



Complete Summary

GUIDELINE TITLE

A clinician's guide to surgical fires: how they occur, how to prevent them, how to put them out.

BIBLIOGRAPHIC SOURCE(S)

ECRI. A clinician's guide to surgical fires: how they occur, how to prevent them, how to put them out. Health Devices 2003 Jan;32(1):5-24.

GUIDELINE STATUS

This is the current release of the guideline.

COMPLETE SUMMARY CONTENT

SCOPE
METHODOLOGY - including Rating Scheme and Cost Analysis
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SCOPE

DISEASE/CONDITION(S)

Injuries from surgical fires (fires that occur on or in a surgical patient)

GUIDELINE CATEGORY

Management
Prevention

CLINICAL SPECIALTY

Anesthesiology
Colon and Rectal Surgery
Dentistry
Dermatology

Neurological Surgery
Nursing
Obstetrics and Gynecology
Ophthalmology
Otolaryngology
Plastic Surgery
Surgery
Thoracic Surgery

INTENDED USERS

Advanced Practice Nurses
Allied Health Personnel
Dentists
Hospitals
Nurses
Physician Assistants
Physicians

GUIDELINE OBJECTIVE(S)

- To provide healthcare professionals with a better understanding of surgical fire risk: why and how fires start, how they can be prevented, and how surgical staff should respond on those rare occasions when they do happen
- To educate surgical, anesthesia, and operating room (OR) nursing staff (including surgeons, anesthesia providers, nurses, and technicians) about the fire risks of surgery
- To help educate engineering, risk management, and patient safety staff concerned about operating room safety

TARGET POPULATION

- Any patient having surgery in an operating room (OR), emergency room (ER), an intensive care unit (ICU), physician's office, or outpatient clinic
- Surgical staff, including surgeons, anesthesia providers, nurses, and technicians

INTERVENTIONS AND PRACTICES CONSIDERED

Prevention of Surgical Fires

1. Minimizing ignition risks during use of electrosurgical devices and surgical lasers (safe and appropriate use of electrosurgical pencils, use of bipolar electrosurgery; use of the laser STANDBY mode)
2. Minimizing ignition risks by selective pre-use wetting of likely fuels present at the incision (gauze, sponges, pledgets, towels)
3. General procedures to minimize ignition risks
4. Specific procedures to minimize ignition risks in oropharyngeal surgery (oropharyngeal gas scavenging, wetted gauze, sponges, or pledgets)
5. Minimizing oxidizer risks (oxygen and nitrous oxide) in general surgery and specifically during oropharyngeal surgery and in general

6. Safe and appropriate use of open source supplemental oxygen
7. Minimizing fuel risks with flammable surgical preps and in general (e.g., cautious use of alcohol-based preps and other flammable liquids, coating of facial hairs)
8. Elements to consider in planning a fire drill for the operating room setting

Responding to Surgical Fires

1. Extinguishing small fires with the hand
2. Response to large fires on or in the patient: stopping the flow of oxidizers, removing burning materials from the patient, extinguishing burning material, caring for the patient
3. Correct procedures for using recommended type of fire extinguisher (carbon dioxide) (Note: Water-based and dry-powder extinguishers are not recommended)
4. Use of halon extinguishers (Note: Halon has been banned from manufacture by international agreement)
5. Use of aqueous solutions, fire blankets, sprinkler systems, and fire hoses to extinguish fires (Note: Fire blankets and fire hoses are specifically not recommended. Sprinkler systems are not likely to become activated by a surgical fire)
6. Evacuation procedures, if required (RACE acronym: Rescue the patient, Alert staff, Confine the smoke/fire, Evacuate the area)

MAJOR OUTCOMES CONSIDERED

Patient morbidity/injury and mortality from surgical fires

METHODOLOGY

METHODS USED TO COLLECT/SELECT EVIDENCE

Hand-searches of Published Literature (Primary Sources)
 Hand-searches of Published Literature (Secondary Sources)
 Searches of Electronic Databases
 Searches of Unpublished Data

DESCRIPTION OF METHODS USED TO COLLECT/SELECT THE EVIDENCE

The strategy for compiling the bibliography for the guideline included:

