Surgical Fires:

Keys to Awareness and Prevention

(*An Online Continuing Education Activity*)

A Continuing Education Activity
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SURGICAL FIRES: KEYS TO AWARENESS AND PREVENTION

(An Online Continuing Education Activity)

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SURGICAL FIRES: KEYS TO AWARENESS AND PREVENTION

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OVERVIEW

A surgical fire is one that occurs on or in a surgical patient and can happen anywhere surgical procedures are performed, including hospital operating rooms, ambulatory surgery centers, and outpatient clinics. While the number of reported surgical fires is low, the goal for any facility where surgical procedures are performed is that a surgical fire never occur. Several voluntary and regulatory agencies publish recommendations, guidelines, and regulations related to fire safety planning and procedures, as well as protocols for reporting a surgical fire, should one occur. Education and awareness are key elements of fire prevention and it takes the active participation of every member of the perioperative team to support these efforts.

The purpose of this continuing educational activity is to provide basic information about surgical fires, including how they occur and practices to prevent them. The fire triangle will be discussed along with the components within the surgical arena that can contribute to the risk of a fire. Regulatory bodies and professional organizations and the specific influence they have over fire safety and prevention will be reviewed, as well as the potential consequences of a surgical fire. Finally, tools that are available for education and prevention of surgical fires will be presented. Case studies will provide the participant with an opportunity to integrate the information presented with patient scenarios and interventions related to surgical fire situations.

OBJECTIVES

Upon completion of this continuing education activity, the participant should be able to:

1. Describe the components of the fire triangle as they relate to the perioperative setting.
2. Discuss potential consequences of a surgical fire.
3. Explain measures that can be implemented to prevent surgical fires.
4. List emergency steps to take in the event of a surgical fire.
5. Identify tools available to assess fire risk in the operating room.
6. Evaluate patient care scenarios for appropriateness of interventions.

INTENDED AUDIENCE

This independent learning activity is intended for use by perioperative nurses, surgical technologists, and other healthcare professionals who are responsible for safe patient practices knowing that fire is always a potential during surgical procedures.

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MINI-VIGNETTE

Mrs. FM, a 54-year-old female is admitted to the Canal Park Ambulatory Surgery Center for a minor surgical procedure. She has several small to medium-sized, elevated skin lesions around the neck area that she would like removed, since they catch in her necklace chains and cause discomfort. Mrs. FM is escorted to the pre-procedure area where she is prepared for the procedure. Her surgeon, Dr. Jessup, has planned with the anesthesia provider to use local anesthetic with monitored sedation because Mrs. FM is very apprehensive about surgery. Mrs. FM walks with the circulating nurse to her operating room and lies on the procedure table. The RN circulator places a grounding pad on Mrs. FM's left anterior thigh, as her surgeon has requested the use of cautery for this procedure. He anticipates some bleeding from the numerous sites and wants to have immediate, accurate hemostasis. The CRNA places a nasal cannula for oxygen on Mrs. FM prior to the placement of drapes that will cover her face while the operative site is exposed. The CRNA explains that the oxygen provides fresh air. Dr. Jessup begins the procedure and experiences some bleeding from one of the lesions. He touches the active electrode pencil to a hemostat placed on the bleeding site. Suddenly, a spark ignites the drape over Mrs. FM's face and a fire erupts.

GETTING STARTED: UNDERSTANDING THE FIRE TRIANGLE

The fire triangle consists of three distinct elements. These include heat or an ignition source, fuel, and an oxidizer,[1] as depicted in Figure 1. Note that all three elements are required and combine in the right proportions under the right conditions to create a chemical reaction: combustion and fire.

Figure 1 – The Fire Triangle

There are various components of each element present in the operating room setting. While preventing surgical fires requires a team approach of all surgical personnel, surgeons are primarily involved with the ignition sources, anesthesia providers control the oxidizers, and the perioperative nurse has the greatest control over the flammable materials. Each of the elements of the fire triangle is discussed individually below and Table 1 summarizes the common sources associated with each element.

Heat/Ignition Sources

An ignition source provides the heat energy that can start a fire when it is exposed to fuel in ambient air or an oxygen-enriched atmosphere. An electrosurgery unit is the most common ignition source in an operating room environment.[2] Electrosurgery is the use of high-frequency electrical current to cut and coagulate tissue. Electrocautery, another ignition source, uses a heated wire or probe to cauterize tissue. It differs from electrosurgery in that the tissue is not part of the electrical circuit and there is no electrical arc generated.[3] Lasers are not cited as frequently in surgical fires, but are dangerous because of the concentration and application of energy.[4] The intense heat at the end of a fiberoptic light cable or scope tip can also be a source of ignition.

Oxidizers

An oxidizer is any gas that can support combustion and may be air, oxygen, and/or nitrous oxide. The use of oxygen during surgery is common. Procedures using regional or local anesthesia often involve the administration of supplemental oxygen to the patient to counteract the respiratory depression effects of sedation. An oxygen-enriched atmosphere is one in which oxygen concentration in the atmosphere exceeds the usual 21% of ambient air.[4] However, even the level of oxygen concentration of ambient air can support combustion of many types of fuels. An example of this is red rubber catheter, which will ignite and burn in 17% oxygen.[5] Deep body cavities, head and neck regions using an endotracheal tube, and underneath surgical drapes are all potential areas for an increased oxygen concentration and higher risk of fire. Nitrous oxide, a commonly used anesthetic gas, can also release oxygen; therefore, increasing the risk and severity of the fire.

Fuels

Many fuels are present in the surgical setting that can support combustion and fire. Most of these items are present either on surgical team members or used on or near the patient. While these items can ignite and burn in ambient air, the risk increases in an oxygen-enriched atmosphere. The use of alcohol-based preps is common in the operating room and safety measures must be implemented to prevent ignition. This is discussed in greater detail in a following section of this activity.

Body hair varies in texture and length and has a high potential to burn and spread fire across the body. Intestinal gases, while not always thought of, can be flammable and should be considered a risk factor especially during bowel surgery or during procedures in the rectal or perineal area. Other fuels that are commonly used during surgery include petroleum based ointments and adhesives.

