INTRODUCTION

Low-flow anesthesia has many advantages in term of decreasing atmospheric pollution, economy and better maintenance of airway temperature and humidification.1,2 Baker in 1994 used following classification for low-flow anesthesia: minimal flow as <500ml fresh gas flow (FGF) per minute, low-flow as >0.5-1 lit/min, medium flow as 2-4 lit/min of FGF and very high-flow as more than 4 lit/min of FGF.3 However, an appropriate sealing is necessary for low-flow anesthesia especially during controlled ventilation.4 Laryngeal Mask Airway (LMA) is regarded as a safer supraglottic airway for general anesthesia compared with endotracheal tubes (ETTs) having an established role on difficult airway and spontaneous ventilation.5,7 Although the LMA does not provide a watertight seal, it has been used largely during positive pressure ventilation in adults and children.8,9 Some studies support the concept of safety of using LMA during low-flow anesthesia.10,11
Postoperative complications after ETT and LMA are common; however, some studies have shown that the incidence of complications like sore throat following ETT usage is much higher than LMA. There are numerous case reports on the complications of LMA like sore throat, hoarseness, bleeding and nerve injury. The most important possible mechanism is high cuff pressure with \( N_2O \) usage during maintenance of anesthesia. Considering the fact that the rate of postoperative complications with ETT is likely to be more than LMA and using LMA during low-flow controlled anesthesia needs tight sealing of airway that needs requiring appropriate inflation of LMA cuff and on the other hand knowing that LMA cuff pressure correlates with sore throat and complications, we decided to compare the postoperative complication between LMA and ETT during low-flow anesthesia with controlled ventilation.

**METHODOLOGY**

After approval of ethics committee of Tabriz University of Medical Sciences, 80 adult patients who were scheduled to undergo elective ophthalmic surgeries with duration of almost one hour were enrolled in this randomized clinical trial. Randomization was performed with Grav Otron 2.0 (http://3d2f.com/tags/randomization).

A power analysis was performed to determine the number of patients needed to detect a 50% difference in the post operative complication between two devices based on previously published study by El-Sefy et al. An alpha error of 0.05 and power of 85% was used for this calculation. As we expected failure to follow up during the study we increased the number of patients in each group to 40. This trial is registered with IRCT registry ID: IRCT201203042582N5. Exclusion criteria consisted of expected difficult airway, history of sore throat or common cold within 10 previous days, known allergy to latex and not being fasted. Patients with ASA class I or II were randomly allocated to two forty patient groups (ETT or LMA). All patients received 2 mg midazolam for premedication. Later, induction of anesthesia was performed with propofol 2mg/kg (Diprivan, Astra-Zenca), Fentanyl 2µg/kg, lidocain 1 mg/kg and atracurium 0.5 mg/kg. Mask ventilation was performed with oxygen 100% for three minutes until achieving suitable condition. In first group, an appropriate size LMA 4 or 5 based on manufacturer recommendation was inserted using standard technique. We instilled isotonic saline over LMA cuffs before insertion. The cuff of LMA then was inflated stepwise until the audible cuff leak decreased. An appropriate size ETT (7.5 for females) and 8 for males was inserted in second group and cuff was inflated until 25 mmHg. Cuff pressure was monitored during anesthesia. After satisfactory ventilation with several manual breathes, the airway device was connected to anesthesia machine. Maintenance of anesthesia was performed with \( O_2/N_2O \) 50%, isoflurane and fresh gas flow of 6 lit/min for 10 minutes to deliver isoflurane and \( N_2O \) during high uptake period after that FGF decreased to 1 lit/min and isoflurane sets to 1%. In case of insufficient anesthesia, 50-100 µg fentanyl was injected. Ventilation was continued with tidal volume of 8 ml/kg and ventilator frequency was adjusted based on ETCO\(_2\). Monitoring during anesthesia included non-invasive blood pressure, ECG, ETCO\(_2\) and pulse oximetry. System leakage (>100 ml/min), rebreathing and any attempt to increase FGF to overcome the leak were monitored during anesthesia. Isoflurane was discontinued 5 minutes to the end of surgery and FGF increased to 6 lit/min and \( O_2 \) to 100% to wash out the anesthetics. Later, patients were extubated and transferred to Post Anesthesia Care Unit (PACU). In PACU the incidence of sore throat, cough, difficulty in swallowing and shivering were monitored for all patients till 2 hours.

All data were analyzed by SPSS version 17. Data were reported as mean±SD. Qualitative and quantitative variables were analyzed with chi square and unpaired t tests respectively. P value less than 0.05 was considered as statistically significant.

