RESEARCH ARTICLE

Incidence of Operating Room Fires During Hand Surgical Procedures

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Abstract

Background: The purpose of the present study is to report the incidence of operating room fires during hand surgical procedures.

Methods: The clinic and OR electronic medical records of seven fellowship-trained orthopedic hand surgeons at a single, large practice were retrospectively reviewed. All upper extremity procedures performed between June 2014 to June 2019 in both hospital and surgery center settings were included in the review. Demographic data was collected. The incidence of operating room fires was determined.

Results: A total of 18,819 hand and upper extremity surgical procedures were included. There were 16,767 (89.1%) cases performed in a surgery center, while 2,052 (10.9%) of cases were performed in a hospital. There were 12,691 (67.4%) soft tissue procedures and 6,127 (32.6%) bony procedures performed. Chlorhexidine gluconate preparation solution was used in 9607 cases (51%). Chloraprep solution was used in 6280 cases (33.4%). Betadine was used in 2,932 cases (15.6%). One surgeon has monopolar electrocautery only available during cases. Five surgeons have bipolar available, and one has both mono and bipolar electrocautery available. There were no fires (0%) identified during the study period.

Conclusion: The incidence of operating room fires during hand surgical procedures is extremely low. While hand surgeons can be reassured that the likelihood of an operating room fire is minimal, surgeons should not become complacent and should maintain a high level of vigilance to prevent these potentially devastating occurences.

Level of evidence: IV

Keywords: Operating Room Fires, Hand Surgery

Introduction

Operating room (OR) fires are a rare but potentially devastating event. Estimates on incidence vary, but at least 650 events have been reported yearly in the United States(1). Given that laws for reporting OR fires vary among states, the true number of fires may be higher. A study of closed malpractice claims demonstrated that most fires occur in an outpatient setting, involve the upper body, and in cases using monitored anesthesia care (MAC)(2).

For an OR fire to occur, three elements must be present. These elements have been dubbed the “fire triangle” and include fuel, heat, and oxygen(3). Fuel sources can be alcohol-based skin preparations (preps), surgical gowns or drapes, or hair. Heat elements are most commonly the electrosurgical cautery unit (bovie), lasers, or fiberoptic lights used in arthroscopy. Supplemental oxygen is commonly administered by anesthesia providers during MAC procedures(3). To decrease risk associated with the use of alcohol-based skin preparations many manufacturers recommend waiting a minimum of 3 minutes (and an hour on unclipped hair) after application of the preps before draping(4).

Given that a substantial number of hand surgical procedures are performed in outpatient setting under MAC anesthesia, understanding the risks and developing strategies for prevention of OR fires has particular relevance. Despite this risk, there is a paucity of data regarding OR fires in the hand surgical literature. The purpose of the present study is to determine the incidence of operating room fires during hand surgical procedures.

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Materials and Methods

Institutional Board Review approval was obtained prior to commencing the study. The clinic and OR electronic medical records of seven fellowship-trained orthopedic hand surgeons at a single, large practice were retrospectively reviewed. All upper extremity procedures performed between June 2014 to June 2019 in both hospital and surgery center settings were included in the review. No procedures were excluded.

Data including patient age, gender, type of surgery, surgical preparation used, and use of electrocautery were collected. Electrocautery usage was determined by each surgeon's typical practice. Current Procedural Terminology – 4 (CPT) codes were used to classify procedures into bone versus soft tissue. In cases where there was more than one code per case, the case was counted as a bone procedure if at least one of the procedures involved bony work. Incidence of OR fires (which included skin burns to the patient) was calculated based on the review of the medical record.

