**INTRODUCTION**

Electrosurgery is used in 80% or more of all surgical procedures. Electrosurgical units (ESU’s) are generators capable of producing a cutting and/or coagulating clinical effect on tissue by the use of alternating current at high frequency (RF – radio frequency, also known as radio surgery). Voltages and currents can be adjusted to produce the desired clinical effect.

Although electrosurgery is considered a prominent surgical procedure that is used across surgery specialties, it is also reported to be the largest contributor of patient injury in the OR. The two most common safety hazards associated with the use of any electrosurgical device are burns and explosion/fire. These devices can also interfere with other electromedical devices or produce a noxious smoke with, as yet, cause undefined harmful effects. Knowledgeable medical staff and electrosurgical product representatives can assist in creating a safer environment in which to apply electrosurgery.

Safety considerations during electrosurgical procedures are necessary to ensure the wellbeing of the patient, the surgical team and other persons present in the operating room. The main safety considerations should be specifically focused on electrosurgical safety, the electrosurgical unit and its proper range of settings, pad placement, individual patient considerations, and other electrical devices and OR products in range of the electrosurgical unit.

**ELECTROSURGICAL SAFETY CONCERNS**

Electrosurgical safety measures are intended to minimize the potential for electrical and other hazards before, during and after procedures that involve the therapeutic application of RF energy. Lack of patient and surgical preparation and improper use of the ESU and its accessories can lead to the two main contributors of patient injury.

First, as a cause of injury, explosion and fire can occur if electrical sparks ignite flammable gases or solutions. Although, fire hazards have been greatly reduced over the years, lack of appropriate safety measures are still causes for concern.

Most flammable anesthetic gases have been eliminated from the operating room; alcohol preps and other flammable vapors can ignite if present when an active electrode is used in the same area. Inadvertent activation of an active electrode positioned on sponges, drapes, or in an oxygen-enriched atmosphere can result in fires.
Second, as a cause of injury, is user burns. These are the least understood and most dangerous hazards in surgery. A patient may be burned by the tip of an active electrode that is accidentally applied to the targeted tissue. A patient or staff member can also be burned by stray energy that escapes from monopolar instruments. This particular type of burn can lead to more serious burns and tissue damage. Three problems attributed to stray energy burns include isolation failure, capacitive coupling, and direct coupling.

Most isolated burn incidents have been eliminated with the design of the isolated units of today. Ground reference units, which are still in the surgery arena, were prone to this type of burn if the patient were touching a grounded area or if the pad were not placed on the patient. In cases like this, the energy would find ground through the easiest means possible. With isolated units, if the energy does not find its way to the dispersive electrode the unit will stop delivering energy.

Capacitance is defined as the establishment of currents between two conductors that are separated by an insulator. In electrosurgery, the phenomenon of capacitive coupling between an insulated electrode and a surrounding metal trocar with plastic screw threads is a possible example of an inadvertent injury.

Direct coupling is defined as intended or unintended contact between active electrode and tissue. Unintended direct coupling may occur due to faulty insulation on an active electrode which can be the result of continual reprocessing or deterioration caused by normal wear and tear of instruments. Direct coupling caused by insulation breakdown is potentially more devastating than capacitive coupling.

The Association of Operation Room Nurses (AORN) recommends the use of a smoke evacuation system to protect operating room staff from inhaling the smoke generated during electrosurgery procedures. AORN cites the potential for bacterial and viral contamination of the smoke and warns that gaseous by-products can be toxic and mutagenic.

The following information is an overview of electrosurgical safety considerations. Education should include the principles of electrosurgery and proper operation, care, and handling of the specific electrosurgical equipment used in the surgical setting. The most effective safety system in electrosurgery is a knowledgeable doctor, nurse, and product support personnel. A basic understanding of electrosurgery and adherence to the necessary precautions will assure a safe environment for both patient and staff.
Purpose/Goal of this Activity
Electrosurgery is used in over 80% or more of all surgical procedures today, and most incidents are caused by user error. Therefore the perioperative nurse plays an integral role in the safe and effective use of the electrosurgical equipment in their clinical practice. Proper care and handling is essential to both the patient and personnel safety throughout the procedure. Technology has continued to advance over the years with the addition of improved discrete output, ground reference isolated units, tissue impedance monitoring at the patient plate and tissue response to the active electrode. This activity was developed to inform participants of safety considerations as they relate to electrosurgery. The goal of this activity is to cover some of the main safety considerations and have each participant obtain a greater understanding and practical tips that can be used during electrosurgical procedures.

