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ORIGINAL ARTICLE

Transoral Laser Microlaryngeal Surgery with MLT Tubes: A Retrospective Case Series

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Abstract
To evaluate effectiveness of using MLT tubes for transoral laser MLS in terms of surgical visualization, complete excision of vocal cord lesions, maintenance of adequate oxygenation and ventilation and the occurrence of any airway related complications. In a retrospective case series study, review of electronic medical records was conducted for 64 patients who underwent transoral laser MLS over an 18-month period. The collected data included vital parameters, mode of ventilation, ET tube details, surgical field of vision, perioperative adverse events and postoperative ventilation requirements. Among the 64 patients, 82.8% of the time, 5 size MLT tubes were used, fixed at mean lengths of 21.6cm in females and 23.07cm in males respectively. A good surgical field of exposure was achieved in 92.2% of patients, with an average FiO2 of 0.29 during laser use and pressure control ventilation mode being the majority choice. 98.4% were extubated on table. The incidence of cuff rupture and bronchospasm was 4.7% and 1.6% respectively with no instances attributable to laser related events. Even though Laser resistant tubes are considered gold standard, MLT tubes can be used by taking adequate precautions to reduce Laser related complications when there is limited availability of laser tubes. *Level of evidence* Case series.

Keywords Micro-laryngeal tubes · Transoral laser micro laryngeal surgery · Airway management

Introduction

Lasers have become increasingly prevalent in airway surgeries, offering surgeons a range of benefits that include precise microscopic control, a surgical environment free of blood, minimized tissue trauma, preservation of healthy tissues, and the maintenance of sterility 1. The focused and coherent light emitted by lasers enables the transmission of intense energy to specific locations 2. In upper airway surgeries, the CO_2 laser or neodymium-doped yttrium aluminium garnet (Nd:YAG) laser is frequently employed. The CO_2 laser, with a wavelength of 10.6 µm, is well-absorbed within a short distance of tissue, making it suitable for precise removal of laryngeal lesions. The Nd:YAG laser, on the other hand, is used for tracheobronchial lesions through a fibreoptic bronchoscope 1.

Laryngo-tracheal surgery poses significant challenges for anaesthesiologists, given the potential for airway compromise during the perioperative period and shared airway during the surgery 3, 4. The use of lasers in these surgeries introduces the additional risk of airway fires, primarily due to the flammability of endotracheal tubes (ETT) and the presence of oxygen 2.

Anaesthesia management during laser surgeries of the airway requires careful planning and communication among multidisciplinary teams. The choice of ventilation mode and airway management technique depends on factors such as patient characteristics, surgery duration, and the type of laryngeal disease. Four methods have been developed to secure the airway during laryngeal surgery: mechanical ventilation, spontaneous ventilation, subglottic jet ventilation, and intermittent apnoeic anaesthesia. Each method has its complications, emphasizing the importance of interdisciplinary planning and communication to make necessary adaptations during surgery 4.

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An endotracheal tube (ETT) provides the most definitive way of securing airway and protection from aspiration 2. Several endotracheal tubes (ETT) have been developed with "laser-resistant" features, intended to protect the surgical field from potential hazards associated with medical lasers. The American Society of Anaesthesiologists now recommends these tubes as the gold standard choice during laser surgery of the respiratory tract 2. However, they are known to cause hindrance to the surgical resection due to larger outer diameters, especially for laryngeal laser surgeries. To overcome this, smaller diameter and longer length tubes such as micro laryngeal tubes have been used (Table 1).

In this retrospective case series, we aimed to assess the efficacy of MLT tubes in Transoral micro laryngeal laser surgeries in terms of maintenance of adequate oxygenation and ventilation by using smallest MLT tube possible, surgical team's exposure to the surgical field and if there were any airway related complications.

Methodology

Following ethical committee approval, we conducted a retrospective analysis of medical records involving 64 cases that underwent elective transoral CO2 laser-assisted micro laryngeal surgery at Cytecare Cancer hospitals, covering the period spanned from January 2022 to June 2023. Inclusion criteria comprised patients aged between 18 and 80 years belonging to ASA classes 1 to 3, specifically those undergoing transoral laser surgery on the vocal cords. Excluded from the study were patients with ASA grades 4 and above, those needing awake intubation, individuals with preoperative tracheostomy or performed before induction, and cases involving airway surgeries other than vocal cord.

