

# Operating Room Fire Safety

Stuart R. Hart, MD,\* Amit Yajnik, MD,\* Jeffrey Ashford, RN,† Randy Springer,‡ Sherry Harvey, RN†

Departments of \*Anesthesiology, †Surgery, and ‡Safety and Security, Ochsner Clinic Foundation,  
New Orleans, LA

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## ABSTRACT

Operating room fires are a rare but preventable danger in modern healthcare operating rooms. Optimal outcomes depend on all operating room personnel being familiar with their roles in fire prevention and fire management. Despite the recommendations of major safety institutes, this familiarity is not the current practice in many healthcare facilities. Members of the anesthesiology and the surgery departments are commonly not actively involved in fire safety programs, fire drills, and fire simulations that could lead to potential delays in prevention and management of intraoperative fires.

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## INTRODUCTION

Fire safety is not a topic on the top of most priority lists in the operating room (OR) today, possibly because a great deal of misinformation exists regarding the subject. Some of the more common misconceptions include (1) OR fires do not happen in today's hospitals; (2) if fires do occur, they were not preventable; (3) fires only occur at inferior facilities; and (4) all staff in the OR know what to do if a fire occurs. Careful coordination and continuous training for all attending healthcare professionals are required to minimize the possibility of this potentially fatal problem. Because surgical fires

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*Address correspondence to*  
Stuart R. Hart, MD  
Vice Chair of Quality Management  
Department of Anesthesiology  
Ochsner Clinic Foundation  
1514 Jefferson Highway  
New Orleans, LA 70121  
Tel: (504) 842-3755  
Fax: (504) 842-2036  
Email: shart@ochsner.org

*Key Words:* Fire, intraoperative, program, safety, team

*Financial disclosure:* None of the authors has a financial or proprietary interest in the subject matter of this article.

*Special thanks to all of the volunteer personnel who participated in the program.*

may occur in a variety of locations throughout the hospital, several departments should be actively involved in training: anesthesiology, surgery, surgical services, nursing, labor and delivery, facilities management, and the safety department. We review this subject and provide the most recent recommendations to facilitate the prevention of OR fires.

## INCIDENCE

The Emergency Care Research Institute (ECRI) is a nonprofit research group that investigates procedures, medical devices, and medications to determine the processes and products that provide the best patient outcomes.<sup>1</sup> A 2009 edition of ECRI's *Health Devices* guide listed the top 10 technology hazards, with surgical fires ranked as number 3.<sup>2</sup> Researchers estimated that surgical fires occur between 550 and 650 times in the United States annually, making them as common as wrong-sided surgeries.<sup>2</sup> Surgical fires involved electrosurgical equipment 68% of the time. The most common sites of fires were the head, face, neck, and upper chest. Supplemental oxygen was also present in most cases.<sup>3</sup> Within the past year, the Centers for Medicare & Medicaid Services shut down surgical operations at the Cleveland Clinic because of 6 fires that occurred in operating suites. Fortunately, only 3 of these cases involved patients.<sup>4</sup> Following this closure, all OR employees had to take a course on surgical fire prevention (with a focus on those involving alcohol-based cleaning solutions); now all personnel involved in surgery undergo monthly fire drills.

## COMPONENTS

Fire is often described as containing 3 components: an oxidizer, an ignition source, and a fuel.<sup>5</sup> Whenever these 3 items are in close contact under appropriate conditions and proportions, a fire will occur. The key to prevention is altering one or more of these components so combustion is not possible. The Anesthesia Patient Safety Foundation (APSF) and ECRI have collaborated to release the *New Clinical Guide to Surgical Fire Prevention*.<sup>6</sup> This guide focuses on 3 specific fire reduction strategies:

1. Recommendations for open oxygen delivery during procedures on the head, face, neck, and upper chest.

**Table 1. Fuel Sources**


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Degreasers
Flammable prepping agents including tinctures (chlorhexidine, thimerosal, iodophor)
Drapes, towels, surgical sponges, dressings, adhesive tapes
PPE: gowns, hoods, masks
Ointments, petrolatum (petroleum jelly)
Benzoin tincture (74%-80% alcohol)
Aerosols
White wax
Alcohol
Egg-crate mattresses, pillows, blankets
Elastic bandages, stockinettes
Collodion
Smoke evacuator hoses
Patient hair (face, scalp body)
GI gases (mostly methane)

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Abbreviations: GI, gastrointestinal; PPE, personal protective equipment.

