark discharge shortly before contact is made. The resulting faradic effects can cause electrical shock particularly if the glove is defective.

Spray coagulation



Spray coagulation is a special form of coagulation procedure. It has long been known under the name fulguration. Here, the active electrode is held several millimetres above the surface of the tissue. The spray current held ready is activated. The especially high voltage of this generator power results in the formation of a spark. This energy creates a superficial, strongly carbonised coagulation zone. By moving the active electrode, large wound areas on the most varied of tissue structures can be coagulated. One of the main applications is coagulation on the opened sternum during heart surgery.

Electrotomy



If by calling up the appropriate parameters on the generator and by selecting a spot active electrode, the temperature in the biological tissue vaporises the intra-cellular fluid, the effect of cell separation is achieved i.e. electrotomy. The temperature ranges required for electrotomy are in excess of 100°C. In a variety of measurement arrangements, temperatures of more than 300°C have been demonstrated.

Electrotomy is not a mechanical separation of the tissue. The vapour created in the region around the active electrode starts a chain reaction in the direction in which the active electrode is moved i.e. the energy of the vapour generated is also applied to neighbouring cells. The described effect is self-perpetuating as long as current is applied. It is also known as the Leidenfrost* effect.

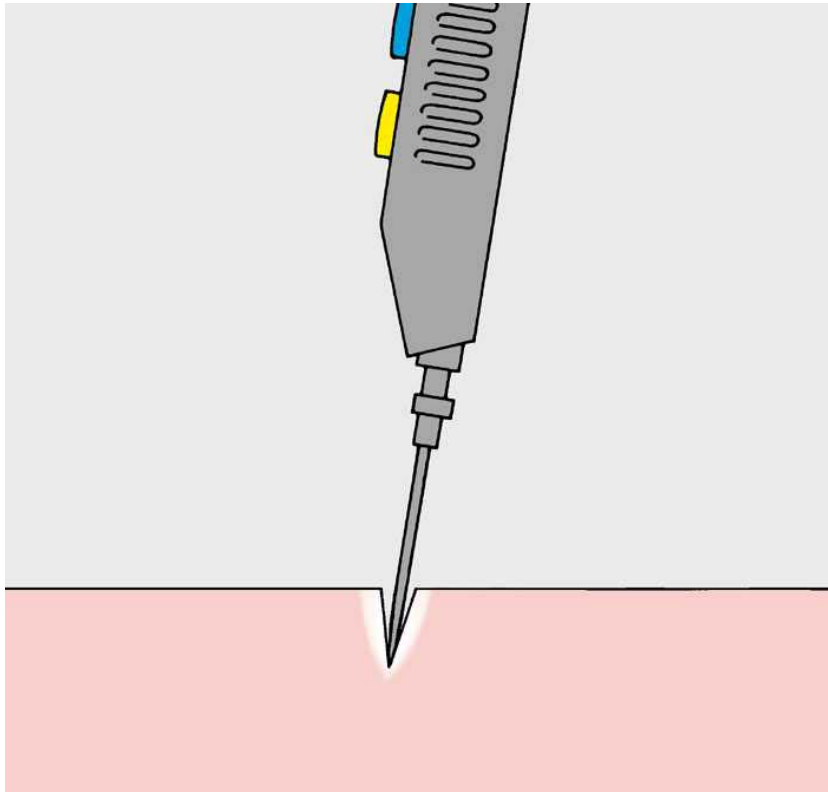
Suitable electrodes are the scalpel, the needle and the wire loop.

By mixing the effects of coagulation and electrotomy, so-called mixed currents can be generated. They are available to the user e.g. as coagulating cutting currents. The procedure is called encrustation cutting. Pure electrotomy produces a smooth scalpel-like incision.

* *Leidenfrost, Johann Gottlieb, 1715 - 1794, Doctor,*

The Leidenfrost phenomenon: drops of water roll around on a very hot metal plate and only evaporate slowly, because they are carried on an envelope of steam.

