

FIRE IN THE OPERATING ROOM DURING TRACHEOTOMY: A CASE REPORT

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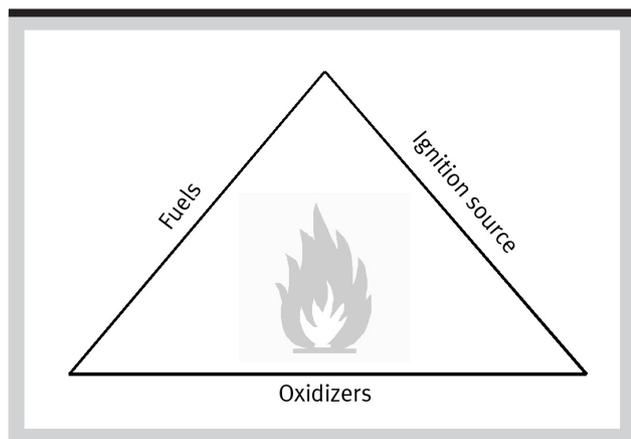
We describe a patient who sustained facial burns during a tracheotomy. The electrosurgical unit indirectly started the fire during monitored anesthesia care when a high inspired oxygen concentration was being delivered to the patient by simple face mask. This case points out the need

for prevention strategies, intraoperative vigilance, and quick intervention to prevent further patient injury any time the electrosurgical unit is used in an oxygen-enriched atmosphere.

Key words: Fire, operating room, tracheotomy.

The risk of surgical fires is always present when surgery takes place. Experts estimate the number of surgical fires in the United States to be 50 to 100 or more per year.¹ Although the incidence is rare, when fires occur, the effects can be devastating to the victims, their families, the hospital, and the surgical staff.^{1,2} Clinicians endeavor to make the operating room (OR) safe, but fire can occur when an ignition source, oxidizers (such as nitrous oxide and oxygen), and fuels are combined. These 3 elements constitute the fire triangle (Figure 1) and are abundant in any OR, providing many opportunities for unexpected fires to occur.^{1,2} The most common sources of ignition are electrosurgery units (68%) and laser equipment (13%).^{1,2} Patients undergoing surgery typically receive oxygen. In fact, the Emergency Care Research Institute found that oxygen-enriched environments are involved in about 74% of fires.² Numerous fuels, including drapes, alcohol-based skin prep solutions, and plastic materials such as endotracheal tubes and oxygen-delivery systems, are abundant in the surgical suites.²

Figure 1. The fire triangle



Although the different members of the surgical team have primary control over various items that are all parts of the fire triangle, all team members must be aware of and vigilant for the factors that together can cause OR fires. For example, surgeons are most often in control of the ignition sources; anesthesia providers control the flow of oxidizing gasses; and circulating nurses control the fuels. Therefore, responsibility for fire prevention is a shared responsibility among the entire surgical team. Effective fire prevention, detection, and response are possible only if the entire surgical team understands the fire risks, is educated about handling these emergencies, and undergoes regular training for a fire scenario.^{1,2}

Case report

A 64-year-old man with a history of throat pain and hoarseness originally sought medical care in April 2003. A biopsy revealed poorly differentiated squamous cell carcinoma. In August of the same year, he was admitted for surgical treatment at a large federal medical center in the Midwest. A computed tomography scan of the neck in late August showed a 5-cm mass in the left soft palate, extending down to the floor of the mouth and involving the left base of the tongue with possible invasion of the mandible. A computed tomography scan of the chest at that time revealed a 4-cm mass in the right upper lobe of the lung. A feeding gastrostomy tube was placed early in September, and dental extractions were done in preparation for treatment of the carcinoma.

The patient was admitted to the medical center for radiation and chemotherapy. He had not had any routine medical care for 30 years. He had a 100-pack-year history of smoking and was currently smoking approximately one-half pack per day. The patient reported drinking 6 to 7 whiskey and colas daily for the past 30 years.

The patient first was admitted to the OR in January 2004 for a direct laryngoscopy with biopsies. The biopsies revealed a large necrotic area of tissue at the base of his tongue, and he was returned to the ward for continued monitoring and treatment.

