Lesson 306: Management of the Patient at Risk For an Operating Room Fire: Part 1

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Read this article, reflect on the information presented, then go online and complete the lesson post-test and course evaluation before the termination date below. (CME credit is not valid past this date.) You must achieve a score of 80% or better to earn CME credit.

TIME TO COMPLETE ACTIVITY: 2 hours
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Professional Gaps

In this 2-part lesson, current recommendations for the prevention and management of operating room fires are reviewed. In Part 1, the incidence of operating room (OR) fires is noted and the efforts by the Anesthesia Patient Safety Foundation (APSF) and the American Society of Anesthesiologists (ASA) to prevent such incidents are described. The “Fire Triad” is explained and the respective roles of OR personnel are delineated. Preparation to prevent fires is outlined. Part 2 discusses the prevention and management of OR fires.

Learning Objectives

At the end of this activity, the participant should be able to:

1. Name the 3 components of the “Fire Triad.”
2. Understand the importance of how a fire is fueled.
3. Provide examples of each component of the “Fire Triad” in the perioperative setting.
4. Describe the anesthesiologist’s role in preventing fires.
5. Appreciate the prevalence of an oxygen-enriched atmosphere in surgical fires.
6. Appreciate appropriate preoperative patient directions in fire prevention.
7. Identify the situations or surgical procedures that increase fire risk.
9. Understand the pre-assigned tasks, especially those of the anesthesiologist.
10. Describe currently available fire extinguishers.

Case History

A 64-year-old Mexican immigrant was scheduled for a resection of an area around his left jaw for removal of a malignant amelanotic lesion, measuring approximately 3 x 3 x 2.5 cm. The patient had a
history of high blood pressure and was taking lisinopril orally (20 mg per day). The patient had limited understanding of English and did not comprehend all of the instructions he was given during preoperative assessment. He had applied an aftershave after being admitted to day surgery the morning of his procedure. In the OR, routine monitors were placed, supplemental nasal oxygen at 4 L/min was delivered, and a combination of IV midazolam (3 mg) and propofol (85 mcg/kg per min) was administered, resulting in a titrated deep plane of anesthesia. Lidocaine 2% was injected into the left jaw and after the initial incision, cautery was used to assist in hemostasis. The patient’s entire face caught fire in a matter of seconds.

Introduction

The APSF, in 2010, offered a fire safety video. A survey of the 587 anesthesia care responders who requested the video indicated that viewing the program prompted a change in their practice. With more than 70,000 anesthesia care providers in the United States, the response rate was clearly low. The ASA has released an updated Practice Advisory that presents the most recent information on the prevention and management of OR fires.

Fires in the Operating Room

The practicing anesthesiologist faces many potential hazards in the OR. One of the most serious of these dangers is the outbreak of fire. Although OR fires are uncommon, they are among the most potentially lethal complications that anesthesiologists may encounter. No national standard requires the reporting of OR fires, nor is there a single database that records the number of fire events. Furthermore, malpractice settlements with confidentiality clauses make it even harder to quantify fire occurrences. As a result, accurate statistics on the incidence of surgical fires are difficult to ascertain. Figures range between 100 and 650 fires per year in the United States. Of these, 20 to 30 fires lead to injury and 1 to 2 fires cause death of the patient or a clinician, or both.

Fires in the OR also are a significant source of liability for anesthesiologists. A 2006 study found that 17% of anesthesia malpractice claims stem from cases in which the patient suffered burns in a surgical fire. An analysis of the ASA Closed Claims database found that just over 2% of claims relate to burns. Burn claims were associated more often with inappropriate care than claims not involving burns (P<0.01). One death was reported following a laser burn in the airway and 2 airway fires resulted in permanent disabling injuries. Payment was made more often in burn claims (72%) than in other claims in the database. Injuries from laser-related fires in the airway were the most severe. These cases not only had the highest payouts, but were also paid 100% of the time.

