

Comparison of Cost Analyses of Laryngeal Mask Airway and Endotracheal Tube Use in Anaesthesia Management: A Prospective Study

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Abstract

Objective/Background: This study aimed to compare the direct costs and clinical outcomes of endotracheal tube (ET) and laryngeal mask (LM) applications, which are widely preferred for airway management during short-term plastic surgery operations lasting up to two hours. **Materials and Methods:** This prospective observational study, conducted between 2018 and 2019, included 80 patients aged 18–65 years undergoing elective plastic surgery. Participants were assigned to either the endotracheal tube (Group ET, n=40) or laryngeal mask group (Group LM, n=40; LMA ProSeal™). Demographic characteristics, procedure times (intubation, extubation, operation), and precise doses of all anesthesia drugs were recorded. Direct medication and medical supply costs for both methods were calculated and statistically compared. **Results:** Intubation ($p<0.001$), extubation ($p=0.029$), and operation ($p<0.001$) times were significantly longer in Group ET. Regarding drug consumption, the doses of remifentanyl, rocuronium, atropine, neostigmine, and the number of airways used were higher in Group ET, whereas only propofol was higher in Group LM. Despite prolonged procedure times and increased drug consumption in Group ET, the mean total cost was significantly higher in Group LM (LM: 173.59 TL vs. ET: 159.08 TL; $p<0.001$). **Conclusion:** Based on direct material and medication costs, the endotracheal tube was found to be a more cost-effective alternative than the laryngeal mask. However, when selecting medical supplies, clinicians must not rely solely on costs but should holistically evaluate patient comfort, hemodynamic stability, and postoperative clinical outcomes.

Keywords: Cost analysis; laryngeal mask; endotracheal tube

1. Introduction

The primary duty of every anesthesiologist is to secure the respiratory tract and maintain control of breathing. Endotracheal tube intubation (ETT) is a well-established, traditional method that provides a highly secure airway; however, it typically requires the

administration of muscle relaxants and subsequent reversal agents. Although endotracheal tube intubation (ETT) has been around for a long time, problems associated with the procedure persist¹. The laryngeal mask airway (LMA), invented in the 1980s, is a supraglottic airway device used to maintain an open airway during short-term surgical procedures². In 2001, Dr. Archibald Brain transformed the classic laryngeal mask airway (cLMA) and designed the LMA ProSeal™³. The LMA ProSeal™ has a large, wedge-shaped cuff, a drainage tube, and a bite block. Notably, the cuff provides excellent ventilation by preventing air leakage at high pressures. Additionally, the drainage tube helps prevent stomach aspiration, facilitating the insertion of a stomach tube and emptying the stomach⁴. The LMA ProSeal™ generally shortens induction and/or emergence times while reducing the rate of lower respiratory tract complications. The time savings and reduced complications associated with the LMA strongly highlight its advantages in many anesthetic settings. Because both ETT and LMA ProSeal™ are widely and safely used in routine anesthesia management depending on surgical requirements, comparing their procedural dynamics and economic impacts is highly relevant.

Socioeconomic changes directly affect the healthcare system. Several interventions are required to deliver healthcare at an appropriate cost without compromising quality⁵. Costs are generally grouped into three categories: direct, indirect, and intangible costs^{6,7}. According to the literature, there are various types of cost analysis, such as cost minimization, cost-benefit analysis, cost-result analysis, cost-efficiency analysis, and cost-value analysis⁸. Direct costs are those associated with providing medical care and can be calculated using market prices. The cost analysis in our study was based on direct costs. Medical care costs include medication, consultations, examinations, expenses, and care provided by healthcare professionals.

Notably, the correct use of resources is essential for the continuity of services provided in operating rooms, especially in university hospitals. Therefore, each university hospital must conduct a cost analysis. In our country, the number of people who applied to see a physician in 2010 was 7.3 per person. The total number of applications was 538 million. Of these, approximately 21 million were made to university hospitals. University hospitals constituted 4% of the total number of applications. However, when social security hospital expenditures are analyzed, payments made to university hospitals constitute 20% of the total. In contrast, the indebtedness rate of university hospitals in 2010 (net debt/income) was 36%. Considering that the rate was only 13% for education and research hospitals affiliated with the Ministry of Health, the high rate of university hospitals is clear. This finding reveals that university hospitals have high rates of indebtedness, an unachievable balance of income and expenditure, and weakened financial sustainability. Despite the Ministry of Health's initiatives to improve the financial status of university hospitals⁹, their financial problems are still increasing.

