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OR Fires! Minimizing the Risk

Fires involving the surgical patient, while statistically small in number compared to the number of surgical procedures performed annually (approximately 27 million), can be disastrous. One to two deaths resulting from OR fires reach the newspaper headlines each year, with many others going unreported. Actual figures on the number of incidents are not available because there is currently no centralized reporting mechanism.

Fires occurring in the operating room usually ignite on or in the patient and can spread at an alarming rate. "For any fire to occur, three factors must be present in the proper proportions. These are an oxygen source, a fuel source, and an ignition mechanism."[1] These three factors together represent the fire triangle, and are commonly found in the surgical setting. Understanding the fire triangle and its components is the first step toward fire prevention, and is the responsibility of the surgical team. "Each member of the surgical team controls a specific side of the triangle: surgeon, heat sources; nurse, fuels; anesthesiologist, oxidizers."[2]

Heat increases the oxidation rate of a fuel-oxygen mixture until combustion occurs. In the surgical arena heat is supplied by various sources, the most obvious being electrosurgical (monopolar and bipolar) devices, electrocautery and lasers. Other sources include overhead lights, defibrillators, heated probes, drills and burs, argon beam coagulators, and fiberoptic light sources and cables. These commonly used tools can produce temperatures from several hundred to a few thousand degrees Fahrenheit. Heat isn't the only culprit! Incandescent sparks produced by electrosurgical accessories (buzzing the hemostat) or high-speed drills and burs; laser energy striking non-anodized metal instruments and damaged laser fibers must also be considered, as well as glowing embers from charred tissue. Sparks can provide enough initial heat to ignite some fuels, especially in an oxygen-enriched (greater than 21% of room air) atmosphere or OEA. While some heat producing devices must come into direct contact with the fuel source to trigger combustion, other devices such as lasers can be several meters away and cause instantaneous ignition. Keeping heat sources isolated and not allowing them to come in contact with fuels is an essential step in fire prevention. For the purpose of this newsletter, suggested measures for controlling heat sources will concentrate on those specific to electrosurgery. These measures include but are not limited to:

- place appropriate active accessories in non-conductive safety holsters when not in use; larger or longer active accessories must be placed away from the patient – either on the back table, mayo stand or in a heat resistant receptacle such as a basin
- activate heat sources only when the tip is in view and deactivate before the tip leaves the surgical site
- avoid open circuit activation when buzzing a hemostat to prevent metal to metal arcing

  (Refer to Clinical Information HOTLINE, Vol.2, Issue 4, Buzzing the Hemostat, What you Should Know)
- use caution in bowel procedures where methane may be present, or in body cavities where oxygen and/or nitrous oxide may accumulate
- prevent eschar build-up on active electrodes that leads to increased resistance and contributes to arcing. (Use of coated electrodes facilitates easy

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removal of eschar, reducing the possibility of embers that may ignite.) Frequently clean all active electrodes.

- avoid activation of heat sources close to dry gauze or surgical drapes
- do not coil, bundle or clamp electrosurgical active cords; this practice may induce currents that could lead to fires or injury to the patient or surgical personnel
- inspect all cords for frays, cuts, or loose connections and check biomedical stickers
- perform electrosurgery using the lowest possible power setting (especially when using needle electrodes), use short activations
- place patient return electrode on a large muscle mass as close to the surgical site as possible
- use the lower voltage cut mode to desiccate tissue rather than the high voltage coag mode
- avoid the use of electrosurgery to cut tracheal rings for entering the airway
- restrict footswitch activation to the user only, preventing unintended activation

Fuels are abundant in the OR and are considered to be anything that can burn. As seen in Table-1[3], many fuels are obvious, such as sponges, drapes, linens, and dressings while others are not so apparent, such as ointments, blood pressure and tourniquet cuffs, and even the patient themselves!

Hair is a commonly encountered, yet unrecognized fuel found on most bodily surfaces in the form of "lanugo" as well as facial and scalp hair. These substances ignite easily, especially in an OEA during head and neck procedures. Several common ointments and prep solutions are extremely volatile and flammable. For example, petroleum-based ointments used in an OEA and applied in a thin layer will ignite when enough heat is present to cause vaporization. "These materials must vaporize and mix with oxygen to allow ignition."[4] Prepping agents that contain alcohol are flammable and pose a real threat in the OR environment. "Studies have shown that solutions in 70 percent alcohol will ignite in temperatures of 900°C and only become nonflammable in concentrations less than 20 percent."[5] Additionally, the common practice of insulating active electrodes with sections of red rubber catheters or similar materials not made of fire resistant substances, is especially hazardous in procedures where oxidizers are present.

Since most fuel sources cannot be eliminated from the OR setting, they must be managed judiciously. Steps that can be taken are:

- avoid the use of flammable agents (alcohol, degreasers, collodion and tinctures) in the presence of an ignition (heat) source; keep in mind the alcohol present in suture packets
- use of proper prepping techniques by not allowing prep solutions to pool under and around the patient or in areas such as the umbilicus or cricoid notch. Excess prep should be blotted and sufficient time allowed for prep solutions to dry and vapors to dissipate and mix with room air prior to draping. This could take up to 10 minutes depending upon the solution used and prepping technique.
- use water-soluble rather than oil based lubricants to coat hair in OEA's (i.e. K-Y Jelly)
- use moist or wet sponges for procedures considered high risk for fire; keep sponges moist throughout the entire case – don't allow drying
- use commercially available insulated electrodes and following the manufacturers' recommended guidelines for reduced power settings
- select surgical gowns and drapes made of materials that resist combustion
- evacuate the chemical/gaseous by-products of electrosurgery (smoke), reducing the potential for combustion

