

Patient Safety Tip of the Week

July 28, 2020 Electrosurgical Safety

Electrosurgery and electrocautery are handy processes in the OR and are used in a variety of surgical procedures. Yet, complications related to electrosurgery are not uncommon. In our many columns on **surgical fires** and the “fire triangle” we’ve noted that electrosurgical devices are the heat source in over 90% of cases. And, electrosurgical devices are also one of the most common causes of **iatrogenic burns**. And, in our June 12, 2102 Patient Safety Tip of the Week “[Lessons Learned from the CDPH: Retained Foreign Bodies](#)” we noted that cautery tips are also one of the most common **surgical items inadvertently retained**. Some studies have also identified **hemorrhage** and **mechanical failure** as adverse consequences of electrosurgery. Some may produce electromagnetic interference that might **interfere with implanted medical devices**. Lastly, these devices are primary causes of **surgical smoke**, which may have deleterious effects on those present in the OR.

Though we usually lump electrocautery and electrosurgery together, they are technically not the same thing ([Mir 2017](#)). In electrocautery, current does not pass through the patient, whereas in electrosurgery there is passage of high frequency alternating electrical current through living tissue to achieve varying degrees of tissue destruction. Also, electrosurgery produces electromagnetic interference and, thus, can interfere with implanted medical devices. But, for the rest of today’s column, we’ll continue lump electrocautery and electrosurgery together.

Overbey et al ([Overbey 2015](#)) searched the FDA’s Manufacturer and User Facility Device Experience (MAUDE) database for surgical energy-based device injuries and deaths reported over a 20 year period. They analyzed 178 deaths and 3,553 injuries. The most common complications were: thermal burns (63%), hemorrhage (17%), mechanical failure of device (12%), and fire (8%). While most events were identified intraoperatively, 9% were identified postoperatively and 9% after discharge. Thermal injury was the most common reason for death (39% of the 178 deaths). Mechanisms for thermal injury were direct application (30%), dispersive electrode burn (29%), and insulation failure (14%). Regarding surgical fires, they were most common with monopolar “Bovie”, especially when they were used in head and neck operations.

Burns and thermal injuries. Thermal burns are obviously the most frequent complication of electrocautery and electrosurgery, but there are several mechanisms for such thermal injuries. Our September 5, 2017 Patient Safety Tip of the Week “[Another](#)

[Iatrogenic Burn](#)” discussed in detail thermal burns related to electrosurgery or electrocautery. We began with a case reported by the California Department of Public Health ([CDPH 2017](#)) in which a patient undergoing bilateral knee replacement surgery suffered a full-thickness thermal injury, related to an electrocautery device that had been set down on the patient without holstering it. See that column for details of the case.

Mundinger et al. ([Mundinger 2007](#)) noted that intraoperative electrocautery burns can be divided into at least 4 categories:

1. direct contact burns resulting from inappropriate operator use of the active electrode
2. burns at the grounding electrode site due to improper attachment or placement
3. burns resulting from electrode heating of pooled solutions
4. burns occurring outside the operative field as a result of circuits generated between the active electrode and an alternate grounding source

Of course, the fifth category would be burns resulting from surgical fires triggered by electrosurgical devices in an oxygen-rich environment.

The above CDPH case is an example of a **direct contact burn** related to failure to holster the electrocautery device and subsequent contact with a patient’s skin. Burns more commonly can develop related to current flow when monopolar electrocautery devices are used. Saaiq et al. ([Saaiq 2012](#)) reported on 3 cases of full-thickness deep burns related to the grounding pad of electrocautery systems. All 3 of their cases involved use of monopolar cautery and **improper placement of the grounding electrode**. The authors note that when the grounding pad is misapplied and loose, this may cause heat generation and sparking at the contact site, without providing an appropriate exit for the current to pass safely through the circuit. Saaiq et al. had the following recommendations:

- The surgeon himself should have a proactive attitude and personally ensure that the grounding pad is adequately applied with firm contact to the skin over an adequate surface area
- Preferably it should be secured to the skin with a crepe bandage
- An area of at least 70 cm² of firm skin-pad contact should be ensured
- Special care should be exercised to re-check the position of the pad if the patient’s position is changed intraoperatively
- One may employ the newer grounding pads with adhesive properties that firmly attach them to skin
- The diathermy machine’s active alarm system will also help to limit the extent of the resultant burn injury
- If a bipolar cautery is employed the risk of grounding pad burns can be eliminated altogether

The authors also note that the **electrical current can also run between the active electrode and an alternate grounding source**. They note the case described by Mundinger et al. ([Mundinger 2007](#)) in which a patient had the grounding pad on her lateral thigh but burns occurred on her forehead related to titanium plates previously implanted in her skull. Mundinger et al. also noted that burns resulting from aberrant circuits have been reported at sites of electrocardiographic lead placement, temperature

probe insertion, uninsulated surgical table contact with the patient, intra-arterial line placement, motor-evoked potential monitoring electrode placement, and electroencephalogram electrode placement. That's pretty scary! How many people would even consider the potential impact of remote hardware in or on a patient's body?

