potion that were short lived, and probably represented epinephrine toxicity. Although the accuracy of test dosing before administering full doses of caudal local anesthetics remains uncertain, we recommend routine test dosing and slow fractional administration of the entire local anesthetic dose when performing caudal epidural blocks in children. Furthermore, with the recent commercial availability of equipment specifically designed for providing pediatric regional anesthesia, we also recommend that, in the future, needles specially designed for regional anesthesia in children be employed.

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Operating Room Fires Initiated by Hot Wire Cautery

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Operating room fires continue to occur, because of the simultaneous presence of a source of ignition.

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Case Reports

Case 1

A healthy 11-yr-old, 40-kg boy was brought to the operating room for excision of two 3-mm lesions superomediol to the right orbit. Local anesthesia with intravenous sedation was used for the surgery. Oxygen at a flow rate of 3 l/min was administered via a nasal cannula. The surgical site was prepared with povidone-iodine and allowed to dry. The face was draped with a fire-resistant drape (Evolution 3 fabric, Kimberly-Clark, Roswell, GA). After incremental intravenous administration of fentanyl (50 mcg), midazolam (1.5 mg), and droperidol (0.625 mg), the surgeon injected 1% lidocaine containing 1:200,000 epinephrine around the lesion and made the initial incision without incident. Shortly thereafter, the surgeon requested a battery-operated 3-volt hot wire cautery (C-Line Accutemp 84-43000, Xomed-Treace, Jacksonville, FL) to control bleeding. His first use of the cautery caused ignition of a dry gauze sponge held in his other hand near the glowing cautery filament. A brisk fire ensued, but the team rapidly extinguished the fire by smothering it with a dry towel. Nevertheless, the boy suffered mixed first and second degree burns of a 12-15 cm² area of his nose, cheeks, upper lip, and anterior nares. There was no respiratory or eye involvement.

A thorough search revealed the charred sponge and no other burned material. The boy made an uneventful recovery and was discharged on the fourth postoperative day. For several months, a small area of his face remained unusually prone to sunburn.

Case 2

A healthy 6-yr-old, 25-kg boy presented for bilateral otoplasty. After being premedicated with 10 mg midazolam and 0.6 mg atropine given orally in 20 cc apple juice, he was brought to the operating room where anesthesia was induced with halothane and nitrous oxide in oxygen. The trachea was intubated without muscle relaxant using a 6.0 mm uncuffed oral Ring-Adair-Elwyn (RAE) tube brought out over the center of the lower lip. A very slight leak occurred between the uncuffed tube and the trachea with positive pressure ventilation. Anesthesia was maintained with 1.0-1.5% halothane and 50% N₂O in oxygen.

The right ear was prepared with povidone-iodine and draped with a plastic drape (1020 Steri-Drape, 3M, St. Paul, MN). Approximately 30 min after making the initial incision, the surgeon asked for a 3-volt hot wire cautery (C-Line Accutemp 84-43000) for hemostasis. Initial use of the cautery led to a brisk flame originating in a dry gauze sponge held in the surgeon's other hand and some melting of the plastic drape. Although promptly extinguished, the fire caused a 2.5 cm × 2.5 cm second degree burn of the preauricular area. After the burn was treated with silver sulfadiazine cream (Silvadene, Marion Merrell Dow, Kansas City, MO), the surgery was completed on both ears without further use of cautery. The burn healed uneventfully.

Case 3

A 23-yr-old, 51-kg healthy woman came to the operating room for excision of two nevi from her right upper arm. Premedication consisted of intravenous midazolam (1.5 mg) and oral ibuprofen (800 mg). Intravenous sedation consisting of alfentanil (250 mcg), lidocaine (50 mg), and propofol (30 mg) was administered while the surgeon injected 0.25% bupivacaine around the nevi. Oxygen was administered via the nasal cannula at a rate of 3 l/min behind a full drape that separated the patient's face and neck from the operating field. After excision of the lesions, the surgeon used a 3-volt hot wire cautery (C-Line Accutemp) to achieve hemostasis. There followed a sudden ignition of a dry gauze sponge held in his other hand, but the fire was extinguished without injury to the patient. An observer noted an "arc" between the hot wire and the nearby gauze.

Case 4

A healthy 43-yr-old, 68-kg man was brought to the operating room for bilateral upper and lower lid blepharoplasties. He was anesthetized with intravenous sedation and local anesthesia. Oxygen was administered at a rate of 3 l/min via the nasal cannula but was discontinued before the use of cautery began. A wet gauze sponge was draped over the patient's nose. While a 3-volt Abco hand-held hot wire cautery (No. 285201, Aaron Medical Industries, St. Petersburg, FL) was being used, there was a sudden yellow flash, and both the upper and lower eyelashes of one of the patient's eyes were singed off. There was no other injury.

Materials and Methods and Results

Battery-operated hot-wire cauteries manufactured by Xomed-Treace were used. The C-Line Accutemp cautery 84-43000 contains two AA batteries (total 3 volts), and the C-Line I-Stat low-temperature cautery 84-41000 contains one 1.5-volt battery. These devices, illustrated in figure 1, reportedly achieve tip temperatures of about 1,200° C and 680° C, respectively. Eight materials commonly found in operating rooms were tested for flammability in room air: plastic nasal cannula (Hudson Oxygen Therapy Sales, Temecula, CA), blue paper operating room cap 72-924B (Anago, Fort Worth, TX), micropore paper tape (3M), x-ray detectible cotton gauze sponges (Kendall-Vistec, The Kendall Company, Mansfield, MA), blue cotton operating room towel 706-B (Medical Action Industries, Farmingdale, NY), plastic eye drape (1020 Steri-Drape, 3M), cellulose-based ophthalmic sponges (Weck-Cel, Edward Weck, Research Triangle

§ Xomed-Treace, Inc.: C-Line Surgical Cauteries Brochure. Jacksonville, FL, 1992

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Park, NC), and surgical gown made of polypropylene-based Evolution 3 fabric (Kimberly-Clark), stated to meet the class I standards of the National Fire Protection Association (NFPA). § NFPA-702-I states that a 6-in sample of fabric mounted at a 45° angle and ignited by a ½-inch flame will have a flame spread requiring more than 20 s.

