DEPARTMENT OF THE ARMY
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MEDCOM Regulation
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Medical Services

FIRES ASSOCIATED WITH THE PERFORMANCE OF SURGICAL PROCEDURES

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1. HISTORY. This is the first printing of this regulation.

2. PURPOSE. The purpose of this regulation is to provide policy and recommendations that will help ensure minimal risk of fires associated with the performance of surgical procedures in any health care setting to include, but not limited to, the following: operating room (OR), office-based, ambulatory surgery, and intensive care unit type.

3. APPLICABILITY. This regulation applies to all U.S. Army Medical Command (MEDCOM) personnel involved in the performance of surgical procedures. This includes, but is not limited to, surgeons (to include oral surgeons and dermatologic surgeons), anesthesia providers, operating and surgical nurses and technicians (to include Phase II training students), sterile processing staff, biomedical equipment repair specialists, and logistics personnel responsible for the purchase of medical supplies. It also includes residents and fellows in all anesthesia and surgical specialties (to include oral surgery and certified registered nurse anesthetist trainees) as well as residents in specialties that call for rotations in an OR, ambulatory surgical, or surgical office-based setting. It is recommended that this policy be periodically discussed in professional staff meetings for the general interest of all assigned providers.

4. REFERENCES. References are listed in appendix A.

5. EXPLANATION OF ABBREVIATIONS.

ECRI.....(formerly) Emergency Care Research Institute
ECU.....electrocautery units
ESU.....electrosurgical units
FDA.....Food and Drug Administration
JCAHO.....Joint Commission on Accreditation of Healthcare Organizations
lpm.....liters per minute
MEDCOM.....U.S. Army Medical Command
OEA.....oxygen-enriched atmosphere
OR.....operating room
SFFP.....surface fiber flame propagation

6. BACKGROUND.

a. According to a broad range of medical literature, there are an estimated 23 million inpatient surgical procedures and 27 million outpatient surgical procedures performed in the United States each year. Based upon data collected by the Food and Drug Administration and by ECRI (formerly Emergency Care Research Institute), an independent nonprofit health services research agency, an estimated 100 surgical fires occur each year, resulting in up to 20 serious injuries and one or two patient deaths.

b. Whenever all elements of the fire triangle are present (fuel source, ignition source, and oxygen), there is an increased risk of fire. This risk is especially heightened during surgeries involving the head and neck because of the proximity of these elements. If any one element of the fire triangle is carefully controlled or mitigated, even to a minimal degree, the risk of fire and patient harm can be greatly reduced.

c. ECRI's recent analysis of case reports reveals that the most common ignition sources are electrosurgical equipment (68 percent) and lasers (13 percent); and the most common fire location is the airway (34 percent), head or face (28 percent), and elsewhere on or inside the patient (38 percent). An oxygen-enriched atmosphere (OEA) was a contributing factor in 74 percent of all cases.

d. Appendix B presents a case example and comments.

e. Appendix C provides a sentinel event alert issue. This alert is especially provided for personnel in remote locations with no other access to the alert.

7. POLICY. Personnel will employ the following precautions, as a minimum, in the performance of surgical procedures wherever performed in a health care setting.

a. Heat and ignition sources.

(1) Heat input from a variety of sources increases the oxidation rate of a fuel-oxygen mixture until combustion occurs. Common heat sources found in a surgical setting include (but are not limited to) overhead lights; electrosurgical units (ESU) and electrocautery units (ECU); heated probes, drills, and burs; and fiberoptic light sources and cables. These sources produce temperatures high enough to ignite most fuels found in the same setting.

(2) Surgeons must exercise caution in selecting the source for cautery. The manufacturer's recommendations for use of the cautery/electrosurgical unit should always be reviewed and taken into consideration in conjunction with other patient- or procedure-specific issues such as the need for use of oxygen, etc.

(3) Whether using electrocautery or hot-wire cautery in the presence of oxygen and especially adjacent to an OEA, surgeons must have an anesthesia provider discontinue the flow of oxygen 60 seconds prior to the application of cautery to the surgery site and during the use of cautery, if clinically feasible. Interactive surgical team communication is essential in this process. Note: Although the literature supports either a 60-second or a 30-second pause before applying cautery, in the interest of an abundance of caution, the MEDCOM supports a 60-second pause.

