J Anesth (2002) 16:97–101

Journal of
Anesthesia

Original articles

Multiple-deep-breath inhalation induction with 5% sevoflurane and 67% nitrous oxide: comparison with intravenous injection of propofol

Kenji S. Suzuki[1], Mitsuhiko Oohata[2], and Naohisa Mori[2]

[1] Department of Anesthesia, Kitakami Saiseikai Hospital, 1-6-8 Hanazono-cho, Kitakami, Iwate 024-8506, Japan
[2] Department of Anesthesiology, Faculty of Medicine, Iwate Medical University, 19-1 Uchimaru, Morioka 020-8505, Japan

Abstract
Purpose. To evaluate the clinical characteristics of multiple-deep-breath inhalation induction with sevoflurane and nitrous oxide followed by the same inhalational anesthetics for maintenance, we compared the technique with intravenous propofol anesthesia.
Methods. Forty patients scheduled for ophthalmic surgery under general anesthesia with a laryngeal mask airway (LMA) were assigned to two groups. Anesthesia was induced with multiple-deep-breath inhalation of 5% sevoflurane and 67% nitrous oxide in oxygen (group S: $n = 20$) or intravenous injection of 1% propofol at the rate of 1200 ml·h^{-1} with spontaneous inhalation of 67% nitrous oxide in oxygen until the patient lost consciousness or received propofol up to 2 mg·kg^{-1} (group P: $n = 20$). We attempted to insert an LMA when the patient's jaw relaxation was adequate. We compared induction times, recovery times, occurrence of adverse events, and patient satisfaction between the two groups.
Results. The mean time to insertion of the LMA was significantly shorter in group P (209 ± 118 s) than in group S (302 ± 102 s; $P < 0.05$). The recovery times did not differ significantly between the groups. There were no serious side effects during the induction and recovery period in either group. Significantly more patients in group P than in group S wanted to have the same anesthetic method (90% *vs* 50%; $P < 0.05$).
Conclusion. Multiple-deep-breath inhalation induction with 5% sevoflurane and 67% nitrous oxide followed by the same inhalational anesthetics for maintenance was safely performed without serious adverse events. However, the induction time was shorter and patient satisfaction was higher in propofol group than in the inhalational group.

Key words Multiple-deep-breath induction · Sevoflurane · Nitrous oxide · Propofol · Laryngeal mask airway

Address correspondence to: K.S. Suzuki
Received: April 11, 2001 / Accepted: November 6, 2001

Introduction

Sevoflurane has a low blood/gas solubility coefficient and is a nonpungent agent, which permits rapid induction using a face mask for adult patients. The vital capacity or multiple-deep-breath technique with 8% sevoflurane can produce loss of consciousness in 40–60 s and is associated with minimal complications compared with those associated with propofol induction [1–4]. In Japan the sevoflurane vaporizer that allows the use of concentrations over 5% is not in common use, and therefore we undertook the present investigation inducing anesthesia with 5% sevoflurane. It has been demonstrated that nitrous oxide added to sevoflurane makes the induction time faster [1,5–7]. We applied induction with sevoflurane carried in nitrous oxide and oxygen for the study group, whereas in the control group the patients were administered nitrous oxide and oxygen via the face mask during induction with intravenous propofol.

Materials and methods

After approval by the Clinical Human Research Committee and informed consent, from the patients had been obtained, 40 patients, aged 18–65 years, ASA physical status 1 or 2, scheduled for ophthalmic surgery were studied. The patients were randomly allocated to receive anesthesia by sevoflurane and nitrous oxide inhalation (group S: $n = 20$) or by intravenous propofol infusion with nitrous oxide inhalation (group P: $n = 20$). Patients who had neurologic disease, were taking any sedative drugs, had adverse reactions to inhalation anesthetics or propofol, or had other serious cardiovascular, respiratory, renal, or metabolic diseases were excluded from the study. Detailed methods of inhalational induction were explained to the patients of group S on the day before surgery. A 20-gauge i.v. cannula was

placed in the patient's forearm vein, and infusion of $2\,ml{\cdot}kg^{-1}{\cdot}h^{-1}$ acetate Ringer's solution was started in the early morning before surgery. The patient was brought to the operating room and connected to the electrocardiograph, noninvasive arterial pressure monitor, and pulse oximeter. End-tidal CO_2 and the concentrations of nitrous oxide and sevoflurane were continuously monitored. The patient received intravenous atropine sulfate 0.25 mg a few minutes prior to induction. Anesthesia was given by either of the two anesthesiologists (KSS or MO) who had had clinical experience of more than 6 years.

