Early Recovery Properties of Sevoflurane and Desflurane in Patients Undergoing Total Hip Replacement Surgery

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ABSTRACT

Background: The pharmacokinetic properties of sevoflurane and desflurane differ from those of other volatile anesthetics. For example, both agents allow more rapid emergence than traditional volatile anesthetics. However, few direct comparisons of the 2 agents have been made.

Objective: The aim of this study was to compare the early recovery properties of desflurane and sevoflurane in patients with American Society of Anesthesiologists physical status I or II undergoing total hip replacement (THR) surgery.

Methods: This open-label study was performed at the Department of Anesthesiology, Erciyes University School of Medicine, Kayseri, Turkey. Early recovery was assessed in the surgical suite by measuring the time to 50% decline of end-tidal volatile concentration of desflurane or sevoflurane; time to extubation, eye opening, orientation, and a modified Aldrete Scale (MAS) score >8 (ie, safe to discharge from the surgical suite); and time to discharge from the postanesthesia recovery room.

Results: Time to 50% decline of end-tidal volatile concentration of desflurane or sevoflurane, tracheal extubation, eye opening, orientation, and an MAS score >8 occurred significantly more rapidly in the desflurane group than in the sevoflurane group ($P < 0.001$). However, the groups did not differ significantly in duration of anesthesia; time to discharge from the postanesthesia recovery room; or incidences of nausea, vomiting, dizziness, and drowsiness in the first 24 hours after anesthesia.

Conclusions: In this study population, desflurane provided significantly more rapid early recovery than sevoflurane, but we did not find any beneficial effects of desflurane on intermediate recovery. The rapid emergence from anesthesia may facilitate more efficient surgical suite use and may be associated with more

benefits after prolonged anesthesia. We suggest that both volatile agents may be acceptable anesthetics for use during THR surgery. (*Curr Ther Res Clin Exp.* 2003;64:301–309) Copyright © 2003 Excerpta Medica, Inc.

Key words: desflurane, sevoflurane, recovery, orientation, total hip replacement surgery.

INTRODUCTION

The pharmacokinetic properties of sevoflurane and desflurane differ from those of other volatile anesthetics. Sevoflurane has a low blood-gas partition coefficient (0.69) and minimal pungency.¹ Desflurane is a volatile anesthetic with a markedly lower blood-gas solubility coefficient (0.42).² Rapid emergence from desflurane and sevoflurane anesthesia has been observed in animals and humans.^{3,4} Both agents allow more rapid emergence than traditional volatile anesthetics.^{5–13} However, few direct comparisons of the 2 agents have been made. A study⁹ of patients undergoing gynecologic laparoscopy showed more rapid early recovery with desflurane than with sevoflurane; in another study¹¹ of patients undergoing outpatient arthroscopy, recovery was more rapid with desflurane, but discharge was not.

The aim of this study was to compare the early recovery properties of desflurane and sevoflurane in patients with American Society of Anesthesiologists (ASA) physical status I (ie, healthy) or II (ie, mild systemic disease) undergoing total hip replacement (THR) surgery.

PATIENTS AND METHODS

This study was performed at the Department of Anesthesiology, Erciyes University School of Medicine, Kayseri, Turkey. The study protocol was approved by the local ethics committee, and oral informed consent was obtained from patients with ASA physical status I or II who were scheduled for THR. After enrollment, patients were randomized to the desflurane or sevoflurane group using an open-label study design.

Patients with clinically significant cardiovascular, respiratory, hepatic, renal, neurologic, psychiatric, or metabolic disease were excluded from the study. Patients with a history of malignant hyperthermia and pregnant, possibly pregnant, or lactating women also were excluded.

Atropine, benzodiazepine, and similar drugs were not used as premedications before induction of anesthesia. During the procedure, the patients were monitored by electrocardiography (II-lead), pulse oximetry, and noninvasive arterial blood pressure measurement. The inspired oxygen concentration and end-tidal concentrations of the anesthetics were recorded continuously. Volatile concentrations of sevoflurane and desflurane were determined using a multigas analyzer (Datex-Engstrom, Datex Medical Instrumentation Corp., Helsinki,

Finland). Sevoflurane was administered using a Sevotec IV $\hat{\text{O}}$ vaporizer (Datex Ohmeda, Madison, Wisconsin), and desflurane was administered using an Ohmeda TEC $\hat{\text{O}}$ vaporizer (Datex Ohmeda).