- Searching the ECRI Health Devices Alerts database (1978-2003) for abstracted references related to fires in the surgical setting
- Pyramid searching of the bibliographies contained within articles and book chapters on surgical fire safety that have been gathered over the past 25 years as part of ECRI's more than 200 surgical fire accident investigations and consultations
- Searching the National Library of Medicine using PubMed on the Internet
- Searching the healthcare facility accreditation literature and facilities-related electrical safety and fire safety standard literature

- Omitted were healthcare setting fire reference materials that were judged not to be significantly related to surgery

Most of the references in the guideline were derived from searches routinely performed over the past 20 years for:

- *Health Devices* hazard reports and guidance articles
- A 1993 surgical text chapter authored by ECRI staff
- ECRI accident investigation related research (1978-2003)
- An uncompleted American Society for Testing and Materials (ASTM) guideline, which ECRI had developed; that work formed the basis for this guideline
- 1999-2000 searches for the statistics of surgical fires and the Food and Drug Administration problem reporting system

NUMBER OF SOURCE DOCUMENTS

ECRI citations: 41

Other medical literature citations: 140

Standards and guidelines: 8

Total citations = 189 (Primary date range: 1969 to 2003)

METHODS USED TO ASSESS THE QUALITY AND STRENGTH OF THE EVIDENCE

Expert Consensus

RATING SCHEME FOR THE STRENGTH OF THE EVIDENCE

Not applicable

METHODS USED TO ANALYZE THE EVIDENCE

Systematic Review

DESCRIPTION OF THE METHODS USED TO ANALYZE THE EVIDENCE

Not applicable

METHODS USED TO FORMULATE THE RECOMMENDATIONS

Expert Consensus

RATING SCHEME FOR THE STRENGTH OF THE RECOMMENDATIONS

Not applicable

COST ANALYSIS

A formal cost analysis was not performed and published cost analyses were not reviewed.

METHOD OF GUIDELINE VALIDATION

Comparison with Guidelines from Other Groups
External Peer Review
Internal Peer Review

DESCRIPTION OF METHOD OF GUIDELINE VALIDATION

Not stated

RECOMMENDATIONS

MAJOR RECOMMENDATIONS

Introduction

Surgical fires--fires that occur on or in a surgical patient--happen only rarely, but their consequences can be grave. They can kill or seriously injure patients, injure surgical staff, and damage critical equipment. The risk of surgical fires is present whenever and wherever surgery is performed, whether in an operating room (OR), a physician's office, or an outpatient clinic.

The Elements of Surgical Fires

The three basic elements of surgical fires constitute the traditional fire triangle. In the OR, these elements are present in the following forms:

- **Ignition sources** include electrosurgical equipment, surgical lasers, electrocautery equipment, fiberoptic light sources, and defibrillators.
- **Oxidizers** include oxygen-enriched atmospheres, nitrous oxide, medical air, and ambient air.
- **Fuels** include common OR material such as mattresses, sheets, gowns, towels, drapes, dressings, and sponges. Other fuels include volatile organic chemicals, body hair, intestinal gases, tracheal tubes, and body tissue.

Each member of the surgical team is associated with—and should be concerned with—one or more sides of the fire triangle. Surgeons are involved mainly with ignition sources, anesthesia providers mainly with oxidizers, and nurses mainly with fuels, although these areas frequently overlap. Each member of the surgical team should understand the various fire hazards presented by each side of the fire triangle and should make a point of communicating information on the risks to the other team members—*intraoperatively* or in seminars, for example.

Recommendations for Preventing Surgical Fires

The following items are examples of ways in which the risk of a surgical fire can be minimized. For a comprehensive list, see the original guideline document.

Minimizing Ignition Risks

During Electrosurgery

- Place the electrosurgical pencil in a holster when it is not in active use--that is, when it won't be needed within the next few moments.
- Activate the active electrode only when the tip is under the surgeon's direct vision.
- Allow the pencil to be activated only by the person wielding it.
- Deactivate the pencil before removing it from the surgical site.
- If open O₂ sources are employed, use bipolar electrosurgery whenever possible and clinically appropriate (such as for cauterization during head and neck surgery). Bipolar electrosurgery creates little or no sparking or arcing.
- Never use insulating sleeves cut from catheters over electrosurgical active electrode tips.
- Never use electrosurgery to enter the trachea during tracheostomy.