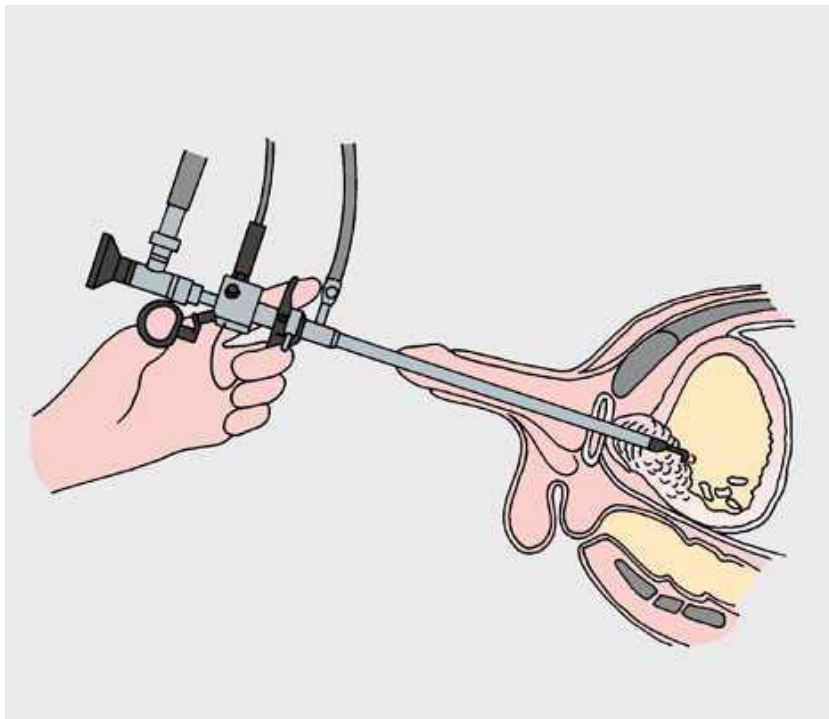
Application of electrotony



If the electrotony effect as described above is produced on the HF generator, the following should be observed:

The controls for activating the HF current on the handle or footswitch are colour coded. The switch function marked blue is allocated to coagulation, and that marked yellow to electrotony. In clinical practice it can often be observed that the allocation of the generator function called up and the required effect are reversed. In these cases, although increasing the current will produce a sufficient effect, the optimum effect can only be achieved using the correct settings.

Transurethral resection (TUR)

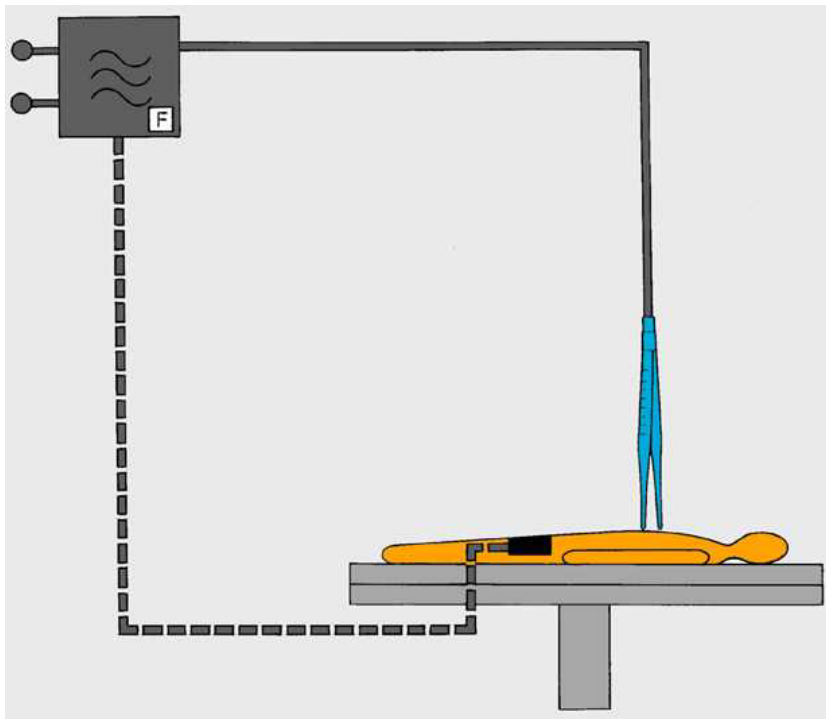


In the field of electrotomy, cutting under water is a special field of application. Here, the objective is to remove tissue from the bladder, filled with a rinsing fluid, through a natural point of access. For this purpose, a wire loop is employed as the active electrode via a resectoscope (contains a light source, an optical system, fluid feed and drainage).