Although there are some studies on the laryngeal mask airway in the literature^{10,11}, there are a limited number of studies focusing on direct cost analysis comparison. The majority of current research is centered on clinical efficiency and complications rather than comprehensive cost-effectiveness models. To the best of our knowledge, our study is one of the few that addresses this topic in the context of plastic surgery cases. Our study aims to compare the costs and clinical outcomes of laryngeal masks and endotracheal tubes, which are both widely used in university and Ministry of Health hospitals, depending on physician's preference.

2. Materials and Methods

Our study was designed as a prospective, observational study. Approval was obtained from the Kahramanmaraş Sütçü İmam University Faculty of Medicine Clinical Research Ethics Committee on July 25, 2018 (number 2018/13-27). The study was conducted

from August 15, 2018, to August 15, 2019, and involved plastic surgery cases. Written informed consent was obtained from all patients. The study included patients between the ages of 18 and 65 years who were expected to undergo plastic surgery lasting between 0 and 2 hours. Patients with renal or hepatic impairment, an age over 65 years, an American Society of Anesthesiologists (ASA) score of IV or higher, or impaired consciousness were excluded from the study. The type of anesthesia was decided by the consultant faculty doctor and the specialist physician based on the surgical intervention to be performed on the patient. Patients were divided into two groups: the endotracheal tube (ET) group (n = 40) and the laryngeal mask (LMA ProSeal™, The Laryngeal Mask Company Limited, Mahé, Seychelles) (LM) group (n = 40).

Preoperatively, vascular access was obtained using an 18-gauge intravenous (IV) cannula. All patients received 0.02–0.03 mg/kg IV midazolam (VEM, İlaç A.Ş., Tekirdağ, Türkiye) 30 minutes before surgery. Once the patients were in the operating room, three-lead electrocardiography, pulse oximetry, and noninvasive blood pressure monitoring (Infinity Delta XL, Dräger, Germany) were performed. Remifentanyl (Ultiva, 2 mg vial, GlaxoSmithKline, UK), at a dose of 1 µg/kg, and propofol (Propofol 1% ampule, Fresenius Kabi, Germany), at a dose of 2 mg/kg, were used for anesthesia induction. An additional propofol dose was administered for intubation in both groups and recorded. Rocuronium (0.6 mg/kg, Muscuron, Koçak Farma İlaç ve Kimya Sanayi A.Ş., İstanbul, Türkiye) was administered to patients undergoing endotracheal intubation. Additionally, atropine sulfate (0.02–0.06 mL/kg, DrogSan İlaçları San. ve Tic. A.Ş., Türkiye) and neostigmine methyl sulfate (0.05 mg/kg, Adeka Pharmaceutical Industry and Trade) were administered to facilitate awakening. In Group LM, atropine sulfate and neostigmine methyl sulfate were not used to reverse muscle relaxation. Sevoflurane (Sevorane Liquid, Abbott, USA) (minimum alveolar concentration: 1%–2%) was used to maintain anesthesia. Initial mechanical ventilation was planned with a tidal volume of 7–8 mL/kg and a respiratory rate of 10–12. Patients achieved normocapnia (30–40 mmHg). Tramadol (1 mg/kg; Abdi İbrahim İlaç San. ve Tic. A.Ş., İstanbul, Türkiye) was administered for postoperative analgesia. All drugs used during the operation were recorded. The following were recorded for all patients: age; sex; BMI; diagnosis; Mallampati and ASA scores; intubation, extubation, and operation times; and drugs used in anesthesia induction and maintenance, as well as their doses.

Our study examined price changes from July 1, 2018, to July 1, 2019. The cost analysis was based on purchasing unit prices. Oxygen and nitrous oxide consumption was not included in the cost analysis. The cost of sterilizing the laryngeal mask was also excluded. Additionally, standard expenses in both groups were excluded, as were physician and personnel expenses because they were the same for both groups.

2.1. Purchasing Unit Prices

Remifentanyl (1 ampule = 2,000 mcg): 12.47 TL (500 mcg × 4; 4 × 3.1175 TL). Remifentanyl is divided into four doses. Propofol (2 mg/kg): 3.80 TL. One ampule was used for each patient. Rocuronium (1 ampule = 50 mg): 5.72 TL. One ampule was used for each patient. Tramadol (1 ampule = 100 mg): 1.13 TL. One ampule was used for each patient. Atropine (1 ampule = 0.5 mg): 0.43 TL. Neostigmine (1 ampule = 0.5 mg): 0.58 TL. Sevoflurane (1 bottle): 525 TL (1/4 price: 131.25 TL per patient). Airway (1 piece): 1.69 TL. Aspirator probe (1 piece): 1.18 TL. Laryngeal mask (1 piece): 1,070 TL. Endotracheal tube: 2.5 TL.

