JOURNAL OF
CONTEMPORARY MEDICINE

DOI:10.16899/jcm.1283829
J Contemp Med 2023;13(3):555-560

Original Article / Orijinal Araştırma

Laryngeal Mask Airway Versus Endotracheal Intubation for Airway Management During Percutaneous Dilatational Tracheostomy

Perkütan Dilatasyon Trakeostomisi için Hava Yolu Yönetiminde Laringeal Maske ve Endotrakeal Entübasyonun Karşılaştırılması

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Abstract

Aim: Tracheostomy is a common procedure performed surgically or percutaneously due to prolonged intubation. During the procedure, airway safety can be ensured using a laryngeal mask airway (LMA) or an endotracheal tube (ETT). The aim of this study was to investigate the complications associated with the use of LMA and ETT during the tracheostomy procedure, operative time, and changes in blood gas parameters.

Material and Method: This study included patients admitted to the Intensive Care Units of Burdur State Hospital between 2019 and 2023. A total of 78 patients were divided into two groups: ETT (n=39) and LMA (n=39). Procedure-related complications, operative time, blood gas data were recorded from the patient files.

Results: There was no statistically significant difference between the LMA and ETT groups in terms of complications. There was also no statistically significant difference in postoperative values of PaCO2 between the groups (p<0.439). The analysis of pre- and post-tracheostomy PaO2 values indicated a decrease in both the LMA and ETT groups (p< 0.001 for both). The comparison of the two groups by the duration of the tracheostomy procedure showed a statistically significant shorter operative time in the LMA group than in the ETT group (p< 0.001).

Conclusion: Our study demonstrated no statistically significant difference between LMA and ETT in terms of complications and changes in blood gas parameters. Tracheostomy with LMA has advantages over ETT, fewer personnel requirements during the procedure, clear vision in bronchoscopy, and shorter operative time.

Keywords: Percutaneous dilatational tracheostomy, laryngeal mask airway, blood gas, complication

Öz

Amaç: Trakeostomi işlemi uzamış entübasyon nedeniyle cerrahi yada perkütan teknik kullanılarak yapılan bir işlemdir. Bu işlem sırasında hava yolu güvenliği laringeal maske (LMA) ya da endotrakeal tüp (ETT) ile sağlanmaktadır. Bu çalışmada trakeostomi işlemi esnasında LMA ve ETT kullanımının komplikasyonlarını, işlem süresini ve kan gazı verilerindeki değişimlerini incelmeyi amaçladık.

Gereç ve Yöntem: Çalışmaya 2019-2023 yılları arasında Burdur Devlet Hastanesi Yoğun Bakım Kliniklerinde yatan hastalar dahil edilmiştir. Çalışmaya dahil edilen 78 hasta; ETT (n=39) ve LMA (n=39) kullanılanlar olarak iki gruba ayrılmıştır. İşleme ait komplikasyonlar, işlem süreleri, hastaların kan gazı verileri hasta dosyalarından kaydedildi.

Bulgular: Gruplar arasında komplikasyonlar açısından istatistiksel fark bulunmadı. LMA ve ETT ile trakeostomi açılan gruplar arasında işlem sonrası PaCO2 değerlerinde istatiksel olarak anlamlı fark yoktu (p<0.439). Trakeostomi öncesi ve sonrası PaO2 değerleri değerlendirildiğinde, hem LMA ve hem de ETT gruplarında düşme olduğu görüldü (her ikisi için de) (p<0,001). Trakeostomi işlemi süreleri karşılaştırıldığında ise LMA grubunda sürenin ETT grubuna göre istatistiksel anlamlı olarak daha kısa olduğu görüldü (p<0,001).

Sonuç: Çalışmamızda komplikasyonlar ve kan gazında meydana gelen değişimler açısından LMA ve ETT arasında herhangi istatistiksel olarak bir fark olmadığı görülmüştür. LMA ile trakeostominin ETT ye göre işlem sırasında daha az personel ihtiyacı olması, bronkoskopide görüş netliği ve işlem süresinin daha kısa olması gibi avantajları vardır.