Table 1 – Common Sources of Fire Triangle Elements[6]

Elements	Heat/Ignition sources	Oxidizers	Fuels
Sources	- Electrosurgery - Electrocautery - Lasers - Fiberoptic light source - Argon beam coagulator - Sparks from high speed power drills and burs	- Oxygen enriched – atmosphere - Nitrous oxide - Ambient air	- Common OR materials * Pillows, blankets, foam * Caps, gowns, gloves, booties * Towels, drapes, dressings - Volatile organic chemicals * Alcohol - Body hair - Intestinal gases - Tracheal tubes
Controlled by	Surgeon	Anesthesia provider	Perioperative Nurse

SURGICAL FIRE – WHY IS THIS SUCH AN IMPORTANT TOPIC?

Contemporary Data

ECRI (formerly the Emergency Care Research Institute) gathers data on surgical fires based on reports they receive each week. Fortunately, surgical fires are rare; they occur in only an extremely small percentage of the approximately 65 million surgical cases each year.[7] Extrapolating from data published by the Pennsylvania Patient Safety Authority in 2007, ECRI estimates that 550 to 650 surgical fires occur nationally each year, making the frequency of their occurrence comparable with that of other surgical incidences, e.g., wrong-site surgery or retained surgical item). Table 2 provides a listing of specific information related to the number, causes, and locations of surgical fires.

Table 2 – Surgical Fire Data Estimates Based on ECRI Accounts of Fires[8]

Number of OR Fires Reported	50-100 annually in the United States
Type of Equipment Involved	Electrosurgical equipment – 70% Lasers – 10% Variety of sources: electrocautery (hot-wire cauterization), fiberoptic light sources, defibrillators, high speed burs (sparks) – 20%
Oxidizers and fuels	Oxygen-enriched atmospheres – 75% Alcohol-based surgical preps – 4%
Location	Airway – 21% Head, neck, upper chest – 44% Elsewhere *on* the patient– 26% Elsewhere *in* the patient – 8%

Potential Consequences of Surgical Fires

Heat, smoke, toxic by-products of combustion, patient and personnel injuries, psychological trauma, damage to equipment, and legal ramifications are all potential consequences of a surgical fire.

Synthetic materials such as plastics and polymers are present in large amounts in most operating rooms. These can create a problem during surgical fires because they create large amounts of heat during combustion. In addition, many of the by-products of combustion are toxic. These include carbon monoxide, cyanide gas and other toxic chemicals. Smoke containing these toxic chemicals can fill the operating room very quickly and impact the visual acuity of the surgical team, adding to the confusion and panic in the room.

Finally the hospital experiences unfavorable outcomes including poor publicity within the community, financial losses resulting from compensation to the patient and family of victims of surgical fires, costs incurred in repairing or replacing damaged equipment and property, and a sense of incompetency in allowing a fire to occur. The emotional toll on the surgical staff should not be minimized. Support for the staff as well as patients and families is extremely important.

FIRE SAFETY INITIATIVES/NATIONAL GUIDELINES

Various regulatory and accrediting agencies, as well as professional organizations, have published standards and guidelines related to the implementation of strategies to prevent surgical fires. Those outlined by the following agencies/organizations will be discussed:

- The Joint Commission
- Centers for Medicare & Medicaid Services
- Association of periOperative Registered Nurses
- National Fire Protection Agency
- ECRI
- American National Standards Institute
- Consumer Product Safety Commission

The Joint Commission

On June 24, 2003, The Joint Commission issued a Sentinel Event Alert on “Preventing Surgical Fires”[9] that outlined the risks associated with surgical fires and discussed strategies for reducing the risk of surgical fires. Following this alert, The Joint Commission announced that the National Patient Safety Goals (NPSGs) for 2005 would include a goal for reducing the risk of surgical fires in ambulatory care settings, as well as for physician office-based procedures. The performance expectations related to reducing the risk of surgical fires outlined by The Joint Commission at that time are presented in Exhibit A.

Joint Commission National Patient Safety Goal 11 Reduce the risk of surgical fires.

Requirement 11A
Educate staff, including licensed independent practitioners and anesthesia providers, on how to control heat sources and manage fuels with enough time for patient preparation, and establish guidelines to minimize oxygen concentration under drapes.

Rationale for Requirement 11A
When surgical fires occur, they often result in serious injury and sometimes death. The unique circumstances in the surgical environment (oxygen-rich atmosphere, flammable materials, and ignition sources) require response and prevention strategies to be specific to the setting. Educating all surgical staff to these distinctions is crucial in reducing/eliminating surgical fires.

Implementation Expectations for Requirement 11A
***A** 1. Organizations assess the risk for surgical fires based on equipment and procedures used.*
***A** 2. The organization establishes guidelines to minimize oxygen concentrations under drapes.*
***(M) C** 3. Organizations that identify themselves at risk provide staff training on methods to minimize oxygen concentration under drapes.*
***(M) C** 4. Organizations that identify themselves at risk provide staff training on methods to avoid the use of flammable solutions and materials.*
***(M) C** 5. Organizations that identify themselves at risk provide staff training on actions to take in the event of a surgical fire.*

Exhibit A: Joint Commission. Implementation Expectations 2007 National Patient Safety Goals[10]

This NPSG was in effect from 2005-2009; in 2010, it was deleted from the Ambulatory Health Care and Office-Based Surgery accreditation programs all together. However, because reducing the risk of surgical fires is still a very important aspect of patient safety, it should be exercised even though it is no longer a goal.[11]

Centers for Medicare & Medicaid Services (CMS)

CMS distributed a memorandum to its State Survey Agency Directors on January 12, 2007 regarding the fire risk when using alcohol-based skin preparations in anesthetizing locations.[12] This memorandum points out the risk of using alcohol-based skin preparations, a fuel source, combined with an oxygen-enriched atmosphere (the oxidizer) found in an anesthetizing environment can ignite and cause a surgical fire. CMS acknowledges that alcohol is an efficacious, cost-effective agent for skin preparation to aid in the prevention of surgical site infections, but also states in the memorandum that, "…use of an alcohol-based skin preparation in inpatient or outpatient anesthetizing locations is not considered safe, *unless* appropriate fire risk reduction measures are taken…."[13]

The CMS outlines the measures expected to be taken by any hospital or ambulatory surgery center based on information from expert organizations.

