REMIFENTANIL REQUIREMENT FOR CLASSIC™, FASTRACH™ AND I-GEL™ LARYNGEAL MASK AIRWAY INSERTION WITH TARGET-CONTROLLED PROPOFOL INFUSION

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ABSTRACT

***Aim**: To determine the 50% effect-site concentration (EC_{50}) of remifentanil in order to provide clinically acceptable insertion conditions for classic laryngeal mask airways (c-LMA), fastrach LMA (f-LMA), and I-gel LMA at a 4 ng mL^{-1} target controlled infusion (TCI) of propofol.*

***Material and method**: This prospective randomized study enrolled 102 patients. Patients were randomly divided into three groups to provide the airway with c-LMA (n=38), f-LMA (n=33), or with I-gel LMA (n=31). After premedication with 0.04 mg kg^{-1} midazolam, remifentanil with effect site 4 ng mL^{-1} TCI was given to the first patient in each group. After achieving target effect-site concentration of remifentanil, TCI propofol 4 ng mL^{-1} effect-site concentration was started in all patients. The dose of remifentanil used for subsequent patients in each group was determined by the response in the previously tested patient by using Dixon's modified up-and-down method with 0.2 ng mL^{-1} step size. Heart rate (HR), mean arterial pressure (MAP), bispectral index (BIS) value, insertion time, number of attempts, and mask ventilation were also recorded.*

***Results**: From Dixon's modified up-and-down method, EC_{50} of remifentanil was determined to be 1.56 ng mL^{-1} for c- LMA, 2.41 ng mL^{-1} for f-LMA, and 1.78 ng mL^{-1} for I-gel LMA. The probit analysis determined that the EC_{50} was 0.648ng mL^{-1} for c-LMA, 0.767 ng mL^{-1} for f-LMA, and 0.754 ng mL^{-1} for I-gel LMA. The EC_{50} values obtained with a probit analysis did not differ significantly from those calculated from the up-and-down method ($p>0.05$). HR and MAP values significantly decreased from baseline values when compared with before insertion or 1 min after insertion in all groups ($p<0.05$). Mean insertion times were 25.2 ±3.2 sec for c-LMA, 27.3±4.8 sec for f-LMA, and 16.9 ±1.3 sec for I-gel LMA. The insertion time for I-gel was significantly shorter than for c-LMA or f-LMA ($p<0.05$).*

***Conclusion**: Fastrach LMA required the highest dose of remifentanil (2.41 ng mL^{-1}), the second highest dose for I-gel, and the lowest dose for classic LMA (1.78 ng mL^{-1}, 1.56 ng mL^{-1}, respectively) in healthy adults.*

***Key words**: Laryngeal mask airway, target-controlled infusion, effect-site concentration, propofol, remifentanil.*

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Introduction

Laryngeal mask airways (LMA) are being used with increasing frequency due to increasing rates of outpatient-based and minimally invasive surgery. In addition to short surgical procedures, LMAs are used in cases of difficult airway management and resuscitation[1,2].

Different types of LMAs are currently available. Classical LMA (c-LMA, Laryngeal Mask Company, Henley-on-Thames, UK), first introduced in 1988, features a soft rubber tube with a silicon cuff at the distal tip that fits tissue around the glottic opening and that can be inserted blindly. Fastrach LMA (f-LMA, North America Inc., San Diego, CA) offers some advantages over classical LMA. In addition to allowing oxygenation and blind tracheal intubation by means of an endotracheal tube, f-LMA's shorter tube length and its metal grip also allow single-handed insertion without moving the patient's head and neck for those with an unstable spine and limited mouth opening. The I-gel LMA (Intersurgical Ltd, Wokingham, Berkshire, UK), which has been available since

2007, has an additional canal to insert a gastric suction tube. Besides this, what distinguishes the I-gel LMA from other laryngeal masks is its state-of-the-art non-inflatable cuff. A soft, gel-like, non-inflatable cuff made of thermoplastic elastomer (styrene ethylene butadiene styrene) completely matches the perilaryngeal anatomy. This design allows the user to readily insert the device with a reliable seal pressures causing less trauma to surrounding tissue[3-7].