On the evening of the fifth postoperative day, the patient was found on his knees in his hospital room bleeding. He had noted bleeding from his mouth and attempted to reach the bathroom when he fell. He was ashen, acutely anxious, and in respiratory distress. His oxygen saturation (SaO_2) while receiving oxygen at 5 L/min was 74%, his respiratory rate (RR) was 46, and his arterial blood gas results were as follows: pH 7.30; pCO_2 , 50; pO_2 , 48; and bicarbonate, 24 mEq/dL. He was transferred to the medical intensive care unit (MICU). On arrival, he was in less respiratory distress and less anxious; his SaO_2 was 96% and RR, 20.

After assessment, it was determined that the bleeding arose from the patient's necrotic tumor, which had compromised his airway, resulting in agitation, hypoxia, and the subsequent fall. He was assumed to have aspirated blood. The patient remained in the MICU and received high-flow oxygen at a concentration of 60% to 95% by face mask and was suctioned frequently to maintain his SaO_2 at more than 90%. The otolaryngology service evaluated the patient on the next day. He was confused and had evidence of a pulmonary infection, with an elevated white blood cell count and fever. The otolaryngology team offered him a tracheotomy for pulmonary toilet and airway protection.

The patient was scheduled for the OR on the next day. On the day of surgery, he still required oxygen by mask at a concentration of approximately 50% to maintain an SaO_2 of 92% to 95%. He remained somewhat confused and had rhonchi audible from the bedside, and he required frequent suctioning. His blood pressure and heart rate were stable, his RR was 20 to 26, and his temperature, 37.5°C.

The patient was transported to the OR with a rebreathing oxygen face mask at a flow rate of 10 L/min. He was moved to the table and positioned, and monitors were applied. The surgical resident was informed about the necessity of keeping the oxygen on by face mask to maintain adequate oxygenation. The oxygen flow through the face mask was at 10 L/min, which translated to an FI_{O_2} of 59%. The patient was given 1.0 mg of midazolam and 100 μg of fentanyl, both in divided doses, before the surgeon's administering local anesthetic into the surgical site. His vital signs were stable, end-tidal carbon dioxide was confirmed, and the patient appeared comfortable. The surgical site was prepped with iodophor scrub and dried, and iodophor solution was applied. He was

draped using sterile cotton towels to square off the anterior portion of the neck, and crumpled towels were placed alongside the neck bilaterally. The upper towel was folded over to expose the patient's eyes and placed over the mask down to the level of the chin.

The surgical resident made an incision in the anterior portion of the neck with a scalpel. Monopolar cautery was used to stop bleeding at the skin edges. Immediately, the surgical resident felt heat and noted that a nearby dry 4×8-inch sponge had ignited. The resident threw the sponge to the floor and then noted that the exposed part of the mask was blackened and there was smoke coming from it. Next, someone shouted, "Fire!" Simultaneously, the face mask and the patient's entire face became engulfed in flames (Figure 2). The CRNA turned the oxygen source off while the staff surgeon removed the flaming mask and threw it to the floor above the head of the table, where it continued to burn and singe the OR table's power cord (Figure 3). The CRNA stamped on the face mask to extinguish the fire while the surgeons and scrub nurse bathed the patient's face with saline-soaked towels. The CRNA noted that a trail of flame was continuing to burn up the oxygen mask's tubing toward the source on the gas machine. The tubing then was disconnected from the oxygen source (Figure 4).

The initial examination of the patient revealed no evidence of increased airway distress. The patient verbalized that his face felt hot. The skin of his upper and lower lips, chin, nose, eyelids, and cheeks had sustained first- and second-degree burns. The surgeons debrided the superficial layer and gently cleaned the patient's face to remove the carbonaceous material. The surgeon applied silver sulfadiazine cream to the affected areas. The patient's SaO_2 decreased to the mid-80s while he was breathing room air, so a second oxygen mask was placed on the patient, and oxygen was given at a rate of 5 L/min. This resulted in an SaO_2 of