"…there is a general consensus that the following fire risk reduction measures are appropriate:

- *Using skin prep solutions that are: 1) packaged to ensure controlled delivery to the patient in unit dose applicators, swabs, or other similar applicators; and 2) provide clear and explicit manufacturer/supplier instructions and warnings. These instructions for use should be carefully followed.*
- *Ensuring that the alcohol-based skin prep solution does not soak into the patient's hair or linens. Sterile towels should be placed to absorb drips and runs during application and should then be removed from the anesthetizing location prior to draping the patient.*
- *Ensuring that the alcohol-based skin prep solution is completely dry prior to draping. This may take 2-3 minutes or more, depending on the amount and location of the solution. The prepped area should be inspected to confirm it is dry prior to draping.*
- *Verifying that all of the above has occurred prior to initiating the surgical procedure. This can be done, for example, as part of a standardized pre-operative "time out" used to verify other essential information to minimize the risk of medical errors during the procedure."*[14]

Policies should be in place to support reducing the risk of OR fires and the implementation of these recommendations must be evident in the patient's medical record.

Association of periOperative Registered Nurses (AORN)

AORN is a professional organization of perioperative registered nurses that supports RNs in the achievement of optimal outcomes for patients undergoing surgery or invasive procedures. To that end, AORN publishes the *Perioperative Standards and Recommended Practices* annually.

The AORN policy and procedure template/sample for Fire Safety in Perioperative Settings[15] provides valuable guidance to all members of the perioperative team in preventing fires during surgical and other invasive procedures and responding appropriately if a fire does occur. AORN provides the following recommended policy statements:

- All perioperative team members are responsible for preventing fires.
- All perioperative team members are responsible for participating in departmental fire safety training.
- Department-specific fire drills will occur quarterly during each shift during which the perioperative department is operational.
- A mock evacuation scenario will occur as one of the fire drills on an annual basis.

- On an annual basis each member of the perioperative team shall be able to:
    - Demonstrate fire extinguishing techniques, including the use of fire-fighting equipment
    - Identify department evacuation routes for each room
    - Identify fire extinguisher locations
    - Locate medical gas panel and demonstrate its operation including turning off medical gases in case of an emergency situation
    - Identify electrical panel locations and procedures for turning off the system

- A fire risk assessment will be performed before each surgical or other invasive procedure in which all there of the parts of the fire triangle (i.e., fuel, ignition source, oxidizer) come together.

- Personnel not directly involved in patient care should report to the staff lounge or other location as dictated by organization-wide fire policy when the fire alarm sounds.

- The decision to evacuate the surgical suite will be made by the RN in charge at the time of the situation, in collaboration with the surgeon, anesthesia care provider, and the fire department personnel, if available.

The procedure specifies interventions that should be followed to prevent a fire on or in a patient, as outlined:

- Scope of a fire risk assessment, i.e., assessing the flammability of all materials used on or around the patient.

- Performing a fire risk assessment.
    - The RN circulator will report fire risk assessment as A, B, C, D, or E, or any combinations of the letters before the procedure begins; these designations are determined by the code assigned to each of the following critical questions:
        A. Is an alcohol-based prep agent or other volatile chemical being used preoperatively?
        B. Is the surgical procedure being performed above the xiphoid process?
        C. Is open oxygen or nitrous oxide being administered?
        D. Is an electrosurgical unit (ESU), laser, or fiber-optic light cord being used?
        E. Are there other possible contributors?

- Procedure interventions for prevention of fire on or in equipment

- Procedure interventions for handling a fire on a patient

- Procedure interventions for handling a fire in a patient

- Procedure interventions for handling a fire on a piece of equipment
- Procedure interventions for handling a fire in another area of the building
- Procedure interventions for evacuation
- Documentation
- Staff competency

In addition, AORN has created a "Fire Safety Tool Kit"16 that provides a variety of educational material, tools, guides, video presentations, and posters to support development of fire prevention strategies in the perioperative environment. The complete AORN Perioperative Fire Safety Took Kit is available online at www.aorn.org.

National Fire Protection Association (NFPA)

Three of the many fire safety standards published by NFPA are especially relevant to the perioperative environment.

- **NFPA 101 (Life Safety Code)**.[17] The Life Safety Code specifies requirements for construction and design of new and existing areas for use by healthcare. This includes requirements for egress; protection from hazards; interior finishes; extinguisher systems; corridor, wall, and door construction; and building services. It also addresses fire exit drills, fire safety planning, and evacuation planning, training of personnel, maintenance of exits, and smoking regulations.
- **NFPA 99 (Health Care Facilities Code)**.[18] A section of NFPA 99 includes information about anesthetizing locations and precautionary measures that should be followed. These measures include methods to safeguard patients and personnel from fire, explosion, electrical burns, and other related hazards that can result from administration of flammable and non-flammable anesthetic gasses. Suggested procedures to follow in the event of fire or explosion are also included in this section.
- **NFPA 53M (Recommended Practice on Materials, Equipment, and Systems Used in Oxygen-Enriched Atmospheres [OEAs]).[19]** This recommended practice discusses fires that occur in oxygen-rich atmospheres, the basics of ignition and combustion, the latest criteria for the safe use of oxygen (liquid/gaseous,) and the design of systems for use in oxygen and OEA). Information is also provided for the selection of materials, components, and design criteria that can be used safely in oxygen and OEAs.

Organizational members of NFPA include the American Society of Anesthesiologists and the American Medical Association (AMA).

ECRI

ECRI is a non-profit organization that uses applied scientific research to determine the best medical procedures, devices, drugs, and processes. This organization provides

valuable information about surgical fire safety and is used as a resource for hospitals nationwide.

ECRI publishes a monthly journal, *Health Devices* and disseminates detailed comparative product evaluations as well as reports of the experiences of end-users including information on OR fire hazards and their prevention.

In 2009, ECRI, in collaboration with the Anesthesia Patient Safety Foundation, released important changes to its recommendations for preventing surgical fires.[20] Most importantly, the organization's recommendations focus on eliminating the traditional practice of open delivery of 100% oxygen during sedation. Securing the airway is recommended if the patient requires an increased oxygen concentration. However, as the oxygen concentration increases in an area, so will the risk of fire; furthermore, fires in oxygen-enriched atmospheres ignite much more easily, burn hotter, and spread more quickly. The goal is to stop open oxygen delivery for surgery around the head and upper chest. For exceptional cases, delivery of the minimum concentration of oxygen necessary to maintain adequate blood oxygen saturation is recommended.

The updated ECRI recommendations are listed in Exhibit B.