Laryngeal masks should be inserted after an adequate depth of anaesthesia is achieved to prevent adverse events, such as laryngospasm, gagging, or movement. Propofol is preferred to thiopental sodium as it has a more prominent depressant effect over pharyngeal and laryngeal reflexes. The most important adverse effect of propofol is hypotension. Propofol, when administered alone to insert LMA, requires higher bolus doses (2.5-3.0 mg kg^{-1}) or target plasma concentration (7-9 μg mL^{-1}), which may cause profound hypotension[8,9].

Opioids are generally used as an adjunct to decrease the required dose of propofol. Opioids aid not only in decreasing the dosage of propofol but also potentiating the positive effects of propofol that diminish the laryngeal and pharyngeal reflexes. Classically, remifentanil has been the opioid of choice to administer with propofol due to the rapid onset of its intense analgesic effect, which helps attenuate painful stimulation during intubation or LMA insertion[10-14]. Combined use of these agents to achieve appropriate insertion conditions may still result in severe hypotension and bradycardia.

Target controlled infusion (TCI) was first proposed in 1997 as a method of continuous infusion as it proved to be less likely to cause overdose-linked adverse effects, providing more pronounced cardiovascular stability than the traditional weight-based technique[15,16]. Initially, the drug doses for TCI were adjusted by the target plasma concentration; however it was shortly revealed that targeting plasma concentration led to a delayed clinical effect due to equilibration between concentrations of effect-site (i.e., site of action, central nerve system) and plasma concentration.

Therefore, it is recommended that effect-site concentration rather than the plasma concentration should be preferred as the monitoring parameter in order to satisfactorily benefit from the application[15]. Schnider and Marsh have proposed two pharmacological models for propofol infusion. The authors each used a different parameter to determine the infusion rates of the drug[17,18]. Marsh's model relies on the patient's weight for the administration of propofol. Schnider's model adjusts the dose and infusion rate by age, gender, height and weight and a well-described time course of the clinical effect from EEG. Minto's model, which is used for TCI of remifentanil, considers age and lean body mass as significant demographic factors to be used to adjust the dose of remifentanil[19].

The optimal effect-site concentration for propofol-only application was studied with different LMA types[3]. Also, optimal remifentanil effect-site concentration for classic LMA insertion during constant dose target-controlled propofol infusion has been reported previously[13]. However, the optimum effect-site concentrations of remifentanil with constant-dose propofol-based TCI for the insertion of classic, fastrach and I-gel LMAs have not yet been assessed. The aim of this study is to determine optimal effect-site remifentanil concentration by using Dixon's modified up-and-down method[20,21] when being co-administered as an adjunct to achieve an effect-site propofol concentration of 4 ng mL^{-1} in clinically acceptable insertion conditions for classic, fastrach and I-gel LMAs. The secondary outcome was the assessment of the insertion conditions, including hemodynamic variables for three different LMAs.

Materials and method

This prospective randomized study was conducted after obtaining approval from the local ethics committee and written informed consent from each patient (Ankara University Medical Faculty Ethics Committe Number: 07-290-13, Melli M). One hundred and two ASA physical status I-II patients, aged 18 to 65 years who were scheduled for minor elective surgery under general anesthesia via LMA were enrolled in the study. Random Allocation Software (RAS) was used to randomly divide patients into three study groups. In Group c-LMA (n=38) classical laryngeal mask, in Group f-LMA (n= 33) fastrach laryngeal mask and in Group I-gel LMA (n=31) I-gel laryngeal mask were used to provide the airway. Patient enrollments in groups were continued until achieving the seven independent pairs of patients who manifested a crossover from a negative response to a positive one.

Patients were included in the study if they had no history of severe cardiovascular, respiratory, renal or hepatic disease, and no gastro esophageal

reflux disease or high risk of aspiration. Those with a previous history of airway difficulty or patients with anticipated airway difficulty (i.e., Mallampati score of 3 or 4, thyromental distance < 65 mm and mouth opening < 35 mm) were excluded as were those known to have an allergy to any study drug. Patients with a body mass index (BMI) smaller than 18 or greater than 30 kg/m2 were also excluded.