During Laser Surgery

- Place the laser in standby mode whenever it is not in active use.
- Activate the laser only when the tip is under the surgeon's direct vision.
- Allow only the person using the laser to activate it.
- Deactivate the laser and place it in standby mode before removing it from the surgical site.
- When performing laser surgery through an endoscope, pass the laser fiber through the endoscope before introducing the scope into the patient. This will minimize the risk of damaging the fiber. Before inserting the scope in the patient, verify the fiber's functionality.
- During lower-airway surgery, keep the laser fiber tip in view and make sure it is clear of the end of the bronchoscope or tracheal tube before laser emission.
- Use appropriate laser-resistant tracheal tubes during upper-airway surgery. Follow the directions in the product literature and on the labels, which typically include information regarding the tube's laser resistance, use of dyes in the cuff to indicate a puncture, use of a saline fill to prevent cuff ignition, and immediate replacement of the tube if the cuff becomes punctured.

In General

- Remove unneeded footswitches so they are not accidentally activated. (Do this only after the attached device has been placed in standby mode.)
- Dispose of electrocautery pencils properly--for example, break off the cauterizing wire and cap the pencil.
- Be aware that fiberoptic light sources can start fires.
- Use a pulse oximeter to monitor the patient's blood oxygen saturation and titrate the delivery of oxygen to the patient's needs.
- Never place active fiberoptic cables on flammable materials.
- Place the fiberoptic light source in standby mode when disconnecting cables.

Minimizing Oxidizer Risks

During Oropharyngeal Surgery

- Use suction as near as possible to any potential breathing gas leak to scavenge the gases from the oropharynx of an intubated patient.
- Wet any gauze or sponges used with uncuffed tracheal tubes to minimize leakage of gases into the oropharynx, and keep them wet.
- Keep all moistened sponges, gauze, pledgets, and their strings moist throughout the procedure to render them ignition resistant.

In General

- Be aware of possible O₂- and O₂/N₂O-enriched atmospheres near the surgical site under the drapes, especially during head and neck surgery.
- Question the need for 100% O₂ for open delivery to the face (for example, when using a nasal cannula); if possible, use air or $\pm 30\%$ O₂ for open delivery, consistent with patient needs.
- If possible, stop supplemental O₂ (if concentration is more than 30%) at least one minute before beginning the use of electrosurgery, electrocautery, or laser surgery on the head or neck.
- Minimize the buildup of O₂ and N₂O (such as from an uncuffed tracheal tube or a laryngeal mask airway) beneath the drapes.
- Use a properly applied incise drape, if possible, to help isolate head and neck incisions from O₂-enriched atmospheres and from flammable vapors beneath the drapes. Proper application of an incise drape ensures that there are no gas communication channels from the under-drape space to the surgical site.
- Consider active gas scavenging of the space beneath drapes during open O₂ delivery, or of the oropharynx of an intubated patient. When scavenging beneath drapes, exercise caution so that the space beneath the drapes does not collapse.

Minimizing Fuel Risks

During Preparation

- Avoid pooling or wicking of flammable liquid preps.
- Allow flammable liquid preps to dry fully before draping; pooled or wicked liquid will take longer to dry than will prep on the skin alone.
- Use a properly applied incise drape, if possible, to help isolate head and neck incisions from O₂-enriched atmospheres and from flammable vapors beneath the drapes. Proper application of an incise drape ensures that there are no gas communication channels from the under-drape space to the surgical site.

In General

- Coat facial hair (including eyebrows, beard, and mustache) near the surgical site with water-soluble surgical lubricating jelly to make the hair nonflammable.
- Be aware of the flammability of tinctures, solutions, and dressings (such as benzoin, phenol, and collodion) used during surgery, and take steps to avoid igniting their vapors.

Recommendations for Responding to Surgical Fires

When a Fire Starts

First Response

Small fires on the patient (such as those caused when a hot electrosurgical pencil ignites drapes on a patient, or when an electrocautery pencil ignites a blotting sponge) can be extinguished by patting out the fire with a gloved hand or towel.