Anahtar Kelimeler: Perkütan dilatasyon trakeostomi, laringeal maske, kan gazı, komplikasyon

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Received *(Geliş Tarihi)*: 15.04.2023 **Accepted *(Kabul Tarihi)*:** 20.05.2023

INTRODUCTION

Tracheostomy is a procedure performed using either a surgical or percutaneous technique in cases of prolonged intubation. The key considerations in choosing tracheostomy include providing a safer airway, improving oral hygiene, facilitating nursing care, and increasing patient comfort.[1] Despite these benefits, there is still no consensus on the optimal timing for performing a tracheostomy. However, prolonged ventilation with endotracheal intubation brings about numerous complications.[2]

In recent years, the percutaneous tracheostomy technique has become the method of choice for tracheostomy in cases of prolonged intubation in intensive care units. The percutaneous dilatation technique has been associated with lower incidence of complications such as bleeding and wound infection compared to surgical tracheostomy. Moreover, percutaneous tracheostomy offers advantages such as lower mortality rates and easier bedside operation.[3]

One of the common challenges associated with the use of an endotracheal tube (ETT) during percutaneous tracheostomy is cuff rupture, and inadvertent perforation of the tracheal ring by the needle through Murphy's eye of ETT, which can result in needle movement along with the ETT and procedure failure.[4,5] To address these challenges, some centers have adopted the use of a laryngeal mask airway (LMA) during the percutaneous tracheostomy procedure in their clinical practice, due to issues associated with the endotracheal tube and prolonged tracheostomy procedures.[6] The use of LMA during the tracheostomy procedure aims to reduce the number of auxiliary personnel required and provide a better angle of view for bronchoscopy, without causing harm.[7]

This study aimed to assess the incidence of complications during and after the tracheostomy procedure using the percutaneous dilatation technique, and to compare the effectiveness of endotracheal intubation and laryngeal mask airway (LMA) in airway management during percutaneous dilatational tracheostomy (PDT).

MATERIALS AND METHODS

The study was carried out with the permission of Afyonkarahisar Health Sciences University Ethics Committee (Date: 07.04.2023, Decision No: 2023/226). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

The study included patients aged 18 and above who were admitted to the Intensive Care Units of Burdur State Hospital between 2019 and 2023. Study data were obtained retrospectively by reviewing patient files. As part of our clinical practice, neck and airway ultrasound (US) is routinely performed for all patients undergoing tracheostomy to determine the tracheal ring where the tracheostomy needle will be inserted. Additionally, bronchoscopy is used throughout the procedure after establishing airway control with an endotracheal tube (ETT) or laryngeal mask airway (LMA).

Tracheostomy was performed using ETT in some patients and under the guidance of LMA in others. Patients were divided into two groups based on the airway management technique used during the tracheostomy procedure. Anesthetic drug doses, arterial blood gas data (including partial pressure of oxygen (PaO_2) and partial pressure of arterial carbon dioxide ($PaCO_2$), with the fraction of inspired oxygen (FiO_2) of 1 as 100% oxygen was used in the study), biochemical data, and information on mechanical ventilator settings were obtained from the patient records. Moreover, data on perioperative and postoperative complications were collected from standardized tracheostomy observation forms recorded in the patient files. The final sample size for analysis was 78 patients after excluding those with missing data, those who did not undergo bronchoscopy, those who underwent emergency tracheostomy, and those who died within 48 hours after tracheostomy. The flowchart of the study is shown in **Figure 1.**

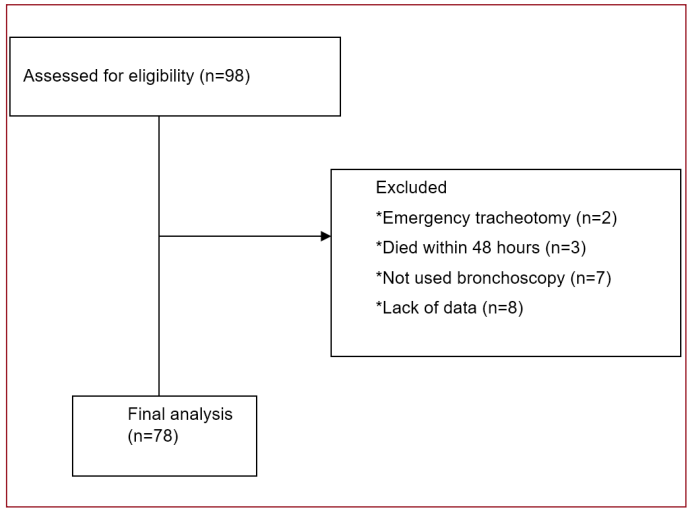

Figure 1. The flowchart of the study

Tracheostomy Procedure

The patients in both groups underwent a standard fasting period of 6 hours before the procedure, following the recommendations of the American Society of Anesthesiology (ASA).[8] Prior to each procedure, 100% oxygen was administered for 15 minutes. Sedation was achieved using propofol (100-200 µg/kg), while muscle relaxation was achieved using rocuronium (0.6 mg/kg).

