

Optimum time of LMA ProSeal removal in adult patients undergoing isoflurane anesthesia: A randomized controlled trial

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Abstract

Background and Aims: Optimum timing of laryngeal mask airway (LMA) removal after general anesthesia with isoflurane is debatable. The objective was to investigate the potential benefits of removing LMA ProSeal at ≤ 0.4 Minimum alveolar concentration (MAC) isoflurane over awake and “deep plane” extubation after short duration laparoscopic gynecological surgery.

Material and Methods: In this prospective randomized trial 90 adult female patients undergoing elective laparoscopic surgery under general anesthesia using LMA ProSeal™ as airway device were included. At the end of surgery, LMA ProSeal™ was removed when the patient was awake, could open mouth following verbal command (Group A); at MAC ≤ 0.4 (Group B); or at MAC of 0.6 (Group C). Adverse airway events like nausea, vomiting, airway obstruction, coughing, bucking, laryngospasm were noted. Statistical analyses were done by SPSS statistical software (IBM SPSS Statistics for Mac OS X, Version 21.0. IBM Corp, Armonk, NY).

Results: Baseline demographic characteristics were comparable in all three groups. Coughing or bucking at the time of LMA removal was higher in group A ($P = 0.004$). Snoring and airway obstruction after LMA removal was significantly higher in group C compared to group A and group B ($P = 0.002$ and $P = 0.011$, respectively). There was significant change in mean arterial pressure and heart rate between before and after LMA removal on group A ($P = 0.008$ and $P < 0.001$, respectively) but not in other groups.

Conclusion: MAC ≤ 0.4 can be considered optimum depth of anesthesia for removal of LMA ProSeal in adult patients undergoing isoflurane anesthesia.

Keywords: Isoflurane, laparoscopy, laryngeal mask, minimum alveolar concentration

Introduction

Optimum timing of laryngeal mask airway (LMA) removal after inhalation anesthesia is a debatable issue. When LMA ProSeal (The Laryngeal Mask Company, Ltd, Wooburn Green Bucks, UK) is removed after airway reflexes have

returned in awake patient, who is able to open mouth on command, it is associated with increased incidence of coughing, bucking, straining, and gastric regurgitation.^[1] On the contrary, deep LMA removal is performed in a spontaneously breathing patient before airway reflexes have returned. However, even sub-hypnotic concentration of inhalation anesthetics depresses chemoreceptor sensitivity and increases pharyngeal dysfunction, which can lead to

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Access this article online	
Quick Response Code:	Website: www.joacp.org
	DOI: 10.4103/joacp.JOACP_238_19

How to cite this article: Maitra S, Baidya DK, Goswami D, Muthiah T, Ramachandran R, Subramanian R. Optimum time of LMA ProSeal removal in adult patients undergoing isoflurane anesthesia: A randomized controlled trial. *J Anaesthesiol Clin Pharmacol* 2021;37:354-9.

Submitted: 31-Jul-2019

Revised: 14-Mar-2020

Accepted: 06-Aug-2020

Published: 12-Oct-2021

upper airway collapse and aspiration, respectively.^[1] Results from the previous studies vary widely mainly because of lack of any standard definition of “awake” and “deep” plane for LMA removal; hence a Cochrane database systematic review suggested the need for well-designed randomized controlled trial in this area.^[2] But definition of “deep” plane of anesthesia for LMA removal is controversial. Conventionally, both awake and deep removal may have their adverse effects.

Removal of LMA when MAC-awake (Minimum alveolar concentration) is achieved can potentially negate complications associated with deep or awake removal of LMA. MAC-awake, which was originally defined as “anesthetic concentration needed to suppress a voluntary response to verbal command in 50% of patients,” is being used as a surrogate marker of awakening at the time of emergence from anesthesia.^[3] Isoflurane is a commonly used inhalational anesthetic and has a MAC-awake end-tidal concentration of 0.49% (0.38MAC).^[3] However, majority of the studies investigating suitable time for LMA removal have been performed in children and with sevoflurane/desflurane.^[4-7] With best of our knowledge, optimum timing of LMA removal in adult patients undergoing surgery under isoflurane anesthesia has not been studied. In this prospective randomized controlled trial, we investigated the potential benefits of removing LMA ProSeal at ≤ 0.4 MAC isoflurane over awake and “deep plane” removal (MAC of 0.6) after short duration laparoscopic gynecological surgery. We hypothesized that LMA removal at 0.4 MAC isoflurane will reduce the complications associated with deep or awake removal. Primary outcome was incidence of adverse airway event (coughing or airway obstruction requiring airway maneuver). Secondary outcome were other airway and hemodynamic complications (snoring, laryngospasm, tachycardia, hypertension).

