Endotracheal Tube Explosion and Its Management

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Abstract: Laser assisted surgeries are very common now and replacing conventional cold steel procedures because their potential of offering bloodless field, short surgical time, small learning curve, user friendly, better machines with precise control and minimal tissue charring. Besides having said this, it has potentially serious complications if precautions are not taken care of, preoperatively and intra-operatively. The complication may vary from temporary reversible to even permanent and life threatening. Discussed in this case report is one such dangerous unlucky incident we encountered during a diode laser assisted subglottic stenosis correction, when the laser resistant endotracheal tube busted in the respiratory tract with some burns of the tracheal mucosa and distal part of the tube flew into the lower respiratory passage. This case report intends to be published to bring into notice this rare but possible fatal complication of this surgery and its management to the budding Laser savvy surgeons.

1. Introduction

The acronym laser stands for "light amplification by stimulated emission of radiation".

Three properties of the light produced by lasers are essential to their function: monochromaticity, coherence, and directionality. Monochromaticity means that the light has only one wavelength. Coherence means that the light waves are in phase and traveling in one direction. Directionality means that the laser beam is very concentrated, as opposed to other forms of light which are diffuse and consequently less intense. Together, these properties influence the controllable parameters of a surgical laser. [1]

Lasers offer surgeons an opportunity for unobstructed vision of the operation field [2] with minimal tissue manipulation and a longer working distance [3]. Decreased risk of postoperative bleeding, increased sterility [2,4], minimal surrounding tissue damage [2], and better intraoperative hemostasis [4] are among the potential benefits of laser surgery. Although fewer complications, side-effects, and better postoperative voice quality [5] have been reported, this is largely technique-dependent.

Despite the notable benefits, laser surgery is not without disadvantages. Laser heat can increase scarring and cause damage to adjacent tissue [4]. With lasers, there is potential for endotracheal explosion, facial burns, mucosal burns, vocal fold webs, stenosis, and glottic incompetence [6].

2. Case report

A 21 year male patient with past history of prolonged intubation following accidental poison ingestion and hospitalization few months back came to our outpatient department. He was managed somewhere in Gujarat in his home town then, came to us with tracheostomy tube in situ. He could not be decannulated there, even after several attempts because of his breathlessness on trial of closure of tracheostoma, developed subglottic stenosis but could not be helped by serial dilatations, for which he travelled to Mumbai to us. Flexible laryngoscopy reconfirmed subglottic stenosis, almost 90% (severe as per Meyer Cottons grading). Condition and prognosis was explained to the patient. After adequate preoperative and preanesthetic checkups, we went ahead with diode laser assisted widening of the stenosis under general anesthesia.
Figure 1. Flexible laryngobronchoscopy suggestive of subglottic stenosis.

A laser resistant fresh red rubber endotracheal tube with foil enveloped all around, was inserted though the tracheostoma and the bulb was inflated with diluted methylene blue dye. Adequate laser safety measures like wet mops peri-orally, laser resistant googles were taken.

Figure 2. Transoral telelaryngoscopic laserization of subglottic stenotic band.

Diode laser was cutting the stenotic band when an explosion was heard with a flash of fire and smog from the tracheostoma. It did not take much from us to realize that the so-called laser resistant endotracheal tube has punctured and oxygen given for ventilation has caught fire.

Figure 3. Endoscopic subglottic view. Diode laser cutting the stenotic band.

Figure 4. Fire in the respiratory passage. Endotracheal tube damaged.

Anesthetist immediately stopped the oxygen supply of ventilation tube and the fire subsided in a while. Fumes were sucked out. Anesthetist informed that he is sensing resistance on ventilation. We pulled the tube out to check for displacement or blockage and fire. But to our surprise, the lower bevelled end of the endotracheal tube was missing, the tube had busted and broken apart with the lower end pushed down, lying obliquely over carina blocking its openings, hence increasing the ventilation pressure.

Figure 5. Distal broken part of endotracheal tube, obstructing respiratory passage and peripheral burns of the respiratory mucosa seen.