By using electrical surgery, tissue structures to be removed can be treated e.g. on a prostate adenoma. Bleeding vessels are sealed with the aid of coagulation.

When the current is switched on, some of the electrical energy is dissipated by the rinsing fluid. As a result, the full HF power is not available at the point of application. Today, HF generators have a special TUR mode with modified technical parameters (adaptation, modulation, dynamic).

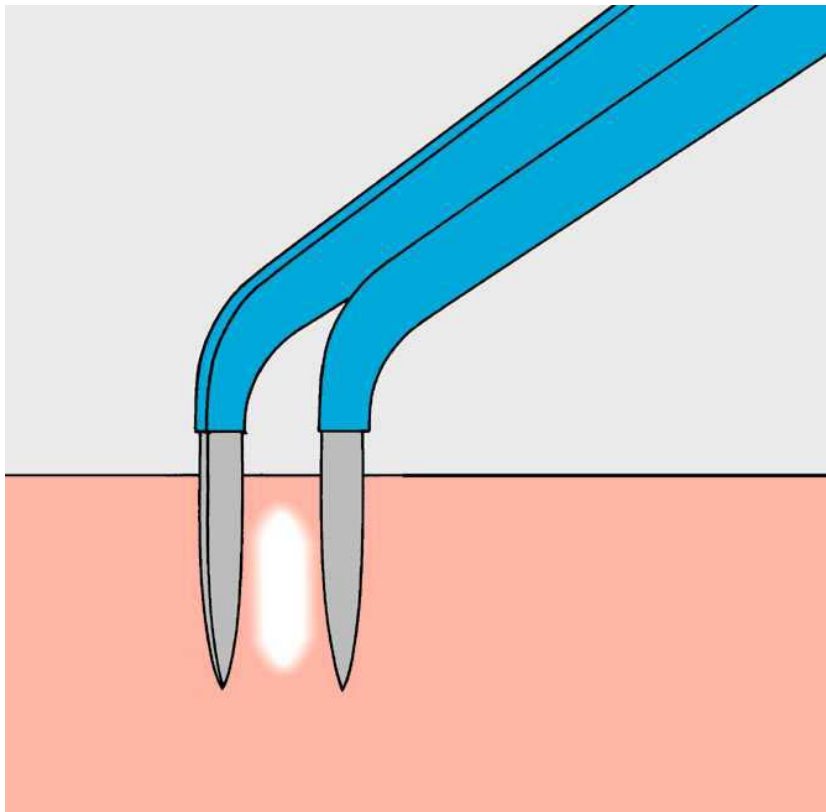
The principle of the bipolar technique



Unlike the monopolar technique, with the bipolar technique the HF current does not flow through the body of the patient to the neutral electrode. Using special design features (insulation), bipolar instruments can be constructed in which the active and neutral electrodes are arranged immediately opposite one another. The best known instrument of this kind are the bipolar forceps. The path taken by the high frequency current is simply from one point of the forceps to the other. The path of the current is therefore very short and the coagulation zone discrete, with a low power requirement. In a comparison between monopolar and bipolar techniques, the bipolar technique is superior from a safety point of view.

The neutral electrode - absolutely essential for monopolar applications - is of no functional significance in bipolar application techniques.

“Bipolar coagulation” application

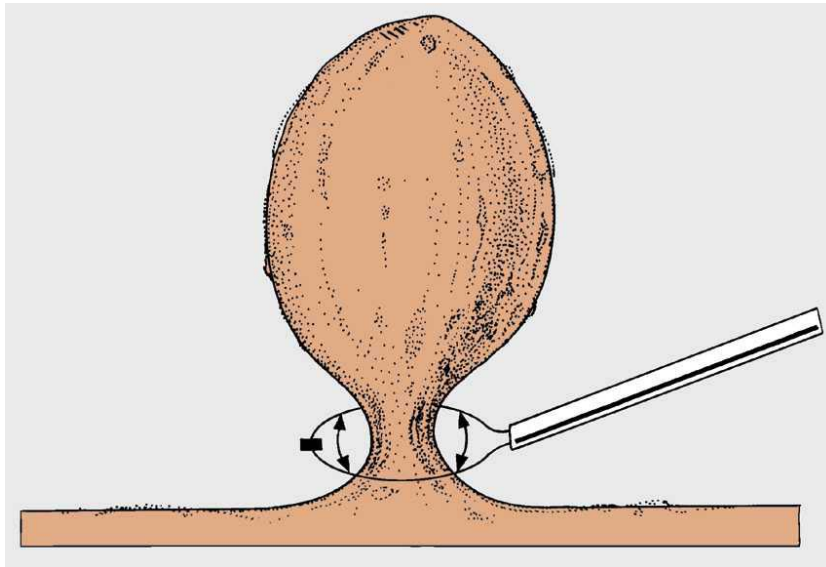


Bipolar coagulation is the most frequently used technique. Usually bipolar forceps, available in a wide range of different designs, are employed.

