The Assessment of Postural Stability After Ambulatory Anesthesia: A Comparison of Desflurane with Propofol

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We designed this study to evaluate postural stability in outpatients after either desflurane or propofol anesthesia. After IRB approval, 120 consenting women undergoing gynecological laparoscopic procedures were randomly assigned to receive either desflurane or propofol-based general anesthesia. After surgery, patients' postural stability was measured as body sway velocity by using a computerized force platform in the following conditions: 1) standing on a firm surface with eyes open versus closed and 2) standing on a foam surface with eyes open versus closed. These measurements were made before anesthesia, immediately after the patient achieved a Post-Anesthesia Discharge Score of 9, and at actual discharge home. At the time patients first achieved a Post-Anesthesia Discharge Score of 9, the body sway in the Propofol group was significantly more than in the Desflurane group when patients were asked to stand on a foam surface with eyes closed (testing the ability of using vestibular information for balance control). We concluded that the desflurane-based anesthetic was associated with better postural control than the propofol-based anesthetic in the early recovery period after outpatient gynecological laparoscopic procedures.

(Anesth Analg 2002;94:60–4)

Early discharge from the hospital after ambulatory surgery has been one of the major goals of modern ambulatory anesthesia (1). Desflurane and propofol are two of the most widely used general anesthetics for ambulatory surgery because of their short-acting properties. Although propofol-based anesthetics were suggested to be associated with a smoother recovery and fewer postoperative side effects (i.e., nausea and vomiting) than desflurane-based anesthetics (2,3), the latter were usually associated with shorter awakening and orientation times. It is not clear which one has a better recovery profile in terms of balance function and the ability to maintain postural stability, which is an important factor to be considered when assessing recovery, home readiness, and street fitness.

Postural stability, measured by using a force platform, is useful in assessment of anesthetic residual effects and balance disturbances after general anesthesia and sedation (4–6). We hypothesized that anesthetic techniques with desflurane or propofol may have different qualitative effects on patients' postural stability; these effects can be detected with an objective and sensitive assessment tool. Because desflurane usually has a shorter emergence time than propofol, we assumed that desflurane may be superior to propofol with respect to the recovery of balance control. Therefore, we designed this study to evaluate balance function by using a computerized force platform, Balance Master (NeuroCom International, Inc., Clackamas, OR), in outpatients after desflurane- and propofol-based anesthetics.

Methods

After institutional ethics committee approval and informed consent, 120 ASA physical status I and II women undergoing outpatient gynecological laparoscopic procedures were enrolled in this clinical study. Patients with known musculoskeletal diseases, psychological disorders, symptoms suggestive of vestibular or neurologic disorders, current or past medical diagnosis or injury affecting balance, or a history of alcohol or drug abuse were excluded.

After preoxygenation with 100% oxygen, anesthesia was induced with fentanyl 1 μg/kg IV and propofol

Presented in part at the annual meeting of the American Society of Anesthesiologists, San Francisco, CA, October, 2000.

Accepted for publication August 22, 2001.

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0003-2999/01

2 mg/kg IV. Laryngoscopy and tracheal intubation were facilitated with mivacurium 0.2 mg/kg IV. After tracheal intubation, according to a computer-generated random number table, anesthesia was maintained either with a propofol 50–200 $\mu g \cdot kg^{-1} \cdot min^{-1}$ IV infusion or with desflurane 3%–5% end-tidal (ET) inhaled in combination with nitrous oxide 60%–70% in oxygen. All patients were mechanically ventilated to maintain an ET carbon dioxide concentration of 32 to 36 mm Hg. Intermittent bolus doses of mivacurium 0.05–0.1 mg/kg IV were administered to maintain adequate muscle relaxation during surgery. Supplemental fentanyl 50-μg IV boluses were administered to treat persistent increases in heart rate (>100 bpm) or mean blood pressure (>30% of the preanesthesia baseline) values despite a maximal IV infusion rate (200 $\mu g \cdot kg^{-1} \cdot min^{-1}$) in the Propofol group and maximal ET concentrations (5%) in the Desflurane group. All patients received ketorolac 30 mg IV and metoclopramide 10 mg IV approximately 30 min before the end of surgery for analgesic and antiemetic prophylaxis, respectively. In addition, 10 mL of bupivacaine 0.25% was injected to the surgical portals. Upon completion of the operation, residual neuromuscular block was reversed with neostigmine 2.5 mg and glycopyrrolate 0.4 mg IV when necessary, and the maintenance anesthetic was discontinued.

