

Hemodynamic Parameters of Low-Flow Isoflurane and Low-Flow Sevoflurane Anesthesia During Controlled Ventilation With Laryngeal Mask Airway

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Background: Nowadays laryngeal mask airway (LMA) is popular as one of the best choices for airway management. Low-flow anesthesia has some advantages like lower pollution, hemodynamic stability and cost effectiveness. Volatile anesthetics are widely used for anesthesia maintenance during operations. Sevoflurane has more hemodynamic stability compared to isoflurane, but there are few studies comparing the hemodynamic stabilities of these two anesthetics during controlled low flow anesthesia with LMA.

Objectives: The aim of this study was to compare the effects of low-flow sevoflurane and low-flow isoflurane on hemodynamic parameters of patients through LMA.

Patients and Methods: Eighty patients, scheduled for elective ophthalmic surgery, were randomly divided into two groups. After induction, an LMA with an appropriate size was inserted in all the patients and they were randomly allocated to two groups of low-flow sevoflurane (n = 40) and low-flow isoflurane (n = 40). Hemodynamic parameters (heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP) and Mean Arterial Pressure (MAP) were recorded at 5, 10, 15, 20, 25 and 30 minutes after the anesthesia induction.

Results: The mean heart rate values were significantly less in the sevoflurane group (P value < 0.05) at 25 minutes after the surgery. The mean Blood Pressure in the isoflurane group was significantly higher compared with the sevoflurane group in 10, 20 and 30 minutes after the surgery (P values = 0.0131, 0.0373 and 0.0028, respectively). These differences were clinically unimportant because heart rate and mean blood pressure were on normal ranges.

Conclusions: Seemingly, low-flow sevoflurane with LMA did not have any significant hemodynamic effect on clinical practice. Therefore, low-flow sevoflurane anesthesia with LMA might be considered in patients with short operations who need rapid recovery from anesthesia.

Keywords: Isoflurane; Laryngeal Mask Airways; Hemodynamics; Sevoflurane; Anesthesia

1. Background

Maintenance of hemodynamic stability during anesthesia is of great importance and numerous agents have been introduced to provide a stable hemodynamic state throughout anesthesia. Sevoflurane, a widely used volatile agent for anesthesia maintenance, is believed to facilitate recovery from surgery, while providing hemodynamic stability. The increasing economic pressure necessitates decreasing fresh gas flow rate to the circuit to the lowest tolerable level (1), in which, however, sevoflurane is degraded to a nephrotoxic compound called compound A. Compound A increases with low fresh gas flow rates, the use of baralyme, and high fresh gas concentrations; however, compound A has not accumulated significantly following administration of an effective carbon dioxide absorber during a low-flow controlled anesthesia and has had no marked renal effects in patients with normal renal function (2-6). Isoflurane has an excellent

safety record due to its low biodegradation, metabolism and stability, when exposed to CO₂ absorbent. To evaluate the effects of sevoflurane on hemodynamic parameters during low-flow anesthesia, it should be compared with isoflurane anesthesia (7-9). Michalowski P. et al. showed that long durations of low-flow anesthesia with sevoflurane or isoflurane were safe (6-10).

The use of low-flow anesthesia with circle system plays an undeniably important role in modern anesthesia practice, as it is advantageous in terms of decreasing the waste of expensive volatile anesthetics, atmosphere pollution, and better control of body temperature and humidity (11). laryngeal mask airway (LMA) is an effective and safe supraglottic device widely used for elective surgeries or difficult airway situations, which has been associated with controversies over its ability to deliver efficient positive pressure ventilation, especially during low-flow anesthesia with

long duration (12, 13). Different studies have shown that LMA could be used in low-flow anesthesia without any undesirable complications (11, 14, 15).

Isoflurane, being extremely insoluble in blood, is of rapid induction and recovery profile. However, dose-dependent depression of respiratory and cardiovascular system could be seen with isoflurane. On the other hand, sevoflurane, a more recent volatile agent with a low blood/gas solubility coefficient even lower than isoflurane, is of a quicker induction and recovery; yet some concerns exist about its cost. Hemodynamic stability during anesthesia could increase safe anesthesia practice and decrease postoperative complications (16).