As this technique is used above all in a number of difficult surgical procedures, it is particularly important that the points of the forceps be kept clean during the course of the operation. Forceps points on which a coagulate has accumulated tend to stick together more. This can result in a vessel, that has already been coagulated, starting to bleed again as the forceps are removed.

The HF generator of a bipolar HF instrument must have a symmetrical output. An asymmetrical output encourages the sticking effect on the points of the forceps.

Because of the reduced energy requirement of this method, the maximum output levels of the bipolar part of a HF surgical instrument is between 80 and 100 watts.

“Bipolar cutting” application

Monopolar cutting and coagulation and bipolar coagulation are, traditionally, widely used applications. Bipolar cutting is a relatively new technique. Through the increasing spread of endoscopy (minimal invasive surgery), the high level of safety of the bipolar technique has resulted in its being used more in this field. Bipolar cutting instruments have also been developed for this purpose. It is of particular advantage for the user if both the limit range and the working characteristics of the HF generator are code matched to the bipolar instrument.

Risks



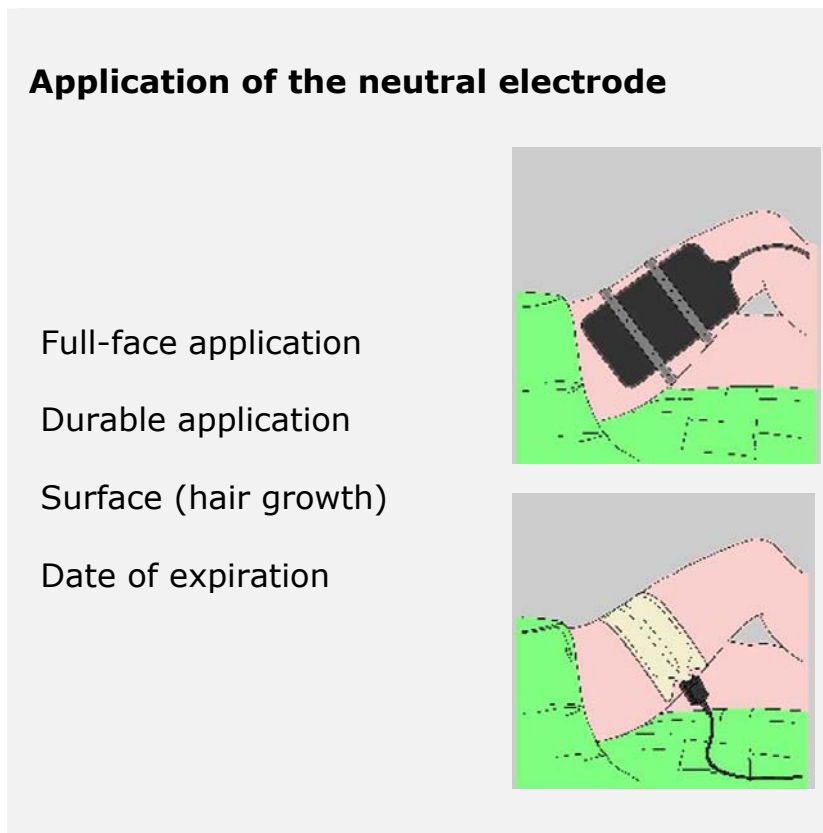
The use of electrosurgical equipment is associated with special risks. For this reason, HF generators and accessories are listed under the "Critical equipment technology" group in the relevant statutory regulations. Risks to patients, operators and third parties can arise from a number of possible causes. Relevant literature, accessible statistics and experience gained by companies show these to be:

- technical deficiency
- unwanted high frequency burning
- incorrect operation
- defective accessories
- ignition of flammable fluids and gases
- risks from improper combination with other equipment

Special mention is made in this context of the fact that patient positioning injury (decubitus) is often erroneously referred to as high frequency burning.

