PERIOPERATIVE FIRE SAFETY

1968
STUDY GUIDE

Disclaimer
AORN and its logo are registered trademarks of AORN, Inc. AORN does not endorse any commercial company’s products or services. Although all commercial products in this course are expected to conform to professional medical/nursing standards, inclusion in this course does not constitute a guarantee or endorsement by AORN of the quality or value of such products or of the claims made by the manufacturers.

No responsibility is assumed by AORN, Inc, for any injury and/or damage to persons or property as a matter of product liability, negligence or otherwise, or from any use or operation of any standards, recommended practices, methods, products, instructions, or ideas contained in the material herein. Because of rapid advances in the health care sciences in particular, independent verification of diagnoses, medication dosages, and individualized care and treatment should be made. The material contained herein is not intended to be a substitute for the exercise of professional medical or nursing judgment.

The content in this publication is provided on an “as is” basis. TO THE FULLEST EXTENT PERMITTED BY LAW, AORN, INC, DISCLAIMS ALL WARRANTIES, EITHER EXPRESS OR IMPLIED, STATUTORY OR OTHERWISE, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY, NON-INFRINGEMENT OF THIRD PARTIES’ RIGHTS, AND FITNESS FOR A PARTICULAR PURPOSE.

This publication may be photocopied for noncommercial purposes of scientific use or educational advancement. The following credit line must appear on the front page of the photocopied document.

Reprinted with permission from AORN, Inc, 2170 South Parker Road, Suite 400, Denver, CO 80231-5711.

Copyright ©2013 “PERIOPERATIVE FIRE SAFETY.” All rights reserved

All rights reserved by AORN, Inc.
2170 South Parker Road,
Suite 400, Denver, CO 80231-5711
(800) 755-2676
www.aorn.org

Video produced by Cine-Med, Inc.
127 Main Street North, Woodbury, CT 06798
Tel (203) 263-0006 Fax (203) 263-4839
www.cine-med.com
# Perioperative Fire Safety

## TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>OVERVIEW/OBJECTIVES</td>
<td>4</td>
</tr>
<tr>
<td>INTRODUCTION</td>
<td>5</td>
</tr>
<tr>
<td>HISTORY OF OPERATING ROOM FIRES</td>
<td>5</td>
</tr>
<tr>
<td>THE FIRE TRIANGLE</td>
<td>5</td>
</tr>
<tr>
<td>Oxidation Sources</td>
<td>6</td>
</tr>
<tr>
<td>Ignition Sources</td>
<td>6</td>
</tr>
<tr>
<td>Fuel Sources</td>
<td>6</td>
</tr>
<tr>
<td>PREVENTION OF OPERATING ROOM FIRES</td>
<td>7</td>
</tr>
<tr>
<td>Fire Risk Assessments</td>
<td>7</td>
</tr>
<tr>
<td>Fuel Management</td>
<td>7</td>
</tr>
<tr>
<td>Management of Oxidizing Sources</td>
<td>8</td>
</tr>
<tr>
<td>High-risk Procedures</td>
<td>9</td>
</tr>
<tr>
<td>Management of Ignition Sources</td>
<td>10</td>
</tr>
<tr>
<td>Preventing Equipment Fires</td>
<td>11</td>
</tr>
<tr>
<td>Fire Drills</td>
<td>11</td>
</tr>
<tr>
<td>Education and Competency Evaluation</td>
<td>11</td>
</tr>
<tr>
<td>Fire Prevention and Management Plans</td>
<td>12</td>
</tr>
<tr>
<td>RESPONDING TO OPERATING ROOM FIRES</td>
<td>12</td>
</tr>
<tr>
<td>Fires on Patients</td>
<td>12</td>
</tr>
<tr>
<td>Fires Inside Patients</td>
<td>13</td>
</tr>
<tr>
<td>Fires Off Patients (Equipment Fires)</td>
<td>13</td>
</tr>
<tr>
<td>Follow-up Activities for all Fires</td>
<td>14</td>
</tr>
<tr>
<td>Fire Extinguishers</td>
<td>14</td>
</tr>
<tr>
<td>Gas Control Valves</td>
<td>14</td>
</tr>
<tr>
<td>Evacuation</td>
<td>15</td>
</tr>
<tr>
<td>CONCLUSION and RESOURCES</td>
<td>15</td>
</tr>
<tr>
<td>REFERENCES</td>
<td>16</td>
</tr>
<tr>
<td>POST-TEST</td>
<td>18</td>
</tr>
<tr>
<td>POST-TEST ANSWERS</td>
<td>21</td>
</tr>
</tbody>
</table>
OVERVIEW
The purpose of this study guide and accompanying video is to educate perioperative personnel on the history, epidemiology, and risks of surgical fires and essential fire safety practices for the perioperative environment.