The cauteries were activated and then touched to a 2.5-cm square of each of the tested materials (the entire Weck-Cel was used) without supplemental oxygen. Five attempts were made with each combination. Results were classified as melting, charring, and flame, and are outlined in table 1. The five attempts generally produced the same qualitative results, although in one instance, the 3-volt cautery ignited the plastic drape.

Preliminary experiments established that the 3-volt cautery caused ignition of a number of materials within 3 s, and that, once ignited, the paper tape, cotton gauze, and cotton towel burned vigorously, whereas the Weck-Cel burned more sluggishly. Figure 2 illustrates a typical fire ignited in a sample of cotton gauze. The other materials did not ignite even on prolonged contact with the 3-volt cautery (except that in one of five attempts, the plastic drape ignited). Instead, these materials either melted or charred. Similarly, melting or charring was observed with all materials when touched by the 1.5-volt cautery. However, the 1.5-volt cautery ignited both the plastic drape and the Weck-Cel when the testing was done in a stream of oxygen at a rate of 2 l/min. The other combinations were not retested in the presence of supplemental oxygen.

Finally, cotton gauze and cotton towel were soaked in saline and wrung out before being touched with the 3-volt cautery in room air. Under these conditions, no flame was produced.

Fig. 1. The 1.5-volt (C-Line I-Stat) and 3-volt (C-Line Accu-Temp) cauteries used for testing.

| Table 1. Ignition of Common Materials with the Hot-wire Cautery |
|---------------------------------|-----------------|-----------------|
| Material                        | 1.5 v            | 3 v             |
| Plastic tubing                  | Melt             | Melt, char      |
| Operating room cap              | Char             | Char            |
| Paper tape                      | Char             | Flame (1–2 s)   |
| Cotton gauze                    | Char             | Flame (1–3 s)   |
| Paper gown                      | Char             | Char            |
| Cotton towel                    | Char             | Flame (2–3 s)   |
| Plastic drape                   | Melt f           | Melt (flame 3 s) |
| Weck-Cel                        | Char f           | Flame (2–3 s)   |

The cautery filament and the test material were held in contact until ignition occurred or until 3 s had elapsed.

* When retested after soaking in saline and wringing out, there was no ignition or charring despite a 10-s attempt.

† Supplemental O₂ at a rate of 2 l/min from a tubing held near the filament made it possible to ignite these materials with the 1.5-volt cautery. The other materials were not tested in an O₂-enriched atmosphere.

‡ In one trial of five, a flame resulted.

Fig. 2. A typical flame produced in a sample of cotton gauze by the 3-volt cautery.

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† Kimberly-Clark Corporation: Evolution 3 Surgical Fabric Technical Data, Roswell, GA, 1990

‡ NFPA: Standards for Classification of Flammability of Wearing Material. Quincy, MA, 1980
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Discussion

Most reports of operating room fires refer to the use of supplemental oxygen and conclude with admonitions to monitor the use of oxygen carefully to avoid allowing it to accumulate in confined areas created by surgical draping and to turn off the oxygen supply before cautery is used. Although we would take these precautions, the present work shows that the combination of a 3-volt hot wire cautery and cotton gauze, paper tape, cotton towels, or Weck-Cels is inherently dangerous without supplemental oxygen. In acknowledgment of this danger, the manufacturer (Xomed-Treace) has inscribed the words, "Do not use in the presence of flammable materials," prominently on the plastic casing of the cauteries. Our findings confirm and extend Chestler and Lemke’s report of two fires caused by disposable cauteries in the absence of supplemental oxygen. Previous brief reports on the fire hazards of the disposable cautery have emphasized the inadvertent locking of the switch in the "on" position or the risk of supplemental oxygen.

The four operating room fires reported here appear to have originated because of the simultaneous use of a hot-wire cautery and a flammable material, and not primarily from the presence of supplemental oxygen. However, supplemental oxygen undoubtedly increased the intensity of the fire in the first case and possibly played a role in the second. It seems unlikely that the presence of supplemental oxygen was important in case 3, where the draping and the distances involved effectively isolated the surgical site from the oxygen, or in case 4, where the supplemental oxygen was turned off carefully before each use of the cautery. We have demonstrated experimentally that, even in the absence of supplemental oxygen, contact between the glowing tip of a 3-volt cauterity and dry cotton gauze invariably causes the gauze to ignite and burn vigorously. A number of other common materials also ignite under these conditions.

Despite the inherent danger of the combination described above, it is common to see a disposable cautery in a surgeon’s one hand and a dry cotton gauze in the other. Contact of the gauze with the cautery tip is liable to produce a fire, the intensity of which would be increased by the presence of supplemental oxygen or nitrous oxide. Should a surgeon need to use the hot-wire cautery, we recommend that the gauze sponges be first soaked in saline and wrung out, so that they will not ignite in room air. In addition, to minimize any remaining danger of fire, we recommend that a supplemental air-oxygen mixture, the oxygen concentration of which is increased as little as possible above 21%, should be employed (as guided by oxygen saturation monitoring), and, where possible, that the oxygen flow should be turned off before each use of the cautery.

References


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