Notable Grand Rounds
of the
Michael & Marian Ilitch
Department of Surgery

Wayne State University
School of Medicine

Detroit, Michigan, USA

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YOUR PATIENT IS ON FIRE

July 19, 2023

About Notable Grand Rounds

These assembled papers are edited transcripts of didactic lectures given by mainly senior residents, but also some distinguished attending and guests, at the Grand Rounds of the Michael and Marian Ilitch Department of Surgery at the Wayne State University School of Medicine.

Every week, approximately 50 faculty attending surgeons and surgical residents meet to conduct postmortems on cases that did not go well. That “Mortality and Morbidity” conference is followed immediately by Grand Rounds.

This collection is not intended as a scholarly journal, but in a significant way it is a peer reviewed publication by virtue of the fact that every presentation is examined in great detail by those 50 or so surgeons.

It serves to honor the presenters for their effort, to potentially serve as first draft for an article for submission to a medical journal, to let residents and potential residents see the high standard achieved by their peers and expected of them, and by no means least, to contribute to better patient care.

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Your Patient is On Fire

A Notable Grand Rounds Presentation

delivered at
Wayne State University
School of Medicine on
July 19, 2023

by

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This paper has been adapted from an oral presentation.

Fig. 1. Fire!

Objectives

This paper explores the factors that contribute to surgical fires, focusing on both the personnel involved and the equipment utilized. Three key components, together comprising the *fire triangle*, play a pivotal role in these incidents. Understanding these components is essential for developing and implementing techniques and best practices to prevent such fires.

Factors Contributing to Surgical Fires

Two case studies illustrate some of the factors:

Case Study 1:

Patient Profile: 33-year-old female diagnosed with carcinoma buccal mucosa, undergoing marginal mandibulectomy under general anesthesia.

Procedure: After nasal intubation of the trachea, the surgical site was cleaned using povidone-iodine followed by isopropyl alcohol. Post-prepping, a drying period of two minutes was observed before commencing surgery. A 5 cm incision was made, and upon activating the electrosurgical unit, a fire erupted near the head.

Immediate Action: The surgeon doused the fire with saline and removed the burning materials. Fire protocols were initiated: oxygen was turned off, and manual bag mask ventilation was employed.

Observation: Residual alcohol solution had seeped into the patient's hair near the right ear beneath the drapes, which ignited from the spark of the electrosurgical unit.

Outcome: The right side of the patient's face suffered second-degree burns (**Fig. 2**).

Fig. 2. Burns from a surgical fire

Case Study 2:

Patient Profile: 82-year-old white female set for pacemaker upgrade surgery in the cath lab, not a standard OR.

Workup: See **Box 1**, next page.

Procedure: The patient, on multiple medications with normal labs, was under local anesthesia. Chlorhexidine was used for prep, and the surgery commenced as scheduled. The patient remained awake, receiving 6 liters of oxygen through a face mask.

Incident: Shortly after the anesthesiologist left the cath lab, a fire broke out. The patient's face mask was entirely burned within seconds, affecting the chin, nose, and majority of the face.

Immediate Action: Oxygen was disconnected, the face mask removed, and saline-soaked gauze was applied. The burned drape was removed to inspect a second-degree burn on the patient's face, ear, and under the mandible on the left. The procedure was halted, hospital risk management was informed, and the surgical wound was closed.

Concerns and Statistics

Study data from the Pennsylvania Patient Safety Authority, extrapolated to the country at large, indicate a recent reduction in the number of surgical fires from 650 to 217 events each year in the United States. However, the actual number of fires is probably higher than estimated since only half of the states require mandatory reporting of such occurrences.

In the ASA (American Society of Anesthesiology) claims database, surgical fires make up about 1.9% of liability claims. Fires caused by electrocautery rose from under 1% in surgeries from 1985-1994 to around 5% currently. The common factors in these incidents remain: open delivery of oxygen, use of monopolar electrosurgical units, and application of alcohol-based solutions.

