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Original Research

Can Laryngeal Mask Airway be the First Choice for Tracheal Stenosis Surgery? A Historical Cohort Study

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Abstract

Objectives: To compare the usage of laryngeal mask airway (LMA) and orotracheal intubation (OTI), which are separate airway management methods in tracheal reconstruction surgeries, in terms of perioperative management, mortality, and morbidity.

Methods: Adult patients who underwent tracheal reconstruction surgery between June 2020 and June 2022 were included in the study, retrospectively. Patients with lost data or primary tracheal malignancy were excluded. Patients who underwent tracheal reconstruction were divided into two groups: LMA and OTI.

Results: Of a total of 57 included patients, the OTI and LMA groups had 30 (52.63%) and 27 patients (47.37%), respectively. The rate of intubated transfer to the intensive care unit and the length of stay in the intensive care unit were significantly higher in the OTI group (p=0. 014, p=0. 031) than those of the LMA group; further, in tracheal cultures, reproduction was also significantly higher in the OTI group (23.33%) (p=0. 007). The postoperative mortality rates were similar in both groups.

Conclusion: Since the absence of tension in end-to-end anastomosis of the trachea is vital for successful surgery, the LMA application (which has no tracheal contact) can be considered superior to OTI. In this study, LMA was successfully applied in all patients. Considering that the aim of anesthesia management should be to provide adequate oxygenation and normocarbia with minimally invasive intervention, we suggest airway management using LMA as the first option for tracheal reconstruction surgery because of the advantages described in this study.

Keywords: Airway management, laryngeal mask airways, orotracheal intubation, postintubation stenosis, tracheal resection

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Airway management during tracheal surgeries is challenging due to the impaired airway anatomy and the need to share the trachea with the surgical team.[1] To maintain oxygenation during tracheal surgery, anesthesiologists may utilize various techniques, including tracheal intubation, application of laryngeal mask airway (LMA), jet ventilation, and extracorporeal membranous oxygenation (ECMO).

For tracheal reconstruction surgeries, ventilation is divided specifically into three stages: pre-tracheal resection, anastomosis, and post-anastomosis.[2] When conventional orotracheal intubation (OTI) is applied, maneuvers such as withdrawal of the tube at the resection stage, advancing

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the tube after anastomosis, and replacing the tube towards the distal end of the anastomosis line are performed. During these maneuvers, the surgical field may become contaminated by the endotracheal tube (ETT). Moreover, the tracheal lesion may get damaged while the ETT is being inserted, especially in cases of subglottic stenosis.[3] When orotracheal intubation is performed, laryngeal mask is often considered as an alternative method in case of unsuccessful intubation. Several case series have reported the safe use of a laryngeal mask (LMA) in tracheal surgeries.[4-9]

In our clinic, OTI and LMA are routinely used for airway management in tracheal surgery. We aimed to use a laryngeal mask to prevent complications associated with repetitive manipulation of the ETT, improve surgical comfort, facilitate faster recovery and achieve greater patient satisfaction.[5,10-12]

This study aimed to compare LMA and OTI techniques for the perioperative management of patients undergoing tracheal reconstruction surgeries.

Patients and Methods

Study Design and Patient Selection

This study was approved by the Clinical Research Ethics Committee with the number of 22.02.60. Written informed consent was waived due to the retrospective study design. The study was conducted according to the Helsinki Declaration. Adult patients who underwent tracheal reconstruction surgery between June 2020 and June 2022 were included in the study. Patients with missing data or primary tracheal malignancy were excluded from the study (Fig. 1).

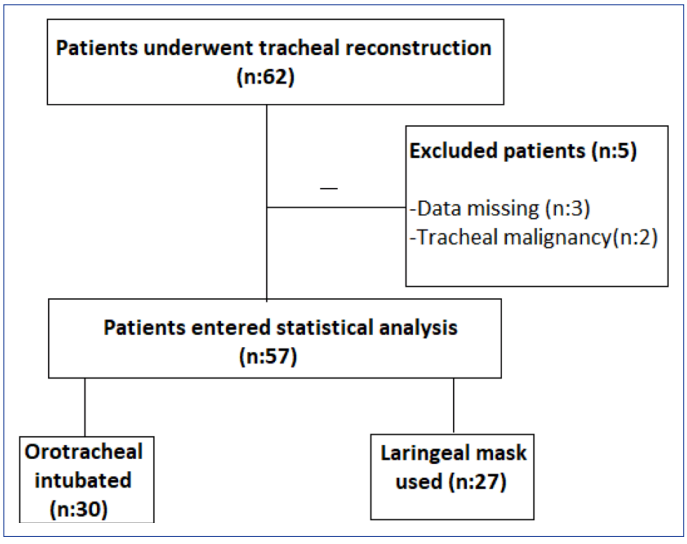

Figure 1. Flow diagram.

