J Anesth (2005) 19:112–117
DOI 10.1007/s00540-004-0300-2

Journal of
Anesthesia

Laryngeal mask airway can be inserted with inhaled desflurane induction

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Abstract
Purpose. In this prospective, randomized, controlled trial, we investigated the reliability of laryngeal mask airway (LMA) insertion with inhaled desflurane.
Methods. Eighty patients undergoing elective surgery were randomized into two groups to receive either 2.5 mg·kg^{-1} propofol ($n = 40$) or tidal breath desflurane ($n = 40$) induction followed by LMA insertion. All patients received fentanyl 1 μg·kg^{-1} 2 min before induction. Inhalation of desflurane was started at 3% and increased by 3% every 3–5 breaths up to settings of 12%.
Results. Insertion of the LMA was faster in the propofol group (131.8 s versus 228.6 s, $P < 0.01$). The number of patients in whom the jaw opening was described as good (95% versus 72.5%, $P = 0.27$, for the desflurane and propofol groups, respectively) and the ease of LMA insertion described as good (87.5% versus 72.5%, $P = 0.6$) were comparable. The LMA was inserted in a single attempt in the majority of patients in both groups (80% versus 77.5%, $P = 0.90$). There were more complications at insertion in the propofol group than in the desflurane group (2.5% versus 19.5%, $P < 0.01$), especially for apnea (7.5% versus 70%, $P < 0.01$) and excitatory movements (2.5% versus 25%, $P < 0.01$). There were significant decreases in the mean arterial pressure in the propofol group compared to baseline data over the first 5 min of induction. Mean arterial pressure, heart rate, and S_{PO_2} remained stable during the same period in the desflurane group.
Conclusion. We demonstrated that inhaled desflurane when used with caution in a controlled manner provided acceptable conditions for LMA insertion.

Key words Desflurane · Laryngeal mask airway · Inhaled induction

Introduction

Insertion of the laryngeal mask airway (LMA) can be accomplished with both inhalational and intravenous induction techniques. Propofol has been recommended as the induction agent of choice when the insertion of an LMA is required [1]; however, it has been associated with several disadvantages. These are prolonged apnea [2], excitatory movements, significant decreases in mean arterial pressure, and pain on injection [3]. Alternatives such as thiopentone and sevoflurane have been investigated.

Sevoflurane has been extensively investigated and it provides induction characteristics and LMA insertion conditions comparable to propofol. Desflurane is known to have a rapid onset and offset of action, thereby making it possible for the anesthetist to control the depth of anesthesia rapidly. It also appears to provide fairly cardiostable anesthesia with preservation of tissue perfusion even in the face of hypotension [4]; however, it is said to be irritating to the airway and therefore is not commonly used for inhalational induction [4,5]. However, two studies have shown that controlled desflurane inhalational induction can be rapid and well tolerated [6,7]. Another study has shown that addition of fentanyl reduced the incidence of cough from 25% to 5% [8]. Furthermore, premedication with both midazolam and fentanyl has also helped to markedly attenuate airway irritability [9].

Coughing occurs during general anesthesia, but it is caused by many factors, including desflurane [10]. In addition, in unpremedicated patients given a gradual induction with desflurane, manifestations of airway irritation such as bronchospasm, laryngospasm, and copious secretions were found to be either mild, moderate, or absent [11].

With the above properties of desflurane in mind, this study was designed to investigate the conditions that desflurane could provide for LMA insertion.

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Received: May 10, 2004 / Accepted: December 23, 2004

In this prospective, randomized, controlled trial, we compared the reliability, quality, and speed of LMA insertion after desflurane inhalational induction versus intravenous induction with propofol.

Methods

The approval of the hospital ethics committee was obtained before the start of the study and written informed consent was also obtained from all the patients who participated. A total of 80 American Society of Anesthesiologists (ASA) I or II patients undergoing surgical or orthopedic operations for which the insertion of a laryngeal mask airway (LMA) was deemed suitable were recruited.