Results

A total of 18,819 hand and upper extremity surgical procedures were included in the analysis. Demographics were available for 10,963 out of 18,819 cases. The mean age was 53 years old. Forty-seven percent were men. 16,767 (89.1%) cases were performed in a surgery center, while 2,052 (10.9%) of cases were performed in a hospital. There were 12,691 (67.4%) soft tissue procedures and 6,127 (32.6%) bony procedures performed [Table 1]. Chlorhexidine gluconate (CHG; Cardinal Health, Dublin OH) preparation solution was used in 9607 cases (51%). Chloraprep (BD, Franklin Lakes NJ) solution was used in 6280 cases (33.4%). Betadine solution (Purdue, Stamford CT) was used in 2,932 cases (15.6%) [Table 2]. Demographic, surgical location, and procedure type per each surgical preparation are summarized in Table 3, 4 and 5. One surgeon had monopolar electrocautery available during cases. Five surgeons had bipolar available, and one had both mono and bipolar electrocautery available.

No OR fires (0%) were identified during the study period.

Table 2 . Demographics, All Patients

Age, mean	53
Gender, % male	47
Surgical Location	
Hospital, n (%)	2052 (10.9)
Surgery Center, n (%)	16767 (89.1)
Surgical Procedure	
Soft Tissue, n (%)	12691 (67.4)
Bony, n (%)	6127 (32.6)

Table 1. Incidence of OR Fires

Prep Method	Cases, n (%)	Surgical Fires, n
Betadine	2932 (15.6)	0
CHG	9607 (51)	0
Chloraprep	6280 (33.4)	0
Total	18819	0

CHG: chlorhexidine gluconate

Table 3. Demographics, Betadine Prep Group

Age, mean	52
Gender, % male	48
Surgical Location	
Hospital, n (%)	281 (9.6)
Surgery Center, n (%)	2651 (90.4)
Surgical Procedure	
Soft Tissue, n (%)	1944 (66.3)
Bony, n (%)	988 (33.7)

Table 4 . Demographics, CHG Prep Group

Age, mean	54
Gender, % male	46
Surgical Location	
Hospital, n (%)	894 (9.3)
Surgery Center, n (%)	8713 (90.7)
Surgical Procedure	
Soft Tissue, n (%)	6245 (65)
Bony, n (%)	3362 (35)

CHG: chlorhexidine gluconate

Table 5. Demographics, Chloraprep Prep Group

Age, mean	54
Gender, % male	46
Surgical Location	
Hospital, n (%)	877 (14)
Surgery Center, n (%)	5403 (86)
Surgical Procedure	
Soft Tissue, n (%)	4480 (71.3)
Bony, n (%)	1800 (28.7)

Discussion

In 2006, an estimated 53.3 million surgical and nonsurgical procedures were performed in U.S. ambulatory surgery centers and in 2010, 51.4 million inpatient procedures were performed in nonfederal hospitals in the United States(5). Although the reported incidence of operating room fires varies up to 650 fires have been reported yearly in the United States(6). This amounts to roughly 1 fire in 100,000 surgical procedures. We were not able to find any prior reports of OR fires during hand surgical procedures, and the incidence of hand surgical OR fire in our study was 0.

There are several potential explanations for this finding. In hand surgical procedures, most surgeons do not use monopolar cautery and are not exposed to high oxygen concentrations given the separation of the surgical site from the oxygen source. Moreover, a relatively small amount of skin is exposed within the surgical field due to the distal nature of the hand. It is plausible that the general guidelines for high fire-risk surgery ie: ear nose and throat, oral surgery, neurosurgery, and others should be different than low fire-risk surgical interventions such as hand surgery.

Prevention is key to prevent surgical fires. The Surgical

Fire Risk Assessment Score has been developed(7). The scale ranges from 0-3 with 3 being high risk. One point is given if each of the following present: surgical site or incision above the xiphoid, open oxygen source and available ignition source. A score of 3 is considered high risk and would alert the operating room team to initiate a high risk pathway. This pathway includes using high-flow/low FiO2, stopping supplemental oxygen at least 1 minute before and while using cautery, using wet sponges, having sterile water of saline available for fire suppression and using the lowest electrocautery setting possible(8). The form also includes an area to document alcohol based prep has had a sufficient time for fumes to dissipate. This is typically three minutes.