Anesthesia Management

Standard anesthesia monitoring (electrocardiography, noninvasive blood pressure monitoring, capnography, and SpO_2 monitoring) and bispectral index (BIS) monitoring (Bispectral Index™ (BIS) Aspect Medical Systems, USA) were used for all patients. Two peripheral intravenous cannulas were inserted for intravenous crystalloid fluid hydration.

After the intravenous administration of midazolam (2mg) as a premedication, general anesthesia was induced using 2 mcg/kg of fentanyl and 1.5-3 mg/kg of propofol, and the target BIS value was set between 40 and 60. A neuromuscular block was provided with 0.6 mg/kg of rocuronium. Anesthesia was maintained with sevoflurane (1%-2%) and remifentanil (0.05-0.2 mcg/kg/min), and oxygen/air mixture (50%/50%). A nasogastric tube was placed to ease esophageal palpation. Following anesthesia induction, radial artery cannulation (20 G) was performed to facilitate invasive blood pressure monitoring and repetitive blood sampling.

In patients undergoing OTI (the OTI group), the ETT cuff was deflated and pulled up to the vocal cord before the tracheal incision. Following the tracheal incision, a sterile ETT was placed distal to the trachea, and the patient was ventilated through a sterile circuit. During the complete closure of the anastomosis line, the ETT was pulled anterogradely with the help of a left guide rope and placed distal to the anastomosis line by the surgical team. The tube was assumed to be contaminated if the tracheal cuff was visualized above the rima glottis. In that case, the tube was removed and a new one was directed retrogradely from the trachea to the oropharynx by the surgical team. Once the tube became visible on direct laryngoscopy, it was pulled using Magil forceps or the two-finger method. Subsequently, the ventilation was continued. At the end of the surgery, the patients were extubated unless the surgical team requested otherwise, such as for maintaining tracheal immobility.

In patients using a laryngeal mask (the LMA group) (AuraGain™ Ambu® Ballerup, Denmark), intraoperative flexible bronchoscopy (Electronic Video Bronchoscope, FUJIFILM®, Tokyo) for visualizing the level of the tracheal stenosis was possible. This approach allowed the surgical team to identify the incision level of the trachea more accurately. This was not possible in the OTI group as the end of the ETT was located beyond the tracheal stenosis level. Following the tracheal incision, a sterile tube was placed distal to the trachea, and the patient was ventilated through a sterile circuit while the LMA was left in place. The sterile tube was removed just before the completion of the anastomosis, and ventilation was continued using the LMA.

Postoperative Follow-Up

At the end of the surgery, all patients were awakened with special neck support and the chest chain was sutured to the surgical area (Grillo method).[13] At the end of the anesthesia, a gentle emergence process was achieved by antagonizing the neuromuscular blockade with 2 mg/kg of sugammadex under low-dose remifentanil (0.05 mcg/kg/min) infusion to avoid mask ventilation, jaw thrust maneuvers, straining, coughing, and re-intubation due to spasms. Intravenous tramadol (1 mg/kg), tenoxicam (20 mg), and paracetamol (1 g) were administered for analgesia prior to emergence. Possible nerve damage of the vocal cords was evaluated via hoarseness, stridor, and dyspnea. All patients were transferred to the intensive care unit (ICU). Patients who did not have any problems during the ICU follow-up were subsequently transferred to the ward.

Data collection

Patient data were accessed from the hospital system and archived patient files. The following variables were recorded: demographic data (age, gender, and BMI), ASA score, the cause and level of tracheal stenosis, comorbidities, surgery duration, anesthesia duration, arterial blood gas data (pH, pO_2, pCO_2, lactate, and base excess [BE], hemoglobin), the length of postoperative hospital stay and ICU stay, airway status in ICU (intubated /extubated), tracheal culture results, hospital mortality, and tracheostomy at discharge, were recorded.

