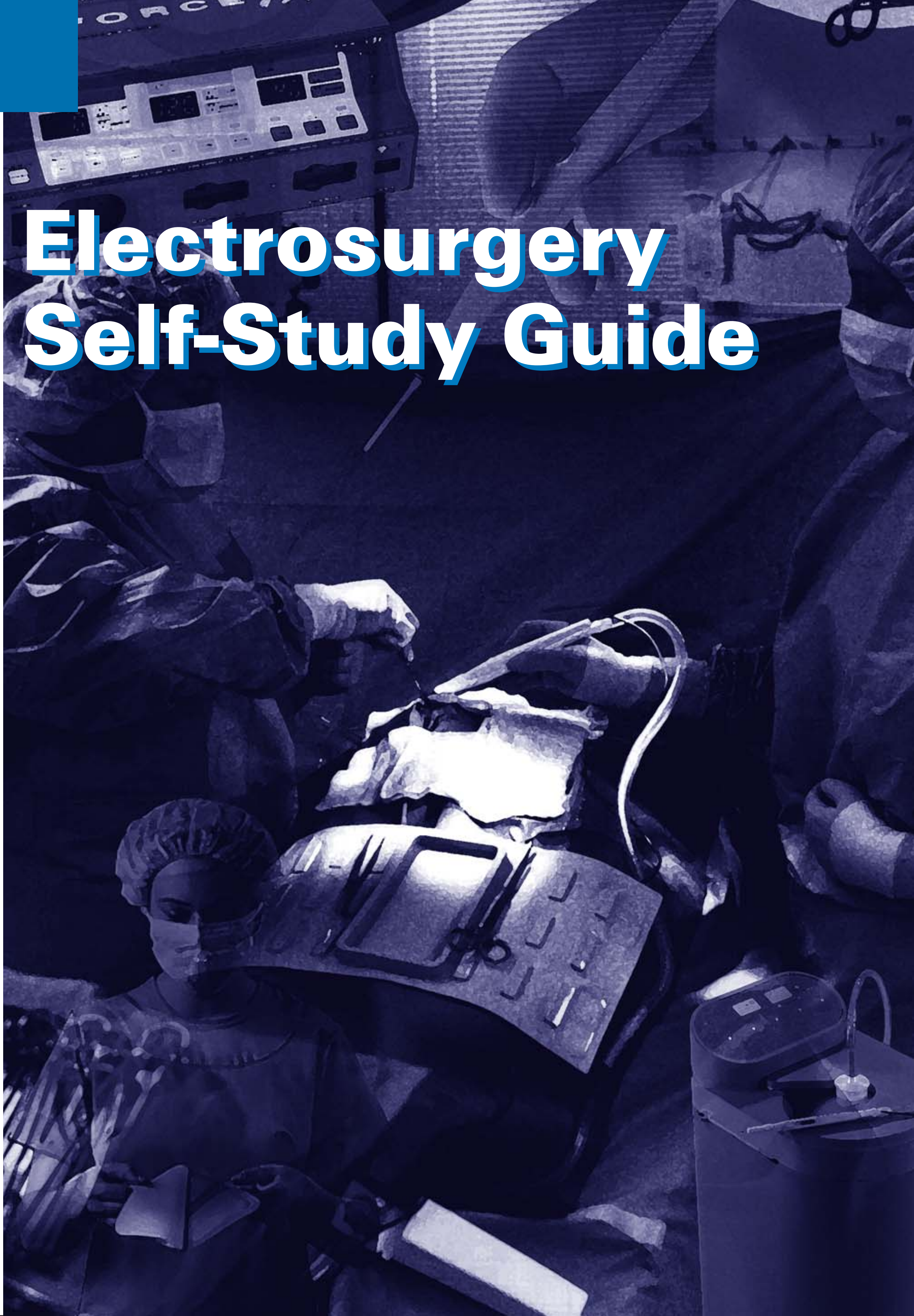
Electrosurgery Self-Study Guide



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Brenda Cole Ulmer, RN, MN, CNOR

Brenda C. Ulmer is a Senior Clinical Educator for Valleylab. In this capacity she creates and presents programs of importance to perioperative nurses and surgeons on topics focusing on patient safety in the operating room. Prior to this position, Ms. Ulmer was Director of Surgical Services at Northlake Regional Medical Center in Atlanta, Georgia. Previous work experience includes staff charge positions at Emory University Hospital in Atlanta.

Ulmer received an associate degree in nursing in 1974 from DeKalb College, a bachelors in 1983 from Georgia State University, and a masters in nursing education from the University of Phoenix in 1996. She has been a certified nurse of the operating room (CNOR) since 1980. Ulmer is also a member of Sigma Theta Tau's nursing honor society.

Ulmer has served on local and national committees for the Association
of periOperative Registered Nurses (AORN) since 1977. She served three terms as member of the national AORN Board of Directors, and was elected President-Elect for AORN on April 1, 1999 in San Francisco. Since 1995, Ulmer has been working with the AORN, OSHA, NIOSH, ANA, physicians and nurses to facilitate the publication of workplace safety guidelines
from OSHA on smoke evacuation. OSHA signed off the draft guidelines internally in the spring of 1998. They are currently under final review for publication in the Federal Register in 1999.

From 1989 to 1994, Ulmer was a member of the CBPN Board of Directors (CBPN Formerly NCB: PNI). She served as President 1990-91 and 1993-94. During her tenure the Board published its first CNOR Study Guide, and started a Registered Nurses First Assistant Certification exam (CRNFA).

Ms. Ulmer has presented numerous programs on nursing issues throughout the world. In 1983 she published the first nursing text on ambulatory surgery: Ambulatory Surgery: A Guide to Perioperative Nursing Care. She is widely published in nursing journals and textbooks.

ELECTROSURGERY SELF-STUDY GUIDE

September, 1999

A self-study guide intended to assist surgeons, perioperative nurses and other healthcare team members to provide safe and effective patient care during electrosurgery procedures.

by
Brenda C. Ulmer, RN, MN, CNOR

Objectives

Upon completion of this activity the participant will be able to:

1.) Relate the properties of electricity to the clinical applications of electrosurgery.

2.) Review four of the variables the surgeon controls that impact surgical effect.

3.) Discuss the relationship between current concentration and tissue effect.

4.) Identify potential patient injuries related to electro surgery and technological advances designed to eliminate these problems.

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A certificate will be provided to each person who completes the offering. The certificate pertains only to completion of the offering and is intended for record-keeping purposes.

Instructions

1. Complete the test questions and check the correct responses with the key. A score of 70% or better is recommended. Please review the self-study guide portions related to missed questions, if necessary.
2. Complete the registration form.
3. Complete the evaluation form.
4. Send the completed registration/evaluation form with the test question responses and $15.00 fee to:

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Expiration Date

This offering was originally produced for distribution in **September 1997**. It was revised in September 1999 and cannot be used after September 2002 without being updated. Therefore, credit will not be issued after **September 30, 2002**.

Note: The terms listed in the glossary are printed in bold in the body of the text of the self-study guide.

Key Concepts

Electricity can be hazardous. Understanding how electricity behaves and relates to electrosurgical function and applications can contribute to its safe use. Many different types of electrosurgical technologies are in use in the surgical setting. The surgeon, perioperative nurse and other healthcare team members must be aware of the implications for use for each technology in order to ensure safe patient care.

Knowledge of the preoperative, intraoperative and postoperative medical and nursing considerations and interventions can impact positive patient outcomes.

Overview

Electrosurgery came into wide use because of the urgent need to control bleeding in operative procedures. There have always been safety concerns when electricity is used in a therapeutic manner. This module will cover the fundamentals of electricity, principles of electrosurgery, clinical applications, technologies, recommended practices and nursing care during electrosurgery.

Introduction

The use of heat to stop bleeding goes back hundreds of years. Over the years researchers constructed a variety of devices which used electricity as a means to heat tissue and control bleeding. Electrosurgery did not come into general use until the late 1920's. A neurosurgeon, Harvey Cushing, worked with a physicist, William T. Bovie, in efforts to develop a means to stop hemorrhage with electricity. Cushing had tried implanting muscle tissue, using bone wax, fibrin clots, and silver clips, but still had patients who could not be operated on safely because of the threat of uncontrolled bleeding. In 1926, using Bovie's device, Cushing applied high frequency current during a neurosurgical procedure. The results were excellent. Cushing then started bringing back his previously inoperable patients because he at last had a means to prevent death from hemorrhage in the operating room (Pearce, 1986). Cushing and Bovie widely published their work. As a result electrosurgical units came into general use in operating rooms around the world. The early units were big, ground referenced units called Bovie's. The technology remained virtually unchanged until 1968 when a small, solid state unit was developed by Valleylab. The solid state units heralded the modern era of isolated outputs, complex waveforms, and hand-activated controls (Pearce).

