

Recommended Practices for Electrosurgery

The following Recommended Practices for Electrosurgery were developed by the AORN Recommended Practices Committee and have been approved by the AORN Board of Directors. They were presented as proposed recommendations for comments by members and others. They are effective July 1, 2009. These recommended practices are intended as achievable recommendations representing what is believed to be an optimal level of practice. Policies and procedures will reflect variations in practice settings and/or clinical situations that determine the degree to which the recommended practices can be implemented. AORN recognizes the various settings in which perioperative nurses practice. These recommended practices are intended as guidelines adaptable to various practice settings. These practice settings include traditional operating rooms (ORs), ambulatory surgery centers, physicians' offices, cardiac catheterization laboratories, endoscopy suites, radiology departments, and all other areas where surgery and other invasive procedures may be performed.

Purpose

These recommended practices provide guidance to perioperative nurses in the use and care of electrosurgical equipment, including high frequency, ultrasound, and argon beam modalities. Proper care and handling of electrosurgical equipment are essential to patient and personnel safety. Electrosurgery, using high frequency (ie, radio frequency) electrical current, is used routinely to cut, coagulate, dissect, ablate, and shrink body tissue. Ultrasonic dissectors fragment tissue by vibration. Vessel sealing devices use a combination of pressure and heat to permanently fuse vessels and tissue. These recommended practices address all of these technologies and do not endorse any specific product.

Recommendation I

Personnel selecting new and refurbished electrosurgical units (ESUs) and accessories for purchase or use should make decisions based on safety features to minimize risks to patients and personnel.

ESUs and accessories are high-risk medical devices. Minimum safety standards for ESU systems have been developed by the Association for the Advancement of Medical Instrumentation (AAMI), approved by the American National Stan-

dards Institute (ANSI), and the International Electrotechnical Commission (IEC).¹

- I.a. ESUs and accessories should be selected based on safety features that minimize patient and personnel injury.²

Historically, the most frequently reported patient injury has been a skin injury (eg, burn) at the dispersive electrode site.² The risk of this type of injury has been minimized through advances in dispersive pad design and the use of return electrode contact quality monitoring.^{2,3}

- I.b. ESUs and accessories should be selected to include technology that minimizes the risk of alternate site injuries.

These injuries can result from use of ground-referenced (ie, spark-gap) ESUs that allow electrical current to seek alternate pathways to complete the circuit.^{1,4} The use of isolated generator ESUs has minimized this risk.³

- I.c. ESUs and accessories should be selected to include technology that minimizes or eliminates the risk of insulation failure and capacitive coupling injuries.

During minimally invasive procedures, alternate site injuries have resulted from insulation failure and capacitive coupling.^{2,4,6-9} These injuries are far more serious than skin burns and have increased in number with the increased use of minimally invasive surgery.¹⁰ Active electrode monitoring, active electrode insulation integrity testers, active electrode indicator shafts, and visual inspection minimize these risks.^{7,9,11-14}

- I.d. ESUs and accessories should be designed to minimize the risk of unintentional activation.

Unintentional activation has resulted in patient and personnel injuries. Unintentional ESU activation has been reported as the cause of 56% of alternate site injuries.^{2,13} Audible activation tones minimize this risk.^{1,15-17}

- I.e. Electrosurgical accessories should be compatible with the ESU.

Injuries have resulted when an ESU accessory intended for bipolar use was inserted into monopolar connectors and

subsequently activated.¹ Appropriate matching and use of accessories specific to the ESU minimizes this risk.

- I.f. Health care organizations should attempt to standardize electrosurgical equipment used within the facility.
Equipment standardization reduces the risk of error.¹⁸

Recommendation II

The ESU should be used in a manner that minimizes the potential for injuries.

Electrosurgical units are high-risk equipment.¹ Potential complications of electrosurgery include patient injuries, user injuries, fires, and electromagnetic interference with other medical equipment and internal electronic devices.² Electrosurgery safety is heightened by adhering to good practices.¹⁸ Adverse events (eg, patient burns and fires) may be reduced by adhering to basic principles of electrosurgery safety.¹⁵

- II.a. Instructions for ESU use, warranties, and a manual for maintenance and inspections should be obtained from the manufacturer and be readily available to users.^{2,19}
Equipment manuals assist in developing operational, safety, and maintenance guidelines, as well as serve as a reference for appropriate use.¹⁹
- II.a.1. Concise, clearly readable operating instructions specific for the device should be on or attached to each ESU.¹⁹
Readily available instructions reduce the risk of operator error.
- II.b. The ESU should be securely mounted on a tip-resistant cart or shelf and should not be used as a shelf or table.
- II.c. The ESU should be protected from liquids.¹⁹
Liquids entering the ESU can cause unintentional activation, device failure, or an electrical hazard.
- II.c.1. Liquids should not be placed on top of the ESU.
- II.c.2. Foot pedal accessories should be encased in a clean, impervious cover when there is potential for fluid spills on the floor.

- II.d. Safety and warning alarms and activation indicators should be operational, audible, and visible at all times.^{1,16-18,20}

Safety and warning alarms alert the operator to potential electrode failure.³ The indicators and alarms immediately alert the perioperative team when the ESU is activated.^{4,18}

- II.e. The ESU should be visually inspected and the return electrode monitor tested according to manufacturer's instructions before use.^{19,20}

The ESU will sound an alarm and not activate if the dispersive electrode is disconnected.^{2,20}

- II.f. Settings should be based on the operator's preference consistent with the intended application and the manufacturer's written instructions for patient size, active electrode type, and return electrode placement.

The ESU's power output capability is dependent on multiple variables related to the patient, generator, accessories, and the procedure.

- II.f.1. The circulating nurse should confirm the power settings with the operator before activation of the ESU.

- II.f.2. The ESU should be operated at the lowest effective power setting needed to achieve the desired tissue effect.^{2,18,20-22}

The likelihood of arcing and capacitive coupling are increased when higher than necessary voltages are used.²²

- II.f.3. If the operator requests a continual increase in power, personnel should check the entire ESU and accessories circuit for adequate placement of the dispersive electrode and cord connections.^{18,19,23}

Prolonged current at high power can cause patient injury. Common causes of ineffective coagulation and cutting are high impedance at the dispersive electrode, poor contact between the dispersive electrode and the patient, and use of an electrolytic irrigation/distention solution.^{23,24}

- II.f.4. The electrode tip should be visually inspected before each use and replaced if damaged.

A damaged active electrode tip may cause a buildup of eschar, creating

increased resistance at the electrode tip. Cleaning a stainless steel tip with an abrasive pad or instrument may create grooves where eschar can collect.²²

- II.g. Perioperative registered nurses should be aware of potential patient safety hazards associated with specific internal implanted electronic devices (IEDs) and the appropriate patient care interventions required to protect the patient from injury.²⁵

Electronic devices implanted in a patient may be affected by other IEDs or medical equipment with which a patient may come into contact in a health care facility. These devices may include cardiac pacemakers, implanted cardioverter defibrillators (ICDs), neurostimulators, implantable hearing devices, implantable infusion pumps, and osteogenic stimulators.²³

- II.h. After use, personnel should
 - turn off the ESU;
 - dispose of single use items;
 - clean all reusable parts and accessories according to the manufacturer’s directions; and
 - inspect accessories and parts for damage, function, and cleanliness.

Following the manufacturer’s cleaning and inspection instructions promotes safe and proper functioning of the equipment.

- II.i. An ESU that is not working properly or is damaged should be removed from service immediately and reported to the designated individual responsible for equipment maintenance (eg, bioengineering services personnel).^{18,19,26}

Medical device users are required to report serious injury and death related to use of a device to the Federal Drug Administration (FDA).²⁶

Recommendation III

The electrical cords and plugs of the ESU should be handled in a manner that minimizes the potential for damage and subsequent patient and user injuries.

Improper handling of cords and plugs may result in breaks in the cord’s insulation, fraying, and other electrical hazards.

- III.a. The ESU’s electrical cord should be adequate in length and flexibility to reach the electrical outlet without stress or the use of an extension cord.¹⁹

Tension on the electrical cord increases the risk that it will become disconnected, frayed, or move the equipment, which may result in injuries to patients and personnel.

- III.a.1. The ESU should be placed near the sterile field, and the cord should reach the wall or column outlet without stress on the cord and without blocking a traffic path.¹⁹

Stress on the cord may cause damage to the cord, posing an electrical hazard.

- III.a.2. The electrical cord should be free of kinks, knots, and bends.

Kinks, knots, and bends could damage the cord or cause leakage, current accumulation, and overheating of the cord’s insulation.

- III.a.3. The ESU plug, not the cord, should be held when it is removed from the outlet.

Pulling on the cord may cause cord breakage, which poses a fire hazard.

- III.a.4. The ESU’s cord should be kept dry.¹⁹

Fluids in or around the ESU connections and cord may cause an electrical hazard as a result of a short circuit.

- III.b. The ESU’s cord should be inspected or electrically tested for outer insulation damage.¹⁹

Cord failures can result in a fire or patient and personnel injuries.