Statistical Analysis

Categorical variables are presented as numbers and percentages and were compared using the Chi-square test. The distribution of continuous variables was evaluated using the Shapiro–Wilk test. Normally distributed variables are presented as means and standard deviations and were compared using the Student's t-test. Continuous variables that were not normally distributed are presented as medians and 25^{th}-75^{th} percentiles and were compared using the Mann–Whitney U test. The paired Student's t-test and the Wilcoxon test were used for comparing the blood gas analysis results within the groups in line with the variables' distribution. For all statistical analyses, statistical significance was set at $p<0.05$. Statistical analyses were performed using SPSS for Windows, version 21.0 (SPSS Inc., Chicago, IL, USA).

Results

The data of 57 patients who underwent elective tracheal reconstruction were statistically analyzed (Fig. 1). The patients were divided into two groups: 1) the OTI group (n=30, 52.63%) and 2) the LMA group (n=27, 47.37%). The demographic data (sex, age, and BMI) and patient comorbidities are shown in Table 1.

The Etiology and Characteristics of Stenosis

Of the 57 patients had a history of intubation in the intensive care unit. The indications for the intensive care unit admissions are shown in Table 1. The tracheal stenosis location, stenosis line length, and the transverse diameter at the narrowest level of the trachea were compared between the groups (Table 2).

Airway Management and Blood Gas Analyses

In our study, cuff perforation was observed in two patients who were managed by OTI after the closure of the anastomosis. In another three patients, the ETT was removed due to contamination, and a new ETT was directed retrogradely from the trachea to the oropharynx. The preoperative and postoperative arterial blood gas parameters of the patients in both groups are compared in Table 3. And no clinically significant difference was found between the ABG results.

Table 1. Patient characteristics

Variables	OTI (n=30)	LMA (n=27)	p
Age (years)	52.63±16.98	48.11±12.98	0.27
Sex			
Male	19 (63.33%)	18 (66.67%)	0.79
Female	11 (36.67 %)	9 (33.33%)	
BMI (kg/m^2)	27.54±4.20	27.12±4.08	0.70
ASA Score			
2	8 (26.67%)	8 (29.63%)	0.87
3	20 (66.67%)	18 (66.67%)	
4	2 (6.67%)	1 (3.7%)	
Systemic Disease			
Yes	13 (43.33%)	10 (38.46%)	0.71
No	17 (56.67%)	16 (61.54%)	
Etiology			
Covid-19	14 (46.67%)	18 (66.67%)	0.13
Other	16 (53.33%)	9 (33.33%)	

Values are expressed as mean±SD or frequency (percentage). The Chi-square and The Student's t test were used for the comparison of categorical and continuous variables, respectively. ASA: American Society of Anesthesiologists. BMI: Body mass index.

Table 2. Stenosis characteristics

Variables (mm)	OTI (n=30)	LMA (n=27)	p
Length	14.9±5.26	18.26±9.61	0.10
Distance to vocal chords	28.6±10.39	30.67±11.33	0.48
Narrowest transvers diameter	7.41±2.43	6.98±2.39	0.51

Values are expressed as mean±SD. The Student's t test was used for the comparison of variables.

Table 3. Arterial blood gas analyses

Variables	OTE (n=30)	LMA (n=27)	p intergroup
pH			
Preoperative	7.39±0.04	7.40±0.04	0.11
Postoperative	7.38±0.07	7.38±0.05	0.76
p	0.20	0.09	
pO_2			
Preoperative (mmHg)	94.66±18.21	101.11±18.75	0.19
Postoperative (mmHg)	111.64±40.92	103.14±29.92	0.38
p	0.038	0.74	
pO_2			
Preoperative (mmHg)	44.03±4.02	43.78±4.68	0.830
Postoperative (mmHg)	43.9±6.74	44.36±6.23	0.79
p	0.89	0.65	
Lactat			
Preoperative (mmol/L)	1.6 (0.95-2.2)	1.2 (0.9-1.6)	0.19
Postoperative (mmol/L)	1.2 (0.78-2.3)	1.1 (0.7-1.8)	0.69
p	0.56	0.95	
Hemoglobin			
Preoperative (g/dL)	12.08±2.11	12.33±1.87	0.64
Postoperative (g/dL)	12.31±2.38	12.61±1.96	0.61
p	0.32	0.39	
Base Excess			
Preoperative (mmol/L)	0.15 (-2.05-4.25)	1.2 (-0.1-3.8)	0.24
Postoperative (mmol/L)	0.5 (-1.63-3.45)	1.8 (-1-4.2)	0.31
p	0.83	0.80	

Values are expressed as mean±SD or median (25^{th} to 75^{th} percentile). p intergroup: comparison between the groups with the Student's t test or Mann-Whitney u test. p value: comparison within the groups with the paired samples Student's t test or the Wilcoxon test.

