

sole use of topical agents in these patients, the addition of SLN block improved patient comfort, required less time, and reduced the total dose of local anesthetic.

SLN block is extremely safe. A review of published series of SLN blocks describes over 1,100 blocks with only one complication.<sup>1-3,10</sup> One patient had a small hematoma in the neck that was easily controlled with manual pressure.<sup>3</sup> The superior laryngeal artery, a branch of the superior thyroid artery, passes through the thyrohyoid membrane along with the internal branch of the SLN nerve. Aspiration prior to the injection of local anesthetic will prevent any inadvertent intravascular injection. As mentioned above, the internal branch of the SLN has no motor fibers. If the external branch is blocked along with the internal branch, ipsilateral cricothyroid muscle paralysis could result. The cricothyroid muscle is a vocal cord tensor and the patient may have a weak voice, loss of vocal range, or have no symptoms.<sup>7</sup>

TEE can often be safely performed with only the combination of topical anesthesia to the hypopharynx and sedation. This approach was not satisfactory for the patient described for two reasons. Adequate administration of topical anesthetic was difficult because of the patient's dyspnea, inability to fully cooperate, and heightened gag reflex. Also, the patient's medical condition deteriorated during the first two attempts to pass the TEE probe. The decline in SpO<sub>2</sub> and blood pressure was most likely from the adverse effect of the patient's sympathetic response to discomfort. The resultant increase in systemic vascular resistance may have increased the regurgitant flow through his mitral prosthesis. The administration of the SLN block allowed the TEE to be completed safely and with no patient discomfort.

In conclusion, this case demonstrates a new application for SLN block TEE. In awake patients, the block is easily performed, is associated with only rare minor complications, and has a high success rate. SLN block may prove to be a valuable addition to the anesthetic management of selected patients undergoing TEE while awake.

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## Airway Fire during CO<sub>2</sub> Laser Surgery Using a Xomed Laser Endotracheal Tube

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The CO<sub>2</sub> laser offers significant advantages over conventional surgical techniques such as increased precision, an intrinsic hemostatic effect, and reduced postoperative

pain and edema. Due to the high-energy density of the laser and its proximity to combustible endotracheal tubes during airway surgery, it has been reported to cause airway fires secondary to tracheal tube combustion.<sup>1-3</sup> The need for an improved endotracheal tube that is resistant to the effects of the laser has led several manufacturers to design special laser endotracheal tubes. The efficacy of some of these tubes has been questioned in an *in vitro* comparison study.<sup>4</sup> The following case report demonstrates the vulnerability of the Xomed® Laser Shield endotracheal tube during clinical use.

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## CASE REPORT

The patient was a 56-yr-old ASA physical status 1 man weighing 79 kg who presented with hoarseness. CO<sub>2</sub> laser excision of a vocal cord polyp was planned. Anesthesia was induced with 100 µg of fentanyl, 400 mg of thiopental, and tracheal intubation was facilitated with succinylcholine 100 mg iv. A 6-mm ID Xomed® (Jacksonville, FL) Laser Shield endotracheal tube was placed. Its cuff was inflated with 5 ml of isotonic saline. No leak of anesthetic gases was heard during positive pressure ventilation. The CO<sub>2</sub> laser was set to 20 W in the pulsed mode of operation with a duration of 0.2 s per pulse. Anesthesia was maintained with 4 l/min N<sub>2</sub>O and 2 l/min O<sub>2</sub> along with isoflurane up to 1.5% as delivered by a calibrated vaporizer. Intermittent iv boli of atracurium provided paralysis.

Near the end of the resection, the surgeon noticed bleeding at the edge of one of the vocal cords. Actuation of the laser for hemostasis resulted in smoke emerging from the patient's mouth with flames noted by the surgeon to be coming from the endotracheal tube. The anesthesiologist also noted flames in the disposable corrugated anesthesia circuit connected to the tracheal tube. The flames were doused with saline. Breath sounds were absent and an obvious leak of anesthetic gas could be heard when the ventilator cycled. The patient's lungs were not being ventilated. The delivery of nitrous oxide and oxygen were terminated and the ventilator turned off. The endotracheal tube was quickly removed, the lungs ventilated *via* mask, and the trachea was reintubated with a polyvinylchloride (PVC) endotracheal tube. Fiberoptic bronchoscopy subsequently revealed extensive burns to the trachea and both bronchi. No fragments of the endotracheal tube were seen in the respiratory tract. The Xomed® tube was later noted to be intact with a ruptured cuff and with evidence of combustion of the cuff and distal shaft. The patient had a long intensive care unit stay requiring positive pressure ventilation, antibiotics, and vigorous pulmonary toilet. He subsequently underwent a permanent tracheostomy and had several dilatation procedures.

## DISCUSSION

Reports of the combustion of endotracheal tubes during laser airway surgery were published soon after the introduction of the CO<sub>2</sub> laser to otolaryngology.<sup>1</sup> The high-energy density (energy/area) of the laser and the fact that it is being operated in close proximity to combustible endotracheal tubes during airway surgery places the tubes at risk for combustion. Another factor favoring combustion is the fact that the anesthetic gases administered may support or enhance combustion.

Endotracheal tube combustion has been reported in 0.4<sup>2</sup> to 0.57%<sup>1</sup> of CO<sub>2</sub> laser airway cases and such tube fires have been reported to be the most common serious complication of CO<sub>2</sub> laser surgery.<sup>5</sup> Previous reports have noted laser-induced endotracheal tube fires when PVC<sup>3</sup> or red rubber (RR)<sup>1,2</sup> endotracheal tubes were used. This marks the first report of a CO<sub>2</sub> laser-induced endotracheal tube fire using a tube designed and manufactured especially for CO<sub>2</sub> laser airway surgery. This is also the first report of retrograde propagation of the fire from the cuffed end of the endotracheal tube to the Y piece and corrugated 22-mm hoses connected to the endotracheal tube.

