

Fire in the Operating Room: Principles and Prevention

Stephen P. Daane, M.D., and Bryant A. Toth, M.D.

San Francisco, Calif.

Learning Objectives: After studying this article, the participant should be able to: 1. Understand the basic causes of operating room fires. 2. Take preventive measures to avoid operating room fires during surgery (including laser surgery). 3. Know how to put out operating room fires.

Summary: Fire is a rare but potentially disastrous operating room misadventure. In this article, the authors describe the elements of operating room fires and present an illustrative case. The risk of fire can be minimized when the operating room team understands the interactions among the three sides of the classic fire triangle: oxidizers, fuels, and ignition sources. Lists of fire prevention techniques and steps to take in the event of an operating room fire are provided. (*Plast. Reconstr. Surg.* 115: 73e, 2005.)

Airway fires and burns to surgically unrelated body areas can result from the combination of an oxygen-rich environment, flammable material, and a heat source during surgery. According to Dr. Gerald Wolf, a professor of anesthesiology at SUNY Downstate as well as a consultant to the Emergency Care Research Institute (an independent healthcare research organization),¹⁻³ there are approximately 100 operating room fires in the United States each year with an average of two deaths annually. Two thirds of reported operating room fires are caused by the cautery as an ignition source, while 13 percent involve lasers. One third of reported fires occur in the airway, 28 percent on the face, 24 percent elsewhere on the patient, and 14 percent within the patient. The majority of reported operating room fires occur in oxygen-enriched environments. According to The Doctors Company, although most

operating room fires are easily preventable, the resulting malpractice cases can be medicolegally indefensible when plaintiffs allege that preventive steps should have been taken.⁴

Fuel sources in the operating room include paper or cloth drapes, gauze sponges, antiseptic skin agents (particularly those with alcohol bases but also including pooled 10% Betadine solution), endotracheal tubes, nasal cannulae, and plastic masks. Polyvinyl chloride endotracheal tubes are particularly dangerous because of their proximity to higher oxygen concentrations. Less obvious fuel sources include lanugo (the fine hair that covers the face and body), adhesives such as benzoin, and bowel gases. Fortunately, flammable anesthetic agents are rarely used in today's operating room environment. *Ignition sources* include all electrocautery and electrosurgery units (monopolar, bipolar, and battery-powered cautery), lasers, fiberoptic lights, defibrillators, drills, and burrs. The temperature at the tip of a cautery unit can reach several hundred degrees, easily hot enough to start a fire; electrosurgery can also cause combustion by producing a spark. Fires involving *oxygen-enriched atmospheres* (defined as any oxygen concentration greater than 21 percent) burn hotter and more vigorously and spread more rapidly than other fires. Many materials that will not burn or sustain a flame in ambient air will do so in an oxygen-rich environment. For example, polyvinyl chloride endotracheal tubes will burn in 26 percent oxygen. Oxygen delivered via nasal cannula tends to pool under surgical drapes and may take

From private practice and the Department of Plastic Surgery, University of California, San Francisco. Received for publication October 31, 2003.

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some time to disperse after it is switched off; therefore, using the lowest possible inspired oxygen concentration to provide adequate oxygen saturation will help to avoid excess oxygen accumulation. Nitrous oxide anesthetics should be avoided when possible because nitrous oxide serves as an oxidizing agent, further promoting a fire.

One of the most critical elements in preventing operating room fires involves communication between the surgeon and the anesthesiologist in cases where electrocautery is used in the head and neck or oropharynx in the presence of supplemental oxygen by cannula or in the presence of an uncuffed pediatric endotracheal tube with an airway leak. If possible, air or a minimal oxygen/air mixture by nasal cannula should be used for open delivery (rather than 100 percent oxygen), titrated to the patient's oxygen saturation on the pulse oximeter. Note that normal saturation readings for adults are usually in the upper 90s, so delivery of a higher oxygen concentration to maintain 100 percent saturation may not always be needed. If possible, supplemental oxygen should be stopped at least 1 minute before use of an electrocautery or laser on the head and neck, or an "incise drape" may be used to isolate head and neck incisions from flammable vapors beneath the drapes.

Once a surgical fire starts, it can spread rapidly. If a cautery unit starts a fire by igniting a gauze sponge or a drape, the fire should be extinguished immediately with a gloved hand or a towel. Larger fires require immediately terminating the flow of the oxidizer (i.e., disconnecting the breathing circuit), removing burning materials, dousing the patient with sterile water to limit thermal injury, and then focusing attention on stabilizing the patient. The anesthesia staff should restore respiration with air (not oxygen) while the surgeon deals with the patient's injuries; the nursing staff can continue to extinguish any burning materials.

