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What Factors Influence Electrosurgical Tissue Effect?

Electrosurgery has been utilized for decades in a wide variety of surgical procedures, yet the dynamics of electrosurgical cutting and hemostasis are not well understood. For **monopolar** electrosurgery to occur, the electrical current must travel through a completed circuit. This is achieved as the current is conducted from the electrosurgical unit (ESU) to the active accessory (typically the pencil), through the patient and back to the ESU by way of the patient return electrode (PRE). The ESU produces tissue effects by concentrating high-frequency electrical current at the target tissue, causing it to heat and thereby altering the cellular structure. The outcome depends on a number of factors; (1) the power setting of the ESU, (2) the waveform (mode) chosen for the output energy, (3) the electrode tip configuration that concentrates the current, and (4) the surgeon's technique.

Power Setting

Power, simply stated, is reflected in the heat produced from the focused application of electrosurgical current (electrons) to the target tissue and the tissues resistance (impedance) to the current. As the current works to overcome the impedance of the tissue, heat is produced. This heat and how it's applied results in a cutting or a coagulating effect at the target tissue zone. The power setting required may differ from patient to patient, depending on the patient's size or the tissues impedance to the flow of the electrical current. For example, adipose tissue is more resistant to electrical current than muscular tissue, which is a good conductor due to its vascularity. With this in mind, obese patients may require higher power settings as opposed to patients proportionate in size and weight.

The site chosen for the PRE in relation to the surgical location will also impact the power requirement. Instructions for placement of the PRE always recommend it be placed as close to the surgical site as possible. The greater the distance between the PRE and the surgical site, the greater the power requirement needed to overcome the amount of tissue between the two sites.

Waveform (Mode)

The effects of electrosurgery are influenced by the selection of the waveform or mode. Generators typically have pure cut, blended cut, and coagulation waveforms for monopolar output. "Cut" is a low voltage waveform with a constant duty cycle or frequency. (Fig.1) Because the duty cycle is always "on", it produces heat very rapidly, causing the cell to rupture. This enables the surgeon to vaporize or cut tissue using a non-contact technique by holding the electrode just above the tissue. If the surgeon touches the electrode to the tissue, it is called desiccation. When utilizing the cut waveform in a desiccate fashion (direct contact) current is driven deeper into the tissue.

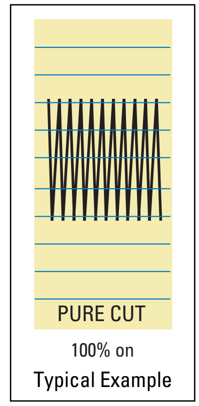

Fig. 1 - Cut Waveform

Conversely, "coagulation" is a high voltage waveform with an interrupted duty cycle. (Fig. 2) Because this waveform has built-in "rest periods," it allows time for the cells to cool down and collapse forming a coagulum resulting in hemostasis. "Fulguration" by definition is a non-contact technique. The active electrode tip is held just above the target tissue to spark across the air gap for a superficial tissue effect. Desiccation can also be achieved using the coagulation waveform and contacting the tissue, but the cut waveform is preferable because of its lower voltage.

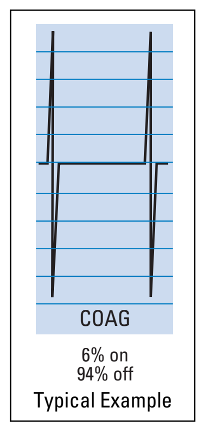

Fig. 2 - Coagulation Waveform

A "blended current" is **not** a mixture of both cutting and coagulation current but rather a modification of the cut mode duty cycle along with an increase in voltage. (Fig. 3) A blend mode is used when hemostasis is desired in combination with cutting.

The only variable that determines whether one waveform vaporizes tissue and the other produces a coagulum is the rate at which heat

(over)

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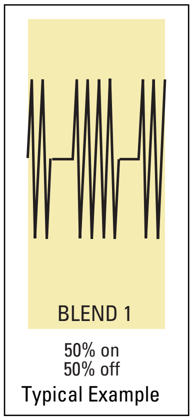

Fig. 3 - Blended Waveforms

is produced. (Principles of Electrosurgery, Valleylab, 1999)

Electrode Tip Configuration/Current Concentration

Active electrode tips vary in their size and configuration. They affect tissue heating differently predicated on their individual design. For example, a needle electrode has a smaller surface area to concentrate the current and produce intense heat. Because of the reduced surface area, power settings should be decreased. In comparison, the larger ball electrode, used for desiccation of broad surfaces, spreads the current over a wider area and produces slower heating of the tissue. A larger electrode will ordinarily require a higher power setting.

Surgeon Technique

Active electrode orientation and activation time also impact tissue effect. For example, a standard blade electrode can be applied to tissue using either the flat surface or the edge. The edge will concentrate the current whereas the flat surface will disperse the current over a wider area. At any given setting, the longer the generator is activated, the more heat is produced. The greater the heat, the farther it will travel to adjacent tissue (thermal spread), possibly with unintended effects.

The speed at which the electrode is moved through the tissue will have different heating effects as well. Moving the electrode quickly will have a superficial tissue effect where moving the electrode more slowly will allow the current to penetrate deeper and affect larger volumes of tissue.

Furthermore, applying the active electrode directly to tissue verses holding it just above the tissue will produce different tissue results depending upon the waveform chosen. For a detailed explanation of these techniques, please refer to the Clinical Information Hotline News, *Basics of Monopolar Electrosurgery, Vol.4, Issue 3.*

Other factors play a role in tissue effect as well. Generators themselves are not created equal. They look different physically, offer a variety of features and vary in the power output they are capable of delivering. There are low, medium and high-powered generators geared toward different surgical needs. More recently, computer technology has enabled certain electrosurgical generators to deliver consistent performance through all tissue types while minimizing the need to adjust power settings. It is important to select a generator equivalent to the requirements of the surgical procedure to ensure effective performance. Reading the user's manual is recommended to become familiar with the generator's features, output characteristics, and safety considerations.

Finally, the presence of eschar (carbonized blood and tissue) on the active electrode will impede the flow of the electrical current because eschar is high in impedance. Keeping the electrode clean and free of eschar will enhance performance by maintaining lower resistance within the surgical circuit. (Principles of Electrosurgery, Valleylab, 1999)

Utilizing electrosurgery to its fullest potential requires a basic understanding of electricity and comprehension of electrosurgical technology and its clinical applications. Achieving these goals and staying abreast of technological advancements and changing practices will promote safe and effective patient care during electrosurgical procedures.

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