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Research Paper

Up in flames: a flammability assessment of alcohol-based hand sanitizers on common perioperative materials

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Abstract

Introduction: The objective of this study was to perform a flammability assessment of alcohol-based hand sanitizers on common perioperative materials. There is an estimated 550–650 surgical fires that occur nationally each year, an instance comparable to that of wrong-site surgery, yet only about 100 operating room fires are reported each year. The median cost of an OR fire settlement claim is $120,166. Generation of fire requires the presence of three components, known as the "fire triad": (1) an oxidizer, (2) an ignition source, and (3) fuel.
Methods: The flammability of five common perioperative materials was assessed (conform stretch gauze, surgical drape, foam headrest, OR towels, and lap sponges). The flammability of these materials was assessed alone and with six test liquids (Purell Advanced, Germ-X, generic hand sanitizer, spray hand sanitizer, ChloraPrep, and sterile water). The assessments with the test liquids were conducted immediately after application and after five minutes. The ignition sources used were a lighter and two spark generators (piezo-electric and battery-powered spark generator).
Results: Two of the five perioperative materials were easily ignitable (OR towels and lap sponges), while the others exhibited flame retardant properties, which manifested itself as "melting" when an ignition source was applied (conform stretch gauze, surgical drape, and foam headrest). ChloraPrep served as the positive control and sterile water served as the negative control. When alcohol-based hand sanitizers and ChloraPrep were added to these materials, the flammability increased. The addition of sterile water to the perioperative materials rendered the material nonflammable. The piezo-electric spark generator did not elicit any combustion of perioperative materials with or without test liquids, but the battery-powered spark generator did.
Conclusion: Commonly used alcohol-based hand sanitizers are flammable. When alcohol-based hand sanitizers are applied to perioperative materials, their flammability increases, even materials which were previously nonflammable. Electrostatic discharge did illicit combustion of alcohol-based hand sanitizer on any perioperative materials tested, and should be recognized as a genuine safety hazard. Although these personal hand sanitizer products are commonly used for their antiseptic properties, one should exercise prudence with their use to avoid causing harm to the patient.

Keywords: *electrostatic discharge; flammability assessment; hand sanitizer; patient safety*

1. Introduction

Alcohol-based hand sanitizers can be found in many perioperative settings. Their use serves as an additional deterrent to the spread of nosocomial infections to the patient, as well as to the healthcare provider.
While the efficacy of alcohol-based hand sanitizers remains undisputed through research, their safety during the operative period has been studied very little. Similar research was accomplished by McDonnell, ET. al. (2011), which had reported the high flammability of the use of ChloraPrep solutions on hair, skin and other perioperative materials. A literature review yielded a case report in the Canadian Journal of Anesthesia, where a patient sustained a burn injury following the application of an alcohol-based surgical scrub (Kim, J., Hyun, J., & Kyong, S., 2013). Another report was made more public in the United States, concerning Ireland Lane on February 2nd 2013, at Doernbecher Children's Hospital, Oregon. This 11-year old girl had alcohol-based hand sanitizer on her while she was making static electricity with her sheets in the hospital and suffered third degree burns. What makes these cases even more interesting is the implication of static electricity as the cause of ignition to the alcohol-based products.
The Emergency Care Research Institute, after extrapolating data published by the Pennsylvania Patient Safety Authority, estimated that 550–650 surgical fires occurred nationally each year, an instance comparable to that of wrong-site surgery." (ECRI Institute, 2009). However, only about 100 operating room fires are reported a year. No report specifics could be found to aide in the specific determination of the major causes of the operating room fires.
Other reports which give further relevance to the research into operating room fires and their causes, is the ASA Closed Claims Project. Operating room fires from 1989 to 2009 were included in this report with a median settlement amount of $120,166 (Mehta, S., Bhananaker, S., Posner, K., & Domino, K., 2013).
These recently reported cases lead to the creation of this bench study, designed to observe the difference in the flammability of various alcohol-based hand sanitizers on perioperative items with two ignition sources (flame and electrostatic).

2. Methods

This bench study was performed in the laboratory, under a chemical/biological hood with safety equipment immediately available (fire extinguishers, emergency shower, and eyewash station). Flammability was assessed on common perioperative materials, such as: conform stretch gauze, surgical drapes, foam headrest, OR towels, and lap pads in both wet and dry states. Attempts to ignite the materials were performed in their dry states, immediately after application of the test liquid, and five minutes after the test liquid application. Ignition sources used were standard butane lighter, piezo-electric spark generator, and a battery-powered spark generator.

The test materials were cut into equal sizes, approximately 3x3 inches and placed on a glass slide attached to a laboratory stand under the hood. The test liquids were placed, one at a time, onto each test material and the appropriate amount of time elapsed before attempted ignition with one of the ignition sources. Results were documented of either successful or unsuccessful ignition in the dry state, immediately after application of test liquid, or five minutes after application of the test liquid.