Figure 2. Burnt face mask



Figure 3. Singed operating room table cord and burnt flooring

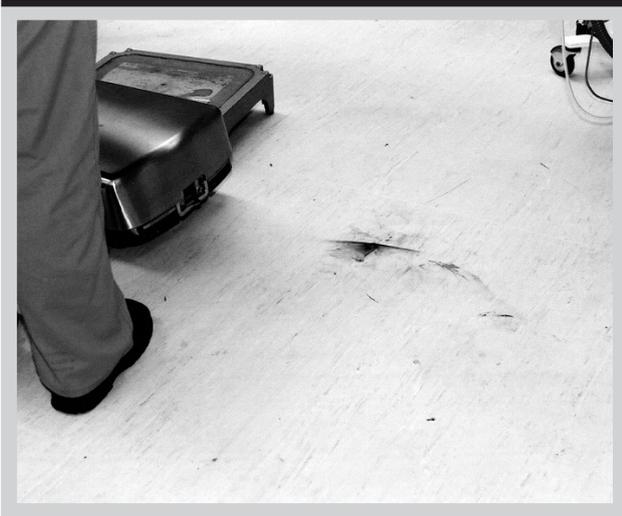
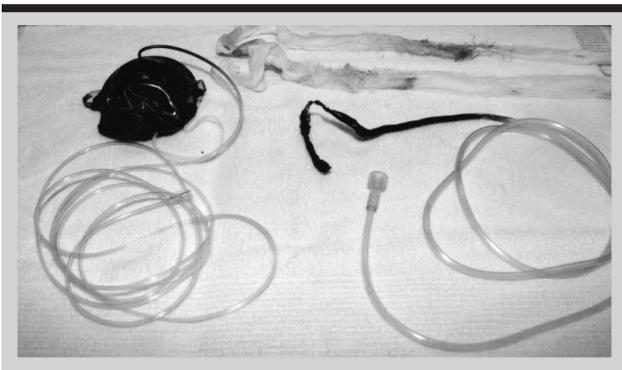


Figure 4. Fire ascending the oxygen supply tubing; burnt sponges in the background



90%. The staff surgeon elected to proceed with the tracheotomy. This was completed without incident. The CRNA titrated an additional 4 mg of midazolam and 150 µg of fentanyl intravenously during the procedure.

On completion of the tracheotomy, the staff surgeon performed a more comprehensive airway examination. A gross secondary visual examination of the oral cavity, oropharynx, nasal passages, and eyes revealed no airway burns. The surgeon then performed a fiberoptic examination of the lower trachea and bronchi. The lower airway examination revealed no carbonaceous material. Examination of the nasal passages demonstrated damage to the skin of the nasal alae, but the mucosa was intact. The patient was given a total of 50 mg of propofol for these procedures. The ophthalmology service examined the patient's eyes. The examination revealed no corneal damage. The patient was transferred to the postanesthesia care unit and was receiving oxygen at 10 L/min per "tra-

cheostomy dome." The patient was awake, anxious, and mouthing words. His vital signs on arrival in the postanesthesia care unit were as follows: blood pressure, 118/47; heart rate, 126; RR, 20; and SaO₂, 93%.

The patient was transferred to the surgical intensive care unit where he was monitored for 6 days. A methicillin-resistant *Staphylococcus aureus* pneumonia developed, requiring vigorous pulmonary toilet. The dermatology service was consulted and continued to observe the patient for evaluation of the burns. Treatment was changed to bacitracin ointment at their recommendation. Initially, the patient experienced facial swelling, more on the left side of the face than on the right. This swelling gradually resolved throughout his stay. The mental health service also was consulted to address the patient's fears and anxieties surrounding the incident. He was transferred to the general surgical ward on postoperative day 6. Treatment was continued for his pneumonia and superficial burns. He was transferred back to the extended care floor on postoperative day 12. Within approximately 3 weeks, the patient's facial burns were nearly healed and he continued to recover. He experienced some increased sensitivity in the facial areas that were burned. As he recovered from the surgery and burns, his cancer went into remission. With his cancer in remission and his pneumonia resolved, the patient desired to return home. He elected to have his tracheostomy closed to go home.

Discussion

Fire in the OR remains a constant danger, despite the absence of the flammable and explosive anesthetic gases.³ During a tracheotomy, 3 elements are present that will support an explosive or combustive event: heat, fuel, and oxygen.⁴ These 3 elements, which constitute the fire triangle, are prevalent in OR settings and provide many opportunities for unexpected fires to occur.² Surgeons most often have control of ignition sources such as electrosurgical units, electrocautery units, lasers, and fiberoptic light sources. Nurses and scrub technicians most often control fuel sources such as surgical drapes and prepping agents. Anesthesia providers control the flow of oxidizers such as oxygen, nitrous oxide, medical compressed air, volatile anesthetics, and ambient air.²