It can be unequivocally stated that, when used properly and competently, electrosurgical systems have proved to be reliable, safe medical systems. This is absolutely conditional upon the operating instructions supplied with each unit being thoroughly understood.

Application of the neutral electrode



Application of the neutral electrode to the patient

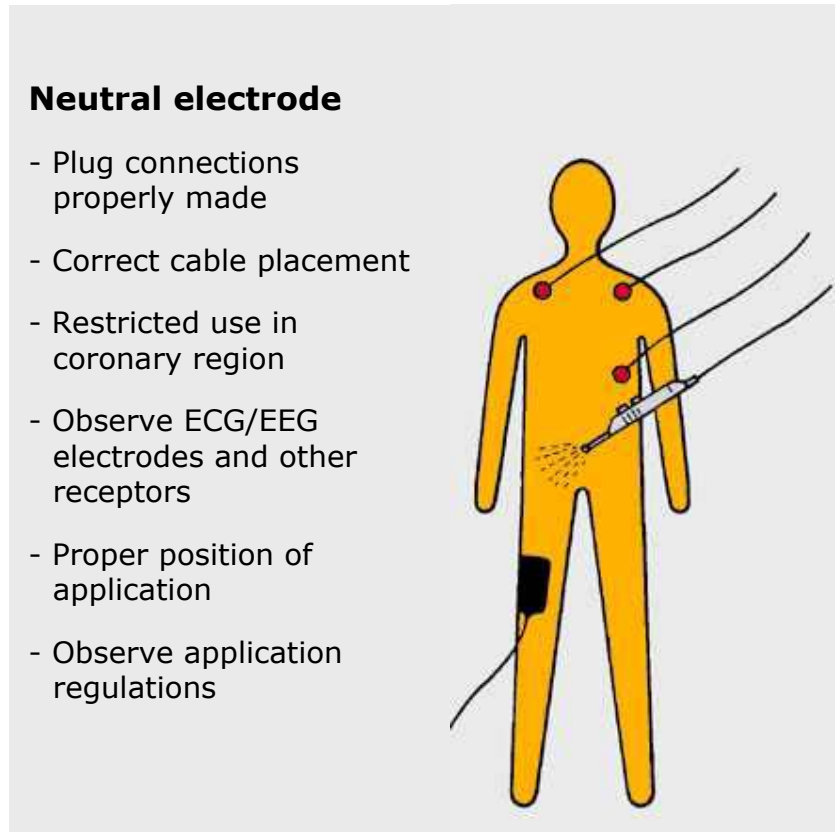
- Full-face, durable placing of the neutral electrode i.e. selection of as large a neutral electrode as possible.
- Application ensuring full contact of the neutral electrode's active surface.
- Keep neutral electrode surface free of soiling and residue.
- Avoid bony protrusions.
- Avoid scar tissue.
- Avoid implants.
- Ensure non-slip application (rubber bands).
- Shave strong hair growth without using alcohol.
- Position neutral electrode as close to the operating area as possible.
- Avoid moisture.

Muscular areas of the upper arm or thighs are particularly suitable as points of application.

If it is not possible to position the neutral electrode properly, the monopolar technique must be avoided and a bipolar technique used in its place.

Failure to observe these application precautions constitutes risking unwanted burns on the patient. The instructions for using the instruments, contained in the operating manual, must be observed.