Data on previous treatments were collected. Clinical preoperative examination was performed and recorded by high-definition video laryngoscopy. When there was a clinical concern or potential for deep infiltration, including significant involvement of the anterior and/or posterior commissures, impaired vocal cord motility, or subglottic spread, a radiological examination was conducted using either computed tomography or magnetic resonance imaging. Medical comorbidities were evaluated and quantified using the American Society of Anaesthesiology (ASA).

MLT Tubes were used in our hospital setup, and standard endotracheal intubation techniques were applied during positioning. Wide bore IV cannula was secured, and monitoring was performed according to standard ASA guidelines. After preoxygenation with 100% fio2 for 3 min and and following the standard general anaesthesia (GA) induction protocol, which involved administering intravenous (IV) Midazolam (0.03 mg/kg), IV Fentanyl (2mcg/kg), IV Propofol (2–3 mg/

Table 1 Patient Demographics and Parameters Monitored

	Minimum	Maximum	Mean	Std. deviation	Q1	Median	Q3
Age	23.00	84.00	57.64	12.94	49.25	58.00	66.00
Height (CMS)	148.00	183.00	165.98	7.76	161.25	168.00	170.00
Weight (KGS)	35.00	97.00	73.09	12.84	64.00	74.10	83.00
BMI	15.75	36.20	26.78	4.26	24.29	26.85	30.03
MLS tube size	5.00	6.00	5.17	0.38	5.00	5.00	5.00
Tube length	17.00	26.00	22.88	1.40	22.00	23.00	24.00
Tidal volume	300.00	480.00	398.16	45.59	350.00	400.00	440.00
Peak Airway Pressure	13.00	32.00	20.55	3.52	18.00	20.00	23.00
ETCO2	27.00	41.00	34.91	3.65	32.00	35.00	38.00
SPO2 during laser	94.00	100.00	98.95	1.66	98.25	100.00	100.00
FIO2 during laser	0.20	0.40	0.29	0.04	0.28	0.30	0.30
Duration of surgery	25.00	300.00	100.47	46.31	70.00	90.00	123.75

Gender		MLS tube size	Tube length
Female	Mean	5.00	21.67
	Median	5.00	22.00
	Std. deviation	0.00	2.18
Male	Mean	5.20	23.07
	Median	5.00	23.00
	Std. deviation	0.40	1.14
	p value	0.144	0.035
	Significance	Not significant	Significant

kg), and IV Atracurium (0.5 mg/kg) for muscle relaxation, standard MLT tube of size 5 or 6 was placed under direct laryngoscopy.

The smallest acceptable MLT tube was typically chosen to maximize the exposure of the surgical field while ensuring adequate oxygenation and ventilation. The tracheal cuff of the MLT tube was filled with methylene blue in saline, reducing the risk of ignition and serving as an indicator of cuff rupture (Fig. 1). The tube was carefully positioned to avoid damage to the lesion and carefully placed at a depth that wouldn't interfere with surgical field (Fig. 2). Tube placement was confirmed through auscultation before the surgeon introduced the suspension laryngoscope. The cuff's position was reassessed and adjusted if necessary again on suspension laryngoscope, avoiding endobronchial intubation and MLS tube cuff not in vicinity of surgical field. A wet neuropatty was placed by surgeon between the vocal cord and MLS tube cuff to prevent cuff rupture during laser use (Fig. 3)

We minimized the delivered oxygen concentration to the smallest required concentration to maintain acceptable saturation before the activation of the laser. ETCO2 was maintained between 35 and 45 mmHg (Fig. 4). After the laser procedure, Fio2 was increased. Airway cart, containing an extra MLS tube of the same size (in case of cuff rupture), smaller size tubes, LMA, and measures to handle airway related fires were kept ready during the surgery. Maintenance of anaesthesia was carried out with Oxygen (minimal Fio_2) + Air + Isoflurane at an MAC of 1.2, and positive pressure ventilation was employed. Patients received Inj. Paracetamol 15 mg/kg iv. Inj. Dexamethasone 0.1 mg/kg iv was given to all patients as an anti—oedema measure. Following airway surgery, there is a risk of laryngeal spasm, aspiration, or airway obstruction due to oedema. To avoid this, post procedure, 4% Lignocaine spray was applied to the vocal cords before extubation. Reversal of muscle relaxation was achieved with Inj. Myopyrrolate. The patients were extubated awake in a propped-up position. All the patients were shifted to PACU or ICU for observation, with continuous monitoring of vital parameters.