On a scale of 1=low, 5=high, relationship of objectives to overall purpose/goal of this activity _____.

Additional comments and suggestions:

TERMS

Fire Triangle
Three (3) elements, ignition (heat) source, fuel source, and oxidizer, that may result in a fire if combined in the right proportions.

Flammability Characteristics
Properties of an item that is capable of burning, including but not limited to combustion, temperature at which combustion will occur, flame spread speed, and flame spread pattern.

Fuel Source
Any item or product in or on the patient that has the property of igniting and burning easily and rapidly (flammable).

Ignition Source
A device or item that is capable of generating sparks or enough heat to produce combustion.

Intestinal Gases
Gases produced by bacteria in the gastrointestinal tract that contain approximately 44% hydrogen and 30% methane, both of which are flammable. A normal colon contains at least 5% oxygen, but these concentrations increase with the administration of general anesthesia using oxygen or nitrous oxide.

Oxygen Enriched Atmosphere (Environment)
Atmosphere (air) with greater than 21% concentration of oxygen. An oxygen enriched atmosphere is favorable to fire and explosion.

Return Electrode Contact Quality Monitoring System
A generic term for an electrosurgical generator technology that monitors the quality of the pad/patient interface by measuring the resistance under the patient return electrode and allows the generator to operate only within the preset safe parameters.
Quality Monitoring of Contact
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.

Smoke or Plume
Byproducts of combustion and/or vaporization of human tissue created by heating with high (radio) frequency electrical current. The smoke or plume contains gases that may be flammable.

SAFETY CHECKS AND ACTIONS
The following steps should be taken by the surgical personnel. These steps can help to ensure ESU safety as it relates to the electrosurgical procedure:

1. Check that the unit has been inspected within the past six months by looking at the inspection sticker adhered to the unit.

2. Inspect the ESU for damage. Test the safety lights and audible alarms.

3. A pre- and post-operative skin test should be documented concerning the patient’s skin integrity.

4. Patient must be grounded by the use of a dispersive electrode (grounding pad). Place the grounding pad nearest the operative site and follow these guidelines:
   a. Clean and dry the operative site.
   b. Place the pad over a large muscle mass.
   c. Avoid scar tissue, hairy surfaces, and avoid bony protrusions.
   d. Check for pools of solution under the patient and/or pad.
   e. Do not place pad over joints or in proximity of orthopedic hardware.
   f. Position patient before grounding pad is placed on the patient.

5. Do not place anything on or around the ESU that may cause electrical interference.
6. All personnel using or assisting with the ESU should receive orientation, training and inservice updates.

7. Understand all alarm indications and be able to troubleshoot the ESU by checking:
   a. Pad site adheres to patient.
   b. Machine connections are properly installed.
   c. Pencil should be replaced.
   d. Biomed’s recommendation to replace the ESU.
   c. Electrosurgery should not be performed in the presence of combustible materials such as flammable anesthesia agents.

8. Understand that the use of electrosurgery for cutting and coagulation of tissue with high-frequency current is commonplace in the OR.

9. Electrosurgery with Pacemakers should be conducted following the recommendation of the Pacemaker manufacturer.

10. Check all electrodes for damage or abnormalities. Replace electrodes that are not in working order. Electrodes should be stored in a non-conductive container. During surgery, the tips should be kept clean.

11. Follow directions for correctly connecting the active electrode to the ESU.

12. Document the ESU number, all the settings used during the procedure, site of the grounding pad, the condition of the patient’s skin before and after the procedure.

13. Report all burns and skin reactions by collecting the grounding pad and active electrode, tagging them, pulling them from service and completing an Occurrence Report.

14. At the end of the procedure, clean the foot pedal, cables, cords, and all other reuseable accessories. Properly dispose of disposables.
A BETTER UNDERSTANDING

The following information is intended to broaden your knowledge of the two most common safety hazards associated with electrosurgery. Understanding and applying the information concerning fire/explosion/smoke and burns can assist in alleviating these hazards associated with the use of ESUs in surgery. To date, more regulatory and reporting agencies are investigating, reporting and improving the awareness and safe practices in reference to patient safety. These findings not only improve safety for the patient, but for the surgical team.