Patients were placed in the supine position with the neck extended by a pillow placed under the shoulders. In the endotracheal tube (ETT) group, the cuff of the tracheal tube was retracted up to the vocal cords, while in the laryngeal mask airway (LMA) group, the endotracheal tube was removed and the LMA was placed. The neck region was cleansed with 10% povidone-iodine and covered with sterile drapes. Five mL of lidocaine 2% with adrenaline was subcutaneously administrated to the second and third

tracheal rings. A vertical incision of 1 cm in length was then made on the skin, and the trachea was visualized using a flexible bronchoscope through ETT or LMA. The needle location was confirmed by bronchoscopy. After advancing the wire through the needle, the tracheostomy cannula was inserted into the tracheal lumen. Bronchoscopy was used for guidance during the procedure. Once the location of the cannula was confirmed, the cuff was inflated.[9]

Statistical Analysis

Categorical variables were presented as percentages and frequencies. Normality of continuous variables was checked using the Shapiro-Wilk test. Normally distributed continuous variables were reported as mean ± standard deviation (SD), while non-normally distributed continuous variables were presented as median and interquartile range (IQR). The chi-square test was used to compare categorical variables between non-survivors and discharged patients, with Fisher's exact test applied when necessary. Independent-sample t-test was utilized to compare normally distributed continuous variables between the groups, while the Mann-Whitney U test was applied for non-normally distributed continuous variables. The paired t-test was used for comparisons of normally distributed variables at two time points, such as preoperative and postoperative $PaCO_2$ values. The Wilcoxon signed-rank testwas used for comparisons of non-normally distributed variables at two time points, including pre- and post-tracheostomy PaO_2.

RESULTS

Of the 78 patients included in the study, 60.3% (n=47) were male and 39.7% (n=31) were female. The median age of the study group was 70 years (IQR=20 years). During the intensive care follow-up, 61.5% (n=48) of our patients died, while 38.5% (n=30) were discharged. The demographic and clinical characteristics of patients who underwent tracheostomy with LMA (n=39) and ETT (n=39) are presented in **Table 1**. The operative time was statistically significantly shorter in the LMA group compared to the ETT group (p<0.001). Postoperative PaO_2 values were statistically significantly higher in the ETT group (p<0.001), while there was no statistically significant difference in postoperative $PaCO_2$ values.

Table 2 shows perioperative and postoperative complications of the tracheostomy procedure in patients who underwent tracheostomy using LMA and ETT.

There was a statistically significant increase in preoperative and postoperative $PaCO_2$ values of both the LMA and ETTgroups (p<0.001), as shown in **Table 3**.

As shown in **Table 4**, there was a statistically significant difference in preoperative and postoperative PaO_2/FiO_2 values of the groups that underwent tracheostomy with LMA and ETT.

Table 1: Demographic and clinical characteristics of patients who underwent tracheostomy with LMA and ETT

	LMA group (n=39)	ETT group (n=39)	p-value
Age (years), median (IQR)	68 (24)	72 (19)	0.097*
Gender			
Male	24 (51.1%)	23 (48.9%)	0.817**
Female	15 (48.4%)	16 (51.6%)	
Height (cm), median (IQR)	165 (10)	165 (10)	0.613*
Weight (kg), median (IQR)	70 (169)	72 (7)	0.110*
BMI, median (IQR)	24.6 (5.6)	26 (3.9)	0.028*
Diagnosis			
COPD	7 (41.2%)	10 (58.8%)	0.411*
Neurologicaldiseases	17 (56.7%)	13 (43.3%)	0.352*
Headtrauma	12 (42.9%)	16 (57.1%)	0.345*
Sepsis	3 (100%)	0	0.240*
SOFA score, median (IQR)	6 (3)	6 (1)	0.120*
APACHE-II score, median (IQR)	19 (8)	21 (6)	0.255*
Operative time (min)	4.52 (0.74)	6.39 (0.42)	<0.001*
Postoperative PaO_2 (IQR)	274 (63)	313 (29)	<0.001*
Postoperative $PaCO_2$ (mean±SD)	45.38±6.07	46.41±5.54	0.439***

*Mann-Whitney U test, **Fisher'sexact test, ***Student's t-test, LMA: Laryngeal Mask Airway; ETT: Endotracheal Tube, IQR: Interquartile range, BMI: Body Mass Index, COPD: Chronic Obstructive Pulmonary Disease, SOFA: The Sequential Organ Failure Assessment