All operating room staff should know the locations of fire extinguishers. Although water, carbon dioxide, and dry powder fire extinguishers are not the first choice for putting out surgical fires because they can potentially cause infection, they may be necessary for fires that engulf a patient. The Emergency Care Research Institute recommends that a 5-pound carbon dioxide extinguisher be mounted just inside the entrance to each operating room; fire blankets are not recommended for use in the operating room.² In severe fires, evacuation of the operating room and activation of fire alarms may be necessary.

CASE REPORT

A 42-year-old woman underwent chalazion excision performed with intravenous sedation and low-flow supplemental oxygen via nasal cannula. Heat from the cautery ignited the polyvinyl chloride nasal cannula tubing, causing burns that resulted in hypertrophic scarring (Fig. 1). This patient has recently undergone skin grafting to the entire upper lip aesthetic subunit.

OPERATING ROOM FIRE SAFETY GUIDELINES

The following are guidelines for avoiding operating room fires^{3,4}: (1) keep the cautery unit in the holster when it is not being used; (2) use a nonconductive plastic clamp to attach the cautery to the surgical field; (3) adjust the cautery settings so that sparks do not occur; (4) have the power disconnected from high-intensity light sources when they are not in use; (5) never allow fiberoptic cables to come into contact with flammable materials; (6) use appropriately protected endotracheal tubes when operating near the trachea during tracheostomy; (7) never use cautery to enter the trachea; (8) use air or air/oxygen mixtures in anesthetic gases; (9) avoid using nitrous oxide, especially during bowel surgery; (10) avoid "tenting" of surgical drapes that would allow accumulation of oxygen; (11) use water-soluble (rather than oil-based) substances to cover lanugo hair; (12) avoid alcohol-based skin preparations and petroleum-based eye ointments; (13) stop supplemental oxygen at least 1 minute before using the cautery on the head and neck; (14) use a properly applied "incise drape" to isolate head and neck incisions from flammable vapors beneath the drapes; (15) use fire-



FIG. 1. A 42-year-old woman developed hypertrophic scarring on the upper lip after ophthalmic surgery. Heat from the cautery unit ignited the polyvinyl chloride nasal cannula tubing in the presence of supplemental oxygen.

retardant surgical drapes; (16) wet all gauze sponges and cotton pledgets during oropharyngeal surgery; and (17) use suction to scavenge the gases from the mouth of an intubated patient during oropharyngeal surgery.

Guidelines specific to laser surgery^{3,5} are as follows: (1) use a combination of intravenous sedation and localized nerve blocks without supplemental oxygen during facial skin resurfacing; (2) limit the laser output to the lowest acceptable power density and pulse duration; (3) place the laser in "standby" mode when it is not in use; (4) remove laser foot switches so they are not accidentally activated; (5) use a wet gauze sponge or aluminum foil to completely wrap the endotracheal tube (or use a metal, laser-safe endotracheal tube) if laser surgery is being performed with endotracheal anesthesia; (6) place moist towels around the patient's face and neck (and moisten gauze sponges) to prevent ignition of the surrounding drapes; (7) use metal (rather than plastic) corneal protectors to prevent thermal injury to the cornea; and (8) never allow laser fibers to be clamped to surgical drapes (clamping can break the fibers, causing ignition of the laser fiber sheath).

Educational videos are a tool that can be used to provide the fire safety training that surgical staff require.⁶ Recommended educational videos regarding operating room fires include "Fire Safety in the Perioperative Setting," published by the Association of periOperative Registered Nurses (AORN),⁷ and "Fire Safety in the O.R.: A Triad of Prevention," published by Molnlycke Health Care.⁸ The Emergency Care Research Institute offers a free poster entitled "Only You Can Prevent Surgical Fires," available for download from their Web site.⁹

DISCUSSION

Approximately 100 operating room fires are reported annually in the United States. They occur during laser skin resurfacing, defibrillator use, and by cautery ignition of preparatory solutions, bowel gases, and surgical drapes or sponges. Explosions can be avoided during bronchoscopy, tracheostomy, and tonsillectomy by adjusting the oxygen/air mixture when an anesthesia machine is being used.¹⁻¹³ When only an oxygen tank is being used, oxy-

gen should be turned down as low as possible or turned off when the cautery is used on the face.

In addition to knowing operating room fire safety guidelines, all persons in the operating room should know the locations of fire extinguishers and how to use them. The operating room team should bear in mind that one of the most important elements in preventing fires is communication, especially with regard to the use of cautery in the presence of supplemental oxygen.

*Stephen Daane, M.D.
2186 Geary Boulevard, Suite 212
San Francisco, Calif. 94115
stevedaane@aol.com*

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