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.1–3,10 One patient had a small hematoma
in the neck that was easily controlled with manual pres-
sure.2 The superior laryngeal artery, a branch of the su-
perior thyroid artery, passes through the thyrohyoid
membrane along with the internal branch of the SLN
erve. 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 pa-
ralysis 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.7

TEE can often be safely performed with only the com-
bination of topical anesthesia to the hypopharynx and se-
dation. 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 Spo2 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 complica-
tions, 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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Anesthesiology

Airway Fire during CO2 Laser Surgery Using a Xomed Laser Endotracheal Tube

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The CO2 laser offers significant advantages over con-
ventional surgical techniques such as increased precision,
an intrinsic hemostatic effect, and reduced postoperative

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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 air-
way fires secondary to tracheal tube combustion.1–3 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.4 The following case report demons-
strates the vulnerability of the Xomed® Laser Shield en-
dotracheal tube during clinical use.
CASE REPORT

The patient was a 56-yr-old ASA physical status 1 man weighing 79 kg who presented with hoarseness. CO2 laser excision of a vocal cord polyp was planned. Anesthesia was induced with 100 mg 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 CO2 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 N2O and 2 l/min O2 along with isoflurane up to 1.5% as delivered by a calibrated vaporizer. Intermittent iv bolus 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 anesthetist 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 reexplanted 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 CO2 laser to otolaryngology.1 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% to 0.5%1 of CO2 laser airway cases and such tube fires have been reported to be the most common serious complication of CO2 laser surgery.5 Previous reports have noted laser-induced endotracheal tube fires when PVC or red rubber (RR)1,5 endotracheal tubes were used. This marks the first report of a CO2 laser-induced endotracheal tube fire using a tube designed and manufactured especially for CO2 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.6 noted that the shaft of the Xomed® tube could not be penetrated or ignited even in an atmosphere of 100% oxygen with a CO2 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.6

In an effort to determine the safest endotracheal tube for CO2 laser surgery, Sosis and Heller4 performed a comparison study of the effect of the CO2 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 Mallinkrodt® Laser-Flex endotracheal tube could withstand the CO2 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.7 studied lung damage in dogs in whom endotracheal tube fires were started with a CO2 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,8,9 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.9,10

Hirschman et al.10 state that as long as a cuffed endotracheal tube is used, it is not necessary to avoid nitrous oxide.

oxide or limit the inspired concentration of oxygen during CO\textsubscript{2} 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\textsuperscript{®} Laser Shield endotracheal tube is ruptured during CO\textsubscript{2} laser surgery and nitrous oxide is being employed under the conditions reported, combustion will occur.

The Xomed\textsuperscript{®} Laser Shield endotracheal tube used in this case was designed for use at CO\textsubscript{2} 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.\textsuperscript{† †} 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\textsuperscript{®} 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\textsubscript{2} 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.\textsuperscript{6} 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\textsuperscript{11} 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.\textsuperscript{12}

The possibility of an endotracheal tube fire during laser airway surgery necessitates that the entire operating room team be prepared for such an emergency.\textsuperscript{**} 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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