PMH is significant for:
- CAD S/P CABG in 2006
- VVI pacemaker
- HTN
- Asthma
- DJD
- Chronic kidney disease
- hypothyroidism

PSH is significant for:
- CABG
- VVI pacemaker

Allergies:
Quinine, Sulpha. drugs

Medications
- Combivent
- Lasix
- Nitrostat
- Aspirin
- Norvasc
- Omeprazole
- Betamethasone cream
- Lipitor

Labs
- CBC: within normal values
- CMP: within normal values

Monitors
- Standard ASA monitors
- Anesthesia
- Versed/ Fentanyl
- Maintenance
- Versed/ Fentanyl
- Oxygen mask 4 liters
- Intraoperative course
- Normal

Box 1. Case Study #2 workup

Most claims arise in outpatient settings, primarily affecting the upper body (85%) during monitored anesthesia care. Compensation was awarded in 78% of the cases, with a median payout of about $120,000.

The critical issue is not the financial aspect but understanding why these incidents occur and preventing their recurrence.

Nature and Causes

To combat the risk of surgical fires, we must first understand their nature and underlying causes.

Surgical fires are defined as fires that occur on, inside, or near a patient while under care or anesthesia, including airway fires and fires within the anesthesia circuit.

An airway fire is a specific type of surgical fire that may or may not include fire in the attached breathing circuit. Airway fires happen most often during ENT procedures when lasers are used. There's a risk that the endotracheal tube can ignite due to the presence of an oxygen source, leading to a fire within the airway.

The most common anatomical sites for fires include the upper airways, trachea, and bronchi, which comprise 28% of such incidents. Fires occurring above the face, head, neck, and chest account for 24%, while fires on other parts of the body and inside the body represent 24% and 14% respectively.

Combined, the face and airway are involved in 62% of surgical fires that are proximate to the oxygen source. Anesthesiologists or CRNAs administer oxygen from the head side, making these areas vulnerable.

Communication between the anesthesiologist and the surgical team is crucial, especially when using devices like electrocautery near the upper chest. The aim should be an oxygen concentration as low as possible. However, sometimes unexpected events lead to an increase in oxygen concentration, which heightens the risk of fire. Examples include the patient's moving unexpectedly, or a drop in saturation levels.

Some procedures with heightened risks include cervical colonization, cesarean sections, facial surgeries, oral surgeries, pneumonectomies, tonsillectomies, tracheostomies, and interventions for intestinal obstructions (see **Box 2**).

Airway fires occur in a confined area with a high concentration of oxygen. The presence of an ignition source in such an environment can lead to a fire, emphasizing the importance of under-

- Cervical conization
- Cesarean section
- Facial surgery
- Oral surgery
- Pneumonectomy
- Tonsillectomy
- Tracheotomy
- Intestinal obstruction

Box 2. Surgical Fires Reported, by Procedures

standing the fire triangle (**Fig. 3**). This consists of (1) a fuel source (e.g., alcohol skin preps, drapes, gauze, sponges, hair, skin), (2) ignition sources (e.g., electrocautery, lasers, fiber optic light sources, drills, defibrillator pads), and (3) oxidizers (oxygen and nitrous oxide).