2. Recommendations for the use of supplemental oxygen during procedures on the head, face, neck, and upper chest.
3. Recommendations for implementing a preoperative time-out to assess fire risk potential for every patient for every procedure.

In the OR, each healthcare worker owns a part of the fire triangle. The fuel source is typically provided by the circulating nurse. Common examples are listed in Table 1. Alcohol-based skin preparations have become more common as a source of fuel since the Centers for Disease Control and Prevention identified them as the preferred method for skin disinfection in most cases.<sup>7</sup> Previous preparation solutions were water based and posed no fire threat. OR personnel must pay particular attention to ensure that these solutions do not pool, are allowed to dry, and do not remain in contact with patients via saturated towels.

The surgeon commonly supplies the ignition source. Electrocautery is one obvious source, but others include lasers commonly used during airway surgeries.<sup>8</sup> Sources are listed in Table 2.

The final component is an oxidizer. Although most people realize that oxygen greatly enhances the rate of combustion, many do not know that nitrous oxide supports combustion in the same manner. Oxidizers lower the temperature at which a fuel will ignite, thus increasing the chance of a fire.

## TYPES OF FIRE AND CONTROL

In non-OR fires, the RACE acronym is a reminder for practitioners to rescue, alarm, confine, and extinguish fires. However, in OR fires this sequence may not be appropriate depending on the type of fire.

**Table 2. Ignition Sources**


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Electrosurgical and electrocautery units, other electrical hemostatic devices
Lasers
Fiberoptic light sources and cables
Sparks from high-speed surgical drills and burrs
Defibrillators
Glowing embers of charred tissue
Flexible endoscopes
Tourniquet cuffs

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OR fires may be subdivided into (1) fires occurring on the patient and (2) fires occurring in the OR environment. If the fire occurs on the patient, the first priority is extinguishing the flames and/or removing the burning material from the patient. Another team member may need to use a CO<sub>2</sub> extinguisher to put out the fire. In this situation, timing is critical. All gases (specifically oxygen and nitrous oxide) should be discontinued immediately. Once the fire is controlled, care for the patient should resume, and further management should be based on the degree of danger from smoke in the area. If the fire is not controlled quickly, then evacuation from the room, notification using the facility's fire detection equipment (such as visual and audible alarms, the emergency operator, and the OR desk), and immediate notification of the fire department should occur. The surgeon typically recognizes the fire first and thus is involved in extinguishing and removing the fire, primarily by dousing the area with saline. Certain items identified in Table 3 should be immediately available in the OR to extinguish a fire.<sup>3</sup> Commonly, drapes are waterproof; thus, the saline must hit all inflamed areas. If saline is not available, another technique involves using moist surgical towels draped across the operator's forearms to smother the flames, with a sweeping motion away from the patient's airway. Patting a fire will only encourage the flames to spread.<sup>9</sup>

Another type of common fire occurs in the patient's airway. This type of fire accounts for 1 to 2 deaths annually in the United States. Airway fires are handled differently than other OR fires. At the first sign of a fire, discontinue all gases and remove the endotracheal tube. Also remove any residually burning items, and pour saline or water into the airway. Reintubate and ventilate the patient with medical air until no smoldering materials remain. Then switch to 100% oxygen for the patient.

In fires that occur in the room but do not involve the patient, electrical equipment is usually involved. The first step is to safely unplug the equipment and

**Table 3. Operating Room Fire Equipment and Supplies That Should Be Immediately Available**

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Several containers of sterile saline
A CO <sub>2</sub> fire extinguisher
Replacement tracheal tubes, guides, facemasks
Rigid laryngoscope blades; may include rigid fiberoptic laryngoscope
Replacement airway breathing circuits and lines
Replacement drapes and sponges

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remove it from the OR. If this cannot be done, the device may need to be extinguished in the room.