OBJECTIVES
After viewing the video and completing the study guide, the participant will be able to:

1. List types of fires that occur in the perioperative environment.
2. Describe the components of the fire triangle and how these apply in procedure rooms.
3. Explain how to prevent and respond to surgical fires.
4. Discuss how AORN’s recommended practices can be used to develop a fire prevention program for the perioperative environment.
INTRODUCTION
Fire is an ever-present risk in health care facilities. The National Fire Protection Association (NFPA) estimates that during 2006-2010, fire departments in the United States responded to an estimated 6,240 structure fires per year that occurred in or on health care properties.¹ On average, these fires caused an estimated six deaths, 171 injuries, and $52 million in property damage annually. Fully 23% of fires in health care facilities occurred in hospitals or hospices and 11% occurred in clinics or physician offices. The majority of fires in health care facilities have involved cooking equipment, but laundry machines, heating equipment, and even lighting have been implicated.¹

A fire anywhere in a health care facility represents a risk for patients, personnel, and visitors; however, surgical fires are particularly hazardous because they create an immediate and potentially devastating risk for patients undergoing surgical or other invasive procedures. Surgical fires every year cause death, severe disability, or permanent disfigurement. The United States does not have a central surveillance system for operating room (OR) fires, which has made it challenging to estimate their incidence. The most recent results from the non-profit ECRI Institute, which has extrapolated data from the Pennsylvania Patient Safety Authority, indicate that surgical fires in US health care facilities have declined from approximately 500 to 600 in 2009 to 200 to 240 in 2012.² These data indicate that hundreds of surgical fires continue to occur in the US every year – despite the fact that these fires are 100% preventable.³

Three overriding principles of operating room fire safety are to prevent, and extinguish fires, and to evacuate persons at risk if necessary. Only by fully understanding the details of fire safety concepts and practices can perioperative registered nurses and their colleagues implement these overriding principles when needed. This study guide describes the history and causes of OR fires and reviews practices to prevent these fires in contemporary health care settings. If an OR fire does occur, perioperative personnel must work quickly, effectively, and as a coordinated team to protect patients and staff. Therefore, the guide also reviews essential practices for responding to OR fires, including ways to extinguish various types of fires and to evacuate a surgical suite if needed. Fires can create panic and confusion, requiring personnel to think on their feet; therefore, in addition to standard educational activities, regular fire drills and competency assessments are indicated to enable all OR personnel to prevent and respond to fires.

HISTORY OF OPERATING ROOM FIRES
Operating room fires have occurred for centuries, and written records of such fires date back to at least 1745.⁴ Early anesthetics such as cyclopropane and ether-based agents were flammable, and their use contributed to explosions and fires during operative and other invasive procedures.⁵,⁶

In an attempt to prevent fires during the era of flammable anesthetics, floors in operating theaters were constructed from antistatic flooring but these floors were costly to install and maintain.⁵ In addition, before approximately 1960 evidence-based consensus recommendations on surgical fire prevention were lacking.⁶ Some anesthesia professionals during this time period contended, for example, that ORs should not be air-conditioned and should be kept humid to prevent the accumulation and conduction of static electricity.⁶ These measures were generally ineffective and the introduction of surgical diathermy and electrocautery intensified the risks associated with use of flammable anesthetics.⁵

In 1956, the first nonflammable anesthetic, halothane, became available and by the 1970s flammable anesthetics were no longer being used in the US and numerous other countries.⁴,⁵ But despite the publication of national evidence-based fire safety recommendations, OR fires remain a serious concern in the 21st century.¹

THE FIRE TRIANGLE
Prevention is the best way to fight a fire. A central concept in fire prevention is the fire triangle, which is based on the observation that in order for a fire to start, it requires oxygen (an oxidizing source), heat (an ignition source), and fuel to be in close proximity to one another.⁴
All three components of the fire triangle are usually present during operative and other invasive procedures; therefore perioperative personnel need to be aware of oxygen, heat, and fuel sources in the OR and understand how to manage these sources to promote patient and staff safety.

**Oxidation Sources**

Oxidation sources in the OR include oxygen and nitrous oxide. The perioperative use of either gas has the potential to create an oxygen-enriched environment, defined as an environment in which there is any increase in the concentration of oxygen above room air level and/or in which any concentration of nitrous oxide is present. An oxygen-enriched environment makes combustion possible at lower temperature and energy levels than in room air, thereby increasing the probability and intensity of fires. In an analysis of more than 20 years of medical malpractice claims from the American Society of Anesthesiologists Closed Claims database, 95% of electrocautery-induced fires involved the use of oxygen, and 84% involved the use of open oxygen delivery systems.

Several conditions can contribute to the formation of an oxygen-enriched environment. Drapes that are not properly positioned can trap oxygen or nitrous oxide underneath them, creating a localized, highly oxygen-enriched environment where the risk of fire is increased. Oxygen also can leak from endotracheal tubes or other parts of the anesthesia circuit. At least one surgical fire occurred when electrocautery was used in proximity to oxygen leaking from around an uncuffed endotracheal tube.

During open thoracic surgeries, lung tissue itself can cause an oxygen-enriched environment. In one reported case, a fire occurred in a patient’s open chest cavity while the left internal mammary artery was being dissected prior to coronary artery bypass graft. Oxygen had entered the surgical field through open pulmonary blebs, causing gauze to ignite in the presence of an electrosurgical unit. A review of the case determined that perioperative personnel did not promptly notify the surgeon of the decrease in tidal volumes caused by the ruptured blebs. This case underscores the importance of fire training and prevention strategies, and the need for vigilance, communication, and rapid response when electrosurgical units are used in an oxygen-enriched environment.

**Ignition Sources**

A number of heat (ignition) sources are used regularly in the OR. These include:

- Electrocautery devices
- Active electrosurgical electrodes
- Lasers
- Fiber-optic light cords
- Defibrillators
- Flexible endoscopes
- Ultrasonic hemostatic or cutting devices
- Heated probes
- Devices that create heat (and possibly sparks) during use, such as orthopedic drills and saws

Electrocautery and electrosurgical units are the most common ignition sources involved in reported OR fires. The analysis of the American Society of Anesthesiologists Closed Claims database identified 103 claims related to OR fires, of which 90% involved the use of electrocautery. The majority of electrocautery fires involved the head, neck, or upper chest, and open oxygen delivery systems were used prior to 84% of electrocautery induced fires. In an analysis of 106 airway fires reported by otolaryngology surgeons, the most common ignition sources were electrosurgical units (59%), lasers (32%), and light cords (7%).