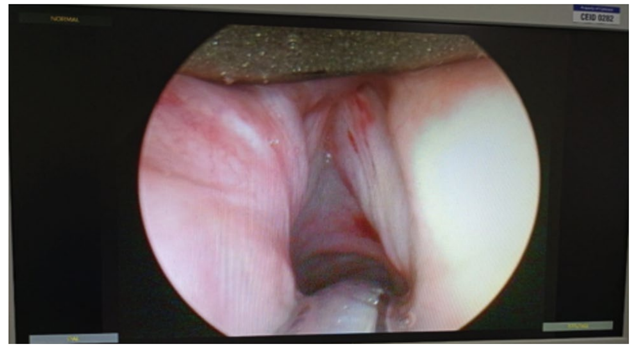

Fig. 2 MLT Cuff placed well below the Vocal cords

Fig. 1 Methylene Blue in saline cuff inflation of MLT to prevent laser fire and it is an indicator for cuff rupture

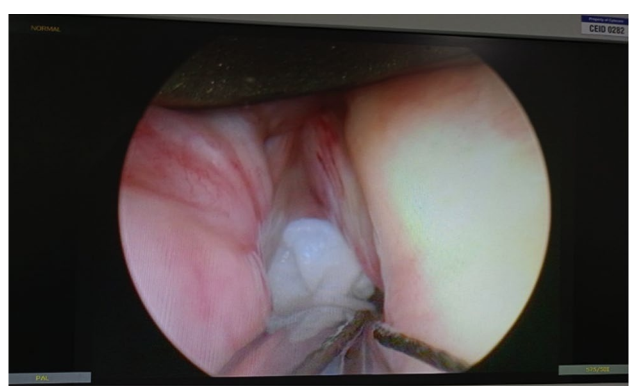

Fig. 3 Placement of a wet neuropatty above the MLT cuff before starting laser excision of lesion

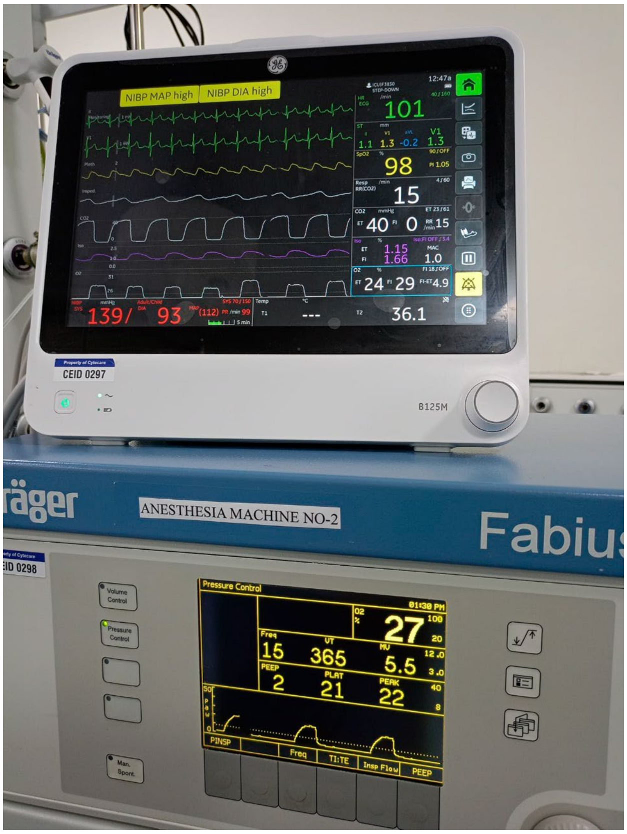

Fig. 4 Intraoperative Monitoring. **A** Fio2 reduced to lowest possible to maintain acceptable saturation **B** Peep not used. **C** Pressure Control Mode–is prefered. **D** Acceptable ETCO2

Results

Statistical Analysis

Categorical variables were expressed as Number of patients and percentage of patients. Continuous variables were expressed as Mean, Median and Standard Deviation and compared across the groups using Mann–Whitney U test/ Kruskal Wallis Test as appropriate. Association between continuous variables were captured by Spearman's Rank Correlation Coefficient. The statistical software SPSS version 22 was used for the analysis. An alpha level of 5% was taken, that is *p* value < 0.05 was considered significant.