ONLY *YOU* CAN PREVENT SURGICAL FIRES

Surgical Team Communication Is Essential

The applicability of these recommendations must be considered individually for each patient.

At the Start of Each Surgery:

- Enriched O_2 and N_2O atmospheres can vastly increase flammability of drapes, plastics, and hair. Be aware of possible O_2 enrichment under the drapes near the surgical site and in the fenestration, especially during head/face/neck/upper-chest surgery.
- Do not apply drapes until all flammable preps have fully dried; soak up spilled or pooled agent.
- Fiberoptic light sources can start fires: Complete all cable connections before activating the source. Place the source in standby mode when disconnecting cables.
- Moisten sponges to make them ignition resistant in oropharyngeal and pulmonary surgery.

During Head, Face, Neck, and Upper-Chest Surgery:

- Use only air for open delivery to the face if the patient can maintain a safe blood O_2 saturation without supplemental O_2.
- If the patient cannot maintain a safe blood O_2 saturation without extra O_2, secure the airway with a laryngeal mask airway or tracheal tube.
  Exceptions: Where patient verbal responses may be required during surgery (e.g., carotid artery surgery, neurosurgery, pacemaker insertion) and where open O_2 delivery is required to keep the patient safe:
  - At all times, deliver the minimum O_2 concentration necessary for adequate oxygenation.
  - Begin with a 30% delivered O_2 concentration and increase as necessary.
  - For unavoidable open O_2 delivery above 30%, deliver 5 to 10 L/min of air under the drapes to wash out excess O_2.
  - Stop supplemental O_2 at least one minute before and during use of electrosurgery, electrocautery, or laser, if possible. Surgical team communication is essential for this recommendation.
  - Use an adherent incise drape, if possible, to help isolate the incision from possible O_2- enriched atmospheres beneath the drapes.
  - Keep fenestration towel edges as far from the incision as possible.
  - Arrange drapes to minimize O_2 buildup underneath.
  - Coat head hair and facial hair (e.g., eyebrows, beard, moustache) within the fenestration with water-soluble surgical lubricating jelly to make it nonflammable.
  - For coagulation, use bipolar electrosurgery, not monopolar electrosurgery.

During Oropharyngeal Surgery (e.g., tonsillectomy):

- Scavenge deep within the oropharynx with a metal suction cannula to catch leaking O_2 and N_2O.

- Moisten gauze or sponges and keep them moist, including those used with uncuffed tracheal tubes.

During Tracheostomy:

- Do not use electrosurgery to cut the trachea.

During Bronchoscopic Surgery:

- If the patient requires supplemental O_2, keep the delivered O_2 below 30%. Use inhalation/exhalation gas monitoring (e.g., with an O_2 analyzer) to confirm proper concentration.

When Using Electrosurgery, Electrocautery, or Laser:

- The surgeon should be made aware of open O_2 use. Surgical team discussion about preventive measures before use of electrosurgery, electrocautery, or laser is indicated.
- Activate the unit only when the active tip is in view (especially if looking through a microscope or endoscope).
- Deactivate the unit before the tip leaves the surgical site.
- Place electrosurgical electrodes in a holster or another location off the patient when not in active use (i.e., when not needed within the next few moments).
- Place lasers in standby mode when not in active use.
- Do not place rubber catheter sleeves over electrosurgical electrodes.

Exhibit B: ECRI Surgical Fires Poster[21]

ANSI coordinates the development and use of voluntary consensus standards in the United States. The Institute oversees the development and use of guidelines for businesses in nearly every sector, including healthcare.[22]

Specific to the operating room, ANSI has developed a number of applicable standards for evaluating and using medical products in the OR.

ANSI Z136.3 – American National Standard for Safe Use of Lasers in Health Care Facilities[23] provides guidance for the safe use of lasers for diagnostic, cosmetic, preventive, and therapeutic applications in health care facilities. The standard covers installation of lasers, operation, calibration, and maintenance as well as recommendations for fire safety related to the use of endotracheal tubes and surgical drapes in laser procedures.

CONSUMER PRODUCT SAFETY COMMISSION

The Consumer Product Safety Commission has published a safety standard that is the most recognized standard followed by manufacturers of surgical gowns and drapes: Standard for Flammability of Clothing Textiles, 16 CFR 1610[24]. This standard is designed to reduce the danger of injury and loss of life by providing on a national basis, standard methods of testing and rating of the flammability characteristics of textiles and textile products for clothing use, including surgical gowns and drapes. Under this method, five

small samples of the material in question are mounted at a 45 degree angle and exposed for one second to an open flame. The time it takes for the flame to spread along the 6-inch length of the sample is recorded and averaged for the five samples. Based on the rate of flame spread, three flammability classes are defined,

- Class 1: Normal Flammability. Time of flame spread is 4 seconds or more. The trade generally regards these textiles as having no unusual burning characteristics.
- Class 2: Intermediate Flammability. This class applies only to textiles with a raised fiber surface. These textiles are recognized as having flammability characteristics between normal and rapid and intense burning.
- Class 3: Rapid and Intense Burning. Time of flame spread is less than 4 seconds. The trade regards these types of textiles as being unsuitable for clothing because of their rapid and intense burning characteristics.

ADDRESSING FIRE SAFETY – SUCCESSFUL STRATEGIES FOR PREVENTION

The Environment

Avoiding the combination of the three elements of the fire triangle is the best method for prevention of surgical fires. The various types of ignition, fuel, and oxidizer sources have been described. Techniques to minimize these risks are outlined below.