All patients received fentanyl 2 $\mu\text{g/kg}$ IV and then breathed 100% oxygen for 3 minutes before the induction of anesthesia with thiopentone 5 mg/kg IV and rocuronium 0.9 mg/kg IV. After loss of consciousness, the trachea was intubated. Anesthesia was maintained with either sevoflurane 1% to 2% or desflurane 3% to 6% in $\text{N}_2\text{O}:\text{O}_2$ at a ratio of 3:1. The inspired concentration of the volatile anesthetic was adjusted to maintain mean arterial pressure within 20% of baseline values. During the maintenance period, ventilation was controlled to maintain normocarbia with a fresh gas flow (4.0 L/min) using a semiclosed circular system. Incremental doses of rocuronium 0.3 mg/kg IV were given. Isotonic saline was administered at a rate of 10 to 15 mL/h/kg, and blood was given, if appropriate.

At the end of surgery, patients were given neostigmine 50 $\mu\text{g/kg}$ IV and atropine sulfate 10 $\mu\text{g/kg}$ IV, and the inhaled anesthetics were discontinued. The lungs were ventilated with 100% oxygen at a fresh gas flow rate of 4 L/min. The trachea was extubated when a regular spontaneous breathing pattern had been reestablished and the patient was able to open his or her eyes on command. We assessed early recovery in the surgical suite using a modified Aldrete Scale* (MAS) score.¹⁴ An observer determined the time to 50% decline of end-tidal volatile concentration of desflurane or sevoflurane, tracheal extubation, eye opening, orientation (determined by the time at which the patient could correctly answer the question, "What is your name?"), and an MAS score >8 (ie, safe to discharge from the surgical suite). Patients were then transferred to a postanesthesia recovery room. When the patient had sufficient hemodynamic and respiratory stability, he or she was discharged from the postanesthesia recovery room and the discharge time was noted.

On the first postoperative day, patients were interviewed to determine the occurrence of postoperative nausea, vomiting, dizziness, and/or drowsiness (rated as nonexistent or existent). Patient-controlled analgesia with meperidine (1 mg/kg loading dose, 5-mg boluses, and 3-mg/h/kg infusion) was provided.

Statistical Analyses

The statistical analyses were performed using Statistica version 4.3 (Statsoft Inc., Tulsa, Oklahoma). Data are reported as mean (SD). Demographic data

*The MAS includes 5 subscales, scored as follows: (1) activity (0 = unable to move ≥ 1 extremities voluntarily or on command, 1 = able to move ≥ 1 extremities voluntarily or on command, and 2 = able to move 4 extremities voluntarily or on command), (2) respiration (0 = apnea, 1 = dyspnea or limited breathing, and 2 = able to breathe deeply and cough freely), (3) circulation (0 = arterial pressure $>50\%$ of preanesthetic level, 1 = arterial pressure 20%–50% of preanesthetic level, and 2 = arterial pressure $<20\%$ of preanesthetic level), (4) consciousness (0 = not responding, 1 = aroused on calling, and 2 = fully awake), and (5) color (0 = cyanotic; 1 = pale, dusky, blotchy, jaundiced, or other; and 2 = pink).

and other variables were analyzed using unpaired Student *t* tests. Descriptive variables were analyzed using the chi-square test or the Fisher exact test. $P < 0.05$ was considered statistically significant.

RESULTS

The study comprised 40 patients (20 patients in each group) (25 men, 15 women; mean [SD] age, 49.5 [9.1] years; range, 32–66 years). The 2 groups were comparable in sex distribution, age, ASA status, and body weight. The duration of anesthesia, the amount of fluids replaced, the amount of blood replaced, and the amount of rocuronium and fentanyl used were also similar in the 2 groups (Table I).

The mean time to 50% decline of end-tidal volatile drug concentration was 24.3 (6.0) seconds in the desflurane group and 31.2 (6.9) seconds in the sevoflurane

Table I. Demographic and clinical characteristics of study patients (N = 40).