Patients with the following conditions were excluded from the study: allergy to propofol, known or suspected susceptibility to malignant hyperthermia, heavy smokers (>20 cigarettes per day), obesity [Body Mass Index (BMI) > 30 $kg \cdot m^{-2}$], history of upper respiratory tract infection within 1 month of surgery, record of medications that can interfere with the study (e.g., anxiolytics, hypnotics), or a suspected or known difficult airway.

Patients were randomized via computer-generated random numbers to either the propofol group or the desflurane group. During the course of the study, 40 patients were recruited into each group. None of the patients were premedicated. Intravenous access was set up prior to induction of anesthesia. Monitors included electrocardiography (ECG), pulse oximetry, non-invasive blood pressure, respiratory rate, end-tidal CO_2, and end-tidal volatile agent concentration (Hewlett-Packard Anaesthetic Module M 1026 A, Boeblinger, Germany).

All patients received fentanyl 1 $\mu g \cdot kg^{-1}$ 2 min before induction and all patients were preoxygenated with 100% oxygen for 3 min. Patients in the propofol group were given propofol 2.5 $mg \cdot kg^{-1}$ mixed with 2 ml of 1% lignocaine in each 20-ml syringe of propofol. Injection was given over 30 s. Timing of induction was commenced at the start of injection and loss of consciousness was indicated by the loss of verbal contact and loss of eyelash reflex.

When the jaw was deemed to be sufficiently relaxed, LMA insertion was attempted. Time to successful insertion of the LMA from the beginning of induction was recorded. If the LMA could not be successfully inserted, gentle ventilation was carried out with 4 $l \cdot min^{-1}$ nitrous oxide and 2 $l \cdot min^{-1}$ oxygen. Further attempts were carried out at 30-s intervals, with each attempt preceded with propofol 0.5 $mg \cdot kg^{-1}$. Additional propofol 0.5 $mg \cdot kg^{-1}$ was given if an adverse event (cough, gag, movement, or laryngospasm) occurred. After the LMA was inserted, the time taken for the return of spontaneous respiration was noted.

Patients in the desflurane group were asked to maintain tidal breathing while induction was carried out with 4 $l \cdot min^{-1}$ nitrous oxide, 2 $l \cdot min^{-1}$ oxygen, and the desflurane setting at 3%. Desflurane was increased by 3% every 3–5 breaths up to settings of 12%. Time to loss of consciousness was recorded and end-tidal desflurane at this point was noted. When the jaw was relaxed, LMA insertion was attempted and the time to successful insertion was noted. End-tidal desflurane concentration was also recorded. If LMA insertion was not successful, the patient was left to breathe spontaneously at 12% desflurane in 4 $l \cdot min^{-1}$ nitrous oxide and 2 $l \cdot min^{-1}$ oxygen. Insertion attempts were repeated at 30-s intervals.

Any adverse event was treated with propofol 0.5 $mg \cdot kg^{-1}$. If the patient became apneic during induction, ventilated was continued with nitrous oxide 4 $l \cdot min^{-1}$, oxygen 2 $l \cdot min^{-1}$, and desflurane set at 12% at 10–12 breaths per minute. Mean arterial pressure (MAP), heart rate (HR), and arterial saturation (Sp_{O_2}) were noted at baseline and then at 1-min intervals until completion of LMA insertion.

The following complications were noted during induction: the presence of cough, gag, excitatory movements, laryngospasm, and breath-holding. The conditions during LMA insertion were recorded, i.e., the degree of jaw opening, ease of LMA insertion, and number of attempts. The degree of jaw opening was graded as good if the jaw was fully opened, moderate if it was partially opened, and poor if the jaw needed to be prized open. Ease of insertion was graded as good if insertion was smooth and easy; moderate if insertion was accompanied by cough, gag, or excitatory movements that were self-limited and settled without intervention; and poor if insertion was met with resistance and cough, gag, or excitatory movements that required treatment with propofol. The following complications during insertion were also noted: cough, gag, excitatory movements, laryngospasm, and apnea. The presence of blood on the LMA, indicating traumatic insertion, was noted at the end of the operation when the LMA was removed and inspected.