In group S, at the start of induction, the gas flow was altered to nitrous oxide $6\,l{\cdot}min^{-1}$ and oxygen $3\,l{\cdot}min^{-1}$, and the vaporizer was opened to 5% for priming of the anesthetic circuit. After two or three deep breaths of room air, the patient was instructed to breathe out to a residual volume. Immediately the face mask was gently placed over the nose and mouth, and the patient subsequently took deep breaths repeatedly until loss of consciousness. Cessation of response to verbal commands was taken to signify loss of consciousness. After loss of the eyelash reflex had been confirmed, ventilation was gently assisted by an anesthesiologist. A laryngeal mask airway (LMA) was inserted without using a laryngoscope when the patient's jaw relaxation was adequate. A size 4 LMA was used in male patients and a size 3 LMA in female patients. After insertion of the LMA, fresh gas flow was reduced to nitrous oxide $4\,l{\cdot}min^{-1}$ and oxygen $2\,l{\cdot}min^{-1}$, and the concentration of sevoflurane was reduced to 2%–3%.

In group P, the patients were administered $6\,l{\cdot}min^{-1}$ of nitrous oxide and $3\,l{\cdot}min^{-1}$ of oxygen by spontaneous inhalation for 5 min. Then intravenous injection of 1% propofol was started at a rate of $1200\,ml{\cdot}h^{-1}$ using an infusion pump (Terufusion STC-525X Terumo, Tokyo, Japan) until the patient lost consciousness or received propofol up to $2\,mg{\cdot}kg^{-1}$. Subsequently the patients were given propofol infusion at a rate of $10\,mg{\cdot}kg^{-1}{\cdot}h^{-1}$ and nitrous oxide/oxygen inhalation at the same ratio. After LMA insertion at the same time as in group S, anesthesia was maintained by inhalation of $4\,l{\cdot}min^{-1}$ nitrous oxide and $2\,l{\cdot}min^{-1}$ oxygen with 6–$8\,mg{\cdot}kg^{-1}{\cdot}h^{-1}$ propofol infusion.

An anesthesiologist repeated verbal commands in a gentle tone of voice without tapping and eyelash stimulation at 5-s intervals during induction, and the observer noted the time to loss of response. The observer also recorded the time to successful insertion of the LMA. If LMA insertion failed, the patient was ventilated with 5% sevoflurane in nitrous oxide/oxygen (group S) or 30–50 mg of intravenous propofol was added (group P) until adequate depth of anesthesia was attained. The mean arterial pressure and heart rate were recorded at preinduction and every minute from induction to 5 min after insertion of the LMA. All complications associated with induction were noted, e.g., coughing, laryngospasm, apnea lasting more than 20 s, hypoxia defined as oxygen saturation (SpO2) less than 96%, increase of secretion, movement, and unacceptable hemodynamic changes.

The concentration of sevoflurane and the infusion rate of propofol were adjusted within ranges of 1.5%–3.0% and 6–$10\,mg{\cdot}kg^{-1}{\cdot}h^{-1}$, respectively, to maintain adequate anesthesia, and 7.5–30 mg of intravenouse pentazocine was administered as necessary according to clinical signs (e.g., movement, tachypnea, tachycardia, and hypertension) during surgery.

At the end of surgery, sevoflurane, propofol, and nitrous oxide were discontinued, and the patient breathed $6\,l{\cdot}min^{-1}$ of oxygen. The times at which the patient responded to verbal commands and was able to lift his or her head and the time to removal of the LMA were recorded. Nausea, vomiting, excitement, or other complications and the requirement for antiemetic or other medications during the recovery period were noted.

The patients were asked to assess the satisfaction of their anesthetic method on a three-point scale: good, bad, or neither, 24 h after surgery or a few days later. They were also asked what was unsatisfactory (e.g., the smell of the anesthetics, pain on injection, postoperative nausea and vomiting [PONV]), and whether they would be willing to undergo anesthetic by a similar technique again in the future.

Data are expressed as mean values ± SD. We used an unpaired *t*-test and chi-square test for comparison of patients' characteristics between two groups. Changes from baseline values were analyzed by repeated-measures analysis of variance followed by Bonferroni/Dunn as a post hoc test. The chi-square test was used for discrete variables. Statistical significance was taken as $P < 0.05$.

Results

There were no significant differences in demographic characteristics between the two groups (Table 1). The range of inspired sevoflurane concentration was 4.2%–4.6%, whereas that of end-tidal sevoflurane concentration at the insertion of LMA was 3.8%–4.5%.