Characteristic	Desflurane (n = 20)	Sevoflurane (n = 20)
Sex, no. (%)		
Women	7 (35)	8 (40)
Men	13 (65)	12 (60)
Age, y		
Mean (SD)	50.6 (8.5)	48.3 (9.7)
Range	35–66	32–64
ASA class, no. (%)		
I (healthy)	11 (55)	12 (60)
II (mild systemic disease)	9 (45)	8 (40)
Body weight, kg		
Mean (SD)	65.5 (10.2)	69.4 (11.0)
Range	49–89	48–90
Duration of anesthesia, min		
Mean (SD)	127.0 (16.1)	129.7 (18.3)
Range	100–160	100–160
Fluid replacement, mL		
Mean (SD)	3005.0 (647.6)	3335.0 (666.7)
Range	2000–4800	2400–4800
Blood replacement, mL		
Mean (SD)	800.0 (290.1)	860.0 (350.0)
Range	400–1200	400–1600
Total rocuronium consumption, mg		
Mean (SD)	86.1 (22.6)	82.7 (21.4)
Range	60–150	60–140
Total fentanyl consumption, µg		
Mean (SD)	139.0 (44.5)	146.8 (48.2)
Range	100–250	100–250

ASA = American Society of Anesthesiologists.

group ($P < 0.001$) (Figure). Times to tracheal extubation, eye opening, orientation, and an MAS score >8 were significantly shorter in the desflurane group than in the sevoflurane group ($P < 0.001$). However, time to discharge from the postanesthesia recovery room was similar in the 2 groups (Table II). The incidences of postoperative complications (nausea, vomiting, drowsiness, and/or dizziness) in the first 24 hours after anesthesia were also similar between groups (Table III).

DISCUSSION

This study shows that both desflurane and sevoflurane are acceptable volatile anesthetics for unilateral THR surgery. Time to discharge from the postanesthesia recovery room and the incidence of postoperative complications were similar in the 2 groups. The time to 50% decline of end-tidal volatile concentration and early recovery were significantly more rapid with desflurane than with sevoflurane.

In previous studies, researchers reported that 1 minimum alveolar concentration (MAC) of desflurane was 3% to 9%^{5,6,8} and 1 MAC of sevoflurane was 1.71%¹⁵ to 2.45%.¹⁶ These values were reduced to 0.6% in adults by adding 60% nitrous oxide.^{1,8,12,17} In accordance with the previous studies, we used desflurane 3% to 6% and sevoflurane 1% to 2% in our study. Therefore, we believe that approximately equipotent concentrations of the 2 agents were given to the 2 groups.

Figure. Time to 50% decline of end-tidal volatile concentration of desflurane and sevoflurane. * $P < 0.001$ between groups.

Table II. Mean (SD) early recovery times (min) in study patients (N = 40).

Time Category	Desflurane (n = 20)	Sevoflurane (n = 20)
Time to tracheal extubation*	5.35 (2.27)	9.10 (1.44)
Time to eye opening on verbal command*	6.25 (1.99)	9.85 (1.13)
Time to orientation*†	6.80 (1.93)	10.20 (1.25)
Time to MAS‡ score >8*§	7.40 (2.03)	10.70 (1.62)
Time to discharge from postanesthesia recovery room	36.60 (7.96)	38.30 (8.38)

MAS = modified Aldrete Scale.

* $P < 0.001$ between groups.

†Determined by the time at which the patient could correctly answer the question, "What is your name?"

‡The MAS includes 5 subscales, scored as follows: (1) activity (0 = unable to move ≥ 1 extremities voluntarily or on command, 1 = able to move ≥ 1 extremities voluntarily or on command, and 2 = able to move 4 extremities voluntarily or on command), (2) respiration (0 = apnea, 1 = dyspnea or limited breathing, and 2 = able to breathe deeply and cough freely), (3) circulation (0 = arterial pressure >50% of preanesthetic level, 1 = arterial pressure 20%–50% of preanesthetic level, and 2 = arterial pressure <20% of preanesthetic level), (4) consciousness (0 = not responding, 1 = aroused on calling, and 2 = fully awake), and (5) color (0 = cyanotic; 1 = pale, dusky, blotchy, jaundiced, or other; and 2 = pink).

§Safe to discharge from the surgical suite.

A possible weakness of the present study was the open-label protocol. However, we believe that our findings are not influenced by the protocol. All patients were randomized to treatment, and an observer objectively assessed the early recovery data. In addition to this, we were not able to blind the anesthetist to the anesthetic because different vaporizers were used to administer the 2 anesthetics.