- III.b.1. The ESU should be removed from use if there is any evidence of breaks, nicks, or cracks in the outer insulation coating of the electrical cord.¹⁹

Recommendation IV

The active electrode should be used in a manner that minimizes the potential for injuries.

Incomplete circuitry, unintentional activation, and incompatibility of the active electrode to the ESU may result in patient and personnel injuries.^{16,27}

- IV.a. The active electrode should be visually inspected at the surgical field before use. Inspection should include but is not limited to

- identifying any apparent damage to the cord or hand piece (eg, impaired insulation),¹⁹ and
 - ensuring compatibility of the active electrode, accessories, the ESU, and the procedure.
Insulation failures allow an alternate pathway for current to leave the electrode and may result in an electrical shock or other injury.
- IV.a.1. A damaged and/or incompatible active electrode, accessory, or ESU should be immediately removed from use.
- IV.b. When not in use, the active electrode should be placed in a clean, dry, non-conductive safety holster.^{2,15,22,28} A plastic or other non-conductive device should be used to secure the active electrode cord to the sterile drapes.²²
Use of a non-conductive safety holster prevents the active electrode from falling off the sterile field and unintentional activation. Unintentional activation of the active electrode may cause burns of the patient, drapes, or personnel.^{2,15}
- IV.b.1. The protective cap of a battery-powered, hand-held cautery should be in place when the cautery is not in use.^{29,30}
Application of the protective cap prevents unintended pressure on the activation button.^{29,30}
- IV.c. The electrode cord should be kept free of kinks and coils during use.
Kinks, knots, and bends could damage the cord, cause current leakage or accumulation, overheat the cord's insulation, or produce unanticipated changes in the surgical effect. "Hot spots" or field intensification are produced by coiling cables. Keeping the cords free of kinks and coils minimizes the risk of patient or personnel injury from conduction of stray current and capacitive current.²¹
- IV.d. The active electrode should be connected directly into a designated receptacle on the ESU.
Incompatibility of the active electrode with the ESU may result in patient and personnel injuries.
- IV.d.1. When needed, only adaptors approved by the manufacturers of both the ESU and the accessory should be used.
- IV.e. Only the user of the active electrode should activate the device whether it is hand or foot controlled.^{20,28}
Activation by the user of the active electrode prevents unintentional discharge of the device to minimize potential for patient and personnel injury.
- IV.f. Active electrode tips should be used according to the manufacturer's instructions.
Failure to use the active electrode as outlined in the manufacturer's directions for use have resulted in patient injuries and surgical fires.³¹⁻³⁴
- IV.f.1. The active electrode tip
- should be compatible with the ESU,
 - should be securely seated into the hand piece, and
 - should not be altered.³⁴
- A loose electrode tip may cause a spark or burn tissue that comes in contact with the exposed, non-insulated section of the tip.^{31,34} Bending the tip can damage the device and alter the desired function. Fires and patient injuries have resulted when insulating sheaths have been made from inappropriate material (eg, rubber catheters).^{32,33}
- IV.g. The active electrode tip should be cleaned away from the incision whenever there is visible eschar.³²
Eschar buildup on the active electrode tip impedes the desired current flow, causing the entire unit to function less effectively and serving as a fuel source, which can lead to fires.³² Debris on the electrode tip can tear tissue, cause re-bleeding, and serve as a foreign body when deposited in the wound.²²
- IV.g.1. Methods to remove debris from the active electrode tip should include but are not limited to
- a moistened sponge or instrument wipe to clean non-stick coated electro-surgical tips on the sterile field,^{16,32} and
 - abrasive electrode cleaning pads to remove eschar from non-coated electrodes on the sterile field.³²

- IV.g.2. The active electrode tip should not be cleaned with a scalpel blade.
Cleaning with a scalpel blade puts perioperative personnel at risk for a percutaneous injury.³⁵
- IV.h. If the active electrode becomes contaminated, it should be disconnected from the ESU and removed from the sterile field.
Disconnection of the contaminated active electrode minimizes the risk of unintentional activation and reduces the potential for patient and personnel injuries.¹⁶
- IV.i. If an active monopolar electrode is being used in a fluid-filled cavity, the fluid used should be an electrically inert, near isotonic solution (eg, dextran 10, dextran 70, glycine 1.5%, sorbitol, mannitol) unless the equipment manufacturer's written directions for use instruct otherwise.^{2,24}
Using an electrolyte solution instead of a nonconductive medium may render the active electrode less effective. Electrolyte solutions conduct and disperse the electrical current away from the intended site.^{18,24}
- IV.j. Fire safety measures should be followed when electrosurgery is in use according to local, state, and federal regulations.^{36,37}
- IV.j.1. Active electrodes should not be activated in the presence of flammable agents (eg, antimicrobial skin prep or hand antiseptic agents, tinctures, de-fatting agents, collodion, petroleum-based lubricants, phenol, aerosol adhesives, uncured methyl methacrylate) until the agents are dry and vapors have dissipated.^{2,38-42}
Alcohol-based prep agents remain flammable until completely dry. Vapors occurring during evaporation also are flammable. Trapping of solution or vapors under incise or surgical drapes increases the risk of fire or burn injury. Alcohol-based skin prep agents are particularly hazardous because the surrounding hair or fabric can become saturated. Pooling can occur in body folds and crevices (eg, umbilicus, sternal notch). Ignition of flammable substances by active electrodes has caused fires and patient injuries. Flammable prep agents can be safely used by adhering to NFPA standards, local fire codes, and AORN recommendations and guidance statements. Use of nonflammable prep agents will minimize this risk.^{16,42-46}
- IV.j.2. Caution should be used during surgery on the head and neck when using an active electrode in the presence of combustible anesthetic gases.^{2,44,47}
- IV.j.3. Opened suture packets containing alcohol should be removed from the sterile field as soon as possible.¹⁶
Ignition of flammable substances by an active electrode has caused fires and patient injuries.^{16,43}
- IV.k. Sponges used near the active electrode tip should be moist to prevent unintentional ignition.^{32,47,48}
Fires have resulted from ignition of dry sponges near the incision site.^{16,49,50}
- IV.l. When battery-powered, hand-held cautery units are used, the batteries should be removed before disposal of the cautery unit.³⁰
Unintentional activation of a battery-powered, hand-held cautery unit after disposal has caused fires.^{29,30}
- IV.m. Electrosurgery should not be used in the presence of gastrointestinal gases.
Gastrointestinal gases contain hydrogen and methane, which are highly flammable. Fires and patient injuries have occurred.^{16,28,40,51,52}
- IV.n. Electrosurgery should not be used in an oxygen-enriched environment.^{28,32,53-55}
An oxygen-enriched environment lowers the temperature and energy at which fuels will ignite.^{28,48} Fires, including airway fires, have resulted from the active electrode sparking in the presence of concentrated oxygen.^{2,16,53,54}
- IV.n.1. The lowest possible oxygen concentration that provides adequate patient oxygen saturation should be used.^{47,48}
Mixing oxygen with nonflammable gases such as medical air reduces the risk of fire.^{16,47}
- IV.n.2. Surgical drapes should be arranged to minimize the buildup of oxidizers

(eg, oxygen and nitrous oxide) under the drapes, to allow air circulation, and to dilute the additional oxygen.^{16,47,48}

- IV.n.3. The active electrode should be used as far from the oxygen source as possible.
- IV.o. Personnel should be prepared to immediately extinguish flames should they occur.^{16,47}

A small fire can progress to a life threatening emergency of a large fire in seconds.¹⁶ ESUs are a potential ignition source and a common cause of surgical fires and patient injury.²⁸
- IV.o.1. Nonflammable material (eg, wet towel, sterile saline, water) should be available on the sterile field to extinguish the fire.^{16,28}

Recommendation V

When monopolar electrosurgery is used, a dispersive electrode should be used in a manner that minimizes the potential for injuries.

Patient skin injuries at the dispersive electrode site are the most reported ESU incidents.² Single use dispersive electrode burns are decreasing with improved technology and the use of safety features. The reports of electrosurgical burns has decreased from 50 to 100 per month in the 1970s to one to two per month in 2007.²

- V.a. The patient's skin condition should be assessed and documented before and after ESU use.

The most frequently reported patient injury from electrosurgery has been tissue damage (eg, burn) at the dispersive electrode site.² Preoperative and postoperative assessments are necessary to evaluate the patient's skin condition for possible injuries.
- V.b. Return-electrode contact quality monitoring should be furnished on general purpose electrosurgery units.¹⁸

The technology of return-electrode contact quality monitoring inhibits the output of the ESU if the return electrode is not in contact with the patient and connected to the ESU. Return-electrode contact quality monitoring confirms that there is adequate contact between the return electrode and the patient. An audible alarm and visual indicator signals the user of a misconnection.^{2,18}

- V.b.1. Dual-foil return electrodes should be used.¹⁸

Dual-foil return electrodes are necessary for contact quality monitoring.¹⁸ The return electrode contact quality monitoring system determines differences in impedance through patient's tissue between the two surfaces. If the impedance is too high as a result of poor contact, the alarm is triggered and the ESU stops functioning.²

- V.c. Return-electrode continuity monitoring should be used if return-electrode contact quality monitoring is not available.

