



Surgical Fires: Trends Associated with Prevention Efforts

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INTRODUCTION

Fires on the operating field are rare events that should never happen, but do. They are dangerous not only to the patient but to the operating room (OR) team members as well. The Pennsylvania Patient Safety Authority did an analysis of reports of surgical fires in its database for the primary purpose of determining if surgical fires continue to be a problem, as identified by the Joint Commission,¹ or if facilities have responded to advisories on prevention, such as those proposed by the American Society of Anesthesiologists.²

ABSTRACT

Fires on the operating field are dangerous to patients and providers. The Pennsylvania Patient Safety Authority did an analysis of the reports of surgical fires in its database. Analysts identified reports of fires submitted over seven years that occurred in the operating room on the surgical field and involved combustion resulting from a combination of heat, oxygen, and fuel. Seventy events that met the analysts' definition of fires on the operating field were reported in the seven years between July 1, 2004, and June 30, 2011. Over the past four years for which data was available, the rate of surgical fires has varied from 0.63 per 100,000 operations (1 per 157,545 operations) in the academic year 2007-2008 to 0.32 per 100,000 operations (1 per 309,305 operations) in the academic year 2010-2011. One-third of the reported events indicated harm to the patient. Risk to providers, rather than patients, was cited in 6% of reports. Surgical fires remain a significant enough risk to justify use of a Fire Risk Assessment Score and adherence to the recommendations of the American Society of Anesthesiologists Task Force on Operating Room Fires and those of the Anesthesia Patient Safety Foundation. (Pa Patient Saf Advis 2012 Dec;9[4]:130-5.)



Scan this code with your mobile device's QR reader to access the Authority's surgical fires toolkit.

METHODS

A panel of patient safety analysts identified surgical fires reported to the Authority between July 1, 2004, and June 30, 2011. Potential reports of interest were identified using the keywords “fire,” “flame,” “ignite,” and “extinguish.” A report was classified as a surgical fire if it

- occurred on the sterile surgical field or in the airway and
- caused combustion of surgical or anatomic substance.

The analysts excluded the following:

- Heat-related injuries caused by direct contact with a heat source, such as electro-surgical active electrodes (Bovie units), lasers, fiberoptic light cord, surgical lights, hot water, or hot instruments
- Normal arcing from electrosurgical active electrodes between tip and tissue without secondary ignition of a substance
- Arcing or ignition of the insulation of electrosurgical active electrodes without secondary ignition of a substance
- Reports of smoke without evidence of combustion
- Heat-related melting without evidence of combustion
- Fires off the surgical field

To calculate the rates at which fires occurred, the Authority obtained the number of trips to the OR (operations) done in Pennsylvania hospitals and ambulatory surgical facilities from the Pennsylvania Health Care Cost Containment Council (PHC4).^{*} Robust numbers of operations were available from July 1, 2007, through June 30, 2011. Those numbers were used to calculate the rate of fires per operation (see Figure). Prior to July 1, 2007, only the number of patients having operations was reported under a uniform format, not the number of operations.