(a) Activate the unit ONLY when the active tip is in view (especially if viewing it through a microscope).

(b) Deactivate the unit BEFORE the tip leaves the surgical site.

(c) Place electrosurgical electrodes in a holster or off of the patient when not in active use. Place lasers in standby when not in active use.

(d) If long, insulated electrosurgical electrode probes are required, use only commercially available insulated probes and confirm the integrity of the insulated surfaces prior to use. Do NOT use red rubber catheter or other materials to sheathe probes.

(4) Electrosurgical units should not be used to cut tracheal rings and enter the airway. Using scissors or a scalpel instead will avoid the risk of fire.

(5) Be aware that fiberoptic light sources can start fires. Complete all cable connections before activating the source. Place source in standby when disconnecting cables.

b. Fuels.

(1) A fuel is anything that can burn, including almost anything and everything that comes into contact with patients as well as substance in/on the patients

themselves. Many are easily identified as flammable but others are not generally thought of as flammable.

(2) Fuels commonly encountered in the surgical setting include, but are not limited to, those summarized below in table 1.

(3) Avoid the use of flammable skin prep solutions, such as flammable, alcohol-based preps. If they must be used, they should be used with extreme caution. Drapes should not be applied until all flammable preps have fully dried; the area under the drapes should be well-vented.

(4) Some prepping agents and ointments are extremely volatile and flammable. Care should be taken to ensure that such agents/ointments (liquid alcohol from a prep) do not pool under the patient and generate vapors beneath the drapes for an extended period of time.

Table 1
Fuels Commonly Encountered in a Surgical Setting

In/On Patient	Hair (face, scalp, body) * GI tract gases (usually methane)
Prepping Agents	Degreasers (ether, acetone) * Aerosol adhesives * Alcohol (also in suture packets) * Tinctures (Hibitane [chlorhexidine digluconate], Merthilate [thimerosal], DuraPrep [idophor])
Linens	Drapes (woven, nonwoven, adherent) * Gowns (reusable, disposable) * Masks * Hoods and caps * Shoe covers * Instrument & equipment drapes & covers * Egg-crate mattresses * Mattresses and pillows * Blankets
Dressings	Gauze * Sponges * Adhesive tape (cloth, plastic, paper) * Stockinettes * Collodion (mixture of pyroxylin, ether, and alcohol)
Ointments	Petrolatum (petroleum jelly) * Tincture of Benzoin (74% to 80% alcohol) * Aerosols (e.g., Aeroplast) * Paraffin * White wax
Equipment/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 & tourniquet cuffs * Stethoscope tubing * Disposable packaging materials (paper, plastic, cardboard) * Smoke evacuator hoses
Gases	Oxygen * Carbon Dioxide * Nitrous Oxide (fuel exacerbator) * Others

(5) Open bottles or basins containing volatile solutions (such as alcohol from suture packs and acetone degreasers) should be closed or removed from the sterile area as soon as possible after use.

(6) Under the right circumstances, some surgical ointments (such as petroleum-based ointments) can burn. Globs of ointment are not easy to ignite because their mass absorbs considerable heat before vaporizing. Thin layers, however, have a low mass per area and need less heat to cause vaporization; thus, they ignite more easily.

(7) Water-based lubricants, such as K-Y Jelly, are mostly water and will not burn; heat simply vaporizes the water in the lubricant, cooling the area. Thus, these lubricants should be used to coat hair to make it fire resistant.

(8) Surgeons are cautioned regarding the need to move surgical drapes as far away from the surgical site as clinically feasible. Open draping should be considered when possible to eliminate the potential for an OEA.

(9) Surgeons should recognize that debris from the operative field could adhere to the cautery device and become a bridging material that may inadvertently bring the heat source into contact with a fuel such as a surgical drape to cause an unexpected ignition. This material is known as a surface fiber flame propagation (SFFP) agent.

(10) Consideration should be given to using an incise drape, if possible, to isolate facial incisions from the oxygen source and to decrease air channels from under the drapes to the surgical site.

(11) If an uncuffed tracheal tube is used during oropharyngeal surgery, gauze or sponges should be soaked in saline to minimize leakage of oxygen into the oropharynx. These items should be kept wet throughout the surgical procedure. Additionally, sponges, gauze, or pledgets (and their strings) should be moistened so that they will resist igniting.