Return-electrode continuity monitoring detects breaks in the return-electrode cord or a misconnection (ie, the cord is not plugged into the ESU).^{2,19}
- V.c.1. If using return-electrode continuity monitoring, a single-foil electrode should be used.²
- V.d. Dispersive electrodes should be compatible with the ESU.

Incompatibility of the electrosurgical unit and the dispersive electrode may result in patient injury.
- V.e. A single-use dispersive electrode should be used once and discarded. If a single-use dispersive electrode must be repositioned, a new single-use electrode should be used.^{23,26}

A reused single-use electrode may not adhere properly to the skin. Replacing the dispersive electrode provides an opportunity to examine the electrode and the patient's skin condition.
- V.f. Dispersive electrodes should be an appropriate size for the patient (eg, neonate, infant, pediatric, adult) and not altered (eg, cut, folded).

Using the appropriately sized dispersive electrode reduces the concentration of current and minimizes the potential for electrosurgical injuries.
- V.g. Before the application of a single-use dispersive electrode
 - the manufacturer's expiration date should be verified and the dispersive electrode

- should not be used if it is past the manufacturer's expiration date;²⁰
- the package containing the dispersive electrode should be opened immediately before use;¹⁹ and
 - the integrity of the dispersive electrode should be checked for flaws, damage, discoloration, adhesiveness, and dryness.^{18, 20, 23, 37}
- Expired, damaged, or dry single-use dispersive electrodes may fail and lead to patient injury.
- V.h. The conductive and adhesive surfaces of the single-use dispersive electrode should be placed on clean, dry skin over a large, well-perfused muscle mass on the surgical side and as close as possible to the surgical site according to the manufacturer's directions for use.^{19, 20}
- Muscle is a better conductor of electricity than adipose tissue.²³
- V.h.1. Single-use electrodes should not be placed over bony prominences, scar tissue, hair, weight-bearing surfaces, potential pressure points, or areas distal to tourniquets.^{5, 18, 19, 23, 58}
- Fatty tissue, tissue over bone, scar tissue, and hair can impede electrosurgical return current flow.⁵⁹ High impedance leads to heating of the tissue, arcing to the tissue under the dispersive electrode, and subsequent burns. Adequate tissue perfusion cannot be assured if the dispersive electrode is placed distal to tourniquets or over scar tissue.²³
- V.h.2. Hair should be removed following recommended practices (ie, clipping) if it interferes with single-use electrode contact with the patient's skin.^{18, 20, 60}
- Burns have resulted when electrodes have been positioned over hairy surfaces. Hair can impede electrosurgical return current flow. Hair may interfere with adequate contact between the patient and the dispersive electrode.^{23, 58, 61}
- V.h.3. The single-use electrode should not be placed over an implanted metal prosthesis.
- The tissue over prostheses contains scar tissue, which impedes return of the electric current. Although there has been no reported injury from superheating of the implant causing a tissue burn, this is a theoretical risk; therefore, it is prudent to avoid placing a dispersive electrode on the patient's skin over the site of a metal implant or prosthesis.
- V.h.4. Placing the single-use dispersive electrode over a tattoo, many of which contain metallic dyes, should be avoided.
- Although there have been no reported electrosurgery injuries from dispersive electrodes placed over tattoos, superheating of the tissue has occurred during magnetic resonance imaging. There is a theoretical possibility of this also happening with electrosurgery.⁶²⁻⁶⁴
- V.i. Following application of the single-use dispersive electrode, uniform contact with the skin should be verified.
- Injuries have been associated with inadequate adhesion of the dispersive electrode. Potential problems include tenting, gapping, and moisture, all of which interfere with adhesion to the patient's skin.⁶⁵⁻⁶⁷
- V.i.1. Corrective measures for poor single-use dispersive electrode contact include, but are not limited to
- removing oil, lotion, moisture, or prep solution;
 - removing excessive hair;
 - changing sites; and
 - applying a new pad.
- V.i.2. Tape should not be used to hold the single-use dispersive electrode in place.
- Taping the dispersive electrode may create localized pressure and increase the current concentration leading to a potential injury.⁶⁸
- V.j. The single-use dispersive electrode should be placed on the patient after final positioning.
- Moving the patient after the application of the dispersive electrode may disrupt the contact to the patient's skin causing tenting, gapping, or moisture collection under the electrode. Injuries have been associated with inadequate contact of the dispersive electrode.^{19, 65-67}

- V.j.1. If any tension is applied to the dispersive electrode cord, the perioperative registered nurse should reassess the integrity of the dispersive electrode, its contact with the patient's skin, and the connection to the ESU.
- V.j.2. If the patient is repositioned, the perioperative registered nurse should verify that the dispersive electrode is in full contact with the patient's skin.
Inadequate contact of the dispersive electrode may result in a burn.^{65,67}
- V.k. The single-use dispersive electrode should be placed away from a warming device.^{65,67}
The heat of a warming device may be cumulative with the heating of the dispersive electrode and may affect how the dispersive electrode adheres to the skin.^{65,67}
- V.l. Dispersive electrodes should be kept dry and protected from fluids seeping or pooling under the electrode.²³
Liquids may prevent the electrode from adequately contacting the skin. These solutions also can cause skin injury and burns from prolonged skin exposure and concentration of electrical current.⁵⁷
- V.m. Contact between the patient and metal devices should be avoided.^{69,70}
Metal devices (eg, OR beds, stirrups, positioning devices, safety strap buckles) could offer a potential alternate return path for the electrical current.^{69,70}
- V.m.1. Patient's metal jewelry that is between the active and dispersive electrode should be removed.
Metallic jewelry, including body piercings, presents a potential risk of burn from directed current (ie, active electrode contact); heat conducted before an electrode cools; and leakage current. Eliminating metal near the activation site minimizes this risk. Jewelry that is left in place, particularly on the hands, has the potential to cause swelling at the site during surgery or recovery.¹⁵
- V.m.2. Patient monitoring electrodes (eg, electrocardiogram, oximetry, fetal) should be placed as far away from the surgical site as possible.²¹
- V.m.3. Needle electrodes for monitoring or non-surgical functions should be avoided.^{18,21}
Stray current may flow through the small contact area of the needle electrode causing a potential alternate pathway and risk of patient burn.^{18,21,71,72}
- V.m.4. When use of needle monitoring electrodes is medically necessary, alternate electrosurgery technologies (eg, bipolar, laser) should be considered.^{18,73}
- V.n. When multiple ESUs are used simultaneously during a surgical procedure, the compatibility of equipment and proper functioning of corresponding electrode monitoring systems should be verified with the manufacturer.
- V.n.1. Separate single-use dispersive electrodes should be used for each ESU.
- V.n.2. The dispersive electrodes should be placed as close as possible to their respective surgical sites and the single-use dispersive electrodes should not overlap.
- V.o. During high-current, long-activation-time, radio-frequency (RF) ablations and other electrosurgical procedures (eg, tumor ablation, bulk tissue resection), considerations should include, but not be limited to
- identifying surgical procedures that require the use of high-current, long-activation-time RF ablation and electrosurgical techniques;
 - taking inventory of RF generators that require special or multiple dispersive electrodes;
 - following the manufacturer's recommendations for use of large-size dispersive electrodes or multiple dispersive electrodes;
 - ensuring proper placement and full patient contact of the dispersive electrode;
 - reviewing the manufacturer's directions for use and requirements for accessories;
 - using and selecting the appropriate non-conductive, near-isotonic solution (eg, sorbitol, mannitol, dextran 10 or 70,
- Alternate pathway burns have been reported at electrocardiogram (ECG) electrode sites and temperature probe entry sites with ground-referenced electrosurgery units.¹⁹

glycine) for irrigation or distention unless contraindicated by manufacturer's directions; and

- using the lowest possible power settings and minimum activation time for obtaining the desired tissue effect.^{2,24,74}

There is an increased risk of dispersive electrode site burns with high-current, long-activation-time procedures.^{2,61,74-76}

- V.o.1. When high current is not adequately dispersed by a single dispersive electrode and there are no specific manufacturer's directions, a second dispersive electrode with an adaptor or a return electrode with a larger conductive surface may be considered for use.^{24,74}

A second dispersive electrode or a larger conductive surface increases the overall dispersive pad surface area for current to return to the generator.⁷⁴

- V.p. When removing the single-use dispersive electrode, the adjacent skin should be held in place and the dispersive electrode peeled back slowly.

Slowly removing the dispersive electrode will avoid denuding the surface of the skin. Skin injuries can result when the adhesive border pulls on the skin during electrode removal.⁷⁷

- V.q. Reusable, capacitive-coupled return electrode systems should be used according to manufacturers' written instructions for safe operation in conjunction with a compatible ESU.