The time to insertion of the LMA was significantly shorter in group P than in group S ($P < 0.05$). However, there were no statistically significant differences in time to loss of verbal response and eyelash reflex between the groups (Table 2). The success rates of insertion of the LMA for the first trial were not different in the two groups (80% in group S and 75% in group P).

There were no severe complications during and after anesthesia in either group. Complications during induc-

tion are shown in Table 3. There were no significant differences in the incidence of adverse airway or circulatory events, but patient movement occurred more frequently in group P than in group S.

Heart rate did not significantly change in either group during induction (Fig. 1). Mean arterial pressure did not differ significantly between the two groups. In group S mean arterial pressure decreased in comparison with the preinduction value 5 min after induction and 5 min after insertion of the LMA, whereas it decreased 2 min after insertion of the LMA and persisted for 5 min after insertion in group P ($P < 0.05$) (Fig. 1). The mean inhaled concentration of sevoflurane was 2.1 ± 0.3%, and the mean infusion rate of propofol was 6.6 ± 0.7 $mg \cdot kg^{-1} \cdot h^{-1}$ during surgery. The percentage of patients who required intraoperative pentazocine was higher in group P (95%) than in group S (10%) ($P < 0.05$) because patient movement occured more frequently in group P. The groups did not differ in then requirements of other drugs during surgery.

Table 4 shows the recovery times and complications after anesthesia. The times to command response, LMA removal, and head lifting were not significantly different between the two groups, and there were no differences

Table 1. Background data[a]

Characteristic	Group S ($n = 20$)	Group P ($n = 20$)
Age (yr)	54 ± 13	52 ± 17
Sex (M/F)	13/7	12/8
Height (cm)	163 ± 10	160 ± 9
Weight (kg)	60 ± 10	61 ± 16
Duration of surgery (min)	125 ± 40	121 ± 39
Duration of anesthesia (min)	158 ± 50	149 ± 39

[a] Plus-minus values are means ± SD

Table 2. Induction times[a]

Time	Group S ($n = 20$)	Group P ($n = 20$)
Time to loss of response to verbal command (s)	65 ± 25	55 ± 29
Time to loss of eyelash reflex (s)	80 ± 26	70 ± 28
Time to insertion of laryngeal mask airway (s)	302 ± 102	209 ± 118*

[a] Plus-minus values are means ± SD
* $P < 0.05$ *vs* group S

Table 3. Occurrence of complications during induction[a]

Complication	Group S ($n = 20$)	Group P ($n = 20$)
Breath holding	5 (25)	5 (25)
Airway obstruction	1 (5)	0
Coughing	3 (15)	5 (25)
Hiccup	0	2 (10)
Excessive salivation	2 (10)	0
Hypoxia	5 (25)	4 (20)
Movement	4 (20)	14 (70)*
Hypertension	2 (10)	1 (5)
Hypotension	1 (5)	1 (5)
Tachycardia	3 (15)	0
Bradycardia	0	1 (5)