**Fuel Sources**

Modern ORs also contain numerous potential fuel sources. Examples include:
Different perioperative team members have primary control over different components of the fire triangle during operative and other invasive procedures. Surgeons, first assistants, and scrub personnel have primary control over ignition sources such as lasers or electrocautery devices. Anesthesia professionals have primary control over oxygen and nitrous oxide. Perioperative registered nurses, scrub personnel, and surgical technologists have primary control over fuel sources, including antiseptic solutions, drapes, and gauze. These distinct domains of responsibility mean that perioperative team members need to communicate and collaborate before and during operative and other invasive procedures to ensure consistent awareness and control of all components of the fire triangle. Operating room fires are more likely when perioperative personnel are complacent, inattentive or distracted, slow to react, unaware of proper firefighting techniques, or lack the appropriate tools for fighting fires.

PREVENTION OF OPERATING ROOM FIRES

Fire Risk Assessments
To prevent OR fires, before every invasive procedure a fire risk assessment should be conducted and the results communicated to the entire perioperative team. The fire risk assessment should identify the components of the fire triangle that are present in the OR, including fuels, ignition sources, and the potential for an oxygen-enriched environment to develop. The fire risk assessment should also determine the type of fire extinguisher required and whether additional fire prevention measures, such as saline or wet towels, are indicated based on specific fuel sources and presence or absence of electrical current. Fire extinguishers and practices for responding to fires are discussed in detail in the section of this study guide titled Responding to Operating Room Fires.

Fuel Management
Management of fuel sources in the OR is the primary responsibility of perioperative registered nurses and is crucial to prevent fires. Perioperative personnel should prevent physical contact between fuel sources and ignition. This practice helps prevent fires by breaking the fire triangle. When managing fuels, it is also important to keep in mind that substances that would not ignite at room air concentrations of oxygen can ignite in an oxygen-enriched environment. In one study, researchers burned multiple samples of five different surgical fuels at oxygen levels of 21% (room air), 50%, and 100%. As oxygen concentration increased, ignition times and total burn times significantly decreased ($p<0.001$). The researchers concluded that common OR materials can ignite in oxygen-enriched environments, and that the risk of ignition and speed of fire propagation increase as oxygen concentration increases.

Two additional concepts related to fuel management are flash points and the difference between flammability and
A flash point is defined as the minimum temperature at which a liquid will vaporize and form an ignitable mixture in the presence of ambient air. Flammable solutions have flash points that are ≤100°F. In contrast, combustible substances have flash points that are >100°F, which means they do not burn as easily. Like all chemicals, flammable and combustible solutions should be handled according to the manufacturer’s written instructions for use, and according to the relevant safety data sheet (SDS) from the Occupational Safety and Health Administration (OSHA). The SDS provides information on the flammability or combustibility of solutions. For flammable liquids, the SDS specifies the lower and upper explosive limits, which are the lower and upper limits of vapor and air concentrations (in percentage form) at which an explosion could occur.

Flammable substances such as alcohol-based skin antiseptic solutions, hand sanitizer, alcohol, acetone, and collodion have served as fuel sources in OR fires. Flammable solutions require careful handling and oversight. They should not be allowed to pool or soak into linens or a patient’s hair. Sterile towels should be used to absorb drips and excess liquid. Before a patient is draped, any material that is saturated with flammable solutions should be removed and the surgical area fully dried with sterile towels. The dry time for flammable solutions ranges from three to 60 minutes, depending on the presence of hair at the site.

Flammable solutions can be highly volatile, meaning that they evaporate easily. Gases or fumes from flammable solutions have ignited during surgery, causing fires. In one report, a patient sustained partial-thickness scalp burns after a flammable alcohol-based prep gel was allowed to wick into the patient’s uncut hair prior to surgery. When the surgeon began using electrocautery to resect a retroauricular scalp mass, fumes from the gel ignited, causing a sponge to catch fire and burning the patient. In the analysis of closed insurance claims, 15% of OR fires were associated with alcohol-based prep solutions and other volatile compounds.

Adequate time should be provided to allow flammable skin antiseptic agents to dry completely and to allow any fumes to dissipate before surgical drapes are applied or a potential ignition source is used. Local and state regulations specify how flammable liquids should be stored, as well as volume limits and locations of dispensers for flammable liquids; these regulations should be consulted and carefully followed.

Liquids rated as combustible also merit specific handling. Formalin, which is commonly used in the OR to fix tissue samples, is combustible and should not be used near ignition sources. Formalin is subject to additional precautions because it contains the carcinogen formaldehyde, and can trigger sensitivity reactions leading to asthma, bronchitis and contact dermatitis. These precautions are described in AORN Recommended Practices for a Safe Environment of Care.

Hair is also a potential fuel source. To prevent hair from catching fire in the presence of an ignition source, a water-based gel should be used to cover facial hair during head and neck surgery. In addition, any eye lubricants that are used should be water-soluble. These actions help decrease the risk of fire by increasing the temperature required for hair to ignite.