- V.q.1. Capacitive-coupling pads should be an appropriate size for the patient (ie, adult, pediatric).^{28,79}

- V.q.2. Skin preparation should not be performed unless otherwise recommended by the manufacturer's written directions.²⁸

- V.q.3. Adequate contact with the patient should be ensured by using minimal materials between the capacitive-coupled pad and patient.²⁹ The use of thick foam, gel pads, and extra linen between the patient and the capacitive-coupling pad should be avoided.

Distance and barriers (eg, positioning devices) between the patient and

electrode may increase the risk of impedance, which can result in an alternate site injury when using a capacitive-coupling pad.⁷⁸

- V.q.4. An isolated generator should be used.⁷⁸

Use of a ground-referenced or grounded generators may cause a ground fault alarm.

- V.q.5. The pad should be cleaned with the health care facility-approved and EPA-registered agent if contaminated with blood or body fluids in accordance with the manufacturer's directions. Acceptable cleaning solutions include a bleach solution diluted 1:10 and o-phenylphenol, o-benzyl-p-chlorophenol, or p-tertiary amylphenol.⁷⁸

- V.q.6. The integrity of the capacitive-coupled pad and cables should be checked for tears or breaks in the surface material before use, and

- pad cables should be replaced if damaged,
- surface damage may be repaired with the manufacturer's repair kit, and
- the pad should be replaced if superficial damage cannot be repaired.

- V.q.7. When two ESUs are used, two capacitive-coupled pads or one capacitive-coupled pad with two cords should be used.

- V.q.8. The pad should be replaced on its labeled expiration date.⁷⁸

Recommendation VI

Personnel should take additional precautions when using electrosurgery during minimally invasive surgery.^{18,80}

Minimally invasive surgery procedures using electrosurgery present unique patient safety risks, such as direct coupling of current, insulation failure, and capacitive coupling.

- VI.a. Personnel should verify that the insufflation gas is nonflammable (ie, carbon dioxide).⁸¹

Carbon dioxide is noncombustible and will not ignite if the active electrosurgical electrode sparks.⁸¹ Gases (eg, oxygen, nitrous oxide, air) are oxidizers that may support combustion. An oxidizer-enriched

environment may enhance ignition and combustion.²⁸

- VI.b. Conductive trocar systems should be used.^{7,8,11,82}
Conductive trocar cannulas provide a means for the electrosurgical current to flow safely between the cannula and the abdominal wall. This reduces high density current concentration and heating of non-target tissue.^{7,8,11,82}
- VI.b.1. Hybrid trocar (ie, combination plastic and metal) systems should not be used.^{8,82,83}
Each trocar and cannula can act as an electrical conductor inducing an electrical current from one to the other potentially causing a capacitive coupling injury.
- VI.c. Minimally invasive surgery electrodes should be examined for impaired insulation before use.^{11,83-85}
Insulation failure of electrodes caused by damage during use or reprocessing provides an alternate pathway for the electrical current to leave the active electrode. Some insulation failures are not visible. This has resulted in serious patient injuries.^{4,7,8,11-13,85}
- VI.c.1. Methods should be used to detect insulation failure, including but not limited to
- active electrode shielding and monitoring,^{11,14}
 - the use of active electrode indicator shafts that have two layers of insulation of different colors,¹¹ and
 - the use of active electrode insulation integrity testers that use high DC voltage to detect full thickness insulation breaks.¹¹
- Active electrode shielding continuously monitors the endoscopic instruments to minimize the risks of insulation failure or capacitive-coupling injuries.^{4,7,9,12-14,83}
The inner layer of the active electrode shaft of a different color is designed to show through the outer black layer if there is an insulation break.¹¹
Testing of the electrode before the procedure identifies damaged electrodes that should be taken out of service. Testing of the electrode with the sterilizable probes and cables alerts the surgeon of an insu-

lation break. The surgical field can be explored and treated if necessary.^{11,85}

- VI.c.2. The lowest power setting that achieves the desired result should be selected.⁸³
Lower power settings for both cut and coagulation reduce the likelihood of insulation failure and capacitive-coupling injuries. Lower power settings also minimize damage from direct coupling when the active electrode is activated while in close proximity to another metal device inserted into an adjacent trocar port.⁷
- VI.d. The active electrode should not be activated until it is in close proximity to the tissue.^{7,8}
Activation only when in close proximity to the tissue minimizes the risk of current arcing and contacting unintended tissue.^{7,8} Activating the electrode when it is not in very close proximity to the targeted tissue increases the risk of capacitive coupling. Capacitance is reduced during closed-circuit activation.
- VI.e. Patients should be instructed to immediately report any postoperative signs or symptoms of electrosurgical injury. Patient postoperative care instructions should include symptoms to look for, including but not limited to
- fever,
 - inability to void,
 - lower gastrointestinal bleeding,
 - abdominal pain,
 - abdominal distention,
 - nausea,
 - vomiting, and
 - diarrhea.^{8,86}
- Symptoms of a minimally invasive electrosurgical injury can occur days after discharge from the perioperative setting and may include infection from an injured intestinal tract. Prompt reporting of electrosurgical injury symptoms ensures timely treatment and minimizes adverse outcomes.^{8,84}

Recommendation VII

Bipolar active electrodes, including vessel occluding devices, should be used in a manner that minimizes the potential for injuries.

Unlike the monopolar ESU, bipolar technology incorporates an active electrode and a return electrode

into a two-poled instrument, such as forceps or scissors.^{6,19,33} Current flows only through the tissue contacted between two poles of the instruments; thus, the need for a dispersive electrode is eliminated.¹⁹ This also eliminates the chance of stray or alternate pathways for current flow.¹⁹ The bipolar ESU provides precise hemostasis or dissection at the surgical site with less potential stimulation or current spread to nearby body structures.¹⁹

- VII.a. Molded, fixed-position pin placement bipolar cords should be used. Bipolar and monopolar plugs should be differentiated to prevent misconnections of active and return electrodes.^{1,27}

Connection of a bipolar active electrode to a monopolar receptacle may activate current, causing a short circuit.

Recommendation VIII

Ultrasonic electrosurgical devices should be used in a manner that minimizes potential for injuries.

Ultrasonic devices have a generator that produces ultrasonic energy and mechanical vibrations rather than electrical energy. Ultrasonic instruments cut and coagulate by using the mechanical energy and heat that is generated to cause protein denaturation and the formation of a coagulum. A blade or probe can be used for sharp or blunt dissection, coagulation, or breaking apart of tissue without damaging adjacent tissues. Some ultrasonic dissectors incorporate an aspirator to remove tissue or fluids from the surgical field.^{83,87}

- VIII.a. When using an ultrasonic electrosurgical device, a dispersive electrode should not be used.

With an ultrasonic electrosurgical device, no electrical current enters the tissue; therefore, the current does not need to be returned to the generator by a dispersive electrode.^{83,87}

- VIII.b. Inhalation of aerosols generated by an ultrasonic electrosurgical hand piece should be minimized by implementing control measures, including but not limited to smoke evacuation systems and wall suction with an in-line ultra low penetration air (ULPA) filter.

Bio-aerosols are routinely produced by ultrasonic devices and pose a hazard to patients and perioperative professionals.

Bio-aerosols contain odorless, toxic gases; vapors; dead and live cellular debris, including blood fragments; and viruses. These airborne contaminants can pose respiratory, ocular, dermatological, and other health-related risks, including mutagenic and carcinogenic potential, to patients and OR personnel. Wall suction with an in-line ULPA filter is only appropriate for a minimal amount of aerosol (ie, aerosols generated using ultrasonic electrosurgery are within the respirable range and include blood, blood by-products, and tissue).⁸⁸

Recommendation IX

Argon enhanced coagulation (AEC) technology poses unique risks to patient and personnel safety and should be used in a manner that minimizes the potential for injury.

Each type of AEC has specific manufacturer's written operating instructions to be followed for safe operation of the unit.

- IX.a. All safety measures for monopolar electrosurgery should be used when using AEC technology.

The AEC unit uses monopolar alternating current delivered to the tissue through ionized argon gas.⁸⁹ The risks of monopolar electrosurgery are present.

- IX.b. Air should be purged from the argon gas line and electrode by activating the system before use, after moderate delays between activations, and between uses.^{2,89,90}

Purging the argon gas line prevents delays in coagulation, minimizing the risk of gas embolism.⁸⁹ Activating without adequately purging may present the greatest risk of embolism when operating in an open cavity.⁸⁹

- IX.c. The argon gas flow should be limited to the lowest level possible that will provide the desired clinical effect.^{2,90}

Argon gas flow is most likely to be directed to tissue without simultaneous coagulation when the initiation of ionization of the argon gas is delayed due to air bubbles in the argon gas line.⁸⁹

- IX.d. The active electrode should not be placed in direct contact with tissue and should be

moved away from the patient's tissue after each activation.^{89,90}

There is a risk of gas emboli when the active electrode is placed in direct contact with tissue. If argon gas pressure exceeds venous pressure in the circulating system and is applied to bleeding vessels, the result is a gas emboli in open surgical procedures.^{2,90,91} The flow of argon gas could enter the open vessel and enter the heart.²

- IX.e. When using the AEC unit during minimally invasive surgical procedures, personnel should follow all safety measures identified for AEC technology.