**RESULTS**

Eighty adult patients (61% female and 31% male) were enrolled in this trial. Demographic characteristic of patients are shown in Table-I, while 37.5% of patients had ASA class I and 63.5% had ASA class II. Leakage was observed in five cases (6.2%), from which two cases were in ETT and three cases in LMA groups (P>0.05). Sore throat complication was observed in 40% and 5% of the patients in ETT and LMA groups respectively.

### Table-I: Demographic characteristics of patients.

|       | LMA  | ETT  | P value |
|-------|------|------|---------|
| M/F   | 15/25 | 18/22 | >0.05   |
| ASA1/II | 18/22 | 14/26 | >0.05   |
| Age   | 65±11.1 | 71±6.75 | >0.05   |
| Anesthesia duration | 41±5 | 37±4 | >0.05 |

P value <0.05 is considered as statistically significant.
and LMA groups respectively (P<0.01, r=0.419). Postoperative shivering was reported in 27.5% and 25% of patients in LMA and ETT groups (P>0.05, r=-0.028). Some patients (6.3%) in ETT group had difficulty in swallowing; however, no similar cases were reported in LMA group. Cough was seen in 22% of all patients (16 and 2 patients in ETT and LMA groups respectively). Postoperative cough and difficulty in swallowing was significantly less in LMA group than ETT group (P<0.05, r=0.25).

General results are shown in Table-II. ETCO2 values measured in two groups revealed no significant difference (36.6±3.2 in ETT group vs. 37.5±2.4 in LMA group).

### DISCUSSION

Respiratory complications in the form of laryngospasm or bronchospasm during emergence from anesthesia, or postoperative sore throat and postoperative cough are major areas of concern while choosing a device for pediatric airway management. The etiology of respiratory tract complications in the perioperative period is multifactorial, including improper endotracheal tube size, cuff design, lack of airway humidity, trauma during insertion and suctioning, high anesthetic gas flow rates and manipulation of the airway and adjacent tissues.18

Engelhardt et al. showed that pressure controlled ventilation using LMA is an alternative to a cuffed ETT during low-flow circle system anesthesia in children. He concluded that low FGF is unlikely to be achieved consistently using an uncuffed ETT due to a substantial leak.19

A meta-analysis was performed on randomized prospective trials comparing the laryngeal mask airway (LMA) with other forms of airway management to determine if the LMA possessed any advantages over ETT or facemask. Advantages of LMA over the ETT included: increased speed and ease of placement by both inexperienced and experienced personnel; improved hemodynamic stability at induction and during emergence; minimal increase in intracorporeal pressure following insertion; reduced anesthetic requirements for airway tolerance; lower frequency of cough during emergence; improved oxygen saturation during emergence; and lower incidence of sore throat in adults. Disadvantages over the ETT were lower seal pressures and a higher frequency of gastric insufflations.20 Ates et al. showed that LMA can be regarded as a safe product for airway maintenance during ophthalmic surgery with a stable circulation and few complications.21

Cameron et al. conclude that LMA provides as good a gas tight seal as a ETT and is of benefit in reducing anesthetic gas pollution.7 These studies showed that LMA could be used as an alternative device for maintenance of anesthesia during spontaneous ventilation. Wahlen and colleagues showed that clinically undetected LMA malpositioning is a significant risk factor for gastric air insufflation in children between 3 and 11 years, undergoing positive pressure ventilation, especially at inspiratory airway pressures above 17 cmH2O.22

Gastric insufflation and tight sealing are concerns of LMA during controlled low-flow anesthesia; however, no significant difference was observed between LMA and ETT administration in this regard in our study. This may be due to the fact that during low-flow anesthesia we checked for correct positioning of LMA and monitored airway pressure to be less than 15-20 cmH2O; additionally, thanks to the modern anesthesia machines, we had low incidence of gastric insufflation and also minimal air leak due to limited FGF.

Honnemann and coworkers showed that the use of LMA was more likely to be associated with gas leak than the use of ETT; however, if modern anesthesia machines and monitors are used, in 96.7% of the patients managed with LMA, a reduction in the FGF to 0.5 L/min was possible. The incidence of postoperative complaints (coughing, sore throat, and swallowing problems) was higher after the use of ETT11, which is similar to our study.

