Lesson S33: Management of the Patient at Risk For an Operating Room Fire: Part 2

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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

This is the second lesson of a 2-part activity covering current recommendations for the prevention and management of operating room fires are reviewed. In Part 1, the efforts by the Anesthesia Patient Safety Foundation (APSF) and the American Society of Anesthesiologists (ASA) to prevent such incidents were described. The “Fire Triad” was explained and the respective roles of OR personnel were delineated. Part 2 will provide a discussion of major elements in the prevention and management of OR fires.

Learning Objectives

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

1. Outline risk prevention methods
2. Understand the most recent recommendations for oxygen delivery
3. Appreciate the relationship between oxygen levels and time to ignition
4. Understand the importance of the type of ETT used
5. Understand proper prepping and draping techniques
6. Be familiar with the flammability of commercially available prepping agents
7. Appreciate the importance of intraoperative communication
8. Explain the proper method for managing a fire in the OR
9. Be familiar with the preassigned tasks and the fire management algorithm that guides them
10. Understand appropriate management of fire in an endotracheal tube intraoperatively

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.

Steps to Fire Safety: Prevention and Management

As discussed in Part 1 of this series, the first step to fire safety is preparation. The second step to safety is prevention. At the core of prevention are specific precautions to be taken during the course of surgery which reduce the risk of morbidity and mortality from fire. Since anesthesiologists determine the flow of oxidizing gases, a determination should be made as to whether supplemental oxygen is necessary or if the patient can be sedated safely on room air. For patients who require 100% oxygen to achieve an oxygen saturation greater than 90% while undergoing head, face, neck or upper chest surgeries, the Anesthesia Patient Safety Foundation (APSF) and the Emergency Care Research Institute (ECRI) recommend that oxygen be delivered to the patient’s airway by endotracheal tube (ETT) with a sealed cuff or by supraglottic airway instead of delivering oxygen openly via nasal cannula.1 In a study that compared the effect of open (nasal cannula) versus closed (nasopharyngeal tube system) delivery methods on ambient oxygen levels, it was found that the closed system reduced ambient oxygen levels essentially to the level of room air.2

The closed delivery method often utilizes endotracheal intubation to deliver room air supplemented with oxygen directly to the lungs. It is important to recognize that the tubing itself can serve as a fuel source especially during oropharyngeal surgeries which often employ the use of electrocautery units (ECU) or lasers. One study noted that polyvinylchloride, red rubber, and silicone endotracheal tubes can be ignited in the presence of oxygen concentrations as low as 26%.3 To reduce this risk, endotracheal tubes can be wrapped with reflective tape that renders it safe to use with LASER. Manufacturers of endotracheal tubes also produce items that are “LASER resistant”. This tubing is strongly recommended for use in oropharyngeal surgeries in which the LASERs or cauteries will be in close proximity to the ETT.4 Regardless of the type of ETT used during airway LASER surgery, it is recommended that the FIO₂ be less than 30% whenever possible, and nitrous oxide be avoided altogether.5 Additionally, tubes with cuffs should be used as proper inflation of the cuff controls the unintentional leak of oxygen creating an “oxygen enriched atmosphere” (OEA).6 Filling the cuff with dyed saline is useful in rapidly identifying any accidental perforation of the tube.7 Additionally, the entire anesthesia circuit should be checked for leaks at regular intervals to reduce the chances of an OEA.

Not only is the method of oxygen delivery an important consideration in the prevention of fires, but also the oxygen concentration (FiO₂) and the rate at which it is delivered. The flow rate of any supplemental oxygen should be set to the lowest possible setting with the goal of reducing unnecessary overflow while still maintaining an appropriate level of blood oxygenation that is closely monitored by pulse oximetry.8 One study noted that O₂ flow rates and FiO₂ varied inversely with time to ignition in the oropharyngeal surgical model.8 Higher concentrations and flow rates of O₂ required only a short exposure time to an active electrocautery for ignition to occur. When FiO₂ was decreased, the time required for ignition was increased.8 Furthermore, in several oropharyngeal surgical models,
neither ignition nor sustained flames could be achieved in oxygen concentrations less than 50%. Thus, it is recommended to deliver supplemental oxygen in a room air mixture.