Patient injury and death have occurred as a complication of argon enhanced technology.⁹⁰

- IX.e.1. Endoscopic CO₂ insufflators should be equipped with audible and visual over-pressurization alarms that cannot be deactivated.^{2,90}

The AEC acts as a secondary source of pressurized argon gas that can cause the patient's intra-abdominal pressure to rise rapidly and exceed venous pressure, possibly creating argon-enriched gas emboli formation. This has resulted in gas emboli.⁹⁰

- IX.e.2. The active electrode and argon gas line should be purged according to the manufacturer's recommendations.^{2,90}

- IX.e.3. The patient's intra-abdominal cavity should be flushed with several liters of CO₂ between extended activation periods.⁹⁰

Flushing the intra-abdominal cavity with several liters of CO₂ between extended periods of deactivation reduces the potential for argon gas emboli formation.⁹⁰

- IX.f. Personnel using the AEC technology should be knowledgeable about signs, symptoms, and treatment of venous emboli.

There is a significant risk of gas embolism when AEC is used during laparoscopic procedures from abdominal over-pressurization and displacement of CO₂ by argon gas.⁹⁰

- IX.f.1. Patient monitoring should include devices that are considered effective for early detection of gas emboli (eg, end-tidal CO₂).^{2,90}

Recommendation X

Potential hazards associated with surgical smoke generated in the practice setting should be identified, and safe practices established.

Surgical smoke (ie, plume) is generated from use of heat-producing instruments such as electro-surgical devices. Airborne contaminants produced during electrosurgery have been analyzed. The electrosurgery plume contains toxic gas and vapors (eg, benzene, hydrogen cyanide, formaldehyde); bio-aerosols; dead and living cell material, including blood fragments; and viruses.⁹²⁻⁹⁴ Many additional hazardous chemical compounds have been noted in surgical smoke.^{92,95-98}

At some level, these contaminants have been shown to have an unpleasant odor, cause problems with visibility of the surgical site, cause ocular and upper respiratory tract irritation, and demonstrate mutagenic and carcinogenic potential.^{92,93,99} The possibility for bacterial and/or viral contamination of smoke plume remains controversial, but has been highlighted by different studies.^{100,101}

The National Institute of Occupational Safety and Health (NIOSH) recommends that smoke evacuation systems be used to reduce potential acute and chronic health risks to personnel and patients.⁹² The Occupational Safety and Health Administration (OSHA) has no separate standard related to surgical smoke. OSHA addresses such safety hazards in the General Duty Clause and Bloodborne Pathogens Standard.⁹⁷

- X.a. Surgical smoke should be removed by use of a smoke evacuation system in both open and laparoscopic procedures.

Potential health and liability risks may be reduced by the evacuation of smoke plume.⁹³

- X.a.1. When large amounts of plume are generated, an individual smoke evacuation unit with a ULPA filter should be used to remove surgical smoke.

- X.a.2. The suction wand of the smoke evacuation system should be no greater than two inches (5.08 cm) from the source of the smoke generation.^{92,93}

Close proximity of the smoke evacuation wand maximizes particulate matter and odor capture and enhances visibility at the surgical site.⁹⁹

X.a.3. Smoke evacuation units and accessories should be used according to manufacturers' written instructions.

Detectable odor during the use of a smoke evacuation system is a signal that

- smoke is not being captured at the site where the plume is being generated,
- inefficient air movement through the suction or smoke evacuation wand is occurring, or
- the filter has exceeded its usefulness and should be replaced.⁹³

X.a.4. When a minimal amount of plume is generated, a central suction system with an in-line ULPA filter may be used to evacuate the plume.⁹² The in-line filter should be placed between the suction wall/ceiling connection and the suction canister.⁹⁹

Central suction units are designed to capture liquids and should not be used without an in-line ULPA filter to remove airborne contaminants.⁹² Low suction rates associated with centralized suction units limit their efficiency in evacuating plume, making them suitable only for the evacuation of small amounts of plume.⁹⁴

X.a.5. When a centralized system dedicated for smoke evacuation is available, the smoke evacuator lines should be flushed according to the manufacturer's instructions to ensure particulate matter buildup does not occur.

Plume particulate can accumulate in the lumens of the centralized system causing decreased suction capability and potential pathogen growth.

X.b. Used smoke evacuator filters, tubing, and wands should be disposed of as potentially infectious waste following standard precautions.^{93,99}

Airborne contaminants produced during electrosurgery or laser procedures have been analyzed and are shown to contain gaseous toxic compounds, bio-aerosols, and dead and living cell material. At some level, these contaminants have been shown to have an unpleasant odor, cause visual problems for

physicians, cause ocular and upper respiratory tract irritation, and demonstrate mutagenic and carcinogenic potential.⁹⁹ The possibility for bacterial and/or viral contamination of smoke plume remains controversial but has been highlighted by different studies.^{100,101}

X.c. Personnel should wear high-filtration surgical masks during procedures that generate surgical smoke.

High-filtration masks are specifically designed to filter particulate matter that is 0.1 micron in size and larger which may protect against residual plume in the air that has escaped smoke evacuation capture.⁹⁵ These masks should not be viewed as absolute protection from chemical or particulate contaminants found in surgical smoke and should not be used as the first line of protection against surgical smoke inhalation.^{95,99}

Recommendation XI

Personnel should receive initial education and competency validation on procedures and should receive additional training when new equipment, instruments, supplies, or procedures are introduced.

Initial education on the underlying principles of electrosurgical safety provides direction for personnel in providing a safe environment. Additional, periodic educational programs provide reinforcement of principles of electrosurgery and new information on changes in technology, its application, compatibility of equipment and accessories, and potential hazards.

Electrosurgical equipment and accessories have been associated with numerous fires and patient injuries.^{2,8,19,53} The National Fire Protection Association has identified ESUs as high-risk equipment, warranting training and retraining of personnel.¹⁹

XI.a. Personnel working with electrosurgery equipment should be knowledgeable about the principles of electrosurgery, risks to patients and personnel, measures to minimize these risks, and corrective actions to employ in the event of a fire or injury.¹⁹

Electrosurgical equipment and accessories have been associated with numerous fires and patient injuries.^{2,8}

XI.b. Personnel should be instructed on the proper operation, care, and handling of the ESU and accessories before use.¹⁹

Incorrect use can result in serious injury to patients and personnel.

- XI.b.1. If multiple types of electrosurgical equipment are used within the facility, training should be provided on all of the equipment.¹⁸
- XI.c. Personnel should be instructed in the risks of electrosurgery during minimally invasive surgical procedures.
Direct coupling is the result of touching the laparoscopic active electrode to another anatomic structure. This can cause necrosis of underlying tissue. Insulation failure of the laparoscopic electrode can be caused by trauma during use or reprocessing. Current leaves the electrode through this alternate pathway. This can cause serious patient injury, particularly when the injury is internal. Capacitive-coupled RF currents can cause undetected burns to nearby tissue and organs outside the endoscope's viewing field. Severe patient injuries have resulted.⁸
- XI.d. Perioperative registered nurses should be knowledgeable about the types of IEDs that may be encountered in the practice setting, and the precautions that must be taken when caring for patients with these devices.²⁵
Electronic devices implanted in a patient may be affected by other IEDs or medical equipment with which a patient may come into contact in a health care facility.
- XI.e. Administrative personnel should assess and document annual competency of personnel in the safe use of the ESU and accessories.
A competency assessment provides a record that personnel have basic understanding of electrosurgery, its risks, and appropriate corrective actions to take in the event of a fire or injury. This knowledge is essential to minimize the risks of misuse of the equipment and to provide a safe environment of care.

Recommendation XII

Documentation should be completed to enable the identification of trends and demonstrate compliance with regulatory and accrediting agency requirements.

Documentation of all nursing activities performed is legally and professionally important for clear communication and collaboration between health care team members and for continuity of patient care.

- XII.a. Documentation using the PNDS should include a patient assessment, a plan of care, nursing diagnoses, identification of desired outcomes, interventions, and an evaluation of the patient's response to the care provided.
Documentation provides communication among all care providers involved in planning and implementing patient care.
- XII.b. Documentation should be recorded in a manner consistent with health care organization policies and procedures and should include, but is not limited to
- electrosurgical system identification serial number;¹⁰²
 - range of settings used;
 - dispersive electrode placement;
 - patient's skin condition before dispersive electrode placement;
 - patient's skin condition after removal of dispersive electrode;¹⁰²
 - adjunct electrosurgical devices used (eg, ultrasonic scalpel, bipolar forceps); and
 - safety holster use.¹⁸

Recommendation XIII

Policies and procedures for electrosurgery should be developed, reviewed periodically, revised as necessary, and readily available in the practice setting.

Policies and procedures assist in the development of patient safety, quality assessment, and improvement activities. Policies and procedures establish authority, responsibility, and accountability within the facility. They also serve as operational guidelines that are used to minimize patient risk factors, standardize practice, direct staff members, and establish guidelines for continuous performance improvement activities.