Fundamentals of Electricity

Electricity is a phenomenon arising from the existence of positively and negatively charged particles, which make up all matter. All matter is made up of atoms. Atoms consist of electrons (negatively charged), protons (positively charged), and neutrons (neutral) particles. Atoms that contain equal numbers of electrons and protons are charge neutral. When forces are introduced that cause electrons to leave their base atoms and move to other atoms, the charges of the atom are changed: those with fewer electrons than protons become positively charged, and atoms with more electrons than protons become negatively charged. During movement, like charges repel each other and unlike charges attract. This electron movement is termed electricity. There are two natural properties of electricity that can impact patient care in the operating room. Electricity, which moves at nearly the speed of light, will, (1) always follow the path of least resistance; and, (2) always seek to return to an electron reservoir like the ground (Chernow, 1993).

Electrical current is produced as electrons flow through a conductor. Electron flow is measured in amperes, or amps. The path electricity follows as it makes its way through a conductor and back to ground is the electrical circuit.

Electricity Variables

There are variables associated with electricity that must be considered when using it in a therapeutic manner.

Current

The two types of current that are used in the operating room are direct current (DC), and alternating current (AC). Direct current uses a simple **circuit** and electron flow is only in one direction. Batteries employ this simple **circuit**. Energy flows from one terminal on the battery and must return to the other terminal to complete the **circuit**.

Alternating currents (AC) switch, or alternate, direction of electron flow. The frequency of these alterations is measured in cycles per second or Hertz (Hz), with one Hertz being equal to one cycle per second. Household current, in the United States, alternates at 60 cycles per second, as does much of the electrical equipment used in operating rooms. Alternating current at 60 Hertz causes tissue reaction and damage. Neuromuscular stimulation ceases at about 100,000 Hertz, as the alternating currents move into the radio frequency (RF)range (Grundemann, 1995).

Resistance

Resistance is the opposition to the flow of **current**. **Resistance** or impedance is measured in ohms. During the use of **electrosurgery** one source of **resistance** or impedance is the patient.

Voltage

Voltage is the force that will cause one amp to flow through one ohm of **resistance**. It is measured in volts. The **voltage** in an electrosurgical generator provides the electromotive force that pushes electrons through the **circuit**.

Power

Power is the energy produced. The energy is measured in watts. In electrosurgical generators the power setting used by the surgeon is either displayed on an LED screen in watts; or, a percentage of the total wattage as indicated on a numerical dial setting (Lister, 1984).

Principles of Electrosurgery

Electrocautery

The **electrocautery** device is the simplest electrical system used in the operating room today. It uses battery power to generate a simple direct current (DC). The **current** never leaves the instrument to travel through the patient's tissue. An example is the small hand-held eye cautery (Figure 1). The battery heats up a wire loop at the end of the device. The cautery is useful in ophthalmic surgery and other very minor procedures in which very little bleeding is encountered. Its use is limited because it cannot cut tissue or coagulate large bleeders. It is further limited because the target tissue tends to stick to the electrode.

The term "electrocautery," or "cautery," is often, and incorrectly, used to describe all types of electrosurgical devices. Its use is only appropriate to describe the simple direct current cautery device.

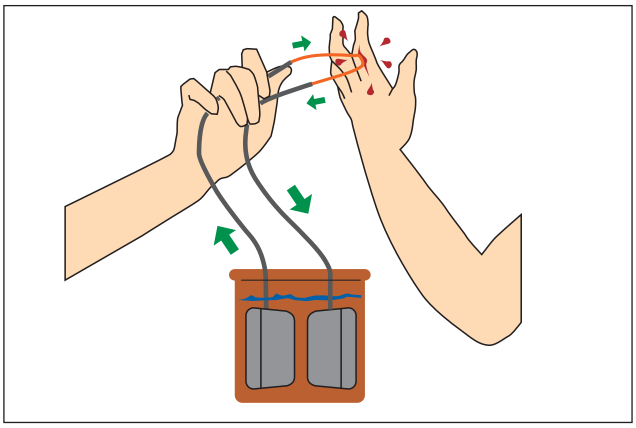

Figure 1 – Electrocautery

Electrosurgery and Radio Frequency Current

A frequently asked question is why electrosurgery generators do not shock patients. The answer is because of the higher frequencies at which generators operate. Radio frequency current alternates so rapidly that cells do not react to this current. AM radio stations operate in the 550 to 1500 KiloHertz (kHz) range. Electrosurgery generators operate in the 200 kHz to 3.3 megahertz (MHz) range (Figure 2). Both of these are well above the range where neuromuscular stimulation or electrocution could occur (Harris, 1978).

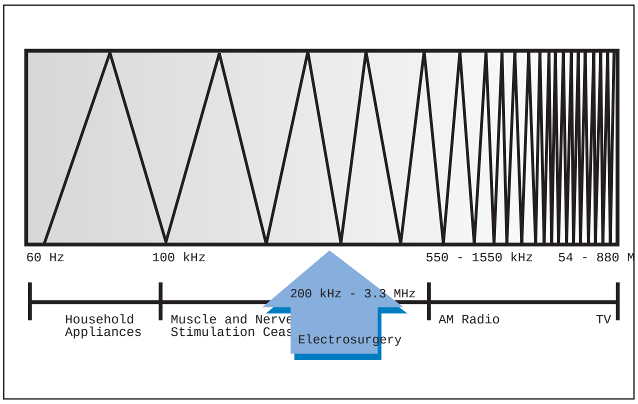

Figure 2 – Frequency Spectrum

Bipolar Electrosurgery

Bipolar electrosurgery is the use of electrical current where the **circuit** is completed by using two parallel poles located close together. One pole is positive and the other is negative. The flow of **current** is restricted between these two poles. These are frequently tines of forceps, but may also be scissors or graspers. Because the poles are in such close proximity to each other, low voltages are used to achieve tissue effect. Most bipolar units employ the cut waveform because it is a lower voltage waveform, and achieves hemostasis without unnecessary charring. Because the current is confined to the tissue between the poles of the instrument and does not flow through the patient, a **patient return electrode** is not needed (Figure 3).

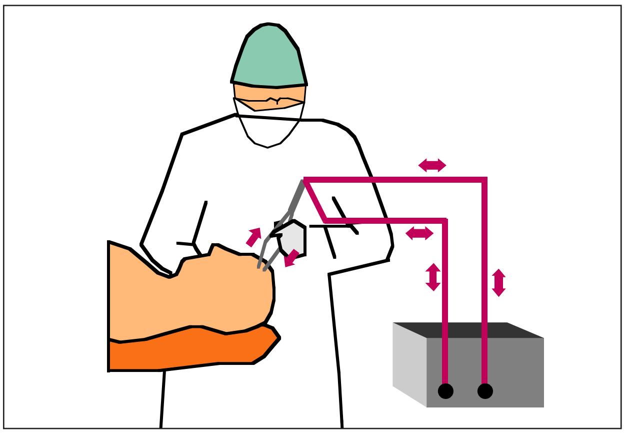

Figure 3 – Bipolar Circuit

Bipolar is a very safe type of **electrosurgery**. There are some disadvantages to the use of bipolar, especially in the microbipolar mode. Bipolar cannot spark to tissue, and the low voltage makes it less effective on large bleeders (Mitchell, 1978). However, there are newer bipolar systems that incorporate a "macro" or bipolar "cut" mode that has higher voltage and is designed for use with the new generation of bipolar cutting instruments.

Bipolar, especially microbipolar, has been widely used in neurosurgery and gynecologic surgery. It may be safer to use when there is a question about the efficacy of using more powerful **monopolar** electrosurgical units (e.g., with pacemakers, implanted automatic cardiac defibrillators).

Monopolar Electrosurgery

The most frequently used method of delivering **electrosurgery** is monopolar, because it delivers a greater range of tissue effects. In **monopolar electrosurgery**, the generator produces the **current**, which travels through an **active electrode** and into target tissue. The **current** then passes through the patient's body to a **patient return electrode** where it is collected and carried safely back to the generator (Figure 4). This is the intended pathway for the electrical **current**. The type of monopolar generator used, along with appropriate surgeon and nursing interventions can help to ensure that this is the path the current takes through the patient.

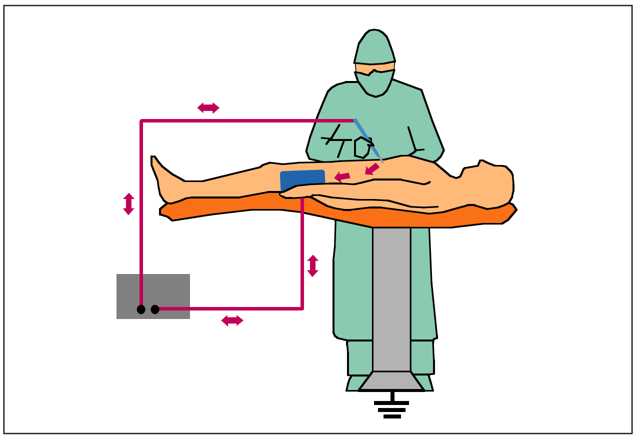

Figure 4 – Monopolar Circuit

Current Concentration/Density

The purpose of both methods of delivery is to produce heat for a desired surgical effect. When **current** is concentrated, heat is produced. The amount of heat produced determines the extent of the tissue effect. Current concentration or density depends on the size of the area through which the current flows. A small area that concentrates the **current** offers more **resistance**, which necessitates more force to push the **current** through the limited space and therefore generates more heat. A large area offers less resistance to the flow of **current** reducing the amount of heat produced (Figure 5).