A total of 64 patients were included in our study, 58% of the patients were aged between 51 and 70 years with 86% being male and 54% identifying as smokers. Hoarseness of voice was the predominant chief complaint in 89% of cases, and 54.8% of patients presented with early glottic cancer. The majority, approximately 45%, had BMI between 25 and 29.9. 47% patients had undergone previous vocal surgey and 12% patients had taken radiotherapy before surgery. ASA class distribution revealed 60% as ASA class 2 and 37.5% as ASA class 3. According to Mallampatti classification, a difficult airway was anticipated in 39% of cases.

In 83% of cases, a 5-size MLT tube was utilized, with a 165 significant difference noted in tube fixation lengths between166 females (22 cm) and males (23 cm) (p value = 0.035) (Table 2). Lowest possible Fio2 was kept to accept saturation above 94%. Mean peak airway pressures was 20.55 and mean EtCo2- 34.91. Mean Fio2 during laser was 0.29% (Fig. 5). Controlled mechanical ventilation was employed in 96% cases with with 59.4% utilizing PCV and 39% VCV (Table 3). Intermittent apnea technique was only

Table 2 MLT tube Size and length fixation

MLS tube size	Frequency	Percent
5	53	82.8
6	11	17.2
Total	64	100.0
Tube length	**Frequency**	**Percent**
17	1	1.6
20	3	4.7
21	3	4.7
22	14	21.9
23	19	29.7
24	22	34.4
25	1	1.6
26	1	1.6
Total	64	100.0

Table 3 Mode of Ventiltaion

Mode of ventilation	Frequency	Percent
PCV	38	59.4
PCV/ Intermittent technique	1	1.6
VCV	25	39.1
Total	64	100.0

Table 4 Field of Vision

Field of vision	Frequency	Percent
Satisfactory vision	5	7.8
Good vision	59	92.2
Total	64	100.0

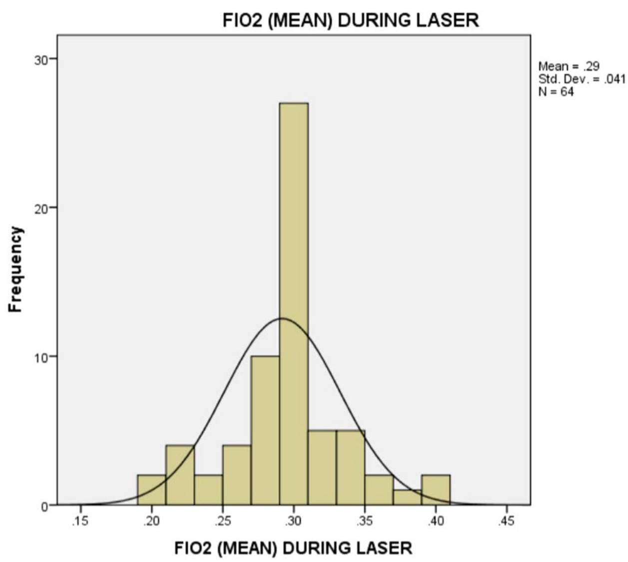

Fig. 5 Bar Chart showing Mean Fio2 during Laser

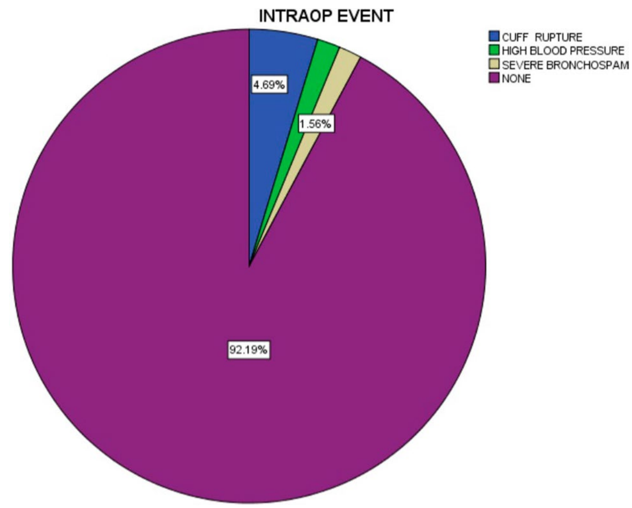

Fig. 6 Pie chart showing Inraop Events

Table 5 Patients requiring Postoperative Ventilation

Post op ventilation	Frequency	Percent
No	63	98.4
Yes	1	1.6
Total	64	100.0

used in two cases with posteriorly located lesions. A satisfactory field of vision was achieved in 92% of cases (Table 4).

