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Comparison of sevoflurane and other volatile anesthetics for cesarean section

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Introduction

Low-concentration halothane or enflurane is generally used for a cesarean section. Sevoflurane is a new volatile anesthetic and its blood/gas partition coefficient is very low. It seems to be suitable for anesthesia that requires rapid induction and emergence, such as cesarean section. In this study sevoflurane was evaluated during anesthesia for cesarean section and compared with halothane, enflurane, and isoflurane.

Material and methods

With informed consent from the subjects, we studied 60 healthy mothers who were to have elective cesarean section under general anesthesia. Premedication consisted of atropine 0.5 mg injected intramuscularly. The patients were randomly allocated into four groups receiving halothane, enflurane, isoflurane, or sevoflurane. Each group had 15 patients.

After preoxygenation, 4 mg·kg^{-1} thiopental and 40 mg succinylcholine chloride were administered intravenously. Following endotracheal intubation, 2 l·min^{-1} oxygen, 4 l·min^{-1} nitrous oxide and one of the volatile anesthetics halothane (0.5%), enflurane (1%), isoflurane (0.7%), or sevoflurane (1%) were used. Then the operation was started. During the incision of the peritoneum, the volatile anesthetic was discontinued. At the time of incision of the uterine serosa, the nitrous oxide was turned off. After the fetus was delivered and the umbilical cord was clamped, 150 mg thiopental and 0.2 mg buprenorphine were administered. Nitrous oxide and one of the volatile anesthetics (0.5% halothane, 1% enflurane, 0.7% isoflurane, or 1% sevoflurane) were added again. At the same time prostaglandin F2α (PGF2α) was injected into the uterine muscle and methylergometrine maleate was injected intravenously.

Blood pressure, heart rate, EKG and SpO_2 were monitored. End-tidal concentrations of the inhalation anesthetics were measured by anesthetic gas monitor (Brüel Kjær, Nærum, Denmark). Apgar score was estimated by pediatricians. Blood loss was estimated by counting the volume in the suction bottle and the weight of the swabs. After the delivery the obstetricians were asked to assess uterine contractility condition as follows:

1. Good, no additional treatment
2. Fair, contraction recovered with uterine massage
3. Poor, additional drugs were necessary

Blood gas of maternal arterial and umbilical venous blood were measured by ABL-3 (Radiometer, Copenhagen, Denmark). Recovery from anesthesia was assessed as follows:

1. Good, less than 10 min from the end of the operation to extubation
2. Fair, from 10 to 20 min from the end of the operation to extubation
3. Poor, over 20 min from the end of the operation to extubation

The patients were interviewed about intraoperative awareness the day after the operation. Routine blood examinations for liver and kidney function, blood cell count, and blood gas were checked during the 7 days after surgery. Values were shown as the means ± SD. Data were analyzed using one-way analysis of variance (ANOVA) and the Mann–Whitney *U*-test, and a *P*-value less than 0.05 was considered significant.

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Results

There was no significant difference among the groups in regard to mean age, height, weight, and gestational age.

The changes in mean blood pressure and heart rate are shown in Fig. 1. The mean blood pressure in the enflurane, isoflurane, and sevoflurane groups and heart rate in the enflurane and sevoflurane groups increased significantly at the beginning of the operation compared with the values before anesthesia.

It took 5 ± 2.5 min from the beginning of the operation to delivery for all groups, and the concentrations of the agents at delivery were 0.07 ± 0.05% (halothane), 0.03 ± 0.06% (enflurane), 0.03 ± 0.05% (isoflurane), 0.03 ± 0.05% (sevoflurane). There was no significant difference among the groups.

The mean values of the Apgar score at 1 and 5 min were over 8 and 9, respectively, and no baby needed resuscitation.

The average blood loss during the operation was 650 ± 231 ml in the halothane group, 688 ± 368 ml in the enflurane group, 731 ± 410 in the isoflurane group, and 796 ± 276 ml in the sevoflurane group. There was no significant difference among these groups. During and after the operation there was no abnormal hemorrhage and no patient needed blood transfusion.

The obstetrician assessed the uterine contractility. The contractility was good in all cases except one in the enflurane group, whose contractility was fair, but that patient's uterine contractions gradually improved with uterine massage.

The blood gas of maternal arterial and umbilical venous blood at delivery is shown in Table 1. There was no significant difference among these groups.

The anesthesiologist assessed recovery from anesthesia. In two cases in the halothane group and one in the enflurane group the recovery was considered to be fair, but even in these three cases no additional treatment was necessary.

The patients were interviewed about intraoperative awareness the day after the operation. None of them reported awareness during the operation.

Transient premature ventricular contraction and premature atrial contraction were seen in some patients in the halothane, enflurane, and isoflurane groups soon after the injection of PGF2α and methylergometrine maleate, but none of the patients needed treatment for arrhythmia.

Routine blood examination for liver and kidney function, blood cell count, and blood gas during the 7 days after the operation indicated no abnormal data that suggested the need for treatment.