Another important aspect of fire prevention is surgical draping technique. In a study of oxygen concentrations in the operating room, Greco et al found that the use of supplemental oxygen increased the risk of unexpected combustion secondary to oxygen pooling below the surgical drapes and in body cavities. The authors concluded that if supplemental oxygen is needed, the surgical drapes should be positioned in a way that minimizes the pooling of oxygen. Recommended methods for decreasing oxygen pooling while using supplemental oxygen during facial surgery include: the “open face” draping technique; the use of compressed air beneath drapes in unsedated patients; and cessation of oxygen supplementation for 60 seconds prior to use of a possible ignition source. The use of drapes can be avoided altogether, but the surgical field must be thoroughly cleaned and allowed to fully dry. Another recommended technique for reducing ambient oxygen is to use suction in and around the mouth.

One of the simplest yet often overlooked elements of fire prevention is intraoperative communication between the members of the surgical team and anesthesia team. Lack of communication has been linked to an increased risk of sentinel events and medical errors. Further demonstrating this fact, problems in communication were determined to be the cause of more than 60% of sentinel events reported to the Joint Commission. The use of clear, directed communication facilitates the exchange of information between all members of the operative team leading to a safer environment for patient care. For example, the anesthesiologist can request to be notified a few minutes prior to use of a LASER or cautery device as oxygen should be turned off at least 1 minute prior use of these devices. Such warning allows sufficient time for the supplement oxygen to dissipate thus reducing the likelihood of OEA. Higher flow rates and FIO2 require a longer interval of time between turning the oxygen off and activating the LASER or electrocautery unit. An additional measure of safety can include suction of the cavity to evacuate residual oxygen. The surgeon should verify that the anesthesiologist is aware of any circumstance when an ignition source will be in proximity to an OEA.

Alcohol based skin preparation solutions are flammable and have been implicated in fires in laboratory studies as well as in reports of adverse occurrences during patient care. After the patient has been properly prepped, the surgeon must allow any combustible (i.e. alcohol based) skin preparation solution time to dry sufficiently and fumes to dissipate before draping the patient. In a study that attempted to recreate a surgical environment that lead to a fire, it was noted that by waiting 5 minutes for the alcohol based prep solution to dry, as opposed to the manufacturer’s recommended 2-3 minutes, no fire was started. If the surgical area is draped before drying occurs, the solution can be absorbed into the drapes or flammable vapors can pool at the surgical site or beneath the drapes, where a heat source can lead to rapid ignition. Furthermore, some recommend that the prep site be dried with a cotton swab and the drape margins covered with clear adhesive tape to prevent vaporization of the alcohol.

### Table 1: Preparation Solutions

<table>
<thead>
<tr>
<th>Alcohol Based Prep Solutions</th>
<th>Water Based Prep Solutions</th>
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<tbody>
<tr>
<td>Duraprep® 0.7% available iodine and 74% isopropyl alcohol</td>
<td>Betadine®</td>
</tr>
<tr>
<td>Chloraprep® 2% chlorhexidine gluconate and 70% isopropyl alcohol</td>
<td>Soloprep®</td>
</tr>
<tr>
<td>Prevail-Fx® 0.83% available iodine and 72.5% isopropyl alcohol</td>
<td>Pharmaseal®</td>
</tr>
<tr>
<td>Cutasept® 63% isopropanol</td>
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leakage into the surgical site. In order to prevent pooling of flammable prep solutions in the body hair (e.g. beard) of patients that are particularly hirsute, it is recommended to shave the area that will be prepped if consent is obtained.