Material and Methods

After obtaining permission from the institute ethics committee and informed consent from the patients 90 female patients aged between 18 and 50 years and American society of Anesthesiologists’ physical status I or II undergoing elective short duration laparoscopic gynecological surgery (<2 hours) under general anesthesia using LMA ProSeal™ as airway device were included in this randomized parallel group trial. Patients with an anticipated difficult airway (mouth opening <3 finger, thyromental distance <3 finger, loose tooth, neck circumference >35 cm, history of previous difficult airway), history of snoring and body mass index >30.0 kg/m², history of smoking, obstructive sleep apnea (OSA), gastro-esophageal reflux disease (GERD), prior postoperative nausea vomiting (PONV), reactive airway disease were excluded from this study. This randomized

controlled trial was registered at the National Clinical Trial Registry of India (www.ctri.nic.in CTRI/2014/12/005302) and patient recruitment was done from January 2015 to August 2017.

All the patients were evaluated thoroughly in the preoperative period and checked against the exclusion criteria of this study. Patients were kept nil per oral for at least 8 h. In the operating room, standard monitors (ECG, NIBP, pulse oxymetry and EtCO₂) were applied, baseline vitals were noted and intravenous access was obtained. All patients received intravenous fentanyl 2 mcg/kg 5 min prior to induction of anesthesia. Following preoxygenation, anesthesia was induced with propofol at a dose of 2–3 mg/kg intravenously preceded by lidocaine 20 mg. After ensuring adequate positive pressure mask ventilation, intravenous injection atracurium 0.5 mg/kg was given to facilitate LMA ProSeal™ insertion. LMA ProSeal™ size was chosen as per manufacturer recommendation based on body weight and gastric drain tube was inserted through LMA ProSeal™. Anesthesia was maintained with oxygen, air, and isoflurane (fresh gas flow rate 1 L/min and FiO₂ 0.5) with a dial setting of isoflurane vaporizer 1–3% targeting an age-adjusted MAC value of 0.8–1. Volume controlled ventilation with tidal volume 8–10 ml/kg and rate 12–16/min was used to target normocarbida. Pneumoperitoneum pressure was kept 12–14 mmHg throughout the surgery. Nasopharyngeal temperature was monitored but neuromuscular monitoring was not done. Intravenous diclofenac was given at the beginning of surgery at a dose of 1.5 mg/kg and intravenous paracetamol was given at a dose of 15 mg/kg toward the end of surgery. Boluses of fentanyl at a dose of 0.5 mcg/kg was given whenever there is a change of heart rate or mean arterial pressure more than 20% from the base line after exclusion of other causes of tachycardia. Supplemental neuromuscular block was maintained by intravenous atracurium at a dose of 0.1 mg/kg when required as decided by change in capnography waveform and rise in airway pressure. Dexamethasone 8 mg at the beginning of surgery and ondansetron 8 mg was used 30 min prior to extubation as PONV prophylaxis. At the end of surgery, isoflurane was switched off, patient’s spontaneous breathing efforts were assisted and residual neuromuscular paralysis was reversed with neostigmine 0.05 mg/kg and glycopyrrolate 0.01 mg/kg. After spontaneous breathing was adequate, fresh gas flow was increased to 4 L/min and LMA was removed (along with gastric drain tube after appropriate suctioning) at appropriate MAC value or after awakening as per group allocation of the patient. Patients were randomly allocated to one of the three groups:

- Group A = LMA ProSeal™ removal after adequate reversal of muscle relaxation and when the patient is awake, can open mouth following verbal command

- Group B = LMA ProSeal™ removal after adequate reversal of muscle relaxation and MAC ≤ 0.4
- Group C = LMA ProSeal™ removal after adequate reversal of muscle relaxation and MAC of 0.6.