Mundinger et al. note that similar burns at sites of contact remote from the operative field and the normal grounding pad may occur on areas of uninsulated surgical table contacting the patient, electrocardiographic leads, temperature probe insertion sites, and sites of placement of various other monitoring devices.

While many thermal injuries from electrosurgery occur on the surface or in the direct visual field of the operator, don't lose sight of the fact that **thermal injuries related to electrocautery devices can also occur internally during surgery**. Such are well known to structures such as bowel and ureters. Such injuries are **often not recognized during the procedure** and result in tissue necrosis and delayed manifestations of symptoms. In fact, most electrothermal injuries to the bowel (approximately 75%) are unrecognized at the time of occurrence ([Alkatout 2012](#)). The result of an unrecognized bowel injury is usually serious, often leading to long-term complications. Alkatout et al. note that small bowel, especially the ileum, is most frequently involved, and the injury may not cause clear cut or rapid symptoms or abnormal laboratory values. Generally speaking, symptoms of bowel perforation following electrothermal injury are usually seen 4 to 10 days after the procedure.

Kaya et al. ([Kaya 2016](#)) also described iatrogenic burns related to electrocautery devices. The authors discussed the differences between the two types of electrocautery, namely "unipolar" (or "monopolar") and "bipolar,". They made the following recommendations:

- The patient should be examined for any metal implants, and any jewelry should be removed.
- The plates to be used must be of suitable size for the surface area and must fully contact the patient's skin surface.
- The plate must be placed close to the surgery site, on a smooth, hairless, clean, dry, and well-vascularized muscle.
- The plate must be properly placed on the patient before the surgery and should be regularly checked in long-lasting procedures, and measures such as cold compression should be taken in case of temperature increase.
- Cut and burn settings of the cautery are of further importance. Cut and burn settings of the cautery device should be verified prior to the procedure by both the surgeon and the OR team.
- Necessary information should be given to the healthcare staff about the installation and connections of the equipment, proper placement of the cautery plate, monitoring of the plate during the procedure, and aspects that need the attention of the user.

A 2018 FDA communication with recommendations to reduce surgical fires also had several good recommendations related to electrosurgical devices in general ([FDA 2018](#)). It recommended all instruments should be inspected for evidence of insulation failure

(device, wires, and connections) prior to use. Those with defects should not be used. It noted that monopolar energy use can directly result in unintended patient burns from capacitive coupling and intra-operative insulation failure. So, it had specific recommendations if a monopolar electro-surgical units (ESU) is used:

- Do not activate when near or in contact with other instruments.
- Use a return electrode monitoring system.
- Tips of cautery instruments should be kept clean and free of char and tissue.
- When not in use, place ignition sources, such as ESU's, electrocautery devices, fiber-optic illumination light sources and lasers in a designated area away from the patient (e.g., in a holster or a safety cover) and not directly on the patient or surgical drapes.

Insulation failure. Another common issue with electro-surgical devices is insulation failure. Small amounts of current can leak through tiny breaks and minute cracks in the instrument's shaft ([Bilski 2020](#)). Then, current can stray from the intended energy path, causing small electrical burns to non-targeted tissue and cause thermal injury. Such defects have been found in up to 20% of laparoscopic instruments and up to 50% of instruments used during robotic surgery. Disposable instruments have a lower incidence of insulation failure compared with reusable instruments ([Alkatout 2012](#)). The distal third of laparoscopic instruments is the most common site of insulation failure. Obviously, meticulous inspection of electro-surgical instruments should be undertaken before every use. The instruments should also be tested before use.

Surgical smoke is a concern any time electro-surgery is used. The smoke generated during electro-surgical procedures can potentially contain viruses (such as HPV), bacteria, cancer cells, hazardous chemicals, and other fine, particulate matter. In the COVID-19 pandemic era, we'd also be concerned that coronavirus might also be aerosolized in surgical smoke, though it is not yet known whether that happens ([AORN 2020a](#)). It's recommended you use smoke evacuation systems and fit-tested surgical N95 masks during procedures in which electro-surgery is used. The AORN Go Clear Award Program ([AORN 2020b](#)) has numerous resources and recommendations about surgical smoke generated by electro-surgery devices and any other type of device.