(12) If a cuffed endotracheal tube is used for oropharyngeal surgery, water should be substituted for air to inflate the cuff. The water has the advantage of acting as a heat sink if cautery is used near the cuff. Also, the cuff will prevent the leakage of oxygen into the oropharynx much better than sponges in the supraglottic area especially if high peak pressures are required for patients such as those with chronic obstructive pulmonary disease.

(13) Supply personnel are cautioned to proactively consider lint production data from drape sources to minimize the potential for SFFP in selecting drape vendors. Fire resistancy and fire retardation data should be considered in the purchase of all supplies that could be used in a surgical setting.

c. Oxidizers.

(1) Most fuels burn only in the gaseous state and ignite only when sufficient vapors have mixed with oxygen. Heat produces these vapors by evaporating liquids or vaporizing solids. Whenever and wherever the oxygen concentration is above 21 percent, an OEA exists.

(2) The oxygen supply system is the most disastrous fire hazard in the health care environment, even though the least likely to occur. While these systems must meet certain design, inspection, and usage requirements, fires still occur, chiefly because oxygen supply components have been repaired or modified in violation of governing codes.

(3) The surgical setting has multiple sources of oxygen to include that provided by anesthesia. Anesthesia often requires delivering oxygen-enriched mixtures above the 21 percent oxygen of room air to ensure proper oxygenation of patients.

(a) The medical necessity in providing supplemental oxygen should be based upon the pathophysiologic condition of the patient and/or the use of hypnotic/narcotic medications.

(b) If the patient's physical condition does require supplemental oxygen, then supplemental oxygen is recommended.

(c) If the patient's respiratory drive is blunted from the use of hypnotics/ narcotics, then oxygen should be used (at a flow rate that will maintain his SaO2>93%).

(d) In situations where hypnotics/narcotics are not used in healthy, awake patients, then supplemental oxygen should be available but not employed if electrocautery will be used.

(4) Anesthesia providers should maximize air exchange beneath drapes by using a high flow (10-15 lpm) medical grade air using a Hudson Hood, Lock Line, or similar type system. This will help reduce the accumulation of carbon dioxide under the drapes and improve patient comfort.

(a) Employ scavenging systems below surgical drapes to reduce the potential for accumulation of carbon dioxide and, if supplemental oxygen is used, an OEA.

(b) Titrate supplemental oxygen based on medical necessity rather than existing practice paradigm. If oxygen is administered, based on patient response, it should be limited to 24 percent or 26 percent via a Venturi mask system (1-2 lpm oxygen flow) or alternatively via nasal cannula at 1-2 lpm.

(5) Any mixture of oxygen and nitrous oxide should be considered an OEA within the context of surgical fires. Heat from sources found in the surgical setting or a fire liberates oxygen from nitrous oxide, allowing it to support combustion.

d. General. Surgical teams are urged to take the initiative to plan and practice their response to fires that may occur in such circumstances, regardless of the low probability of occurrence. It is strongly recommended that procedures to ensure appropriate response by all members of the surgical team to fires associated with surgical procedures be developed, implemented, tested, trained, and then reevaluated as part of the organization's Performance Improvement Program.

Appendix A

References

The following references provide additional information to the user of this regulation.

Barnes, A.M., and Frantz, R.A., Do oxygen-enriched atmospheres exist beneath surgical drapes and contribute to fire hazard potential in the operating room? *Aana J* 68: p 153, 2000.

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Greco, R.J, Gonzalez, R., Johnson, P., Scolieri, M., Rekhopf, P.G., and Heckler, F. Potential dangers of oxygen supplementation during facial surgery. *Plast Reconstr Surg* 95: p 978, 1995.

Ho, S.Y., and French, P., Minimizing fire risk during eye surgery, *Clin Nurs Res* 11: p 387, 2002.

Joint Commission on Accreditation of Healthcare Organizations, Sentinel Event Alert, Issue 29, 24 June 2003.

National Fire Protection Association 99, Health Care Facilities chapter 7, Electrical Equipment.

Rodgers, L.A., and Kulwicki, A. Safety in the use of compressed air versus oxygen for the ophthalmic patient. *Aana J* 70: p 41, 2002.