Table 2: Complications of patients who underwent tracheostomy using LMA and ETT

	LMA group (n=39)	ETT group (n=39)
ETT cuffrupture	0	4 (10.3%)
Unplanned extubation	1 (2.6%)	0
Bleeding	1 (2.6%)	1 (2.6%)
Esophagealperforation	1 (2.6%)	0
Pneumothoraxemphysema	1 (2.6%)	0
Desaturation	1 (2.6%)	1 (2.6%)
Bronchospasm	1 (2.6%)	0
Increasein plateaupressure	1 (2.6%)	0
Pneumonia	5 (12.82%)	3 (7.69%)

LMA: Laryngeal Mask Airway, ETT: EndotrachealTube

Table 3: Pre- and post-tracheostomy blood gas $PaCO_2$ values of the LMA and ETT groups

	Preoperative $PaCO_2$ (mean±SD)	Postoperative $PaCO_2$ (mean±SD)	p-value
LMA group	40.15-4.77	45.38-6.07	<0.001*
ETT group	38.21-3.66	46.41-5.54	<0.001*

*Paired t-test, LMA: Laryngeal Mask Airway, ETT: Endotracheal Tube, SD: Standard Deviation

Table 4: Pre- and post-tracheostomy blood gas PaO_2/FiO_2 values of the LMA and ETT groups

	Preoperative PaO_2/FiO_2	Postoperative PaO_2/FiO_2	p-value
	Median(min-max)	Median (min-max)	
LMA group	328 (284-447)	274 (221-406)	<0.001*
ETT group	345 (282-449)	313 (270-421)	<0.001*

*Wilcoxon signed-rank test, LMA: Laryngeal Mask Airway, ETT: Endotracheal Tube

DISCUSSION

This study investigated the complications and operative times of LMA and ETT used for airway management during PDT procedures, as well as changes in respiratory mechanics and arterial blood gas parameters depending on the technique employed.

Respiratory failure often necessitates mechanical ventilation for critically ill patients in the intensive care unit. Either endotracheal intubation or tracheostomy is used for respiratory support. However, prolonged endotracheal intubation can lead to undesirable effects such as laryngeal injury, subglottic stenosis, increased sedation requirements, and difficulties in weaning from ventilatory support.[10]

During percutaneous tracheostomy, airway safety is established by utilizing either ETT or LMA, each with its own set of advantages and disadvantages. The PDT procedure performed with the assistance of endotracheal intubation can have various disadvantages, such as cuff rupture, puncture of the tube by needle, or inadvertent migration into Murphy's eye.[11]

Our study showed that various complications may develop during the PDT procedure. Airway and pulmonary complications were more frequently observed in the LMA group, although no statistically significant difference was found between the two groups in terms of complications. Cuff rupture was the most common complication in the ETT group, while pneumonia was the most frequent complication in the LMA group.

A large-scale study by Vargas et al. screening patients who underwent PDT reported that oxygen saturation decreased in 6.2% of the patients, indicating desaturation.[12] Our study demonstrated decreased oxygen saturation during the PDT procedure, with a desaturation rate of 2.56%. In the LMA group, there was 1 patient with bronchospasm and 1 patient with an increase in plateau pressure. We believe that this may be caused by secretions passing from the trachea to the bronchi and bronchioles, as the LMA used during the procedure is wider and does not settle on the epiglottis, thus not blocking the tracheal tract.

Yaghoubi et al. reported a rate of 5.7% for ETT cuff rupture during PDT,[13] while Araujo et al. reported a rate of 1.7% for ETT rupture.[14] In our study, we observed an endotracheal cuff rupture rate of 10.25%.

The incidence of bleeding, which is one of the early complications of tracheostomy, ranges from 0.6 to 5%.[15] Early bleeding is usually minor and not life-threatening, occurring within 48 hours and originating from superficial veins, and can be controlled with pressure. On the other hand, major bleedings result from tracheo-arterial fistula development during the procedure.[16] In our study, no major bleeding was observed after the PDT procedure, while the rate of minor bleeding was 2.56%. Bleeding was successfully controlled with pressure before proceeding with the procedure.

