Basic Principles of Electrosurgery and Energized Dissection: Monopolar, Bipolar and beyond

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Introduction

The World Journal of Medical Education and Research (WJMER) (ISSN 2052-1715) is an online publication of the Doctors Academy Group of Educational Establishments. Published on a quarterly basis, the aim of the journal is to promote academia and research amongst members of the multi-disciplinary healthcare team including doctors, dentists, scientists, and students of these specialties from around the world. The principal objective of this journal is to encourage the aforementioned, from developing countries in particular, to publish their work. The journal intends to promote the healthy transfer of knowledge, opinions and expertise between those who have the benefit of cutting edge technology and those who need to innovate within their resource constraints. It is our hope that this will help to develop medical knowledge and to provide optimal clinical care in different settings. We envisage an incessant stream of information flowing along the channels that WJMER will create and that a surfeit of ideas will be gleaned from this process. We look forward to sharing these experiences with our readers in our editions. We are honoured to welcome you to WJMER.

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Basic Principles of Electrosurgery and Energized Dissection: Monopolar, Bipolar and beyond

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Introduction

Electrosurgery is an integral part of modern surgery. It has allowed faster operating, reduced blood loss and discovery of newer surgical techniques. Diathermy is the main available technique, using heat generated by electricity to affect the target tissues, and current advances include energized dissection. Safe use of these technologies in theatre requires a basic grasp of their mechanisms of action and potential pitfalls.[5, 7]

Electrocautery vs Electrosurgery

The terms electrocautery and electrosurgery are often confused. Electrocautery is an old system for haemostasis which is now rarely employed. It uses direct current (DC) to generate heat to tip of a metal instrument, thereby causing blood to coagulate. Electrosurgery uses modern instruments that harness alternating current (AC) and transfer this energy to tissues in a variety of ways.[1]

Monopolar diathermy

The first commercial monopolar device was designed by William T. Bovie and famously first used by renowned neurosurgeon Harvey Cushing in 1926.[1] It works by producing heat at an active electrode, as the electric circuit is completed.

The circuit involved can be seen in Figure 1. The energy is supplied by a high frequency AC generator of 100KHz to 4MHz. This high frequency current avoids stimulation of underlying muscles and nerves. The indifferent (or dispersive) electrode is a metal plate with a large surface area that is placed on a flat part of the patient, typically the thigh, buttock or back. It needs to have a large surface area (>100cm^2) to provide a low impedance to current and poor contact can cause burns at the site. The plate must also be placed away from any metal implants to avoid the current passing into this and causing heat damage.[5]

The active electrode has a small surface area for contact with the target tissues; the increased impedance to the current means heat is focused. In monopolar diathermy, the electrode usually takes the form of a metal tip, in the pencil-type devices used in theatres.

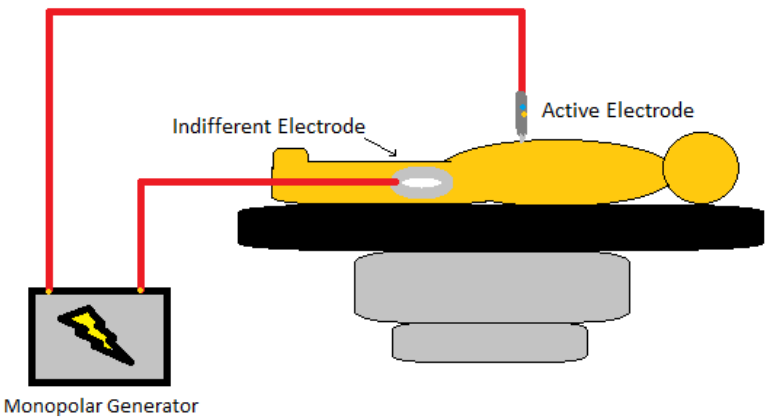

Figure 1*: Illustration of the electricity circuit from a monopolar diathermy*

There are two options in monopolar diathermy: Cut (Yellow) and 'Coag'/Coagulation (Blue).

Cut (Yellow button or pedal)
The cutting action of monopolar diathermy is achieved by a continuous electric current waveform action which vaporises the tissues on contact (see Figure 2). This allows cutting of tissues without coagulation and the effect is similar to being cut with a scalpel. There are studies that suggest skin incision using this diathermy may reduce post-op pain. . The 'Cut' setting sometimes has two settings called 'Pure' and 'Blend' depending on the levels of energy involved.[5]

Coagulation or 'Coag' (Blue botton or pedal)
This uses the same AC current but the waveform is only on 6% of the time (see Figure 2). This allows coagulation of tissues while cutting. 'Coag' can be used directly through the active electrode or through a conducting device such as insulated forceps to direct the coagulation more accurately. As with 'Cut' there are two modes: desiccation (also called 'forced coag') and fulguration ('spray coag').[5]