The same two anesthetists were responsible for all patients; the first anesthetist was in charge of inducing the patient and all LMA insertions were done by the second anesthetist who was blinded to the induction method. The second anesthetist would wait in the induction room and would only be called into the operating room to insert the LMA and grade the conditions for LMA insertion. An independent assistant recorded complications during induction and insertion. After completing insertion of the LMA, both groups of pa-

tients received desflurane, nitrous oxide, and oxygen for maintenance of anesthesia.

The patients' physical attributes were analyzed using Student's *t* test; Welch's *t* test was used for instances where a normal distribution could not be assumed, i.e., age, weight, height, and BMI. The hemodynamic data within each group were analyzed using analysis of variance (ANOVA) for repeated measurements, and the comparison of data at the same time phase between the two groups was analyzed by unpaired t-test.

Results are expressed as mean ± SD where applicable. Chi-squared tests, incorporating Fisher's exact test where appropriate, were used for the variables of complications of induction and insertion and quality of LMA insertion. $P < 0.05$ was considered to be statistically significant. From our literature review, the meta-analysis done by Hwan and Williams showed that the proportion of patients in whom the LMA was successfully inserted at the first attempt with the aid of propofol was 0.84 [12]. Taking a 30% difference in the proportion of patients with successful LMA placement at one attempt as being clinically important, we calculated that 38 patients would be required in each group for an 80% chance of detecting a true difference.

Table 1. Demographic data

Parameter	Desflurane ($n = 40$)	Propofol ($n = 40$)	*P* value
Age (year)	36.6 ± 13.8	42.5 ± 24.1	0.18
Women/men	17/23	12/28	0.10
ASA I/II	33/7	33/7	1.00
Weight (kg)	60.7 ± 4.0	61.8 ± 11.4	0.57
Height (m)	1.74 ± 0.53	1.76 ± 0.63	0.13
BMI ($kg \cdot m^{-2}$)	20.0 ± 3.9	21.2 ± 3.3	0.14

Data are mean ± SD
ASA, American Society of Anaesthesiologists; BMI, Body Mass Index

Results

The patients in both groups were comparable in terms of their physical characteristics (see Table 1). Induction was, as expected, significantly faster in the propofol group compared to the desflurane group (see Table 2). End-tidal desflurane concentration at loss of consciousness was 3.43% ± 1.53%. The overall incidence of complications was similar during induction, 3% for the desflurane group and 2.5% for the propofol group. Notably, the incidence of cough was only 5% in the desflurane group.

Insertion of the LMA was also accomplished faster in the propofol group (see Table 2). End-tidal desflurane concentration at the insertion of the LMA was 7.30% ± 1.05%. However, more importantly, the number of patients in whom the jaw opening was described as good (95% versus 72.5%, $P = 0.27$, for desflurane and propofol, respectively) and the ease of LMA insertion was described as good (87.5% versus 72.5%, $P = 0.6$) were comparable. The LMA was inserted at the first attempt in the majority of patients in both the desflurane and propofol groups (80% versus 77.5%, $P = 0.90$). The LMA was inserted within three attempts in all patients. Two patients in the desflurane group and 16 patients in the propofol group required treatment with (additional) propofol for successful insertion. No patient required the use of suxamethonium.

There were more complications at insertion for the propofol group (19.5% versus 2.5%, $P \leqslant 0.01$) (see Table 3). There were also higher incidences of apnea (70% versus 7.5%, $P < 0.01$) and excitatory movements (25% versus 2.5%, $P = 0.007$) in the propofol group. Apnea lasted 133.8 ± 21.1 s in the propofol group compared to 43.9 s ± 6.9 in the desflurane group ($P < 0.01$). Return of spontaneous respiration was faster in the desflurane group (14.1 ± 43.8 s versus 110.5 ± 133.7 s, $P < 0.01$).