Management of Oxidizing Sources
Proper management of oxidizing sources is critical to prevent OR fires. Perioperative personnel should evaluate the potential for an oxygen-enriched environment to occur and communicate this risk to team members. Oxidizers should be used with caution when they are near any ignition or fire source. To decrease the likelihood of an oxygen-enriched environment in the OR, patients who require supplemental oxygen should receive the lowest possible concentration that ensures adequate oxygen saturation. If a patient requires more than 30% supplementary oxygen, a laryngeal mask airway or endotracheal tube should be used, unless contraindicated, such as if the patient is required to be able to respond verbally during the procedure.

The flow of oxygen should be turned off at the end of procedures. In addition, the anesthesia circuit – including the endotracheal tube, the seal between the tube and the
Additional precautions are indicated for operative and other invasive procedures in which open oxygen or nitrous oxide are used, particularly when drapes are placed over the patient’s head.12 During these procedures, a second system should be used to deliver 5-10 L/min of medical air to flush oxygen from under the drapes. Drapes should be positioned in such a way as to allow oxygen to flow freely rather than accumulating under the drapes.12,24,25,27 During use of a warming blanket with an attached head drape, a hole should be cut in the drape around the endotracheal tube, the patient’s head should be lifted and repositioned frequently if possible, and the warmer blower should be kept on while the drape is in place.12,25 These practices help prevent oxygen from building up under the drape.25

Proper storage of oxidizers is essential to avoid fire hazards. Oxygen, nitrous oxide, and other medical gases should be stored based on volume, need for immediate use, and regulatory requirements.12,22 The NFPA and regulatory agencies publish and enforce requirements for storage of medical gases. Requirements related to fire safety include the following:22

- The room used for storage should have a fire resistance rating of at least one hour; negative pressure; and at least eight air exchanges per hour.
- The cylinders should be secured with chain-like devices or placed in racks to prevent them from tipping and falling.
- Cylinders should not be stored in an egress hallway.

In addition, valves on gas cylinders should be closed properly to prevent leakage during storage.12 Containers of liquid oxygen must be handled, filled, stored, and transported in accordance with state and federal regulations and manufacturers’ written instructions and labeling.12,22 Liquid oxygen containers should be stored in a cool, dry place that is either outside the building, or inside the building if the containers will not be exposed to open flames or high-temperature devices, will be secured to prevent tipping, will be kept away from foot traffic, and will not be in danger of sustaining damage from falling devices.

High-risk Procedures
Some operative and other invasive procedures are associated with a greater risk of fire on (or in) a patient compared with other procedures.12 The greatest risk of fire occurs during procedures above the xiphoid process and in the oropharynx.30 Examples of such procedures include removal of lesions on the head, neck, or face; tonsillectomy; tracheotomy; burr hole surgery; and laryngeal papilloma removal. Procedures of the head and neck are associated with increased risk of fires because anesthetic gases are most likely to accumulate in this area, resulting in an oxygen-enriched environment near the surgical site. In a study of 106 airway fires reported by otolaryngologists, 27% percent of fires occurred during endoscopic airway surgery, 24% during oropharyngeal surgery, 23% during cutaneous or transcutaneous head and neck surgery, and 18% during tracheostomy.13 Fully, 81% of fires occurred while supplemental oxygen was in use.
In one study, researchers evaluated the risk of fire during oropharyngeal surgery by grounding an electrosurgical unit to a whole raw chicken, inserting an endotracheal tube into the empty central cavity of the chicken, and performing electrocautery on the tissue near the endotracheal tube while titrating varying concentrations and flow rates of oxygen through the tube. Fire (defined as ignition with a sustained flame) started inside the chicken cavity at oxygen concentrations as low as 50%, if electrocautery was used for approximately two minutes. At higher flow rates and concentrations of oxygen, fires began after only 15-60 seconds of electrocautery use. These results highlight the role of an oxidizing source in the fire triangle—an oxygen-enriched environment makes ignition possible at decreased heat or energy levels. Notably, the researchers were unable to achieve ignition with a sustained flame at oxygen concentrations less than 50%, regardless of the amount of time electrocautery was used. The researchers concluded that decreasing the fraction of inspired oxygen to less than 50% could markedly decrease the risk of airway fires during oropharyngeal surgery.

Bowel surgeries also are associated with increased fire risk because the bowel contains hydrogen and methane gases, which are flammable. In patients with pneumoperitoneum, the increased risk of fire in the patient extends to the peritoneal cavity. In a recent report, explosive combustion occurred in the patient’s peritoneal cavity when a handheld electrosurgery electrode was used to enter the abdomen. The patient had small bowel perforation with secondary peritonitis and pneumoperitoneum. Perioperative personnel need to be alert to the risk of bowel gas igniting when opening the bowel, and when opening the peritoneum in cases of bowel perforation.

Additional precautions should be taken during surgeries at high-risk sites. Incisions in an oxygen-enriched environment might be made with a scalpel instead of an active electrosurgical electrode. An ignition source should NOT be used to enter the bowel when distended with gas. During surgical procedures above the xiphoid process and in the oropharynx, radiopaque sponges should be placed at the back of the throat to help stop oxygen leaks, and endotracheal tubes should be inflated with tinted solutions so that cuff ruptures can be promptly identified. In addition, before electrocautery, battery-powered hand-held cautery units, or lasers are used, supplemental oxygen or nitrous oxide should be stopped for one minute and an adhesive incise drape should be placed between the surgical site and the oxygen source.

Management of Ignition Sources
To prevent fires, it is crucial to understand various ignition sources in the OR and precautions related to use of these sources. Electrosurgical units and lasers can become ignition sources, particularly when used in the presence of oxidizers, flammable solutions, or volatile or combustible chemicals or liquids. Fiber-optic light cables can become ignition sources if the light source is left on while connected to the power source; is disconnected from the working element; and is then allowed to touch drapes, sponges, or other fuel sources. Perioperative team members should follow AORN recommendations and manufacturer instructions when using ignition sources.