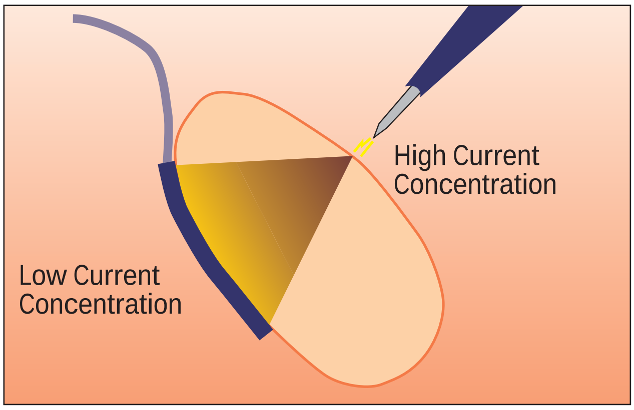

Figure 5 – Current Concentration/Density

Electrosurgical Mode Differentiation

Electrosurgical generators can produce current in three different modes, each with distinct tissue effects. The modes are **cut**, **fulguration** and **desiccation**.

Electrosurgical Cut

The **cutting** current is a continuous waveform (Figure 6).

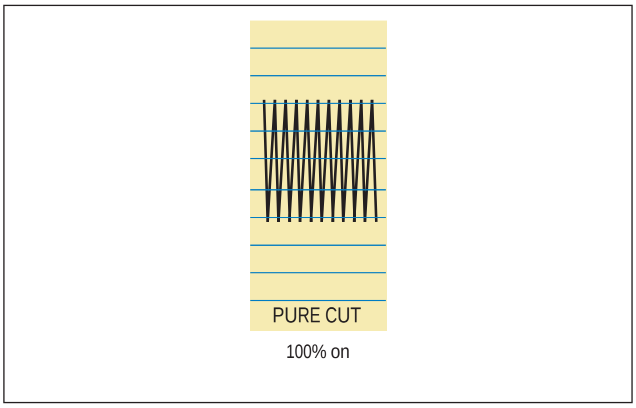

Figure 6 – Cut Waveform

Since the delivery of **current** is continuous, much lower voltages are required to achieve the desired effect of tissue vaporization. To achieve a **cutting** effect, the tip of the **active electrode** should be held just over the target tissue. The current vaporizes cells in such a way that a clean tissue cut is achieved (Figure 7). The cut mode of the generator is also a good choice for achieving coagulation of tissue through **desiccation**.

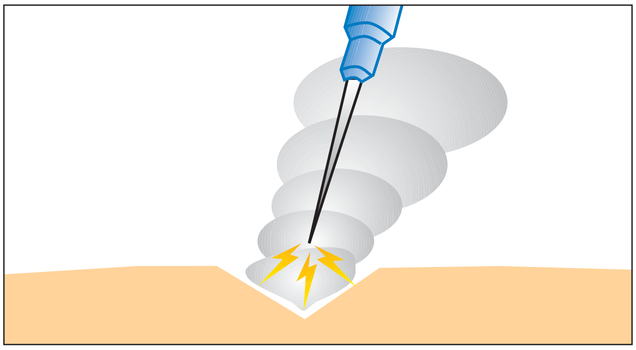

Figure 7 – Vaporization or Cutting

Blended Mode

The blended mode on a generator is a function of the cut waveform. Blended currents produce **voltages** higher than that of the pure cut mode. The generator output is modified to a dampened waveform that produces some hemostasis during **cutting** (Tucker, 1998). There are several blended waveforms that provide different ratios of coagulation with the cutting **current** by modifying the duty (on/off) cycle (Figure 8). Examples of blend waveforms from different generators are:

Blend 1 = 50% on/50% off

Blend 2 = 40% on/60% off

Blend 3 = 25% on/75% off

Variations of cut to coagulation blends may occur among manufacturers. Generally, however, a higher blend number means more coagulation.

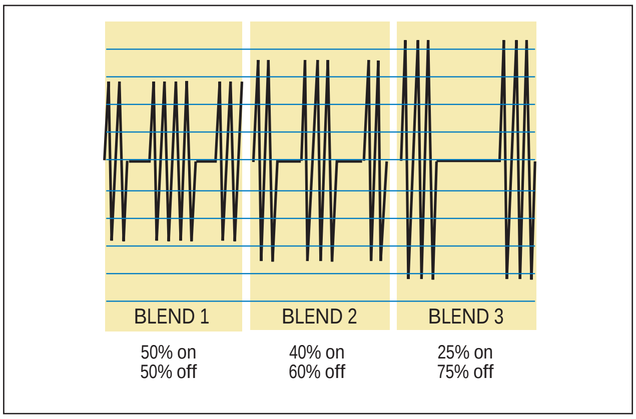

Figure 8 – Blended Waveforms

Fulguration

Tissue **fulguration** is achieved with the coagulation mode on the generator. The coagulation mode produces an interrupted or dampened waveform with a duty cycle that is on about 6% of the time (Figure 9).

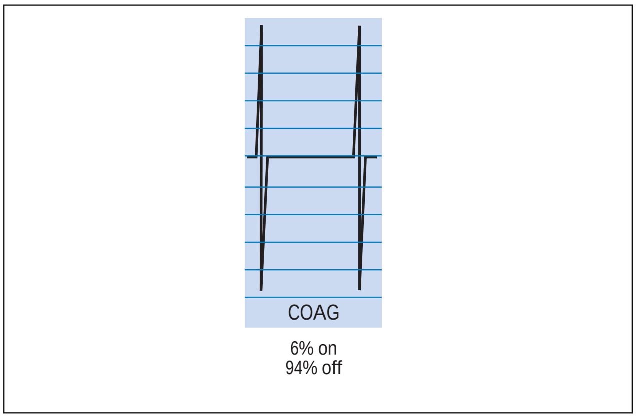

Figure 9 – Coagulation Waveform

The coagulation current produces spikes of voltage as high as 5000 volts at 50 watts. The tissue is heated when the waveform spikes, and cools down in between spikes, thus producing coagulation of the cell during the 94% off cycle of he waveform.

The correct method for achieving **fulguration** when using coagulation is to hold the tip of the **active electrode** slightly above the target tissue (Figure 10).

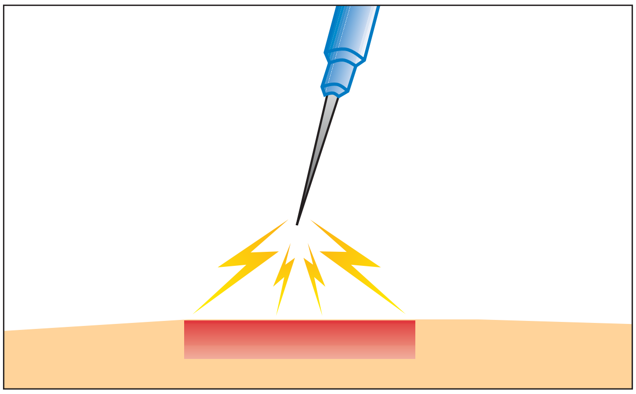

Figure 10 – Fulguration

Desiccation

Electrosurgical **desiccation** can be produced using either the **cut** or **coagulation** mode on the generator. The difference between **fulguration** and **desiccation** is that the tip of the active electrode must contact the target tissue in order to achieve **desiccation** (Figure 11). The desired mode to achieve tissue **desiccation** through direct contact is the cut waveform.

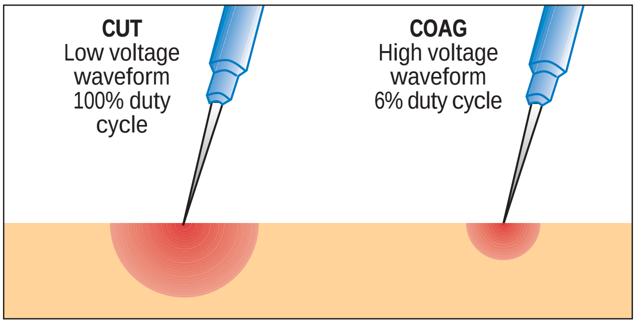

Figure 11 – Desiccation

Other Variables That Impact Tissue Effect

The electrosurgical mode that the surgeon uses has a definite impact on patient tissue. There are other variables that can also alter the outcome of the electrosurgical tissue effect:

TIME – The length of time that the surgeon uses the active electrode determines the amount of tissue effect. Too long an activation time will produce wider and deeper tissue damage. Too short an activation time will not produce the desired tissue effect.

POWER – The power setting the surgeon uses will alter tissue effect. The surgeon should always use the lowest setting to achieve the desired tissue effect. The setting will differ from patient to patient. Muscular patients of weight and height in proper portions will require lower power settings than obese or emaciated patients. The location of the return electrode in relation to the surgical site will impact the power required to overcome the amount of tissue mass (resistance) between the two (2) sites.