Schlager, A., and, Staud, H. New equipment to prevent carbon dioxide rebreathing during eye surgery under retrobulbar anesthesia. *BR J Ophthalmol* 83: p 1131, 1999.

For further reading on this subject, refer to ECRI at http://www.mdsr.ecri.org/. Enter "fires" into the “search terms” line.

Appendix B

Case Example

1. Case.

A medical treatment facility experienced a serious fire in the OR. The case involved a middle-aged patient who was admitted for a planned same-day facial surgery of the lower eyelid. The patient was draped with clear plastic drapes around the surgical site and flame retardant paper drapes layered over the plastic drapes. The anesthesia provider was flowing supplemental oxygen to the patient at 3L/minute via nasal cannula under the drapes. The surgeon proceeded with removal of skin following pre-induction markings. During the course of the procedure, the surgeon used a high-temperature, hot-wire cautery device to control the bleeding points.

It was at this point that there was an ignition, with a sudden flash of flames occurring around the nasal aspect of the left side of the face. The staff responded instantly, simultaneously discontinuing oxygen flow while removing the drapes, which were the fuel for the fire. Although the fire was extinguished and appropriate clinical interventions immediately followed, the patient did experience predominately first- and second-degree burns about the face with some third-degree spotting also noted. Post-incident, the patient has progressed under the care of several involved consultant specialists.

2. Comments.

Heat and ignition source. In the incident described above, the surgeon's choice of the 2200-degree hot-wire cautery was consistent with the manufacturer's recommendation. However, the instantaneous maximum intensity of the heat source demands special care in use, especially in proximity to flammable substances and supplemental oxygen, a known fire accelerant.

Oxidizer. In the incident cited, an OEA was created beneath the surgical drapes that accelerated the fire once ignition occurred. This caused the team to question why supplemental oxygen was used in a patient who had been assessed as American Society of Anesthesiologists physical status classification I and for whom no medical necessity for oxygen was evident (see paragraph 7c(3)(a)-(d) in this regulation for additional information on medical necessity). In discussions with anesthesia providers, it was concluded that it was a customary cautionary practice to have oxygen flowing to maintain the patient's saturation level as close to 100 percent as possible. In so doing in this incident, oxygen was unable to dissipate from the folds of the drapes and remained in proximity to the heat source and fuel.

Fuel source. All surgical personnel should be apprised of the lack of substantial protection afforded by the fire retardancy of most surgical drapes. This is exacerbated by the existence of an OEA, which dramatically increases the combustion potential between a cautery device and the drapes.

Appendix C

Sentinel Event Alert
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http://www.jcaho.org/about+us/news+letters/sentinel+event+alert/print/sea_29.htm

Preventing surgical fires

In the fire triangle--heat, fuel, and oxygen--each element must be present for a fire to start. And, though the incidents are significantly under reported, too often all three elements come together in a hospital's surgical suite, yielding disastrous consequences. Though they are considered rare occurrences in the health care environment, surgical* fires are certainly one of the most frightening and devastating experiences for everyone involved. While exact numbers are not available, of the more than 23 million inpatient surgeries and 27 million outpatient surgeries[1,2] performed each year, estimates--based on data from the Food and Drug Administration (FDA) and ECRI, an independent nonprofit health services research agency--indicate that there are approximately 100 surgical fires each year, resulting in up to 20 serious injuries and one or two patient deaths annually.[3]

Root causes identified

To date, two cases of operating room* fires have been reported to the Joint Commission for review under the Sentinel Event Policy, each resulting in serious injury to the patients. In nearly all cases studied by the FDA, ECRI, and JCAHO, the cause of the fire can be attributed to activities relating to a side of the fire triangle. ECRI's recent analysis of case reports reveals that the most common ignition sources are electrosurgical equipment (68 percent) and lasers (13 percent); and the most common fire location is the airway (34 percent), head or face (28 percent), and elsewhere on or inside the patient (38 percent). An oxygen-enriched atmosphere was a contributing factor in 74 percent of all cases.[3]

A host of flammable materials are found in the surgical suite, from the wide range of alcohol-based prepping agents and linens such as drapes, towels, gowns, hoods, and masks to the multiple types of dressings, ointments, and equipment and supplies used during surgery. Common ignition sources found in the OR are electrosurgical or electrocautery units (ESUs, ECUs), fiberoptic light sources and cables, and lasers. In addition, ESUs, lasers, and high-speed drills can produce incandescent sparks that can fly off the target tissue and ignite some fuels, especially in oxygen-enriched atmospheres.