- XIII.a. The health care organization's policies and procedures for electrosurgery must be in compliance with the Safe Medical Devices Act of 1990, amended in March 2000.²⁶
- XIII.a.1. When patient or personnel injuries or equipment failures occur, the ESU

should be removed from service and the active and dispersive electrodes retained if possible.¹⁰²

Retaining the ESU, the active and dispersive electrodes, and packaging allows for a complete systems check to determine electrosurgical system integrity.¹⁰²

- XIII.a.2. Incidents of patient or personnel electrical injury or equipment failure should be reported as required by regulation to federal, state, and local authorities and to the equipment manufacturer.¹⁰² Device identification, maintenance and service information, as well as adverse event information should be included in the report from the practice setting.

Documentation of details of the electrosurgical equipment and supplies allows for retrievable information for investigation into an adverse event.¹⁰²

- XIII.b. Policies and procedures for electrosurgery should include, but are not limited to the following:

- safety features required on ESUs;
- equipment maintenance programs;
- required supplemental safety monitors;
- equipment checks before initial use;
- reporting and impounding malfunctioning equipment;
- reporting of injuries;
- preoperative, intraoperative, and postoperative patient assessments;
- precautions during use;
- ESU sanitation; and
- documentation.

- XIII.c. An introduction and review of policies and procedures for electrosurgery should be included in orientation and ongoing education of personnel to assist in the development of knowledge, skills, and attitudes that affect surgical patient outcomes.

Review of policies and procedures assists health care professionals in the development of knowledge, skills, and attitudes that affect patient outcomes.

- XIII.d. A written fire prevention and management policy and procedure should be developed by a multidisciplinary group that includes all categories of perioperative personnel.^{18,36}

Fire is a risk to both patients and health care workers in the perioperative setting.

- XIII.d.1. The policy and procedure should describe processes to be implemented to safely manage different fire scenarios.

Recommendation XIV

A quality assurance/performance improvement process should be in place that measures patient, process, and structural (eg, system) outcome indicators.

A fundamental precept of AORN is that it is the responsibility of professional perioperative registered nurses to ensure safe, high-quality nursing care to patients undergoing surgical and invasive procedures.¹⁰³

- XIV.a. Structure, process, and clinical outcomes performance measures should be identified that can be used to improve patient care and that also monitor compliance with facility policy and procedure, national standards, and regulatory requirements.¹⁰⁴

- XIV.a.1. Process indicators may include, but are not limited to information about adverse patient outcomes and near misses associated with electrosurgery, which should be collected, analyzed, and used for performance improvement.¹⁰³

- XIV.b. Electrosurgical devices should be tested before initial use, inspected periodically, and receive preventive maintenance by a designated individual responsible for equipment maintenance (eg, biomedical engineering services personnel).¹⁹

Periodic preventative maintenance ensures continued safe operation of electrosurgical devices.¹⁹

- XIV.c. Each ESU should be assigned an identification or serial number.

This number allows designated personnel to track function problems and document maintenance performed on individual ESUs.

- XIV.d. Each health care organization should be responsible for staying abreast of evolving technology that may impact patient care and safety.

Electrosurgical technology continues to evolve, changing the way in which surgical hemostasis is achieved.

Glossary

Active electrode: The electrosurgical unit (ESU) accessory that directs current flow to the surgical site (eg, pencils, various pencil tips).

Active electrode indicator shaft: An active electrode composed of two layers of insulated material of different colors. The inner layer is a bright color, the outer layer is black. When the bright colored inner layer is evident upon visual inspection, a break in the insulation is indicated.

Active electrode insulation testing: Devices designed to test the integrity of the insulation surrounding the conductive shaft of laparoscopic electrosurgical active-electrode instruments. The devices detect full thickness breaks in the insulation layer.

Active electrode monitoring: A dynamic process of searching for insulation failures and capacitive coupling during monopolar surgery. If the monitor detects an unsafe level of stray energy, it signals the generator to deactivate.

Alternate site injury: Patient injury caused by an electrosurgical device that occurs away from the dispersive electrode site.

Argon-enhanced coagulation: Radio frequency coagulation from an electrosurgical generator that is capable of delivering monopolar current through a flow of ionized argon gas.

Bioengineering services personnel: Those individuals in an institution who are trained and qualified to check, troubleshoot, and repair medical equipment.

Bipolar electrosurgery: Electrosurgery in which current flows between two tips of a bipolar forceps that are positioned around tissue to create a surgical effect. Current passes from the active electrode of one tip of the forceps through the patient's desired tissue to the other dispersive electrode tip of the forceps—thus completing the circuit without entering another part of the patient's body.

Capacitance: Ability of an electrical circuit to transfer an electrical charge from one conductor to another, even when separated by an insulator.

Capacitive coupling: Transfer of electrical current from the active electrode through intact insulation to adjacent conductive items (eg, tissue, trocars).

Capacitively coupled return electrode: A large, nonadhesive return electrode placed close to and forming a capacitor with the patient, returning electrical current from the patient back to the electrosurgical unit (ESU).

Current: A movement of electrons analogous to the flow of a stream of water.

Direct coupling: The contact of an energized active electrode tip with another metal instrument or object within the surgical field.

Dispersive electrode: The accessory that directs electrical current flow from the patient back to the electrosurgical generator—often called the patient plate, return electrode, inactive electrode, or grounding pad.

Dual foil electrode: A dispersive return electrode that has two foil conductive surfaces on a single non-conductive adhesive pad. The two foil surfaces are connected independently through the same return electrode cord to the ESU. The dual foil design allows the return electrode quality monitor to detect impedance differences between the conductive surfaces. If a difference is detected between the two foil surfaces, the ESU will alarm and shut down. Dual foil electrodes are a necessary component of return electrode quality monitoring.

Electrosurgery: The cutting and coagulation of body tissue with a high-frequency (ie, radio frequency) current.

Electrosurgical accessories: The active electrode with tip(s), dispersive electrode, adapters, and connectors to attach these devices to the electrosurgery generator.

Electrosurgical unit: The generator that produces a high-frequency current waveform that is delivered to tissues, the foot switch with cord (if applicable), the electrical plug, cord, and connections.

Endoscopic minimally invasive: Surgical techniques that use endoscopic approaches rather than dissection.

Eschar: Charred tissue residue.

Generator: The machine that produces radio frequency waves (eg, ESU, power unit).

Ground-referenced electrosurgical unit: A system in which electrical current is sent to the patient and follows the path of least resistance back to the ground. This technology, which no longer is manufactured, produces high-frequency, high-voltage current and sometimes is referred to as a “spark gap” unit.

Insulator: A material that does not conduct electricity.

Insulation failure: Damage to the insulation of the active electrode that provides an alternate pathway for the current to leave that electrode as it completes the circuit to the dispersive electrode.

Isolated electrosurgical unit: A system in which electrical current is sent to the patient and selectively returns and is grounded through the generator.

Monopolar electrosurgery: Electrosurgery in which only the active electrode is in the surgical wound, and the electrical current is directed through the patient's body, received by the dispersive pad, and transferred back to the generator, completing the monopolar circuit.

Oxygen-enriched environment: Atmosphere containing more than 21% oxygen, frequently occurring in the oropharynx, trachea, lower respiratory tract, and near the head and neck during administration of oxygen to the patient.

Return electrode continuity monitor: A safety feature of a single foil dispersive electrode that detects an unconnected dispersive electrode or a break in the return electrode cord.

Return-electrode contact quality monitoring: A dynamic monitoring circuit measuring impedance of the dispersive return electrode. If the dispersive electrode becomes compromised, the circuit inhibits the ESU's output.

Ultra low particulate air (ULPA): Theoretically, a ULPA filter can remove from the air 99.9999% of bacteria, dust, pollen, mold, and particles with a size of 120 nanometers or larger.

Ultrasonic scalpel: A cutting/coagulation device that converts electrical energy into mechanical energy, providing a rapid ultrasonic motion.

Vessel sealing device: Bipolar technology that fuses collagen and elastin in the vessel walls and permanently obliterates the lumen of the vessel.

REFERENCES

1. Association for the Advancement of Medical Instrumentation. *ANSI/AAMI HF18:2001. Electrosurgical Devices*. Arlington, VA: Association for the Advancement of Medical Instrumentation; 2001.
2. ECRI. Electrosurgery. *Healthcare Risk Control Risk Analysis*. 2007;4(Surgery and Anesthesia 16).
3. Electrosurgical units. *Health Devices*. 1998;27(3):93-111.
4. Odell RC. Pearls, pitfalls, and advancements in the delivery of electrosurgical energy during laparoscopy. *Problems in General Surgery*. 2002;19(2):5-17.
5. Jones CM, Pierre KB, Nicoud IB, Stain SC, Melvin WV 3rd. Electrosurgery. *Curr Surg*. 2006;63(6):458-463.
6. ECRI. Laparoscopic electrosurgery risks. *Operating Room Risk Management*. 1999;2(Surgery 19):1-11.
7. Guidance section: ensuring monopolar electrosurgical safety during laparoscopy. *Health Devices*. 1995;24(1):20-26.
8. Wu MP, Ou CS, Chen SL, Yen EYT, Rowbotham R. Complications and recommended practices for electrosurgery in laparoscopy. *Am J Surg*. 2000/1;179(1):67-73.
9. Vilos GA, Newton DW, Odell RC, Abu-Rafea B, Vilos AG. Characterization and mitigation of stray radiofrequency currents during monopolar resectoscopic electrosurgery. *J Minim Invasive Gynecol*. 2006;13(2):134-140.