ELECTRODE – The size of the **active electrode** influences the tissue effect of the generator. A large electrode needs a higher power setting than a smaller one because the current is dispersed over a wider surface area (Figure 12). A clean electrode will need less power to do the same work as a dirty one because eschar buildup has higher **resistance** and will hamper the passage of the current. Electrodes can be coated with Teflon (PTFE) or an elastomeric silicone coating to reduce eschar buildup. These coated blades wipe clean with a sponge and eliminate that need for a "scratch pad" which causes grooves on stainless steel electrodes that may contribute to eschar build-up. These different types of blades should be evaluated because some will enable the surgeon to use lower power settings, reducing the potential for thermal spread. In addition, some coated electrodes are bendable, have a non-flake coating and retain their cleaning properties longer than other coated electrodes.

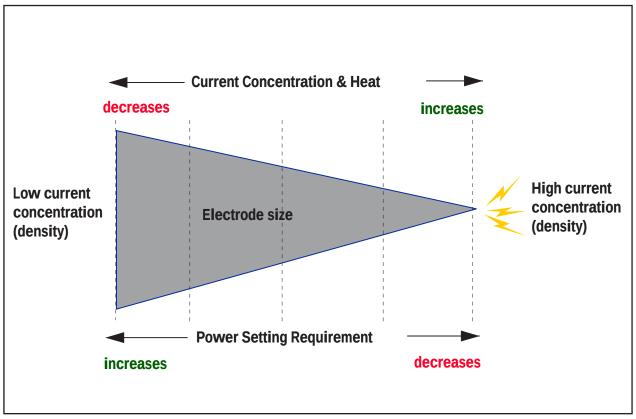

Figure 12 – Current Concentration Effect on Power Settings

TISSUE – Patient tissue can determine the effectiveness of the generator. The physical characteristics of the patient's body will determine the amount of impedance encountered by the electrosurgical **current** as it attempts to complete the **circuit** through the return electrode to the generator. A lean muscular patient will conduct the electrosurgical current much better than an obese or an emaciated patient.

Electrosurgical Technologies

As the sophistication of surgical procedures has evolved over time, so too have electrosurgical technologies. Meeting the challenge of improved patient care is but one of the goals of the medical manufacturing partner within the health care arena. The surgeon and perioperative nurse must be familiar with both long-standing technologies and with emerging ones so that the safest and most effective care is available to patients.

Ground-Referenced Generators

The first generation of electrosurgery units that were developed in the early 1900's were ground-referenced. When using these units, it is earth ground that completes the electrosurgical circuit. These units were spark-gap systems with high output and high performance (Hutchisson, 1998), making them popular with surgeons. The major hazard when using a grounded system is that **current division** can occur. If the electrical **current** finds an easier (lower resistance) and quicker way to return to ground, and if the **current** were sufficiently concentrated, the patient could be burned at any point where the current exits the patient's body (Figure 13).

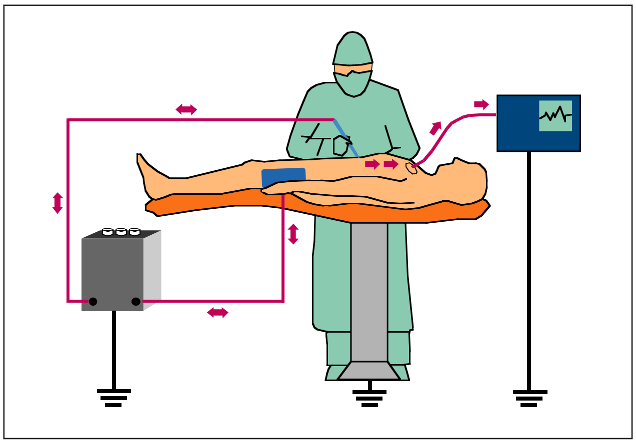

Figure 13 – Current Division

This could be where the patient's hand touches the side of the OR bed, a knee touches a stirrup, or any number of alternate exit sites (Figure 14).

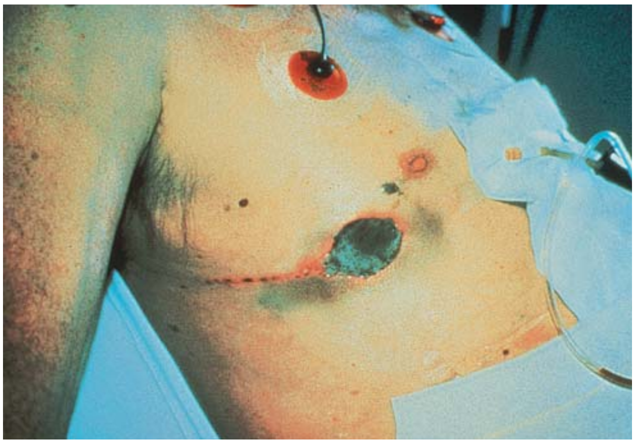

Figure 14 – Alternate Site Burn

In early models of ground-referenced generators, the surgeon could use **electrosurgery** regardless of whether a **patient return electrode** was attached to the patient. This resulted in patient burns. Later models offered a cord fault alarm, which alerted the staff if the **patient return electrode** was not plugged into the generator. The disadvantage was that **electrosurgery** could still be used even if the **patient return electrode** was not on the patient. Burns could also occur at the return electrode site.

In 1995 the Emergency Care Research Institute (ECRI) stated that "spark-gap units are outdated and have been largely superseded by modern technology". The Institute recommended that hospitals with surgeons who still insist on using ground-referenced units should obtain signed statements from these surgeons acknowledging the risk of using spark-gap electrosurgical units (Kirshenbaum, 1996).

Solid-State Generators

Solid-state generators were introduced in 1968. These units were much smaller and used "isolated" circuitry. In isolated units, the electrical **current** produced by the generator is referenced to the generator and will ignore all grounded objects that may touch the patient except the return electrode. With isolated generators **current division** cannot occur and there is no possibility of alternate site burns (Figure 15).

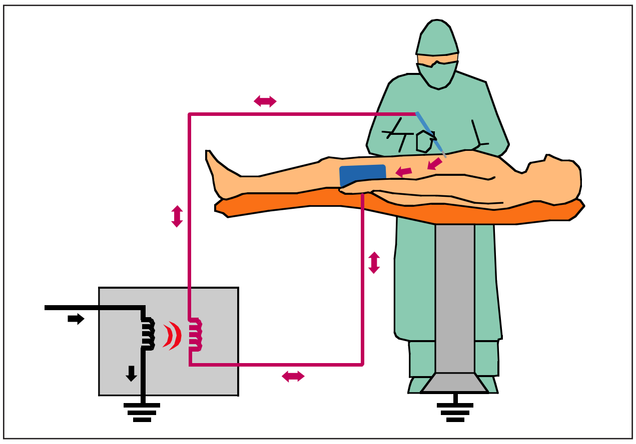

Figure 15 – Isolated Circuit

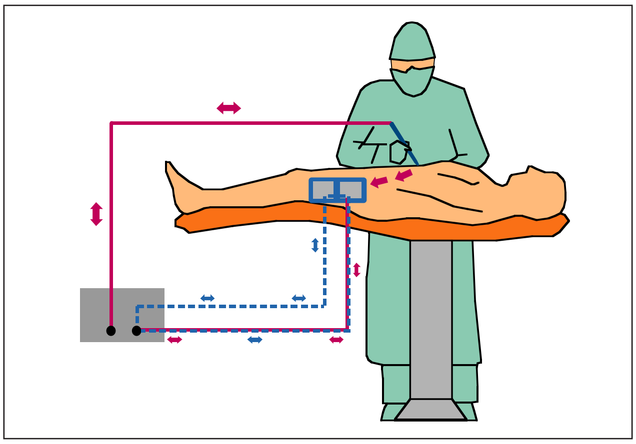

Figure 17 – Return Electrode Monitoring System

An isolated generator will not work unless the **patient return electrode** is attached to the patient. However, without additional safety features, the generator cannot determine the status of the contact at the pad/patient interface. Should the **patient return electrode** be compromised in the quantity or quality of the pad/patient interface in some way during surgery, a return electrode burn could occur (Figure 16). The perioperative nurse must be certain that the **patient return electrode** is in good contact with the patient throughout the surgical procedure.

Figure 16 – Pad Site Burn

Contact Quality Monitoring

Patient return electrodes employing a contact quality monitoring system were introduced in 1981. **Contact quality monitoring** uses a split pad system whereby an interrogation current constantly monitors the quality of the contact between the patient and the **patient return electrode** (Figure 17).

If a condition develops at the **patient return electrode** site that could result in a patient burn, the system inactivates the generator while giving audible and visual alarm signals. This represents a major safety device for patients and perioperative personnel since return electrode burns account for a majority of patient burns during **electrosurgery**. According to ECRI many electrosurgery burns could be eliminated by a **patient return electrode** quality contact monitoring system (ECRI, 1999).

Monopolar Electrosurgical Hazards During Minimally Invasive Surgery

In the past few years the number of laparoscopic procedures has risen dramatically and is expected to continue (Figure 18) (MDI, 1996).