The fact that most OR fires are easily preventable makes the resulting malpractice claims essentially indefensible. Several case reports suggest that the lack of knowledge of fire safety has led to injury and even death from OR fires. A working knowledge of fire prevention, safety, and awareness is indispensable for the practicing anesthesiologist. This article addresses the proper precautions that clinicians should take to avoid an OR fire, as well as what should be done during such an incident.

The Fire Triad

For a fire to occur, 3 specific components are necessary: an ignition source, a fuel supply, and an oxidizing agent. Together, these 3 elements compose the “Fire Triad.” Reducing any of these parts results in a smaller fire, and removing any 1 element eliminates the possibility of a fire altogether.
In the OR, many different factors can contribute to each part of the triad. Therefore, it is important to recognize which factor serves as the igniter, fuel, or oxidizing agent in the OR to prevent the assembling of a combustible combination (Table 1).

### Table 1. Commonly Found “Fire Triad” Items in the OR

<table>
<thead>
<tr>
<th>Igniters</th>
<th>Electric cautery devices, lasers, heated probes, drills, burrs, argon beam coagulators, fiber-optic light cables, defibrillator paddles, overhead surgical lights, electrical equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuels</td>
<td>Tubes, sponges, drapes, gauze, alcohol-based prepping solutions, hand sanitizer, degreasers such as ether and acetone, masks, patient's hair or skin or tissue, dressings, ointments/tinctures, gowns, gastrointestinal tract gases, bed linens, gloves, packaging materials, and endotracheal tubes</td>
</tr>
<tr>
<td>Oxidizing agents</td>
<td>Oxygen, nitrous oxide</td>
</tr>
</tbody>
</table>

Ignition comes from a concentrated source of heat or a spark. Examples of commonly used tools in the OR that can produce these situations are electrosurgical/electrocautery units, lasers, and light sources. A survey of practicing otolaryngologists found that 91% of fires in which they were involved were started by either electrocautery units or lasers. An analysis of Closed Claims data found that the percentage of fires started by cautery units has increased since 1985. Even after these tools are turned off, enough heat may be stored to cause ignition; thus, it is important to ensure that these probes are not directed at or in contact with a fuel supply.

Anything that is flammable is considered a fuel. Many things in the OR serve this purpose. One would normally associate flammability with linens, prepping agents, and dressings. Other items that one might not consider are the patient’s body or contents within the body—methane gas in the gastrointestinal tract—ointments, and medical equipment. In the past, flammable anesthetic agents such as ether or cyclopropane were more commonplace and often served as a fuel source. By halogenating alkanes in the late 1950s to early 1960s, scientists developed nonflammable, less toxic anesthetics—iso-flurane, sevoflurane, desflurane—that now are the agents of choice. In fact, flammable agents are banned in ORs in the United States.

Oxygen is the main oxidizing agent to which surgical teams are exposed. Oxygen is found in room air at 21% but also can be delivered directly to the patient at higher concentrations in oxygen-enriched mixtures, creating an oxygen-enriched atmosphere (OEA). In an OEA, ignition occurs more easily, fires burn hotter and are more difficult to extinguish, and items that normally do not burn can combust. For example, a study that assessed the flammability of surgical drapes found that the time to ignition was inversely proportional to the ambient oxygen concentration. Furthermore, the authors observed no difference in time to ignition of flammable drapes versus nonflammable surgical drapes in an OEA. In addition, nitrous oxide can decompose into nitrogen and oxygen in the presence of heat, thereby increasing oxygen concentrations in ambient air. Therefore, it is important to note that although it is not considered an oxidizing agent, nitrous oxide can produce oxygen, forming an OEA.