Surgical fires. We've, of course, discussed electro-surgical devices extensively in our many columns on surgical fires (see list below). They are the heat source in over 90% of surgical fires. The most important intervention needed is good communication between the surgeon and the anesthesiologist. The surgeon must announce in advance his/her intent to use the electrocautery/electro-surgery device so that the anesthesiologist can temporarily halt the flow of oxygen while a heat source is about to be used. Similarly, good communication with nursing staff is important to ensure that any alcohol-based skin disinfectant has had adequate time to dry before use of the electro-surgical device.

Electromagnetic interference. Lastly, we mentioned that some electro-surgical devices produce electromagnetic interference and, thus, can interfere with implanted medical devices. It is always wise to know what implantable medical devices your patient may have and whether use of your electro-surgical device might interfere with that.

There are a variety of simple tools out there to remind you of safe electrosurgical practices. Jaisa Olasky, M.D., offered the following 10 tips for safer electrosurgery ([Olasky 2018](#)):

- Always use the lowest power setting possible to get the effect you want
- Understand the true functions of cut and coag
- Understand that technique is as important as choosing the right settings
- Understand proper placement for dispersive electrodes
- Choose the right instrument for the case
- Beware of insulation failures
- Beware that injuries can happen outside the field of vision
- Make sure everyone knows where the foot pedal is
- Take smoke evacuation seriously
- Understand the fire triangle

Similarly, Alkatout et al. ([Alkatout 2012](#)) had this list of safety measures for prevention of electrosurgical complications:

- Inspect insulation carefully
- Use the lowest possible power setting
- Use a low-voltage waveform (cut)
- Use brief intermittent activation
- Do not activate in open circuit
- Do not activate in close proximity or direct contact with another instrument
- Use bipolar electrosurgery when appropriate
- Select an all metal cannula system as the safest choice
- Utilize available technology (tissue response generator, active electrode monitoring) to eliminate concerns about insulation failure and capacitive coupling

There are also several safety checklists for electrosurgery available ([ECRI 2020](#), [3M 2020](#), [Bovie 2019](#)). These are very practical. The 3M checklist also has a nice list of “do’s and don’ts”.

Our prior columns on iatrogenic burns:

- March 2009 “[Risk of Burns during MRI Scans from Transdermal Drug Patches](#)”
- June 1, 2010 “[Iatrogenic Burns](#)”
- October 5, 2010 “[More Iatrogenic Burns](#)”
- December 23, 2014 “[Iatrogenic Burns in the News Again](#)”
- March 2015 “[Another Source of Iatrogenic Burns](#)”
- September 5, 2017 “[Another Iatrogenic Burn](#)”
- June 5, 2018 “[Pennsylvania Patient Safety Authority on Iatrogenic Burns](#)”

Our prior columns on surgical fires:

- December 4, 2007 “[Surgical Fires](#)”
- April 29, 2008 “[ASA Practice Advisory on Operating Room Fires](#)”
- November 2009 “[ECRI: Update to Surgical Fire Prevention](#)”
- January 2011 “[Surgical Fires Not Just in High-Risk Cases](#)”
- March 2011 “[APSF Fire Safety Video](#)”
- November 2011 “[FDA Initiative on Preventing Surgical Fires](#)”
- December 13, 2011 “[Surgical Fires Again](#)”
- April 24, 2012 “[Fire Hazard of Skin Preps Oxygen](#)”
- April 2013 “[Reminder: Hand Sanitizers Are Flammable](#)”
- June 25, 2013 “[Update on Surgical Fires](#)”
- October 1, 2013 “[Fuels and Oxygen in OR Fires](#)”
- August 12, 2014 “[Surgical Fires Back in the News](#)”
- December 16, 2014 “[More on Each Element of the Surgical Fire Triad](#)”
- December 2015 “[Unique Ignition Sources in Surgical/OR Fires](#)”
- January 10, 2017 “[The 26-ml Applicator Strikes Again!](#)”
- January 9, 2018 “[More on Fire Risk from Surgical Preps](#)”
- June 2018 “[ISMP on Fire Risk from Skin Preps](#)”
- July 2018 “[FDA on Surgical Fires](#)”
- September 11, 2018 “[Lessons from a Surgical Fire](#)”
- May 7, 2019 “[Simulation Training for OR Fires](#)”
- July 2019 “[Surgical Fire – A New Risk Factor](#)”

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