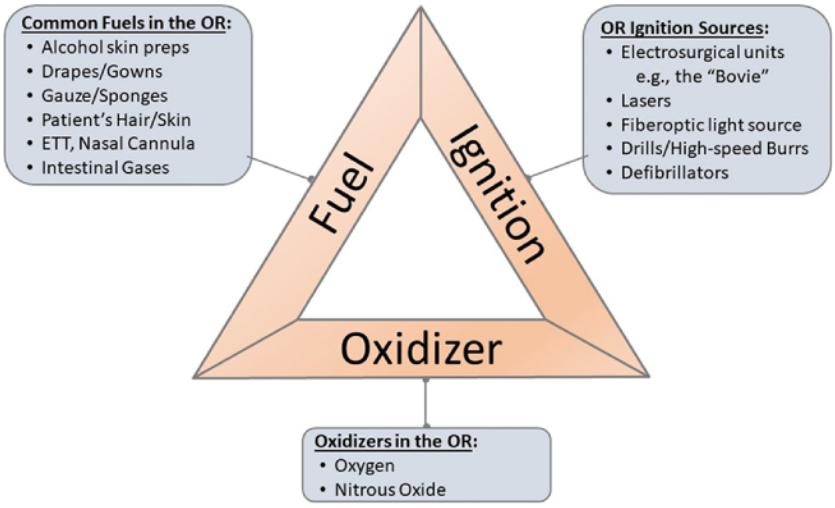

Fig. 3. The Fire Triangle – The 3 elements that must come together for a fire to occur

Oxygen supports combustion. In the anesthesia context, any concentration above 21% increases the risk of a fire. Thus, keeping a patient on room air, which has an oxygen concentration of around 21%, is safest. The National Fire Protection Association warns that any atmospheric oxygen concentration above 23.45% is dangerous. Oxygen is heavier than air, so it settles and can concentrate, raising the risk of combustion. The room might have 21% oxygen, but the presence of a 100% oxygen source in the vicinity can elevate that concentration.

Electrocautery, lasers, fiber optic lights, and other ignition sources are typically under the control of the surgical team. In the operating room, gases such as methane, especially from the patient's gastrointestinal tract, can also act as combustion sources.

Sometimes equipment can malfunction and start overheating. The nursing team usually handles most of the preps, including alcohol, linen, drapes, sponges, and plastic equipment. Other concerns include drapes on the OR table and pads underneath the patient. Notably, a patient's hair, especially after being prepped with alcohol, and surgical caps worn by patients can become fire hazards.

It is crucial after prepping to ensure that the prep is fully dry before placing drapes. While many materials used in the operating room are fire-resistant, they can still burn and produce toxic smoke. If a fire is not put out within 30 seconds, the smoke itself can become overwhelming.

Prevention

The key to managing a fire in the OR is prevention. Everyone in the room is responsible for fire safety (**Fig. 4,** next page). During the "time out" process, especially for cases above the xiphoid level, all staff need to acknowledge the fire risk and discuss prevention. The anesthesia team handles the delivery of medical gases, while the surgical team manages ignition sources. OR staff apply preps and use other equipment.

It is imperative to conduct a fire assessment before surgery and to be aware of high-risk procedures—any procedure above the xiphoid level poses a high risk for surgical fires. Consider the available ignition sources and delivery of supplemental gases.

While it is common for patients in the OR to receive oxygen, it is not always necessary. If a patient's oxygen saturation is 92% in room air, they do not need supplemental oxygen to reach 100% saturation. An emphasis on teamwork ensures that surgeons provide adequate local anesthesia so that the anesthesia team does not need to over-sedate patients, which can lead to potential fire risks.

Fire Extinguishers

Every OR should be equipped with fire extinguishers. There are different types of extinguishers (**Fig 5**), with the combination A/B/C type (not shown) being most suitable for operating rooms as it can handle class A, B, and C fires. These extinguishers contain dry chemicals that interrupt the chemical reaction of fires.

First and foremost, all OR staff must always know the location of a fire extinguisher. In emergencies there is no time to search for one. Equally important: It is essential not only to *have* the fire extinguisher but also to know *how to use* it. OR staff should familiarize themselves with the operation of a fire extinguisher, in the OR or even at home. Small fire extinguishers can be bought from stores like Home Depot.

