Postprint: Application of Sevoflurane and Laryngeal Mask Airway in Cesarean Section for Parturients with Cardiac Disease Complicating Pregnancy

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Abstract

Objective: To investigate the feasibility and safety of sevoflurane inhalation general anesthesia via laryngeal mask airway (LMA) in pregnant women with cardiac disease undergoing cesarean section. Methods: Fifty-two pregnant women with cardiac disease, ASA class II-III, cardiac function class II-III, undergoing elective cesarean section were randomly divided into two groups: LMA group and tracheal intubation group. The LMA group received induction with 6% sevoflurane inhalation plus 6 L/min oxygen, with sevoflurane inhalation for maintenance. The intubation group received propofol 1.5 mg/kg and remifentanil 1 g/kg injection; after Narcotrend electroencephalographic monitoring reached D0 level (conventional anesthetic state), rocuronium 0.9 mg/kg was injected, followed by tracheal intubation after 1 minute, with sevoflurane inhalation for maintenance. Recordings were made of systolic blood pressure, diastolic blood pressure, mean arterial pressure, heart rate, and electroencephalographic changes at each time point: before anesthesia induction (T0), at intubation (LMA placement) (T1), at skin incision (T2), and at extubation (LMA removal) (T3) in both groups, as well as time from start of surgery to fetal delivery, time from uterine incision to fetal delivery, time from drug discontinuation to patient awakening, Apgar scores of neonates at 1, 5, and 10 minutes, sevoflurane consumption in both groups, and a statistical analysis was performed on maternal comfort during hospitalization. Results: Heart rates at LMA insertion and removal in the LMA group were 82.17±2.35 beats/min and 82.56±5.83 beats/min, respectively, both significantly lower than those in the intubation group ($P<0.05$); mean arterial pressures were 69.89±10.39 mmHg and 73.54±11.25 mmHg, respectively, significantly lower than those in the intubation group ($P<0.05$). No statistically significant differences were observed in

other indices between the two groups (P>0.05). Times from drug discontinuation to extubation and awakening in the LMA group were 5.59±3.15 minutes and 7.26±3.21 minutes, respectively, significantly lower than those in the intubation group (P<0.05). No statistically significant differences were found in surgical time and fetal delivery time between the two groups (P>0.05). No statistically significant differences were observed in Apgar scores of neonates at 1, 5, and 10 minutes between the two groups (P>0.05). With the same depth of sedation maintained intraoperatively, sevoflurane consumption in the LMA group was lower than that in the intubation group, but the difference was not statistically significant (P>0.05). Comfort scores in physiological and psychological aspects given by parturients in the LMA group were 74.2±12.4 points and 69.2±10.1 points, respectively, both significantly higher than those in the intubation group (P<0.05). No statistically significant differences were observed in scores for hospital environment, service attitude, and health education between the two groups (P>0.05). Conclusion: Sevoflurane inhalation general anesthesia via LMA demonstrates significant anesthetic efficacy in cesarean section for parturients with cardiac disease, with better postoperative comfort evaluation compared to inhalational general anesthesia with intubation.

Full Text

Preamble

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Abstract

Objective: To investigate the feasibility and safety of sevoflurane inhalation general anesthesia via laryngeal mask airway (LAM) in cesarean section for pregnant women with cardiac disease. **Methods:** Fifty-two pregnant women with cardiac disease, classified as ASA physical status II-III and scheduled for elective cesarean section, were randomly divided into two groups: the LAM group and the tracheal intubation group. The LAM group received induction with 6% sevoflurane in 6 L/min oxygen, with maintenance via sevoflurane inhalation. The intubation group received intravenous propofol 1.5 mg/kg and remifentanil 1 μg/kg; after reaching D0 level on Narcotrend monitoring (routine anesthesia state), rocuronium 0.9 mg/kg was administered, followed by tracheal intubation 1 minute later, with sevoflurane inhalation for maintenance. Systolic blood pressure, diastolic blood pressure, mean arterial pressure, heart rate, and electroencephalography were recorded at four time points: before anesthesia induction (T0), at intubation (LAM placement) (T1), at skin incision (T2), and