2.2. Statistical Analysis

The data were analyzed using SPSS version 25.0 for Windows (Statistical Package for the Social Sciences). Descriptive statistical methods (number, percentage, mean, and standard deviation) were used to evaluate the data. Suitability to normal distribution was examined using a Q–Q plot, histogram, and Kolmogorov–Smirnov or Shapiro–Wilk test.

Kurtosis was checked to ensure it was within the range of ± 3 . Chi-square analysis was used to examine homogeneous distribution in Groups ET and LM according to demographic characteristics. An independent samples t-test was performed to determine differences in quantitative data between the two groups. A p value of <0.05 was considered statistically significant.

3. Results

A total of 80 patients were included in the study, with 40 in each group. No significant differences were noted between the groups regarding age or BMI values ($p > 0.05$) (Table 1).

Table 1. Demographic and clinical characteristics of the study groups

Variables		Group ET (n=40)		Group LM (n=40)		Test	p
		n	%	n	%		
Sex	Female	21	52.5	16	40.0	$\chi^2=1.257$	p=0.185
	Male	19	47.5	24	60.0		
Diagnosis	Head injury	5	12.5	3	7.5	$\chi^2=18.539$	p=0.012*
	Mammoplasty	12	30.0	9	22.5		
	Septorhinoplasty	5	12.5	0	0.0		
	Tissue defect	9	22.5	8	20.0		
	Squamous cell carcinoma	6	15.0	4	10.0		
	Extremity contracture	2	5.0	7	17.5		
	Scoop ear	0	0.0	2	5.0		
	Tissue injection	0	0.0	6	15.0		
	Vaginoplasty	1	2.5	0	0.0		
	Neurofibromatosis	0	0.0	1	2.5		
Mallampati	1	9	22.5	11	27.5	$\chi^2=0.647$	p=0.776
	2	18	45.0	19	47.5		
	3	13	32.5	10	25.0		
ASA	1	24	60.0	28	70.0	$\chi^2=1.093$	p=0.696
	2	14	35.0	10	25.0		
	3	2	5.0	2	5.0		
		$\bar{X}$	SS	$\bar{X}$	SS	t	p
Age		36.60	14.73	35.55	18.08	t=0.285	p=0.777
BMI		27.44	6.04	25.12	3.66	t=1.364	p=0.089

* $p < 0.05$. ASA: American Society of Anesthesiologists.

However, a significant difference between the groups was observed in the times of intubation, extubation, and operation. The intubation and extubation times, as well as the operation time, were longer in Group ET ($p < 0.001$, $p = 0.029$, and $p < 0.001$, respectively) (Table 2).

Table 2. Comparison of intubation, extubation, and operation times

Variables	N	$\bar{X}$	SS	t	p
Intubation time (min)				5.772	$<0.001^*$
Group ET	40	159.75	42.16		
Group LM	40	95.22	56.71		
Extubation time (min)				2.229	0.029*
Group ET	40	275.42	205.42		

Variables	N	X	SS	t	p
Group LM	40	191.50	121.77		
Operation time (min)				7.002	<0.001*
Group ET	40	105.22	36.40		
Group LM	40	56.80	24.24		

* $p < 0.05$.

Significant intergroup differences were observed in the doses of remifentanyl, propofol, rocuronium, atropine sulfate, and neostigmine methylsulfate, as well as in the number of airways used ($p = 0.020$, $p = 0.048$, $p < 0.001$, $p < 0.001$, $p < 0.001$, $p < 0.001$, respectively). The doses of remifentanyl, rocuronium, atropine sulfate, and neostigmine methylsulfate, as well as the number of airways used, were higher in Group ET than in Group LM. However, the propofol dose was higher in Group LM than in Group ET (Table 3).

Table 3. Comparison of anesthesia drug doses and airway supplies used

Variables	N	X	SS	t	p
Remifentanyl (μg)				2.376	0.020*
Group ET	40	82.75	20.28		
Group LM	40	71.37	22.47		
Propofol (mg)				-2.012	0.048*
Group ET	40	172.25	32.46		
Group LM	40	202.50	89.37		
Rocuronium (mg)				40.267	<0.001*
Group ET	40	49.00	7.69		
Group LM	40	0.00	0.00		
Tramadol (mg)				1.927	0.058
Group ET	40	77.87	16.82		
Group LM	40	71.37	13.10		
Atropine (mg)				32.356	<0.001*
Group ET	40	0.92	0.18		
Group LM	40	0.00	0.00		
Neostigmine (mg)				32.865	<0.001*
Group ET	40	2.27	0.43		
Group LM	40	0.00	0.00		
Number of airways (n)				5.444	<0.001*
Group ET	40	0.52	0.50		
Group LM	40	0.05	0.22		
Number of aspirator probes (n)				0.000	1.000
Group ET	40	1.02	0.27		
Group LM	40	1.02	0.15		

* $p < 0.05$.