After patients were transferred to the operating room, electrocardiography (ECG), peripheral oxygen saturation (SpO_2), noninvasive blood pressure (NIBP) and bispectral index (BIS) (A-2000TM, Version 3.4; Aspect Medical System Inc., Newton, MA, USA) monitoring were applied. Intravenous cannulation was performed, and saline infusion was started according to the 4:2:1 rule. All patients were premedicated with 0.04 mg kg^{-1} intravenous midazolam. Baseline heart rate (HR), mean arterial pressure (MAP), SpO_2 and BIS values were recorded. In all groups, the very first patient's induction of anaesthesia was started with TCI of remifentanil with an effect-site concentration of 4 ng mL^{-1} according to Minto's model (B. Braun's Infusomat Space TCI, B. Braun Melsungen AG34209, Melsungen Germany). Remifentanil was prepared in 100 mL 0.9% saline bags, and the final concentration was 20 μg mL^{-1}. The response obtained from each patient determined the effect-site concentration of remifentanil for the next patient in a sequential manner in each group according to Dixon's modified up-and-down method[20, 21] with a 0.2 ng mL^{-1} step size. In cases where the LMA insertion conditions were unacceptable or LMA insertion had failed, the dose of remifentanil was increased 0.2 ng mL^{-1}. If LMA insertion succeeded in satisfactory conditions, remifentanil dose was decreased 0.2 ng mL^{-1} for the next subject in the same group. Once the predetermined effect-site concentration of remifentanil was reached, propofol infusion was started with TCI (B. Braun's Infusomat Space TCI, B. Braun Melsungen AG34209, Melsungen Germany) by using Schnider model effect-site concentration of 4 ng mL^{-1} in all patients following 40 mg iv lidocain bolus. Oxygenation via face mask was maintained in all patients after loss of eyelash reflex.

Insertion of laryngeal mask was attempted 5 min after the effect-site propofol dose of 4 ng mL^{-1} had been reached and BIS <40 achieved. All LMAs were lubricated with water-soluble gel before insertion. Proper LMA size was determined according to the manufacturer's advice set by weight.

Mask ventilation and insertion of LMA were performed by the same experienced anesthesiologist (OSC) who was blinded to the remifentanil dose being used. She also rated insertion conditions and mask ventilation [Mask ventilation scores: easy, intermediate (need for oropharyngeal airway or other adjuvants) or difficult (inadequate, unstable or requiring two practioners)].

Insertion conditions of LMA were assessed beginning at the time of insertion till 1 min after the insertion using a scale similar to that was used in previous studies (Table 1)[12,22]. If a total of less than 10 points were earned from the six parameters (more than 2 intermediate or 1 poor conditions) during LMA insertion or if there was failure in placing LMA, it was considered a failure followed by an increase in the dose of remifentanil. When a total score of 10 or more was reached, the insertion was considered successful and clinically acceptable, which in turn led to a decrease in the drug dose. Two insertion attempts were allowed per patient. If the insertion failed in two attempts, 0.6 mg kg-1 rocuronium was administered and the patient was intubated.

Variable	Insertion conditions		
	Excellent	Intermediate	Poor
	(2 points)	(1point)	(0 point)
Mouth opening	Good	Moderate	Force required
Ease of LMA insertion	Easy	Moderate	Force required
Patient response			
Swallowing	Nil	Slight	Gross
Coughing or gagging	Nil	Slight	Gross
Head and body movements	Nil	Slight	Gross
Laryngospasm	Nil	Slight	Severe

Table 1: Scoring conditions for LMA insertion.

Hemodynamic variables and BIS values were recorded at basal and at 1 minute intervals subsequently until 1 min after the LMA had been placed.

Anesthesia during the operation was maintained with propofol and remifentanil. Target effect-site propofol concentration was adjusted to maintain a

BIS value between 40 and 60, and target effect-site remifentanil concentration adjustment was done to maintain mean arterial pressure within the 20% range of the baseline. Patients were ventilated to maintain normocapnia with a 50-50% O_2-air mixture. No other anesthetic applications were implemented so that the procedure was standardized.

Hypotension was defined as a MAP <60 mmHg that persisted for more than 1 min and was treated by incremental 5-mg boluses of intravenous ephedrine. A heart rate <40 beats/min lasting for at least 1 min was defined as bradycardia and treated with 0.5 mg of intravenous atropine. All patients were interviewed postoperatively to evaluate their memory recall. Insertion time of LMA was considered as the time between the end of the mask ventilation and moment when the wave of capnograpy was seen.