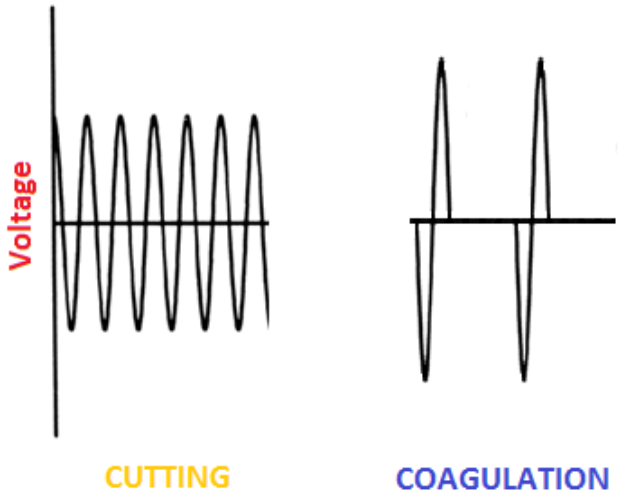

***Figure 2**: Differences in electricity currents between cutting and coagulation mode of diathermy*

Desiccation ('Forced Coag')
This allows more precise coagulation and the electrode needs to be in touch with the target tissue. The voltages are somewhat lower in desiccation mode compared to Fulguration but with slightly higher currents (0.5W vs 0.1W).[5]

Fulguration ('Spray Coag')
This is good for haemostasis and 'sprays' a shower of sparks a few millimetre away from the targeted tissue. It is achieved by using very high voltages (around 6000V) with lower currents. It should be avoided on delicate

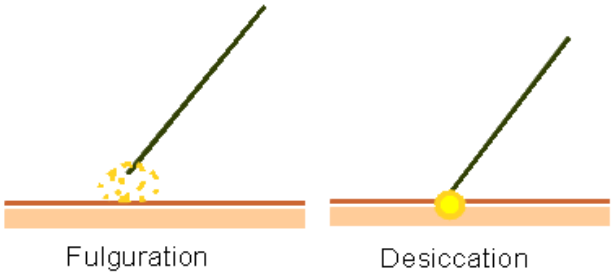

***Figure 3**: An illustration of the different effects between fulgaration and desiccation.*

organs like bowel and near large vessels as the effect is less controlled than desiccation and can cause thermal injuries.[5]. Figure 3 illustrates the effect of both these modes of coagulation.

Precautions
If you are intending to use diathermy, you need to ascertain whether your patient has a pacemaker. If so, a Cardiologist should be consulted and the pacemaker will need to be put on the 'safe mode' during surgery as otherwise the current can damage the device. The plate will need to be applied as far away as possible from the pacemaker. Monopolar diathermy is also contraindicated in some patients with implantable cardio-defibrillators (ICDs) and neuro-stimulators, as these can cause continuous defibrillation or paralysis.[5]

Monopolar diathermy should also never be used on end-arterial organs which include fingers, ears, the nose and the penis. If the main supplying artery is thrombosed, it can result in necrosis and self-amputation.[5]

Risks
There is a risk of surgical fires when using diathermy[3]. The volatile gases and rich oxygen supply in theatres makes fires in theatres particularly dangerous. If using alcohol-based skin preparations, care must be taken to ensure this has fully dried and no pooling has occurred before the current is activated.

There have been concerns regarding the smoke emitted from diathermy, particularly about their potentially carcinogenic properties. However, studies have shown that the contents of the fumes are similar to that of normal city air.[2]

Bipolar diathermy
Bipolar diathermy works via a very simple mechanism to monopolar except the indifferent electrode is also within the hand held diathermy device. This usually takes the form of bipolar forceps, with the electrodes on either side of the forcep jaws. The targeted tissues are held lightly between the jaws, causing coagulation.[5]

Newer haemostatic devices such as the Ligasure® or Enseal® have improved upon the basics of bipolar diathermy to reliably seal vessels as large as 7mm in diameter.[5] These work by controlling the amount of energy delivered to the tissues between the jaws, usually till it is heated to 100°C. These devices are now widely used in General Surgery and Gynecology.[7]

Energised Dissection

This is one of the newer methods of dissection and haemostasis which uses ultrasound. The most commonly used device is the Harmonic® scalpel and it has jaws which are placed around the target tissue. These jaws vibrate at high frequency (55,000 times/ second) which coagulates and cuts the tissue. It can be safely used to seal vessels up to 5mm in diameter.[6]

This method of dissection has revolutionised liver surgery through the use of the Cavitron Ultrasonic Surgical Aspirator (CUSA). The CUSA uses ultrasound to disperse and aspirate cells during liver resection. This allows the surgeon to transect through the liver without cutting the vessels and bile ducts. The bile ducts and vessels remaining are then clipped, cut using spray diathermy or stapled using vascular staplers depending on the size of the vessel. This device is also used frequently in neurosurgery due it to ability to dissect tissues around vital structures safely.[7]

Future

Technology in all fields is continuing to advance and developments in devices capable of dissecting safely with minimal loss promise to provide more precise application of energy sources.

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