The importance of timely management during intraoperative fires cannot be overstressed. Patient burns cause an immediate response to the involved tissues, which is seen as a coagulative necrosis, with the degree of involvement depending on the temperature to which the skin is exposed and the duration of the exposure. The initial response primarily results from the direct transfer of energy to the tissues. This thermal energy may cause irreversible tissue damage by denaturing and coagulating proteins.<sup>10</sup> Skin is an effective barrier; in the case of surgical fires, most of the initial damage is confined to epidermis and dermis. Unfortunately, a significant amount of humoral mediators (cytokines, prostaglandins, oxygen free radicals, histamine, complement) are released that can cause vasoconstriction, vasodilation, increased capillary permeability, and edema locally as well as in distant organs.<sup>11</sup> These issues with edema result from changes in Starling forces, starting with decreased interstitial hydrostatic pressure in the burned tissue. Increased capillary permeability leads to decreased plasma oncotic pressure and increased interstitial oncotic pressure, with a resultant fluid shift resulting in marked edema. The edema is greater in the affected areas because of the lower interstitial pressure. These issues rapidly become life threatening when the airway is involved. What may appear to be a minor injury can completely close off an airway over the course of a few hours.

### Fire Extinguishers

When dealing with fire extinguishers, one of the first priorities is location. In our facility, the OR fire extinguishers are clearly identified by a plastic sign extending from the wall near the ceiling (Figure 1). This signage is not required by the fire code; at other facilities, the devices may be more difficult to locate. They should be located near pull stations, stairwells, and fire exits.

All fire extinguishers used in the OR are of the ABC variety, meaning that they are effective in fighting all types of fires (A, ordinary combustibles; B, flammable



**Figure 1. Fire extinguisher sign.**

liquids; C, electricity). The dry chemical fire retardant used is ammonium phosphate and is mildly corrosive in moist environments. When the patient is the fuel source, a CO<sub>2</sub> extinguisher (effective on electrical fires and flammable liquids) would be preferable because of its lack of ammonium phosphate and thus the reduction in contamination and tissue damage. Proper use involves the PASS (pull pin, aim, squeeze, and sweep) technique.

### Fire Alarms

Centrally monitored fire, smoke, and heat sensors are located throughout our hospital. The pull stations are located near stairwells. When any fire is present, both visual (strobe lights) and audible alarms activate. The hospital fire response plan immediately goes into effect, notifying the fire response team about the appropriate area to respond. The response team includes but is not limited to security and facility management personnel. On their arrival, they determine what additional resources are required and whether evacuation of the area is necessary. The alarms also signal on the floors above and below the triggered alarm. The fire department is notified in all of these events. Normally when a fire alarm is activated, the building must be evacuated. In the case of a



**Figure 2. Gas shut-off valve.**

hospital fire alarm, the safety professionals on site determine whether an evacuation is necessary. Routinely, an evacuation is not performed because of the inherent risk of moving critically ill patients.

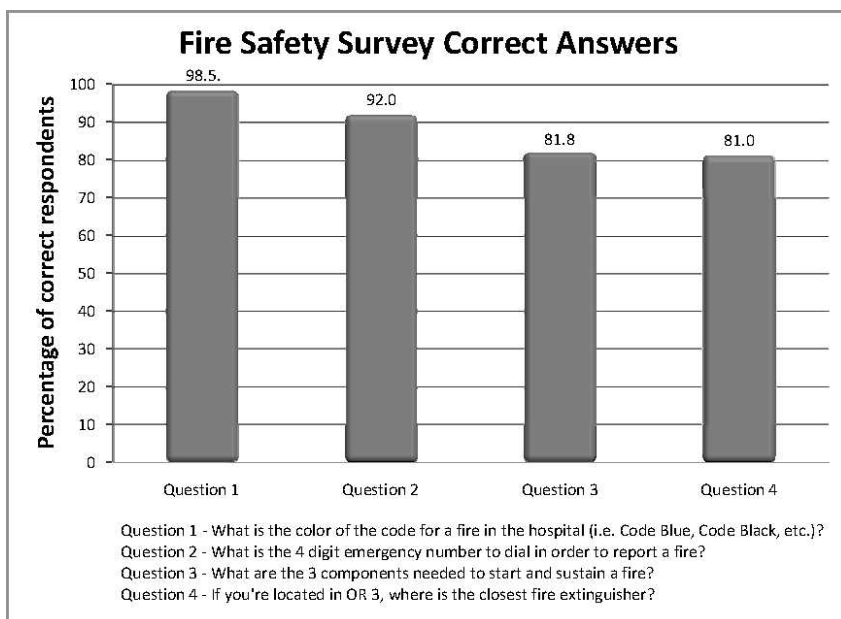
However, in the event of an actual fire, everyone would be notified of the potential for evacuation as well as the plan to have the fire confined and controlled.