- *Minimizing Ignition Risks*[25]
    - During Electrosurgery
        - Place active electrode in a holster or other secured location off the patient when not in active use
        - The active electrode should only be activated by the user
        - Activate the electrode tip only when it is under the user's direct vision
        - Deactivate the unit before the electrode tip leaves the surgical site
        - Use bipolar electrosurgery whenever possible and clinically appropriate if open oxygen sources are employed
        - Never use insulating sleeves that are cut from catheters or packing material and placed over electrosurgical active electrode tips. Use only those tips that are manufactured with insulation
        - Never use electrosurgery to enter the trachea
        - Never use electrosurgery in close proximity to flammable materials in an oxygen-enriched atmosphere
        - Disconnect and remove contaminated electrosurgical active electrodes from the surgical field
    - During Laser Surgery
        - Limit the laser output to the lowest effective power density and pulse duration

        - Test-fire the laser before use to assure alignment of the therapeutic and aiming beams
        - Place the laser in standby mode when not in use
        - Do not allow anyone other than the user to activate the laser
        - Activate the laser only when the tip is under the user's direct vision
        - Use instruments and devices that minimize reflection of the laser
        - Do not clamp laser fibers to drapes – the fibers may break and allow a stray beam
        - During lower airway procedures, keep the laser fiber tip in view and be sure it is clear of the bronchoscope or tracheal tube before emission of the laser
        - Use a backstop when possible to avoid tissue injury distal to the surgical site
        - Use laser resistant tracheal tubes during upper airway surgery. Follow manufacturer's recommendations for inflation of the cuff
        - Pack around the tracheal tube with wet gauze and keep it wet
        - Keep all moistened gauze, packing, and sponges wet during the procedure to help resist ignition
        - If possible, soak towels that are placed around the operative site in sterile water or saline to minimize the risk of igniting the towels
    - General Considerations
        - Remove unneeded footswitches to avoid accidental activation of electrosurgery devices
        - Dispose of electrosurgery pencils properly – remove the cautery wire
        - Remember that fiberoptic light sources can start fires – complete the cable connections before activating the light source
        - Never place active fiberoptic cables on drapes or other flammable materials
        - Keep the fiberoptic light source in the standby mode or off until ready to use or when disconnecting the cables

- *Minimizing Oxidizer Risks*[26]
    - In general
        - Be aware of the fact that enriched oxygen and nitrous oxide atmospheres can vastly increase the flammability of drapes, sponges, plastic, and hair
        - Note areas where oxygen enriched atmospheres is possible – under drapes and in the fenestrations, especially during head, neck, and upper chest surgery

        - Question the need for 100% oxygen by mask or nasal cannula during head and neck surgery – can air or oxygen below 30% be used instead?
        - Stop supplemental oxygen one minute before using electrocautery, electrosurgery, or laser on head, neck, and upper chest surgery
        - Arrange the drapes to avoid accumulation of oxygen and nitrous oxide
        - Avoid the use of nitrous oxide during bowel surgery – the gas can diffuse into the bowel and enrich intestinal gas mixture, increasing flammability
    - During oropharyngeal surgery
        - Use suction deep within the oropharynx to scavenge gases of an intubated patient
        - Wet gauze or sponges used with uncuffed tracheal tubes to minimize leakage of gases into the oropharynx
        - Keep all sponges moist throughout the procedure to aid in ignition resistance

- *Minimizing Fuel Risks*[27]
    - In general
        - Coat hair on the head and face with water-soluble lubricant to make the hair non-flammable
        - Be aware of the flammability of tinctures, solutions, dressings, and packing used during surgery and avoid igniting the vapors
        - Make sponges ignition resistant by moistening with sterile water or saline
    - During prep
        - Be aware that alcohol based preps are flammable
        - Avoid wicking or pooling of flammable prepping solutions
        - Allow flammable prep solution to fully dry before draping (wait at least 2-3 minutes)
        - Remove towels or drapes used during the prep to collect solution from the surgical field

- *General Environmental Considerations*
    - Keep equipment in good repair – check cords and connections for wear and tear or cracked/broken insulation
    - Check equipment for routine biomedical inspection stickers to assure equipment is safe and functioning properly
    - Avoid tripping hazards from electrical cords and footswitch cords
    - Check the electrosurgery unit's grounding pad to assure proper placement and integrity
    - Always check equipment prior to use to verify proper functioning
    - Keep activation tones on equipment loud enough to hear over other room noises so that all are aware when the device is in use
    - Avoid spill hazards by keeping liquids away from electrical devices

Administrative Activities

Avoiding or preventing surgical fires requires the collaboration and support of all members of the healthcare team. Hospital administrators, physicians, nurses, and other members of the team must be active participants in all phases of fire safety. It is also important to highlight Material Management's role in OR Fire Prevention. While this department is typically removed from the activities of the OR, it does influence outcomes.

An anonymous report to AORN of a near miss fire highlights the importance of collaboration between Materials Management and operating room personnel in reducing the risk of surgical fires.[28]

> A particular brand of wound packing material was purchased to replace the one previously used in the OR. This new packing had a higher alcohol content in it. The packing was placed in the patient's wound and electrocautery was used to control some residual bleeding. The packing ignited a small fire. The fire was extinguished quickly, but it could have been prevented if the OR personnel were aware of the product change. Another example includes a fire that occurred due to a change in prepping solution that had a high alcohol content. A warning about flammability hazards went out to hospital material managers and was received the week before, but the information was not passed on to the OR. Communication between the materials management department and the OR is a crucial component of the collaborative healthcare team.

Policies and procedures that address the management of fire risks and hazards, fire prevention, and response to fire should be adopted and enforced by managers at all levels in the hospital. Education, including the use of fire drills, should be provided to all members of the healthcare team. Each member of the perioperative team has a responsibility during the response to a fire and these activities must be included in the education and training for fire safety. Minimizing risks is paramount to prevention of surgical fires. Proper use of fire containing or extinguishing equipment is another important aspect of fire safety that should be addressed during education and drills.

Fire Drill

As previously noted, one aspect of surgical fire safety is conducting department-specific fire drills. A fire safety plan should be established and practiced fire drills implemented. The drill should incorporate all members of the perioperative team as well as the hospital safety officer and local fire department. The team members should know and understand their functions in the event of a fire. By using several scenarios and facilitators to encourage discussion at each phase of the fire drill, interactive learning can occur.[29]

A mock fire drill might include:

- Removing burning drapes from a surgery patient
- Smothering flames
- Deactivating ignition sources

- Locating and using fire alarms and extinguishers
- Determining the need for evacuation and evacuating the patient to the nearest identified safety zone
- Disconnecting oxygen, containing or extinguishing a fire, and maintaining the patient's airway
- Protecting the surgical wound and patient during evacuation
- Documenting and reporting a fire
- Using the fire extinguisher properly

Responding to a Surgical Fire

A surgical fire can mean life or death to a patient. An immediate appropriate response is important to protect the life of the patient and to minimize injury that can result from a surgical fire. The initial response should not be to locate a fire extinguisher. A surgical fire can spread so quickly that by the time the fire extinguisher is obtained and used, the fire could be out of control. The response to an OR fire differs based on the type of fire, but the ultimate goal is to protect the patient. ECRI provides specific guidelines for extinguishing a fire and caring for the patient, as described: [30]

Small Fires:

- Pat out or smother the fire – using a gloved hand or towel.
- Remove burning material from the patient – and extinguish.