FIRE, EXPLOSION OR SMOKE

A troubling fact during surgical procedures is that fires can occur. The most common ignition sources for surgical fires are electrosurgery, cautery (hot wire), light sources and sparks (arcs), and lasers. In a frightening statistic reported by the Emergency Care Research Institute, over half of the fires occur in the patient’s airway or around their head, face, neck and chest. The flammable sources that fuel fires during electrosurgery include anesthetic gases, tubes, drapes and surgical gowns. The key to preventing surgical fires is following safety policies.

Fire Triangle

The fire triangle is a combination of three factors that are considered the major contributors to surgical fires. A better understanding of these elements can assist in decreasing fires during procedures such as electrosurgery. Most importantly, the key is to communicate among the surgical staff. Any fire requires a fuel, ignition source and oxygen. Each of these factors is typically under the control of a surgical team member (a nurse will be responsible for preparation and the draping of the patient; the anesthesiologist administers oxygen; and the surgeon operates the ESU).

Oxygen

Over three quarters of flash fires are related to an oxygen-enriched environment. This happens when oxygen concentrations are at approximately 50 percent and higher.

ELECTROSURGERY:
SAFETY CONSIDERATIONS

Registration Form

Name

Address

City

Social Security or License Number

Medical Organization Affiliation

Email address

QUIZ FORM

(Circle your quiz responses here)

1. A B C D 6. A B C D
2. A B 7. A B
3. A B C D 8. A B
5. A B C D 10. A B
5. The Emergency Care Research Institute reports that over ______ percent of fires attributed to electrosurgery occur around the patient’s head and face and in their airway.
   a. 20%
   b. 30%
   c. 50%
   d. 90%

6. R.A.C.E. stands for what electrosurgical safety procedure?
   a. rescue, alarm, contain, exit
   b. run, alarm, combust, electrocute
   c. rescue, alarm, contain, extinguish
   d. run, act, call, exit

7. Electrosurgical hazards are rarely attributed to faulty equipment.
   a. True
   b. False

8. When alcohol is used as a prep agent, it should be wet when electrosurgery begins.
   a. True
   b. False

9. Mixing two conductive instruments during electrosurgery can cause capacitive coupling.
   a. True
   b. False

10. Too much current flow applied to a small area for an extended period of time never causes first, second, or third degree burns.
    a. True
    b. False

It has been proposed that safely monitoring the patient’s blood oxygenation while dispensing less oxygen and room air can help minimize the risk of oxygen related fires.

Fuel
Fuel such as prepping agents, drapes and gowns, and patient’s hair ignite fires started during surgery. One quarter of the fires start due to alcohol-based prepping (these give off flammable vapors while drying) of the surgical site before electrosurgery.

Prevention of fuel related fires include carefully prepping the patient to prevent wet hair, pillows, and linens. Be aware of alcohol vapors present under drapes that can ignite easily during the procedure.

Ignition sources
ESUs, along with lasers, cautery units, light sources and bur sparks can easily ignite fuels during oxygen-enriched procedures. Careful use and handling of these appliances can help reduce sparks, smoke and fires.

Some precautions include allowing the alcohol to completely dry on the surgical area. Also, be aware of the active tips and deactivate when moving away from the surgical site. Place electrodes in holders when not in use.

Smoke or plume
Electrosurgical smoke is a mixture of water, bioaerosols, carbonized particles and both living and non-living cellular material. Hazards of this mixture relate to respiratory damage and harmful concentrations of chemical by-products. This smoke also includes noxious odor. Removal and/or filtration of smoke is recommended. High filtration surgical masks can be worn to prevent most of the particles from being breathed into the surgical personnel. Smoke evacuation systems combined with approved ventilation techniques are recommended. Follow facility’s current policy on smoke evacuation.

Explosion
Proper maintenance of the ESU can prevent equipment problems that can lead to sparks, fire and explosion. Faulty wiring can spark and ignite flammable gases or surgical items such as drapes.