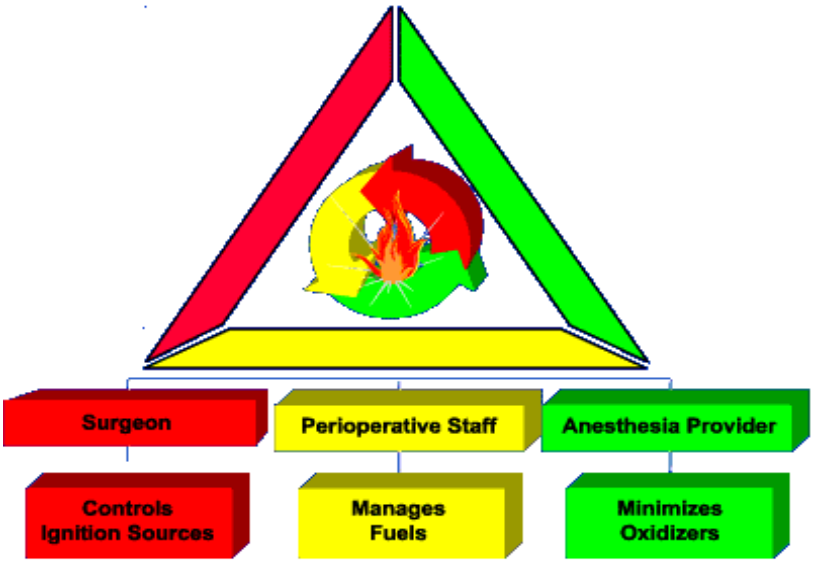

Fig. 4. OR fire risk management responsibilities

It is of course crucial to have the right extinguisher for the type of fires that might occur in an OR. The fire risk assessment commonly used considers factors such as the use of alcohol-based prep agents or volatile chemicals preoperatively. The assessment asks:

- Is the surgical procedure being performed above the xiphoid process?
- Is open oxygen or nitrous oxygen being administered?
- Will an ESU, laser, or fiber-optic light cord be used?
- What other possible contributors to a fire might exist?

If the risk assessment score is 3 or above, the risk of fire is high, especially when using alcohol-based preps.

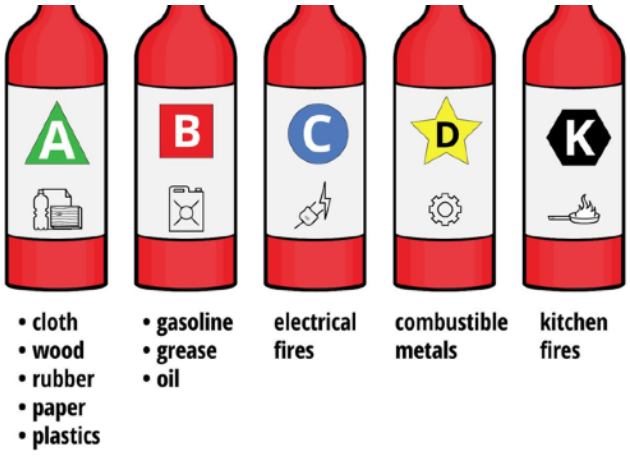

Fig. 5. Types of fire extinguisher. Types A, B, and C are sometimes combined in one cylinder.

For high-risk scenarios:

- Fire extinguishers must be present in the OR.
- All OR staff should know the location of the oxygen shut-off valve.
- Implement routine prevention measures, even for procedures below the xiphoid—they can still lead to fires.
- Ensure there is documentation in the EMR about discussions on how to prevent and manage fires.
- Be cautious of gases like methane and ensure regions like the perirectal area are protected with wet roll gauze when using tools like lasers or cauteries.

For anesthesia:

- Only use oxygen when necessary, limiting the flow and avoiding contamination of the environment.

- Adjust the approach based on the patient's physical status, using tools like pulse oximetry to guide oxygen therapy.
- It is vital not to aim for saturations above the patient's baseline levels.
- Minimize sedation and prioritize local anesthesia and communication with patients.
- Understand the differences and implications of tools such as nasal cannula and face masks. For instance, face masks can have a higher reservoir of 100% oxygen, which can be dangerous near ignition sources.