Overall, cuff rupture occurred in three cases intraoperatively during laser use, and one patient experienced bronchospasm (Fig. 6). No other significant intraoperative events were recorded. Mean operative time was 100 min. All patients, except for one who underwent extensive surgery, were successfully extubated and transferred to the PACU/ ICU postoperatively (Table 5).

Discussion

The laser was incorporated into the medical community, with an emphasis placed on its potential capability to remove cancerous lesions due to its continuous wave, high output power, and means of focusing its beam on a small area. The ability to focus the laser beam on a small area allows for minimal tissue manipulation, providing surgeons with unobstructed visibility of the operation field. Since 1972, CO_2 lasers have been the primary choice for treating various pathologies, including vocal cord keratosis, nodules, polyps, papillomas, carcinoma in situ, and T1 cancer. Its wavelength at 10,600 nm is well-absorbed by water, making it effective for interacting with biological tissues 5.

The CO_2 laser is well-recognized for its coagulative and hemostatic properties, making it effective in treating flat lesions such as leukoplakia, papillomas, or verrucous carcinoma. Its unique capability to blend cutting with controlled coagulation, dependent on the focus, positions it as a preferred tool for managing early glottic cancer while minimizing damage to surrounding tissues 5. Early glottic cancer (Tis, T1a, T1b, T2) is notably one of the most curable malignancies in the head and neck, attributed not only to the early symptom of hoarseness facilitating prompt diagnosis but also to the distinct lymphatic drainage pattern of the glottis, resulting in fewer than 1% of patients developing cervical metastasis 6.

In our case series, a majority of patients were diagnosed with early glottic cancers, known for their high curability, and any delay in surgery can adversely affect outcomes. To address the challenge of obtaining Laser-resistant tubes and to avoid surgical delays, MLT tubes were utilized in our hospital setup. This adaptive approach ensures timely intervention and contributes to optimizing the therapeutic outcomes for patients with early glottic cancer.

Continuous lasers were preferred for flat lesions due to their coagulative and haemostatic properties, while pulsed lasers were more effective in avoiding heat build-up and minimizing damage to surrounding tissues, making them useful for incisions 5. Despite the numerous benefits of using lasers in airway surgery and reduced incidence of airway fires with the usage of less flammable anaesthetic agents, the potential for airway fire still exists which can be a constant threat to patient safety 7.

Operating room fires pose a potential risk in various surgical procedures, with the three essential components being oxidizer (such as oxygen or nitrous oxide), ignition source (like lasers) and fuel which is present in virtually all cases. The majority of these fires occur in surgeries involving head, neck, or upper chest during monitored anesthesia care where high flow of oxygen is used. Managing the oxidizing component, particularly oxygen levels, becomes crucial to reduce fire risks. While complete elimination of the risk is challenging due to the necessity of these components for successful surgery, careful separation of the elements in the fire triangle can minimize the risk 8.

Upon ignition, oxygen reacts with a fuel source to generate heat, gas, and light. At sea level, the atmosphere consists of 21% oxygen, making it the predominant "oxidizer." Nitrous oxide serves as another significant oxidizer in operating and procedure rooms 8. A review of operating room fires revealed that 85% of incidents occurred during surgeries involving the head, neck, or upper chest. Furthermore, 81% of these cases occurred during procedures conducted under monitored anesthesia care. These fires are typically attributed to increases in oxygen content at the surgical site due to open source of oxygen at the surgical site 9.

In "closed" settings, a recent assessment of otolaryngology procedures revealed that in 97% of surgical fires during general anesthesia cases, the delivered inspired oxygen exceeded 30%. Even so-called "laser-resistant" endotracheal tubes (ETTs) were not recommended for use with oxygen content greater than 30% due to the risk of fire if damaged or leaking 8. In our case series, the mean fraction of inspired oxygen during laser use was 0.29%. and mean oxygen saturation throughout the procedure was 98%.