During surgery, cautery units should be kept holstered and light sources should be disconnected or turned off when not in use. Cautery tips should be kept clean to reduce heat and sparking. The use of igniters near a fuel source should be avoided while an OEA exists, for example, hemostasis can be achieved in a leaking blood vessel with a hemostat or a vessel loop as opposed to cautering. “Cold cutting” (e.g. surgical scissors, scalpel) should be used to open visceral lumens to avoid the ignition of naturally produced methane gas. “Cold cutting” should also be used to open the peritoneal cavity in patients undergoing emergent laparotomy when the presence of free gas or bowel perforation is suspected. Sponges and gauze should be moistened when used in close range to possible sources of ignition. Coarse body hair or lanugo near the surgical site should be coated in water-based jelly to reduce the risk of burning.

Managing a Fire

In the operating room setting, the outbreak of fire is sometimes preceded by warning signs such as unusual sounds (“pop”), odors, heat, movement of the drapes or the breathing circuit, patient movements or complaints, and of course smoke, flashes or flames. When a member of the surgical team notes one or several of these signs, the operative team should be alerted, surgery should be stopped and it should be determined if there is a fire or risk of a fire developing. If there is no indication of fire, the surgery can proceed as planned. If a fire has ignited, members of the team should stop surgery, announce its presence, and begin the preassigned fire management tasks that were discussed in Part 1 of this activity. (This can be reviewed in Table 2.) The ASA Practice Advisory includes an algorithm (Figure 1) that guides the decision-making process that should occur when completing these tasks.
Figure 1: Algorithm for Prevention and Management of Fire in the Operating Room

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Fire Prevention:
- Avoid using ignition sources in proximity to an oxidizer-enriched atmosphere
- Configure surgical drapes to minimize the accumulation of oxidizers
- Allow sufficient drying time for flammable skin prepping solutions
- Moisten sponges and gauze when used in proximity to ignition sources

Yes

Is this a High-Risk Procedure?
An ignition source will be used in proximity to an oxidizer-enriched atmosphere

No

- Avoid using ignition sources in proximity to an oxidizer-enriched atmosphere
- Agree upon a team plan and team roles for preventing and managing a fire
- Notify the surgeon of the presence of, or an increase in, an oxidizer-enriched atmosphere
- Use cuffed tracheal tubes for surgery in the airway; appropriately prepare laser-resistant tracheal tubes
- Consider a tracheal tube or laryngeal mask for monitored anesthesia care (MAC) with moderate to deep sedation and/or oxygen-dependent patients who undergo surgery of the head, neck, or face
- Before an ignition source is activated:
  - Announce the intent to use an ignition source
  - Reduce the oxygen concentration to the minimum required to avoid hypoxia
  - Stop the use of nitrous oxide

Early Warning Signs of Fire
- Fire is not present; Continue procedure

HALT PROCEDURE
- Call for evaluation

FIRE IS PRESENT

AIRWAY FIRE:
- Immediately, without waiting
- Remove tracheal tube
- Stop the flow of all airway gases
- Remove the sponges and any other flammable material from the airway
- Pour saline into airway

NON-AIRWAY FIRE:
- Immediately, without waiting
- Stop the flow of all airway gases
- Remove the drapes and all burning and flammable materials
- Extinguish burning materials by pouring saline or other means

If Fire Is Not Extinguished on First Attempt
Use a CO₂ fire extinguisher
IF FIRE PERSISTS: activate fire alarm, evacuate patient, close door, and turn off gas supply to room

Assess patient status and devise plan for management

Fire Out

AIRWAY FIRE:
- Immediately, without waiting
- Remove tracheal tube
- Stop the flow of all airway gases
- Remove the sponges and any other flammable material from the airway
- Pour saline into airway

NON-AIRWAY FIRE:
- Immediately, without waiting
- Stop the flow of all airway gases
- Remove the drapes and all burning and flammable materials
- Extinguish burning materials by pouring saline or other means