10. Physician Insurers Association of America. *Laparoscopic Injury Study*. Rockville, Md: Physician Insurers Association of America; 2000:1-5.
11. ECRI. Safety technologies for laparoscopic monopolar electrosurgery; devices for managing burn risks. *Health Devices*. 2005;34(8):259-272.
12. Evaluation of Electroscope Electroshield System. *Health Devices*. 1995;24(1):11-19.
13. Dennis V. Implementing active electrode monitoring: a perioperative call. *Ssm*. 2001;7(2):32, 34-38.
14. Harrell GJ, Kopps DR. Minimizing patient risk during laparoscopic electrosurgery. *AORN J*. 1998;67(6):1194-1196.
15. Electrosurgery safety issues. PA-PSRS Patient Safety Advisory. 2006;3(1):1-3.
16. ECRI. The patient is on fire! A surgical fires primer. http://www.mdsr.ecri.org/summary/detail.aspx?doc_id=8197. Accessed November 4, 2009.
17. Burns and fires from electrosurgical active electrodes. *Health Devices*. 1993;22(8-9):421-422.
18. Electrosurgical safety: conducting a safety audit. *Health Devices*. 2005;34(12):414-420.
19. Annex D. The safe use of high-frequency electricity in health care facilities. In: *Health Care Facilities Handbook*. 10th ed. Quincy, MA: National Fire Protection Association; 2005.
20. ECRI Institute. Electrosurgery checklist. *Operating Room Risk Management*. 2007;2(Surgery 10).
21. De Marco M, Maggi S. Evaluation of stray radiofrequency radiation emitted by electrosurgical devices. *Phys Med Biol*. 2006;51(14):3347-3358.
22. Massarweh NN, Cosgriff N, Slakey DP. Electrosurgery: history, principles, and current and future uses. *J Am Coll Surg*. 2006;202(3):520-530.
23. ESU burns from poor dispersive electrode site preparation. *Health Devices*. 1993;22(8-9):422-423.
24. Skin burns resulting from the use of electrolytic distention/irrigation media during electrosurgery with a rollerablation electrode. *Health Devices*. 1998;27(6):233-235.
25. AORN guidance statement: Care of the perioperative patient with an implanted electronic device. In: *Perioperative Standards and Recommended Practices*. Denver, CO: AORN, Inc; 2009:207-228.
26. Food and Drug Administration. Medical device reporting: Manufacturer reporting, importer reporting, user facility reporting, distributor reporting. *Fed Regist*. 2000;65:4112-4121.
27. Misconnection of bipolar electrosurgical electrodes. *Health Devices*. 1995;24(1):34-35.
28. ECRI Institute. Surgical fire safety. *Health Devices*. 2006;35(2):45-46.
29. Center for Devices and Radiological Health. Manufacturer and User Facility Device Experience (MAUDE) Database Adverse Event Report 421908. Reported October 9, 2002. http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfMAUDE/Detail.CFM?MDR_FOI_ID=421908. Accessed November 4, 2009.
30. Fire caused by improper disposal of electrocautery units. *Health Devices*. 1994;23(3):98.
31. Alternate-site burns from improperly seated electrosurgical pencil active electrodes. *Health Devices*. 2000;29(1):24-27.

32. Ignition of debris on active electrosurgical electrodes. *Health Devices*. 1998;27(9-10):367-370.
33. Center for Devices and Radiological Health. Manufacturer and User Facility Device Experience (MAUDE) Database Adverse Event Report 393590. Reported May 7, 2002. http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfMAUDE/Detail.CFM?MDRFOI_ID=393590. Accessed November 4, 2009.
34. ECRI Institute. Hazard report. Improperly seated electrosurgical active electrodes can burn patients. *Health Devices*. 2007;36(10):337-339.
35. AORN guidance statement: sharps injury prevention in the perioperative setting. In: *Perioperative Standards and Recommended Practices*. Denver, CO: AORN, Inc; 2009:275-280.
36. Recommended practices for a safe environment of care. In: *Perioperative Standards and Recommended Practices*. Denver, CO: AORN, Inc; 2009:415-437.
37. AORN guidance statement: fire prevention in the operating room. In: *Perioperative Standards and Recommended Practices*. Denver, CO: AORN, Inc; 2009: 195-203.
38. *NFPA 99 Standard for Health Care Facilities*. Quincy, MA: National Fire Protection Association; 2002: Issue C.13.1.3.2.2:182.
39. A clinician's guide to surgical fires. How they occur, how to prevent them, how to put them out. *Health Devices*. 2003;32(1):5-24.
40. Beesley J, Taylor L. Reducing the risk of surgical fires: are you assessing the risk? *J Perioper Pract*. 2006;16(12):591-597.
41. Tentative interim amendment. In: *NFPA 99 Standard for Health Care Facilities*. Quincy, MA: National Fire Protection Association; 2005: 13.4.1.2.2-A-13.4.1.2.2.3.
42. Fire hazard created by the misuse of DuraPrep solution. *Health Devices*. 1998;27(11):400-402.
43. Center for Devices and Radiological Health. Manufacturer and User Facility Device Experience (MAUDE) Database Adverse Event Report 32071. Reported July 31, 1995. http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfMAUDE/Detail.CFM?MDRFOI_ID=32071. Accessed November 4, 2009.
44. Barker SJ, Polson JS. Fire in the operating room: a case report and laboratory study. *Anesth Analg*. 2001;93(4):960-965.
45. Position statement on fire prevention. http://www.aorn.org/PracticeResources/AORNPositionStatements/Position_FirePrevention/. Accessed November 4, 2009.
46. *Standard for Health Care Facilities Tentative Interim Amendment: Germicides and Antiseptics*. Quincy, MA: National Fire Protection Association; 2005.
47. A Report by the American Society of Anesthesiologists Task Force on Operating Room Fires. Practice Advisory for the Prevention and Management of Operating Room Fires. *Anesthesiology*. 2008;108(5):786-801.
48. ECRI Institute. Surgical fires. *Operating Room Risk Management*. 2006;2(Safety 1):1-18.
49. Center for Devices and Radiological Health. Manufacturer and User Facility Device Experience (MAUDE) Database Adverse Event Report 441523. Reported August 23, 2002. http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfMAUDE/Detail.CFM?MDRFOI_ID=441523. Accessed November 4, 2009.
50. Ortega RA. A rare cause of fire in the operating room. *Anesthesiology*. 1998;89(6):1608.
51. Soussan EB, Mathieu N, Roque I, Antonietti M. Bowel explosion with colonic perforation during argon plasma coagulation for hemorrhagic radiation-induced proctitis. *Gastrointestinal Endoscopy*. 2003;3;57(3): 412-413.
52. Smith C. Home study program. Surgical fires—learn not to burn. *AORN J*. 2004;80(1):23-27, 29-31, 33-4.
53. Smith TL, Smith JM. Electrosurgery in otolaryngology-head and neck surgery: principles, advances, and complications. *Laryngoscope*. 2001;111(5):769-780.
54. Electrosurgical airway fires still a hot topic. *Health Devices*. 1996;25(7):260-262.
55. Manufacturer and User Facility Device Experience (MAUDE) Database. Adverse event report no. 837984: Electrosurgical unit. http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfMAUDE/Detail.CFM?MDRFOI_ID=837984. Accessed November 4, 2009.
56. Manufacturer and User Facility Device Experience (MAUDE) Database. Adverse event report no. 767284: Dispersive electrode. http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfMAUDE/Detail.CFM?MDRFOI_ID=767284. Accessed November 4, 2009.
57. Demir E, O'Dey DM, Pallua N. Accidental burns during surgery. *J Burn Care Res*. 2006;27(6):895-900.
58. Center for Devices and Radiological Health. Manufacturer and User Facility Device Experience (MAUDE) Database Adverse Event Report 523194. Reported March 31, 2004. http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfMAUDE/Detail.CFM?MDRFOI_ID=523194. Accessed November 4, 2009.
59. Manufacturer and User Facility Device Experience (MAUDE) Database Search. Adverse event report no. 115111: Dispersive electrode. http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfMAUDE/Detail.CFM?MDRFOI_ID=115111. Accessed November 4, 2009.
60. Recommended practices for preoperative patient skin antisepsis. In: *Perioperative Standards and Recommended Practices*. Denver, CO: AORN, Inc; 2009: 549-568.
61. Manufacturer and User Facility Device Experience (MAUDE) Database. Adverse event report no. 1021169: Grounding plate. http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfMAUDE/Detail.CFM?MDRFOI_ID=1021169. Accessed November 4, 2009.
62. Ratnapalan S, Greenberg M, Armstrong D. Tattoos and MRI. *AJR Am J Roentgenol*. 2004;183(2):541.
63. Franiel T, Schmidt S, Klingebiel R. First-degree burns on MRI due to nonferrous tattoos. *AJR Am J Roentgenol*. 2006;187(5):W556.
64. Wagle WA, Smith M. Tattoo-induced skin burn during MR imaging. *Am J Roentgenol*. 2000;174(6):1795.
65. Center for Devices and Radiological Health. Manufacturer and User Facility Device Experience (MAUDE) Database Adverse Event Report 495428. Reported October 15, 2003. http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfMAUDE/Detail.CFM?MDRFOI_ID=495428. Accessed November 4, 2009.
66. Center for Devices and Radiological Health. Manufacturer and User Facility Device Experience (MAUDE) Database Adverse Event Report 499965.