1. Large fires on or in the patient require a more comprehensive response: Stop the flow of oxidizers to the patient. In many cases, this will cause the fire to go out or at least lessen in intensity.
2. Remove the burning materials from the patient, and extinguish them. This is the only way to protect the patient from the heat of these materials.
3. Care for the patient swiftly. Restore breathing if necessary (with air, never O₂) and deal with any injuries.

(There is some debate over this sequence--specifically, the order in which the first two steps should be carried out. The guideline developers believe they should be performed simultaneously; others disagree. In any case, they should both be done as close to instantaneously as possible.)

If Evacuation is Necessary

In some very rare cases, extreme smoke and fire conditions may force the evacuation of the OR where the fire occurs. In such cases, the acronym **RACE** defines the actions that should take place: **r**escue the patient if possible, **a**lert staff in nearby ORs and activate fire alarm systems, **c**onfine the smoke and fire by shutting all doors and closing off gas, vacuum, and power systems, and **e**vacuate the OR and, if necessary, the surgical suite.

Putting Out the Fire

If the fire cannot be extinguished by the methods discussed under First Response in the original guideline document, then other means may be required.

Fire Extinguishers

Although they should not be the first resort when dealing with a surgical fire, fire extinguishers may be needed to deal with fires that engulf or that have migrated off the patient.

The correct procedure for using any fire extinguisher can be recalled by the acronym **PASS**: **p**ull the pin, **a**im the horn or nozzle, **s**queeze the trigger, and **s**weep out the fire. The basic types of fire-extinguishing devices commonly available in ORs are water-based, CO₂, and dry powder. Not all of these are equally safe or effective. Of them, the guideline developer prefers CO₂ extinguishers, and recommends that a 5 lb CO₂ extinguisher be mounted just inside the entrance of each OR in the hospital.

Other Ways to Put Out a Fire

Other, less common means of extinguishing surgical fires include halon, aqueous solutions found in the OR, fire blankets, sprinkler systems, and hoses. Again, these are not all equally safe or effective.

Halon is highly effective at putting out fires but has been banned from manufacture by international agreement because of its effect on atmospheric ozone.

Aqueous solutions include bottled saline solution, bottled water, and tap water.

Fire blankets--typically wool blankets treated with fire retardants that are placed over a fire to smother it--should never be located in an OR and should never be used for patient fires. Their use will likely cause more severe injuries to the patient. However, they can be placed outside it in case of a fire on a conscious person, such as a surgical team member. In such a fire, the person can actively use the blanket, is likely not O₂-enriched, and can tell others where fire is still burning.

For more details on this subject, refer to the original guideline document.

Sprinkler systems are often found in the ORs of newer facilities. They may activate only in response to large fires. Like water from extinguishers, sprinkler system water is not sterile and could, under some circumstances, present an electric shock hazard.

Fire hoses are sometimes found in hallways and stairwells of older facilities. Water from hoses is not sterile. The water can also create an electric shock hazard. In addition, the water stream itself can deliver sufficient force to cause injury or mechanical damage and can make the hose difficult to hold onto. The guideline developers do not recommend the uses of fire hoses to extinguish surgical fires.

In the Aftermath

After the fire, the OR and all materials and devices involved in the fire should be secured until an investigation can be completed. Statements from the staff should be taken as soon as possible after the incident.

Fire Drills

Fire drills not only allow staff to practice for a fire but also help troubleshoot any difficulties that might occur. Some elements to consider in planning a fire drill are:

- The proper response of each surgical team member and the operating suite staff
- How the patient can easily and safely be moved to another OR
- How the spread of smoke should be prevented (for example, through the use of smoke doors and air duct dampers)
- The location and operation of fire extinguishers, fire alarm pull stations, and exits

- What the response of additional fire-fighting personnel (such as the fire response team and local fire department) should be

For a more comprehensive list, see the original guidance document.