Pneumothorax and subcutaneous emphysema are also among the complications that may occur during the PDT procedure. Fikkers et al. reported a rate of 1.4% for subcutaneous emphysema and 0.8% for pneumothorax during PDT.[17] Kaiser et al. reported a rate of 2.08% for subcutaneous emphysema without tracheal wall damage.[18] In our study, subcutaneous emphysema was observed in only one patient in the LMA group (2.56%), which resolved within a few days without any respiratory complications. There were no cases of pneumothorax in both the LMA or ETT groups.

One of the rare but fatal late complications of the tracheostomy procedure is tracheo-esophageal fistula (TEF), which develops as a result of injury to the posterior tracheal wall. Epstein et al. reported that the incidence of this complication is below 1%.[19] A review by Goldenberg et al. reported that the rate of TEF after PDT was 0.08% and it was fatal.[20] In our study, TEF after PDT was observed only in the LMA group with a rate of 2.56%, and the case was managed through surgical intervention and returned to a normal course.

In a study comparing the effectiveness of LMA and ETT during the PDT procedure, Döşemeci et al. reported statistically significantly shorter operative time with LMA than with ETT.[21] Similarly, another study showed that the duration of PDT with LMA was shorter compared to ETT.[9] In our study, the duration of PDT with LMA was found to be statistically significantly shorter than with ETT. This may be considered as a reason to prefer LMA, as reduced operative time leads to decreased exposure to anesthetic drugs.

During the PDT procedure with ETT, the assistance of a second person is required to control the airway, specifically to pull the endotracheal tube up to the vocal cords. However, with LMA, there is no need for a second person to take control of the airway. Dexter et al. reported that the angle of view in bronchoscopy was better with LMA as it was located on the vocal cords, in contrast to ETT.[22] In our study, we also found that the use of LMA provided a better angle of view for the tracheal rings during the procedure, and the entry of the tracheostomy needle through the tracheal ring was visualized more clearly.

Previous studies have shown a statistically significant difference between pre- and post-PDT $PaCO_2$ values in both ETT and LMA, with postoperative $PaCO_2$ values being higher. Moreover, the increase between preoperative and postoperative measurements is greater with ETT. This has been attributed to the fact that bronchoscopy with ETT prolongs the operative time and is associated with airway leakage.[21,23,24]

In our study, postoperative $PaCO_2$ values were statistically significantly higher than preoperative values in both the ETT and LMA groups during the PDT procedure. However, the comparison of the ETT and LMA groups revealed no statistically significant difference in preoperative and postoperative $PaCO_2$ values.

Linstedt et al. reported a decrease in the PaO_2/FiO_2 ratio in both the LMA and ETT groups in their study comparing the use of LMA and ETT in the PDT procedure.[24] In our study, the comparison of preoperative and postoperative blood gas measurements also revealed a statistically significant decrease in PaO_2/FiO_2 values in both groups.

A study by Zhang et al. comparing surgical tracheostomy and PDT reported no statistically significant difference between the two groups in terms of ventilator-associated pneumonia (VAP).[25] Similarly, Terragni et al. reported a VAP rate of 8.3%.[26] In our study, the evaluation of bacterial growth of deep tracheal aspirate cultures, clinical findings, and the presence of pneumonia before and after the PDT procedure showed that 12.82% of patients in the LMA group and 7.69% of patients in the ETT group developed pneumonia. However, there was no statistically significant difference between the groups. We believe that the development of pneumonia is not solely related to the PDT procedure. Further prospective studies with larger sample sizes are needed to confirm these results.

Our study has some limitations that should be considered. The first limitation of our study is its retrospective and single-center design. The second limitation is the small number of patients.

CONCLUSION

Tracheostomy is a common procedure performed in intensive care units, particularly in cases of prolonged mechanical ventilation. The use of ultrasound (US) and flexible bronchoscopy (FOB) during the PDT procedure is considered a reliable and effective method for airway evaluation. Our study showed a decrease in pre- and post-tracheostomy PaO_2/FiO_2 values in both the LMA and ETT groups. Moreover, the duration of the tracheostomy procedure was found to be statistically significantly shorter in the LMA group compared to the ETT group. Based on our results, we believe that the use of LMA is preferable due to its shorter operative time, increased patient comfort, reduced personnel requirement, and improved clarity of vision during bronchoscopy.

ETHICAL DECLARATIONS

Ethics Committee Approval: The study was carried out with the permission of Afyonkarahisar Health Sciences University Ethics Committee (Date: 07.04.2023, Decision No: 2023/226).

Informed Consent: The data were obtained retrospectively from electronic medical records.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

Financial Disclosure: The authors declared that this study has received no financial support.

Author Contributions: All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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