

Surgical Fires: Prevention and Safety

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About 90–100 surgical fires occur annually in the United States, with some of them causing serious injury, disfigurement, and even death.¹ Although surgical fires are uncommon, their actual prevalence might be higher than estimates suggest because minor fires — i.e., those that don't cause significant damage — and “near-miss” events sometimes go unreported even if they were potentially hazardous.

The consequences of surgical fires can be catastrophic for patients, healthcare providers, and healthcare facilities. Yet, nearly all of these surgical fires are preventable. This article provides an overview of surgical fires and discusses ways that healthcare providers and facilities can take proactive steps to prevent these dangerous occurrences.

Understanding Surgical Fires

Surgical fires, unlike other types of healthcare fires, typically involve an anesthetized patient, which creates an additional complication for healthcare staff. An anesthetized patient lying on an operating room (OR) surgical table is not capable of self-preservation and must rely on the surgical team to protect their well-being. Thus, team awareness of where and how surgical fires occur is imperative.

The traditional hospital OR is a primary site for surgical fires, but they also can occur in other locations, such as ambulatory surgery centers and endoscopy suites. Even a physician's office can be the potential site of a surgical fire.

The three main elements of fire — fuels, oxygen, and ignition sources — are found in any OR setting. Fuel sources inside the surgery suite include skin preparations, bone adhesives, aerosols, ointments, surgical drapes, scrubs, towels, masks, gowns, mattress pads, plastic bags, suction canisters, tubing, sponges, tapes, dressings, gloves, suture supplies, wiring, and airway maintenance devices.

The surgical team must understand that any material or item with a carbon chemical base can be ignited and will burn. Some alcohol-based skin preparation agents and bone adhesives are extremely flammable, and vapors can pool unnoticed underneath a patient. Fuel sources also include the patient and patient-related items, such as body hair, fatty tissue, and gastrointestinal gases (e.g., hydrogen and methane).

Oxygen sources inside the surgery suite include ambient air, medical air, nitrous oxide, and an oxygen-enriched atmosphere. If an oxygen-fed fire occurs in the OR, staff should anticipate a hot, rapidly intensifying, spreading fire. Any fire that involves an oxygen-enriched atmosphere will be difficult to extinguish. Staff should also understand that nitrous oxide, when subjected to a fire, can liberate oxygen to support combustion.

Typical ignition sources in the surgery suite include electrosurgical units (ESUs), electrocautery devices, fiber optic light sources, lasers, defibrillators, high-speed drills, and electrical cords. Some of these devices can produce temperatures exceeding several thousand degrees, which greatly exceeds the normal ignition temperature of most fuel sources. Even after these devices are used, the tip temperature can remain hot enough to ignite surrounding fuel sources.

Some surgical fires last only seconds (i.e., flash fires). Others can grow exponentially; for example, a spark occurring in an oxygen-enriched atmosphere can grow to a fire in

Surgical Fire Example: No Harm, No Foul?

A surgeon accidentally stepped on the footswitch of an unholstered laser, which momentarily fired a concentrated beam of light into a surgical drape. The surgeon quickly moved his foot off the footswitch, but a small circular burn patch had already begun to develop. A surgical technician quickly knocked the drape to the floor, and a circulating nurse doused it with sterile water.

The surgical team responded immediately and appropriately. The patient was anesthetized at the time, nobody was harmed, and the fire was incidental. Later, the team members discussed the incident among themselves, but no one escalated the issue to risk management or reported it to the local fire department.

Although no harm occurred, reporting the incident would have provided the team an opportunity to evaluate what happened, identify potential safety concerns, and develop strategies to address them.

nanoseconds. Once a fire develops and gains headway, it can produce hot toxic gases and copious amounts of choking smoke. A growing fire of this magnitude will limit staff's breathing and visibility. As hot toxic gases and smoke are produced, panic and confusion may ensue.

Fortunately healthcare organizations, providers, and staff can prevent most surgical fires through education, training, and implementation of strategies to minimize fire risks.

Preventing Surgical Fires

Educate and Train

Surgical fire education and training often is directed only at nursing staff. Although the nursing staff usually controls the fuel sources, other team members might control the other critical elements that can lead to fires. For example, the surgeon typically controls the ignition sources, and the anesthesia provider typically controls the oxygen sources. Also, it is possible that these activities may overlap in a surgical setting.