- Reported November 25, 2003. http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfMAUDE/Detail.CFM?MDRFOI_ID=499965. Accessed November 4, 2009.
67. Center for Devices and Radiological Health. Manufacturer and User Facility Device Experience (MAUDE) Database Adverse Event Report 516905. Reported February 16, 2004. http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfMAUDE/Detail.CFM?MDRFOI_ID=516905. Accessed November 4, 2009.
68. Manufacturer and User Facility Device Experience (MAUDE) Database. Adverse event report no. 851317: Dispersive electrode. http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfMAUDE/Detail.CFM?MDRFOI_ID=851317. Accessed November 4, 2009.
69. Center for Devices and Radiological Health. Manufacturer and User Facility Device Experience (MAUDE) Database Adverse Event Report 286226. Reported July 6, 2002. http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfMAUDE/Detail.CFM?MDRFOI_ID=286226. Accessed November 4, 2009.
70. Center for Devices and Radiological Health. Manufacturer and User Facility Device Experience (MAUDE) Database Adverse Event Report 396295. Reported May 16, 2002. http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfMAUDE/Detail.CFM?MDRFOI_ID=396295. Accessed November 4, 2009.
71. Russell MJ, Gaetz M. Intraoperative electrode burns. *J Clin Monit Comput*. 2004;18(1):25-32.
72. Stecker MM, Patterson T, Netherton BL. Mechanisms of electrode induced injury. Part 1: theory. *Am J Electroneurodiagnostic Technol*. 2006;46(4):315-342.
73. Patterson T, Stecker MM, Netherton BL. Mechanisms of electrode induced injury. Part 2: Clinical experience. *Am J Electroneurodiagnostic Technol*. 2007;47(2):93-113.
74. ECRI Institute. Higher currents, greater risks: preventing patient burns at the return-electrode site during high-current electrosurgical procedures. *Health Devices*. 2005;34(8):273-279.
75. Manufacturer and User Facility Device Experience (MAUDE) Database. Adverse event report no. 1069874: REM PolyHesive II electrode, ESU, dispersive. http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfMAUDE/Detail.CFM?MDRFOI_ID=1069874. Accessed November 4, 2009.
76. Manufacturer and User Facility Device Experience (MAUDE) Database. Adverse event report no. 907879: Generator. http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfMAUDE/Detail.CFM?MDRFOI_ID=907879. Accessed November 4, 2009.
77. Skin lesions from aggressive adhesive on Valleylab electrosurgical return electrode pads. *Health Devices*. 1995;24(4):159-160.
78. MegaDyne Mega 2000 return electrode. *Health Devices*. 2000;29(12):445-460.
79. Center for Devices and Radiological Health. Manufacturer and User Facility Device Experience (MAUDE) Database Adverse Event Report 401617. Reported June 24, 2002. http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfMAUDE/Detail.CFM?MDRFOI_ID=401617. Accessed November 4, 2009.
80. Recommended practices for endoscopic minimally invasive surgery. In: *Perioperative Standards and Recommended Practices*. Denver, CO: AORN, Inc; 2009:347-359.
81. Greilich PE, Greilich NB, Froelich EG. Intra-abdominal fire during laparoscopic cholecystectomy. See comment. *Anesthesiology*. 1995;83(4):871-874.
82. Tucker RD, Voyles CR, Silvis SE. Capacitive coupled stray currents during laparoscopic and endoscopic electrosurgical procedures. *Biomed Instrum Technol*. 1992;26(4):303-311.
83. Wang K, Advincula AP. "Current thoughts" in electrosurgery. *Int J Gynaecol Obstet*. 2007;97(3):245-250.
84. Shirk GJ, Johns A, Redwine DB. Complications of laparoscopic surgery: how to avoid them and how to repair them. *J Minim Invasive Gynecol*. 2006;13(4):352-359.
85. Yazdani A, Krause H. Laparoscopic instrument insulation failure: the hidden hazard. *J Minim Invasive Gynecol*. 2007;14(2):228-232.
86. Brunner LS, Suddarth DS, Smeltzer SCO, Cheever K, eds. Management of patients with intestinal and rectal disorders. In: *Brunner & Suddarth's Textbook of Medical-Surgical Nursing*. 11th ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2008:1231-1281.
87. McCarus SD. Physiologic mechanism of the ultrasonically activated scalpel. *J Am Assoc Gynecol Laparosc*. 1996;3(4):601-608.
88. Ott DE, Moss E, Martinez K. Aerosol exposure from an ultrasonically activated (Harmonic) device. *J Am Assoc Gynecol Laparosc*. 1998;5(1):29-32.
89. Matthews K. Argon beam coagulation. New directions in surgery. *AORN J*. 1992;56(5):885-889.
90. Fatal gas embolism caused by overpressurization during laparoscopic use of argon enhanced coagulation. *Health Devices*. 1994;23(6):257-259.
91. Veyskemans F, Michel I. Venous gas embolism from an Argon coagulator. *Anesthesiology*. 1996;85(2):443-444.
92. National Institute for Occupational Safety and Health. NIOSH Hazard Control/Control of Smoke From Laser/Electric Surgical Procedures-HC11. <http://www.cdc.gov/niosh/hc11.html>. Accessed November 4, 2009.
93. ECRI Institute. Smoke evacuation systems, surgical. *Healthcare Product Comparison System*. 2007.
94. Ball K. *Lasers : The Perioperative Challenge*. Denver, CO: AORN, Inc; 2004.
95. Ulmer BC. The hazards of surgical smoke. *AORN J*. 2008;87(4):721-738.
96. Hoglan M. Potential hazards from electrosurgery plume—recommendations for surgical smoke evacuation. *Can Oper Room Nurs J*. 1995;13(4):10-16.
97. US Department of Labor Occupational Safety and Health Administration. Safety and Health Topics: Laser/Electrosurgery Plume. <http://www.osha.gov/SLTC/laserelectrosurgeryplume/index.html>. Accessed November 4, 2009.
98. Alp E, Bijl D, Bleichrodt RP, Hansson B, Voss A. Surgical smoke and infection control. *J Hosp Infect*. 2006;62(1):1-5
99. American National Standards Institute. Safe use of lasers in health care facilities. Orlando, FL: Laser Institute of America; 2005.
100. Garden JM, O'Banion MK, Shelnitz LS, et al. Papillomavirus in the vapor of carbon dioxide laser-treated verrucae. *JAMA*. 1988;259(8):1199-1202.

101. Hallmo P, Naess O. Laryngeal papillomatosis with human papillomavirus DNA contracted by a laser surgeon. *Eur Arch Otorhinolaryngol*. 1991;248(7):425-427.

102. ECRI Institute. Investigating device-related skin "burns". *Operating Room Risk Management*. 2(3):1-10.

103. Quality and performance improvement standards for perioperative nursing. In: *Perioperative Standards and Recommended Practices*. Denver, CO: AORN, Inc; 2009:65-74.

104. Improving organization performance. In: *Comprehensive Accreditation Manual for Hospitals: The Official Handbook*. Oakbrook Terrace, IL: Joint Commission on Accreditation of Healthcare Organizations; 2007:PI-8-PI-9.

Acknowledgements

LEAD AUTHOR

Mary Ogg, RN, MSN, CNOR

Perioperative Nursing Specialist
AORN Center for Nursing Practice
Denver, Colorado

CONTRIBUTING AUTHOR

Cecil A. King, MS, RN, CNOR

Perioperative Clinical Educator
Cape Cod Hospital
Hyannis, Massachusetts

PUBLICATION HISTORY

Originally published March 1985, *AORN Journal*.
Revised April 1991; revised July 1993.

Revised November 1997; published January 1998, *AORN Journal*. Reformatted July 2000.

Revised November 2003; published February 2004, *AORN Journal*.

Revised November 2004; published in *Standards, Recommended Practices, and Guidelines*, 2005 edition. Reprinted March 2005, *AORN Journal*.

Revised July 2009 for online publication in *Perioperative Standards and Recommended Practices*.

Minor editing revisions made in November 2009 for publication in *Perioperative Standards and Recommended Practices*, 2010 edition.