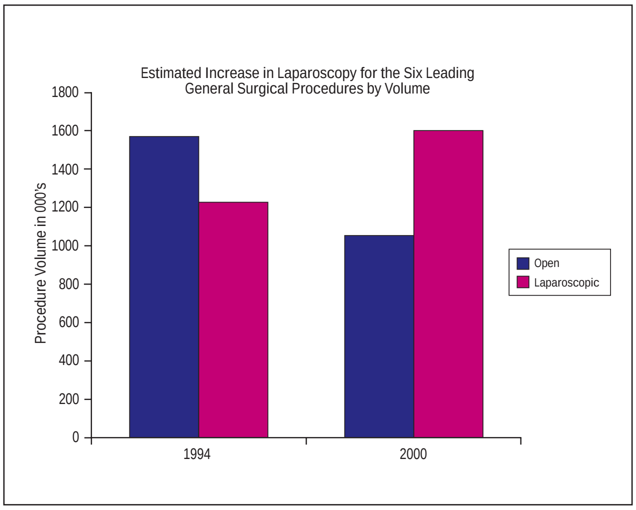

Figure 18 – Estimated Increase in Laparoscopy for the Six Leading General Surgical Procedures by Volume

This increase has brought concerns about **monopolar electrosurgery** when used during minimally invasive procedures. There have been reports of severe illness and death following laparoscopy where use of electrosurgery has been implicated as a cause (ECRI, 1995). The hazards associated with endoscopic **electrosurgery** use are:

- direct coupling
- insulation failure
- capacitive coupling

Each of these can cause severe patient injury if the current is highly concentrated at the point of contact.

In determining when and how these hazards occur, it is useful to divide the **active electrode** and cannula system into four zones (Figure 19).

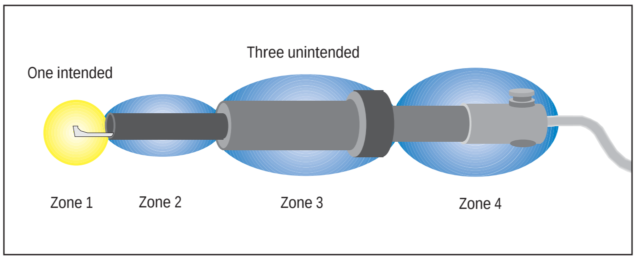

Figure 19 – Four Zones of Injury

Zone 1 is the area at the tip of the **active electrode** in view of the surgeon. Zone 2 encompasses the area just outside the view of the surgeon to the end of the cannula. Zone 3 is the area of the **active electrode** covered by the cannula system. This is also outside the view of the surgeon. Zone 4 is the portion of the electrode and cannula that is outside the patient's body. The greatest concern is the unseen incidence of stray electrosurgery current in Zones 2 and 3 (Harrell, 1998).

Direct coupling occurs when the **active electrode** is activated in close proximity or direct contact with other conductive instruments within the body. This can occur within Zones 1, 2, or 3. If it occurs outside the field of vision and the current is sufficiently concentrated a patient injury can occur.

Insulation failure occurs when the coating that is applied to insulate the **active electrode** is compromised. This can happen in multiple ways that range from repeated uses to rough handling to using very high voltage current. There is also concern that some **active electrodes** may not meet the standards for electrosurgical devices set by the Association for the Advancement of Medical Instrumentation (AAMI), and the American National Standards Institute (ANSI). **Insulation failure** that occurs in Zones 2 or 3 could escape detection by the surgeon and cause injury to adjacent body structures if the current is concentrated (Figure 20).

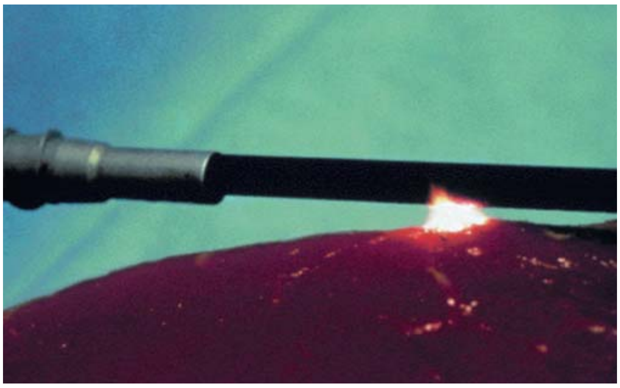

Figure 20 – Insulation Failure

Capacitive coupling is the least understood of the endoscopic electrosurgical hazards. Anytime two conductors are separated by an insulator a capacitor is created. For example, a capacitor is created by inserting an active electrode, surrounded by its insulation, down a metal cannula (Figure 21).

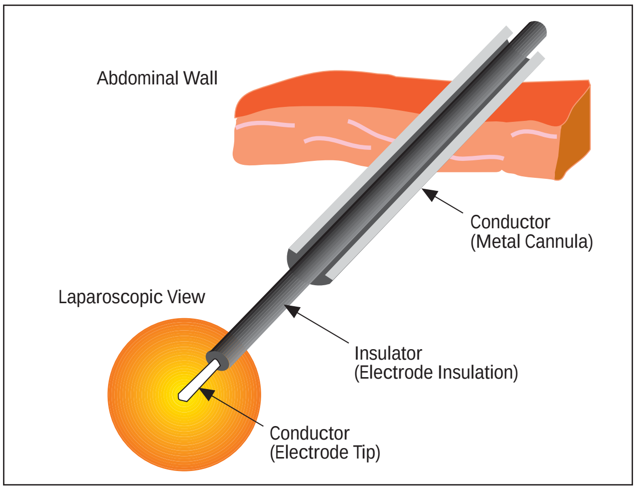

Figure 21 – Instrument/Metal Cannula Configuration

Capacitively coupled electrical current can be transferred from the **active electrode**, through intact insulation and into the conductive metal cannula. Should the cannula then come in contact with body structures, that energy can be discharged into these structures and damage them (Harrell). With an all-metal cannula, electrical energy stored in the cannula will tend to disperse into the patient through the relatively large contact area between the cannula and the body wall. Because the contact area is relatively large, the electrical energy is less concentrated and less dangerous. For this reason it is unwise to use plastic anchors to secure the cannula because it isolates the **current** from the body wall. Some institutions use plastic trocar cannula systems because they wrongly believe them to be safer. The plastic systems can also be dangerous because the patient's own conductive tissue within the body can form the second conductor, creating a capacitor. The patient's omentum or bowel draped over the plastic cannula could discharge stored energy to adjacent body structures.

Recommendations to avoid electrosugical complications during minimally invasive surgery are:

- Inspect insulation carefully
- Use lowest possible power setting
- Use low voltage (cut) waveform
- Use brief intermittent activation vs. prolonged activation
- Do not activate in open circuit
- Do not activate electrode in close proximity or direct contact with metal/conductive object
- Use bipolar electrosurgery when appropriate
- In the operative channel for activated electrodes
  - Select an all metal cannula system as the safest choice
  - Do not use a hybrid system (metal and plastic components)
- Utilize available technology
  - Tissue response generator to reduce **capacitive coupling** in the low voltage waveform
  - **Active electrode monitoring** system to eliminate concerns with **insulation failure** and **capacitive coupling**

Active Electrode Monitoring

The risks posed to the patient by insulation failure and capacitive coupling can be alleviated with **active electrode monitoring**. The **active electrode monitoring** system is used together with the electrosurgical unit (Figure 22). When in place, this system continuously monitors and actively shields against stray electrosurgical **current.** According to ECRI, active electrode monitoring is the most effective means to minimize the potential for patient injuries due to insulation failure or **capacitive coupling** (Kirshenbaum, 1996).

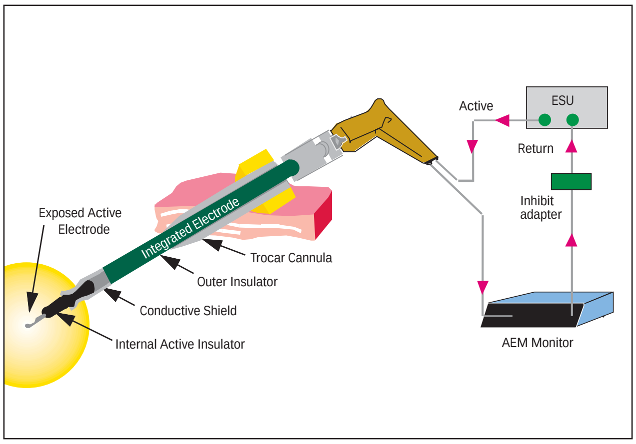

Figure 22 – Active Electrode Monitoring

Argon Enhanced Electrosurgery

In the late 1980's an argon delivery system was combined with **electrosurgery** to create argon enhanced electrosurgery. This modality of electrosurgery should not be confused with a laser. The argon gas shrouds the **electrosurgery** current in a stream of ionized gas that delivers the spark to tissue in a beam-like fashion (Figure 23). Argon is an inert, nonreactive gas. It is heavier than air, and easily ionizes. Because the beam concentrates the electrosurgical **current** a smoother, more pliable eschar is produced. In addition, the argon disperses blood, improving visualization. Because the heavier argon displaces some of the oxygen at the surgical site, less smoke is produced. When used during surgery, argon-enhanced electrosurgery can reduce blood loss and surgical time (Rothrock, 1999).