[a] Values are numbers (%) of patients
* $P < 0.05$ *vs* group S

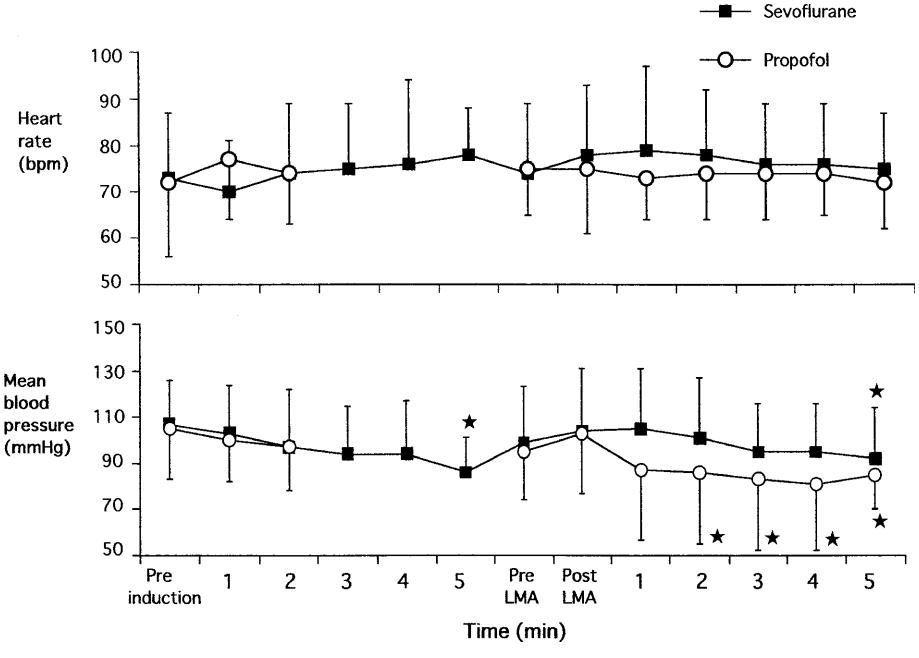

Fig. 1. Changes in heart rate and arterial blood pressure during induction. *Closed squares*, Group S; *open circles*, group P. *Preinduction*, baseline; *time 1,2,3,4,5*, times (min) after placement of the mask and successful insertion of the laryngeal mask airway (*LMA*); *pre LMA*, time at beginning of attempt to insert LMA; *post LMA*, time at successful insertion of LMA. Values are expressed as means ± SD. ★ $P < 0.05$ *vs* preinduction value.

Table 4. Recovery times and adverse events after anesthesia[a]

Measurement	Group S ($n = 20$)	Group P ($n = 20$)
Time to command response (min)	8.9 ± 5.1	11.7 ± 11.6
Time to removal of laryngeal mask airway (min)	10.5 ± 5.9	13.1 ± 11.5
Time to possibility of head lift (min)	17.0 ± 11.1	23.1 ± 14.6
Delay for emergence (%)	1 (5)	1 (5)
Excitement (%)	3 (15)	2 (10)
Nausea (%)	5 (25)	2 (10)
Vomiting (%)	1 (5)	0
Headache (%)	3 (15)	0
Hypertension (%)	4 (20)	1 (5)

[a] Values are means ± SD or number (%) of patients

Table 5. Patient satisfaction with anesthetic methods[a]

Satisfaction	Group S ($n = 20$)	Group P ($n = 20$)
Good	1 (5)	13 (65)
Bad	9 (45)	2 (10)
Neither	10 (50)	5 (25)

[a] Values are number (%) of patients. Chi-square test, $P = 0.0003$

Table 6. Unsatisfactory factors with anesthetic methods

Factor	Group S ($n = 20$)	Group P ($n = 20$)
Mask unpleasant	5 (25)	3 (15)
Smell unpleasant	10 (50)	0*
Pain on intravenous injection	0	1 (5)
Postoperative nausea and vomiting	5 (25)	3 (15)
Postanesthetivc sore throat	1 (5)	2 (10)
Postanesthetic headache	3 (15)	0

[a] Values are number (%) of patients
* $P < 0.05$ *vs* group S

in the number of patients with adverse events during the recovery period.

Patient satisfaction was higher in group P than in group S ($P < 0.05$) (Table 5). The unsatisfactory factors are shown in Table 6. Significantly more patients in group S found the smell unpleasant ($P < 0.05$). Fifty percent of patients in group S and 90% of patients in group P were willing to have anesthesia by the same method again ($P < 0.05$).

Discussion

In our study the times to loss of consciousness, loss of eyelash reflex, and insertion of the LMA in the sevoflurane group were greater than those in other trials of 7.5%–8% sevoflurane [1–3,5,7]. The time to insertion of the LMA was faster with propofol, although there were no significant differences in the time to loss of consciousness and eyelash reflex between the two groups in our study. If the patients in group P were not administered nitrous oxide prior to intravenous propofol injection, the induction times of the two groups might be anticipated to be similar [8]. We must administer nitrous oxide also to the patients in group S for 5 min before induction to standardize the condition of the two groups, but it two anesthetic machines are needed for the gaseous induction group. We did not record the time between the beginning of LMA insertion and the finish of successful insertion in this study. If a long time was taken to judge the degree of jaw relaxation or LMA insertion failed, a longer time might be required to attain an adequate depth of anesthesia for the second time in group S, because the level of anesthesia would decrease during the removal of the mask.

There were no serious complications, and there was no significant difference in the incidence of complications between groups during induction in the present study, but there were slightly fewer airway complications in the propofol group. If the patient inspires a large amount of the room air during the trial of insertion of the LMA, oxygen saturation must decrease abruptly resulting from diffusion hypoxia, because he was administered nitrous oxide just before the insertion. Excitation was not observed in any of the patients, but movement was more common in the propofol group, although it did not interfere with the induction procedure. This result of patient movement differed from that in other previous studies [1,3,9]. It may be considered that the induction dose of propofol in our study was less than that in the other studies. The decrease of mean arterial pressure was milder in the sevoflurane group than in the propofol group, a result similar to that in other reports [2,3,10].