Statistical analysis

Statistical analysis was performed using a statistical package programme (SPSS 11.5, Chicago, IL, USA). The effect-site concentration of remifentanil required for successful laryngeal mask airway insertion in 50% of adults (EC_{50}) was determined by calculating the mean of the midpoint concentration of seven independent pairs of patients who manifested a crossover from a negative response to a positive one (i.e. failure to success of laryngeal mask airway insertion)[13, 14, 20, 21]. EC50 and its confidence interval (CI) were also determined by a probit analysis. In order to determine the changes in haemodynamic parameters, F1-LD-F1 design which is a nonparametric two-way factorial repeated measures design (treatment group and time as factors) was used[23]. In this analysis, we tested the average treatment effect, time effect and the effect of their interaction by an ANOVA type statistic (Fn) and summarized the results with the median (minimum-maximum) and relative treatment effect (RTE) that shows the tendency for the participants in one group to have higher or lower values compared with the values of all participants in a study. RTE can range between 0 and 1. $p< 0.05$ was considered as statistically significant.

Results

One hundred and two patients were found to be eligible and enrolled in this study. Patient characteristics are presented in Table 2. There were no significant differences between groups in terms of age, gender, BMI and ASA physical status ($p>0.05$).

	Classic LMA Group (n=38)	Fastrach LMA Group (n=33)	I-gel LMA Group (n=31)	p
Age (yr)*	41.79±12.67	43.61±13.26	37.36±12.06	0.083
Gender (F/M)**	19/19	22/11	21/10	0.157
BMI (kg m-2)*	26.44±(3.02)	26.70±2.89	25.15±3.29	0.083
ASA physical status (I/II)**	16/22	13/20	12/19	0.075

Table 2: Patient characteristics of study groups.
BMI: Body mass index, ASA: American Society of Anesthesiologists
*The cells for variables with * represent mean±standard deviation, ** represent frequencies*

LMA insertion was achievable in all patients; however, totally optimal LMA insertion conditions were reached in only 74.5% (n=76) of patients. There was no difference between groups in terms of meeting the ideal insertion conditions ($p>0.05$). Some two patients in the c-LMA group, 3 in f-LMA group, and 2 in I-gel LMA group required a second attempt. None of the patients required intubation.

Mask ventilation was rated as easy in 83 patients (81.37%), intermediate in 12 patients (11.76%), and difficult in 7 patients (6.86%). There was no significant difference between the groups relating to the mask ventilation evaluation scores ($p>0.05$). Having an easy or intermediate mask ventilation score did not affect the ratio of meeting optimal LMA insertion conditions in any of three groups ($p>0.05$). Patients in whom insertion conditions were acceptable had lower mean BMIs than patients who failed to create satisfactory conditions; however, this difference did not reach the level of statistical significance (25.78 vs. 26.89 kg.m-2) ($p>0.05$).

Figures 1-3 show individual concentration-response associations according to the up-and-down sequence in three groups. Using Dixon's modified up-and-down method, the effective concentration (EC_{50}) of remifentanil for 50% of patients with TCI being 4 μg mL^{-1} propofol was calculated as an average of seven crossover (failure-to-success) midpoints. The EC_{50} of remifentanil was detected to be 1.56 ng mL^{-1} for c-LMA, 2.41 ng mL^{-1} for f-LMA, and 1.78 ng mL^{-1} for I-gel LMA.

The probit analysis determined that the EC_{50} was 0.648 ng mL-^{1} (95% CI, 0.121-1.186ng mL^{-1})

for c-LMA, 0.767 ng mL-1 (95% CI, 0.101-1.487 ng mL-1) for f-LMA, and 0.754 ng mL^{-1} (95% CI, 0.124-1.387 ng mL^{-1}) for I-gel LMA. The EC_{50} values obtained via the probit analysis did not differ from the EC_{50} values calculated using the Dixon's modified up-and-down method.