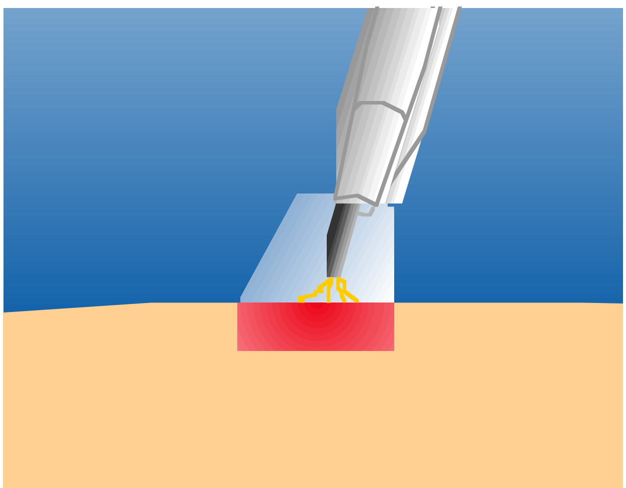

Figure 23 – Argon Enhanced Electrosurgery

Tissue Response Technology

The latest technology in electrosurgical generators uses a computer-controlled tissue feedback system that senses tissue impedance (resistance). This feedback system provides consistent clinical effect through all tissue types. The generator senses tissue resistance and automatically adjusts the **current** and output voltage to maintain a consistent surgical effect. This feedback system reduces the need to adjust power settings for different types of tissue. It also gives improved performance at lower power settings and voltages, which helps to reduce the risk of patient injury (Figure 24).

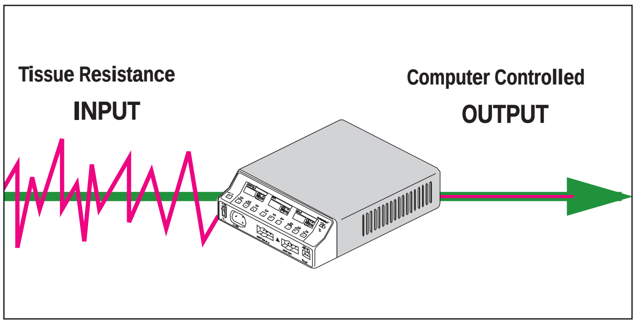

Figure 24 – Tissue Response Technology

Vessel Sealing Technology

A specialized generator/instrument system has been developed that is designed to reliably seal vessels and tissue bundles for surgical ligation both in laparoscopic and open surgery applications. It applies a modified form of **bipolar electrosurgery** in combination with a regulated optimal pressure delivery by the instruments in order to fuse the vessel walls and create a permanent seal (Figure 25).

The output is feedback-controlled so that a reliable seal is achieved in minimal time independent of the type or amount of tissue in the jaws. The result is reliable seals on vessels up to 7 mm in diameter or tissue bundles with a single activation. The thermal spread is significantly reduced compared to traditional **bipolar** systems and is comparable to ultrasonic **coagulation.** The seal site is often translucent, allowing evaluation of hemostasis prior to cutting. The seal's strengths are comparable to mechanical ligation techniques such as sutures and clips and are significantly stronger than other energy-based techniques such as standard bipolar or ultrasonic **coagulation.** The seals have been proven to withstand more than three times normal systolic blood pressure.

Figure 25 – Vessel Sealing Technology

Bipolar Generator

- Low Voltage - 180V
- High Amperage - 4A
- Tissue Response

Instruments

- High pressure
- Open (reposable)
- Laparoscopic (disposable)

System Operation

- Applies optimal pressure to vessel/tissue bundle
- Energy delivery cycle:
  - Measures initial resistance of tissue and chooses appropriate energy settings
  - Delivers pulsed energy with continuous feedback control
    - Pulses adapt as the cycle progresses
  - Senses that tissue response is complete and stops the cycle

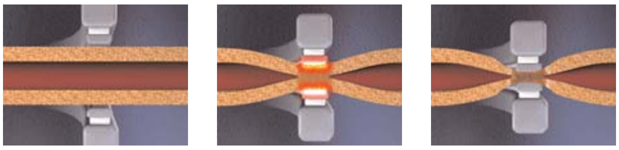

Figure 26 – Vessel Sealing System Operation

Smoke Evacuation

In 1994 the Association of Operating Room Nurses (AORN) first published recommended practices stating that patients and perioperative personnel should be protected from inhaling the smoke generated during electrosurgery (AORN, 1999). Smoke evacuation should be part of room set-up whenever smoke or plume generating equipment is used. That could include electrosurgical units or lasers.

Toxic fumes and carcinogens have been isolated from surgical smoke (Ulmer, 1997). Formaldehyde and benzene are but two of the substances that have been isolated from smoke. The Occupational Safety and Health Administration (OSHA), has issued a booklet with recommendations for protecting workers from the hazards of benzene (OSHA, 1987). Using protective equipment, such as a smoke evacuator, can decrease the risk associated from inhaling these substances. In September, 1996, the National Institute for Occupational Safety and Health (NIOSH) issued a hazard alert through the Centers for Disease Control's (CDC) healthcare facility network. The alert recommended that laser and electrosurgical smoke be evacuated and filtered to protect healthcare workers (NIOSH, 1998).

Patients, as well as surgical staff, are exposed to smoke during laparoscopic procedures. Researchers have determined that the byproducts contained in smoke are absorbed into the patient's bloodstream, producing substances such as methemoglobin and carboxyhemoglobin that can pose a potential hazard to the patient (Ott, 1997).

Before surgery the perioperative nurse should determine the volume of smoke that will be produced during the procedure, and select the appropriate smoke evacuation system. The vacuum source should be portable, easy to set up and use.

Figure 29 – Smoke Evacuator System

A filtration system with a triple filter offers the greatest protection. This system consists of a prefilter to filter out large particles; an Ultra Low Penetrating Air (ULPA) filter to capture microscopic particles; and a charcoal filter to adsorb, or bind to the toxic gases (Figure 27)

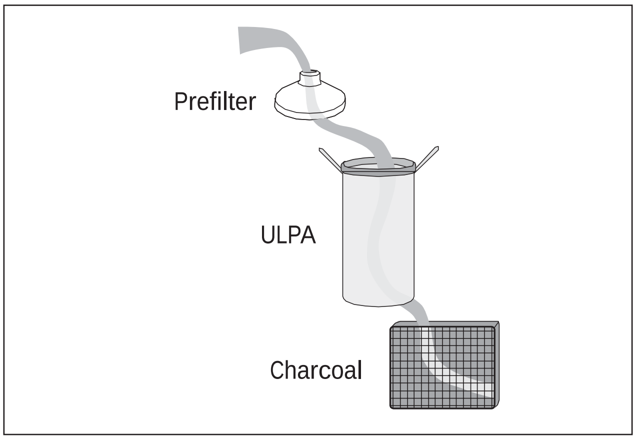

Figure 27 – Triple Filter System

The vacuum source should be able to pull 50 cubic feet per minute of air through the system. This ability provides the most effective evacuator, and will offer the nurse the flexibility to select the appropriate capture device to use with it. The surgical team may elect to use a carriage that mounts on the electrosurgical pencil to evacuate the smoke (Figure 28).

Figure 28 – Electrosurgical Pencil with Smoke Evacuation Attachment

This is the most convenient method to evacuate smoke, but it may be less effective during procedures that produce a large volume of smoke. A system that gives the perioperative staff the option of selecting evacuation settings will be of use in a wide variety of surgical procedures (Figure 29).

Electrosurgical Accessories

Electrosurgical units are only part of the electrosurgical system. Another, integral, part is the accessories. These include **active electrodes**, holsters, and **patient return electrodes** (grounding pads).

Active Electrodes

Active electrodes deliver concentrated **current** to the target tissue. There is a wide assortment of active electrodes available for both bipolar and monopolar units. **Active electrode** pencils or forceps may be controlled by handswitches or foot pedals. Pencil tips are available in needles, blades, balls, and loops (Figure 30). Some **active electrodes** are a combined suction and coagulation instrument. As minimally invasive surgery has gained popularity, active laparoscopy electrodes have also been developed. They are available as disposable and reusable products.