Additionally, significant intergroup differences were noted in relation to atropine sulfate, neostigmine methyl sulfate, airway costs, and total cost averages ($p < 0.001$, $p < 0.001$, $p < 0.001$, respectively). Atropine sulfate, neostigmine methyl sulfate, and airway costs were higher in Group ET than in Group LM. However, the total cost was higher in Group LM than in Group ET ($p < 0.001$) (Table 4).

Table 4. Comparison of direct medication and material costs

Variables	N	X	SS	t	p
Remifentanyl (TL)				0.000	1.000
Group ET	40	3.11	0.00		
Group LM	40	3.11	0.00		
Propofol (TL)				-1.638	0.106
Group ET	40	3.35	0.28		
Group LM	40	3.65	1.14		
Rocuronium (TL)				—	—
Group ET	40	5.72	0.00		
Group LM	40	0.00	0.00		
Tramadol (TL)				0.000	1.000
Group ET	40	1.13	0.00		
Group LM	40	1.13	0.00		
Atropine (TL)				32.356	<0.001*
Group ET	40	0.79	0.15		
Group LM	40	0.00	0.00		
Neostigmine (TL)				32.865	<0.001*
Group ET	40	2.63	0.50		
Group LM	40	0.00	0.00		
Sevoflurane (TL)				—	—
Group ET	40	131.25	0.00		
Group LM	40	131.25	0.00		
Airway (TL)				5.749	<0.001*
Group ET	40	0.92	0.85		
Group LM	40	0.08	0.37		
Aspirator probe (TL)				0.570	0.571
Group ET	40	1.25	0.52		
Group LM	40	1.20	0.18		
Isotonic sodium chloride (TL)				0.000	1.000
Group ET	40	6.40	0.00		
Group LM	40	6.40	0.00		
Endotracheal tube / LM price (TL)				—	—
Group ET	40	2.50	0.00		
Group LM	40	26.75	0.00		
Total cost (TL)				-59.833	<0.001*
Group ET	40	159.08	0.98		
Group LM	40	173.59	1.17		

* $p < 0.05$. TL: Turkish Lira.

4. Discussion

The use of laryngeal mask airways (LMAs) versus endotracheal tubes (ETTs) in anesthesia management has been widely studied, with a focus on clinical outcomes, efficiency, and cost-effectiveness. Several studies suggest that using an LMA is associated with shorter induction and recovery times, fewer perioperative complications, and potential economic benefits compared to an ETT in various surgical settings^{12,13}. In our study, despite having longer intubation, extubation, and operation times, as well as higher doses of remifentanyl, rocuronium, atropine sulfate, and neostigmine methylsulfate, and a higher number of airways used, Group ET had a lower total cost. In our study, we used LMA on a per-patient basis to take into account sterilization costs, the risk of transmitting infections, and complications associated with reuse. The fact that the unit price of the

laryngeal mask (1,070 TL) is much higher than that of the endotracheal tube (2.5 TL) may explain why the ET group is more cost-effective despite the increased medication and time costs.

Although ETT is a traditional and secure method, it requires the administration of muscle relaxants and reversal agents, which may explain the prolonged intubation and extubation times observed in our study. Furthermore, clinical data indicate that ETT increases the likelihood of throat irritation and stimulation, leading to significantly higher rates of postoperative sore throat compared to the LMA ProSeal™¹⁴. Additionally, postoperative nausea and vomiting can be up to 40% more frequent in patients undergoing ETT¹⁴. In their retrospective comparative study of 157 patients who underwent denotolalveolar surgery in 2002, Todd and colleagues reported that the LMA reduced recovery time by 13 minutes compared to the ETT and lowered costs¹⁵. Furthermore, as indicated in Table 1, a statistically significant difference was observed between the ET and LM groups in terms of surgical diagnosis ($p = 0.012$). Therefore, when evaluating the results, it is essential to consider that diagnoses (e.g., cranial trauma, mammoplasty) may serve as confounding factors affecting the duration of surgery. In their study of elective outpatient surgeries involving healthy adults, Macario and colleagues reported that cost-effectiveness was more favorable in surgeries lasting over 40 minutes and in cases where LMA devices could be reused after being sterilized 40 times. The fact that the study was conducted in 1995 may explain the price difference compared to current conditions, and reusing an LMA after 40 sterilizations may also carry a risk of complications¹⁶.