Rieger et al. showed that there is a distinct pattern of laryngo-pharyngeal complaints following the use of the LMA and ETT and with regard to minor laryngo-pharyngeal morbidity, the advantage of the LMA to ETT is questionable.23

Yu and coworkers in a study showed that for the patients receiving general anesthesia, the use of the LMA resulted in a statistically and clinically significant lower incidence of laryngospasm.

| Complications          | LMA | ETT | P value |
|------------------------|-----|-----|---------|
| Leak                   | 3   | 2   | 0.6     |
| Sore throat            | 2   | 16  | 0.001   |
| Difficulty in swallowing | 0  | 5   | 0.02    |
| Cough                  | 2   | 16  | 0.001   |
| Shivering              | 11  | 10  | 0.7     |

P value <0.05 is considered as statistically significant.
during emergence, postoperative hoarseness, and coughing than when using the ETT. 24

Wrong and colleagues showed that cuff pressure in LMA is closely related to the development of sore throat with higher pressures increasing its likelihood. Hence, cuff pressures should be measured routinely using a manometer to minimize the incidence of sore throat. 25,26

Bugard et al. showed that a significant increase in cuff pressure is seen during the first 60 minutes. Three minutes after insertion of the laryngeal mask, cuff pressure can be significantly reduced without any major gas leakage. Postoperative sore throat can be reduced when cuff pressure is continuously monitored and kept on low-pressure values. 16

Dadmehr et al. showed that there was no significant difference between the LMA and ETT regarding complications (nausea, vomiting, coughing and sore throat) in the first 24 hours following the surgery. 27

Postoperative shivering between two groups did not show any significant difference, as we used the same anesthetic during similar surgeries with equal duration of anesthesia between two groups which is like to previous studies. 28 Incidence of postoperative cough and difficulty in swallowing between two groups had a significant difference in favor of LMA group which was similar to the previous studies. It might be due to the more neural defect with ETT compared to LMA.

Incidence of complications after anesthesia with LMA seems to be related to intra-cuff pressure, so in lower pressure we expect to have lower complications; however, during low-flow anesthesia we need higher cuff pressure to achieve tight sealing and avoid any probable air leak. The results obtained from our study showed that opposed to mentioned sentences, complications of LMA during low-flow anesthesia are lower than ETT which may be due to better and careful insertion techniques and careful monitoring of LMA position.

**In conclusion:** If we use careful insertion techniques, correct LMA positioning and routine monitoring of LMA cuff pressure, we could use LMA as a safe alternative with lower incidence of post operation complications compared to ETT during low-flow controlled anesthesia with modern anesthetic machines.

**Limitations of the study:** Our study was a single center study in ophthalmic surgery patients, therefore, larger multi-center studies with larger sample sizes are recommended to show the differences between complications of LMA and ETT during low-flow controlled anesthesia. We evaluated only some of the complications between ETT and LMA and some others like gastric insufflations are not mentioned in this study. We also evaluated the complications for two hours after anesthesia and we didn’t compare complications after two hours.

**ACKNOWLEDGMENT**

Special thanks to Dr. Jafar Rahimipanahi, Dr. Mohammadreza Afhami, Mr. Shahrkh Teshnedel, Mr. Qorbanali Tarinezhad and operating room staff of Nikookary hospital.