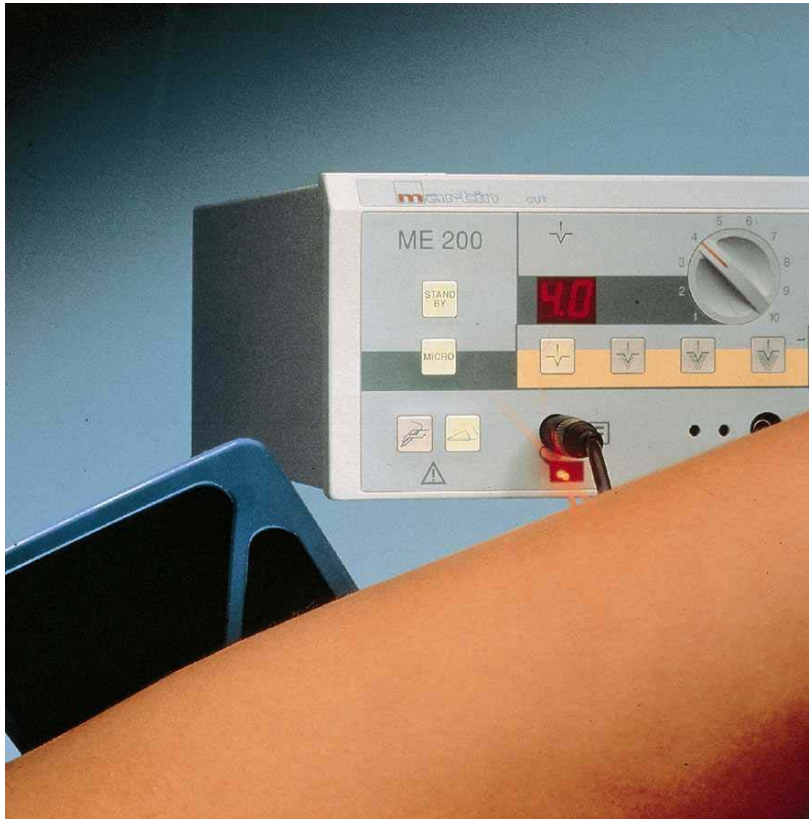
Technical safety when applying the neutral electrode



In addition to the basic regulations for applying the electrode, the following technical instructions should be followed:

- The neutral electrode in perfect working order
- Plug connections properly made
- Correct cable placement i.e.
 - cable not touching the patient
 - cable run as short as possible
 - avoidance of cable coiling
 - cable not touching other conductors e.g. ECG cables
 - patient not lying on the cable
- Restricted use in coronary region
- Observe ECG/EEG electrodes and other receptors
- Correct positioning of the neutral electrode
- Observe application regulations

Types of neutral electrodes



Today there are four different types of state of the art neutral electrodes. They fall into the following groups:

- Disposable neutral electrodes

Disposable neutral electrodes are available as single and multiple face electrodes. These electrode types are particularly convenient to use as they are self-adhesive. Disposable adhesive electrodes are subject to the above-mentioned application regulations. In particular, care should be taken to ensure that no moisture accumulates beneath the electrode face (disinfectant). This electrode type also requires the application surface to be shaved more often where there is strong hair growth.

Disposable neutral electrodes have a limited shelf life. For this reason, they should be marked with a "use by" date. Electrodes that have passed this date must not be used.

- Reusable neutral electrodes

Reusable neutral electrode types made of silicon rubber are now also available as single and double face electrodes.

The latest development in the neutral electrode sector is the twin face rubber neutral electrode. This electrode not only has all the features of a reusable component, it also enables application of the two faces to be monitored. Electrosurgical instruments that are equipped with the appropriate circuitry, monitor the application resistance and thus the full application of the electrode surface to the patient.

These electrodes must be cleaned before being reused. To restore their electrical properties, they can be steam sterilised at specific intervals, on the rubber programme setting.