Large Fires:

- Stop the flow of oxidizers (anesthetic gases, Oxygen) to the patient – disconnect the breathing circuit, and turn off gas tanks.
- Remove the burning materials from the patient – to protect the patient from the heat of these materials as they can continue to cause thermal damage to the patient. Another team member should extinguish the burning material.
- Care for the patient immediately.
    - Resume patient ventilation (with air, not oxygen) that was stopped initially.
    - Control any bleeding.
    - Evacuate the patient to another room if there is danger from smoke or fire.
    - Assess the patient for injuries and treat as needed.

Airway Fires (these steps should be performed immediately and rapidly at the first sign of fire):

- Disconnect the breathing circuit from the tracheal tube.

- Remove the tracheal tube and have another team member extinguish the fire. Remove any cuff protective devices or remaining segments of the burned tube that may be smoldering in the airway.
- Pour saline or water into the patient's airway.
- Care for the patient.[31]
    - Reestablish the airway and resume ventilation with air. When the risk of fire is completely removed, resume 100% oxygen.
    - Examine the airway to determine the extent of damage and treat accordingly.

Unacceptable methods for extinguishing OR fires are:

Fire Blankets

A fire blanket is a wool blanket treated with fire retardants that is placed over a fire to smother it. Fire blankets are mentioned here as a method that should never be used in the operating room environment.[32] A fire blanket may be ineffective in extinguishing a surgical fire because it can trap the fire next to and under the patient. Placing the fire blanket on a patient may also displace surgical instruments and injure the patient. Further, as with any material in an oxygen-enriched atmosphere, a fire blanket can and will burn.

Aqueous Solutions

The use of aqueous solutions, such as bottled water or saline may be considered for extinguishing non-electrical fires. Keep in mind the level of fluid-resistance of surgical drapes may not allow the water or saline to reach the site of the fire, potentially rendering water or saline ineffective.

Fire Extinguishers

While the use of a fire extinguisher should not be the first choice for dealing with a surgical fire, it may be needed if the fire cannot be contained or the fire engulfs the patient or migrates to staff and other areas of the room. ECRI recommends the use of carbon dioxide (CO_2) extinguishers for use in the OR.[33] ECRI further recommend that a 5-pound extinguisher be mounted just inside the entrance to each OR. The CO_2 extinguisher smothers and cools a fire by expelling a fog of cold carbon dioxide gas and snow. This leaves no residue and is not likely to injure a patient or staff member.

Staff Education

Staff should be educated in the proper selection and use of a fire extinguisher. The acronym **PASS** is useful acronym in teaching OR personnel how to effectively use a fire extinguisher.

P – **Pull** the activation pin

A – **Aim** the nozzle at the base of the fire

S – **Squeeze** the handle to release the extinguishing agent

S – **Sweep** the stream over the base of the fire

When a surgical fire cannot be controlled and the patient is in danger of smoke or fire, evacuation must occur. The acronym **RACE** is typically used to provide guidelines for patient evacuation due to fire.

R – **Rescue** the patient. Disconnect the patient from the anesthesia machine for moving and use an ambu bag to ventilate until able to reconnect the patient to a ventilator in another area.

A – **Alert** staff and sound the Alarm. Everyone in the surgical area must be aware of the fire and perform the functions assigned through the fire safety plan.

C – **Confine** flames and smoke. Close the doors to the OR, shut off gas valves, turn off electrical power at the circuit breaker panel, and communicate these actions. Again, the persons responsible for these activities should be delineated in the fire safety plan.

E – **Evacuate**. The anesthesiologist is typically in charge during an evacuation. The patient is taken to a designated safe area and appropriate treatment is provided.

Fire Safety Tools

The use of tools such as checklists and protocols are useful in prevention of surgical fires. As previously noted, the AORN Fire Safety Tool Kit provides templates and resources that can be accessed through the AORN website for use by any healthcare institution. An appropriate time to perform a fire risk assessment is in the immediate pre-operative period by incorporating it with the “time out” that is performed prior to the start of any surgery or invasive procedure. The goal of the assessment tool is to create an awareness of potential hazards and to initiate critical thinking among the team members to facilitate a safe surgical procedure. A fire risk assessment should contain certain specific items as demonstrated in Exhibit C.

FIRE RISK ASSESSMENT TOOL

Instructions for use

Purpose

To assist the perioperative team in determining and communicating the potential fire risk for each individual patient.

Instructions for use

1. This risk assessment is intended to be used with the Policy and Procedure which contains additional information on fire prevention.
2. The circulating nurse will complete the risk assessment to determine the risk level designation. The risk level designation of A, B, C, D, E is determined by the code assigned to each of the critical questions below that have an affirmative response. The results may be any one letter or any combination of the letters.
3. The circulating nurse will report those having a positive response to the surgical team during the "Time Out" as A, B, C, D, or E or any combinations of the letters.
4. The perioperative team should complete the interventions corresponding each letter before and/or during the surgical procedure to decrease the potential risk of a fire occurring.
5. The following interventions for fire prevention are taken from the policy and procedure for Fire Safety in Perioperative Settings and are provided here as an easy reference.

A. Is an alcohol-based prep agent or other volatile chemical being used preoperatively?

Actions

1. Prevent pooling of skin prep solutions on or around the patient.
2. Remove prep-soaked linen and disposable prepping drapes before placing surgical drapes.
3. Allow skin prep agents to dry and fumes to dissipate before draping the patient and using an ignition source (e.g., ESU, laser).
4. Conduct skin prep "time out" to validate the prepping agent is dry before draping the patient.
5. Allow chemicals (e.g., alcohol, collodion, tinctures) to dry thoroughly and vapors to dissipate before using an ignition source.

B. Is the surgical procedure being performed above the xiphoid process?

Actions

1. Coat head and facial hair near the surgical site with water-soluble surgical lubricant to decrease flammability.
2. Use an adhesive incise drape.