2. Objectives

The aim of present study was to compare the effects of low-flow sevoflurane and low-flow isoflurane on hemodynamic parameters of patients through LMA.

3. Patients and Methods

After approval of the Ethics Committee of Tabriz University of Medical Sciences, 80 American Society of Anesthesiologists (ASA) class I/II patients, aged 20-75 years old, scheduled for elective ophthalmic surgery, were enrolled in this study (registration No. IRCT201202202582N4). Block randomization was performed to allocate patients into two groups. The exclusion criteria included previous history of difficult airway, malignant hyperthermia, diabetes mellitus, hypertension or previous history of taking antihypertensive drugs, chronic alcoholism, renal disease, smoking, recent history of sore throat or common cold within the previous 10 days, patients with full stomach, and known allergy to latex. Premedication was performed with midazolam 1 mg in all the patients. Anesthesia induction in all the patients was performed with propofol (Diprivan 1%) 2 mg/kg, Fentanyl 2 µg/kg, lidocaine 1 mg/kg and atracurium 0.4 mg/kg. Mask ventilation with 100% oxygen (6 L/min) was performed after induction for 1.5 minutes. An LMA with an appropriate size (based on the manufacturer's recommendation) was inserted laterally or in the standard technique, after the appropriate depth of anesthesia was achieved. Later, LMA was inflated until the appropriate seal was achieved; adequacy of the seal was assessed with auscultation of the anterior neck and chest as well as disappearance of leakage during inflation. After that, the patients were randomly allocated into two groups (isoflurane and sevoflurane). In the isoflurane group, maintenance of anesthesia was achieved with isoflurane 2% with fresh gas flow rate of 6 L/min for 10 minutes to deliver sufficient amount of isoflurane and N₂O during the high uptake process. Finally, the flow was reduced to 1 L/min and the isoflurane set to 1% (El-Seify et al. protocol) (11). In the sevoflurane group, maintenance of anesthesia was performed with sevoflurane 2.5% and the fresh gas flow rate of 6 L/min; similar to the other group, after the initial uptake period, the fresh gas flow rate was

reduced to 1 L/min and the sevoflurane set to 2%. In case of insufficient anesthesia, 50 µg of fentanyl was injected. All the patients were ventilated with a tidal volume of 8 mL/kg and respiratory rate of 12/min with a Dräger ventilator. Electrocardiography, heart rate, end tidal CO₂, inspiratory and expiratory N₂O, isoflurane and sevoflurane concentrations, peak and plateau airway pressures, and noninvasive blood pressure monitoring were used in all the patients. In case of increase in inspiratory pressure lower than 20 cmH₂O, the patients were excluded from the study. As each patient was being monitored, air leak should not have increased over 100 mL/min. In case of an air leak, the fresh gas flow was increased to 2.5 L/min for a short period. If the problem was solved, the fresh gas flow rate would be decreased to 1 L/min. If hemodynamic instability (more than 25% change in hemodynamic parameters compared to the base line) occurred during anesthesia which was resistant to treatment, low flow protocol would be terminated. Eight minutes prior to the end of the anesthesia, isoflurane was discontinued, and in the other group, five minutes prior to the end of the anesthesia, sevoflurane was discontinued, and 100% oxygen at increased flow rate of 6 L/min was administered to the washout anesthetics. After removing the LMA, the patients were transferred to the postanesthesia care unit (PACU). The hemodynamic parameters (heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP) and Mean Arterial Pressure (MAP) were recorded at 5, 10, 15, 20, 25 and 30 minutes after anesthesia induction.

3.1. Statistical Methodology

All the data were analyzed with SPSS. Chi-square test was used for qualitative variables and t-test for quantitative variables. P value less than 0.05 was considered statistically significant.

