

Fire safety in the operating room

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The operating room environment is considered a potentially significant fire hazard. The role of the anesthetist in preventing and handling fires is pivotal to patient survival. Means of preventing fires as well as extinguishing them are discussed.

Key words: Fire hazards, operating room, safety.

In today's healthcare environment, fires in hospitals usually are small and seldom publicized. According to the Federal Emergency Management Agency, United States Fire Administration 1991 statistics, there were 2,260 hospital fires that resulted in 1 death and 132 injuries.¹ Because many fires or "close calls" only appear in incident reports and are never reported to the local fire department that has jurisdiction, the actual number of fires may never be known.

A hospital is considered a safe place, a place to go for help and healing. When a fire occurs in such a location it is considered newsworthy. Several such fires have been reported by the national news media and in professional publications.

The anesthetist's role in operating room fire safety is significant. Before the use of flammable anesthetics was discontinued, the operating room was recognized as a potentially significant fire hazard area in hospitals. Anesthetists who have entered healthcare after the flammable anesthetic era

may be unaware of the dangers posed by a fire in the surgical suite.

The technology in today's operating rooms is again requiring anesthetists to increase their level of fire awareness. The causative factors associated with operating room fires will be examined, suggestions will be provided to avoid fires, and actions that should be taken in an operating room fire will be discussed.

Requirements for a fire

The creation of a fire requires a fuel source, an ignition source, and an oxygen source. This is known as the fire triangle. The ignition source is frequently controlled by the surgeon and the oxygen source by the anesthetist.² There are numerous fuel sources, including surgical drapes, gowns, hair, skin, endotracheal tubes, and surgical preparation solutions.

After a fire occurs, fire investigators attempt to determine the factors responsible for the fire (fuel and ignition source) and any other factors that may have changed or influenced the fire triangle.

Ignition sources

The three most common ignition sources involved in operating room fires today are lasers, the electric surgical unit, and high-intensity light cords.³

When lasers were first introduced into clinical medicine, there were reports of fires. These fires

often occurred in the airway after the endotracheal tube had been ignited (Figure 1). Such fires directly involve the anesthetist. This has resulted in several homemade "fire safe" endotracheal tubes being described in the literature. The medical products industry, in response to the need for a better solution, has developed several "laser safe" endotracheal tubes. This subject has been covered in detail by other authors.⁴

Figure 1

Burning endotracheal tube in an oxygen enriched atmosphere



Electric surgical units are another ignition source. The temperature of the spark at the end of the cauter tip is several hundred degrees. The electric surgical unit produces heat by concentrating electrical current at the tip of the electrode. If fuel and oxygen are present, a fire may result. Usually, the only substance that burns is the patient's tissue when it is safely cauterized. However, items that have been or could be ignited include drapes, hair, skin preparation solutions (alcohol, acetone, or DuraPrep[®]), petroleum-based eye lubricant, intestinal gas, and endotracheal tubes.

A fire occurred at the University of Los Angeles Medical Center when a surgical drape was ignited. According to an account of the incident, "The surgical team had just finished cauterizing bleeding vessels in the abdominal cavity. They had opened the chest to repair a damaged right atrium. The scrub nurse, standing on the patient's right side, felt heat near her lower leg. Drapes near the floor were on fire."⁵ "The smoke became so thick, the staff could not extinguish the flames. The smoke forced the nine-member surgical team from the room. The patient died."⁶

After an intensive investigation, it was surmised that the accidental activation of the switch while the electrode tip was unprotected resulted in the drapes, which were in an oxygen-enriched environment, being ignited.

The author, while administering an anesthetic for an endoscopic cholecystectomy, observed the surgeon, who was working within the patient's abdomen, change the connecting wire to the cauter probe. This resulted in two electric surgical unit wires on the sterile operating field. When he activated the foot switch and did not see any effect in the abdomen, he instructed the circulating nurse to increase the power. After the voltage had been turned up, a "crackle" was heard when the switch was activated. The surgeon had connected the wrong wire to his instrument, and the active wire was arcing against the patient's skin. This resulted in several large blisters, and it melted part of the drape.

An additional source of ignition is a high-intensity fiberoptic light source. The temperature at the end of a fiberoptic light cord is well above the ignition temperature of most surgical drapes. In an incident related to the author, a scrub nurse received a 1-cm burn on her leg from a light cord that had melted the drape and burned a hole through her scrub suit. The nurse was fortunate that the operating room gown did not burst into flames.

Fuel source

Items that are used in hospitals must meet national standards for flammability. Considerable material has been written elsewhere pertaining to the flammability of endotracheal tubes when they are used around lasers. However, there has been limited material published about endotracheal tube flammability when such a tube is used with an electric surgical unit.

After the author presented a talk on fire safety, a nurse anesthetist related the following incident. An endotracheal tube fire occurred during a tonsillectomy with the administration of isoflurane/

nitrous oxide and oxygen anesthesia. The endotracheal tube (polyvinyl chloride, no cuff, resulting in a slight oxygen leak into the pharynx) was ignited by an arc from an electric cautery spark. The tube was quickly withdrawn, and the patient suffered no sequelae. The incident was not reported to the local fire department.