### Gas Shut-Off Valves

Shut-off valves are used to stop the flow of gases into the ORs and are designed so the handle sticks out into the hallway when the valve is in the off position. Typically, these handles are behind clear plastic shields that must be removed to access the handles (Figure 2). The front of these gas supply consoles should be clear of medical supplies and clutter at all times. At our facility, a member of the Anesthesiology Department notifies the appropriate individuals if the gases need to be shut off.

### RECOMMENDATIONS

Virtually all surgical fires are preventable. The core point of the new ECRI and APSF recommendations (with limited exceptions) is that the traditional practice of open delivery of 100% oxygen should be discontinued during head, face, neck, and upper chest surgery.<sup>3</sup> Use only medical air for open delivery to the face. If the patient's condition warrants supplemental oxygen, secure the airway with a laryngeal mask airway, endotracheal tube, or other suitable device to prevent excess oxygen contamination of the surgical site.<sup>3</sup> The exception to this rule would be a case in which a patient must be responsive but needs supplemental oxygen while having a procedure on the head, face, neck, or upper chest. In this situation, the lowest concentration of oxygen should be used, starting at 30% in air. If concentrations of oxygen



**Figure 3. Precourse staff survey results.**

**Table 4. Operating Room Director Telephone Survey**

	<b>System Hospitals, No. (%)</b>	<b>Local Hospitals, No. (%)</b>	<b>National Hospitals, No. (%)</b>
Fire drills	4/7 (57)	3/5 (60)	10/10 (100)
Anesthesia involved	3/7 (43)	2/5 (40)	4/10 (40)
Surgeons involved	2/7 (29)	1/5 (20)	3/10 (30)

delivered have exceeded 30% prior to using a source of ignition, stop oxygen and deliver medical air at 5 to 10 L/min for at least 1 minute to dissipate any trapped oxygen. Enter the trachea only with cold devices such as scalpels or scissors. Finally, communication among the team members is essential. These recommendations include the implementation of a surgical fire prevention and management program involving all members of the surgical team. This should also include a fire risk time-out for all cases involving electrocautery, electrosurgery, or lasers.

### **OUR EXPERIENCE: TEAM INVOLVEMENT IS ESSENTIAL**

Last year, under the direction of the OR Nurse Educator and the Safety Department, OR personnel had their first installment of a fire safety and prevention program. This year, the program was expanded to include the Anesthesiology and Obstetrics departments as well as the surgeons. At a pretest given at the initial conference session, videos from the Association of periOperative Registered Nurses (AORN) featuring family members of patients killed in

**Table 5. Operating Room (OR) Personnel**

Scrub technician	Circulating nurse
Physician assistant and surgery resident	Surgeon
Anesthesiologist	Anesthesia resident and CRNA
Anesthesia technician	Medical student
X-ray technicians	Perfusionist
OR assistants and orderlies	Environmental services

Abbreviation: CRNA, certified registered nurse anesthetist.

surgical fires were shown. The pretest sampled the most basic fire prevention information; 50% of the attendees missed at least one question (Figure 3). A physician and the hospital safety analyst gave an overview on operative fires and safety. An informal survey revealed that approximately one-fourth of the attendees had experienced an OR fire during their careers. An intraoperative fire demonstration followed by a question-and-answer session completed the program.