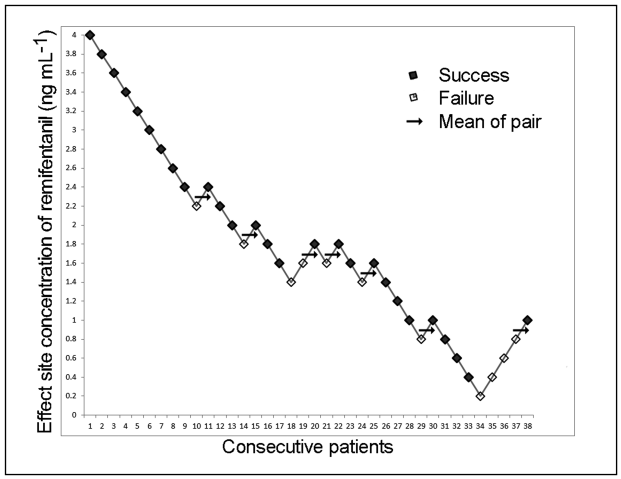

Figure 1: Patient responses to classic laryngeal mask airway insertion. Arrows indicate the midpoint of the remifentanil effect-site concentration of all independent pairs of patients involving crossover from a negative response to a positive response (failure to success of laryngeal mask airway insertion). EC_{50} of remifentanil was determined as 1.56 ng mL^{-1} for classic LMA.

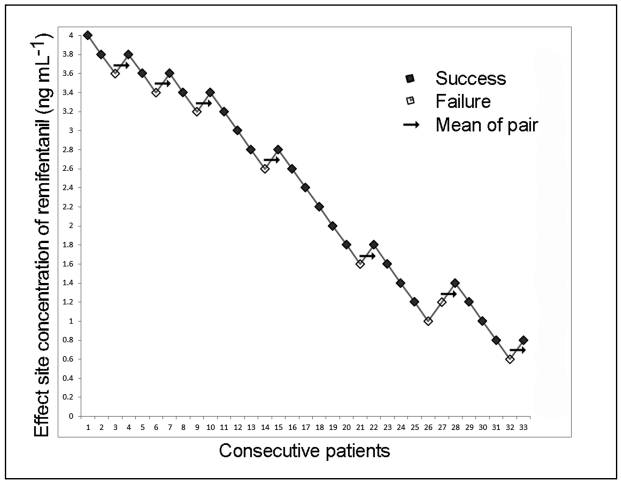

Figure2. Patient responses to fastrach laryngeal mask airway insertion. Arrows indicate the midpoint of the remifentanil effect-site concentration of all independent pairs of patients involving crossover from a negative response to a positive response (failure to success of laryngeal mask airway insertion). EC_{50} of remifentanil was determined as 2.41 ng mL^{-1} for fastrach LM**A**

Hemodynamic parameters of patients are shown in Table 3. Baseline MAP values (p=0.490) and heart rates (p=0.144) didn't differ among the three groups. MAP and HR values measured before and 1 min after the LMA insertion were significantly reduced in comparison with baseline values in all groups (p<0.001). There was, however, no significant difference between the hemodynamic values obtained before and 1 min after the insertion in any of the groups (p>0.05). None of the patients had clinically significant hypotension or bradycardia periods requiring additional intervention or treatment. Patient interviews performed postoperatively revealed that there were no patients with memory recall. BIS values measured before and 1 min after the insertion were significantly decreased in all groups when compared to baseline values (p<0.05), but BIS values measured before and 1 min after the insertion were not different in any group (p>0.05). No difference was detected between the groups in terms of BIS values obtained (p>0.05).

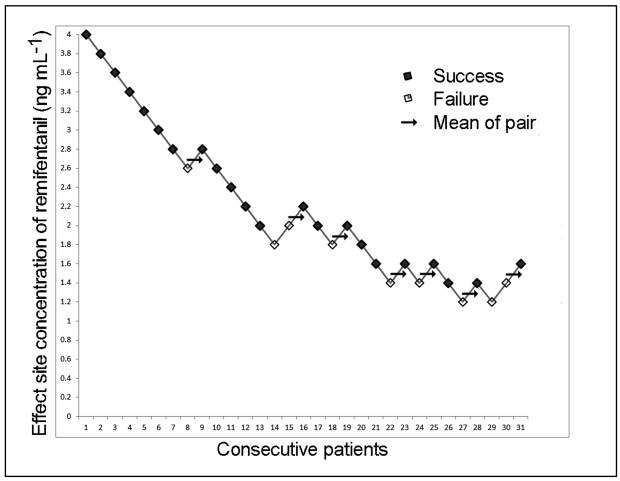

Figure 3: Patient responses to I-gel laryngeal mask airway insertion. Arrows indicate the midpoint of the remifentanil effect-site concentration of all independent pairs of patients involving crossover from a negative response to a positive response (failure to success of laryngeal mask airway insertion). EC_{50} of remifentanil was determined as 1.78 ng mL-^{1} for I-gel LMA.