Electrosurgical units should be used at the lowest possible power setting that is appropriate for the procedure. The active electrode should be kept clean to prevent ignition of debris on its tip, and should be kept away from surgical drapes, linens, oxygen, nitrous oxide, or combustible anesthetic gases. Active electrodes, return electrodes, and protective covers for the electrode tip should be approved by the manufacturer for the particular electrosurgical unit being used. In addition, the active electrode should only be activated when it is close to the target tissue and away from other metal objects that could conduct heat or cause arcing. Minimally invasive electrosurgical electrodes should be inspected and removed from service if the insulation is not intact.

When lasers are used, wet towels and saline should always be kept on the sterile field and moist towels, sponges, and drapes should be placed around the surgical site. Both water and the appropriate type of fire extinguisher should be readily available. Laser-resistant endotracheal tubes should be used when a laser is used during upper airway procedures. Neither lasers nor active electrodes should be activated in the presence of flammable solutions until the solutions have dried and fumes have dissipated.

Other potential ignition sources include defibrillators, drills, burrs, saw blades, lights, and light cables. Saline should be used to cool drills, burrs, saw blades, and other devices that create heat when operated. These devices should be placed on the Mayo stand or back table when not in use. Light
sources that are not in use should be placed in standby mode or turned off. Light cables should be inspected before use and removed from service if broken light bundles are detected. Defibrillator paddles and pads should be the correct size for the patient and should only be used with manufacturer-recommended lubricants in order to prevent sparking and decrease the amount of energy needed for defibrillation.12,24

**Preventing Equipment Fires**

Equipment fires are a serious risk in the OR. For example, an overheated ventilator circuit has been determined to be the cause of at least two surgical fires.39 Several essential steps can help prevent fires on or in equipment. Personnel should inspect electrical cords and plugs and remove damaged equipment from service.12 Power cords need regular inspection because they are likely to be damaged during daily use.22 There also have been reports of OR fires resulting from improper cleaning or malfunctions of booms and other equipment.40,41

Personnel should check equipment to ensure that biomedical inspection stickers are current. Equipment that is not current should be removed from service.12 In addition, fluids should be kept off lasers, electrocautery equipment, and other electrical devices. Equipment safety features such as audible alarms should NOT be bypassed or disabled. Finally, manufacturer’s written instructions for use and AORN recommended practices should be followed when using any ignition source, including lasers, electrocautery devices, active electrosurgical electrodes, and fiber-optic light cords.12

Smoke in the OR can indicate an immediate risk of fire.12 If equipment begins smoking unexpectedly, it should be disconnected from the source of electrical current. The equipment should then be moved out of the OR if it is safe to do so. Moving the equipment out of the OR decreases the risk of injury to patients and personnel in the room.34

**Fire Drills**

To ensure that all personnel understand their responsibilities in the event of fire, health care facilities should schedule fire drills at least as often as required by the local authority with jurisdiction;12 however, it is important to recognize that the local authority may not have adopted the most current guidelines from the NFPA. These guidelines state that fire drills should occur during every shift at least quarterly and that drills should include evacuation at least once annually or as specified by the relevant codes.42

Planning for a fire drill is crucial. Every drill should be a meaningful learning experience for personnel and for the health care organization as a whole. Drills should include challenges such as blocked exits, malfunctioning equipment, heavy or unwieldy OR tables or stretchers, and crowded rooms.4 A number of observers should be on hand during fire drills to observe and evaluate the response of personnel.12 Observers can be given the AORN Fire Drill Evaluation form with as much information filled in and completed beforehand as possible. Furthermore, a debriefing session should occur after every fire drill to identify any concerns and plan actions for future improvement.

**Education and Competency Evaluation**

At the first sign of an OR fire, perioperative personnel need to work together rapidly to perform several steps simultaneously.43 For this reason, it is important that all members of the OR team understand the risks of fire, how to mitigate these risks, and how to respond to various types of fires. Education and competency evaluation programs are essential to achieve these outcomes.
Fire safety education and competency validation should include the following:\textsuperscript{12}

- The fire triangle
- Perioperative fire risk assessments
- Locations and use of fire extinguishers and other fire-fighting equipment
- Evacuation routes for every room
- Location and operation of medical gas panels, instruction on how to turn them off in an emergency and who is responsible for determining if they should be turned off
- How and when to turn off ventilation and electrical systems
- Location of fire alarm pull stations
- How and when to activate the fire safety and evacuation plan and contact the local fire department
- Roles and responsibilities of team members during specific fire scenarios

Some studies point to educational gaps in perioperative fire safety.\textsuperscript{43,44} For example, an assessment of OR fire safety awareness programs in New Orleans, Louisiana, and the United States overall indicated that more than half of programs surveyed did not involve all OR staff, and that many health care institutions did not involve key persons such as surgery and anesthesia personnel in fire safety education and preparation activities.\textsuperscript{43} In an evaluation of a fire simulation in a obstetric OR, personnel did not know where fire extinguishers or fire safe zones were located.\textsuperscript{44} AORN recommends that perioperative team members receive education and competency validation related to fire safety.\textsuperscript{12}

**Fire Prevention and Management Plans**

AORN recommends that health care facilities develop written plans for preventing and managing OR fires. A fire prevention and management plan should specify policies, procedures, and team member responsibilities for preventing and responding to fires. These responsibilities include communicating with other team members, following policies and procedures to prevent fires, and responding appropriately and safely to different fire scenarios, including: activating fire alarms, extinguishing fires, and following evacuation routes and levels.