When using lasers:

- Use only laser endotracheal tubes when working in the airway.
- Be aware of potential fire risks from drapes, sponges, towels, and linens. Protect the patient's body, hair, skin, and adipose tissue appropriately.
- Give special attention to alcohol-soaked items, ensuring they are allowed to dry properly, especially around the head and hair regions.
- It is crucial to give 2 to 3 minutes for areas to dry and avoid pooling of alcohol. Remove any soaked material from the field and, if possible, avoid flammable prep on the skin. If used, ensure it dries adequately and follow manufacturer recommendations.
- When prepping areas near the hair, chest, or armpits, let it dry, and consider applying a water-based gel afterward.

Water-Based Gels: For procedures, especially near the head, water-based gels are recommended. They help to avoid complications.

Avoid Petroleum-Based Products: For any facial surgery, petroleum-based eye ointments are not recommended, as they could cause burns.

Oxygen Precautions: When draping, ensure it is done in such a way that oxygen does not get trapped around the patient's head and neck. Use tools such as suctions and blenders to reduce the concentration of trapped oxygen.

Draping Protocols: Drapes should be arranged to allow maximum observation, communication with the patient, and easy access for airway manipulation.

Equipment Maintenance: Regularly inspect equipment and send malfunctioning or faulty tools for repairs. This includes ensuring that the tips of instruments are clean and free from any char or tissue.

Electrosurgical Units: Use with caution, ensuring they are not activated near or in contact with other instruments. When possible, use a bipolar electrocautery—it is safer.

Ignition Sources: Only use when necessary and avoid high-risk surgeries with a high concentration of supplemental oxygen. This includes ensuring that ignition sources do not enter gas-filled areas, such as a distended bowel, which could cause explosions.

Laser Precautions: Use moist towels around the surgical site and moist sponges in the throat when lasers are involved.

Ointment & Gel Selection: Choose water-based ointments and ensure the ultrasound gel is also water-based.

Skin Prep Protocols: Prevent pooling of solutions, allow agents to dry, and ensure the area is dry before draping.

***Fire Protocol*: In the event of a fire, prioritize the safety of the patient. Stop surgery, disconnect the breathing circuit, remove burning material, and extinguish the fire.**

Education & Drills: Regularly train new staff on fire safety and consider implementing surgical fire drills to ensure everyone knows how to handle such emergencies.

Promote Safety Culture: Encourage reporting of near misses, ensure all fires are reported, and conduct debriefing sessions to evaluate and learn from any incidents. Aim to create a culture where all staff members can speak up without fear of retaliation.

Equipment Preparedness: Make sure the operating rooms have the necessary firefighting equipment and that all staff know how to use it.

Summary

Fostering a culture of safety, vigilance, and continuous education can significantly reduce the risk of surgical fires and ensure the safety of both patients and medical staff.

Understand Root Causes: After studying surgical fires for over four decades, it is known that most originate from oxygen that is provided to the patient coming into contact with an ignition source.

Beware of Ignition Factors: Tools such as lasers can serve as ignition sources. Combining these tools with flammable materials, such as specific fabrics or drapes, can further exacerbate the problem.

Guard Against Oxygen Overuse: Some investigations suggest that not all patients require standard oxygen during surgery. Yet, many are supplied with oxygen concentrations higher than necessary. This overuse can be a prime contributor to the risk of fires.

Use Demonstrative Experiments: Investigations have shown the effects of fires on synthetic materials designed to emulate human skin. When these materials are exposed to conditions similar to surgeries where oxygen is being provided, they easily catch fire. The damage doesn't just remain localized; it can spread to adjacent areas such as the upper chest, chin, eyes, and more.

Know the Statistics: Over the last decade, there has been a notable 65% decline in surgical fires, but even one such incident is one too many, given the potential severe consequences.

Understand the Impact: Despite the decline, approximately 130 patients per year still suffer from severe facial injuries due to these fires. While the numbers might seem relatively small, the gravity of the situation is enormous for the affected patients and cannot be overlooked.

Implement Safety Protocols: The overarching message is the importance of stringent safety measures and protocols. While advancements and training have reduced the risks, it is crucial for medical professionals to be constantly vigilant. In short: While steps have been taken to minimize the occurrence of surgical fires, there remains a continuous need for awareness, training, and vigilance to ensure patient safety.

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