Shock/Electrocuton (See also page 11, Electric shock)
Internal faults in the ESU can cause shock or electrocution. Proper grounding and unit maintenance can prevent these faults. Proper use of extension cords and keeping electrical cords dry are important safety considerations.
The Joint Commission on Accreditation of Health Care Organizations (JCAHO) and other agencies and organizations reporting to the FDA recommend a fire safety policy, posting of surgical fire prevention tips in the surgical area and over scrub sinks, and fire drills.

**Fire drills**
Closing fire doors, knowing the location of fire extinguishers and how to operate them, fire alarms, fire exits, and relying on the person(s) responsible for gas valves and electrical pane operation are all standard OR fire drill elements. More specific elements during electrosurgery include proper immediate response from each surgical team member. These include but are limited to:

- Surgeons should quickly remove burning materials.
- Anesthesia staff should disconnect the breathing equipment.
- Nurses and other staff in close proximity should extinguish burning materials and alert other surgical suite staff.
- Move patient safely to another surgical location if necessary.

If patient evacuation is required, follow the R.A.C.E. procedure recommended by most surgical facilities. R.A.C.E. is an abbreviation for rescue (alert staff of fire and possible evacuation), alarm (pull fire alarm and continue putting out fire), confine (keep OR doors closed to prevent spread of fire), and extinguish (put out fire and begin patient evacuation).

**Extinguishing a fire**
To quickly and safely extinguish a fire, it is recommended that a 5 lb. CO2 fire extinguisher mounted inside the surgical area entrance be available. CO2 does not leave a residue on the patient, staff, or equipment nor is it harmful to the patient. The fire extinguisher can put out small fires on cloth, plastic, paper, burning liquid or electrically energized fires.

Because fires start quickly and reaction time is so immediate, fire blankets are not recommended by the ECRI or JCAHO. Fire blankets must be removed from the wall, unfolded, and applied to the patient. The blankets can also trap gases that can feed the fire and displace sharp instruments into the patient or trap fire next to the patient causing more severe burns. Responses should be documented into policy and practiced in drills.

In case of fire, most surgical facilities utilize fire extinguisher using the P.A.S.S. procedure. P.A.S.S. stands for (P) pull pin, (A) aim at base of fire, (S) squeeze extinguisher handle, and (S) sweep nozzle across fire.

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**TRAINING MODULE QUIZ**

**Electrosurgery: Safety Considerations**

Instructions: Select the best answer for each question. Record your answers on the Quiz Form at the bottom of the Registration Form.

1. Electrosurgery is used in what percent of all surgical procedures?
   a. 20%
   b. 40%
   c. 60%
   d. 80%

2. In electrosurgery, the patient is part of the electric circuit.
   a. True
   b. False

3. Harmful concentrations of chemical by-products can be eliminated from entering surgical staff respiratory systems by using one of the following.
   a. a larger electrosurgical generator
   b. a high filtration surgical mask
   c. a smoke evacuation system
   d. a high filtration surgical mask used with a smoke evacuation system

4. The three factors associated with the Fire Triangle are contributors to surgical fires. All fires require ______, ______, and ______.
   a. smoke, alcohol, and oxygen
   b. ignition sources, fuel, and water
   c. fumes, sparks, and air
   d. fuel, ignition sources, and oxygen
**BURNS**

Most site burns received during an electrosurgical procedure can be attributed to misuse of the ESU. Unintentional or avoidable burns are probably the most dangerous hazard associated with electrosurgery. These burns can happen directly at the active electrode site or at an alternate site. Burns can come directly from contact with electrical wires or indirectly from overheated wires. First, second, and third degree burns occur when too much current flow is applied to a small area for too long a period.

Capacitive coupling (active electrode electricity transferred through intact insulation to nearby conductive items, such as trocars or tissues), damaged insulation, improper handling of ESU accessories and flammable solutions cause most burns during ESU. Direct coupling (electrical transfer of energy from an active electrode that contacts directly with a noninsulated metal instrument that is inside the surgical field) is responsible for more burns than capacitive coupling. (See also page 4.)

To reduce the risk of capacitive or direct coupling, the use of active electrode monitoring is recommended. This technology reduces stray electrical burns by adding electrical shields combined with an electronic current monitor. Other ways to reduce electrical burns includes the following:

- Inspect all active electrodes for insulation damage before use
- Avoid contact with metal instruments when using an active electrode
- Use bipolar probes when possible.