C. Is open oxygen or nitrous oxide being administered?

Actions

1. Use the following strategies to manage the risks of both oxygen and nitrous oxide.

2. Configure surgical drapes to allow sufficient venting of oxygen delivered to the patient via mask or nasal cannula.
3. Deliver 5 L to 10 L/min of air under the surgical drapes to flush out excess oxygen via a separate administration system, if oxygen is being administered via mask or nasal cannula.
4. Titrate oxygen to the lowest percentage necessary to support the patient's physiological needs.
5. Stop supplemental oxygen for one minute before using electrosurgery, electrocautery, or laser for head, neck, or upper chest procedures.
6. Use cuffed endotracheal tubes when possible.
7. Inflate endotracheal tube cuff with tinted saline (e.g., methylene blue).
8. Evacuate surgical smoke to prevent accumulation in small or enclosed spaces, i.e. back of throat.
9. Pack wet sponges around the back of the throat to help retard oxygen leaks.
10. Suction oropharynx deeply before using ignition source if oxygen is used.
11. Check anesthesia circuits for possible leaks.
12. Turn off the flow of oxygen at the end of each procedure.

D. Is an ESU, laser, or fiber-optic light cord being used?

Actions: ESU Use

1. Place the patient return electrode on a large muscle mass close to the surgical site.
2. Keep active electrode cords from coiling.
3. Store the ESU active electrode in a safety holster when not in use.
4. Keep surgical drapes or linens away from the activated active electrode.
5. Moisten drapes if absorbent towels / sponges will be in close proximity to ESU active electrode.
6. Do not use an ignition source to enter the bowel when it is distended with gas.
7. Keep ESU active electrode away from oxygen, if possible.
8. Keep the active electrode tip clean.
9. Use only active electrodes or return electrodes that are manufacturer approved for the type and model of ESU being used.
10. Use only approved protective covers as insulators on the active electrode tip (i.e., NOT red rubber catheter or packing materials).
11. Activate the active electrode only when in close proximity to the target tissue and away from other metal objects that could conduct heat or cause arcing.
12. Inspect minimally invasive electrosurgical instruments for impaired insulation; remove electrode from service if insulation is not intact.
13. Use cut or blend settings instead of coagulation when possible.
14. Use the lowest possible power setting for the ESU.
15. Only the person controlling the active electrode activates the ESU.
16. Remove active electrode tip from electrosurgical / electrocautery unit before discarding

Actions: Laser Use

1. Use a laser-resistant endotracheal tube when using laser during upper airway procedures.
2. Place wet sponges around the tube cuff if operating in close proximity to the endotracheal tube.
3. Place wet sponges or towels around the surgical site for all laser procedures.
4. Only the person controlling the laser beam activates the laser.
5. Verify that water and an appropriate type of fire extinguisher are available before using the laser.

Actions: Fiber-optic Light Cord Use

1. Place the light source in standby mode or turn it off when the cable is not in active use (e.g., used within 5 to 10 seconds).
2. Inspect light cables before use; remove from service if broken light bundles are visible.
3. Secure the working end (i.e., the end that is inserted into the body) of the telescope or cord on a moist towel or away from any drapes, sponges, or other flammable materials.

Fire Risk Assessment Tool

A. Is an alcohol-based prep agent or other volatile chemical being used preoperatively?

☐ **Yes**
☐ **No**

B. Is the surgical procedure being performed above the xiphoid process?

☐ **Yes**
☐ **No**

C. Is open oxygen or nitrous oxide being administered?

☐ **Yes**
☐ **No**

D. Is an ESU, laser, or fiber-optic light cord being used?

☐ **Yes**
☐ **No**

E. Are there other possible contributors (e.g. defibrillator, drills, saws, burrs)?

☐ **Yes**
☐ **No**

Exhibit C – AORN Fire Risk Assessment Tool[34]

SUMMARY

The risk of a surgical fire is a reality every day in the perioperative environment. Many regulatory agencies and professional organizations are involved in providing guidelines and strategies for reducing the risks for surgical fires. All members of the healthcare team must be aware of the roles they play in the prevention of a surgical fire. Should a fire break out, these same team members must have a clear understanding of their roles in the management of a surgical fire. This is accomplished through administrative actions of implementation and enforcement of policies, procedures, and protocols for fire prevention and management. Education is a valuable tool in promoting awareness of the risks for a surgical fire and supporting management of a fire if it occurs. Each member of the perioperative team – surgeon, RN, scrub, anesthesiologist, CRNA, ancillary personnel, and other OR staff members – must be educated in their specific roles and activities to be performed during a surgical fire. The risk of fire may be significantly decreased using fire drills, routine education of and review of policies, and assessment tools. Positive patient outcomes are realized when the healthcare team functions as a cohesive group to promote safety.

CASE STUDIES

The following case studies presented to allow the learner to synthesize and apply the concepts discussed in the study guide to workplace scenarios. Read the scenarios carefully, integrating the data and information to discuss the points to consider.

Case Study 1 – Mrs. PJ

Mrs. PJ is a 35-year-old female admitted for an exploratory laparotomy. She has had several abdominal surgeries in the past and the surgeon suspects she has significant adhesion formation. Music was playing in the OR. The surgery is performed using electrosurgery to remove multiple adhesions in the abdominal cavity. During the procedure, the surgeon places the active electrode pencil on the drape beside the incision while inspecting a site inside the abdominal cavity. The assistant leans forward to obtain a better view of the procedure. The scrub nurse notes a "funny smell" but continues loading suture onto the needle driver she had picked up to prepare for closing the incision. After a few more seconds the circulator thinks she barely hears the high pitch sound that is audible when the electrosurgical generator is activated. She notifies the surgical team. The scrub nurse turns to look at the surgical site and notes smoke. Suddenly a small fire erupts on the drape where the active pencil was lying. The scrub immediately takes her basin of saline from the back table and throws it on the smoking site.

Points to Consider:

- How might the surgical team have prevented the inadvertent activation of the electrosurgery unit?
- Was the use of saline appropriate to extinguish the fire?
- What could have been done in the OR environment to promote a more rapid awareness of the electrosurgical pencil activation?

Discussion of Points to Consider:

- How might the surgical team have prevented the inadvertent activation of the electrosurgery unit?
    - The electrosurgical hand piece should always be holstered or placed in another location off the patient when not in use. The holster should be placed somewhere easy to access, but away from the surgical site.
    - The electrosurgery device should only be activated by the surgeon while directly visualizing the device and the surgical site.
    - The electrosurgery device should be deactivated while still in contact with the tissue to avoid sparking.
- Was the use of saline appropriate to extinguish the fire?
  Saline and water are appropriate to use for some fires, but not on electrical fires. The electrosurgical unit is powered by electricity and the use of water with electricity creates a potential danger of electrocution.