A computer generated random number (www.randomizer.org) list was used to prepare serially numbered sealed envelopes containing the details of the technique to be followed during extubation and was handed over to the anesthetic team (not part of the investigating team). The anesthetic team opened the envelope and followed the mentioned technique of LMA removal at the end of surgery. An anesthesiologist from the investigating team who was blinded to the allocation of the patients and intraoperative data recorded the data.

Following parameters were noted at LMA removal: Coughing or bucking with LMA *in situ* or after removal of LMA, airway obstruction requiring airway maneuver (chin lift and jaw thrust) after LMA removal, noisy breathing/snoring after LMA removal, desaturation ($SpO_2 \leq 93\%$) during or after LMA removal, nausea/vomiting up to 30 min after LMA removal. Hemodynamic parameters were noted at the time when decision was made to remove the LMA and one minute after LMA removal. Patients were transported to post anesthesia care unit, received oxygen by facemask at 5 L/min and vitals were monitored.

In the absence of previous such studies, we planned to recruit $n = 30$ patients, in each group on pilot basis with a total of 90 patients for the study to have normal distribution of data. Demographic data were expressed as mean \pm SD (age, weight, height) or proportion (ASA physical status). Intergroup comparisons of the continuous variables were done by Wilcoxon Signed rank test. Qualitative data were compared using Fisher's exact test or Chi-square test as applicable. A P value of less than 0.05 was considered significant. All statistical analyses have been done by SPSS statistical software (IBM SPSS Statistics for Mac OS X, Version 21.0. IBM Corp, Armonk, NY).

Results

Ninety-six patients were assessed for eligibility and 90 patients were recruited [Figure 1]. Baseline demographic characteristics of the patients and duration of surgery in three groups were comparable [Table 1]. Coughing and bucking at the time of LMA removal was significantly different in three groups (13 in 30 patients in group A versus 7 in 30 patients in group B and 2 in 30 patients in group C; $P = 0.004$, Chi-square test). However, airway obstruction requiring airway maneuver such as jaw thrust or chin lift was also significantly different across the groups (11 in 30 patients in group C versus 3 in

30 patients in group B and 1 in 30 patients in group A, respectively; $P = 0.002$; Fisher's exact test) as is incidence of noisy breathing after LMA removal (10 in 30 patients in group C versus 2 in 30 patients in group A and B; $P = 0.011$; Fisher's exact test). Despite the difference in requirement of airway maneuver, incidence of oxyhemoglobin desaturation was similar in three groups ($P = 0.493$, Fisher's exact test). Similarly, laryngospasm was observed in one patient in group B and two patients in group C but it was not significantly different. All adverse airway event data are mentioned in Table 2. Overlapping of complications were also noted. Those who had laryngospasm also had desaturation and airway obstruction requiring maneuver. Similarly those patients who had vomiting also had reported nausea prior to or after vomiting.

There was a significant change in the heart rate and mean arterial pressure in group A patients before and after LMA removal ($P < 0.001$ and $P = 0.008$, respectively; Wilcoxon matched pair test). Mean arterial pressure and heart rate were similar before and after LMA removal in rest of the group [Table 3].

Discussion

Principal findings of this randomized controlled trial are that LMA ProSeal removal at deep plane of anesthesia (MAC of 0.6) is associated with higher need for airway maneuver (jaw thrust/chin lift) and LMA ProSeal removal in "awake state" is associated with coughing/bucking and increased hemodynamic response compared to LMA ProSeal removal at MAC ≤ 0.4 . However, adverse airway events such as laryngospasm and desaturation were similar in all three groups.

Timing of LMA removal in pediatric patients is well studied; majority of the studies have reported less respiratory adverse events when LMA is removed in "deep" plane of anesthesia. Lee *et al.* reported that during sevoflurane anesthesia, the LMA can be safely removed at an approximate 0.80–0.86 MAC in 95% of anesthetized children.^[4] Another prospective study reported that at an end-tidal concentration of 1.84% of sevoflurane, LMA removal was successful in 50% of the children.^[5] Shim *et al.* determined the end-tidal concentration of sevoflurane for LMA removal in adult patients was 1.18% and LMA could be removed without any adverse events in 95% of the patients.^[6] Similarly, another prospective study determined that end-tidal concentration of desflurane to allow smooth LMA removal was 3.9% in adult patients.^[7] Koo CH, *et al.* in their meta-analysis of deep versus awake extubation and LMA removal in pediatric patients have recommended deep extubation to minimize overall airway complications