The Xomed® Laser Shield endotracheal tube is constructed from silicone that has been externally coated with

a silicone layer containing metal particles. In a comparison study of the Xomed® Laser Shield with PVC and RR endotracheal tubes, Hayes *et al.*<sup>6</sup> noted that the shaft of the Xomed® tube could not be penetrated or ignited even in an atmosphere of 100% oxygen with a CO<sub>2</sub> laser set to 25 W with a spot diameter of 1.1 mm and a duration of 1 s. PVC or RR tubes could be easily ignited at these settings. However, with a longer duration of laser exposure, an intense "blow-torch" fire resulted in the Xomed® tube. In contrast to the Xomed® tube's shaft, they note that its cuff was perforated by only 1–2 J of laser energy (energy in J = power in W × duration in s). Hayes *et al.* note that the probability of endotracheal combustion is increased as the concentration of oxygen or nitrous oxide is increased.<sup>6</sup>

In an effort to determine the safest endotracheal tube for CO<sub>2</sub> laser surgery, Sosis and Heller<sup>4</sup> performed a comparison study of the effect of the CO<sub>2</sub> laser on the shafts of specially modified or designed endotracheal tubes for laser surgery including the Xomed® Laser Shield tube. They found that the shafts of RR endotracheal tubes wrapped with 3M® no. 425 or Venture® 1 mil copper foil and the stainless-steel Mallinckrodt® Laser-Flex endotracheal tube could withstand the CO<sub>2</sub> laser operating at 70 W operating for 1 min with a beam diameter of 0.68 mm in air when 5 l/min of oxygen was directed through the tubes. In their study, the Xomed tube rapidly broke into fragments and burned vigorously within 3 s of the laser's actuation. They noted that combustion of the Xomed® tube was more difficult to extinguish than that of burning RR tubes even after the oxygen was stopped and the tube was flooded with water.

Ossoff *et al.*<sup>7</sup> studied lung damage in dogs in whom endotracheal tube fires were started with a CO<sub>2</sub> laser. They note that the combustion of silicone endotracheal tubes led to the deposition of silica ash along the entire tracheobronchial tree. Histologic sections taken from the midtrachea showed acute inflammation, ulceration of the mucosa, and polymorphonuclear lymphocyte infiltration. They state that the silica ash may predispose to silicosis and therefore silicone endotracheal tubes should not be used for laser airway surgery. Their study also noted less histopathologic damage after fires occurring with RR endotracheal tube ignition than after the ignition of PVC tubes.

Nitrous oxide has been shown to support combustion secondary to its exothermic decomposition,<sup>8,9</sup> thus, nitrous oxide should be avoided during laser airway surgery. Instead, nitrogen or helium should be used along with the minimal inspired concentration of oxygen compatible with a satisfactory oxygen saturation.<sup>9,\*\*</sup>

Hirshman *et al.*<sup>10</sup> state that as long as a cuffed endotracheal tube is used, it is not necessary to avoid nitrous

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oxide or limit the inspired concentration of oxygen during CO<sub>2</sub> laser airway surgery because the exterior of the tube is exposed only to air and thus the gases flowing through the tube will not affect its combustion. The present case refutes this argument and clearly demonstrates that if the endotracheal tube cuff of a Xomed® Laser Shield endotracheal tube is ruptured during CO<sub>2</sub> laser surgery and nitrous oxide is being employed under the conditions reported, combustion will occur.

The Xomed® Laser Shield endotracheal tube used in this case was designed for use at CO<sub>2</sub> laser power levels up to 25 W in the pulse mode of laser operation with pulse durations of 0.1–0.5 s per pulse.<sup>††</sup> The manufacturer states that at a power level of 25 W, 25 pulses of 0.1-s duration or 5 impacts at 0.5 s perforated the Xomed® tube. However, the manufacturer does not mention whether these specifications refer only to the shaft of the tube or also its cuff. In view of the fact that the cuff was perforated with the CO<sub>2</sub> laser set at 20 W with a pulse duration of 0.2 s in the case reported, the specifications do not appear to apply to the cuff. This is in accordance with the findings of Hayes *et al.*<sup>6</sup> who noted cuff perforation after 1–2 J of energy. This corresponds to 10–20 W of power with a pulse duration of 0.1 s.

Endotracheal tube cuffs pose a significant hazard during laser airway surgery because they cannot be protected by techniques such as foil wrapping. Furthermore, the alignment of the laser along the axis of the operating laryngoscope predisposes to its direction into the trachea. In laser airway procedures, the choice of an undersized endotracheal tube to minimally obscure the surgeon's field results in the need for a large inflated cuff; this presents a hazardous target for an incorrectly aimed laser.

The present case demonstrates the limited protection afforded by saline<sup>11</sup> in protecting the cuff. As a further means of protecting endotracheal tube cuffs from the laser, wet pledgets that are kept moist may be placed above the endotracheal tube cuffs to shield them from the laser's energy.<sup>12</sup>

The possibility of an endotracheal tube fire during laser airway surgery necessitates that the entire operating room

team be prepared for such an emergency.<sup>\*\*</sup> When a fire is detected, all anesthetic gases including oxygen should immediately be terminated and ventilation of the patient's lungs stopped since combustion will be diminished by the interruption of gases that in turn may promote it. The endotracheal tube should be removed because even brief combustion will render most endotracheal tubes useless as a patent airway. Any flames should be extinguished with saline. The ventilation should then be managed by mask until the decision as to whether to reintubate the trachea with an endotracheal tube or rigid bronchoscope is made on the basis of the degree of injury that has occurred.

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