at extubation (LAM removal) (T3). Additional recorded parameters included time from surgery start to fetal delivery, time from uterine incision to fetal delivery, time from drug discontinuation to patient awakening, neonatal Apgar scores at 1, 5, and 10 minutes, sevoflurane consumption, and maternal comfort during hospitalization. **Results:** Heart rates at LAM insertion and removal were 82.17±2.35 beats/min and 82.56±5.83 beats/min respectively, both significantly lower than in the intubation group (P<0.05). Mean arterial pressures at these time points were 69.89±10.39 mmHg and 73.54±11.25 mmHg, also significantly lower than in the intubation group (P<0.05). Other parameters showed no statistically significant differences between groups (P>0.05). Time from drug discontinuation to extubation and awakening were 5.59±3.15 minutes and 7.26±3.21 minutes respectively in the LAM group, significantly shorter than in the intubation group (P<0.05). No significant differences were observed in operative time or fetal delivery time between groups (P>0.05). Neonatal Apgar scores at 1, 5, and 10 minutes were comparable between groups (P>0.05). While sevoflurane consumption was lower in the LAM group, the difference was not statistically significant (P>0.05). Maternal comfort scores for physical and psychological comfort were 74.2±12.4 and 69.2±10.1 respectively in the LAM group, significantly higher than in the intubation group (P<0.05). No significant differences were found in scores for hospital environment, service attitude, or health education (P>0.05). **Conclusion:** Sevoflurane inhalation general anesthesia via LAM demonstrates significant anesthetic efficacy in cesarean section for pregnant women with cardiac disease, with superior postoperative comfort compared to intubation-based inhalation anesthesia.

Keywords: pregnancy complicated with heart disease; sevoflurane; laryngeal mask airway

Introduction

Pregnancy complicated with heart disease represents a serious condition in obstetrics and remains a leading cause of maternal mortality, posing a significant challenge for both obstetric and anesthesiology departments. The mode of delivery and maternal-fetal prognosis vary depending on the type of cardiac disease and cardiac function classification [**?**]. For pregnant women with complex cardiac conditions or poor cardiac function, cesarean section is relatively safer based on maternal and fetal conditions [**?**]. Beyond the physiological changes of pregnancy, the pathophysiological alterations associated with cardiac insufficiency and even Eisenmenger' s syndrome make the selection of optimal anesthesia to minimize hemodynamic fluctuations and maintain stable physiological function during surgery a major challenge in obstetric anesthesia research [**?**]. Sevoflurane, a novel rapid-onset inhalational anesthetic, has been used in obstetric anesthesia with proven efficacy. Low-concentration sevoflurane does not significantly inhibit uterine contractions [**?**] and has no effect on neonatal Apgar scores when used in general anesthesia for cesarean section [**?**]. While tracheal

intubation is commonly used for airway control in clinical anesthesia, the laryngeal mask airway offers advantages including fewer complications and greater hemodynamic stability [**?**]. For pregnant women with cardiac disease who require more stable intraoperative hemodynamics, the combination of LAM with sevoflurane inhalation may be beneficial for circulatory stability, reduced postoperative complications, and improved comfort, though reports in this population remain limited [**?**]. This study compared sevoflurane inhalation anesthesia with LAM versus tracheal intubation in 52 pregnant women with cardiac disease undergoing elective cesarean section, aiming to explore the feasibility of sevoflurane inhalation anesthesia and compare the advantages of different ventilation methods in this high-risk population.

1.1 General Information

This study was approved by our hospital' s ethics committee, and all patients provided informed consent. Fifty-two pregnant women with cardiac disease scheduled for elective cesarean section between November 20, 2015 and November 20, 2016 were enrolled. Cardiac conditions included atrial septal defect (8 cases), ventricular septal defect (4 cases), patent foramen ovale (6 cases), patent ductus arteriosus (9 cases), mitral valve disease (10 cases), tricuspid valve disease (3 cases), arrhythmia (7 cases), dilated cardiomyopathy (3 cases), and hypertrophic cardiomyopathy (2 cases). Patients were randomly divided into tracheal intubation and LAM groups (n=26 each) using a random number table. The LAM group had a mean age of 27.12±2.45 years (range 22-38), while the intubation group had a mean age of 27.25±3.29 years (range 23-37). Inclusion criteria were: no hepatic insufficiency, normal renal function, no consciousness disorders, and no history of neurological disease. Exclusion criteria included coagulation dysfunction, congenital fetal malformations on ultrasound, and other severe comorbidities.