Thus, one of the best methods for preventing surgical fires is to educate and train every member of the surgical team — e.g., the surgeon, surgical resident, anesthesia provider, scrub nurse, circulating nurse, charge nurse, surgical technician, and students — about the basic elements that contribute to fire and how best to control them.

The following sections provide strategies for minimizing the risks associated with ignition sources, fuel sources, and oxygen/oxidizer sources — the main elements of fire. Organizations can use these strategies as part of fire-prevention educational efforts.

Implement Risk Strategies

Various government agencies, professional organizations, and researchers have published guidance on reducing surgical fire risks over the years. The recommendations presented below represent best practices identified by these groups and individuals:

- Conduct a fire risk assessment at the beginning of each procedure.
 - The highest risk procedures involve an ignition source, delivery of supplemental oxygen, and the operation of the ignition source near the oxygen (e.g., head, neck, or upper chest surgery).

- Ensure adequate communication among members of the surgical team.
 - All members of the surgical team should actively participate in communication to reduce risks, including verbally stating specific risks, verifying strategies to address risks, identifying team members' roles in preventing and managing fires, providing ongoing monitoring, and speaking up when safety issues occur.
- Take safety precautions when using supplemental oxygen.
 - Evaluate the patient's need for supplemental oxygen. Any increase in oxygen concentration in the surgical field increases the chance of fire. At concentrations of approximately 30 percent, a spark or heat can ignite a fuel source.
 - If supplemental oxygen is necessary, particularly for surgery in the head, neck, or upper chest area:
 - Deliver the minimum concentration of oxygen needed to maintain adequate oxygen saturation for your patient.
 - When possible and appropriate, use a closed oxygen delivery system, especially when delivering high concentrations of supplemental oxygen (greater than 30 percent).
 - Take additional precautions to exclude oxygen from the field if using an open delivery system. For example, use draping techniques that avoid accumulation of oxygen in the surgical field.
- Take safety precautions when using surgical suite items that may serve as a fuel source.
 - Prevent alcohol-based antiseptics from pooling during skin preparation.
 - Remove alcohol-soaked materials from the prep area.
 - Use the appropriate size applicator for the surgical site.
 - Allow adequate drying time, as prescribed in the labeling, for the specific product. If the product is used on hairy areas or in skin folds, extend the drying time.
 - Ensure the skin is dry before draping the patient and beginning surgery.
 - Be aware of other surgical suite items that may serve as fuel sources, such as:

- Products that may trap oxygen, such as surgical drapes, towels, sponges, and gauze — even those which claim to be “flame-resistant.”
 - Products made of plastics, including some endotracheal tubes, laryngeal masks, and suction catheters.
 - Patient-related sources such as hair and gastrointestinal gases.
- Take precautions when using devices that may service as an ignition source.
 - Consider alternatives to using an ignition source for surgery of the head, neck, and upper chest when delivering high concentrations of supplemental oxygen (greater than 30 percent).
 - If an ignition source must be used, allow time for the oxygen concentration to decrease. It may take several minutes for a reduction of oxygen concentration in the area, even after stopping the gas or lowering its concentration.
 - Inspect all instruments for evidence of insulation failure (device, wires, and connections) prior to use. Do not use if any defects are found.
 - If a monopolar ESU is used, do not activate it when near or in contact with other instruments. Use a return electrode monitoring system.
 - Keep the tips of cautery instruments clean and free of char and tissue.
 - When not in use, place ignition sources — such as ESUs, electrocautery devices, fiber-optic illumination light sources, and lasers — in a holster or safety cover. Do not place devices on the patient or surgical drapes.
 - Recognize that other items that generate heat, including drills and burrs, argon beam coagulators, and fiber-optic illuminators, can also serve as potential ignition sources.
- Plan and practice how to manage a surgical fire.
 - Stop the main source of ignition. Turn off the flow of flammable gas; unplug electrical devices that may be involved.
 - Extinguish the fire. Use a safe method to smother the fire, such as water or saline, and a CO₂ or other extinguisher if the fire persists.