Previous studies^{18–21} have confirmed earlier recovery after both desflurane and sevoflurane anesthesia compared with that of isoflurane. The practical benefit of earlier emergence leading to more rapid discharge from the postanesthesia recovery room has been demonstrated in only 1 comparative study involving desflurane and isoflurane.¹⁹ In another study, Naidu-Sjosvard et al¹¹ compared desflurane and sevoflurane for maintenance following IV induction

Table III. Incidence (no. [%] of patients) of postoperative complications in the first 24 hours after anesthesia.*

Postoperative Complication	Desflurane (n = 20)	Sevoflurane (n = 20)
Nausea	6 (30)	5 (25)
Vomiting	2 (10)	3 (15)
Drowsiness	1 (5)	2 (10)
Dizziness	0 (0)	1 (5)

*Some patients experienced >1 postoperative complication.

with propofol, and although early recovery was assessed as being better in the desflurane group, no difference in the time to discharge was found between the 2 groups. Also, we found no between-group difference in the time to discharge from the postanesthesia recovery room.

Tarazi and Philip⁸ reported that mean time to eye opening (5 minutes in both groups), mean time to obeying commands (5 minutes in both groups), and mean time to the patient stating his or her name (7 and 8 minutes in the sevoflurane and desflurane groups, respectively) were similar in the 2 groups; however, the time to discharge was ~30 minutes faster with sevoflurane than desflurane. Furthermore, the visual analog scale scores for nausea, discomfort, and wakefulness were similar in the 2 groups. Unlike Tarazi and Philip,⁸ Mahmoud et al¹³ reported that mean time to eye opening (2.8 and 7.0 minutes in the desflurane and sevoflurane groups, respectively), mean time to orientation (4.8 and 9.8 minutes, respectively), and mean time to discharge from the postanesthesia recovery room (15.5 and 23.7 minutes, respectively) were significantly different between the 2 groups ($P < 0.001$), and mean time to discharge from the hospital was ~30 minutes faster in the desflurane group (3.0 hours) than in the sevoflurane group (3.5 hours) ($P < 0.01$). Welborn et al²² compared the use of desflurane, sevoflurane, and halothane in 80 children undergoing outpatient ear, nose, and throat surgery. They found no difference in the incidence of nausea and vomiting or time to discharge between the 3 agents, although a significantly higher incidence of delirium was found in the desflurane group (55%) compared with the halothane (25%) and sevoflurane (10%) groups ($P = 0.008$). Our findings on early recovery are in agreement with those of Mahmoud et al.¹³ Although patients recovered more rapidly after desflurane anesthesia than after sevoflurane, sevoflurane was not associated with higher incidences of postoperative nausea, vomiting, drowsiness, and/or dizziness. Our findings on postoperative complications agree with those in previous studies.^{11–13,18–23}

Welborn et al²² reported that mean times to awakening (4.7 vs 8.0 minutes) and early recovery (9.3 vs 17.1 minutes) were more rapid with desflurane than with sevoflurane, respectively. However, they also found that later recovery times did not differ between the 2 groups. Nathanson et al¹⁸ reported that the use of desflurane led to more rapid emergence (4.8 vs 7.8 minutes) and shorter time to extubation (5.1 vs 8.2 minutes) compared with sevoflurane ($P < 0.05$). Despite the more rapid emergence, subsequent recovery end points (eg, times to orientation, ambulation, and hospital discharge) did not differ between the 2 groups. Dupont et al²³ reported that early recovery was twice as rapid with desflurane as with sevoflurane or isoflurane in patients undergoing pulmonary surgery. Our study confirms previous findings that desflurane leads to a shorter time to eye opening and tracheal extubation.

CONCLUSIONS

In this study population, desflurane provided significantly earlier recovery than sevoflurane, but we did not find any beneficial effects of desflurane on intermediate recovery. The rapid emergence from anesthesia may facilitate more efficient

surgical suite use and may be associated with more benefits after prolonged anesthesia. We suggest that both volatile agents may be acceptable anesthetics for use during THR surgery.

