Flammability of topical preparations and surgical dressings in cutaneous and laser surgery: A controlled simulation study

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Background: Surgical fires are a rare, but serious complication of dermatologic procedures involving electrosurgical and laser devices. Given the lack of data regarding basic fire safety principles, many dermatologists remain unaware of this potential risk.

Objective: We evaluated the flammability of topical preparations and surgical drapes commonly encountered in the immediate operative field during cutaneous and laser surgery.

Methods: Surgical dressings, drapes, and pork belly skin were examined for fire risk upon exposure to isopropyl alcohol, chlorhexidine gluconate, and aluminum chloride under dry, saturated, and damp conditions. Both electrosurgery and a carbon-dioxide laser were used as ignition sources.

Results: At least some char was observed in 86 of 126 simulated conditions (68%). Flames occurred in 2 test conditions: dry underpad drapes and cotton balls exposed to the carbon-dioxide laser. In general, drapes and dressings dampened or saturated with isopropyl alcohol failed to ignite with electrofulguration or electrodessication, although sparks and moderate char developed on pork belly skin and the underpad drape. Materials dampened or saturated with chlorhexidine gluconate, which contains isopropyl alcohol, generated less smoke and char compared with materials exposed to aluminum chloride, which does not contain alcohol.

Limitations: Future studies may assess the flammability of materials in the setting of oxygen supplementation.

Conclusion: In common cutaneous surgical environments, electrosurgery or ablative laser may lead to char and rarely to fire. Char may be seen in up to two thirds of simulated conditions, and in a minute proportion of conditions, fire is observed. (J Am Acad Dermatol 2012;67:700-5.)

Key words: carbon-dioxide laser; electrosurgery; fire; patient safety; skin preparation; surgical fires.

Although often overlooked, surgical fires are a potential hazard of both cutaneous and laser surgery. According to the Emergency Care Research Institute, approximately 50-100 surgical fires occur in the United States each year, the majority of which involve electrosurgical or laser devices.[1] Dermatologists routinely use electrodesiccation, yet may be unfamiliar with the inherent flammability of commonly encountered topical preparations and surgical dressings. Carbon-dioxide laser resurfacing also carries a potential fire risk, especially if performed in an oxygen-enriched environment.[2]

To our knowledge, controlled studies have not been performed to evaluate topical preparations, such as disinfectants and/or hemostatic agents, as a fuel source in the setting of electrosurgery or

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carbon-dioxide laser surgery. In fact, fire risk and prevention techniques are inadequately addressed in the dermatologic literature, with much of the data on fire safety related to surgical procedures conducted under general anesthesia rather than ambulatory cutaneous and laser surgery. In this study, we conducted live simulations to evaluate the flammability of commonly used topical preparations and surgical dressings/drapes in the setting of electrosurgery and carbon-dioxide laser use.

CAPSULE SUMMARY

- Electrosurgical and laser devices contribute to more than 90% of surgical fires.
- Exposure of dry materials to carbon-dioxide laser can generate flames. When exposed to electrosurgery and carbon-dioxide laser, materials soaked with aluminum chloride produce more smoke and char than those soaked with isopropyl alcohol.
- Dermatologists should be aware of flammable materials within the surgical field and educate staff regarding fire safety practices.

METHODS

Dry fuel sources

Surgical dressings and drapes were selected based on their frequency of use in procedural dermatology, and included: gauze (Kendall Curity, 12-ply 4-in × 4-in United States Pharmacopeial Convention type VII gauze sponge); cotton surgical towel; surgical drape (Graham professional poly-lined towel/drape); cotton balls; and absorbent underpad drape (Tendersorb Underpads, Tyco Healthcare—Kendall). In addition, fresh pork belly skin was also chosen to simulate human skin.

Liquid fuel sources

Topical fluid preparations were selected based on their widespread use in dermatologic surgery and known potential for flammability, and included: isopropyl alcohol 70% (Hydrox Laboratories); chlorhexidine gluconate 4.0% wt/vol (Hibiclens, Mölnlycke Health Care); and aluminum chloride 35% (Delasco Dermatologic Lab and Supply Inc).

Ignition sources

The ignition sources were also selected based on their frequency of use in procedural dermatology, and included electrofulguration, electrodesiccation, and carbon-dioxide laser. The energy levels were based on commonly used parameters. Electrofulguration (Hyfrecator 2000, ConMed Corp, Utica, NY) was set at 18 W using the high output port, with the tip advanced toward the surface of the material until an arc was maintained for 5 seconds. Electrodesiccation (Hyfrecator 2000, ConMed Corp) was also set at 18 W using the high output port, with the tip gently pressed onto the surface of the material for 5 seconds. As we limited the study conditions to those most commonly used in dermatology practices, we did not study electrocoagulation. The carbon-dioxide laser (UltraPulse Active FX, Lumenis Inc, Santa Clara, CA) was set at 12.5 mJ and 150 Hz, with a 7-mm square scan size and density setting at 3. One full scan size of the carbon-dioxide laser was performed on each material.

Given that povidone iodine has a short duration of action, is inactivated in the presence of blood, and is now uncommonly used by dermatologic surgeons, who tend to favor chlorhexidine, we chose not to include povidone iodine as a treatment arm. Significantly, povidone iodine does not include an alcohol base, and so may be expected to be less flammable than the other solutions that were tested.

Experimental procedure

All surgical dressings and drapes, and pork belly skin, were examined for fire risk upon exposure to each of the 3 ignition sources under dry, saturated, and damp conditions, with the latter 2 conditions using each of the 3 liquid fuel sources. The amount of dry material tested allowed for absorption of 15 mL of fluid, which was used as the definition of "saturated." Damp conditions were attained by squeezing excess fluid out of the material and then pressing it between 2 pieces of paper towel. With regard to the pork belly skin, saturated conditions were characterized by a thin layer of fluid on the surface of the tissue, and damp conditions were met when enough fluid was wiped off to leave only a moist sheen on the surface.

Outcome definitions

"Spark" was recorded if electrofulguration produced sparks from the tip of the electrode to the tested material, or if electrodesiccation produced sparks from the edges of the electrode tip while in contact with the tested material. The presence of a visible plume was recorded as "smoke." If fire occurred, this was recorded either as "focal flame" if limited to the test area, or "spreading flame" if the fire spread beyond the tested site. If no flame was observed, but charring was visible, this was graded as mild, moderate, or severe char (Fig 1). All outcomes were rated based on forced agreement between 2 dermatologists trained in