

CASE REPORTS

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Airway Fire during Tracheostomy: Extubation May Be Contraindicated

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AIRWAY fire can occur from ignition of airway tissue or an endotracheal tube (ETT), or both, by either a laser or electrocautery. In such an event, management protocol calls for immediate removal of the ETT.¹ However, removal of the ETT may result in irreversible loss of the airway because patients undergoing tracheostomy often have an increased risk for a difficult airway. The recommendation does not address the risk of potential airway loss.

Case Report

A 28-yr-old, 100-kg man was scheduled for elective tracheostomy. The patient's lungs had been ventilated in the intensive care unit for 35 days after emergency craniotomy for a closed head injury. During the course of intensive care unit stay the patient remained comatose and adult respiratory distress syndrome developed, which was now resolving. The airway evaluation revealed an *in situ* 8.0-mm ID polyvinyl-chloride ETT, swollen lips, an edematous tongue protruding out of the mouth and an oropharynx filled with secretions. The preoperative vital signs included blood pressure: 150/90 mmHg; heart rate: 80 beats/min; and intracranial pressure: 15 mmHg. The preoperative arterial blood gases on fractional inspired oxygen tension (F_{iO_2}) of 0.5 and positive end-expiratory pressure (PEEP) of 10 cm water with a tidal volume of 650 ml and a respiratory rate of 25 breaths/min were as follows: pH: 7.31; arterial carbon dioxide tension (P_{aCO_2}): 47 mmHg; arterial oxygen tension (P_{aO_2}): 146 mmHg; bicarbonate (HCO_3^-): 23 mEq/L; and BE: -3.2 mEq/L.

General anesthesia was induced with 300 mg intravenous propofol and maintained with 0.4% inspired isoflurane and a 35% oxygen/air mixture. The vital signs remained stable within 10% of the baseline values. Electrocautery was used for coagulation by the surgeons. The

patient was administered 100% oxygen immediately before insertion of the tracheostomy tube. Suddenly, the surgeons reported a blue flame shooting up vertically from the patient's neck. The breathing circuit was disconnected immediately from the ETT; 20 ml saline, 0.9%, was flushed into the ETT. The fire extinguished promptly. The ETT was not removed because the ability to reintubate was uncertain. Despite a leak around the perforated cuff, the seal was sufficient to generate a peak inspiratory pressure of 20 cm water by maintaining the reservoir bag F_{iO_2} volume *via* the oxygen flush mechanism. Meanwhile the surgeons were able to insert the tracheostomy tube into the trachea. The patient's vital signs remained stable throughout the event, and the lowest oxygen saturation (Sp_{O_2}) was 91%. After confirming correct positioning of the tracheostomy tube, the ETT was removed and noted to be burned to charcoal black in some portions around the perforated cuff.

Fiberoptic bronchoscopy performed in the operating room and postoperatively revealed generalized upper-airway edema consistent with prolonged intubation, no distal airway burn injury, and minimal burn injury to the proximal aspect of the tracheostomy site. The patient experienced no sequelae from the airway fire. The patient was successfully weaned from the ventilator on the fifth postoperative day and discharged to rehabilitation 3 weeks later.

Discussion

Hazards of airway fire with usage of a laser and electrocautery have been well documented (table 1). The management protocol for airway fire calls for immediate removal of the ETT.¹ However, if the airway is judged to be difficult to reestablish, removal of the ETT may be contraindicated. In patients with upper airway edema secondary to prolonged intubation or upper-airway diseases, the risk of failed intubation or reintubation is greatly increased. Loss of the airway would be especially disastrous for patients with limited pulmonary reserve.

In all previous reports, the discussion concentrated on prevention and management of the airway fire. Immediate removal of the ETT was recommended because it may continue to generate thermal and chemical injury to the airway from residual heat and toxic fume.^{1,2} However, these injuries may be minimal if the tracheostomy stoma serves as an effective vent.

In certain circumstances, the benefits of leaving the

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Table 1. Case Reports of Airway Fire