**Division of Labor and the Role of the Anesthesiologist**

The division of labor in the OR also leads to an inherent separation of responsibility for fire safety. The anesthesiologist is chiefly responsible for monitoring the oxidizers that are in and around the patient;
the surgeon typically is responsible for controlling the surgical instruments that can cause ignition; and the nurses are in charge of combustible materials. It is important that each member of the team is cognizant of his or her respective responsibility for the Fire Triad and keep the elements from combining and potentially resulting in combustion or explosion. Although there is a division of responsibility for the parts of the triad, in the event of a fire, surgeons, nurses, and anesthetic care providers should act in an organized and coordinated fashion to extinguish the fire as soon and as safely as possible.

The division of responsibility among OR personnel leads different groups to focus on a single part of the triad as opposed to the triad as a whole. This challenge underscores the need for team planning before the case and clear communication during the case. In 2011, a survey of 22 hospitals was conducted to determine which staff members participate in the fire safety and prevention workshops. Although the fact that many institutions are holding these seminars should be encouraging, the workshops were being conducted for the surgeons, surgical nurses, and anesthetists separately. As suggested above, in developing institutional policies to reduce the risk for fire outbreak, a multidisciplinary approach including all involved health care professionals is critical to the success of such policies.

The division of labor allows the anesthesiologist to focus mainly on the oxygen (or nitrous oxide) that is delivered to the patient. In relation to fire prevention, the anesthesiologist’s main goal is to titrate the inspired oxygen to the lowest amount necessary to maintain the patient’s oxygenation within safe levels. This level will vary depending on the particular patient and the procedure being performed. Furthermore, as both oxygen and nitrous oxide are colorless and odorless, it is the anesthesiologist’s responsibility to communicate ongoing use and/or presence in the surgical field to the surgeons. An OEA is present in approximately 75% of OR fires. The anesthesiologist, therefore, must play close attention to the selected method of oxygen delivery and the gas flow rate because he or she can dramatically reduce the likelihood of a fire, if not completely eliminate it. The Joint Commission recommends: “As a general policy, use air or fraction of inspired oxygen (FiO2) at or less than 30% for open delivery to prevent surgical fires.” The anesthesiologist must choose which method is most appropriate based on the surgical procedure being performed.

Steps to Fire Safety: Preparation

The first step to decreasing the morbidity and mortality of OR fires is preparation. Preparation is the precautions taken before a patient is brought to the OR. Fire safety equipment should be checked for availability and functional status. The hallways leading to the OR should be kept clear of patient beds, surgical machinery, and anything else that may obstruct access to fire safety equipment, medical gas valves, or in the worst case, impede evacuation of an OR altogether. The location of fire extinguishers, sterile saline, fire alarms, medical gas valves, self-inflating Ambu bags, and flashlights should be clearly marked and easily accessible. Items that must be readily available in the OR at all times include sterile saline, a carbon dioxide (CO2) fire extinguisher (Figure), replacement intubation and airway equipment (laryngoscope, endotracheal tubes, breathing
circuit tubing, etc.), drapes, and sponges.  

All members of the OR staff—surgeons, anesthetic care providers, surgical technicians, nurses, and students—should be properly trained in fire safety practices with the pre-assigned roles explained to each member of the team in the event that a fire occurs (Table 2). When a fire occurs, if members complete their pre-assigned tasks, they should then help others complete their respective tasks. Team members should be taught rescue methods and evacuation protocols including turning off the medical gases to the room, activating the fire alarm, and initiating a hospital-wide alert often termed a “Code Red.”

**Table 2. Pre-Assigned Tasks in the Event of OR Fire**

**Anesthesiologist**
- Turn off oxygen/nitrous oxide and maintain ventilation with mask respirator (ie, Ambu bag).
- Communicate with the circulator to turn off the medical gas shut-off valves.
- Disconnect all electrical equipment on the anesthesia machine.
- Disconnect any leads, lines, or other equipment that may anchor the patient.
- Maintain the patient’s anesthesia during transport.

**Surgeon**
- Remove from the patient materials that may be on fire.
- Control bleeding and prepare the patient for evacuation.
- Conclude the procedure as soon as possible.
- Place sterile towels or covers over the surgical site.