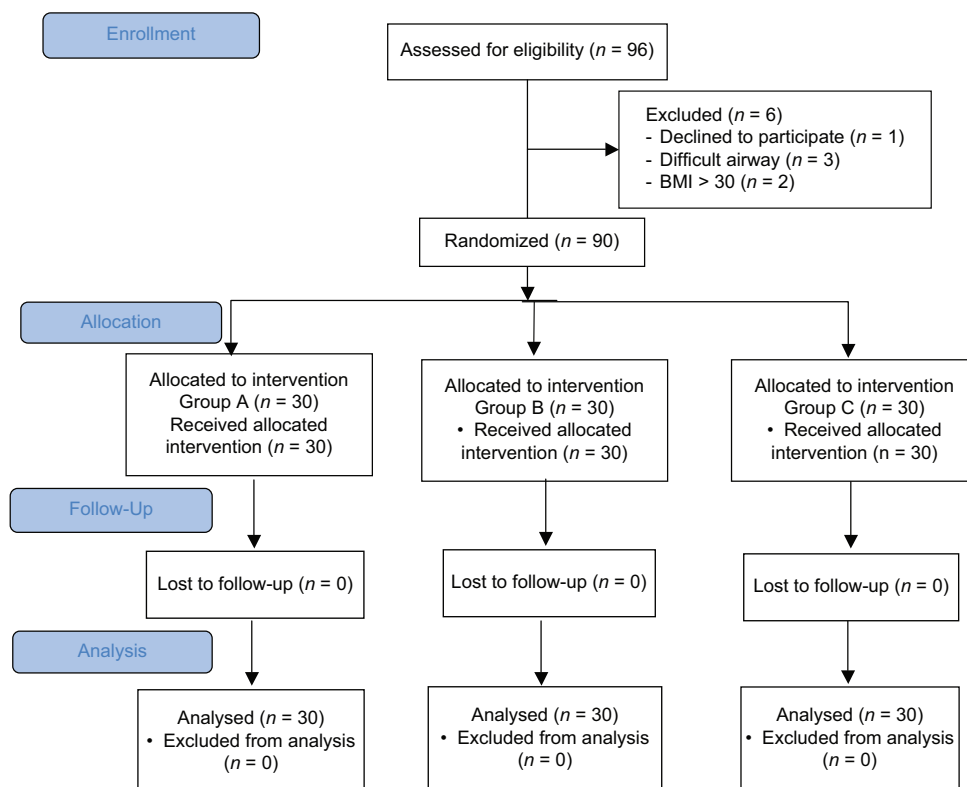


Figure 1: CONSORT Flow Diagram

Table 1: Comparison of baseline demographic parameters in three groups [Data expressed as mean (SD), median [range] or proportions as applicable]

	Group A (n=30)	Group B (n=30)	Group C (n=30)	Significance
Age (years)	29.8 (2)	29.9 (1.9)	30.3 (3.3)	P=0.73 ^s
Body weight (kg)	55.1 (5.2)	54.9 (4.9)	53.8 (4.7)	P=0.54 ^s
ASA PS (I/II)	21/9	19/11	19/11	P=0.82 ^e
Duration of surgery (minutes)	47 (8.7)	46 (8.2)	45 (11.3)	P=0.17 ^s
LMA size (size 3/4)	8/22	8/22	10/20	P=0.81 ^e
Number of attempts at LMA insertion (First/second/third)	23/6/1	23/7	23/6/1	P=0.89 ^e
Cumulative intraoperative fentanyl (mcg)	116.7 (14.4)	109.5 (11.1)	122.8 (10.9)	P=0.23 ^s

^sOne way ANOVA test. ^eChi-square test

Table 2: Adverse Clinical characteristics of LMA removal in three groups [Data expressed as proportions]