The fire prevention and management plan should also clarify the required content for and frequency of fire safety education activities, including fire drill procedures. Furthermore, the plan should include details of the facility’s fire risk assessment tool.

Creating a fire prevention and management plan requires time, expertise, and multidisciplinary collaboration. AORN recommends that fire prevention and management plans be developed by a multidisciplinary group of key stakeholders.\textsuperscript{12} Group members should include perioperative registered nurses, unlicensed assistive personnel, anesthesia professionals, physicians, local fire department representative, risk management personnel, the safety officer, and facilities and engineering personnel.

**RESPONDING TO OPERATING ROOM FIRES**

Operating room fires are categorized by type and proximity to the patient. It is useful to consider three major categories of OR fires – those that occur on, in, and off the patient. Fires on the patient affect the hair, skin, or overlying drapes. Fires in the patient affect a body cavity. Fires off the patient do not directly involve the patient but occur in close proximity.

Approximately 70% of fires directly involving patients are fires on the body, usually the head, neck, or chest.\textsuperscript{24} The remaining 30% of fires ignite inside the patient—usually in the endotracheal tube and the airway, but also in the bowel. Operating room fires that occur off the patient typically involve a piece of equipment. The majority of fatal OR fires are airway fires.\textsuperscript{27}

Operating room fires of all types represent an immediate risk to the safety of patients and personnel; however, each type of fire requires a different response. The following sections describe how to respond to fires on, in, and off patients. These practices may vary in order or might occur simultaneously, depending on the fire and the number of personnel involved.

**Fires on Patients**

If a fire starts on a patient, perioperative personnel should alert team members and then extinguish the fire by pouring non-flammable liquids such as saline on the fire or by smothering the fire with a towel.\textsuperscript{12} At the same time, the anesthesia professional should cease administration of airway gases.\textsuperscript{3,12,24}

Fire extinguishers should not be used as a first line of defense in an OR fire, because obtaining the fire extinguisher can require additional time, which translates to additional risk to the patient and staff. In addition, fire blankets should not be used in the OR for several reasons:\textsuperscript{3,12,24}

- Fire blankets are made of wool, which can ignite in an oxygen-enriched environment.
- They can potentially spread fire or cause wound contamination.
• They can trap fire next to or under a patient.
• They can potentially dislodge instruments, causing further harm to the patient.

If a small fire starts on a patient, water or normal saline can be poured slowly on the base of the fire to extinguish it; however, if the fire is underneath a waterproof drape, the drape will need to be removed in order to fight the fire. A second method is to smother the fire: a perioperative team member holds a towel between the fire and himself/herself and between the fire and the patient’s airway. The team member then leans toward the patient, places one arm at the dropped end of the towel, and drops the other end of the towel over the fire. Next, the free hand is swept over the towel to extinguish the fire. When the fire is extinguished, the towel is lifted off the patient to allow heat accumulated underneath to disperse. The team member’s face and body should be kept as far away from the fire as possible. The fire should NOT be patted because this will fan the flames and could cause the fire to spread.

If a large fire starts on a patient, the flow of anesthetic gases to the patient should be stopped and the breathing circuit disconnected from the anesthesia machine. If an airway fire occurs, perioperative registered nurses should assist anesthesia professionals to disconnect and remove the anesthesia circuit, and turn off the flow of oxygen. The endotracheal tube should be removed to eliminate the fuel source and saline should be poured in the airway to cool the burned tissue. These steps should be performed in collaboration with the anesthesia professional. Perioperative registered nurses should then help to re-establish and examine the airway. The surgical field should be assessed for secondary fire, the patient should be assessed for injuries, and the physician should be notified as needed.

Fires Inside Patients
If a fire occurs in a patient, team members should be alerted and the anesthesia professional should help to determine the necessary response. If an airway fire occurs, perioperative registered nurses should assist anesthesia professionals to disconnect and remove the anesthesia circuit, and turn off the flow of oxygen. The endotracheal tube should be removed to eliminate the fuel source and saline should be poured in the airway to cool the burned tissue. These steps should be performed in collaboration with the anesthesia professional. Perioperative registered nurses should then help to re-establish and examine the airway. The surgical field should be assessed for secondary fire, the patient should be assessed for injuries, and the physician should be notified as needed.

Fires Off Patients (Equipment Fires)
Equipment fires in the OR typically occur off but in the proximity of the patient. If a fire occurs on a piece of
equipment, team members should be alerted and the equipment should be disconnected from its electrical source. If the plug cannot be removed from the outlet, the appropriate electrical panel should be shut off. Any gases that are flowing to the equipment should also be shut off. Based on the size of the fire, the equipment either should be removed safely from the OR, or the room should be evacuated. A fire extinguisher should be used to put out the fire, if appropriate, and alarms should be activated if needed.

**Follow-up Activities for all Fires**

Perioperative managers and administrators should be informed of all OR fires in accordance with the facility’s protocols. Leadership personnel should be notified even if the fire is small and is immediately extinguished. In addition, it is important that all materials that were involved in the fire be saved so that the fire department and risk management officers can investigate and determine the cause of the fire. These steps are often the responsibility of the circulating registered nurse who is responsible for the OR where the fire occurred.