REFERENCES

1. Eger EI II. New inhaled anesthetics. *Anesthesiology*. 1994;80:906–922.
2. Eger EI II. Partition coefficients of I-653 in human blood, saline, and olive oil. *Anesth Analg*. 1987;66:971–973.
3. Eger EI II, Johnson BH. Rates of awakening from anesthesia with I-653, halothane, isoflurane, and sevoflurane: A test of the effect of anesthetic concentration and duration in rats. *Anesth Analg*. 1987;66:977–982.
4. Eriksson H, Haasio J, Korttila K. Recovery from sevoflurane and isoflurane anaesthesia after outpatient gynaecological laparoscopy. *Acta Anaesthesiol Scand*. 1995;39:377–380.
5. Ghouri AF, Bodner M, White PF. Recovery profile after desflurane–nitrous oxide versus isoflurane–nitrous oxide in outpatients. *Anesthesiology*. 1991;74:419–424.
6. Smiley RM, Ornstein E, Matteo RS, et al. Desflurane and isoflurane in surgical patients: Comparison of emergence time. *Anesthesiology*. 1991;74:425–428.
7. Philip BK, Kallar SK, Bogetz MS, et al. A multicenter comparison of maintenance and recovery with sevoflurane or isoflurane for adult ambulatory anesthesia. The Sevoflurane Multicenter Ambulatory Group. *Anesth Analg*. 1996;83:314–319.
8. Tarazi EM, Philip BK. A comparison of recovery after sevoflurane or desflurane in ambulatory anesthesia. *J Clin Anesth*. 1998;10:272–277.
9. O'Keefe NJ, Healy TE. The role of new anesthetic agents. *Pharmacol Ther*. 1999;84:233–248.
10. Pollard BJ, Elliott RA, Moore EW. Anaesthetic agents in adult day case surgery. *Eur J Anaesthesiol*. 2003;20:1–9.
11. Naidu-Sjosvard K, Sjoberg F, Gupta A. Anaesthesia for videoarthroscopy of the knee. A comparison between desflurane and sevoflurane. *Acta Anaesthesiol Scand*. 1998;42:464–471.
12. Umbrain V, Keeris J, D'Haese J, et al. Isoflurane, desflurane and sevoflurane for carotid endarterectomy. *Anaesthesia*. 2000;55:1052–1057.
13. Mahmoud NA, Rose DJ, Laurence AS. Desflurane or sevoflurane for gynaecological day-case anaesthesia with spontaneous respiration? *Anaesthesia*. 2001;56:171–174.
14. Aldrete JA, Kroulik D. A postanesthetic recovery score. *Anesth Analg*. 1970;49:924–934.
15. Katoh T, Ikeda K. The minimum alveolar concentration (MAC) of sevoflurane in humans. *Anesthesiology*. 1987;66:301–303.
16. Scheller MS, Saidman LJ, Partridge BL. MAC of sevoflurane in humans and the New Zealand white rabbit. *Can J Anaesth*. 1988;35:153–156.
17. Cahalan MK, Weiskopf RB, Eger EI II, et al. Hemodynamic effects of desflurane/nitrous oxide anesthesia in volunteers. *Anesth Analg*. 1991;73:157–164.
18. Nathanson MH, Fredman B, Smith I, White PF. Sevoflurane versus desflurane for outpatient anesthesia: A comparison of maintenance and recovery profiles. *Anesth Analg*. 1995;81:1186–1190.

19. Tsai SK, Lee C, Kwan WF, Chen BJ. Recovery of cognitive functions after anaesthesia with desflurane or isoflurane and nitrous oxide. *Br J Anaesth.* 1992;69:255–258.
20. Cromwell TH, Eger EI II, Stevens WC, Dolan WM. Forane uptake, excretion, and blood solubility in man. *Anesthesiology.* 1971;35:401–408.
21. Blanco E, Vidal MI, Blanco J, et al. Comparison of maintenance and recovery characteristics of sevoflurane–nitrous oxide and enflurane–nitrous oxide anaesthesia. *Eur J Anaesthesiol.* 1995;12:517–523.
22. Welborn LG, Hannallah RS, Norden JM, et al. Comparison of emergence and recovery characteristics of sevoflurane, desflurane, and halothane in pediatric ambulatory patients. *Anesth Analg.* 1996;83:917–920.
23. Dupont J, Tavernier B, Ghosez Y, et al. Recovery after anaesthesia for pulmonary surgery: Desflurane, sevoflurane and isoflurane. *Br J Anaesth.* 1999;82:355–359.

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