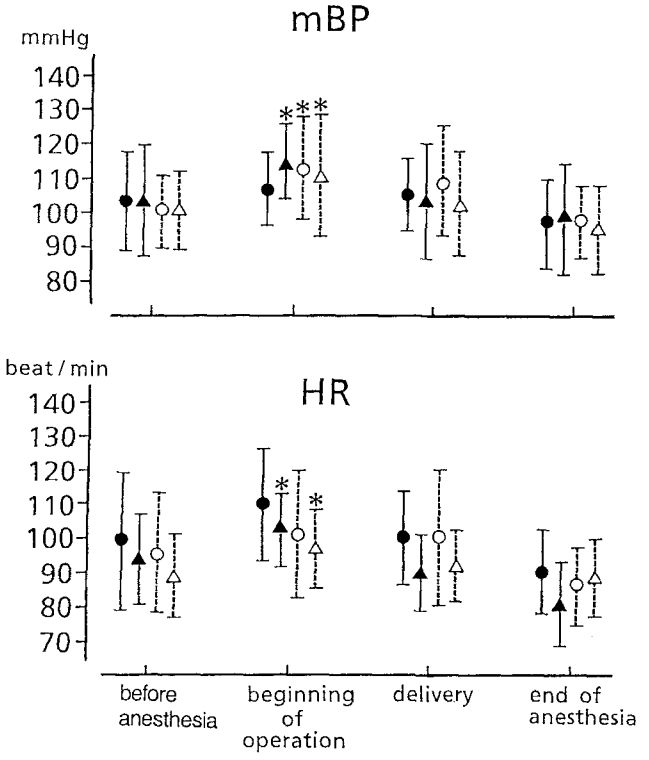

Fig. 1. Changes in mean blood pressure and heart rate. The mean blood pressure in the enflurane, isoflurane, and sevoflurane groups and heart rate in the enflurane and sevoflurane groups increased at the beginning of the operation compared with the values before anesthesia. Values represent mean ± SD. $^*P < 0.05$ compared with pre-induction value. *Solid circle*, halothane group; *solid triangle*, enflurane group; *open circle*, isoflurane group; *open triangle*, sevoflurane group

Discussion

Low doses of volatile anesthetics have been used for cesarean section because they decrease the likelihood of maternal postoperative recall and awareness of intraoperative events, may improve uterine blood flow, do not result in increased uterine bleeding, do not induce abnormal hypotension, and do not depress the newborn [1,2].

Sevoflurane is a new volatile anesthetic, and its alveolar concentration rises more rapidly than that of other presently available, potent inhalation anesthetic [3]. We evaluated low concentration (1%) sevoflurane for cesarean section. Although Asada et al. [4] used sevoflurane for cesarean section, the concentration range was from 3% to 4% at the start of anesthesia and from 0.5% to 4% after delivery. He reported that uterine contractions were fair in 2 and poor in 2 of 12 patients. In our experiment uterine contractions were good in all the patients in the sevoflurane group. The reason is that 1% sevoflurane alone has no muscle relaxant effect, although sevoflurane has a strong

Table 1. Blood gas of maternal artery and umbilical vein at delivery

	Halothane	Enflurane	Isoflurane	Sevoflurane
Maternal artery				
PaO_2 (mmHg)	286 ± 103	235.3 ± 106	228 ± 58	270 ± 81
$PaCO_2$ (mmHg)	29 ± 4	28 ± 3	29 ± 3	30 ± 5
pH	7.426 ± 0.05	7.443 ± 0.03	7.45 ± 0.03	7.43 ± 0.05
HCO_3^- (mEq·L^{-1})	18.8 ± 20	19 ± 1	20 ± 1	20 ± 1
BE (mEq·L^{-1})	−4.1 ± 2.10	−3.6 ± 1.0	−1.3 ± 0.80	−2.0 ± 1.60
Umbilical vein				
PaO_2 (mmHg)	32.5 ± 7.1	30.3 ± 6.2	32 ± 7	33 ± 6
$PaCO_2$ (mmHg)	41.7 ± 5.8	40.5 ± 3.8	44 ± 5	41 ± 5
pH	7.342 ± 0.03	7.355 ± 00 0	7.33 ± 0.04	7.35 ± 0.05
HCO_3^- (mEq·L^{-1})	22.3 ± 2.4	22.7 ± 1.6	23 ± 2	23 ± 1
BE (mEq·L^{-1})	−2.9 ± 1.90	−2.1 ± 1.20	−2.4 ± 1.60	−1.9 ± 1.30

Mean ± SD.
BE, base excess.

potentiation effect on neuromuscular block by relaxants [5].

The minimum alveolar concentration (MAC) for sevoflurane is reported to be 1.71% for healthy Japanese (mean age 48) [6] or 2.05% for North Americans (mean age 38) [7]. One percent sevoflurane would be equivalent to 0.49%–0.58% MAC according to previous reports. This might be a little lower than the other volatile anesthetics in this study. Sevoflurane has the characteristic of more rapid induction and recovery than other agents, and in our anesthesia technique nitrous oxide and volatile anesthetics were discontinued prior to the delivery so that maternal recall might occur. However, there was no patient in this study who was conscious during the operation and had postoperative recall. Buprenorphine might contribute to loss of awareness during an operation.

In this study there was no apparent difference between sevoflurane and the other volatile anesthetics with regard to blood pressure, heart rate, Apgar score, blood loss, uterine contractility, blood gas of maternal artery and umbilical vein, recovery from anesthesia, and intraoperative awareness.

There were some patients who had transient arrhythmia after delivery in the halothane, enflurane, and isoflurane groups. The arrhythmia might be connected with the PGF2α injected into the uterine muscle and methylergometrine maleate injected intravenously after delivery [8,9]. On the other hand, no patient had arrhythmia in the sevoflurane group. Sevoflurane dose not appear to be arrhythmogenic in dogs, and the arrhythmogenic dose of epinephrine exceeds that found during anesthesia with isoflurane [10]. This is an advantage during anesthesia for cesarean section.

This investigation showed that low-dose sevoflurane has the same advantages as the other three anesthetics in that it does not induce hypotension, depress uterine contractility, result in increased uterine bleeding, or depress the newborn; neither does it induce maternal post-operative recall or awareness of intraoperative events, and no arrhythmia was seen during anesthesia. Therefore sevoflurane is a useful anesthetic agent for cesarean section.

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