Emergence times were determined at 1-min intervals from discontinuation of the general anesthetic to awakening (i.e., opening eyes on verbal command) and orientation (i.e., correctly stating the date, place, and person). Upon arrival in the postanesthesia care unit, Post-Anesthesia Discharge Score (PADS) (7) was assessed at 15-min intervals until the time the patient was clinically judged "home ready" (i.e., the PADS score reached 9–10). Postoperative pain, nausea, drowsiness, and dizziness were evaluated at 30-min intervals by using 10-point self-assessing verbal scores (0 = none, 10 = worst imaginable) until the time of discharge home. Rescue medication for pain included fentanyl 25- to 50-μg IV boluses or acetaminophen-codeine compound (i.e., Tylenol No. 3), one or two tablets. Postoperative nausea and vomiting were treated with metoclopramide 10 mg or an ondansetron 4-mg IV bolus.

Postural stability was measured with a computerized force platform, Balance Master. The Balance Master system is mobile equipment (capable of bedside measurement) consisting of dual static force plates and a computerized monitor. Each footplate rests on two force transducers, with the sensitive axes oriented vertically. The transducers in turn provide input to the computer. The software program filters the center of pressure data and then calculates, tracks, and displays the center of gravity (COG) on the monitor. Data from the assessments can be recorded and reviewed on screen or printed out, in the forms of COG sway or moving velocity (degrees per second).

The COG sway velocity under the following four conditions was measured: 1) standing on a firm surface with eyes open, 2) standing on a firm surface with eyes closed, 3) standing on a foam surface with eyes open, and 4) standing on a foam surface with eyes closed (Foam-EC). These measurements were made at three time points: 1) before anesthesia, 2) immediately after a PADS score of 9, and 3) at actual discharge home. The research assistant who performed postoperative assessments was not aware of what general anesthetics were administered to the study patients.

Before the study was initiated, a power analysis was performed on the basis of the results of testing a population of clinically asymptomatic subjects with postural stability assessment on the Balance Master (8). According to the results, the mean of the COG sway velocity at Foam-EC in subjects aged 20–69 yr is 1.49 ± 0.45 degrees per second (± SD). With this estimate, the detection of a 20% clinically relevant difference in this primary end point between the two treatment groups requires 49 subjects per group ($\alpha = 0.05$, $\beta = 0.1$) to be evaluated (statistical software: nQuery Advisor™ 1.0; Statistical Solutions, Boston, MA). The unpaired (two-sample) and paired (one-sample) Student's *t*-tests were performed for comparisons of all continuous variables between and within the study groups, respectively; the Kruskal-Wallis test was performed for comparisons of patient self-assessing verbal scores; and the χ^2 test with Yates' continuity correction, as appropriate, was performed for comparisons of other nonparametric variables, such as the incidence of postoperative side effects. Data are expressed as mean values ± SD, and *P* values of <0.05 were considered statistically significant.

Results

Of the 120 enrolled outpatients, 16 patients (6 in the Desflurane group and 10 in the Propofol group) did not complete the assessments because of unwillingness to participate in the study postoperatively. The reason was the inconvenience of the balance test (e.g., each test has to be repeated three times to ensure the accuracy of the result), which required patients to take approximately 5–10 min to complete. Therefore, the data from 104 outpatients were analyzed.

The two treatment groups were comparable with respect to age, weight, height, ASA physical status, duration of surgery and anesthesia, intraoperative drug dosages, and fluid volumes (Table 1). The baseline values of Balance Master scores (Table 2), as well as patients' self-assessing verbal scores for pain, nausea, drowsiness, and dizziness at any pre- and postoperative assessment times, were similar in the two study groups (Table 3).

Table 1. Demographic Data, Duration of Surgery and Anesthesia, Anesthetic and Analgesic Dosages, and Fluid Volumes in the Two Study Groups

Variable	Group	
	Desflurane	Propofol
Number (*n*)	54	50
Age (yr)	35 ± 8	34 ± 6
Weight (kg)	66 ± 12	65 ± 11
Height (cm)	159 ± 6	159 ± 6
ASA physical status (I/II)	51/3	48/2
Anesthesia time (min)	31 ± 13	33 ± 12
Surgery time (min)	21 ± 11	23 ± 10
Intraoperative propofol (mg)	190 ± 47	393 ± 142
Propofol rate ($\mu g \cdot kg^{-1} \cdot min^{-1}$)	—	110 ± 48
Intraoperative desflurane (ET%)	3.2 ± 1.3	—
Intraoperative fentanyl (μg)	101 ± 29	114 ± 33
Intraoperative fluid (mL)	745 ± 294	756 ± 253
PACU fluid (mL)	228 ± 107	216 ± 108

Data are expressed as mean value ± SD unless otherwise noted.
ET = end-tidal; PACU = postanesthesia care unit.