**Scrub Nurse**
- Remove from the patient materials that may be on fire and help put out the fire.
- Obtain sterile towels or covers for the surgical site and instruments; gather a minimal number of instruments onto a tray or basin and place it with the patient for transport.
- Assist with patient transfer from the OR table to a stretcher/bed for transport out of the OR.

**Circulating Nurse**
- Ensure the patient’s safety by remaining with him or her and comforting him or her.
- Activate the fire alarm system and call the fire code to alert all necessary personnel.
- Extinguish small fires or douse them with liquid if appropriate.
- Remove any burning material from the patient or sterile field, and extinguish it on the floor.
- Collaborate with the anesthesiology provider on the need to turn off the medical gas shut-off valves.
- Carefully unplug all equipment if the fire is electrical.
- Be aware of the safest route for escape.
- Obtain a transport stretcher if necessary.
- Remove IV solutions from poles and place them with the patient for transport out of the OR.

OR, operating room
Adapted from reference 20.

Members of the OR team also should be educated on the different classes of fires, the appropriate choice of a fire extinguisher, and how to use it properly (Table 3). The mnemonic “PASS” can be used to remember the steps of fire extinguisher activation. First, pull the pin at the handle and then aim at the base of the fire. Next, squeeze the handle (or trigger) and sweep back and forth across the base of the fire. Carbon dioxide fire extinguishers are recommended for the OR. Approved for Class B, Class C, and limited Class A fires, their broad spectrum of coverage enables them to extinguish fires of many different types. Furthermore, they extinguish fires by displacing the ambient oxygen with CO₂, thereby removing the oxidizer component of the Fire Triad, making them the better choice when the patient is
the fuel source.\textsuperscript{21,25} Although dry chemical extinguishers have the broadest spectrum of coverage, they leave a corrosive residue after use that can contaminate the field or cause tissue damage, and thus are not preferred in the OR setting.\textsuperscript{21}

### Table 3. Fire Classes and Fire Extinguishers

<table>
<thead>
<tr>
<th>National Fire Protection Association Classes of Fires</th>
<th>Approved Coverage of Fire Extinguishers for Fire Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class A: Fires involving ordinary combustible materials (e.g., wood, paper, cloth, and most plastics)</td>
<td>Air pressurized water: Class A</td>
</tr>
<tr>
<td>Class B: Fires involving flammable liquids or grease</td>
<td>CO\textsubscript{2}: Class B, C, and limited Class A</td>
</tr>
<tr>
<td>Class C: Fires involving energized electrical equipment</td>
<td>Dry chemical (sodium bicarbonate or potassium bicarbonate): Class B and C</td>
</tr>
<tr>
<td>Class D: Fires involving combustible metals (e.g., magnesium, titanium, potassium, and sodium)</td>
<td>Multi-purpose dry chemical (monoammonium phosphate): Class A, B, and C</td>
</tr>
<tr>
<td>Class K: Fires involving combustible cooking oils and fats</td>
<td>CO\textsubscript{2}, carbon dioxide</td>
</tr>
</tbody>
</table>

Compiled from reference 25.

Afterward, a fire drill may be conducted to evaluate the proficiency of the OR team in fire safety and help familiarize them with the exits, evacuation routes, location of the extinguishers, and shut-off valves for medical gas and electrical supply. A case report explains that an OR fire drill enhanced the team’s response to fire outbreak.\textsuperscript{26} While these drills should be performed at regular intervals in accordance with local, state, and Joint Commission guidelines, the ASA recommends that they take place outside of patient care hours and have dedicated educational time set aside for them.\textsuperscript{2}