Fire Out

1 Ignition sources include but are not limited to electrosurgery or electrosurgical units and lasers.
2 An oxidizer-enriched atmosphere occurs when there is any increase in oxygen concentration above room air level, and/or the presence of any concentration of nitrous oxide.
3 After minimizing delivered oxygen, wait a period of time (e.g., 1-3 min) before using an ignition source. For oxygen-dependent patients, reduce supplemental oxygen delivery to the minimum required to avoid hypoxia. Monitor oxygenation with pulse oximetry, and if feasible, inspired, exhaled, and/or delivered oxygen concentration.
4 After stopping the delivery of nitrous oxide, wait a period of time (e.g., 1-3 min) before using an ignition source.
5 Unexpected flash, flame, smoke, or heat, unusual sounds (e.g., a "pop," "snap," or "boom") or odors, unexpected movement of drapes, discoloration of drapes or breathing circuit, unexpected patient movement or complaint.
6 In this algorithm, airway fire refers to a fire in the airway or breathing circuit.
7 A CO₂ fire extinguisher may be used on the patient if necessary.
There are two types of fires that can occur in the operating room: those that ignite directly on or in the patient; and those that ignite in the room but away from the patient. The type of fire must be considered when determining the best possible approach to extinguishing it while maintaining the safety of the patient and the operative team. If a fire ignites on a piece of equipment that is not directly on the patient, the equipment should be unplugged and removed from the room so that it can be extinguished outside of the operative area. If the equipment cannot be removed from the OR, a fire extinguisher must be used. A member of the surgical team, preferably the circulating nurse, should activate the fire alarm, alert the front desk and call the emergency number for a full facility response.

If there is a high risk of smoke or if the fire cannot be adequately controlled, the OR must be evacuated. It is imperative that the door be closed and all oxygen supply to the room be turned off.

If a burning object is located directly on the patient, the object should be quickly removed even if this action results in contamination of the sterile field. Oxygen flow should be simultaneously turned off. A fire requires the three components of the fire triad to continue to burn. As such, removal of any one piece of the triad will contribute to extinguishing the fire. The flames should be extinguished with water or saline away from the patient.

Modern surgical drapes are water resistant. Thus, flaming drapes must be removed and fully submerged in water (e.g., sink, bucket) in order to completely extinguish a fire. Fire blankets should not be used on patients in the operative setting. Although the blanket can confine the fire, it will also concentrate the heat. In addition, a fire may continue to burn undetected beneath the blanket if an oxygen source continues to supply the fire.

If a fire ignites inside the patient, sterile water or saline can be poured into the body cavity to extinguish the fire. However, if an ETT ignites within the airway, immediate removal of the tube is necessary to prevent escalation of injury to the oropharynx and the lungs. Sterile water or saline can be poured into the airway and the flow of all gases should be stopped. Mask ventilation with room air should be continued until it is safe to reintubate the patient. If such an emergency occurs with a patient who is known to have an airway that is difficult to intubate, consideration may be given to leaving the ET tube in place to avoid losing access.

If a fire is too big or cannot be successfully extinguished with saline or water, a full scale facility fire response should be activated and a carbon dioxide fire extinguisher employed (Dual Class BC rating). (Classes of fire extinguishers were discussed in Part 1 but can be reviewed in Table 3.) As part of the response, the OR desk should be notified, the gas supply to the room turned off, the OR evacuated and the door closed and not reopened. When the fire has been extinguished, evaluation of the patient should take place. In the event of an airway fire, ventilation should continue without the use of enriched oxygen or nitrous oxide if possible. Bronchoscopy should be considered to evaluate thermal injury, retained ETT or other residual matter before clearing for reintubation. If any soot is noted in the airway, the patient should be intubated...
immediately. If the fire did not involve the airway, the patient should still be evaluated for smoke inhalation related injuries.\textsuperscript{15}

When a room is evacuated, a wet towel should be placed at the base of the door to limit the spread of fire and smoke, and the door must not to be reopened by the surgical staff. After the fire, the room should be left untouched so that members of the fire department in conjunction with facility safety officials can conduct a thorough investigation into the etiology of the fire.