Culp and colleagues evaluated five fuel sources which were analyzed in three levels of oxygen concentration; 21%, 50%, and 100%. Three test samples of each material were burned in a manner similar to that established by the Consumer Product Safety Commission. Time to sample ignition and time to complete burn were measured with video analysis. The median ignition time in 21% oxygen was 0.9 s, in 50% oxygen 0.4 s and in 100% oxygen 0.2 s. The median burn time in 21% oxygen was 20.4 s, in 50% oxygen 3.1 s and in 100% oxygen 1.7s. The time to ignite and total burn times decreased as oxygen concentration increased reaching statistical signifance. Flammability characteristics differed by material and oxygen concentration. Utility drapes and surgical gowns did not support combustion in room air, whereas other materials quickly ignited. Flash fires were detected on woven cotton materials in oxygen-enriched environments(9).

There is no agreement on which antiseptic is best for use in hand surgery. A 2016 study did find DuraPrep (3M, United States) and Betadine to be superior to ChloraPrep for skin decontamination. However no surgical site infections were noted within 30 days in either group for a total of 119 patients evaluated(10). Asadpoor-Dezaki et al found an alcohol-based product had superior immediate effects when compared to betadine but showed no difference at 2 hours (11). The group's recommendation was to use alcohol based preparations in emergent situations. Seigerman, et al. found 4x4s soaked in antiseptic solution were preferable to commercial applicators. With the use of 4x4s, there were less missed areas than with the prepackaged applicators(12).

Although alcohol based solutions have excellent antiseptic properties, Chang claimed alcohol-containing antiseptics were greatest risk to having a fire in the operating room(13). In the report by Rocos and Donaldson five million incident reports were queried, and 13 reports of a surgical fire were found. Eleven were due to flammable skin preparation and two to misuse of equipment causing ignition. Four occurred due to the solution not being dry during the procedure, four due to flammable solution soaked swaps within the field and three due to solution soaked drapes(14). Alcohol-based skin preps are frequently blamed for fueling surgical fires, and additional published reports have supported this(15,16). In light of these findings, the use of a non–alcohol-based prep (2% chlorhexidine or 0.7 to 1% iodine) may seem like an attractive alternative in order to reduce fire risk. Unfortunately, this runs counter to recent 2017 recommendation for the use of alcohol-based antiseptic agents (for intraoperative skin preparation to decrease superficial and deep surgical site infections) by the Centers for Disease Control and Prevention(17,18). As more data emerge regarding alcohol-based preps, clinicians will need to compare the risk of fire to the risk of surgical infections to appropriately protect their patients from fire and/or infection.

There are several limitations to our study. First, the retrospective nature of the study limited our ability to assess several aspects of the OR environment that might influence the development of an OR fire. Specifically, we were not able to determine whether electrocautery was used in each specific surgical case and, if so, at what time during the procedure (and after the surgical prep), this was used. We were also not able to determine whether supplemental oxygen was provided by anesthesia and, if so, at what level or delivery method (eg nasal cannula, face mask, etc.). Although all providers and institutions included in the study abide by the recommendations set forth by the respective prep solution manufacturers, we were not able to determine the time between the surgical prep and draping of the patients. There were some patients for whom demographic information was not available, though the absence of this information does not change our rate of OR fires and we do not expect that age or gender would have a substantial influence on risk of fire. Finally, since we (fortunately) did not experience any OR fires, we are not able to comment on specific risk factors for the development of a fire during hand surgery.

We did not identify a single case of an operative fire in our review of almost 19,000 hand surgery cases. While this information should be reassuring to hand surgeons, a high level of vigilance should be maintained and hand surgeons should not become complacent to this risk. However, a reassessment of the fire-risk guidelines and procedures as they relate to low risk procedures such as hand and upper extremity may be appropriate.

Conflict of interest: The authors do not have any conflicts of interest to disclose related to this study

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