**Fire Extinguishers**

AORN recommends that fire extinguishers be selected for the OR based on the directives of the NFPA and the local authority with jurisdiction. The NFPA classifies fires as follows:

- **Class A** fires involve combustible materials, such as wood, paper, cloth, most plastics, and human tissue.
- **Class B** fires involve flammable liquids or grease.
- **Class C** fires involve energized electrical equipment. When the equipment is unplugged, the fire becomes a class A or B fire because the electrical current is disconnected.

Fire extinguishers are labeled with a letter or combination of letters according to the types of fires for which their use is indicated. According to the NFPA, either a water mist extinguisher or carbon dioxide extinguisher may be used in the OR. Water mist extinguishers are rated Class 2A:C. Carbon dioxide extinguishers are rated Class B and Class C, but may also be used for Class A fires.

To operate a fire extinguisher, personnel should follow the PASS technique:

- **Pull** the pin.
- **Aim** at the base of the fire.
- **Squeeze** the handle.
- **Sweep** the fire extinguisher from side to side.

Fire extinguishers should be located no more than 30 to 75 feet from the center of the OR, or as determined by the local authority with jurisdiction, depending on the type of hazard and extinguisher. Fire extinguishing equipment and supplies should be regularly inspected, tested, and maintained.

**Gas Control Valves**

Turning off the gas supply to a room can help contain a fire because removing the oxidizer (source of oxygen) helps break the fire triangle. Shut-off valves are used to stop the flow of gases into ORs. Gas control panels are usually located in the hallway near each OR. There is usually a different valve for each type of gas used in the room; however, facility policies and procedures should specify who has the authority to decide when the gas supply to a room should be turned off. Generally, persons with this authority are anesthesia professionals. Circulating registered nurses and other personnel should only turn off the gas supply to a room if they have been directed to do so by a designated staff member.
Perioperative registered nurses and other personnel should recognize medical gas control valves and the areas they control. In addition, medical and other equipment such as carts, stretchers, and beds should not be placed in locations that block access to medical gas control valves, pull alarms, or electrical panels.

Evacuation
Evacuation in the event of OR fire is rarely necessary; however, a specific set of steps should be performed in the event an evacuation is required. A useful mnemonic for remembering these steps is RACE, which stands for Rescue, Alarm, Contain, and Evacuate if needed.

If a designated professional determines the need to evacuate, perioperative personnel should first perform Rescue by removing patients and staff from the site of fire. Patients should be carried or transported on procedure beds or gurneys if necessary. Patients should be initially evacuated to a safe place that is located beyond the first set of smoke barriers. After rescue, the Alarm at the pull station should be activated to alert all personnel in perioperative areas, particularly adjacent rooms, to the presence of fire. The next step is to Contain (or confine) the fire. The OR doors should always be kept closed, and should be closed as personnel leave the room. Containing a fire also means turning off the electrical and medical gas supply to the affected room or rooms.

Finally, the entire operating suite should be Evacuated if fire, smoke, and/or fumes pose a danger to patients in adjoining areas. Examples of situations that could merit evacuation include a drape fire on the floor that has not been extinguished or a fire in the overhead lights. Patients and personnel should be evacuated to a designated area that is beyond the first set of smoke barriers. Health care providers should go to the closest safe location where they can resume caring for patients. Personnel should follow additional facility guidelines and designated evacuation routes.

Evacuation routes should be developed in collaboration with local authorities, guided by NFPA regulations, and clearly posted in multiple locations. Health care personnel and emergency responders should be educated about how to implement the evacuation plan, which should specify the roles and responsibilities of personnel in the event of evacuation.

CONCLUSION AND RESOURCES
Operating room fires pose a serious risk to the safety of patients and personnel. The risk of surgical fires persists in modern ORs because perioperative and other invasive procedures commonly involve all three elements of the fire triangle – fuel, heat, and oxygen. An OR fire can cause death, injury, or substantial property damage within seconds to minutes after ignition. To prevent OR fires, perioperative registered nurses and their colleagues need to implement recommended practices to prevent fires and collaborate rapidly and effectively to extinguish fires on, in, or near patients. In the event of an evacuation because of fire, perioperative personnel are responsible for rescuing patients and staff, activating alarms, containing the fire, and evacuating persons at risk if needed.

To carry out these responsibilities, perioperative personnel need to understand the components of the fire triangle and how they interact to start a fire, recognize their own and team member roles and responsibilities in the event of fire, and communicate effectively with colleagues to perform fire risk assessments and alert team members of hazards or the presence of a fire.

The AORN fire safety toolkit and additional AORN publications provide numerous resources for OR managers, nurse educators, and other personnel tasked with fire safety planning, education, and competency evaluations. These tools are available to AORN members at the AORN website, www.aorn.org.
REFERENCES


POST-TEST
PERIOPERATIVE FIRE SAFETY

Multiple choice assessment. Select the response that best answers each question.

1. The average estimated number of surgical fires every year in the United States is
   a. 20 to 30
   b. 200 to 240
   c. 700 to 1000
   d. 2000 to 2500
   e. 2500 to 2700

2. Choose the FALSE statement about perioperative fire prevention and management plans.
   a. They should be developed by a multidisciplinary group of key stakeholders.
   b. They should describe key content and frequency of fire safety education activities.
   c. They should specify policies and procedures for fire prevention and response.
   d. They generally are not needed unless required by a health care facility’s insurance policy.
   e. They should specify team member roles and responsibilities during fire prevention and response.