1.2 Methods

All parturients fasted for 6-8 hours before surgery. After entering the operating room, routine monitoring was established, followed by left radial artery and right internal jugular vein catheterization under local anesthesia for invasive blood pressure and central venous pressure monitoring. In the intubation group, induction consisted of intravenous propofol 1.5 mg/kg and remifentanil 1 μg/kg; after reaching D0 level on Narcotrend monitoring, rocuronium 0.9 mg/kg was administered, followed by tracheal intubation 1 minute later. Maintenance included remifentanil infusion [0.05-0.2 μg/(kg · min)] and sevoflurane inhalation (2-3%) with constant oxygen flow at 2 L/min. Intraoperative Narcotrend levels were maintained at D0-D2 (routine anesthesia state), with sevoflurane concentration and remifentanil infusion rate adjusted according to anesthetic depth and vital signs. The LAM group received 6% sevoflurane with 6 L/min oxygen via tight-fitting face mask; after reaching D0 level on Narcotrend, remifentanil 1 μg/kg was administered intravenously, followed by insertion of a size 4.0 LAM while

preserving spontaneous respiration. Intraoperative management was similar to the intubation group. Sevoflurane concentration was adjusted based on EEG monitoring, with all patients maintaining Narcotrend values at D2. Sevoflurane consumption was recorded for both groups. After discontinuing remifentanil, all patients were connected to intravenous analgesia pumps containing: sufentanil 50 μg + flurbiprofen axetil 250 mg + granisetron 17.92 mg diluted to 100 mL with normal saline, with a continuous infusion rate of 2 mL/h.

1.3 Observation Indicators

Maternal systolic blood pressure, diastolic blood pressure, mean arterial pressure (MAP), and heart rate were recorded before anesthesia induction (T0), at intubation (LAM placement) (T1), at skin incision (T2), and at extubation (LAM removal) (T3). Additional recorded parameters included time from surgery start to fetal delivery, time from uterine incision to fetal delivery, intraoperative sevoflurane consumption, time from drug discontinuation to patient awakening, neonatal Apgar scores at 1, 5, and 10 minutes, and maternal comfort during hospitalization.

1.4 Statistical Methods

Data were processed using SPSS 22.0. Measurement data were expressed as mean±standard deviation and analyzed using t-tests. Count data were analyzed using ^{2} tests. $P<0.05$ was considered statistically significant.

Results

2.1 Basic Patient Characteristics

Comparative analysis revealed no statistically significant differences in maternal age or gestational weeks between the two groups ($P>0.05$).

2.2 Intraoperative Vital Signs

Heart rate and MAP at LAM placement (T1) were significantly lower in the LAM group compared to the intubation group ($P<0.05$). Similarly, heart rate and MAP at LAM removal (T3) were significantly lower in the LAM group ($P<0.05$). Other parameters showed no statistically significant differences between groups ($P>0.05$, Table 1).

2.3 Maternal Awakening Time, Operation Time, and Fetal Delivery Time

Time from drug discontinuation to extubation was significantly shorter in the LAM group ($P<0.05$). Maternal awakening time was also significantly shorter in the LAM group compared to the intubation group ($P<0.05$). No significant differences were observed in operation time or fetal delivery time between groups ($P>0.05$, Table 2).

2.4 Intraoperative Sevoflurane Consumption and Bleeding

With constant oxygen flow at 2 L/min and all patients maintaining Narcotrend values at D2, intraoperative sevoflurane concentration was (1.5±0.3)% in the LAM group and (2±0.4)% in the intubation group. Although sevoflurane consumption was lower in the LAM group, the difference was not statistically significant (P>0.05). No patients in either group experienced major hemorrhage.

2.5 Neonatal Apgar Scores at 1, 5, and 10 Minutes

No statistically significant differences were found in neonatal Apgar scores at 1, 5, and 10 minutes between the two groups (P>0.05, Table 3).

2.6 Maternal Comfort Scores

A comfort questionnaire was distributed to all 52 parturients, with 52 valid responses collected. The LAM group reported significantly higher scores for physical comfort and psychological comfort compared to the intubation group (P<0.05). While no statistically significant differences were observed in scores for hospital environment, service attitude, or health education (P>0.05, Table 4), the LAM group consistently achieved higher ratings across all domains.