**Electric shock**

Shock or low frequency electrocution can occur via the ESU’s input power. These hazards are attributed to faults in the unit or because the patient is connected directly to the ground through the dispersive pad. Precautions include keeping the cord, plug and sockets dry, ESU maintenance checks and proper placement and use of dispersive pads.

**Dispersive electrode (grounding pad)**

The use of a grounding pad (dispersive electrode) is recommended to reduce the risk of injury during monopolar surgery. Audible and visual alarms on the ESU indicate potential problems in placement, connection or use. The following steps using the grounding pad should be taken:
Inspect and document the skin area on the patient where the pad is being placed.

Be aware of skin-to-skin contact, contact pathways from metal or jewelry or stray radio frequency currents.

Avoid placing the pad over bony prominences, on top of burned, scarred or hairy tissue or distal to the tourniquet.

Place the pad over a large area of skin, close to the operative site after the patient is positioned on the surgical table.

Glove burns
When an electrode is activated too soon or a forceps is not in contact with the tissue, the current can actually develop strong heat that can penetrate both natural and synthetic latex gloves and cause burns to the surgeons’ hands.

Some steps that can be taken to avoid painful glove burns include:

- Check for proper connections of the electrodes and switches. Also check ESU setup avoiding cable loops.
- Use only the accessories manufactured for that particular ESU.
- Use insulated forceps.
- Apply active electrode to the tissue. During coagulation apply forceps first and then activate.
- The integrity of the glove decreases with oils from the hands and contact with liquids. Change gloves regularly during electrosurgery.

Electrode cords
Radio frequency leakage can pass through the cord of an electrosurgical device that is secured with a metal clamp. Coiled cable can become damaged and expose the insulation. These things can allow alternate current pathways leaving the electrode. Stray current can lead to patient and staff burns. It is good practice to avoid metal clips and sharp objects from coming in contact with cords and prevent cords from coiling during the procedure. Always inspect cords before and after each electrosurgery.

Automatic implantable cardiac defibrillators (AICD)
Patients that have an AICD device implanted must have that device deactivated before an electrosurgical procedure. The possibility of an electrical shock is prominent when the AICD is not deactivated. It is recommended that additional safety precautions such as having a defibrillator readily available and having continuous EKG monitoring be used.

Special considerations for Pacemakers
Special safety considerations should also be observed when using electrosurgery on a patient with a Pacemaker. These steps, combined with ESU and PACemaker manufacturers’ recommendations, can help to eliminate patient burns or patient vitals’ instability.

- Set the ESU to the bipolar mode and power settings.
- Place dispersive electrode as close to surgical site as possible but distal to the Pacemaker site.
- Avoid activating ESU at a rate close to the patient’s heart rate.
- Closely monitor the patient’s ECG during the procedure.

Other ESU-related safety issues
Other safety issues such as design error or labeling error, device failure, improper maintenance, testing, or failure to perform a proper incoming inspection should be considered. Safety issues related to the user can include failure to read labels, not understanding and properly using automated ESU features, incorrect surgical use and incorrect ESU control settings. Proper training and electrosurgical knowledge are key to electrosurgery safety.

SUMMARY
 Responsibility during electrosurgical procedures can alleviate hazards related to fires and burns. This booklet outlines the main contributors to electrosurgical fires and burns which includes the fire triangle elements and unsafe surgical practices. It also makes recommendations released by medical authoritative agencies that will assist in the awareness of electrosurgical safety hazards. Understanding, practicing, and reporting failures surrounding electrosurgery can greatly improve the safety procedures practiced by the surgical team and their medical facilities. Additional knowledge in reference to the ESU’s functionality, electrical shock and arc, input power and ESU frequency electrocution would be valuable in the broader understanding of electrosurgical safety. Additional references are available through the FDA, ECRI, AORN, JCAHO and other medical agencies and organizations.
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**NOTED**

AORN, Recommended Practices for Electrosurgery.

ECRI, Health Focus on Preventing Fires During Surgery. ECRI Press

Medical Devices; Current Good Manufacturing Practices (CGMP); Final
Rule. Department of Health and Human Services. Food and Drug
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