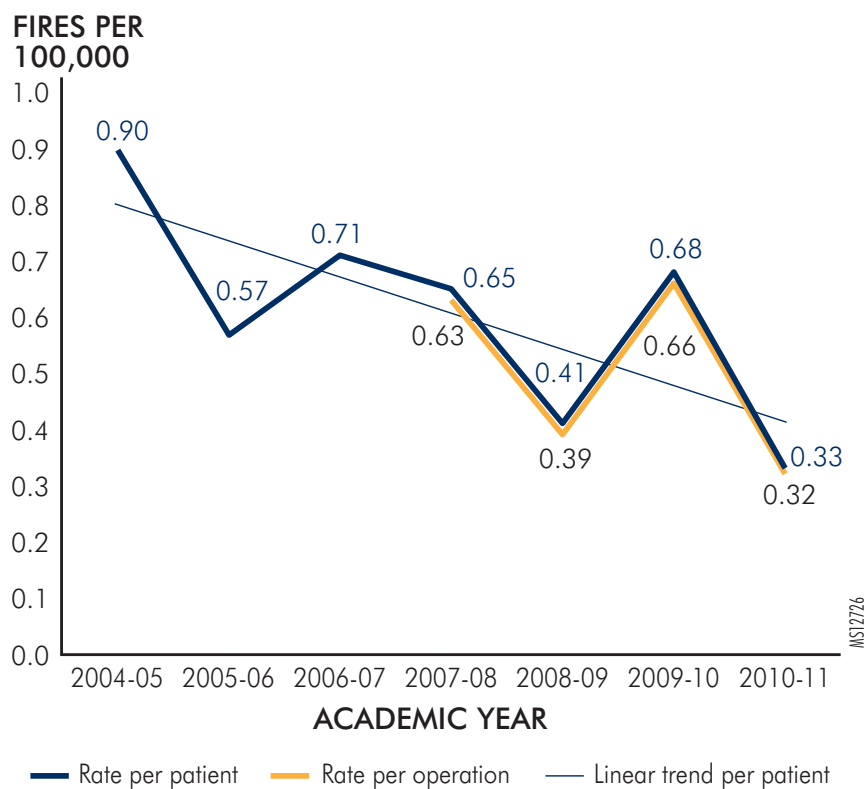
To extend observations of the rates of surgical fires to the entire period between July 1, 2004, and June 30, 2011, the number of surgical patients was used to calculate the rate

^{*} The Pennsylvania Health Care Cost Containment Council (PHC4) is an independent state agency responsible for addressing the problem of escalating health costs, ensuring the quality of health care, and increasing access to health care for all citizens regardless of ability to pay. PHC4 has provided data to this entity in an effort to further PHC4's mission of educating the public and containing health care costs in Pennsylvania.

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This analysis was not prepared by PHC4. This analysis was done by the Pennsylvania Patient Safety Authority. PHC4, its agents and staff, bear no responsibility or liability for the results of the analysis, which are solely the opinion of this entity.

Figure. Trends in Surgical Field Fires



of fires per surgical patient (see Figure). A surgical patient was a patient who had one or more operations during an admission. If the same patient had a second admission, he or she was counted as a second surgical patient.

Some facilities did not provide the number of surgical patients or operations for some quarters. However, no fires were reported from those facilities during those quarters.

RESULTS

In the seven years between July 1, 2004, and June 30, 2011, 70 reports met the analysts' definition of fires on the operating field.

A total of 7,172,132 operations were reported to PHC4 during the four-year time period from July 1, 2007 through June 30, 2011 (see Table 1). A total of

36 fires on the operating field were reported to the Authority during the same time period. The rate of surgical fires ranged from 0.63 per 100,000 operations (1 per 157,545 operations) from July 1, 2007, through June 30, 2008, to 0.32 per 100,000 operations (1 per 309,305 operations) from July 1, 2010, through June 30, 2011. In the same time periods, the number of operations per patient averaged 1.03 operations per patient.

A total of 11,651,199 patients were reported having operations during the seven-year time period from July 1, 2004, through June 30, 2011 (see Table 2). As noted above, a total of 70 fires on the operating field were reported to the Authority during the same time period. The rate of surgical fires ranged from 0.90 per 100,000 surgical patients (1 per 110,649 surgical patients) from

July 1, 2004, through June 30, 2005, to 0.33 per 100,000 surgical patients (1 per 300,973 surgical patients) from July 1, 2010, through June 30, 2011. This noticeable downward trend is not statistically significant by linear regression ($R = -0.72$, $R^2 = 0.52$, $p < 0.10$ by two-tailed levels of significance).