Several years ago, the government established a flammability standard for children's sleepwear; however, no such standard exists for surgical drapes. There is some confusion in the literature, fostered at times by drapery manufacturers, that quoted national Fire Protection Association (NFPA) Standard 702 (Standard for Classification of the Flammability of Wearing Apparel) and standards developed by the Consumer Product Safety Commission. Of the two standards, the NFPA 702 is the more stringent; however, it is not currently used by the NFPA.^{7,8} There is an excellent monograph by *ECRI Health Devices*, which provides a detailed review of surgical drapes.⁹

Role of oxygen

Oxidizers are necessary for combustion. The most common ones in the operating room are oxygen and nitrous oxide. Increased levels of oxygen enable substances that are not flammable at ordinary oxygen levels to burn with extreme intensity in an oxygen enriched atmosphere.

Several years ago, a patient's eyebrow and eyelid were burned after petroleum-based eye lubricant was ignited by a battery-operated eye cautery instrument. At the time, the patient's face was being flushed with oxygen from a face tent or chin mask, as is often done during eye surgery.¹⁰

A fire occurred in an intensive care unit during a cardiac resuscitation attempt when a spark from an improperly held defibrillator paddle ignited a bed sheet that was surrounded with increased ambient oxygen that was being used during the procedure.¹¹

Human behavior in a fire

Actual fires are not like those depicted on television or in the movies. Fire behavior presents a dynamic, changing situation that can produce intense heat and large quantities of black smoke. It can be said that plastic or foam rubber is "thick black smoke just waiting to be released into the air by fire."

Behavioral studies have been done on how people react in a fire.¹² Investigators have found that the first reaction is disbelief: "This can't be happening!" As a result, the next reaction is to "do nothing." This scenario is frequently reinforced in a hospital when the alarm sounds and there is no

smoke in the area. Patients are taken to an operating room and anesthetized, in the belief it was just another incidence of "burnt toast" or an alarm malfunction.

The third reaction is consideration of the possibility that a fire may exist, especially if the smell of smoke is noticed ("I trust my senses"). The fourth step is to take some action, such as removing the endotracheal tube, leaving the area, or exploring further. Such behavior often leaves the individual with only enough time to choose and follow a single option for action.

Fire prevention in the operating room

The best method of fighting a fire is to avoid having one in the first place. Great emphasis should be placed on prevention.^{13,14} Because the anesthetist controls the sources of oxygen, he or she plays a significant role in fire prevention. As stated earlier, fuels that do not burn or burn with difficulty ignite and burn vigorously when they are near oxygen enriched atmospheres.

Every operating room fire education program should include elements of a pre-fire plan that are consistent with the pre-fire plan for the entire institution. The program should include specific actions that can be taken by the operating room personnel to prevent fires. For example:

- Keep the electric cautery tip in a holster when it is not being used.
- Turn on and off all high-intensity light sources after all connections have been made and just before their use.
- Use appropriately protected endotracheal tubes when lasers are being utilized.
- Use air or an air-oxygen mixture in the anesthetic gases when ignition is possible.
- Tent surgical drapes so that pockets of oxygen cannot accumulate.
- Use water-soluble substance, such as K-Y jelly, instead of petroleum-based ointments.
- Use surgical drapes that resist ignition.
- Know the location of the fire extinguisher and how to use it.
- Practice using the extinguisher with real fires.
- Know the location of all fire alarm pull stations and fire exits.

When a fire occurs

All fires begin small. Quick action by those in the room can often extinguish a fire easily. Fires that occur in an oxygen enriched atmosphere grow larger very rapidly and require planned teamwork to extinguish.

When there is a fire in the airway, black smoke

may be seen coming from the patient's mouth and also in the expiratory limb of the breathing circuit. The following actions should be taken.¹⁵

- Believe your eyes: There is a fire.
- Quickly remove the endotracheal tube from the patient's mouth and pass it to another person to be extinguished. Save it for later examination.
- Examine the airway, perform a bronchoscopy to remove any particulate material such as soot or pieces of plastic, and treat the patient as medically indicated.
- Complete a critical incident report, and make sure it is given to the local fire department.

If the surgical drape catches fire, call for help at once; if the fire is very small, it could be covered to snuff it out. However, it may be best to remove the drape from the patient immediately and place it on the floor, away from the area. Water or saline that is thrown onto a water-repellent surface may simply flow away before it has had time to soak in and extinguish the fire.

If your clothing catches fire, drop to the floor and roll. This helps smother the flames and keeps the air around your face clear of heat and smoke.

General fire safety

The vast majority of people who die in fires do so in one- and two-family homes. Therefore, no article on fire prevention would be complete if it failed to mention home fire safety. Check your smoke detectors and home fire extinguisher frequently. Keep matches and lighters out of children's reach, that is, above the 5-foot level. Keep the fire department phone number near the phone and above all, practice Operation EDITH (exit drills in the home). Ask family members to help plan fire escape routes from every room.

When traveling, stay at hotels that are equipped with sprinkler systems. Inquire before you make reservations. Verify where exits are located before retiring for the night, and do not use elevators if a fire alarm sounds. Observe the location of the emergency exits when in a restaurant. Carry a fire extinguisher in the car.

You are the most important factor in maintaining a fire-safe home or work environment.

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