Risk reduction strategies

"The basic elements of a fire are always present during surgery and a misstep in procedure or a momentary lapse of caution can quickly result in a catastrophe," says Mark Bruley, vice president, Accident and Forensic Investigation, ECRI. "Slow reaction or

the use of improper fire-fighting techniques and tools can lead to damage, destruction, or death." Bruley notes that virtually all surgical fires are preventable and that their impact can be lessened through an understanding of fire and how to fight it. "Each member of the surgical team--the surgeon, the anesthesiologist, and the nurses--controls a specific side of the triangle and by properly managing their technique and part of the equation, surgical fires can be avoided," says Bruley.

ECRI offers a free poster entitled *Only You Can Prevent Surgical Fires* that summarizes preventative recommendations based on the organization's more than 25 years of research and publication on surgical fires. The poster is available at www.mdsr.ecri.org/asp/dynadoc.asp?id=195&nbr=413558. These recommendations include:

- Staff should question the need for 100 percent O_2 for open delivery during facial surgery and as a general policy, use air or FiO_2 at $\leq$30 percent for open delivery (consistent with patient needs).
- Do not drape the patient until all flammable preps have fully dried.
- During oropharyngeal surgery: Soak gauze or sponges used with uncuffed tracheal tubes to minimize leakage of O_2 into the oropharynx, and keep them wet; and moisten sponges, gauze and pledgets (and their strings) so that they will resist igniting.
- When performing electrosurgery, electrocautery, or laser surgery: Place electrosurgical electrodes in a holster or another location off the patient when not in active use; and place lasers in STANDBY when not in active use.

Also, ECRI recommends that staff should participate in special drills and training on the use of fire-fighting equipment; proper methods for rescue and escape; the identification and location of medical gas, ventilation, and electrical systems and controls, as well as when, where, and how to shut off these systems; and use of the hospital's alarm system and system for contacting the local fire department.

Joint Commission recommendations

JCAHO recommends that health care organizations help prevent surgical* fires by:

1. Informing staff members, including surgeons and anesthesiologists, about the importance of controlling heat sources by following laser and ESU safety practices; managing fuels by allowing sufficient time for patient prep; and establishing guidelines for minimizing oxygen concentration under the drapes.
2. Developing, implementing, and testing procedures to ensure appropriate response by all members of the surgical team to fires in the OR*.
3. Organizations are strongly encouraged to report any instances of surgical fires as a means of raising awareness and ultimately preventing the occurrence of fires in the future. Reports can be made to JCAHO, ECRI, the Food and Drug Administration (FDA), and state agencies, among other organizations.

Resources

ECRI offers a clinical website called "Medical Device Safety Reports" where published articles and educational posters on surgical fires are available free of charge; go to http://www.mdsr.ecri.org/ and enter "fires" into the Search Terms line.

Bibliography

[1] Hall MJ, Owings MF. 2000 National Hospital Discharge Survey. Advance data from vital and health statistics; No 329. Hyattsville, Maryland: National Center for Health Statistics. 2002.

[2] Hall MJ, Lawrence L. Ambulatory surgery in the United States, 1996. Advance data from vital and health statistics; no. 300. Hyattsville, Maryland: National Center for Health Statistics. 1998.

[3] ECRI. A clinician's guide to surgical fires: how they occur, how to prevent them, how to put them out [guidance article]. *Health Devices* 2003; 32(1):5-24. To purchase a copy, contact ECRI at (610) 825-6000, ext. 5888.

*The terms surgical and operating room include all invasive procedures and the locations where they are done.

The proponent of this publication is the Office of the Assistant Chief of Staff for Health Policy and Services. Users are invited to send comments and suggested improvements on DA Form 2028 (Recommended Changes to Publications and Blank Forms) to Commander, U.S. Army Medical Command, ATTN: MCHO-CL-Q, 2050 Worth Road, Fort Sam Houston, TX 78234-6026.

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