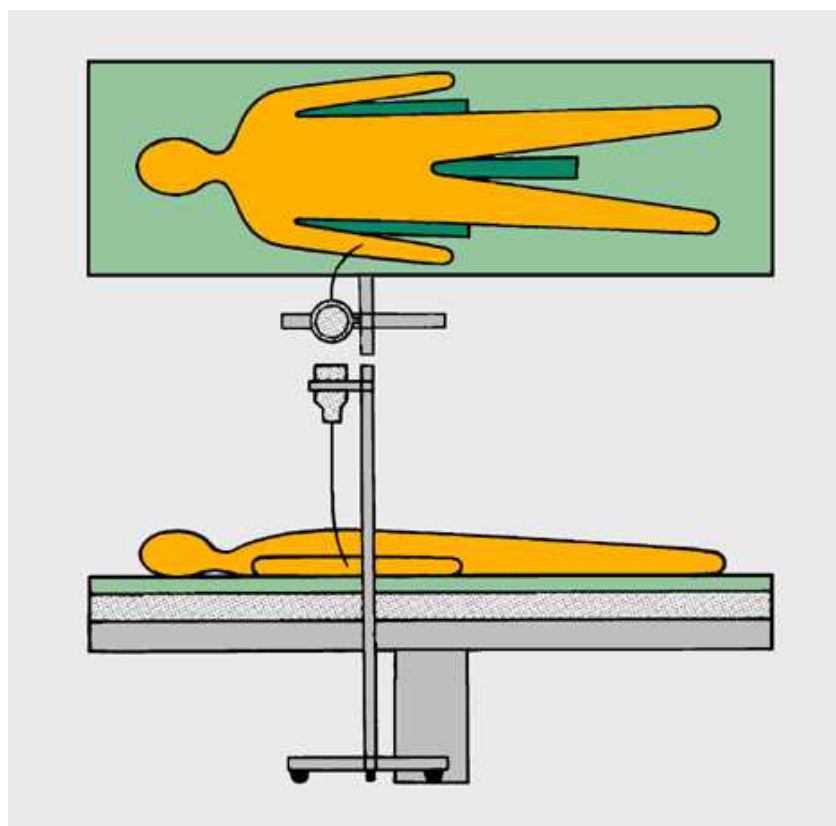
Example of a high frequency burn

This type of patient injury concerns unwanted burning **beneath** the neutral electrode. This is probably the result of two factors:

1. The application area was not shaved although obviously necessary.
2. Residual moisture (probably disinfectant) has obviously been trapped between the surface of the skin and the electrode.

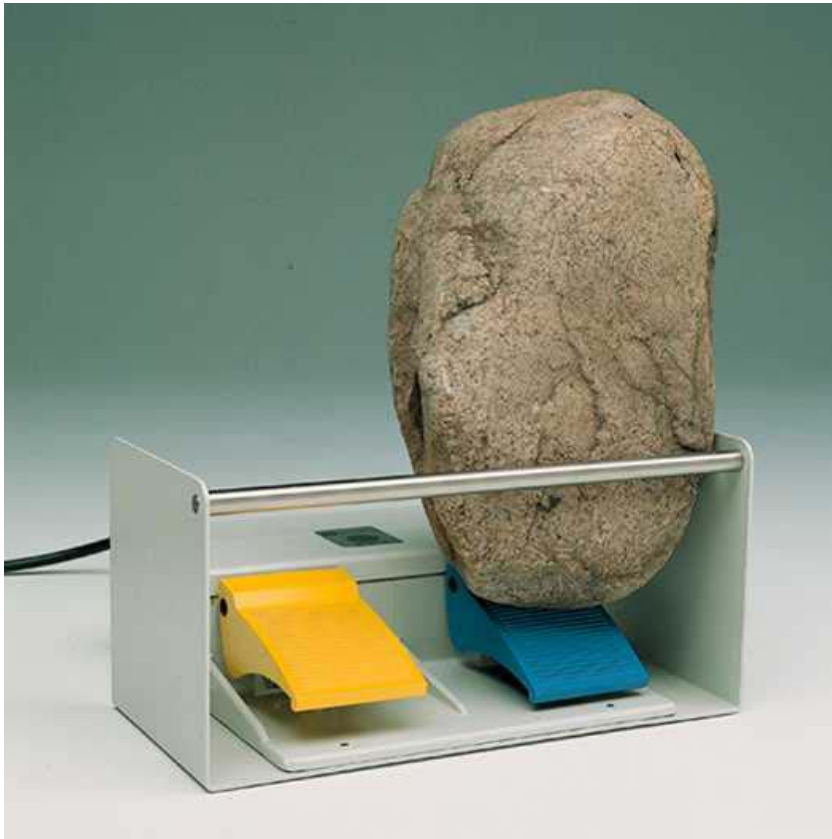
The HF energy flowing towards the neutral electrode passed through the conducting fluid bridge with a low electrical resistance. This led to a concentration of current density at these points and hence to burning.

Correct patient positioning



When employing electrocautery apparatus, it is crucial that the patient be placed on an insulating operating table cover, and on a dry, absorbent, water-proof sheet. All conducting surfaces and contact points, like arm rests and foot supports, must be insulated from the patient. The requirement to insulate the patient from the operating table must apply to the whole surface of the patient's body and thus all possible contact points.

Care should be taken to ensure that the extremities and the trunk are insulated from each other. When using liquids, like disinfectants for example, they must not be allowed to moisten dry sheets. Pools of moisture must be suctioned off rapidly and completely.