**REFERENCES**

1. Frohlich D, Schwall B, Funk W, Hobbahn J. Laryngeal mask airways and uncuffed tracheal tubes are equally effective for low flow or closed system anesthesia in children. Br J Anesth. 1997;79:289-292.
2. Logan M. Breathing system. Effect of fresh gas flow rate on enflurane consumption. Br J Anesth. 1994;73(6):775-778.
3. Baker AB. Low flow and close circuits. Anesth Intensive Care. 1994;22:341-342.
4. Baum J. Low flow anesthesia. Eur J Anesthesiol. 1996;13:432-435.
5. Mahmoodpoor A. Role for the second anesthesiologists in failed intubations. Anesth Analg. 2006;102(3):971.
6. Smith I, Joshi G. The laryngeal mask airway for outpatient anesthesia. J Clin Anesth. 1993;5:22s-28s.
7. Cameron AE, Sievert J, Asbury A, Jackson R. Gas leakage and laryngeal mask airway. A comparison with the tracheal tube and face mask during spontaneous ventilation using a circle breathing system. Anesthesia. 1996;51(12):1117-1119.
8. El Seify Z, Khattab AM, Shaaban A, Radojevic D, Jankovic I. Low flow anesthesia: efficacy and outcome of laryngeal mask airway vs pressure optimized cuffed endotracheal tube. Saudi J Anesth. 2010;4(1):6-10.
9. Mason DG, Bingham RM. The laryngeal mask airway in children. Anesthesia. 1990;45:760-763.
10. Mollhoff T, Burgard G, Prient T. Low flow and minimal flow anesthesia using the laryngeal mask airway. Eur J Anesth. 1996;13:456-462.
11. Honemann CW, Hahnenkamp K, Mollhoff T, Baum JA. Minimal flow anesthesia with controlled ventilation: comparison between laryngeal mask airway and endotracheal tube. Eur J Anesth. 2001;18:458-466.
12. Reier CE. Bleeding, dysphagia, dysphoria, dysarthria, severe sore throat, and possible recurrent laryngeal, hypoglossal and lingual nerve injury associated with routine laryngeal mask airway management. Where is the vigilance? Anesthesiology. 2004;101:1242-1244.
13. Endo K, Okabe Y, Maruyama Y, Tsukatani T, Furukawa M. Bilateral vocal cord paralysis caused by laryngeal mask airway. Am J Otolaryngol. 2007;28:126-129.
14. Stewart A, Lindsay WA. Bilateral hypoglossal nerve injury following the use of the laryngeal mask airway. Anaesthesia. 2002;57:264-265.
15. Brimacombe J, Clarke G, Keller C. Lingual nerve injury associated with the ProSeal laryngeal mask airway: a case report and review of the literature. Br J Anaesth. 2005;95:420-423.
16. Burgard G, Mollhoff T, Prien T. The effect of laryngeal mask airway pressure cuff on postoperative sore throat incidence. J Clin Anesth. 1996;8(3):198-201.
17. Tu HN, Saidi N, Lieutaud T, Bensaid S, Menival V, Duvaldestin P. Nitrous oxide increases endotracheal cuff pressure and the incidence of tracheal lesions in anesthetized patients. Anesth Analg. 1999;89:187-190.
18. Cozine K, Stone JG. Determinants of postoperative sore throat. Anesthesiology. 1993;79:24.
19. Engelhardt T, Johnston G, Kumar MM. Comparison of cuffed, uncuffed tracheal tubes and laryngeal mask airways in low flow pressure controlled ventilation in children. Pediatr Anesth. 2006;16(2):140-143.
20. Brimacombe J. The advantages of the LMA over the tracheal tube or facemask: a meta-analysis. Can J Anaesth. 1995;42(11):1017-1023.
21. Ateş Y, Alanoğlu Z, Uysalel A. Use of the laryngeal mask airway during ophthalmic surgery and few complications: a prospective audit. Acta Anaesthesiol Scand. 1998;42:1180-1183.
22. Wahlen BM, Heinrichs W, Latorre F. Gastric insufflations pressure, air leakage and respiratory mechanics in the use of laryngeal mask airway (LMA) in children. Paediatr Anaesth. 2004;14:313-317.
23. Rieger A, Brunne B, Hass I, Brummer G, Spies C, Striebel HW, et al. Laryngo-pharyngeal complaints following laryngeal mask airway and endotracheal intubation. J Clin Anesth. 1997;9(1):42-47.
24. Yu SH, Beirne OR. Laryngeal mask airways have a lower risk of airway complications compared with endotracheal intubation: a systematic review. J Oral Maxillofac Surg. 2010;68(10):2359.
25. Wong JG, Heaney M, Chambers NA, Erb TO, Von Ungern-Sternberg BS. Impact of Laryngeal Mask Airway cuff pressure on the incidence of sore throat in children. Paediatr Anaesth. 2009;19:464-469.
26. Mc Hardy FE, Chung F. Postoperative sore throat: cause, prevention and treatment. Anaesth. 1999;54(5):444-453.
27. Dadmehr H, Negargar S, Mahmoodpoor A, Ghaderi B, Anvari H, Rahmani A. Comparison of the effects of endotracheal tube and laryngeal mask airway on immediate postoperative complications in elective operation. Shiraz E Med J. 2010;11:191-197.
28. Idrees A, Anees Khan F. A comparative study of positive pressure ventilation via Laryngeal Mask Airway and Endotracheal Tube. J Pak Med Assoc. 2000;50:333-338.

Authors:

1. Ali Peirovifar,
   Associate Professor of Anesthesiology,
   Fellowship of Critical Care Medicine, Faculty of Medicine,
2. Mahmood Eydi,
   Associate Professor of Anesthesiology, Faculty of Medicine,
3. Mir Mousa Mirinejhad,
   Associate Professor of Anesthesiology, Fellowship of cardiovascular anesthesia, Faculty of Medicine,
4. Ata Mahmoodpoor,
   Assistant Professor of Anesthesiology, Fellowship of Critical Care Medicine, Faculty of Medicine,
5. Afshaneh Mohammadi,
   Medicine student, Faculty of Medicine,
6. Samad EJ Golzari,
   Physical Medicine and Rehabilitation Research Center,
   Students’ Research Committee,
1-6: Anesthesiology Research Team,
   Department of Anesthesiology,
   Tabriz University of Medical Sciences,
   Tabriz, Iran.