Discussion

Pregnancy complicated with heart disease is a relatively common condition in obstetrics, with maternal mortality rates reaching 10-15%. Peripartum cardiac function status significantly impacts outcomes, with mortality substantially higher in women with poorer cardiac function [**?**]. Hemodilution and increased blood volume during pregnancy elevate cardiac preload, which can exceed the compensatory capacity of the diseased heart, leading to heart failure, pulmonary hypertension, and pulmonary edema that endanger both mother and neonate. These risks are even greater during delivery, making anesthetic management particularly challenging [**?**]. Combined spinal-epidural anesthesia is conventionally used for cesarean section but requires specific positioning, and prolonged catheter placement is common in pregnant women. Furthermore, the sympathetic blockade and vasodilation associated with neuraxial anesthesia can cause hemodynamic instability and supine hypotensive syndrome, potentially precipitating maternal heart failure. Additionally, pregnant women with cardiac disease often receive anticoagulant therapy and may have coagulation abnormalities, making neuraxial anesthesia contraindicated. In contrast, general anesthesia offers rapid induction, reliable efficacy, and provides excellent analgesia, sedation, and muscle relaxation while maintaining hemodynamic stability [**?**]. Therefore, this study focused on parturients with cardiac disease undergoing general anesthesia.

Anesthetic options are limited in pregnant women undergoing cesarean section due to concerns regarding fetal exposure and postpartum breastfeeding. For

women with cardiac disease, medication choices are further restricted by cardiac functional status. Ideal analgesic agents should provide potent analgesia with minimal cardiac depression, rapid metabolism, and minimal excretion into breast milk. Research has demonstrated that remifentanil, an opioid analgesic, maintains stable intraoperative hemodynamics while providing effective analgesia in parturients with cardiac dysfunction undergoing cesarean section, with the added benefits of rapid metabolism and minimal impact on breastfeeding [**?**]. Sevoflurane, with a blood/gas partition coefficient of 0.63-0.69, offers rapid induction and elimination with minimal effects on respiration and hemodynamics, ensuring high safety. Our results show that maintaining sevoflurane at D0-D2 levels with remifentanil infusion at 0.1-0.2 μg/(kg · min) provided adequate analgesia and sedation. This suggests that sevoflurane can provide satisfactory sedation for pregnant women with cardiac disease undergoing cesarean section while maintaining hemodynamic stability. No patients in our study experienced major hemorrhage due to uterine contraction inhibition from sevoflurane, likely attributable to the relatively low dosage used. Notably, sevoflurane consumption was lower in the LAM group, though this difference lacked statistical significance, possibly due to sample size limitations.

Sevoflurane' s low blood/gas partition coefficient facilitates elimination primarily through the lungs, with low blood solubility. The rapid fetal delivery in cesarean section minimizes fetal drug exposure, making sevoflurane' s effects on the fetus negligible. Inhalational sevoflurane is safe for both mother and infant, with 3.5% sevoflurane showing no significant respiratory depression in neonates and no impact on Apgar scores [**?**, **?**]. Our findings similarly demonstrated normal Apgar scores at 1, 5, and 10 minutes in both groups, with no statistically significant differences ($P>0.05$).

Pathophysiological changes during the peripartum period, including endocrine and circulatory alterations, capillary engorgement, and fluid retention, increase the difficulty of tracheal intubation and the risk of intubation-related complications [**?**]. The laryngeal mask airway provides a convenient tool for maintaining airway patency with minimal trauma and fewer postoperative complications [**?**]. Our study showed that heart rate and MAP at LAM placement (T1) and removal (T3) were significantly lower in the LAM group compared to the intubation group ($P<0.05$), indicating that sevoflurane inhalation anesthesia with LAM and spontaneous breathing helps reduce maternal heart rate and mean arterial pressure during induction and emergence. The LAM causes less physiological stimulation than tracheal intubation, reducing stress responses and maintaining relatively stable heart rate and blood pressure, making it particularly suitable for cesarean section in women with cardiac disease [**?**].

Our results demonstrated that time from drug discontinuation to extubation was 5.59 ± 3.15 minutes and awakening time was 7.26 ± 3.21 minutes in the LAM group, both significantly shorter than in the intubation group ($P<0.05$). No significant differences were observed in operation time or fetal delivery time between groups. Comfort questionnaire results revealed significantly higher physi-

cal and psychological comfort scores in the LAM group compared to the intubation group. Although no statistical differences were found in hospital environment, service attitude, or health education scores, the LAM group consistently achieved higher ratings overall. These findings indicate that sevoflurane inhalation anesthesia via LAM provides greater patient comfort and satisfaction.

In conclusion, this study demonstrates that sevoflurane inhalation general anesthesia via LAM is safe and feasible for cesarean section in pregnant women with cardiac disease, offering superior postoperative comfort and satisfaction compared to intubation-based inhalation anesthesia while avoiding the side effects and ethical concerns associated with high-dose propofol sedation. However, due to the limited number of cases, further research is needed to determine the optimal intraoperative sevoflurane concentration.

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