Correct operation of the equipment

Electrosurgical systems are medical products that entail risks. Before using any such system, the operator must receive instruction on handling the equipment. It is absolutely essential that the operating instructions for electrosurgical apparatus be observed. This equipment must only be used in a proper condition i.e. instrument and accessories must be in full working order. The instructions concerning its operation must be followed. Improper use e.g. uninterrupted activation is hazardous and is forbidden. The surgical handle must not be put down with other instruments. Surgical handle or footswitch must not be inadvertently operated. Accessories must not be leaned on or used for support.

If there is any doubt as to the technical reliability of the equipment, it should be taken out of service immediately and checked by the maintenance engineers.

Medical equipment may only be used in rooms that comply with the relevant technical requirements, relevant statutory requirements and technical regulations (medically used rooms).

Handling flammable liquids and gases



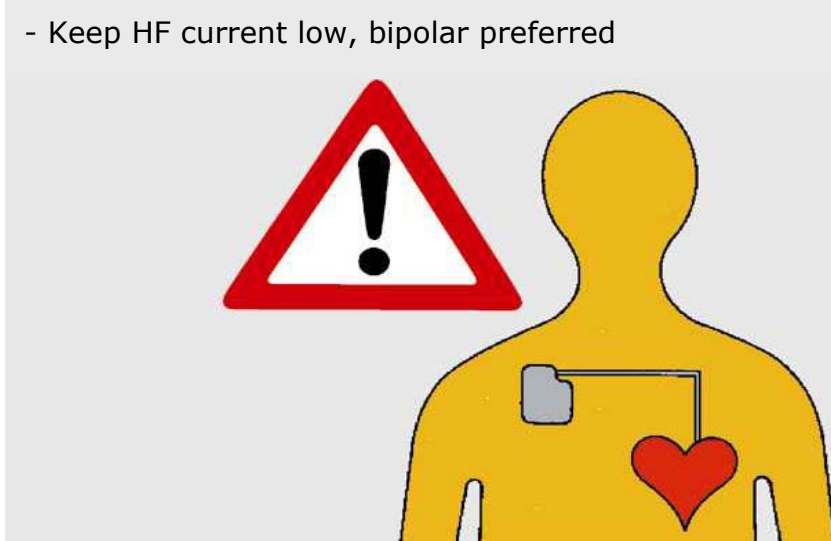
It should be remembered that when using electrocautery equipment, sparking may occur. When using anaesthetic, skin cleansing, degreasing and disinfectant agents there is the danger that the spark created by the active electrode can cause an ignition. The possibility of an explosion is an extreme potential danger for all those present. For this reason special regard must be paid to all hazard warnings when using flammable fluids and gases. Strict compliance with the safety regulations is essential.

Individual cases have also been reported of endogenous gases igniting. In view of this risk, appropriate measures must be taken.

Application of electrosurgery on patients with pacemakers

Patients with pacemakers

- Patient-Monitoring
- Keep an operational defibrillator ready
- Keep HF current low, bipolar preferred



There are restrictions on the application of electrosurgery to patients carrying cardiac pacemakers. In the worst cases, the pacemaker function may be impaired, possibly resulting in ventricular fibrillation and irreparable damage to the pacemaker unit.

Pacemaker patients must therefore be monitored during operating procedures involving electrosurgery. Under certain circumstances, earlier models of ECG equipment can cause so-called high frequency interference. In these cases palpatory pulse monitoring must be carried out.

The necessary equipment for emergency heart therapy must be kept ready (e.g. an operational pacemaker, fully working defibrillator).

Special regard must be paid to the regulations governing the application of electrosurgery. It is important that as low an HF current as possible is applied. Wherever possible, bipolar techniques must be given precedence over monopolar techniques.

The use of fully working accessories



Before use, all accessories should be carefully checked for visible signs of damage and defects. All accessories must be subjected to regular technical checks, just as for main equipment. Defective and damaged accessories must, without fail, be taken out of service. The safety aspects of combining electrocautery equipment and accessories from different manufacturers must be checked before use by someone competent to do so (e.g. manufacturer, test department). A certificate must be issued.

Suitable and tested accessories for an electrocautery instrument are usually listed in the operating instructions for the equipment or in an accessory data specification applicable to the system.

maxium®



For further information about our HF program, please contact us.

Accessories



Standard accessory components like double-pedal footswitch, electrode handle, rubber neutral electrode etc.

Work station in the test area for measuring instrument characteristics



CE mark



CE mark with code of the Notified Body as marking of a medical product suitable for free trade within the EU.

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