- Remove all drapes and burning materials and assess for evidence of smoldering materials.
- For airway fires, disconnect the patient from the breathing circuit, and remove the tracheal tube. Move the patient to a safe environment. Reestablish the airway to resume respiratory care.
- Review the fire scene and remove all possible sources of flammable materials.²

Other Strategies

In addition to the aforementioned strategies, the following tips also can help surgical teams reduce the risk of OR fires:

- Ensure that any piece of electrically powered equipment or equipment used to supply power is operated in accordance with the manufacturer's recommended operating guidelines.
- Identify a current preventive maintenance sticker on medical equipment prior to use. An additional biomedical engineering calibration sticker might also be on the device, which will indicate the most recent measured output levels.
- Remove from service and appropriately tag any piece of medical equipment that has outdated sticker information, appears to be damaged, doesn't work properly, or is otherwise questionable in the mind of the operator. Do not change or alter any medical device to improve the performance of that device.
- Inspect cables and electrical supply cords in the surgical area before use. If the cable or cord is too short, frayed, cut, or pulled tight, it could pose a potential electrical safety concern.
- Do not turn on medical devices prior to plugging them into a receptacle. Likewise, do not pull the plug out of a receptacle while a device is still on. Either situation may increase the risk of a fire. If the device is placed on a cart, the cart should be a stable platform not prone to tipping over.
- If a piece of medical equipment begins to emit a burning odor or shows signs of sparking or smoking, immediately unplug the device, remove it from the OR, and call biomedical engineering immediately.

- Operate ESUs, electrocautery devices, and lasers at the lowest possible output settings to accomplish the surgery.
- Any time a fiber-optic light source is used, secure it away from the ends of any drape. Turn off fiber-optic light sources when not in use.
- Develop guidelines for patients that address hair care products, facial care products, and makeup. These products often can add to the fuel load. Coat any facial hair near the surgical site with a water soluble surgical jelly to eliminate a potential fuel source.
- Moisten sponges, gauze, and other items that are going to be used in or near the surgical site with saline or sterile water to lessen the chance of ignition. Consider using towels soaked in the same manner.
- Replace oxygen tubing that is leaking as quickly as possible, and shut off oxygen between surgical cases and overnight.
- Handle nitrous oxide with the same precautions as oxygen, as it poses the same hazard.

In Summary

Although surgical fires are not common, they can have devastating effects on patients, providers, and facilities. Surgical fire prevention requires education, training, and awareness. The surgical team should understand how fires can potentially start in the OR; how to control heat, fuel, and oxygen sources; and how to respond if a surgical fire occurs.

Additionally, providers and staff should be aware of the importance of reporting surgical fires and near-miss situations — even if they do not result in harm — to increase understanding of how these incidents occur and how the team can avoid them. Taking proactive steps to avoid and control fire risks might ultimately prevent a tragedy.

Endnotes

¹ ECRI. (n.d.). Surgical fire prevention. Retrieved from www.ecri.org/solutions/accident-forensic-investigation-services/surgical-fire-prevention

² Council on Surgical and Perioperative Safety. (2015). Recommendations for healthcare professionals on preventing surgical fires. Retrieved from www.cspsteam.org/recommendations-for-healthcare-professionals-on-preventing-surgical-fires; U.S. Food and Drug Administration. (2018, May 29). *Recommendations to reduce surgical fires and related patient injury: FDA Safety Communication*. Retrieved from www.encision.com/wp-content/uploads/2021/09/Recommendations-to-Reduce-Surgical-Fires-and-Related-Patient-Injury_-FDA-Safety-Communication_-_FDA.pdf; Ehrenwerth, J. (2023, September 27 [last updated]). Fire safety in the operating room. *UpToDate*. Retrieved from www.uptodate.com; Stormont, G., Anand, S., & Deibert, C. M. (2023, January 29 [last updated]). Surgical fire safety. In *StatPearls* [Internet]. Treasure Island (FL): StatPearls Publishing. Retrieved from www.ncbi.nlm.nih.gov/books/NBK544303/; The Joint Commission. (2023, October 18). Updated surgical fire prevention for the 21st century. *Sentinel Event Alert*, 68, 1–5. Retrieved from www.jointcommission.org/-/media/tjc/newsletters/sea-68-surgical-fire-prevention2-10-9-23-final.pdf

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