Again, fuels burn only in the gaseous state and ignite only when sufficient vapors have mixed with oxygen. "Although oxygen from the air combines with fuels during a fire, the operating room has other sources of oxygen."[6] The most common form of oxygen delivery in the OR is by anesthesia. To properly oxygenate the patient, oxygen-enriched mixtures with greater than 21% oxygen of room air are commonly delivered. Anytime oxygen concentration is greater than 21% an oxygen-enriched atmosphere exists. This supplementation can be delivered by several different methods, such as endotracheal (ET) tube, nasal cannulae or mask. Some methods of oxygen delivery are considered open sources because oxygen can easily escape, while an ET tube connected to the breathing circuit is considered closed. Closed sources have also been known to leak and should be monitored carefully.

Oxygen tends to settle in low-lying areas, such as beneath drapes or in the chest cavity, because it is heavier than air. Availability of accumulated oxygen allows for a fire to ignite, burn faster and be more difficult to extinguish. Many materials not susceptible to combustion in room air will burn in an OEA. Pure oxygen is not the only concern. Nitrous oxide, commonly mixed with oxygen should also be considered an OEA. "Heat from sources found in the OR or a fire liberates oxygen from nitrous oxide, allowing it to support combustion."[7] Efforts to help minimize oxidizer buildup should include:

- prevent accumulation of oxygen and nitrous oxide in the oropharynx and beneath surgical drapes by tenting to allow dissipation; consider alternatives to open oxygen sources
- verify all oxygen delivery circuits are leak-free
- use moist packing around ET tubes without cuffs (predominantly in pediatric cases)
- avoid the use of oil-based ET tube lubricants
- use pulse oximetry to determine oxygen saturation levels and the acutal need for 100% oxgen supplementation; (ECRI suggests considering the use of room air or a low concentration of oxygen balanced by an inert gas such as nitrogen or helium may be adequate)
- inflate ET tube cuff with methylene blue-tinted water or saline during airway procedures; this practice aids in

detecting a compromised cuff and an oxygen leak

- during oropharyngeal procedures especially, discontinue the flow of oxygen at least one minute before and during the use of a heat source such as electrosurgery; requires good communication skills between the surgeon and anesthesia provider

All fires start small but can rapidly progress to a larger fire within 30 seconds. Quick action is essential to not only contain the flames but disrupt the fire triangle. All hospitals have a plan of action for fires and drills are conducted at regular intervals, but fire intervention involving the patient in the surgical setting is not practiced enough, if at all. Three basic steps to perform in rapid succession during a fire emergency should include: "stopping the flow of breathing gases to the patient, removing the burning materials from on or in the patient and caring for the patient."[8] These basic steps do not take the place of a comprehensive fire protocol established by a multi-disciplinary team in your facility nor does this newsletter cover all facets of prevention and intervention. Surgical fires pose a risk of serious injury or even patient death. Minimize the risk and make fire prevention a priority in addition to developing a solid plan of action!

Table-1

Fuels Commonly Encountered in Head and Neck Surgery

Patient	Hair (face, scalp, body) GI tract gases (mostly methane)
Preparation agents	Degreasers (ether, acetone) Aerosol adhesives Alcohol (also in suture packets) Tinctures (Hibitane [chlorhexidine digluconate], Merthiolate [thimerosal], DuraPrep [iodophor])
Linens	Drapes (woven, nonwoven, adherent) Gowns (reusable, disposable) Masks Hoods and caps Shoe covers Instrument and equipment drapes and covers Egg-crate mattresses Mattresses and pillows Blankets
Dressings	Gauze Sponges Adhesive tape (cloth, plastic, paper) Ace bandages Stockinettes Collodion (mixture of pyroxylin, ether, and alcohol)
Ointments	Petrolatum (petroleum jelly) Tincture of benzoin (74%-80% alcohol) Aerosols (e.g., Aeroplast) Paraffin White wax
Equipment and Supplies	Anesthesia components (breathing circuits, masks, airways, tracheal tubes, suction catheters, pledgets) Flexible endoscopes Coverings of fiberoptic cables and wires (e.g., ESU leads, ECG leads) Gloves Blood pressure and tourniquet cuffs Stethoscope tubing Disposable packaging materials (paper, plastic, cardboard) Smoke evacuator hoses Some instrument boxes and cabinets

1 Podnos YD, Williams RA: FIRES in the operating room. *Bulletin of the Am. College of Surgeons*, 82:8: 14-17,1997.

2 ECRI. "The Patient is on Fire!" Understanding the Fire Hazard. *Health Devices* 1992 Jan; 21 (1) :19-23.

3 *Ibid.*

4 *Ibid.*

5 Podnos YD, Williams RA: FIRES in the operating room. *Bulletin of the Am.College of Surgeons*, 82:8: 14-17, 1997

6 de Richemond AL, Bruley ME: Head and Neck Surgical Fires. *Complications in Head and Neck Surgery*. Mosby Publisher: St. Louis, MO, 1993.

7 ECRI. "The Patient is on Fire!" Understanding the Fire Hazard. *Health Devices* 1992 Jan; 21 (1): 19-23.

8 de Richemond, AL, Bruley ME: Head and Neck Surgical Fires. *Complications in Head and Neck Surgery*. Mosby Publisher: St. Louis, MO, 1993.