3. The three components of the fire triangle are oxidizing source, ignition source, and fuel source.
   a. True
   b. False

4. The three overriding principles of operating room fire safety are
   a. awareness, communication, teamwork
   b. oxidizing source, heat source, fuel source
   c. inspect, check, respond
   d. prevent, extinguish, evacuate
   e. source, extinguish, safety

5. Examples of ignition sources include
   a. electrocautery units and active electrosurgical electrodes
   b. fiber-optic light cords
   c. lasers
   d. a and c
   e. a, b and c

6. A fire risk assessment should be performed
   a. only before procedures involving electrocautery, an electrosurgical unit, or a laser
   b. only if requested by the surgeon or first assistant
   c. before all operative procedures
   d. only before surgical procedures above the xiphoid process and in the nasopharynx
   e. only if the patient requires more than 30% supplemental oxygen

7. The flash point of flammable materials is ________, while the flash point of combustible materials is ___________
   a. less than 100° F, greater than 100° F
   b. greater than 100° F, less than 100° F
   c. equal to 100° F, greater than 100° F
   d. less than 120° F, greater than 120° F
   e. greater than 120° F, less than 120° F

8. Oxidizing sources in the operating room include
   a. oxygen
   b. nitrous oxide
   c. carbon dioxide
   d. a and b
   e. a, b and c

9. Fuel sources in the operating room include
   a. gauze sponges
   b. floor glue
   c. ceiling tile
   d. scrubs
   e. surgical instruments

10. Perioperative registered nurses and scrub personnel have primary control over which component of the fire triangle during an operating or other invasive procedure?
    a. oxidizing sources
    b. fuel sources
    c. ignition sources
    d. a and b
    e. a and c
11. Choose the **FALSE** statement about fire risks in the operating room.
   a. Patients with their heads draped are at increased risk of fire because supplemental oxygen can accumulate under drapes.
   b. Substances that would not ignite in room or medical air can do so in an oxygen-enriched environment, which may occur in the operating room.
   c. Evaporated gases from flammable prep solutions can ignite, especially if they are allowed to accumulate under drapes.
   d. Bowel surgeries are associated with the highest risk of surgical fires.
   e. A piece of equipment that is smoking unexpectedly represents an immediate fire risk.

12. Fire blankets should **NOT** be used in the operating room because they
   a. are made of wool, which can catch fire in an oxygen-enriched environment
   b. can cause wound contamination or move instruments at the surgical site
   c. can trap fire next to or under a patient
   d. all of the above
   e. b and c

13. Which of the following fire safety practices should be implemented when a laser is used during surgery?
   a. keep wet towels and saline on the sterile field
   b. place moist sterile towels, sponges, and drapes around the surgical site
   c. use standard endotracheal tubes for upper airway procedures involving laser
   d. allow fumes from flammable solutions to dissipate before activating the laser
   e. a and b only
   f. a, b, and c only
   g. a, b, and d only
   h. a and d only
   i. c and d only

14. Which type of fire extinguisher is most appropriate to extinguish a fire on or in a patient?
   a. carbon dioxide extinguisher
   b. ammonium phosphate or other dry powder extinguisher
   c. water mist extinguisher
   d. foam extinguisher
   e. a or c

15. Patients and personnel must be evacuated because of an operating room fire. The proper order of steps to take is
   a. alarm, confine/contain, rescue, evacuate
   b. rescue, alarm, confine/contain, evacuate
   c. rescue, evacuate, alarm, confine/contain
   d. confine/contain, alarm, rescue, evacuate
   e. alarm, rescue, evacuate, confine/contain

16. If evacuated because of a fire, health care personnel should go
   a. to the front doors of the building
   b. outside the building
   c. behind at least two sets of fire doors
   d. to the nearest stairwell
   e. to the nearest safe location where they can resume caring for patients

17. A scrubbed perioperative registered nurse observes a fire start on a patient in the operating room. After alerting the team, the nurse should immediately
   a. obtain and operate the nearest fire extinguisher by using the PASS technique
   b. pat the flames with a drape
   c. smother the fire with a towel or pour nonflammable liquid on the fire
   d. lift the patient and transport him or her out of the room
   e. turn off the oxygen source
18. Which practice is NOT recommended to prevent fires during surgeries at high-risk sites?
   a. use an ignition source to enter gas-distended bowel
   b. pack the back of the throat with radiopaque sponges prior to tonsillectomy
   c. stop supplemental oxygen or nitrous oxide for one minute before using an ignition source
   d. place an adhesive incise drape between the surgical site and the oxygen source
   e. inflate endotracheal tubes with tinted solutions prior to tracheotomy

19. If an airway fire occurs, perioperative team members should be prepared to help the anesthesia professional do which of the following?
   a. disconnect and remove the anesthesia circuit and turn off the flow of oxygen
   b. remove the endotracheal tube from the airway, including any burned fragments
   c. pour saline or water into the airway
   d. examine and re-establish the airway
   e. assess the surgical field for secondary fire
   f. all of the above

20. All of the following are appropriate practices to manage oxidation sources in the operating room EXCEPT
   a. administer the lowest concentration of oxygen needed to maintain adequate oxygen saturation
   b. use a laryngeal mask or endotracheal tube if the patient needs more than 30% supplemental oxygen
   c. ensure that there are no leaks in the anesthesia circuit
   d. turn the warmer blower off when using a warming blanket with an attached head drape
   e. prevent oxygen from accumulating under drapes
POST-TEST ANSWERS
PERIOPERATIVE FIRE SAFETY

1. b
2. d
3. a
4. d
5. e
6. c
7. a
8. d
9. a
10. b
11. d
12. d
13. g
14. a
15. b
16. e
17. c
18. a
19. f
20. d