Due to limited budgets for healthcare services, all institutions must efficiently use their available resources while striving to provide the best possible care. For this reason, cost analysis studies are necessary to compare the scope of application, effectiveness, and alternatives of various treatments¹⁷⁻²⁰. Cost analysis can inform the development of future financial plans based on historical cost data²¹. A study observed that using an intravenous fentanyl infusion instead of nitrous oxide in low-flow anesthesia with desflurane did not affect hemodynamics. However, using a fentanyl infusion in low-flow anesthesia increases anesthesia cost and Bispectral Index (BIS) values. Notably, using BIS doubled the anesthesia cost²². A comparative study of the internal medicine intensive care unit (ICU) and the Anesthesiology ICU determined that laboratory examinations were performed more frequently in the internal medicine ICU, whereas surgical interventions and consultation requests to other departments were performed more frequently in the anesthesiology ICU²³. It should be noted that there is no easy, uniform method for cost analysis. Intensive care physicians who prioritize patient survival may sometimes consider cost analysis trivial, and may even resist it²⁴. A study comparing the effects of minimal-flow and low-flow anesthesia during thyroid or parathyroid surgery revealed lower cost with minimal-flow anesthesia. However, more caution is warranted due to the risk of a partial decrease in antioxidant parameters²⁵. Therefore, medical complications should be considered when evaluating anesthesia costs.

A study comparing the costs of patients undergoing general (GA) and spinal anesthesia (SA) up until discharge found that GA patients had higher costs. Specifically, anesthesia management costs were higher under GA than under SA. This is likely due to higher preoperative and postoperative care costs for GA patients. The cost of medications required for SA was found to be lower than that required for GA patients²⁶. Although SA is simple, inexpensive, and easy to learn, with a high success rate, it has disadvantages, including hypotension and a high incidence of headaches due to dural perforation²⁷. In the hands of an experienced operator, the LMA achieved high placement success rates, particularly among unselected patients. Notably, accurate placement rates were nearly 100%, and complications were rare²⁸. In our study, the placement rate was 100%. A retrospective study of 542 patients who underwent lumbar discectomy and laminectomy

revealed that SA had lower operating, indirect, and total costs compared with GA. Furthermore, a shorter hospital stay, shorter anesthesia and surgery times, and lower estimated blood loss contributed to the reduced SA costs²⁹. Another study found that balanced anesthesia using esmolol for patients undergoing nasal surgery was less expensive than total intravenous anesthesia (TIVA) using propofol³⁰. A comparative study of GA and regional anesthesia (RA) costs in patients undergoing carotid endarterectomy found that operating room costs, postoperative resources, and hospital stays were lower for those undergoing RA³¹. Toward the end of the last century, the appropriate use of healthcare resources gained significance globally. A study conducted in our country reported that patients scheduled for elective surgery after routine examinations could positively impact their family and country's budgets if they chose to undergo surgery in their city or local area³².

Despite robust findings favoring the overall cost-effectiveness and efficiency of LMA and ETT in many contexts, gaps remain in their use. Future research should focus on the impact of strict single-use policies versus high-reuse policies on true long-term cost-effectiveness, comparative effectiveness and costs in high-risk populations or complex surgeries, and real-world barriers to widespread adoption given institutional procurement practices.

5. Limitations

Our study has certain limitations. Since it is a single-center study, its results cannot be generalized. Since the type of anesthesia was decided jointly by the consulting faculty member and the specialist physician based on the surgical procedure to be performed, patients could not be randomized. This situation could be considered a potential source of selection bias. The cost of purchasing the materials used may differ depending on each hospital's financial conditions. Additionally, the drugs and treatments used can vary by hospital, leading to cost differences. Operating room practices, patient acceptance criteria, patient characteristics, and cost analysis methods may also differ among hospitals. A more comprehensive cost analysis could not be performed because LMA sterilization, oxygen/nitrogen consumption, and physician/staff costs were not included in the study.

6. Conclusion

Based on the direct material and medication cost data obtained in our study, we determined that using an endotracheal tube may be more cost-effective than using a laryngeal mask. However, this study did not evaluate important clinical factors such as patient comfort, hemodynamic stability, and postoperative complications. Therefore, it would be incorrect to conclude that the endotracheal tube is entirely "more advantageous" based solely on cost. When making decisions regarding medical supply preferences, hospital administrators and clinicians should use a comprehensive approach that considers not only cost analyses but also patient-specific clinical outcomes and comfort.

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