Reference	Surgery	Ignition Source	Venting Route	Site of Flame/Fire	Site of Smoke	Site of Burns	Severity/Extent of Airway Burns
Cozine <i>et al.</i> (1981)	Bronchoscopy	Laser	None	None	Mouth	All major airways	Upper airway obstruction diffuse pulmonary burn
Casey <i>et al.</i> (1983)	Bronchoscopy	Laser	None	Larynx	Mouth	Carina	Ulcerated carina intubation for 10 days
Sosis <i>et al.</i> (1990)	Bronchoscopy	Laser	None	ETT circuit	Mouth	Trachea bronchi	Extensive, serious burns permanent tracheostomy
Bowdle <i>et al.</i> (1987)	Tracheostomy	Electrocautery	Tracheostomy opening	Tracheostomy	None	Neck skin	None
Bailey <i>et al.</i> (1990)	Tracheostomy	Electrocautery	Tracheostomy opening	Tracheostomy	None	Trachea	Superficial
Le Clair <i>et al.</i> (1990)	Tracheostomy	Electrocautery	Tracheostomy opening	Tracheostomy	None	Trachea	Superficial
Aly <i>et al.</i> (1991)	Tracheostomy	Electrocautery	Tracheostomy opening	Tracheostomy	None	Trachea	Superficial
Lim <i>et al.</i> (1997)	Tracheostomy	Electrocautery	Tracheostomy opening	ETT	None	None	None
Boyd <i>et al.</i> (1969)	Tonsillar surgery	Electrocautery	Pharynx mouth	Lips	None	Pharynx uvula	Superficial
Simpson <i>et al.</i> (1986)	Tonsillar surgery	Electrocautery	Pharynx mouth	Pharynx lips	None	Pharynx uvula tongue carina L main bronchus	Superficial
Hirshman <i>et al.</i> (1980)	Bronchoscopy	Laser	Tracheostomy opening	Tracheostomy	None	Trachea	Superficial
Rita <i>et al.</i> (1982)	Bronchoscopy	Resectoscope	Tracheostomy opening	Tracheostomy	None	Trachea main bronchi	Superficial
Snow <i>et al.</i> (1976)	Bronchoscopy (Patient 1)	Laser	Tracheostomy opening and around the uncuffed ETT?	Present (not specified)	None	Trachea	Superficial
	Bronchoscopy (Patient 2)	Laser	Around the uncuffed ETT?	Present (not specified)	None	Trachea	Superficial
Burgess <i>et al.</i> (1979)	Bronchoscopy	Laser	Around the uncuffed ETT?	ETT	None	None	None

ETT = endotracheal tube.

ETT in may outweigh the risks after the airway fire is extinguished. The ETT may still allow acceptable ventilation of the lungs with oxygen, especially when the airway is edematous enough to provide a reasonable seal around the perforated cuff. In addition, the ETT can serve as a conduit for a tube exchanger;³ this consideration may be extremely important if the airway is difficult to reestablish.

With regard to the burn injury characteristics, the severity and extent of the burn injury may differ between those sustained during laser bronchoscopy and those occurring during tracheostomy. In fact, the variable findings in severity and extent of the burn injuries in 15 previously reported cases of airway fire (table 1)⁴⁻¹⁷

seem to confirm the hypothesis that a serious thermal or chemical injury from airway fire is not likely when the flame or smoke is vented out through a tracheostomy opening or the oropharynx before reaching the distal airway.

Among the 15 cases, severe and extensive burn injuries to the airways as a result of airway fire were reported in only 3.⁴⁻⁶ The three airway fires occurred during laser bronchoscopy in which no possible route for venting was present. Consequently, no flashes of fire were visible outside the patient airways. All three cases reported smoke coming out of the patients' mouths, indicating combustion of the airway tissue or the ETTs, or both. Finally, all the three burn injuries extended to the distal

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airways, resulting in serious respiratory complications. Therefore, when airway fire occurs during laser surgery in which no proximate vent exists, a blowtorch flame can only shoot into the distal aspect of the tracheobronchial tree and, in theory, create more damage. In addition, a chemical injury could develop in the distal airway when smoke is present.¹ It is not clear, however, if there is a direct relation between lack of a nearby vent and presence of smoke.

Conversely, there were 10 reported cases of airway fire in which potential routes for venting, such as tracheostomy openings or unobstructed oropharynx, were present.⁷⁻¹⁶ These airway fires occurred during tracheostomy (five cases), tonsillar surgery (two cases) and laser airway surgery with a preexisting tracheostomy opening (three cases).

With regard to the five airway fire cases during tracheostomy, four cases reported flashes of fire visible outside the patients' tracheostomy sites, indicating that the flames were vented. No smoke was seen in any of these five cases. Finally, none of the five patients sustained distal airway burns, and the tracheal burns were superficial, localized, and inconsequential.⁷⁻¹¹ When an airway fire occurs during tracheostomy with a ETT *in situ* just proximal to the tracheostomy opening, a blow-torch flame is often seen to be vented out through the tracheostomy opening, and this may prevent an extensive burn injury by the heated gas to the distal aspect of the tracheobronchial tree.⁹ However, a thermal injury will probably occur if the fire is not extinguished completely or if the heat is not dissipated quickly.

The two cases of airway fire during tonsillar surgery^{12,13} and the three cases during laser airway surgery¹⁴⁻¹⁶ reported similar findings: vented flames at the mouths or the tracheostomy openings but no smoke or serious burn injuries. In these cases, open mouths and preexisting tracheostomy openings served as venting routes.

In the remaining 2 of 15 cases, the airway fire occurred during laser bronchoscopy, no smoke was seen, and the patients sustained only minor, localized burn injuries, although neither a tracheostomy opening nor an unobstructed oropharynx were available as venting routes.¹⁶⁻¹⁷ These two patients were being ventilated through uncuffed ETTs, and possibly a sufficient air leak around the ETT minimized the damage.¹⁸

In conclusion, it seems prudent to specify the circumstances in which the ETT should be removed immediately after the occurrence of airway fire. It is necessary to consider the benefits and the risks involved in removing

the ETTs in patients with potentially difficult airways. Because the most common cause of anesthesia-related morbidity and mortality is hypoventilation and hypoxemia from difficult airway management¹⁹ and a severe and extensive burn injury seems unlikely with airway fire during tracheostomy, further critical review of the airway fire management protocol is warranted.

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