The incidence of fires on the operating fields in Pennsylvania hospital ORs and ambulatory surgical facilities should be considered within the context of initiatives to prevent surgical fires. Those initiatives have been as follows:

- 2003: Joint Commission Sentinel Event Alert on preventing surgical fires¹
- 2005 to 2009: Joint Commission National Patient Safety Goal for ambulatory surgery
- 2008 to 2009: American Society of Anesthesiologists' "Practice Advisory for the Prevention and Management of Operating Room Fires"²
- 2010: Anesthesia Patient Safety Foundation's fire safety video³
- 2011 to present: Food and Drug Administration Preventing Surgical Fires initiative⁴

An analysis of the 70 reports of fires on the operating field reinforces the information driving the existing initiatives.¹⁴

Patient harm was reported in 23 reports (33%), and no harm was reported in 46 (67%) of the 69 reports with information about harm. Three events involved fires in the surgeons' hands, and one involved a fire on the scrub technician's gown. None of these four events produced harm to the staff or patient.

Of the 65 reports with information about the ignition source, the source of ignition was an electrosurgical unit (Bovie unit) in 38 reports (58%), a fiberoptic light cord in 25 reports (38%), and a laser in 2 reports (3%).

The role of oxygen was highlighted in seven reports, with two specific mentions



Table 1. Rates of Fires per 100,000 Surgical Operations

YEAR	NO. OF PATIENTS*	NO. OF OPERATIONS*	OPERATIONS PER PATIENT	NO. OF SURGICAL FIRES†	OPERATIONS PER FIRE	RATE OF SURGICAL FIRES PER 100,000 OPERATIONS
July 2007 to June 2008	1,683,170	1,732,996	1.03	11	157,545	0.63
July 2008 to June 2009	1,727,387	1,775,920	1.03	7	253,703	0.39
July 2009 to June 2010	1,757,928	1,807,384	1.03	12	150,615	0.66
July 2010 to June 2011	1,805,835	1,855,832	1.03	6	309,305	0.32
Total	6,974,320	7,172,132	1.03	36	199,226	0.50

* Data obtained from the Pennsylvania Health Care Cost Containment Council.

† Surgical fires reported to the Pennsylvania Patient Safety Authority.

Table 2. Rates of Fires per 100,000 Surgical Admissions

YEAR	NO. OF PATIENTS*	NO. OF SURGICAL FIRES†	PATIENTS PER FIRE	RATE OF SURGICAL FIRES PER 100,000 PATIENTS
July 2004 to June 2005	1,549,082	14	110,649	0.90
July 2005 to June 2006	1,572,611	9	174,735	0.57
July 2006 to June 2007	1,555,186	11	141,381	0.71
July 2007 to June 2008	1,683,170	11	153,015	0.65
July 2008 to June 2009	1,727,387	7	246,770	0.41
July 2009 to June 2010	1,757,928	12	146,494	0.68
July 2010 to June 2011	1,805,835	6	300,973	0.33
Total	11,651,199	70	166,446	0.60

* Data obtained from the Pennsylvania Health Care Cost Containment Council.

† Surgical fires reported to the Pennsylvania Patient Safety Authority.

of nasal cannulas, one specific mention of a “leak” in the oxygen tubing, one specific mention of an oxygen mask over a tracheostomy stoma, and one specific mention of using an electro-surgical unit to incise a trachea during a tracheostomy. Nitrous oxide was not mentioned as a source of oxidizer in any reports.

The materials that caught fire were noted in 66 reports, with multiple materials noted in some reports. They included surgical items and/or patient sources. Of the surgical items, drapes were most commonly ignited (involved in 30 reports), followed by surgical sponges (13); bone cement (3); surgical towel, gown, or gloves (1 each); and accessory cable (1). Of the patient sources of combustion, hair and tissue in the incision were most common (11 each), with individual mentions of lip, palate, soft tissue, and bowel gas.

Alcohol-based skin preparations were mentioned in three reports. Two of the reports stated the skin was dry when the electro-surgical unit was used, igniting hair. The other report noted that a sponge used to help dry the skin was left on the field and was ignited by the electro-surgical unit.