CLINICAL ALGORITHM(S)

None provided

EVIDENCE SUPPORTING THE RECOMMENDATIONS

TYPE OF EVIDENCE SUPPORTING THE RECOMMENDATIONS

The type of supporting evidence is not specifically stated for each recommendation. However, the recommendations are based on a thorough understanding of the clinical, scientific, and technological facts surrounding the occurrence of surgical fires. The recommendations are also supported by published peer-reviewed articles listed in the guideline's bibliography.

BENEFITS/HARMS OF IMPLEMENTING THE GUIDELINE RECOMMENDATIONS

POTENTIAL BENEFITS

- Minimization of the risk and damage caused by surgical fires by educating the surgical team about how fires start and what to do when they occur
- Alerting staff members to "hidden" fire risks, such as unsuspected oxygen-enriched atmospheres and less-than-obvious fuels
- Education of staff members regarding which equipment to use and not to use when a fire does occur

POTENTIAL HARMS

- On rare occasions, some extreme surgical fires will involve heavy smoke and fire conditions that may force the staff to evacuate the operating room. In such cases, reasonable attempts to rescue the surgical patient from the fire and the operating room should be made. Several rescuers will likely be needed to deal with disconnecting the patient from devices and, possibly, to move the operating table. The rescuers should not place themselves at severe risk, though each individual will have to decide what level of risk he or she considers to be severe.
- The water in water-based extinguishers that may be used to put out a fire in an operating room is not sterile and could cause a patient infection.
- Using a water-based extinguisher could result in an electric shock to the user because the water may be electrically conductive. Any water that has pooled in, on, or around electrically energized devices could cause an electric shock.
- Dry-powder extinguishers are considered a last resort in surgical fires because the very fine powder cannot mix with water and is therefore difficult to remove from a wound. The powder is also an airway and mucous membrane irritant that could interfere with breathing and visibility. The

extinguisher will also contaminate the entire operating room when discharged because the powder is very fine and widely dispersed.

QUALIFYING STATEMENTS

QUALIFYING STATEMENTS

These guidelines can provide clinicians with a basic understanding of how and why surgical fires can occur. While these recommendations are crafted to minimize the risks of surgical fire with minimal effect on clinical practice, it is incumbent on practitioners to use good clinical judgment in providing safe and effective treatment to their patients.

IMPLEMENTATION OF THE GUIDELINE

DESCRIPTION OF IMPLEMENTATION STRATEGY

The guideline developers believe that the information contained in the guideline is relevant to practitioners in many clinical specialties. However, the guideline is vital to members of the surgical team (surgeons, anesthesia staff, and operating room nurses). The developers recommend that surgical team members be made aware of the information in the guideline through patient safety programs and healthcare risk management initiatives.

INSTITUTE OF MEDICINE (IOM) NATIONAL HEALTHCARE QUALITY REPORT CATEGORIES

IOM CARE NEED

Staying Healthy

IOM DOMAIN

Safety

IDENTIFYING INFORMATION AND AVAILABILITY

BIBLIOGRAPHIC SOURCE(S)

ECRI. A clinician's guide to surgical fires: how they occur, how to prevent them, how to put them out. *Health Devices* 2003 Jan;32(1):5-24.

ADAPTATION

Not applicable: The guideline was not adapted from another source.

DATE RELEASED

2003 Jan

GUIDELINE DEVELOPER(S)

ECRI - Private Nonprofit Research Organization

SOURCE(S) OF FUNDING

ECRI

GUIDELINE COMMITTEE

Accident and Forensic Investigation Group, Health Devices Group

COMPOSITION OF GROUP THAT AUTHORED THE GUIDELINE

Biomedical, electrical, and mechanical engineers, scientists, and clinicians

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GUIDELINE STATUS

This is the current release of the guideline.

GUIDELINE AVAILABILITY

Print copies: Available from ECRI, 5200 Butler Pike, Plymouth Meeting, PA 19462-1298; Phone: (610) 825-6000; Fax: (610) 834-1275; E-mail: info@ecri.org Web: www.ecri.org.

AVAILABILITY OF COMPANION DOCUMENTS

None available

PATIENT RESOURCES

None available

NGC STATUS

This NGC summary was completed by ECRI on June 18, 2003. The information was verified by the guideline developer on September 8, 2003.

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