4. Results

The demographic characteristics of patients are shown in Table 1. Age, gender, duration of surgery, ASA, physical status and surgery types in both groups did not have statistical differences. Base line hemodynamic parameters of patients in the two groups did not have statistically significant differences. The mean heart rate values between the two groups had significant differences (P value < 0.05) 25 minutes after the induction; however, these differences were not statistically significant during 5, 10, 15, 20 and 30 minutes (P value > 0.05). SBP showed significant differences between the two groups in 10, 15 and 30 minutes after induction (P values of 0.005, 0.006 and 0.037, respectively). A statistically significant difference was observed between the two groups in 10 and 30 minutes after the induction regarding DBP (P values of 0.0354 and 0.0028, respectively). In addition, the mean blood pressure had significant differences between the two groups in 10, 20 and 30 minutes after the induction (P values of 0.0131, 0.0373 and 0.0028, respectively) (Table 2).

Table 1. Demographic Characteristics of Patients ^{a,b}

Variable	Isoflurane	Sevoflurane
Age, y	67	63
Gender, Male/Female	50	50
Duration of surgery, min	29	27:27
ASA (I/II)	55/45	65/35
Surgery type		
Cataract	92.5	87.5
Corneal transplantation	2.5	2.5
Vitrectomy	2.5	0
Displacement of intraocular lens	2.5	0
DCR	0	5
Trabeculectomy	0	2.5
Pterygium	0	2.5

^a Abbreviations: ASA, American Society of Anesthesiologists; DCR, Dacryocystorhinostomy.

^b Data are presented as %.

Table 2. Hemodynamic Parameters of Patients ^a

Variable	Time, min					
	5	10	15	20	25	30
HR						
Sevoflurane	84.83 ± 7.52	81.18 ± 5.86	76.45 ± 5.69	74.90 ± 5.48	72.54 ± 5.01 ^b	72.09 ± 4.30
Isoflurane	87.6 ± 11.17	81.75 ± 10.22	79.78 ± 11.63	78.33 ± 12.20	78.96 ± 13.99	76.58 ± 10.35
SBP						
Sevoflurane	123.8 ± 10.86	119.9 ± 6.64 ^b	118.9 ± 6.25 ^b	118.5 ± 5.90	116.8 ± 5.64	117.3 ± 5.17 ^b
Isoflurane	128.0 ± 8.49	124.3 ± 6.99	123.4 ± 8.10	120.6 ± 9.48	119.6 ± 8.07	124.2 ± 9.00
DBP						
Sevoflurane	78.38 ± 7.95	74.63 ± 6.09 ^b	75.20 ± 5.62	73.15 ± 5.61	72.86 ± 7.50	71.36 ± 5.51 ^b
Isoflurane	80.85 ± 6.07	77.63 ± 6.09	76.00 ± 4.96	75.50 ± 6.58	75.00 ± 8.20	80.83 ± 7.63
MBP						
Sevoflurane	93.48 ± 8.53	90.20 ± 5.22 ^b	89.83 ± 4.36	88.28 ± 4.08 ^b	87.04 ± 5.59	86.00 ± 4.21 ^b
Isoflurane	96.78 ± 6.27	93.23 ± 5.42	91.53 ± 5.39	90.88 ± 6.59	89.96 ± 7.66	94.58 ± 7.35

^a HR, heart rate; SBP, systolic blood pressure; DBP, diastolic blood pressure; MBP, mean blood pressure.

^b P value < 0.05.

5. Discussion

Hemodynamics during anesthesia can be affected by at least three independent factors: type of anesthesia, type of surgery, and patients' cardiovascular status. The last two factors were presumably similar among our patients, as they all had reasonably normal left ventricular function and were scheduled for elective ophthalmic surgery. Nowadays, LMA has an important role in difficult airway and anesthesia management (17, 18). Peirovifar et al. showed that LMA can be used as a safe alternative with lower incidence of postoperative complications compared with Endotracheal Tube (ETT) during low-flow controlled anesthesia with modern anesthetics (19). Sevoflurane may

attenuate the arterial baroreflex function during anesthesia, which may adversely affect the hemodynamic stability of patients receiving sevoflurane anesthesia (20). Driessen et al. showed that horses under sevoflurane anesthesia may require less pharmacological support in the form of dobutamine compared with isoflurane-anesthetized horses (21). This could be due to less suppression of vasomotor tone. Bennett SR showed that at equivalent doses, sevoflurane had comparable hemodynamics with isoflurane. Both agents, when used as primary anesthetic, showed similar recovery characteristics with no statistical difference at any stage of the study (22).