The Intraoperative Characteristics and Postoperative Follow-Up

The intraoperative characteristics and postoperative follow-up data of the two patient groups are shown in Table 4. All patients in the LMA group were adequately ventilated and weaned successfully. In the OTI group, the surgical team requested tracheal immobility for six (20%) patients; therefore, they were transferred to the ICU with intubation (p=0.014). The mean duration of postoperative ICU stays and the number of patients with positive tracheal culture were significantly higher in the OTI group than in the LMA group (Table 4). Moreover, two patients in the LMA group died due to cardiac failure, and three patients in the OTI group died due to pneumosepsis. Of the patients who were discharged, four in the OTI group needed a tracheostomy, while none in the LMA group needed this intervention (p=0.045).

The Effect of Coronavirus Disease (COVID-19)

Patients with and without a history of COVID-19 were compared in terms of mortality and the need for tracheostomy after tracheal reconstruction surgery (Table 5). The mortality rate was similar between the OTI [2 (8%)] and LMA [3 (9.4%)] groups (p=0.86). Three patients with a history of COVID-19 (10.3%) were discharged with a tracheostomy. In contrast, only one patient (4.3%) in the non-COVID group needed this intervention (p=0.42).

Discussion

To date, there have only been case reports or long-term case series comparing the use of LMA and OTI in tracheal reconstruction surgeries.[2,5,7,11,12] To the best of our knowledge, this is the first cohort study to compare these techniques in patients requiring tracheal reconstruction.

The most common reason for tracheal reconstruction is tracheal stenosis caused by chronic inflammatory heal-

Table 4. Intraoperative characteristics and postoperative follow-up data

Variables	OTI (n=30)	LMA (n=27)	p
Duration of surgery (min)	118.77±42.19	108.26±36.49	0.32
Duration of anesthesia (min)	149.33±37.13	141.67±42.11	0.47
Postoperative airway status			
Intubated	6 (20%)	0 (0 %)	0.014
Extubated	24 (80%)	27 (100%)	
LOS -ICU (day)	2 (2-5.25)	2 (2-2)	0.031
LOS -Hospital (day)	9 (8-17.75)	11 (8-19)	0.82
Positive tracheal culture	7 (23.3 %)	0 (0 %)	0.007
Mortality	3 (10%)	2 (7.41%)	0.73
Airway in discharged patients			
Spontaneous ventilated	23 (85.19%)	25 (100%)	0.045
Tracheostomized	4 (14.81%)	0 (0%)	

Values are expressed as mean±SD, median (25^{th} to 75^{th} percentile) or frequency (percentage). The Chi-square test was used for the comparison of categorical data. The Student's t test and Mann-Whitney u test were used for the comparison of continuous variables in line with their distributions. ICU: intensive care unit, LOS: length of stay.

Table 5. Patient comparison according to their COVID-19 history

Variables	Non-COVID-19 (n=25)	COVID-19 (n=32)	p
Postoperative airway status			
Intubated	5 (20%)	1 (3.1%)	0.039
Extubated	20 (80%)	31 (96.9%)	
Airway in discharged patients			
Spontaneous ventilation	22 (95.7%)	26 (89.7%)	0.42
Tracheostomized	1 (4.3%)	3 (10.3%)	
Mortality	2 (8%)	3 (9.4%)	0.86

Values are expressed as frequency (percentage). The Chi-square test was used for comparison.

ing of the tracheal mucosa following injury as a result of intubation or tracheostomy.[13,14] Our results support this pathophysiology as all our patients had a history of OTI or tracheostomy.