Table 2. Conditions of LMA insertion

	Desflurane ($n = 40$)	Propofol ($n = 40$)	*P* value
Time to loss of consciousness (s)	104.1 ± 32.1	57.5 ± 17.9	<0.01
Time to insertion of LMA (s)	228.6 ± 59.9	131.8 ± 59.2	0.86
Good jaw opening	38	29	0.27
Good ease of insertion	35	29	0.45
Single attempt	32	31	0.90
Blood on LMA	2	5	0.25
Time for return of spontaneous respiration (s)	14.1 ± 43.8	110.5 ± 133.7	<0.01

Data are mean ± SD
LMA, laryngeal mask

Table 3. Complications during induction and insertion of the LMA

	Desflurane ($n = 40$)	Propofol ($n = 40$)
Complications of induction		
Cough	2	0
Gag	0	0
Excitatory movements	1	4
Laryngospasm	0	0
Breath-holding	3	0
Complications of insertion		
Cough	0	0
Gag	0	1
Laryngospasm	1	0
Excitatory movements	1*	10
Apnea	3*	28

Data are number of patients
*Significantly different from propofol at $P < 0.01$

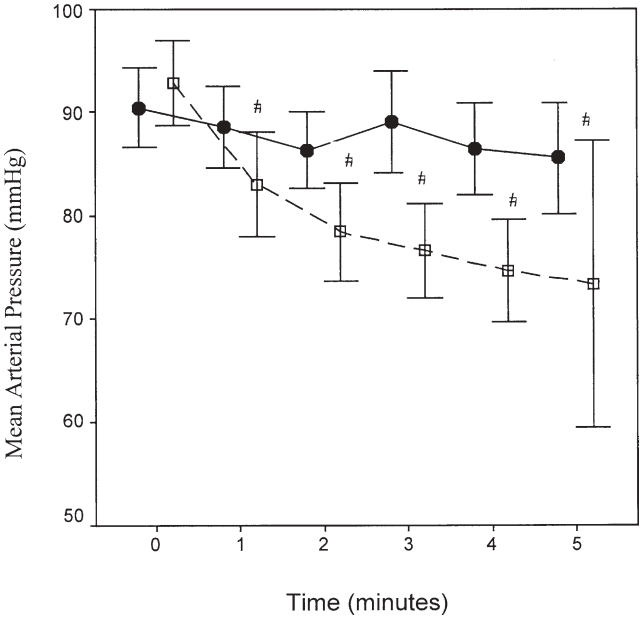

Fig. 1. Mean arterial pressure over the first 5 min. *Circles*, desflurane group; *squares*, propofol group; #, $P < 0.05$ versus baseline