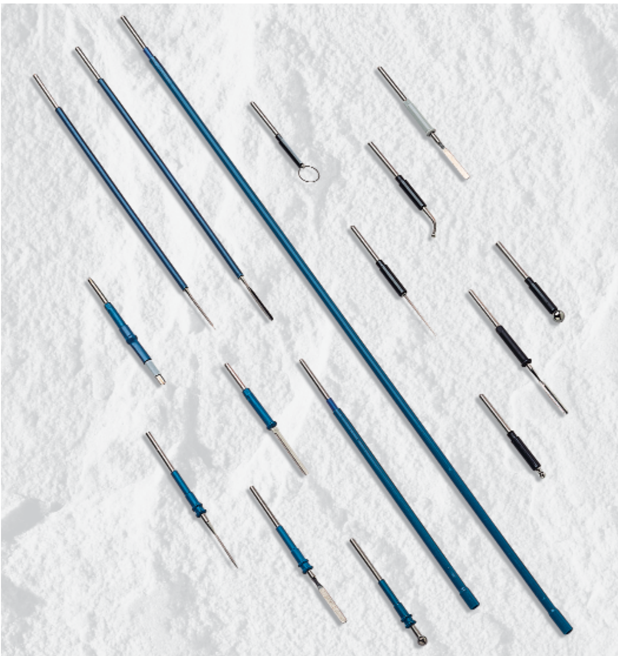

Figure 30 – Active Electrodes

In 1991 an electrosurgical device was developed for use with the ultrasonic surgical aspirator (Figure 31). The ultrasonic surgical aspirator handpiece attaches to a command console. When in operation, the ultrasonic handpiece vibrates at a frequency of 23,000 times per second. That frequency is above the range of human hearing, thus the name ultrasonic. The device does not emit sound waves or light waves. Its vibrating tip works by contacting tissue. When it does, fragmentation occurs. By itself, the ultrasonic handpiece provides no hemostasis. When an electrosurgical module is added to the handpiece, the surgeon is able to fragment, cut or coagulate tissue, simultaneously or independently.

Figure 31 – Ultrasonic Surgical Aspirator Handpiece with Electrosurgical Module Attachment

Holsters

Holsters are a vital safety component of the electrosurgical system. When **active electrodes** are not in use, they should be placed in holsters where they will be easily accessible and visible to the surgical team. They should be of the type recommended by the manufacturer for use with electrosurgical **active electrodes**, and should meet standards for heat and fire resistance. Patient safety can be threatened by the use of pouches and other makeshift holsters not intended for use with electrosurgery **active electrodes.**

Patient Return Electrodes

Patient return electrodes, or grounding pads, collect the monopolar **current** that has entered the patient and allow it to be safely removed and returned to the generator. There are many types of **patient return electrodes** used, ranging from metal plates to dual section pads. Reusable metal plates are made of stainless steel and fit under the patient. With such plates, conductive gel must be used to improve the conductive plate/patient interface. The quality of contact depends on gravity and the amount of gel used. A disposable version of this plate is also used. It is made of cardboard and covered with foil. Neither type plate conforms to body contours and effectiveness may vary. Pre-gelled, disposable foam pads adapt well to body contours and an adhesive edge helps to hold the pad on the patient. They come in many shapes and sizes. When using them, it is important to store cartons flat so that the gel does not accumulate on one side of the pad. During use the drier side of an improperly stored pad could contribute to an electrosurgical burn. Gelled pads can also dry out during long storage periods, thereby compromising their conductivity. When using gelled pads, care must be taken to rotate the stock and store the cartons properly.

Conductive adhesive pads are similar to gel pads but instead of gel they use a layer of adhesive over the pad surface. The adhesive promotes conductivity and good contact with the patient's skin. These pads may be a dry conductive adhesive or a high moisture conductive adhesive. Both conform well to body contours. A high moisture product will tend to increase patient skin conductivity during use. These types of pads are also available in the split dual section design. The split pad design incorporates an "interrogation circuit" which is part of a system to actively monitor the amount of impedance at the patient/pad interface because there is a direct relationship between this impedance and the contact area. The system is designed to deactivate the generator before an injury can occur, if it detects a dangerously high level of impedance at the patient/pad interface.

It is important to place the return electrode properly on the patient. The **patient return electrode** should be as close as possible to the surgical site and should be positioned over a large muscle mass. Muscle conducts electrical **current** better than fatty tissue, scar tissue or bony prominences (Fairchild, 1997). **Patient return electrodes** should not be placed over metal prostheses because the scar tissue surrounding the implant increases resistance to the flow of electrical **current.** The pad site should be clean and dry, and free from excessive hair. The **patient return electrode** should not be placed where fluids are likely to pool during surgery. If the patient has a pacemaker, the **patient return electrode** should be placed as far away as possible so that it directs the **current** away from the pacemaker. The pacemaker manufacturer should be consulted to determine whether or not the pacemaker is susceptible to electrical interference. The pacemaker should be checked for proper function postoperatively.

It is also important to read and follow the manufacturer's recommendations for the **patient return electrode** being used. These recommendations are legal and binding instructions when using the product. Failure to follow recommended use could constitute negligence should an incident occur.

Perioperative Care of the Patient

Care of the patient during **electrosurgery** can be enhanced by following routine and systematic procedures. Points to include during perioperative care of the patient during **electrosurgery** include, but are not limited to:

Preoperative

- Know which Electrosurgical unit (ESU) will be used and how to use it. Consult the instruction manual for specific instructions or questions.
- Have all equipment and accessories available and use only accessories designed and approved for use with the unit.
- Check the operation of the alarm systems.
- Avoid the use of flammable anesthetics.
- Place EKG electrodes as far away from the surgery site as possible.
- Do not use needle EKG monitoring electrodes, they may transmit leakage **current** (Atkinson, 1992).
- Check the line cord and plug on the ESU. Extension cords should not be used.
- Do not use any power or accessory cord that is broken, cracked, frayed or taped.
- Check the biomedical sticker to insure the generator has undergone a current inspection.
- Cover the foot pedal with a plastic bag.
- Document the generator serial number on the perioperative record.
- Record exact anatomical pad position and skin condition of the pad site.
- Do not cut or alter a **patient return electrode**.

Intraoperative

- If alcohol based skin preparations are used, they should be allowed to dry prior to draping (Meeker, 1991).
- Use the lowest possible power settings that achieve the desired surgical effect. The need for abnormally high settings may indicate a problem within the system.

- Position cords so that people cannot trip over them. Do not roll equipment over electrical cords.
- If the patient is moved or repositioned, check the **patient return electrode** to be sure that it is still in good contact with the patient. **Patient return electrodes** should not be repositioned. If the **patient return electrode** is removed for any reason, a new pad should be used.
- When an **active electrode** is not in use, remove it from the surgical field and from contact with the patient. An insulated holster should always be used.
- Do not coil **active electrode** cables, or grounding pad cables. This will increase leakage current and may present a potential danger to the patient.
- If possible, avoid "buzzing" hemostats in a way that creates metal to metal arcing. If "buzzing" a hemostat is necessary, touch the hemostat with the **active electrode** and then activate the generator. This will help eliminate unwanted shocks to surgical team members.
- Use endoscopes with insulated eye pieces.
- Keep **active electrodes** clean. Eschar build-up will increase resistance, reduce performance, and require higher power settings.
- Do not submerse active accessories in liquid.
- Note the type of **active electrode** used on the perioperative record.
- If an ESU alarm occurs, check the system to assure proper function. Document any alarm intervention.
- Do not use the generator top as a storage space for fluids. Spills could cause malfunctions (Hutchisson, 1998).

Postoperative

- Turn off the ESU.
- Turn all dials to zero.
- Disconnect all cords by grasping the plug, not the cord.
- Inspect **patient return electrode** site to be sure it is clear of injury (AORN, 1999).
- Inspect **patient return electrode** after removal. If an undetected problem has occurred, such as a burn, evidence of that burn may appear on the pad.
- Discard all disposable items according to hospital policy.
- Remove and discard the plastic bag covering the foot pedal.
- Clean the ESU, foot pedal, and power cord.
- Coil power cords for storage.
- Clean all reusable accessories.

Routine Care and Maintenance of ESU Equipment

- Routinely replace all reusable cables and **active electrodes** at appropriate intervals, depending upon usage.
- Have a qualified Biomedical Engineer inspect the unit at least every six months.
- If an ESU is dropped, a Biomedical Engineer should inspect it before it is used again.
- Replace adapters that do not provide tight connections.
- Inspect "permanent" cords and cables for cracks in the insulation.

Proper use and maintenance of electrosurgical equipment can prolong its life and reduce costly repairs.

Summary

Surgeons and perioperative nurses have the opportunity to combine their unique technical skills and knowledge with the latest technology to provide high quality patient care. Positive patient outcomes can be successfully achieved through good medical and nursing practice combined with careful documentation. The importance of skill and knowledge is especially critical during the use of **electrosurgery.** An educated surgeon or nurse is the patient's best advocate.

Glossary

Active Electrode
An electrosurgical instrument or accessory that concentrates the electric (therapeutic) current at the surgical site.

Active Electrode Monitoring
A system that continuously conducts stray current from the laparoscopic electrode shaft back to the generator and away from patient tissue. It also monitors the level of stray current and interrupts the power should a dangerous level of leakage occur.

Alternating Current
A flow of electrons that reverses direction at regular intervals.

Bipolar Electrosurgery
Electrosurgery where current flows between two bipolar electrodes that are positioned around tissue to create a surgical effect (usually desiccation). Current passes from one electrode, through the desired tissue, to another electrode, thus completing the circuit without entering any other part of the patient's body.

Bipolar Instrument
Electrosurgical instrument or accessory that incorporates both an active and return electrode pole.