The saline that was used was in a basin on the back table. One should use caution when using water or saline from a basin, as it could become mixed with other solutions that might actually enhance a fire. It is best to use sterile water or saline from a bottle. While it is not the case here, another risk is that the water or saline could be contaminated and the risk of a surgical site infection increases.

- What could have been done in the OR environment to promote a more rapid awareness of the active electrode pencil activation?
  While the surgeon may enjoy hearing his music played during surgery, music volumes must be low because the surgical team has a responsibility to assure safety in the OR. The electrosurgery unit has an audible tone that indicates activation that must be audible at all times.

  The music volume should be low because, the team would have heard the activation tone immediately and perhaps have prevented the fire.

Case Study 2 – Mr. LP

Mr. LP is an 80 year old male admitted to the outpatient clinic for excision of a lesion from the left upper chest. The procedure is scheduled for local anesthetic with sedation. Mr. LP is accompanied by his grandson, who comments to the nurses that he hopes the surgeon does not use sticky tape on his grandfather because his skin is so thin that it might tear. The nurse has assessed the frail skin integrity already and assures the grandson that they will use caution dressing the surgical wound. Before the procedure begins, the CRNA places a nasal cannula with oxygen running at 3L/min on Mr. LP's face. As soon as the nurse finishes prepping the left upper chest area with an iodine/alcohol-based prep, the surgeon begins draping. He places towel drapes around the lesion he plans to remove and then puts a disposable fenestrated drape over the site. The CRNA clips the tops of the drape to the IV poles, creating a barrier between the patient's face and the surgical site. The surgeon begins by making a wide excision around the lesion. Bleeding starts and he uses the electrosurgical pencil to begin hemostasis. As he activates the pencil, a flame erupts. The surgeon tries to extinguish the flame with his hand, but pulls back as the heat from the flame causes pain. The CRNA stands up, screaming, but does not remove the oxygen. The scrub only has 4x4's on the table, as this is a small lesion and she did not expect much bleeding. There is no water or saline open or immediately available. The surgeon pulls the drapes from the site and lays them over the flame, finally putting the fire out. Mr. LP suffers severe burns to his upper chest and neck.

Points to Consider:

- What could the circulating nurse have done regarding the prep to reduce fire risk?
- Discuss the affect supplemental oxygen had on this situation.
- How did the use of towels and the draping technique add to the risk for fire?

- What tool(s) could the surgical team have used to help prevent this fire?

Discussion of Points to Consider:

- What could the circulating nurse have done regarding the prep to reduce fire risk?
  The prep solution is alcohol-based. When using this type of prep it should be completely dry before draping the area. In this situation, the circulating nurse should have informed the surgeon that the prep needed drying time before draping began. Another option is to use a different prep solution that is not flammable.

- Discuss the affect supplemental oxygen had on this situation.
  The use of the supplemental oxygen at 100% via a nasal cannula provides an oxygen-enriched atmosphere. This is one side of the fire triangle that supports the creation and maintenance of fire. When the fire started, the oxygen should have been removed and turned off immediately.

- How did the use of towels and the draping technique add to the risk for fire?
  The towels provided a fuel source, as they are flammable. The towels were placed immediately after prepping, so the wet alcohol prep soaked into the towels, increasing their flammability. By draping the disposable drape up over the face, it allowed accumulation of the nasal oxygen, thus enhancing the oxidizer. The fenestration allowed the accumulated oxygen to flow toward the incision site, providing a continuous oxidizer to fuel the fire.

- What tool(s) could the surgical team have used to help prevent this fire?
  The use of a fire risk assessment tool would have benefited this surgical team immensely. Checking for fuel sources, oxidizers, and ignition sources would have sent up the “red flag.” The prep solution should be dry prior to draping. The necessity of the supplemental oxygen should have been evaluated. Could the procedure have been performed without oxygen? If oxygen was needed, it should be delivered at the minimum concentration necessary for adequate oxygenation, beginning at 30% and increasing as necessary (if open delivery over 30% is necessary, 5 to 10 L/min of air should be delivered underneath the drapes to wash out excess O_2). Additionally, the CRNA and surgeon should have communicated that electrosurgery was needed so that the oxygen could have been turned off for at least one minute prior to activation of the active electrode to diminish the oxygen concentration in the area and reduce the risk of ignition. Alternate forms of draping should have been considered as well.

  Finally, the room was not prepared for a surgical fire. The scrub did not have anything available to extinguish the fire. The surgical team was taken by surprise and the responses were not immediate and rapid enough to avoid significant patient injury. Routine fire education with drills could have supported rapid, appropriate responses from the surgical team and a more positive patient outcome.

GLOSSARY OF TERMS

Electrocautery	Use of a conductor heated by an electric current to cauterize tissue.
Electrosurgery	Use of an electric current passing through tissue to cut, cauterize, or desiccate tissue. In electrosurgery, unlike electrocautery, the patient is part of the electric circuit.
Fire	A rapid, self-sustaining oxidation, accompanied by varying intensities of heat and light.
Flammability	The tendency of a material to burn with a flame; many materials that are nonflammable in air become flammable if the oxygen content of the gaseous medium is increased.
Fuel	Any material that will maintain combustion under specified environmental conditions.
Ignition	Setting or catching on fire.
Laser	Acronym for Light Amplification by the Stimulated Emission or Radiation; a device that transforms light of various frequencies into an extremely intense, small, and nearly nondivergent beam of monochromatic radiation.
OR fire	Any fire that occurs in an operating room – not necessarily one that involves the patient.
Oxidizer-enriched atmosphere (OEA)	An atmosphere that enhances ignition and combustion because of the presence of oxygen, at or above atmospheric concentration, nitrous oxide, or a combination of the two. The most commonly encountered type of oxidizer-enriched atmosphere is the oxygen-enriched atmosphere, in which the oxygen concentration exceeds 21% by volume.

Synthetic	A compound formed through chemical process by human agency, as opposed to those of natural origin (i.e. synthetic fibers and polymers).
Surgical fire	Burning of material on or in a surgical patient.

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