Grosenbaugh D.A. showed that sevoflurane induced cardiorespiratory effects, comparable to those of isoflurane and halothane. The cardiac output was greater and the respiratory rate was less compared with halothane at 1.5 Minimum Anesthetic Concentration (MAC). Sevoflurane anesthesia was characterized by good control of anesthesia depth during induction, maintenance, and recovery. The recovery time after sevoflurane anesthesia was comparable to that of isoflurane and the recovery was smooth and controlled in a manner consistent with that of halothane (23). Weinberg L. in a review showed that sevoflurane at 2 L/min cost 19 times more than isoflurane at 0.5 L/minute. During the financial years of 1997 to 2007, they found a progressive shift from the cheaper isoflurane to more expensive agents, sevoflurane and desflurane, a shift associated with marked increases in costs (24). This shift might have been due to short recovery periods and less postoperative complications with sevoflurane compared with isoflurane.

Isik et al. showed that low-flow desflurane and sevoflurane anesthesia did not adversely affect hemodynamic parameters, hepatic and renal function in children (25). Sivaci et al. showed that respiratory mechanics were affected by desflurane with low-flow anesthesia in patients undergoing laparoscopic abdominal surgery. No significant influence on respiratory mechanics was seen related to sevoflurane anesthesia (26). Fukuda and colleagues suggest that prolonged anesthesia with low-flow sevoflurane could have effects on hepatorenal function similar to prolonged anesthesia with high-flow sevoflurane and low-flow isoflurane (27). Higuchi et al. showed that low-flow sevoflurane and isoflurane anesthesia had the same effects on hepatic function, as assessed by plasma alpha glutathione S-transferase concentrations (28).

Chen and colleagues assessing 80 adult Chinese patients showed that compared with isoflurane, sevoflurane anesthesia had the clinical advantages of maintaining stable hemodynamics and rapid recovery in (29). El-Seify et al. in a study showed that with adjustment of the tube cuff pressure, LMA can be safe and effective in establishing an air-tight seal during controlled ventilation under low fresh gas flow of 1 L/min (11). These studies showed that low-flow sevoflurane was safe, especially in patients with short operation periods needing faster recovery, which was in accordance with our study revealing that sevoflurane was a safe anesthetic in this regard.

Regarding the hemodynamic parameters, our study showed that there were significant differences only in the 25th minute between the two groups, which were not clinically important, as the heart rates of patients were in the normal range. Similar to the previous studies, we showed that DBP, SBP and MBP in the sevoflurane group were significantly lower than the isoflurane group. This might have been due to the effect of sevoflurane on cardiorespiratory reflexes, which however seemed to be clinically unimportant as none of the patients needed vasopressor support in the sevoflurane group. Experience

and careful consideration of the characteristics of inhaled anesthesia agents, surgery and patient-specific factors, allow anesthesia care providers to meet the rapidly-changing needs of patients receiving inhaled anesthesia in a safe and cost-effective manner.

5.1. Limitation of the Study

Our study was a single center study in patients who were candidates for ophthalmic surgery; so, larger trials are needed. Cost is very important in medicine practice, but we did not mention the cost of sevoflurane. Therefore, it can be studied as another research to compare the costs of anesthetics beside their clinical effectiveness and complications.

It seems that low-flow sevoflurane with LMA does not have any significant hemodynamic effects on clinical practice; thus, it might be considered as an appropriate anesthetic in patients undergoing short operations and who need rapid recovery of anesthesia under controlled low-flow anesthesia.

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Authors' Contributions

Ata Mahmoodpoor: preparing the manuscript concept and draft, Samad EJ Golzari: editing the manuscript, Haniye Molseqi: data collection and analysis, Masoud Parish: preparing the manuscript draft and design of the study, Ali Peirovifar: editing and revision of the manuscript, Sohrab Negargar: literature review and manuscript drafting.

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