He et al.[15] stated that the absence of tension in the end-to-end anastomosis of the trachea is vital for surgical success and reduces the complication rate. In this regard, LMA may be superior to tracheal intubation, since with LMA use, no tracheal contact below the vocal cord occurs. However, the use of LMA has several other disadvantages, including high risk of aspiration and insufficient oxygenation/ventilation of critical tracheal stenosis.[12,16] None of these complications were observed in this study, and LMA was performed successfully in all patients. Previous studies compared oxygenation/ventilation methods for tracheal reconstruction surgery and found that the use of LMA was inferior to orotracheal intubation in terms of oxygenation/ventilation.[17,18] In our study, oxygenation was better in the OTI group throughout the surgery, but there were no significant differences in the arterial oxygen pressure values between the groups, both preoperatively and postoperatively. Adequate ventilation was also verified using arterial carbon dioxide pressure values, which were comparable between the groups, both preoperatively and postoperatively.

Postoperatively, six (20%) patients in the OTI group were transferred to the ICU in an intubated state. When intubation time is prolonged, anesthesiologists must be conservative because of the risk of hypoxemia. In contrast, when using LMA, anesthesiologists can wean the patients immediately. Moreover, patients with a positive tracheal culture result were all from the OTI group. Furthermore, the length of stay in the intensive care unit was significantly longer in the OTI group than in the LMA group. These issues are the key negative aspects of airway management using OTI. Of note, this is the first study to demonstrate an association between OTI and a higher positive tracheal culture rate.

The success rate of tracheal surgeries is >95% in the literature.[19-21] The complication rate in a previous case series is

also high (15%-39%).[22-24] Importantly, the effect of airway management on postoperative survival has not been studied.[2,13] In our study, there was no difference in the mortality rate between the groups. However, two patients in the LMA group who died, died from cardiac causes and not from infection. Conversely, three patients in the OTI group who died, died of septic shock. Mortality may be due to ventilator-associated pneumonia or tracheal contamination from orotracheal intubation reflected in the positive bacterial growth in the tracheal cultures.[25] To the best of our knowledge, this is the first study to demonstrate a relationship between OTI, a positive bacterial culture, and mortality.

Since our study coincided with the post-COVID-19 pandemic period, some of the recruited patients had COVID-19-related laryngotracheal stenosis. COVID-19-related laryngotracheal stenosis has also been reported by Beyoglu et al.[26] Although not the primary aim of our study, we also divided the patients into those with and without COVID-19 based on the presence/absence of COVID-19 pneumonia in their medical history for comparisons. The postoperative survival rate between those with and without COVID-19 was similar. This result suggests that a history of COVID-19 pneumonia did not affect patient survival after OTI or LMA for tracheal reconstruction surgery.

This study has several limitations. First, the study was designed retrospectively due to the rarity of tracheal reconstruction surgery cases. However, we had minimal data loss which facilitated the comparison of our selected objective parameters. Moreover, the effects of external factors were managed by having the same surgical and anesthesia team. Second, we were only able to obtain tracheal culture samples from the patients who were intubated at the admission to the ICU or during the follow-up in the ICU. Nevertheless, none of the patients in the LMA group were intubated due to respiratory failure, and those who were intubated due to cardiac reasons had negative tracheal culture results. Third, data relating to the sequelae of COVID-19 pneumonia, such as carbon monoxide diffusion capacity and the period between COVID-19 recovery and tracheal reconstruction surgery, were not available.[27]

Conclusion

The aim of anesthesia management during tracheal reconstruction is to provide adequate oxygenation and ventilation to the patient using the least invasive interventions. Our findings suggest that airway management using LMA should be considered as the first option instead of OTI in tracheal reconstruction surgery. Randomized controlled prospective studies to validate our findings are urgently required.

Disclosures

Ethics Committee Approval: The study was approved by Basaksehir Cam and Sakura City Hospital Ethics Committee (Number: 01.04.2022, number: 2022.02.60.

Authorship Contributions: Concept – O.A., O.S., F.G.O., T.A.; Design – O.A., E.M., A.B., T.A.; Supervision – O.A., H.A., F.G.O.; Data collection &/ or processing O.A., A.K., O.S., A.B.; Analysis and/or interpretation – O.A., T.A., E.M., F.G.O.; Literature search – O.A., O.S., H.A., A.B., F.G.O.; Writing – O.A., O.S., T.A., E.M.; Critical review – O.A., F.G.O., H.A.

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