Physics of Medical Devices

seventh lecture

Electrosurgical Unit

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Electrosurgery

makes use of high-frequency electrical current to cut, coagulate, desiccate, and fulgurate tissue and can be performed using either monopolar or bipolar-energy in conjunction with a specialized instrument. Each of these two modalities has specific advantages and understanding the difference between the two can help you understand the differences in how they're used.

Bipolar electrosurgery

Bipolar electrosurgery uses lower voltages so less energy is required. But, because it has limited ability to cut and coagulate large bleeding areas, it is more ideally used for those procedures where tissues can be easily grabbed on both sides by the forceps electrode. Electrosurgical current in the patient is restricted to just the tissue between the arms of the forceps electrode. This gives better control over the area being targeted, and helps prevent damage to other sensitive tissues. With bipolar electrosurgery, the risk of patient burns is reduced significantly.In the most common techniques, the surgeon uses forceps that are connected to the electrosurgical generator. The current moves through the tissue that is held between the forceps. Because the path of the electrical current is confined to the tissue between the two electrodes, it can be used in patients with implanted devices to prevent electrical current passing through the device

causing a short-circuit or misfire. It is always recommended to review the implanted device user manual prior to preforming any electrosurgical application, to avoid complications.

MonopolarElectrosurgery

Monopolar electrosurgery can be used for several modalities including cut, blend, desiccation, and fulguration. Using a pencil instrument, the active electrode is placed in the entry site and can be used to cut tissue and coagulate bleeding. The return electrode pad is attached to the patient, so the electrical current flows from the generator to the electrode through the target tissue, to the patient return pad and back to the generator. Monopolar electrosurgery is the most commonly used because of its versatility and effectiveness.

Grounding

In electrosurgery, the term grounding refers to the relationship between the dipole circuit (active electrode—patient—return electrode) and earth ground. Three relationships between the dipole circuit and earth ground are possible: direct grounding, isolated grounding circuitry, and capacitive grounding circuitry.

Direct Grounding.

The return portion of the circuit is connected directly to earth ground. Direct grounding is considered unsafe and is not used in modern ESUs because it invites numerous alternate pathway possibilities with the potential for unintended burns.

Isolated System

The output current is floating free of ground. This means that the patient ground is referenced to the ESU rather than earth ground. The machine is, in turn, referenced to earth ground via special circuitry that avoids alternate pathways. If the patient should inadvertently be placed in contact with another grounded object, this circuit will detect the loss of current and disable the ESU. It should be noted that if an ESU using isolated grounding circuitry is activated while the active electrode is not in contact with the patient, it is possible for alternate site burns to occur if the patient is in contact with a direct path to ground (*i.e.*, a metal operating table), and the ESU is not equipped with a sentry circuit.

Function of the Patient Return Electrode

The function of the patient return electrode is to remove current from the patient safely. A return electrode burn will occur if the heat produced, over time, is not safely dissipated by the size or conductivity of the patient return electrode.

Types of Currents

Electrosurgical generators are capable of producing a variety of current waveforms. Depending on the clinical results desired, different waveforms can be used to produce differing tissue effects. An understanding of the ways in which the electrosurgical generator can modify current is necessary to better understand the options available to the surgeon.

Any current can be classified as either direct current or alternating (varying) current. Direct current is constant, never changing in direction (polarity) or magnitude. Direct current is the type produced by batteries. It is not used in electrosurgery because of its tendency to produce depolarization of neural and muscular tissue.

The Electrical Circuit

An electrical circuit is a closed current pathway along which electricity flows. Any current flowing in a direction or a path other than the intended one may lead to undesired outcomes, such as alternate site burns or shocks.

The type of circuit used in electrosurgery is termed a dipole circuit. A dipole circuit consists of two electrodes in contact with a dielectric or substance with limited electrical conductivity. In electrosurgery, human tissue is the dielectric. Diathermic heating occurs from electrical losses (transformation of the electrical energy into heat), which occur in the dielectric (tissue) located between the two electrodes. Two types of dipole circuits are possible: bipolar and unipolar.

Tissue Effects

It is difficult to precisely predict the effects of electrical energy on tissue in the clinical setting. Many variables have the potential to affect results in electrosurgery. Because many of these parameters are not detailed by investigators, it is difficult to interpret differences in results reported in electrosurgical studies.

To understand electrosurgery, it must be clear that the effects obtained are the result of heat. This heat may be derived from an external source and transmitted to tissue by conductance (cautery), or, as in the case of both

laser and electrosurgery, be produced within the tissue by an external source of energy. Due to the rapid changes in the direction (polarity) of current flow with the use of high frequency alternating current, there is no net transfer of electrons, and likewise, no movement of ions across cell membranes (depolarization). Part of the heat generated is from the tissue's impedance (resistance to current flow), but the majority of heat stems from the rapid vibration of molecules within the tissue under the effect of the changing electromagnetic field.

Clinical Results In Infertility Surgery

In surgery, the purpose of which is to restore or preserve reproductive function, hemostasis and minimal tissue trauma are of paramount importance. Techniques that minimize postoperative bleeding and tissue necrosis should produce fewer adhesions to compromise reproductive function, and thus offer improved results.

Of the various mechanical factors contributing to female infertility, the two most common are pelvic adhesive disease and endometriosis. Several studies have reported results achieved by the use of either CO_2 laser or electrosurgery in the treatment of these conditions, but only a few have directly compared the two modalities.

Clinical Results In General Gynecologic Surgery

Several studies have examined the role of electrosurgery in abdominal wall incision in humans. In a large, prospective, unrandomized, uncontrolled study of 23,649 surgical wounds, Cruse and Foord[24] found that use of the electrosurgical knife doubled the infection rate across all categories of operations. In a prospective, randomized study of 88 cholecystectomy incisions, Pearlman and associates[25] determined that electrosurgical incisions were faster to perform, and more hemostatic than incisions made with either a scalpel or a laser, but that there was no difference in postoperative pain and wound healing. The number of infections and wound hematomas was similar among the three groups. The power of this study was such that it was calculated to have an 80% chance of detecting a 25% difference in each parameter.