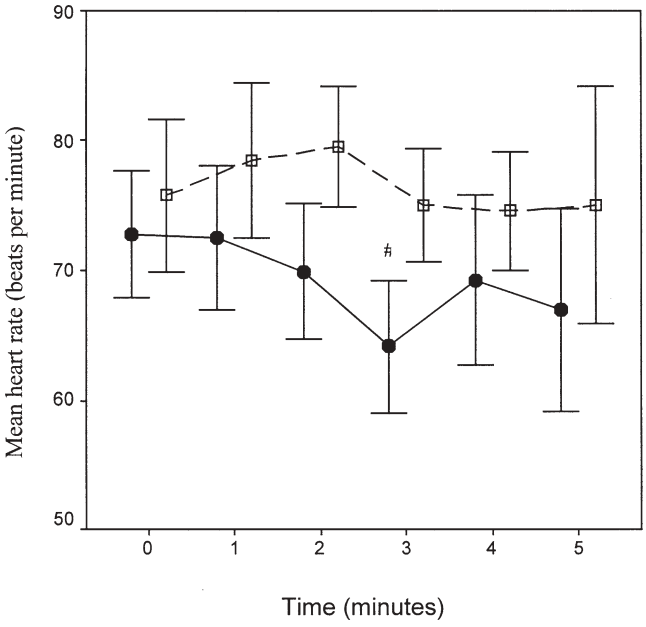

Fig. 2. Mean heart rate over the first 5 min

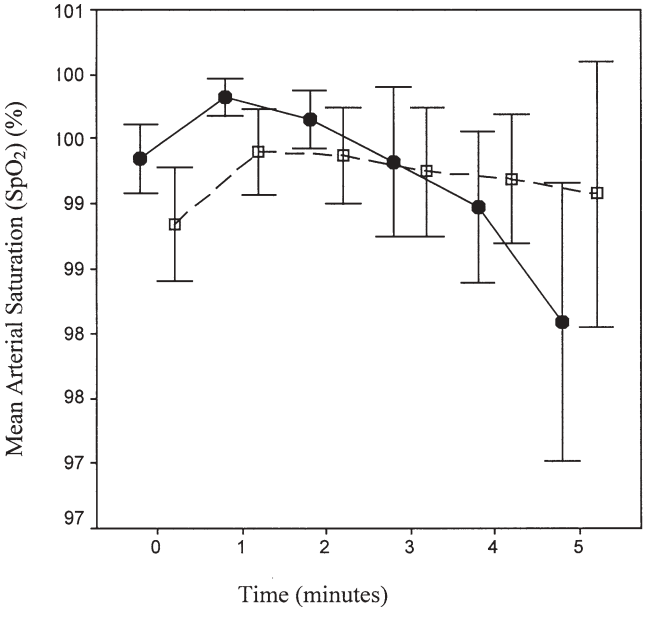

Fig. 3. Mean arterial saturation (%) over the first 5 min

As for the hemodynamics, mean arterial pressure, heart rate, and Sp_{O_2} were relatively stable in the desflurane group over the induction time (see Figs. 1–3). Within the propofol group, there were significant decreases in mean arterial pressure during the first 5 min, compared to the baseline ($P < 0.05$) (see Fig. 1). Heart rate and Sp_{O_2} were stable (see Figs. 2, 3). There were no significant differences in mean arterial pressure, heart rate, and Sp_{O_2} between the two groups over the induction/insertion time.

Discussion

This study demonstrated that desflurane induction could be smooth and rapid and could provide adequate conditions for LMA insertion. In the desflurane group, jaw relaxation was adequate and the LMA was easily inserted in the majority of patients at the first attempt. It

could be a clinically useful factor to note that these findings were not statistically different from those of the propofol group.

Although the induction and insertion times were significantly longer in the desflurane group, this was as expected because desflurane concentrations were increased in a controlled stepwise fashion. Successful placement was accomplished within 228.6 s, only 96.8 s longer than that for the propofol group. This time difference was small in the context of the total duration of the procedure.

The overall incidence of complications was significantly higher in the propofol group during insertion, notably that of apnea and excitatory movements. The rates of apnea and excitatory movements were consistent with findings in other studies [13]. The high incidence of apnea with propofol necessitates hand ventilation by the anesthetist, therefore nullifying the benefit of freeing the anesthetist's hands by using a LMA [14]. Taken in the clinical context, apnea and excitatory movements are troublesome but not serious side effects of using propofol.

Airway excitation and cough, a main concern during induction with desflurane, occurred in 5% of patients. This contrast in the incidence of airway irritation when compared to other studies (reported incidences of 26%–59%) could be explained by several factors [8]. The addition of fentanyl has been reported to help attenuate airway irritability [8,9]. With this protocol, desflurane concentration was increased even as 1 MAC was approached. The low blood gas solubility of desflurane could have permitted quick establishment of deep levels of anesthesia and ablation of airway reflexes when delivered in this manner [9].