	Group A (n=30)	Group B (n=30)	Group C (n=30)	Significance
Nausea within 30 min post surgery (Y/N)	5/25	6/24	7/23	P=0.812
Vomiting within 30 min post surgery (Y/N)	2/28	2/28	3/27	P>0.999
Coughing at the time of LMA removal (Y/N)	13/17	7/23	2/28	P=0.004
Airway obstruction requiring maneuver (Y/N)	1/29	3/27	11/19	P=0.002
Laryngospasm (Y/N)	0/30	1/29	2/28	P=0.770
Desaturation (Y/N)	1/29	2/28	4/26	P=0.493
Snoring (Y/N)	2/28	2/28	10/20	P=0.011

except airway obstruction.^[8] Although the existing literature favors removal of LMA at a deeper plane of anesthesia,^[4,7,8] the instruction manual of the LMA suggests that LMA may be removed in awake patients with intact upper airway reflexes.^[9] Moreover, many clinicians prefer to remove LMA in awake patients to avoid airway obstruction. A Cochrane

database systematic review that included 15 RCTs was unable to comment upon the superiority of the either technique.^[2] Authors of that review suggested the need for further well designed randomized controlled trials in this area. However, most important challenge in designing RCT in this aspect was to define both “deep” and “awake” state of anesthesia.

Table 3: Hemodynamic changes after LMA removal in three groups, data expressed as median [IQR]

	Group A			Group B			Group C		
	Before	After	P	Before	After	P	Before	After	P
Mean arterial pressure	68 [66-74]	69.5 [68-73]	P=0.008	70 [67-74]	71 [68-74]	P=0.073	70 [68-74]	71.5 [67-75]	P=0.582
Heart rate	78.5 [75-87]	87 [78-95]	P<0.001	79 [68-88]	80.5 [69-89]	P=0.052	69.5 [64-78]	71 [65-75]	P=0.873

Our findings suggest that MAC ≤ 0.4 is the optimum time for removal of Proseal LMA. The previous studies in children using sevoflurane anesthesia suggest removal of LMA at deep plane of anesthesia.^[4,5] Similar finding was reciprocated in adult patients using sevoflurane (End tidal 1.18%) and desflurane anesthesia (end-tidal 3.9%).^[6,7] These concentrations of sevoflurane and desflurane are approximately 0.6 MAC, which is considered deep plane. However, sevoflurane and desflurane are less soluble than isoflurane, get readily washed out and patient awakens faster.^[10] Therefore, awake removal of LMA using sevoflurane and desflurane anesthesia may be associated with increased incidence of coughing, bucking, hemodynamic changes, and even laryngospasm. Moreover, since these anesthetic agents wash out fast and patient awakens fast there should be less risk of airway obstruction and requirement of jaw thrust even if the LMA is removed at deeper plane. Therefore, deep removal of LMA may be justified while using sevoflurane or desflurane. On the contrary, isoflurane gets eliminated slower and provides a smoother but longer transition to awake state compared to desflurane or sevoflurane. Therefore, removal of LMA at a deeper plane may be associated with more chance of airway obstruction and requirement of jaw thrust as observed in this study. In the current study, awake removal of LMA was associated with coughing, bucking and hemodynamic changes in isoflurane anesthesia, similar to the previous studies using desflurane or sevoflurane anesthesia. So MAC ≤ 0.4 may be considered a better time to remove LMA in isoflurane anesthesia as complications associated with both “deep” or “awake” removal are minimized.

It is worth mentioning that deep removal may have advantages in certain situations.^[7] For example, there were less hemodynamic changes with “deep” removal; though the magnitude of small difference may not be important in otherwise healthy patients, it would be more beneficial in cases where tachycardia is undesirable, such as in patients with coronary artery diseases (CAD) or mitral stenosis. In the current study, however, none of the patients had hypertension or CAD. Though “deep” removal of LMA (MAC 0.6) was associated with more need for airway support, incidence of oxyhemoglobin desaturation was not increased.

The strengths of the study are: First, this was the first study to investigate appropriate removal time of Proseal LMA (commonly used LMA in laparoscopic surgery) using

isoflurane anesthesia (commonly used inhalational agent). Second, factors which can influence LMA removal time, like presence of OSA, reactive airway disease, smoking, GERD were all excluded and almost in all patients LMA insertion was successful within two attempts. Our study has several limitations. First, although blinded anesthesiologists assessed the outcome parameters, the awake group of patients could be identified for obvious reasons. Second, we did not measure the exact MAC value in awake group during LMA removal. However, the MAC values were between 0.1 and 0.15 MAC in all the patients. Third, we used balanced anesthesia technique with inhalational agent isoflurane. So the results of the same may not hold true in case of intravenous anesthetic technique.

Conclusion

MAC ≤ 0.4 can be considered optimum depth of anesthesia for removal of LMA Proseal in adult patients undergoing isoflurane anesthesia.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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