Table 2. COG Sway Velocities (Degrees per Second) in the Two Study Groups

Variable	Group	
	Desflurane	Propofol
Firm surface, eyes open		
Preanesthesia	0.26 ± 0.11	0.26 ± 0.09
PADS score of 9	0.37 ± 0.17*	0.39 ± 0.16*
Actual discharge	0.28 ± 0.13	0.28 ± 0.11
Firm surface, eyes closed		
Preanesthesia	0.31 ± 0.13	0.30 ± 0.11
PADS score of 9	0.42 ± 0.20*	0.39 ± 0.13*
Actual discharge	0.32 ± 0.13	0.29 ± 0.11
Foam surface, eyes open		
Preanesthesia	0.54 ± 0.14	0.58 ± 0.14
PADS score of 9	0.69 ± 0.26*	0.71 ± 0.27*
Actual discharge	0.55 ± 0.17	0.59 ± 0.18
Foam surface, eyes closed		
Preanesthesia	1.31 ± 0.32	1.44 ± 0.32
PADS score of 9	1.43 ± 0.36*	2.11 ± 0.97*†
Actual discharge	1.32 ± 0.37	1.52 ± 0.38

Data are expressed as mean value ± SD.
COG = center of gravity; PADS = Post-Anesthesia Discharge Score.
* $P < 0.05$ compared with preanesthesia value; † $P < 0.05$ compared with the Desflurane group.

Forty-eight (89%) and 46 (92%) patients in the Desflurane and Propofol groups, respectively, received reversal medication at the end of surgery. After surgery, patients' awakening time and orientation time were significantly shorter in the Desflurane group than the Propofol group (Table 3). However, there was no difference found in the times from the discontinuation of general anesthetics to patients' first achieving PADS scores of 9 and actual discharge home.

At the time patients first achieved a PADS score of 9, the COG sway velocities under the four testing conditions were all significantly ($P < 0.01$) increased above their baselines in all study patients (Table 2). However, there were no differences between the two study groups except for the values under the condition of Foam-EC. The average increases of the COG sway velocity in Foam-EC at this time were 20.5% vs 44.5% ($P < 0.05$) above the baseline values in the Desflurane and Propofol groups, respectively (Fig. 1). By the time of patients' actual discharge home, all the COG sway velocities returned to >85% baseline values, and no difference was found between the two study groups (Table 2). An average of 70 min between patients achieving a PADS score of 9 and home discharge was used for patient instruction, patient drinking and eating, waiting for escorts, and changing clothes.

Table 3. Recovery Times, Postoperative 10-Point Self-Assessing Scores, and Rescue Medications in the Two Study Groups

Variable	Group	
	Desflurane	Propofol
Awakening time (min)	3.5 ± 1.8	4.6 ± 2.2*
Orientation time (min)	8.1 ± 2.5	9.8 ± 3.3*
PADS = 9 time (min)	62 ± 18	60 ± 18
Home discharge (min)	138 ± 29	134 ± 24
Self-assessing scores at 60 min after surgery		
Pain	2 (0–8)	2 (0–8)
Nausea	0 (0–8)	0 (0–5)
Drowsiness	2 (0–8)	2 (0–8)
Dizziness	0 (0–4)	0 (0–6)
Postoperative rescue medications		
Fentanyl	0	0
Acetaminophen-codeine	18 (33)	18 (36)
Metoclopromide	5 (9)	3 (6)
Ondansetron	0	0

Data are expressed as mean value ± SD, median (range), and *n* (%).
PADS = Post-Anesthesia Discharge Score.
* $P < 0.05$ compared with the Desflurane group.

Discussion

Static posturography, or the quantitative assessment of human stability, has been applied in aerospace medicine, in otolaryngology, in evaluation of the interaction of drugs and alcohol, in studies of the susceptibility of humans to falling, and in measurements of recovery from anesthesia. In the literature, several methods and apparatus have been used to assess postural stability (9). An instrumented force platform, which measures body sway, was described by Korttila (4). It was sensitive to detect balance disturbances after thiopentone, diazepam, and methohexitone anesthesia. Computerized posturography (i.e., force