The locations of the fires were noted in 34 reports, with 3 noting more than one site. Sites on the surface of the patient’s body were mentioned in 32 reports, internal sites were mentioned in 6, and fires on the surgeons’ hands were mentioned in 3 (see Table 3). Of the 38 surface and internal patient sites mentioned, 25 were located in the head or neck areas.

Twenty-three reports mentioned 26 ways in which the fire was extinguished. Six ignited surgical sponges were removed from the surgical field and extinguished. One surgical drape was removed and

doused with saline. One surgical sponge was moved to a basin of sterile saline. Seven reports mentioned removing, disconnecting, or turning off the light cord when it was the source of igniting surgical drapes. Including the report of the flaming surgical drape, just mentioned, and the report of a tracheal fire below, five reports mentioned dousing the fire with saline or water. Three fires were reportedly extinguished using towels, one noted to be wet. One surgeon put out a bone cement fire with his or her hand. A fire caused by using the electro-surgical unit to enter the trachea was extinguished with a combination of the surgeon’s hand, followed by dousing the site with saline and discontinuing supplemental oxygen.

[The surgeon] was opening trachea with cautery. A flash fire occurred at site and was immediately extinguished with [the surgeon’s] finger

followed by saline. Anesthesia also immediately turned off [the supplemental oxygen].

DISCUSSION

A coordinated approach to surgical fire prevention and response by the surgical team is important to eliminate fire hazards and to minimize the time until the fire is extinguished.¹⁴ Three elements are necessary for a fire: a heat source, oxygen, and a fuel. The surgeon is usually in control of the heat source, most commonly an electrosurgical unit, and can remove it from the field. The anesthesia professional is usually in control of the supplemental oxygen source and can eliminate the oxidizer component of the fire triangle. The circulating nurse or scrub technician can help ensure meticulous application of alcohol-containing skin-prepping solutions and ensure that they are dry before the application of surgical towels and drapes; can ensure occlusive draping when indicated; can keep exposed ends of fiberoptic light cords off the surgical field; and can ensure the availability of moist sponges, towels, and aqueous solutions.

Response to a Surgical Fire

Surgical fires are preventable, but if a fire occurs, the surgeon and other surgical team members can immediately remove burning materials from the patient and can help by extinguishing the fire with an aqueous solution, their hands, or a wet sponge or towel. Ideally, a wet sponge or wet towel is always available in the sterile setup for such an emergency. The anesthesia professional should minimize the availability of oxygen. Burning materials that have been removed from the patient can then be extinguished by other team members, if needed, with an aqueous solution, or in extreme cases, with a carbon dioxide fire extinguisher.

Prevention of Surgical Fires

More prudent than a coordinated team response to the tracheal fire above would

Table 3. Location of Surgical Fires as Reported to the Pennsylvania Patient Safety Authority

LOCATION	NO.
External	32
Head	18
Scalp	2
Face	13
Face	4
Periorbital	9
Eyelid	1
Eyebrow area	3
Eyebrow	2
Eyelashes	3
Ear	3
Neck	5
Neck	4
Tracheal stoma	1
Shoulder	1
Chest	2
Legs	5
Legs	1
Leg	2
Thigh	2
Trocar site	1
Internal	6
Nasopharynx	1
Trachea	1
Chest cavity (surgical sponges)	2
Abdominal cavity (bowel gas)	1
Hip incision (bone cement)	1
Surgeon's Hand	3
Surgeon's hand	2
Surgeon's finger	1

be to avoid the risk by not incising the trachea with an electrosurgical unit in the first place.^{2,5}

The Christiana Care Health System in Wilmington, Delaware, has developed a simple, brief Fire Risk Assessment Score to identify operations at increased risk for surgical fires.⁶ The score assesses the presence or absence of three elements. A score identifying the following three elements present indicates a high risk for a surgical fire:

— Christiana Fire Risk Assessment Score:

- Surgery above the xiphoid
- Open oxygen source
- Available ignition source (e.g., electrosurgery, laser, fiberoptic light cord)

The Fire Risk Assessment Score can easily be included in either the WHO Surgical Safety Checklist preoperative briefing or the Universal Protocol time-out.