The mean (±standard deviation) insertion times were 25.2 ±3.2 sec for c-LMA, 27.3±4.8 sec for f-LMA, and 16.9 ±2.3 sec for I-gel LMA. The difference in the insertion times between c-LMA and f-LMA groups was not statistically significant (p>0.05). However, the insertion time for I-gel was significantly shorter than those for c-LMA and f-LMA (p<0.05).

Discussion

The results of our study have demonstrated that fastrach LMA insertion requires higher doses of remifentanil to create acceptable clinical conditions as compared to the classic LMA and I-gel

LMA at a 4 ng mL^{-1} propofol TCI effect-site concentration.

	Group c-LMA			Group f-LMA			Group I-gel LMA			Factor		
	Baseline	Insertion	1 min after insertion	Baseline	Insertion	1 min after insertion	Baseline	Insertion	1 min after insertion	Group	Time	Interaction
HR	80 (55-148) 0.62	68 (43-114) 0.39	68 (44-115) 0.34	85 (55-133) 0.71	68 (50-97) 0.38	67 (48-97) 0.36	86 (56-119) 0.69	75 (49-99) 0.49	72 (53-99) 0.47	0.144	<0.001	0.076
MAP	91(71-122) 0.70	72(50-106) 0.33	73(50-101) 0.35	98(55-114) 0.76	74(51-115) 0.36	74(56-119) 0.40	92(62-124) 0.70	77(51-105) 0.43	76(52-113) 0.41	0.490	<0.001	0.303

Table 3. Heart rate and mean arterial pressure values of groups during study period.
HR: Heart rate, MAP: Mean arterial pressure
**cells represent median (minimum-maximum) and RTE (relative treatment effect)*

The structural differences of different types of LMAs can affect anesthesia requirements. Different airway equipment interacts with different parts of the airway resulting in varying push and strain forces on the airway. This is likely to generate dissimilar hemodynamic and airway reflexes. Therefore, the depth of anesthesia needed to provide stabile hemodynamic response and suppress airway reflexes differs from one type of LMA to another. Fastrach and classic LMAs have a cuff that is inflated after insertion. Additionally, f-LMA has a rigid curved tunnel that can accommodate cuffed endotracheal tubes of up to 8-mm if intubation is needed. I-gel LMA has an amorphous gel-like, non-inflatable cuff designed to completely suit the perilaryngeal anatomy; however, I-gel has a part (buccal cavity stabilizer) that is wider and more rigid than that of a classic LMA and accommodates the gastric channel and ventilation port together. The results of this study suggest that structural differences between the three LMAs lead to a difference in the EC_{50} remifentanil doses required to maintain a 4 ng mL^{-1} propofol TCI. Fastrach-LMA required the highest mean dose of remifentanil (2.41 ng mL-1), most likely due to its rigid curved tunnel. One can expect considerably lower doses of remifentanil for I-gel LMA given its uncuffed design; however, we found that I-gel LMA required the second highest mean dose, and c-LMA the lowest dose (1.56 ng mL^{-1} and 1.78 ng mL^{-1}, respectively). Several factors might have made this happen. The first would be the experience of the practitioner. I-gel LMA is easier for junior practitioners or paramedics to insert quickly than c-LMA[24,25]. In our study, all LMAs were inserted by the same experienced anesthetist (OSC) (over than 200 occasions with each of the models) with similar success rates.We believe that the cuff design is not the only factor determining the required concentration of remifentanil; the wider part of the I-gel LMA, which contains the gastric channel and ventilation port, might have increased the dose of remifentanil needed to insert the I-gel in clinically acceptable insertion conditions. Also, Janakiraman et al.[4] demonstrated a success rate of 86% for c-LMA and 54% for I-gel on the first attempt. After the first attempt, they switched to a larger I-gel LMA that increased the success rate with the device, though the rate was still lower than with c-LMA (84% vs. 92%, respectively). They also found that c-LMA was easier to insert than I-gel (90% vs. 80%, respectively). We used an I-gel LMA size that was recommended by the manufacturer; however, an I-gel of a different size might also change our results.

