Prevention of Surgical Fires: A Certification Course for Healthcare Providers

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An estimated 550 to 650 surgical fires occur annually in the United States. Surgical fires may have severe consequences, including burns, disfigurement, long-term medical care, or death. This article introduces a potential certification program for the prevention of surgical fires. A pilot study was conducted with a convenience sample of 10 anesthesia providers who participated in the education module. The overall objective was to educate surgical team members and to prepare them to become certified in surgical fire prevention. On completion of the education module, participants completed the 50-question certification examination. The mean pretest score was 66%; none of the participants had enough correct responses (85%) to be considered competent in surgical fire prevention. The mean posttest score was 92.80%, with all participants answering at least 85% of questions correct. A paired-samples t test showed a statistically significant increase in knowledge: t (df = 9) = 11.40; P = .001.

Results of the pilot study indicate that this course can remediate gaps in knowledge of surgical fire prevention for providers. Their poor performance on the pretest suggests that many providers may not receive sufficient instruction in surgical fire prevention.

Keywords: Fire triangle, prevention, situational awareness, surgical fires.

The occurrence of a surgical fire is a devastating and tragic event. Recent reports reveal that there are 550 to 650 surgical fires per year in the United States, reflecting a 2-fold increase since 2005.[1,2] These numbers, however, may underestimate the prevalence of surgical fires because there is no mandatory national reporting system in the United States.[3] The consequences of a surgical fire include severe burns, disfigurement, long-term medical care, and death. In fact, 1 to 2 surgical fires a year are fatal.[2] Despite advances in anesthesia and surgical equipment, fires in the operating room (OR) continue to occur, perhaps because of increased surgical volume and laser procedures. Education can help to prevent these tragedies. This article introduces a potential certification education and training program, for all members of the surgery team, for the prevention of surgical fires. The proposed program is designed to increase surgical team members' awareness of surgical fires, validate and verify individuals' and team members' knowledge in prevention of surgical fires, improve team communication and shared responsibility for surgical fire prevention, and improve patient safety.

• ***Fire Triangle.*** A fire occurs as the result of a chemical process known as oxidation. During oxidation, oxygen combines with hydrogen and carbon to form water and carbon dioxide. This rearrangement of molecules results in the release of energy that produces flame with sufficient heat. Sometimes energy cannot be released faster than it is created, resulting in combustion or fire.[4] Three elements, known as the fire triangle, must be present for a surgical fire to occur: an oxidizer, a fuel source, and an ignition source.[3-5] If any of the 3 components are not present, there will be no fire. All 3 components of the fire triangle are typically available and regularly used in the OR.

The first element of the fire triangle is an oxidizer. An oxidizer is a substance that releases oxygen and as a result of its release, produces heat.[6] Oxygen is the most common oxidizing material in the OR, and an oxygen-enriched environment, as commonly found in the OR, contributes to 70% of reported surgical fires.[7] Alone, it is not a combustible element, no matter how high the concentration. However, in the presence of a fuel and heat source, it only takes a spark for combustion to occur.[2-5]

The second element of the fire triangle is the fuel source. A fuel source is any substance that bonds with oxygen to produce heat. Because of the nature of the chemical reaction, most fuels burn in the gaseous state and ignite only when sufficient vapors have mixed with oxygen.[6] In the OR, fuel sources can be anything that will burn, including the patient. Surgical drapes are the most common fuel source in the OR, and their use has been implicated in 80% of the surgical fires reported.[7-9] Evidence suggests that other common fuel sources include alcohol-based preparation solutions, sponges, gauze, endotracheal tubes, and warming blankets.[10-13]

The third component of the fire triangle is an ignition source. An ignition source is any object that creates a high enough temperature to begin a chemical reaction between an oxidizer and a fuel by evaporating liquids or vaporizing solids. For example, ignition of preparation solutions occurs around 900°C, a temperature that

is easily reached by many devices used in the OR.[14] Of the reported surgical fires, 70% involved some form of electrocautery device (eg, Bovie cautery [Bovie Medical Corp] or monopolar).[15] Other heat sources include surgical lasers, fiberoptic light sources and cables, high-speed surgical drills, and surgical burrs.[16,17]