When our fire safety program began, only the surgical team was involved; it now includes numerous other stakeholders. We were interested in learning about approaches adopted at other institutions. A telephone survey (see Appendix for survey) of surgical nursing directors and OR charge nurses within our system, statewide, and nationwide revealed that more than half of the safety awareness programs surveyed did not involve all OR staff (Table 4). This is a huge oversight; prevention, the primary goal, is best accomplished by excellent communication and by making all members of the OR team aware of the risks

**Table 6. Guidelines for Operating Room (OR) Fire**

<b>Patient and OR Personnel Fire (Nonairway)</b>	<b>Patient Fire (Airway)</b>	<b>Equipment and Environment Fire</b>
Extinguish flame, remove smoldering material, soak area with saline, sweep with moist towel	Discontinue gas delivery; remove ETT and smoldering fuel sources (sponges, etc) from airway	If safely possible, unplug device and remove from OR to extinguish
Discontinue airway gases until fire controlled	Irrigate with saline, assess damage, and resume care of patient	If unable to remove, obtain fire extinguisher and extinguish
Assess damage and resume care of patient	Intubate, use medical air, confirm all sources extinguished	N/A
Obtain fire extinguisher	Administer 100% oxygen	See above
Activate fire pull box and call surgery desk and emergency number	Activate fire pull box and call front desk and emergency number	Activate fire pull box and call front desk and emergency number
Assess smoke risk	Assess smoke risk	Assess smoke risk
If not controlled promptly, consider evacuation; confine and shut off OR gas supply	If not controlled promptly, consider evacuation; confine and shut off OR gas supply	If not controlled promptly, consider evacuation; confine and shut off OR gas supply

Abbreviations: ETT, endotracheal tube; N/A, not applicable.

of an OR fire. A typical OR includes a wide variety of personnel (Table 5). Each member should be aware of procedural fires risks and have the opportunity to raise any potential concerns. At the first sign of a fire, several steps must be performed simultaneously, requiring communication and coordination among all team members. Time is of the essence, and advanced awareness of these roles must exist to optimize patient outcomes.

One never knows who will be present when the fire occurs; thus, the role of each member may change in any given scenario. Table 6 provides a simplified guideline for all 3 types of OR fires. Flexibility on the part of team members will be successfully executed only with timely preparation and practice. The American Society of Anesthesiologists (ASA) recommends fire safety simulation.<sup>5</sup> More than 200 staff members attended our annual Fire Safety Program, and we are currently involved in disseminating the lessons we learned to our other facilities. More information about OR fire prevention and management is available at the AORN, APSF, ASA, and ECRI websites.

## CONCLUSIONS

Intraoperative fires occur more commonly than most people recognize. Fire safety in the OR is every team member's responsibility. Prevention is the first step, but when fires occur, optimal outcomes depend on coordinated team efforts. This team approach, along with a comprehensive fire safety program, is a continued effort to make a safer healthcare environment for every worker and patient. Unfortunately, many institutions do not involve the key players (surgery and anesthesia department members) in the education and preparation process. By involving all team members, optimal outcomes for patients at this vulnerable time may be achieved. Our patients expect us to know the risks and management of this potentially life-threatening occurrence. Future work on fire safety should look into developing a national registry that surveys actual fire hazard time-out usage and the effects of the previously mentioned recommendations on the incidence and severity of OR fires.

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## APPENDIX

A telephone survey was performed by calling the surgical control desk at participating hospitals within our health system, within our city, and at nationally recognized institutions in the United States (U.S. News). The surgical director of nursing was contacted and if that person was unavailable, then the operating room charge nurse was surveyed.

The survey consisted of the following questions:

### Fire Safety Program Survey

1. Does your surgery department perform annual fire drills? Does your surgery department perform any type of fire safety education?
2. Exactly what do they do? How often? Is it a demonstration or a simulation?
3. Who is involved? OR nursing, ancillary staff (scrub techs, orderlies), anesthesia department, surgeons?

*This article meets the Accreditation Council for Graduate Medical Education competencies for Patient Care and Systems-Based Practice.*