Some procedures are deemed high-risk because the surgery will require bringing together the 3 components of the Fire Triad into close proximity, greatly increasing the probability of combustion (Table 4). The risk is particularly acute in facial or oropharyngeal surgeries, as high concentrations of oxygen are flowing through a plastic endotracheal tube immediately adjacent to a cautery. Approximately 21% of OR fires involve these sites.\textsuperscript{23} Therefore, preoperative discussion should take place among all members of the surgical team to determine the risk for fire based on the surgery being performed, as well as a list of surgical tools and materials to be used during the procedure.\textsuperscript{2} The Fire Risk Assessment Score is a simple assessment\textsuperscript{27} that can be performed in seconds during the surgical timeout. The scale ranges from 0 (very low risk) to 3 (high

### Table 4. Types of Surgeries With High Risk For Fires

- Oropharyngeal surgery: tonsillectomy, adenotonsillectomy
- Facial surgery: removal of lesions on head, face, or neck; cataract or other eye surgery
- Endoscopic laser surgery: removal of laryngeal papillomas
- Cutaneous/Transcutaneous surgery
- Tracheostomy
- Burr hole surgery

Adapted from reference 2.
risk), with 1 point allotted for each of the following:

- Surgical site above the xiphoid;
- Presence of an open oxygen source, such as a face mask or nasal cannula;
- Use of an ignition source, including a cautery or laser.

In cases of high risk for OR fires (score 3), the team should outline the plan to minimize the risk by taking the proper precautions.

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REFERENCES


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Post-test

1. The number of fires in the operating room (OR) in the published literature ranges from ______ with approximately ______ of them leading to death.
   a. 100 to 200, 1 to 2
   b. 100 to 650, 1 to 2
   c. 100 to 650, 5 to 10
   d. 200 to 650, 1 to 2

2. The 3 components of the “Fire Triad” are ______.
   a. fire, igniter, fuel
   b. fire, fuel, oxidizer
   c. Igniter, fire, oxidizer
   d. Igniter, fuel, oxidizer

3. A survey conducted among otolaryngologists found that the most common ignition sources leading to surgical fires are ______.
   a. lasers and electrocautery units
   b. lasers and surgical lights
   c. electrocautery units and fiber-optic light cables
   d. electrocautery units and drills

4. In the division of labor in the OR, anesthesiologists are mostly responsible for the ______ whereas surgeons are mostly responsible for the ______.
   a. fuel, sources of ignition
   b. fuel, oxidizers
   c. oxidizer, sources of ignition
   d. oxidizer, fuel

5. An oxygen-enriched atmosphere is present in ______ of surgical fires that have occurred.
   a. less than 60%
   b. 60% to 70%
   c. 70% to 80%
   d. more than 80%
6. All of the following supplies are replacement items that must be available in the OR at all times, except ______.
   a. fire blanket
   b. sterile saline
   c. CO2 fire extinguisher
   d. replacement intubation and airway equipment

7. All of the following are pre-assigned tasks of the anesthesiologist except:
   a. Turn off oxygen/nitrous oxide and maintain ventilation with mask respirator (ie, Ambu bag).
   b. Activate the fire alarm system and call the fire code to alert all necessary personnel.
   c. Communicate with the circulator to turn off the medical gas shut-off valves.
   d. Disconnect all electrical equipment on the anesthesia machine.

8. What are the criteria that determine if a surgery is high-risk for fire?
   a. Surgical site below the xiphoid, open oxygen system, and use of ignition source
   b. Surgical site below the xiphoid, open oxygen system, and use of a fuel source
   c. Surgical site above the xiphoid, closed oxygen system, and use of ignition source
   d. Surgical site above the xiphoid, open oxygen system, and use of ignition source

9. The recommended type of fire extinguisher for the OR is ______ which is approved for ______ fires.
   a. water, Class A
   b. water, Class A and B
   c. CO2, Class B and C
   d. CO2, Class B, C, and some A

10. All of the following procedures are considered to present a high risk for fire except ______.
    a. burr hole surgery
    b. endoscopic laser removal of laryngeal papillomas
    c. tonsillectomy
    d. wisdom teeth extraction