• ***Common Surgical Sites for Surgical Fires.*** The most frequent anatomic sites of occurrence for a surgical fire are the head, neck, or chest.[5] Procedures in these areas carry the highest risk of fire because the components of the fire triangle are in close proximity to one another. Specifically, fuel and ignition sources are dangerously close to an oxygen source during these types of procedures. An example is the tracheostomy procedure in which the surgeon creates an artificial opening in the trachea. Because the trachea is the main pipeline that supplies oxygen to the lungs, the 3 elements of the fire triangle have a higher risk of convergence, therefore resulting in a surgical fire.[18]

• ***Team Member Roles in the Fire Triangle.*** Many recommendations have been issued to prevent surgical fires, most of which involve controlling the 3 components of the fire triangle. The effectiveness of managing the 3 components of the fire triangle depends on the cohesiveness of the surgical team. All members of the surgical team must understand the fire triangle as well as their specific role in fire prevention. A review of the literature suggests that each component of the fire triangle is the individual responsibility of a specific team member during a procedure: fuel sources (the OR nurse and the surgical technician), oxidizers (the anesthesia provider), and ignition sources (the surgeon).[5] Knowledge by an individual provider of a specific arm of the fire triangle is fundamental to preventing surgical fires; however, individual knowledge is not enough. The proposed certification program builds on this foundation and shifts the paradigm from individual provider roles for surgical fire prevention to prevention that is the shared responsibility of the entire surgical team.

• ***Situational Awareness.*** The theoretical framework used in the development of the proposed certification program is situational awareness. Situational awareness is "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future."[19] Simply stated, situational awareness is "knowing what is going on."[20] With a team-based situational awareness approach, team members develop accurate expectations of team performance by drawing on a common knowledge base. Team members must share their knowledge relative to the (1) task and team goals, (2) individual tasks, and (3) team members' roles and responsibilities. Tasks include a specific set of situational awareness elements determined by each team member's responsibilities. If one member lacks situational awareness, that particular team member becomes the weak link in the team. The quality of the team members' situational awareness is based on their shared knowledge and, therefore, may serve as an indicator of team coordination and effectiveness.[20,21]

The purpose of this project was to develop a certification program that can be standardized for the prevention of surgical fires for all members of the surgical team: registered nurses, surgical technicians, anesthesia providers, and surgeons. Currently, the program can be implemented at providers' institutions and is designed to increase situational awareness and the knowledge necessary to prevent a surgical fire. A pilot implementation of the program with anesthesia providers will be presented to illustrate the training process. Provider knowledge about surgical fire prevention was assessed before and after the training course to examine changes in knowledge about prevention.

Methods

• ***Program Development.*** Phase 1 of the proposed certification program was the development and implementation of the educational module. Competencies and objectives for the certification program were developed following guidelines and current best practices. For instance, 2013 guidelines, from the American Society of Anesthesiologists (ASA) and the 2013 Fire Prevention Algorithm by the Anesthesia Patient Safety Foundation (APSF), recommend that only the minimum concentration of oxygen should be used to avoid hypoxia. In addition, for procedures requiring deep sedation or for procedures in the airway, a closed oxygen delivery system such as an endotracheal tube should be used.[3] The US Food and Drug Administration recommends that a fire risk assessment be conducted before the procedure and that surgeons place electrocautery devices in the holster when not in use.[1] Finally, the Association of periOperative Registered Nurses (AORN) recommends that alcohol-based skin preparation solutions be given an adequate amount of time to dry, that the skin be dried completely before draping, and that incise or fenestrated drapes be used.[2] The format for the certification program's course manual was modeled after the professional certification course *Advanced Cardiac Life Support* (ACLS) by the American Heart Association.[22]

The overall objective of the proposed certification program was to educate surgical team members and prepare them to become certified in the prevention of surgical fires. Core objectives included individual and team development of situational awareness through: (1) development of knowledge of the 3 components of the fire triangle and their contribution to the occurrence of surgical fires; (2) development of knowledge of procedures that pose a high risk for the occurrence of a surgical fire; (3) development of awareness of situations

conducive for the development of a surgical fire; (4) effective communication among team members regarding the potential for a surgical fire; and (5) recognition and implementation of effective strategies for the prevention of a surgical fire through goal-directed tasks.