Ignition sources provide the heat source that can start a fire should the heat source come in contact with some fuel or oxygen source. The electrosurgical units are the most common ignition source in surgical fires.² The tip of the electrocautery can reach 1,500°F, more than enough to ignite most organic materials.² The flow of current can be momentary, but the heat

can be maintained by the buildup of char at the tip of the cautery or on the tissue surface. Char can retain heat and even glow briefly. Lasers are the second most frequently cited source in surgical fires and can cause damage if misfired or misdirected.² Fiberoptic light sources can provide enough energy to melt, scorch, or ignite materials. To minimize the ignition risks, the electrosurgical tips should be placed in a holster when they are not in active use and lasers should be placed on standby. Fiberoptic cables should never be placed on flammable materials.²

Most of the fuels found in ORs can ignite and burn in air, but all can burn in oxygen-enriched environments.² Common OR materials that can serve as fuels include the operating table mattress, sheets, and blankets; surgical gowns, caps, gloves, and booties; patient gowns and straps; and towels, drapes, dressings, and sponges. Fire retardants are used in some of these materials but cannot be relied on to prevent fires.² Skin prep solutions often contain alcohol, acetone, or benzoin. These solutions can wick into hair or linens or pool under the drapes. Many other common materials in the OR can serve as fuels: petroleum-based ointments; plastic equipment, including hoses and cables, masks, circuits, and endotracheal tubes; patient's hair, tissues, and bowel gases; and countless others.² To minimize the fuel risks during prep, be aware that the alcohol-based preps are flammable. Avoid pooling and wicking, and allow prepped areas to dry fully before draping. In general, be aware that most materials in the OR are flammable, and take precautions to prevent fires.²

Oxidizers are gases, such as oxygen and nitrous oxide, that can support combustion. Oxygen at concentrations above that of ambient air typically is provided to patients by endotracheal tube, face mask, or nasal cannula. This can create oxidizer-enriched atmospheres that support ignition and combustion.² Oxidizer-enriched atmospheres are those in which the oxygen concentration exceeds 21% by volume. As the oxygen concentration rises, so typically does the risk of fire.² Many materials that would not burn or sustain a flame in ambient air will do so in an oxygen-enriched environment. To minimize the oxidizer risks in the OR, be aware that both oxygen and nitrous oxide support combustion. Also, be aware of possible oxygen and oxygen/nitrous oxide-enriched atmospheres that may exist near the surgical site under the drapes, especially during head and neck surgery. Question the need for high oxygen concentrations, and, if possible, adjust the concentrations to the minimal level that the patient can tolerate.² To help dissipate combustible gases, tent the drapes to allow gases to dissipate away from the

operating table. Use a properly applied incise drape, if possible, to help isolate the head and neck incisions from oxygen-enriched atmospheres and from flammable vapors beneath the drapes.²

After analyzing the details of this case, the anesthesia providers determined that the risk of fire could have been reduced. Whenever possible, the oxygen concentration should be lowered. In this case, the patient had a compromised airway and poor oxygenation. The anesthesia team could have foregone sedation and attempted local anesthesia for the tracheotomy, but even without sedation in the MICU, this patient required high-flow oxygen to maintain adequate oxygenation. The anesthesia team believed that it would be in the patient's best interest to keep the oxygen by face mask, and this was communicated to the surgeon. The team could have improved that communication by reporting the specific oxygen concentration to the attending surgeon. In turn, the surgeons should have used saline-soaked gauze and consider soaked towels around the incision and oxygen source to decrease the chance of ignition, especially because of the leak potential surrounding the mask.

When a fire occurs, it can start and grow rapidly in the presence of oxygen,³ as it did in this case. Every member of the perioperative team must be educated about handling fire emergencies and extinguishing fires quickly. The potential risk for fire in all cases, especially head and neck cases, must be identified and appreciated. Steps to reduce those risks should be taken. When a fire happens, quick action during the first few seconds can make the difference between a survivable event and a poor outcome with permanent patient injury. The primary concern is for the patient. We were fortunate. Although the fire was unexpected, sudden, and impressive, our patient sustained minimal injury and made a full recovery from the burns.

REFERENCES

1. Beyea SC. Preventing fires in the OR. *AORN J*. 2003;78:664-666.
2. A clinician's guide to surgical fires. How they occur, how to prevent them, how to put them out. *Health Devices*. 2003;32:5-24.
3. Fires in the operating room: still occurring. *Quality Review in Anesthesia*. March/April 2004;7(1)2.
4. Thompson JW, Colin W, Snowden T, Hengestic A, Stocks R, Watson SP. Fire in the operating room during tracheotomy. *South Med J*. 1988;91:243-247.

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