The broken distal end of the tube was taken out with the help of 0° telelaryngoscopy. Larynx and
Trachea were inspected for thermal injury and perforation if any. We found three to four superficial mucosal burns but not perforations. Wet mopping of burns was done. Stenosis was widened further using diode laser. Montgomery T-tube was placed and adjusted via a transverse neck incision and sutured back, to avoid the restenosis of the subglottic segment.

Figure 6. Endotracheal tube broken at the tube and bulb junction.

Patient was kept under observation for three days, along with intravenous steroids to reduce edema, antibiotics and tranquilizers. On re-inspection after three days, to our utter surprise, all the burns were almost healed, charring cleared, and respiratory passage looked normal. Patient was sent home with the T-tube in situ and removed after six months. Patient responded well as there was no restenosis till he was under follow up for subsequent two years. T-tube was removed and tracheostoma closed without any issue of dyspnea.

3. Discussion

When performing laser surgery, it is necessary to consider the amount of thermal damage to the target and surrounding tissues. Tissue damage is dependent upon the tissue absorption coefficient, the wavelength of the laser, power density, and the length of time over which the energy is delivered [7]. An additional property which can affect the severity of tissue damage is thermal relaxation time, the time required for tissue to lose 50% of its heat through diffusion [8]. One can decrease tissue damage by allowing heated tissue to cool during a procedure, which can be accomplished through the use of a pulsed laser.

To avoid many heat-related problems caused by lasers, the entire operating team should be educated about potential complications and safety precautions [9]. With microlaryngeal laser surgery, there are opposing needs for both airway access and ventilation. For this reason, good communication, especially between the surgeon and anesthesiologist, and plans with different alternatives available are crucial to ensure safe and effective procedures [2]. CO₂ lasers have more immediate and intense effects than other lasers, so it is especially important to be informed and careful when using this instrument. The most dramatic laser complication, endotracheal tube fire [2,10,11] can be avoided by paying attention to safety and delivery, as well as using laser-resistant endotracheal tubes [2,10]. It has been proven that red rubber tubes present less danger than plastic tubes [12,13]. Wrapping the tubes in saline-coated gauze pads has been presented as an option [2,6,10], but maintaining the moisture of these can be difficult, and if allowed to dry, gauze pads present an even greater fire hazard [13]. Other options to reduce the risk of fire include limiting the oxygen content in the anesthetic gas to 30%, not using a tube, wrapping the tube in reflective metal [6], using a metal tube, and jet ventilating with a needle or metal tube [2,6,10].

In order to prevent thermal damage, surgeons should choose the shortest possible time pulse and highest possible power that will accomplish the procedure [10,14]. Using a higher pulse power for a shorter period of time results in less tissue damage than using a lower power for a longer period of time [14].

4. Conclusion

Protocol of airway fire.

- Stop ventilation.
- Disconnect oxygen source.
- Remove the burned endotracheal tube & examine the airway.
- Mask ventilate the patient & re-intubate.
- Survey the extent of injury with flexible bronchoscope.
- Monitor the patient for 24 hours.
- Administer steroid to reduce inflammation & edema.
- Provide antibiotics & ventilator support if indicated.

Airway fire precaution & management.

To reduce airway fire certain precautions should be observed:

- Consider a tubeless technique like spontaneous ventilation, apneic technique, or jet ventilation.
- Use an appropriate laser endotracheal tube.
• Reduce inspired oxygen as tolerated by the patient to < 30% ideally 21%.
• Use either air or helium to dilute oxygen (N₂O aids combustion).
• Fill endotracheal tube cuff with saline-dye mixture
• Completely soaked gauze should be placed within & around the airway to reduce ignition risk.
• Limit the duration & intensity of exposure, continuous mode allow heat buildup.
• Maintain a ready source of water in case of fire (multiple 60 ml filled syringes).

These steps will not eliminate the risk of airway fire but reduce it.

5. References