The ignition sources used, Bic butane lighter, piezo-electric and battery-powered spark generator, were individually tested with the various test liquids and test materials in the dry state, immediately after application of the test liquid, and five minutes after the test liquid. The butane lighter and piezo-electric igniter was purchased from a home improvement store. The piezo-electric igniter is commonly used as the ignition source for propane gas grills and has a variable voltage output (depending on distance between anode and cathode) anywhere between 7kVDC-10kVDC. The battery-powered spark generator was built from electrical components consisting of a 12VDC battery, flyback transformer, transistor, and resistors. The voltage generated from the battery-powered spark generator is estimated to be 20kVDC (based on manufacturer specifications of the flyback transformer output).

3. Results

The results revealed two of the five perioperative materials were easily ignitable (OR towels and lap sponges). Three of the five perioperative materials exhibited flame-retardant properties, which manifested as "melting" when an ignition source was applied (conform stretch gauze, surgical drape, and foam headrest). When alcohol-based hand sanitizers and ChloraPrep were added to these materials, the flammability rapidly increased. The addition of sterile water to the perioperative materials rendered the material nonflammable. The piezo-electric spark generator did not elicit any combustion of perioperative materials with or without test liquids, but the battery-powered design ignited all test materials with alcohol-based hand sanitizer and Chlora-prep applied to them. All of these results are outlined in the following figure:

Operating Room Materials							
Test Liquids			Conform Stretch Gauze	Drape	Headrest	OR Towel	Lap Pad
	Purell with Aloe	Dry	Melts	Melts	Melts	+	+
		Immediate	+	+	+	+	+
		5 Minutes	+	+	+	+	+
	Germ-X	Dry	Melts	Melt	Melts	+	+
		Immediate	+	+	+	+	+
		5 Minutes	+	+	+	+	+
	Generic	Dry	Melts	Melt	Melts	+	+
		Immediate	+	+	+	+	+
		5 Minutes	+	+	+	+	+
	Hand Spray Sanitizer	Dry	Melts	Melts	Melts	+	+
		Immediate	Flashed and Out	Flashed and Out	Flashed and Out	Flashed and Burn	Flashed and Burn
		5 Minutes	Melts	Melts	Melts	+	+
	ChloraPrep	Dry	Melts	Melts	Melts	+	+
		Immediate	+	+	+	+	+
		5 Minutes	+	+	+	+	+
	Sterile H_2O	Dry	Melt	Melts	Melts	+	+
		Immediate	-	-	-	-	-
		5 Minutes	-	-	-	-	-

Fig. 1: Flammability of selected operating room materials when exposed to test liquids, elapsed time intervals, and open flame (Bic lighter).

4. Discussion

The flammability assessment yielded results supporting the hypothesis that alcohol-based hand sanitizers are highly flammable. The butane lighter performed as expected, especially when introduced to a highly flammable substance, alcohol-based hand sanitizers. With regards to the piezo-electric spark generator, it was unable to create any ignition to any of the alcohol-based hand sanitizers, even the ChloraPrep (the control positive). Speculation as to why the piezo-electric spark generator could not elicit combustion could include the fact that the voltage was comparably lower than that of the battery-powered spark generator. The voltages produced by the piezo-electric spark generator are consistent with the lower end of what a human being can produce and discharge as static electricity. This bench study was unable to demonstrate the danger of causing ignition to an alcohol-based hand sanitizer with lower energy levels of static electricity that a human being can discharge.

The battery-powered spark generator performed remarkably well and demonstrated the safety issues associated with the use of alcohol-based hand sanitizers in the perioperative setting. According to the Electrostatic Discharge Association (2014), anywhere from 6kV to 35kV of electricity can be generated by the average human being, with activities ranging from sitting at a bench to walking across a carpet. In a recent publication, The Centers for Medicare & Medicaid Services (CMS) have proposed lowering the operat-

ing room relative humidity requirement from a minimum of 35 percent to at least 20 percent (2013). This was done after extensive research concluded that no adverse effect to system performance, patient safety, or clinical outcome would result. This minimum standard exists due to the use of "flammable anesthetics." Reduction in humidity does lend to an increase in static discharge voltages. While there is no denial that the highly flammable, volatile anesthetics of the past are not used today, nitrous oxide is still used and does support combustion, but the biggest concern is the implementation of alcohol-based hand sanitizers in the perioperative environment. So, flammable anesthetics have essentially almost been totally removed from the operating room, but now an equivalent threat has taken its place.

5. Conclusion

Commonly used alcohol-based hand sanitizers are flammable. When alcohol-based hand sanitizers are added to perioperative materials, their flammability increases, even materials that were not previously flammable. Electrostatic discharge from the piezoelectric source could not illicit combustion of any alcohol-based hand sanitizers on any perioperative materials tested, but the battery-powered design did yield flammability results. Although these personal alcohol-based hand sanitizer products are commonly used for their antiseptic properties, one should exercise prudence with their use to avoid causing harm to the patient. Patient safety is always at the forefront of everything that is done during the perioperative experience. All operating room personnel need to be aware of this common flammability hazard, and to be firmly vigilant to the task of caring for our patients to the best of our abilities.

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