**Management of the Case Presented**

In the case presented, the surgeon immediately poured normal saline into the surgical field. The anesthesiologist turned off the oxygen that was being delivered through the nasal cannula. Immediate cooling significantly decreased the potential depth and destruction of skin and associated tissues. There were no hemodynamic or ventilatory issues. The patient suffered mostly second degree burns along his face. He was treated by plastic surgical staff. Therapy included antibiotics, dressings, and intravenous hydromorphone. The patient did not require any skin grafts. Fortunately, due to the location of the aftershave, there was no ocular damage. Personnel met with appropriate directors including the nursing director in the operating room and the anesthesia director to gather information and ensure that no one needed counseling and that they were able to continue performing their duties in the OR. One nurse was sent home for the day. The anesthesia machine was sequestered to ascertain that it was functioning properly and that the O\textsubscript{2} valve did not stick or deliver more oxygen than the setting. The fire marshal was informed of the events. A Root Cause Analysis Committee was assembled and events were studied. Protocols were reviewed within the institution and significant improvement in communication with translators for patients in which English was not there first language was instituted.

**Conclusion**

Fire remains as much a danger today as it was in the days of flammable anesthetics. Some argue that fires are an even greater danger today, as perioperative personnel are less vigilant due to the non-flammable nature of anesthetic agents currently used. Furthermore, ignition sources such as electrocautery units and LASERs are routinely used coupled with fuel sources such as supplemental oxygen and nitrous oxide creating the perfect modern recipe for combustion. The risk of fire outbreak exists when these three components of the fire triad are in close proximity. Thus, precautions must be taken to avoid or at the very least minimize the potential for these sentinel events. Despite the fact that surgical fires are rare, their incidence is not decreasing. A decline in the rate of fires requires that operating room personnel, including anesthesiologists, become familiar with fire safety in the operating room.

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REFERENCES

post-test

1. It is not appropriate to use _________ when extinguishing a fire on a surgical patient.
   a. water
   b. sterile saline
   c. a damp surgical towel
   d. a fire blanket

2. When a large fire requires that a room be evacuated, staff should
   a. place a wet towel at the base of the closed door
   b. ensure that the door remain wide open
   c. return as soon as possible to clean up the soot
   d. find a suitable fire extinguisher to put out the flames

3. The first step to managing a fire ignites on a patient is to
   a. announce its presence and stop the surgery
   b. remove the burning object and turn off the oxygen
   c. pour saline on the patient
   d. alert the front desk and pull the fire alarm

4. Which of the following prep solutions does not contain alcohol?
   a. Duraprep
   b. Chloraprep
   c. Soloprep
   d. Prevail-Fx

5. Recommendations to reduce fire risk during oropharyngeal surgeries do NOT include
   a. using LASER resistant tubing or wrapping the tubing in reflective tape
   b. using tubes with cuffs and filling the cuff with dyed saline
   c. keeping the FiO2 less than 30%
   d. using an oxygen and nitrous oxide mixture
6. In the presence of an electrocautery in oropharangeal surgery, a fire will ignite faster when
   a. O2 flow rates and FIO2 are increased
   b. O2 flow rates and FIO2 are decreased
   c. supplemental oxygen is delivered in a room air mixture
   d. O2 concentration is less than 50%

7. Which of the following are warning signs of a fire?
   a. smoke and flames
   b. heat and movement of surgical drapes
   c. odors and “pop” sounds
   d. all of the above

8. The proper approach to extinguishing a flaming surgical drape is to immediately
   a. spray the flames with an appropriate fire extinguisher
   b. pour sterile saline on the drape
   c. remove the drape and submerge it in water
   d. cover it completely with a fire blanket

9. The management of a non-airway fire does not require
   a. removal of an ETT from the airway
   b. stopping the flow of airway gases
   c. removal of burning objects
   d. assessing the patient status after the incident

10. Methods to reduce ambient oxygen levels do not include
    a. positioning surgical drapes to minimize the pooling of oxygen
    b. titrating the supplemental oxygen to the lowest level possible while keeping O2 saturations within normal ranges
    c. using suction in and around mouth and beneath the drapes
    d. using a mixture of nitrous oxide with oxygen