Maintenance of intraoperative anesthesia was thought to be easier with the gaseous method, because fewer patients in the sevoflurane group required additional pentazocine.

Awakening from anesthesia was slightly faster in the sevoflurane group, although there were no differences in time to command response, removal of LMA, and head lifting between the groups. Smith [2] demonstrated in day-case anesthesia that patients in the propofol group were eligible for discharge earlier than those in the sevoflurane group because of a reduced incidence of PONV. In the present study, one woman patient in the sevoflurane group complained of nausea that continued for about 24 h after surgery. The incidence of PONV was slightly lower in the

propofol group, but the difference was not statistically siginficant.

Patient satisfaction with the anesthetic technique was at variance with that of previous investigations [1–3,6,7,11–14], although no report showed that more patients preferred gaseous induction to intravenous induction. In our study fewer patients in the sevoflurane group were satisfied with the anesthetic method they had undergone, because of the smell of inhaled gas, nausea after anesthesia, etc. One reason for patient dissatisfaction may be that the mutiple-deep-breath technique with 5% sevoflurane requires a longer time for induction the time of exposure to the smell is thus prolonged.

In conclusion, multiple-deep-breath inhalation induction with 5% sevoflurane and 67% nitrous oxide and subsequent insertion of an LMA for adult patients can be performed without serious adverse events. The occurrence of side effects during the induction and recovery period did not differ between the two groups, but the time to insertion of the LMA was significantly shorter and patient satisfaction with the anesthetic method was higher in the propofol group than in the sevoflurane group.

References

1. Hall JE, Stewart JIM, Harmer M (1997) Single-breath inhalation induction of sevoflurane anaesthesia with and without nitrous oxide: a feasibility study in adults and comparison with an intravenous bolus of propofol. Anaesthesia 52:410–415
2. Smith I, Thwaites AJ (1999) Target-controlled propofol *vs* sevoflurane: a double blind, randomised comparison in day-case anaesthesia. Anaesthesia 54:745–752
3. Thwaites A, Edmends S, Smith I (1997) Inhalation induction with sevoflurane: a double-blind comparison with propofol. Br J Anaesth 78:356–361
4. Philip BK, Lombard LL, Roaf ER, Drager LR, Calalang I, Philip JH (1999) Comparison of vital capacity induction with sevoflurane to intravenous induction with propofol for adult ambulatory anesthesia. Anesth Analg 89:623–627
5. Muzi M, Robinson BJ, Ebert TJ, O'Brien TJ (1996) Induction of anesthesia and tracheal intubation with sevoflurane in adults. Anesthesiology 85:536–543
6. Yurino M, Kimura H (1994) The influence of additional nitrous oxide during rapid anesthetic induction with sevoflurane. J Anesth 8:406–409
7. Yurino M, Kimura H (1995) Comparison of induction time and characteristics between sevoflurane and sevoflurane/nitrous oxide. Acta Anaesthsiol Scand 39:356–358
8. Jellish WS, Lien CA, Fontenot HJ, Hall R (1996) The comparative effects of sevoflurane versus propofol in the induction and maintenance of anesthesia in adult patients. Anesth Analg 82:479–485
9. Coste C, Guignard B, Menigaux C, Chauvin M (2000) Nitrous oxide prevents movement during orotracheal intubation without affecting BIS value. Anesth Analg 91:130–135
10. Smith I, Ding Y, White PF (1992) Comparison of induction, maintenance, and recovery characteristics of sevoflurane-N_2O and propofol-sevoflurane-N_2O with propofol-isoflurane-N_2O anesthesia. Anesth Analg 74:253–259
11. Yurino M, Kimura H (1995) A comparison of vital capacity breath and tidal breathing techniques for induction of anaesthesia with high sevoflurane concentrations in nitrous oxide and oxygen. Anaesthesia 50:308–311
12. Yurino M, Kimura H (1993) Induction of anesthesia with sevoflurane, nitrous oxide, and oxygen: a comparison of spontaneous ventilation and vital capacity rapid inhalation induction (VCRII) techniques. Anesth Analg 76:598–601
13. Sloan MH, Conard PF, Karsunky PK, Gross JB (1996) Sevoflurane versus isoflurane: induction and recovery characteristics with single-breath inhaled inductions of anesthesia. Anesth Analg 82:528–532
14. Song D, Joshi GP, White PF (1998) Fast-track eligibility after ambulatory anesthesia: a comparison of desflurane, sevoflurane, and propofol. Anesth Analg 86:267–273