• ***Participants.*** Following approval by the Human Research Subject Office at the University of Miami, a convenience sample of anesthesia providers from an urban, freestanding, ambulatory surgical center was recruited. Ten anesthesia providers, 7 Certified Registered Nurse Anesthetists (CRNAs) and 3 anesthesiologists, volunteered to participate in the education module of the course. Participants who had been involved in a surgical fire or received recent instruction in the prevention of surgical fires were not eligible for participation.

• ***Procedure.*** Each participant received a course manual written by the program developer/author (MF). The course was conducted over a single 2-hour class session and included an instructor-led visual presentation, followed by a question-and-answer session. Topics presented included the fire triangle, providers' responsibility for elements of the fire triangle, procedures that pose a high risk for the occurrence of a surgical fire, prevention strategies for high-risk procedures, team situational awareness, goal-directed tasks, and evidenced-based case studies.

• ***Measures.*** A 50-question, multiple-choice measure of surgical fire prevention was created for this course. Examination questions were written by the program developer/author (MF) and were based on chapter objectives and case studies in the course manual. Participants completed the measure before and after the training course to evaluate change in knowledge of surgical fire prevention. Competence in surgical fire prevention was defined as 85% or higher of correct responses.

Results

The mean pretest surgical fire prevention score was 66.60 (standard deviation [SD] = 8.17). None (0%, range = 56-82) of the participants had enough correct responses (85%) to be considered competent in surgical fire prevention. The mean score on the posttest was 92.80 (SD = 3.79). All (100%, range = 86-98) participants answered at least 85% of the items correctly on the posttest. A paired-samples *t* test showed a statistically significant increase in knowledge, t (df = 9) = 11.40; P = .001.

Discussion

As the volume of surgeries and the use of laser equipment for procedures increase, there are greater risks for surgical fires. The proposed certification program for surgical fire prevention is designed to enhance patient safety and improve clinical outcomes by providing all surgical team members with an education program and training protocol for surgical fire prevention.

Results of the pilot test of the certification program with anesthesia providers were promising. A paired *t*-test analysis showed a significant increase in surgical fire knowledge after completing the course. No provider had scores in the competent range before the training course, but all scores were in the competent range after the course. Results indicated that this course can remediate gaps in surgical fire prevention knowledge of providers. Although this is a very small sample of providers, their poor performance on the pretest suggests that many providers do not receive sufficient instruction in fire prevention.

This pilot study was limited by the small sample size and nonrepresentativeness of the participant providers. To truly evaluate the effectiveness of the proposed certification course, larger studies with randomized designs and longer follow-up periods must be conducted. It may be necessary to have a booster training at regular follow-up points for providers to retain knowledge gained in this course.

The course is designed for all members of the surgical team to complete together. Although not directly examined in the pilot testing phase, it is recommended that the entire surgical team participate in training together to have the most effective learning experience. Observational studies of team communication and application of knowledge during high-risk procedures should be included in the future to test the theoretical mechanisms of action of the training course. In addition, future research should measure the effectiveness of team communication and collaboration during simulation and compare with team communication and collaboration without simulation.

Finally, this pilot study was limited because the certification examination did not have extensive evidence of validity. Efforts to provide initial evidence of validity of the examination commenced in 2014. The knowledge assessment used in this pilot project will be evaluated by the program developer and subject matter experts for rigor and to ensure all objectives for certification are assessed.

As a final point, acquiring certification in the prevention of surgical fires ensures patient safety for all surgical patients. It will be comforting for patients to know that surgical team members are credentialed practitioners who have completed a certification process that ensures the verification and validation of the knowledge necessary to prevent the occurrence of surgical fires. Based on informal comments from providers with knowledge of this course, the information is useful and helpful to provide a safe surgical milieu.

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