The mean insertion time was longer for the f-LMA and c-LMA groups than for the I-gel group, probably due to the fact that no cuff inflation is required for I-gel LMA. Atef et al.[26] observed insertion times similar to our results for I-gel and c-LMA. In another study, the mean insertion time was shorter for I-gel LMA (11.12 ± 1.8 sec); however, they administered rocuronium bromide, which might have facilitated the insertion of I-gel LMA[27].

LMA insertion was achievable in all patients, but only three-fourths of all attempts were successful in our study. No difference was observed between the groups in terms of successfully instituting the insertion conditions. Our rates of instituting conditions cannot be compared with those of relevant studies due to the use of different study protocols and criteria adapted for outcome measurements[3,4,13]. For instance, Tsutsui et al. considered patient response as a failure only if gross movement of the body or limbs occurred[3].

During the study period, MAP, HR and BIS values obtained before and 1 min after the insertion were significantly lower than baseline values in all groups. There was no difference in the hemodynamics and BIS values between measurements done before and 1 min after LMA insertion. Also, none of the patients needed intervention for the treatment of hypotension or bradycardia. These findings suggest that the goal of achieving an adequate depth of anesthesia was achieved in this study without causing any deleterious effect on hemodynamic variables for three different types of LMA; however, it does not make sense to compare hemodynamic variables among groups because each patient received different remifentanil doses.

Our results might have been influenced by our study protocol, which included the sequence of drug administration - the standby time before inserting laryngeal masks and after achieving the target effect-site concentration of drugs as well as the administration of midazolam and lidocaine. In the present study, EC_{50} of remifentanil for successful c-LMA insertion was 1.56 ng mL^{-1}. Kim et al.[10] administered relatively higher doses of midazolam (0.05 mg kg^{-1}) and lidocaine (1 mg kg^{-1}) prior to the LMA insertion and reported similar EC50 for remifentanil (1.78 ng mL^{-1}) with 3.5 ng mL-1 propofol TCI. In a study that used a similar lidocaine dose but no midazolam premedication, EC50 of remifentanil was detected as 3.04 ng mL^{-1} during a 3.5 ng mL^{-1} propofol TCI[13]. Midazolam can deepen propofol-based anesthesia and facilitate the LMA insertion, thereby decreasing the remifentanil requirement. Also, the use of lidocaine administration to attenuate propofol pain may suppress airway reflexes and hemodynamic responses.

There are some limitations of our study. Grading LMA insertion conditions according to the observer's assessment, especially for conditions scored as intermediate or poor, may be considered a subjective way of doing so. To minimize or eliminate such possible difference, all LMA insertions and assessments were done by the same investigator, who was blinded to the remifentanil doses. In addition, that physician was experienced with three types of LMAs. Nevertheless, this may prevent the reproduction of our results by practitioners who have different levels of experience.The ability to predict the anesthesia requirement before inserting different types of LMA is particularly important in patients with poor physical status. All patients enrolled in our study were ASA I-II, 18- to 65-year-old, otherwise healthy individuals. Pharmacokinetics and pharmacodynamics of both study drugs may be different in geriatric population. Poor physical status complicated by concomitant severe diseases may affect the hemodynamic response to drugs. Therefore, the exclusion of these groups of patients probably produced hemodynamic responses well tolerated in all study groups. Our results may not be generalized to the entire adult population. However the results of our study can provide insights into the drug requirement predictions for different patient groups.

In conclusion, our results suggest that Fastrach LMA insertion necessitates higher doses of remifentanil compared to classic LMA and I-gel LMA at a constant effect-site concentration of propofol TCI. The effect site EC_{50} level for remifentanil was determined as 1.56 ng mL^{-1} for classic LMA, 2.41 ng mL-1 for fastrach LMA, and 1.78 ng mL^{-1} for I-gel LMA with 4 ng mL^{-1} effect-site concentration of propofol TCI in otherwise healthy adults. Further studies are warranted to evaluate remifentanil doses that would be required to use various types of LMA and produce acceptable clinical conditions in different patient groups (e.g., geriatric, obese, children).

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