A score of 3 indicates a high risk for a surgical fire. A score of 2 indicates a low risk, with potential for conversion to high risk. A score of 1 indicates low risk. When an operation is assessed as being at high risk for a surgical fire, risk mitigation should be done to decrease the risk. ECRI Institute has summarized these mitigation strategies related to surgery of the head, face, neck, and upper chest and for oropharyngeal procedures, bronchoscopic surgery, and tracheostomy.⁵

The American Society of Anesthesiologists Task Force on Operating Room Fires and the Anesthesia Patient Safety Foundation have determined that the most important practice for managing the risk of a surgical fire is to determine if supplemental oxygen is needed to maintain adequate arterial oxygen saturation. This assessment is especially important when the oxygen would be administered in an “open” fashion, via a nasal cannula or face mask, thereby saturating the surgical field with high oxygen concentrations. Keeping oxygen concentrations less than 30% is desirable to prevent rapidly spreading fires. When there is a risk of fire and the patient requires supplemental oxygen to maintain an adequate arterial oxygen saturation, a controlled airway, such as an endotracheal tube or laryngeal mask, is recommended to help isolate the oxidizer from the heat source.^{2,7}

There are defined exceptions in which supplemental oxygen delivery may be required via an open source on the face.^{5,8}

For such cases, fire risks will be reduced by starting with an administered concentration of oxygen of less than 30% and titrating the oxygen to the lowest concentration needed to maintain an adequate arterial oxygen saturation. Risks will be reduced further by using occlusive draping techniques to minimize the flow of dangerously high concentrations of oxygen from under the drapes onto the surgical field.^{5,8}

Electrosurgical active electrodes (Bovie units) should not be used, if possible, in high-risk situations. If used, the power settings should be as low as possible for surgical needs.⁹ Bipolar electrodes could also be used.

It should also be noted that the end of a fiberoptic light cord is about as dangerous to place on the surgical drapes as a lit cigar. Azizi notes that the temperature from a fiberoptic light cord with a new bulb in the light source can reach 670 degrees Fahrenheit.¹⁰

Moist sponges minimize the risk of setting a sponge on fire. A dry sponge can be ignited easily, especially in the presence of an oxygen-enriched atmosphere, whereas a moist sponge resists ignition.⁸ Water or saline should also be available for dousing a fire. A five-pound carbon dioxide fire extinguisher should be available in the OR.^{2,7}

The number of fires involving bone cement was the same as the number involving alcohol preps.

Care should be taken with alcohol preps. Of note, two of the reports involving alcohol preps said the skin was dry, but the electrosurgical unit caused the hair to catch fire. The prep should dry for at least three minutes to allow full evaporation of the alcohol, and longer for hairy areas or areas involving body crevasses or skin folds. Avoid pooling of the alcohol-based solutions. Drape only after all alcohol has dried.⁷

The Authority offers a surgical fire toolkit at http://patientsafetyauthority.org/EducationalTools/PatientSafetyTools/airway_fires/Pages/home.aspx. Additional information about surgical fire prevention is also available through ECRI Institute at https://www.ecri.org/Products/Pages/Surgical_Fires.aspx.

CONCLUSION

Surgical fires remain a significant enough risk to justify use of a Fire Risk Assessment Score, the communication that should occur with a Fire Risk Assessment Score of 2 or 3,⁶ and adherence to the recommendations of both the Anesthesia Patient Safety Foundation³ and the American Society of Anesthesiologists Task Force on Operating Room Fires.^{2,5}

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NOTES

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PENNSYLVANIA PATIENT SAFETY ADVISORY

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