Different modes of ventilation- Spontaneous ventilation with topical anaesthesia, intermittent apnoea technique, General anaesthesia with PPV and tubeless techniques. In our hospital setup we used General anaesthesia with PPV using an MLT as it's the most definite way of securing an airway as it prevents the leakage of anaesthetic gas or oxygen 2, 4. Opting for a closed circuit or a secure airway is the preferred method for delivering supplemental oxygen, as opposed to using an open circuit. Leakage from around uncuffed endotracheal tubes have been shown to contribute towards electrocautery-induced fires 10, therefore cuffed endotracheal tubes, optimally placed and with a good seal, are preferable (and also, we did not want to delay surgery in patients with early glottic cancers which can be curable with early surgery due to scarcity of Laser resistant tubes during the covid and post covid times.

ETT acts a fuel in the laser related airway fire triad. Endotracheal tubes (ETTs) do not guarantee protection against fires. Surgeons must remain vigilant to avoid direct contact with the laser, irrespective of the ETT type 8. In a recent review, the ETT itself served as the fuel source in 49% of operating room fires during airway surgery 11. In high-risk scenarios, especially in laser surgery of the larynx, it is recommended to use metal-reinforced "laser-safe" tubes. It's important to highlight that these tubes are not fail-safe, as fires can still be easily started if the cuff is damaged or if the laser is directed at the tip of the tube 12.

Microlaryngeal tube can also be used when endotracheal intubation is planned for the vocal cord laser surgeries 13. These MLT tubes are long, narrow, cuffed tracheal tube about 30 cm long and 4–6 mm internal diameter, and gives a reasonable surgical view of the larynx leaving atleast anterior 2/3rd of the glottis unobscured 13. This allows conventional, positive pressure ventilation to be used 14· In comparison to the laser resistant tubes, MLT tubes have a smaller outer diameter. Surgeon had better access to the lesion and improved visibility during surgery, enabling more precise and meticulous surgical interventions. Initially, we utilized 6 size micro laryngeal tubes (MLT) for our surgical procedures. However, to improve the visualization of the surgical field, we transitioned to using 5 size MLT tubes. In 82.8% patients, 5 size MLT tube was used and adequate ventilation was achieved and good field of vision was noted in 92.2% cases. Even in few patients with BMI > 30, we were able to ventilate the patient with 6 size MLT tube, but co relation between the tube size and BMI was found statistically not significant.

As described by Pt Wilson in his article about ignition of tracheal tubes during tracheostomy- efforts were made to avoid cuff rupture by the scattered laser beams by placing the cuff of the MLT tube more distally in the trachea than usual whilst still maintaining a safe distance from the carina 15.

Disadvantage of using these MLT is that these are smaller diameter tubes and ventilation using these tubes might require high inflation pressures. In our study the mean peak airway pressure intraop was 20.55 cmH20. There is always a risk of fire with MLT tubes in comparison to the laser resistant tubes. And these tubes obscure the posterior surgical field, making it difficult to access the lesion placed posteriorly 13. In our case series, only one patient had posteriorly placed lesion for which we employed intermittent apnea technique using the MLT tube.

Cuff is the most vulnerable part of the ETT 2. As recommended by the current American Society of Anaesthesiologists guidelines, we instilled methylene blue in the cuff to indicate cuff rupture during laser use even though However, the addition of fluid to the cuff system may prolong the process of cuff deflation 16. This could also help to reduce the airway fire in case it occurs 17.

Further protection of the ETT cuffs can be obtained by placing moistened pledgets above them and keeping the pledgets moist throughout the procedure 18. In our case, we asked the surgeon to place a wet neuropatty just above the cuff after the rigid bronchoscope was introduced. Cuff rupture was noted in 3 of our cases. there were no fire related injuries.

With the usage of apnoea techniques for laser airway surgy- we have started employing THRIVE for shorter duration of Laser airway surgeries. Even though laser resistant tubes are considered to be the gold standard if mechanical ventilation is planned- MLT tubes can be used by taking adequate precautions. Therefore, it is essential to customize our plan accordingly to ensure that safety is not compromised at that particular point in the procedure.

Conclusion

Effective communication and collaboration between the surgical and anesthesia teams are important for successful laser surgery. A thorough understanding of the procedure and seamless coordination are crucial components of this process. Although laser-resistant tubes are widely regarded as the gold standard for endotracheal intubation in such surgeries, our positive experiences with 5-sized MLT tubes in a majority of patients has been successful in providing adequate oxygenation and ventilation with minimal intraoperative events when there was shortage of Laser resistant tubes.