The use of nitrous oxide in conjunction with desflurane instead of just desflurane in oxygen could have helped to reduce the period of cough and excitation because the second gas effect enhances the uptake of desflurane [15]. Nitrous oxide itself has an anesthetic effect that is additive to that of desflurane [11]. Therefore induction is accelerated with decreased occurrences of excitation [16]. However, desflurane induction should still be used with caution even with the aid of fentanyl and nitrous oxide, given its potential to cause respiratory complications.

The depth of anesthesia achieved with inhaled desflurane seemed to produce a more uniform condition for LMA insertion. Only two patients in the desflurane group needed propofol treatment to aid in the placement of the LMA, compared to 16 patients in the propofol group. The fact that more patients in the propofol group warranted further doses of propofol than those in the desflurane group illustrated that conditions for LMA placement using the recommended propofol dose of $2.5\,mg \cdot kg^{-1}$ were variable.

Desflurane also appeared to be associated with stable hemodynamics. The heart rate and mean arterial pressure remained relatively stable over the induction period compared to the preinduction value. On the other hand, there were significant decreases in mean arterial pressure during induction compared with baseline values with the use of propofol. Decreases in mean arterial pressure are well tolerated in fit young patients, but may necessitate additional treatment in patients who are dehydrated or who have medical problems such as severe coronary artery disease.

Inhalational induction with desflurane can provide a smooth transition from induction to maintenance because both phases of anesthesia are accomplished with the same agent. Using propofol for induction and an inhalational agent for maintenance may result in a lag time during which propofol concentration is in decline while the inhalational agent concentration is in the process of being built up.

Induction with desflurane also circumvents the pain of injection associated with propofol, which has an incidence varying from 10% if the cannula is placed in the antecubital fossa and up to 58% if the cannula is placed in the dorsum of the hand [13]. This can be attenuated if lignocaine is added to the propofol mixture beforehand. So far, most studies concerned with inhalational induction have looked at LMA insertion with sevoflurane. Sevoflurane has already been found to provide satisfactory conditions for LMA insertion comparable to propofol [14,17]: the LMA was inserted between 127 and 240 s after induction [14,17–19] and the incidence of cough ranged from 2.6% to 11.4%, excitatory movements from 13% to 36%, laryngospasm from 0% to 11.4%, and gag from 10.4% to 22.7% [14,17–19]. The results obtained using desflurane compare favourably with those of sevoflurane.

As for recovery characteristics after sevoflurane or desflurane anesthesia, the times to opening eyes, following commands, and extubation upon stopping the agent were less in the desflurane group. Home discharge readiness in ambulatory surgery was found to be earlier in the desflurane group in one study, but not different between the two agents in others [20–22].

However, because anesthetists are more familiar with sevoflurane, induction with sevoflurane would appear to be simpler and quicker. Although we are not suggesting that desflurane should replace sevoflurane as an inhalational induction agent, we feel that induction with desflurane should not be as feared as it has been in the past and that this investigation can serve as a starting point for further investigations into using desflurane during inhaled induction. A direct comparison between desflurane and sevoflurane in a randomized controlled study in a given population will give a clearer picture.

One drawback with this study was that some might argue that the patients should have been interviewed regarding the acceptability of desflurane inhalation, although no patient in this group made any complaint about desflurane induction being unpleasant. The cost of using desflurane to facilitate the placement of the LMA was calculated. Based on the local unit cost of desflurane at S$123 per 240 ml, the average cost was $5.90. The mean amount of propofol used for induction was 168 mg (range 125–250 mg). Based on the use of 1 vial of 200 mg propofol per patient, the cost incurred was S$4.46. In contrast, the cost of sevoflurane induction was calculated to be S$12.17 in a local study [14], the unit cost of sevoflurane being S$363 per 250 ml.

In conclusion, inhaled desflurane provided acceptable conditions for LMA insertion and the hemodynamic profile during induction of anesthesia was stable. Desflurane can be considered as an alternative induction agent when inhalational induction is required, bearing in mind that caution still needs to be exercised when desflurane is used in this manner.

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