Blend
A waveform that combines features of the cut and coag waveforms; current that cuts with varying degrees of hemostasis.

Capacitive Coupling
The condition that occurs when electrical current is transferred from one conductor (the active electrode), through intact insulation, into adjacent conductive materials (tissue, trocars, etc.).

Cautery
The use of heat or caustic substances to destroy tissue or coagulate blood.

Circuit
The path along which electricity flows.

Coagulation
The clotting of blood or destruction of tissue with no cutting effect; electrosurgical fulguration and desiccation.

Contact Quality Monitoring
A system that actively monitors tissue impedance (resistance) at the interface between the patient's body and the patient return electrode and interrupts the power if the contact quality and/or quantity is compromised.

Current
The number of electrons moving past a given point per second, measured in amperes.

Current Density
The amount of current flow per unit of surface area; current concentration directly proportional to the amount of heat generated.

Current Division
Electrical current leaving the intended electrosurgical circuit and following an alternate path of least resistance to ground; typically the cause of alternate site burns when using a grounded generator.

Cut
A low-voltage, continuous waveform optimized for electrosurgical cutting.

Cutting
Use of the cut waveform to achieve an electrosurgical effect that results from high current density in the tissue causing cellular fluid to burst into steam and disrupt the structure. Voltage is low and current flow is high.

Desiccation
The electrosurgical effect of tissue dehydration and protein denaturation caused by direct contact between the electrosurgical electrode and tissue. Lower current density/concentration than cutting.

Diathermy
The healing of body tissue generated by resistance to the flow of high-frequency electric current.

Direct Coupling
The condition that occurs when one electrical conductor (the active electrode) comes into direct contact with another secondary conductor (scopes, graspers). Electrical current will flow from the first conductor into the secondary one and energize it.

Direct Current
A flow of electrons in only one direction.

Electrosurgery
The passage of high frequency electrical current through tissue to create a desired clinical effect.

ESU
ElectroSurgical Unit.

Frequency
The rate at which a cycle repeats itself; in electrosurgery, the number of cycles per second that current alternates.

Fulguration
Using electrical arcs (sparks) to coagulate tissue. The sparks jump from the electrode across an air gap to the tissue.

Generator
The machine that coverts low-frequency alternating current to high-frequency electrosurgical current.

Ground, Earth Ground
The universal conductor and common return point for electric circuits.

Grounded Output
The output on a electrosurgical generator referenced to ground.

Hertz
The unit of measurement for frequency, equal to one cycle per second.

Insulation Failure
The condition that occurs when the insulation barrier around an electrical conductor is breached. As a result, current will travel outside the intended circuit.

Isolated Output
The output of an electrosurgical generator that is not referenced to earth ground.

Leakage Current
Current that flows along an undesired path, usually to ground; in isolated electrosurgery, RF current that regains its ground reference.

Monopolar Electrosurgery
A surgical procedure in which only the active electrode is in the surgical wound; electrosurgery that directs current through the patient's body and requires the use of a patient return electrode.

Monopolar Output
A grounded or isolated output on an electrosurgical generator that directs current through the patient to a patient return electrode.

Ohm
The unit of measurement of electrical resistance.

Pad
A patient return electrode.

Patient Return Electrode
A conductive plate or pad (dispersive electrode) that recovers the therapeutic current from the patient during electrosurgery, disperses it over a wide surface area, and returns it to the electrosurgical generator.

Power
The amount of heat energy produced per second, measured in watts.

Radio Frequency
Frequencies above 100 kHz that transmit radio signals; the high-frequency current used in electrosurgery.

Resistance
The lack of conductivity or the opposition to the flow of electric current, measured in ohms.

RF
Radio frequency.

Tissue Response Technology
An electrosurgical generator technology that continuously measures the impedance/resistance of the tissue in contact with the electrode and automatically adjusts the output accordingly to achieve a consistent tissue effect.

Vessel Sealing Technology
An electrosurgical technology that combines a modified form of electrosurgery with a regulated optimal pressure delivery by instruments to fuse vessel walls and create a permanent seal.

Volt
The unit of measurement for voltage.

Voltage
The force that pushes electric current through resistance; electromotive force or potential difference expressed in volts.

Watt
The unit of measurement for power.

Waveform
A graphic depiction of electrical activity that can show how voltage varies over time as current alternates.

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Self-Study Guide Test Questions

1.) Electricity always seeks
- a.) the path of most resistance to return to earth ground.
- b.) the path of most resistance to return to its source.
- c.) the path of least resistance to return to earth ground.
- d.) the path of least resistance to return to its source.

2.) The properties of electricity include
- a.) current, circuit, resistance and voltage.
- b.) current, ground, current and voltage.
- c.) current, resistance, hertz and voltage.
- d.) current, circuit, ground and amperage.

3.) Neuromuscular stimulation from the flow of alternating electric current ceases at frequencies above
- a.) 50,000 cycles per second.
- b.) 100,000 cycles per second.
- c.) 200,000 cycles per second.
- d.) 350,000 cycles per second.

4.) When current concentration/density is high
- a.) the resistance is reduced.
- b.) the resistance is unaffected.
- c.) heat is produced.
- d.) heat is dissipated.

5.) A patient return electrode is not required when using bipolar electrosurgery because
- a.) the voltage is too low to cause an injury.
- b.) the voltage is confined to the target tissue.
- c.) the current is confined between the two poles of the instrument.
- d) the current disperses in the tissue at the tip of the instrument.

6.) As the current concentration is increased
- a.) the power setting requirement is decreased.
- b.) the power setting requirement is increased.
- c.) the heat produced in the tissue remains the same.
- d.) the heat produced in the tissue is decreased.

7.) The cutting waveform can be modified to provide simultaneous hemostasis (blended waveform) by
- a.) decreasing the voltage and increasing the duty (on/off) cycle.
- b.) increasing the voltage and decreasing the duty cycle.
- c.) decreasing the voltage and decreasing the duty cycle.
- d.) increasing the voltage and increasing the duty cycle.

8.) Contact quality monitoring is a system that
- a.) constantly monitors the quality of the pad/patient interface.
- b.) constantly monitors the quality of the generator/pad interface.
- c.) combines isolated and interrogation circuitry to monitor output.
- d.) combines isolated and interrogation circuitry to monitor resistance.

9.) The hazards associated with endoscopic electrosurgery use include all of the following except
- a.) direct coupling.
- b.) current division.
- c.) insulation failure.
- d.) capacitive coupling.

10.) Tissue response technology incorporates a computer-controlled tissue feedback system that
- a.) automatically changes the power settings.
- b.) automatically reduces the amount of power required.
- c.) senses the conductivity of the target tissue.
- d.) senses the impedance/resistance of the target tissue.

11.) The smoke produced from the electrosurgical device is
- a.) not as harmful as laser plume and need not be evacuated.
- b.) not as harmful as laser plume, but should be evacuated.
- c.) potentially as harmful as laser plume and evacuation is recommended.
- d.) potentially as harmful as laser plume and evacuation is optional.

12.) The site selected for the patient return electrode should be all of the following except
- a.) over a large muscle mass.
- b.) as close to the surgical site as possible.
- c.) protected from fluid invasion.
- d.) close to a pacemaker to divert the current.

13.) Vessel sealing technology is incorporated into a specialized electrosurgical generator that combines
- a.) modified monopolar electrosurgery with regulated pressure delivery.
- b.) modified bipolar electrosurgery with regulated pressure delivery.
- c.) increased voltage electrosurgery with decreased pressure delivery.
- d.) decreased voltage electrosurgery with decreased pressure delivery.

Test Key

1.) c	5.) c	9.) b	13.) b
2.) a	6.) a	10.) d	
3.) b	7.) b	11.) c	
4.) c	8.) a	12.) d	

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2. Did the activity meet your personal learning objectives? ❑ ❑
3. Do you plan on changing any aspect of your practice as a result of this activity? If yes, what? ❑ ❑

Scoring Key: 5=Excellent 4=Good 3=Average 2=Fair 1=Poor

Organization of content	5 4 3 2 1
Effectiveness of this learning method	5 4 3 2 1
Relevance of content to practice	5 4 3 2 1
Relevance of test questions to content	5 4 3 2 1
Overall quality	5 4 3 2 1

Suggestions for additional topics to be presented in this format:

Comments:

Valleylab designates this educational activity for a maximum of 2 hours in Category 1 credit toward the AMA Physician's Recognition award. Each physician should claim only those hours of credit that he/she actually spent in the educational activity.

Offering accredited for 2 contact hours of continuing education for nurses.

Test Question Responses

Please circle the correct response.

1.) a b c d
2.) a b c d
3.) a b c d
4.) a b c d
5.) a b c d
6.) a b c d
7.) a b c d
8.) a b c d
9.) a b c d
10.) a b c d
11.) a b c d
12.) a b c d
13.) a b c d

Expiration Date

This offering was originally produced for distribution in **September 1997**. It was revised in September 1999 and cannot be used after September 2002 without being updated. Therefore, will not be issued after **September 30, 2002**.

Specifications subject to change without notice.

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