Implementing precautionary measures likes placing the tube cuff deeper, utilizing methylene blue for cuff inflation, reducing FiO_2 levels during laser use, strategically placing a wet neuropatty above the cuff, employing short pulses for laser application, ensuring optimal surgical exposure and maintaining adequate muscle relaxation during laser, further enhances the safety profile of laser surgeries. These precautions contribute significantly to improved surgical outcomes.

By adopting this comprehensive approach, we ensure a safer and more successful laser surgery experience, benefiting both the medical teams and the patients involved.

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Declarations

Conflict of interest None.

Informed consent Retrospective Case Series.

References

1. Hemantkumar I (2017) Anesthesia for laser surgery of the airway. Int J Otorhinolaryngol Clin 9(1):1–5. https://doi.org/10.5005/jp-journals-10003-1250
2. Doroshenko M, Guerra A, Vu L (2021) Airway for laser surgery
3. Pearson K, McGuire B (2017) Anaesthesia for laryngo-tracheal surgery, including tubeless field techniques. BJA Edu 17(7):242–248. https://doi.org/10.1093/bjaed/mkx004
4. Yan Y, Olszewski AE, Hoffman MR et al (2010) Use of lasers in laryngeal surgery. J Voice. https://doi.org/10.1016/j.jvoice.2008.09.006
5. Ansarin M, Cattaneo A, Santoro L et al (2010) Laser surgery of early glottic cancer in elderly. Acta Otorhinolaryngol Ital 30(4):169
6. Akhtar N, Ansar F, Baig M, Abbas A (2016) Airway fires during surgery: management and prevention. J Anaesthesiol Clin Pharmacol. https://doi.org/10.4103/0970-9185.175710
7. Jones TS, Black IH, Robinson TN, Jones EL (2019) Operating room fires. Anesthesiology. https://doi.org/10.1097/ALN.0000000000002598
8. Mehta SP, Bhananker SM, Posner KL, Domino KB (2013) Operating room fires: a closed claims analysis. Anesthesiology. https://doi.org/10.1097/ALN.0b013e31828afa7b
9. Kaddoum RN, Chidiac EJ, Zestos MM, Ahmed Z (2006) Electrocautery-induced fire during adenotonsillectomy: report of two cases. J Clin Anesth. https://doi.org/10.1016/j.jclinane.2005.09.032
10 Greco RJ, Gonzalez R, Johnson P, Scolieri M, Rekhopf PG, Heckler F (1995) Potential dangers of oxygen supplementation during facial surgery. Plastic Reconstr Surg. https://doi.org/10.1097/00006534-199505000-00004
11 Roy S, Smith LP (2015) Surgical fires in laser laryngeal surgery: Are we safe enough? Otolaryngol Head Neck Surg (United States). https://doi.org/10.1177/0194599814555853
12 Nirgude AS, Hemantkumar I (2017) Anesthesia considerations in microlaryngoscopy or direct laryngoscopy. Otorhinolaryngol Clin. https://doi.org/10.5005/jp-journals-10003-1252
13 English J, Norris A, Bedforth N (2006) Anaesthesia for airway surgery. Contin Edu Anaesth Crit Care Pain. https://doi.org/10.1093/bjaceaccp/mki060
14 Wilson PTJ, Igbaseimokumo U, Martin J (1994) Ignition of the tracheal tube during tracheostomy. Anaesthesia. https://doi.org/10.1111/j.1365-2044.1994.tb04419.x
15. Upper Airway Management Guide Provided for Laser Airway Surgery- Annette G. Pashayan
16 Apfelbaum JL, Caplan RA, Connis RT et al (2013) Practice advisory for the prevention and management of operating room fires: an updated report by the American Society of Anesthesiologists Task Force on Operating room fires. Anesthesiology. https://doi.org/10.1097/ALN.0b013e31827773d2
17 Hagberg CA (2013) Benumof and Hagberg's Airway Management. Elsevier, Amsterdam. https://doi.org/10.1016/C2009-0-40751-7
18. Sosis MB (1995) Saline soaked pledgets prevent carbon dioxide laser-induced endotracheal tube cuff ignition. J Clin Anesth. https://doi.org/10.1016/0952-8180(95)00070-X