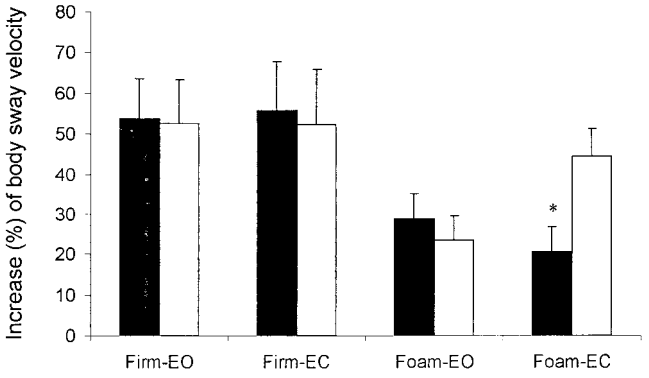

Figure 1. Increase of body sway velocity above the preanesthesia baseline at the time of patients achieving a Post-Anesthesia Discharge Score of 9 in the two study groups. ■ = Desflurane group; □ = Propofol group. *$P < 0.05$ compared with the Propofol group. Firm-EO = firm surface, eyes open; Firm-EC = firm surface, eyes closed; Foam-EO = foam surface, eyes open; and Foam-EC = foam surface, eyes closed.

platform) has been used in clinical practice for assessing and differentiating disturbances of vestibular, visual, and proprioceptive functions and central coordination (10,11). The reliability of outcome measures obtained with the Balance Master has been evaluated in healthy subjects (12). Interclass correlation coefficients revealed excellent reliability of limits of stability measures and the position of the COG (coefficients $\geq$0.75). Reliability and validity of measures obtained from 20 stroke patients by using Balance Master suggest that test-retest reliability of data is great for complex tests of balance (13).

In this study, patients' postural stability was assessed with Balance Master's Static Sway Test, Modified Clinical Test for Sensory Interaction on Balance (14). At the time patients were first able to start walking without assistance after surgery, the balance function measured with Balance Master was significantly impaired compared with the preanesthesia values. Among the four testing conditions, standing on the foam surface with eyes closed had significantly more body sway velocity in the Propofol group compared with the Desflurane group.

A significant increase of the body sway in patients after desflurane- and propofol-based anesthetics at the time of a PADS score of 9 indicates that achieving clinical home discharge criteria, especially within an hour after general anesthetics, may not guarantee the complete restoration of patients' balance function. On the criteria of ambulation in PADS, a full score of 2 is given to a patient able to ambulate with a steady gait. This is a clinical score, and the criteria may not determine full recovery of the balance function of a patient. Steward and Volgyesi (9) used a stabilimeter to measure changes in the activity of postural muscles during the later stages of recovery from halothane anesthesia in a series of healthy pediatric outpatients and reported that the postural muscle activity was normalized 75 minutes after the anesthetic. Ledin et al. (15) used a computerized dynamic posturography to study postural control before and after propofol anesthesia in patients undergoing microlaryngoscopy. They found that the equilibrium performance returned to baseline values within two hours.

The greater body sway velocity in the Propofol group than the Desflurane group under the condition of eyes closed on a foam surface may indicate that propofol-based anesthetics are associated with more vestibular disturbances. Patients in this testing condition had only vestibular information available and accurate; their visual information was unavailable, and somatosensory information was inaccurate. Patients in the Desflurane group had more postural stability than the Propofol group, which indicates that they may have less difficulty using vestibular information for balance control. This may be caused by a more rapid and complete elimination of central nervous effects after desflurane than propofol. Other factors, including residual nitrous oxide, fentanyl, mivacurium, prophylactic antiemetic, and so on, may also have combined effects with desflurane and propofol. In an early study using a force plate system to test patients' postural stability after IV thiopental or propanidid, Eriksen et al. (16) reported that a significant increase in body sway in the sagittal direction occurred three hours after the termination of anesthesia.

One of the criticisms of this study is whether the two study groups were given comparable anesthetics. It was unfortunate that the Bispectral index monitor was not used to ensure comparable depth of hypnosis with the two anesthetic techniques. However, the general anesthetics were delivered according to the standard clinical criteria (e.g., vital signs). The propofol average infusion rate of 110 $\mu g \cdot kg^{-1} \cdot min^{-1}$ may have a different intraoperative Bispectral index value to desflurane's average ET concentration of 3.2%. The value, however, might be comparable in terms of adequate depth of anesthesia for the procedure, according to the similar intraoperative analgesic requirements and comparable awakening time to other reported studies of the two general anesthetics. Another concern about the study includes the effects of nitrous oxide on the middle ear and possible vestibular influence of antiemetics. However, these effects were balanced between the two study groups because of the randomized assignment and similar antiemetic treatment. Thus, the possibility of bias is minimal.

The assessment of postural stability by using qualitative and quantitative measurements may be of value in the assessment and documentation of exact variables of postanesthetic and postanalgesic recovery. It may be recommended in the objective assessment of residual effects of old and new anesthetic and

analgesic regimens used in ambulatory surgical procedures. In our experience, the Balance Master test could provide a simple and objective evaluation of postural stability. It is a more practicable research tool in the routine clinical setting compared with complicated methods such as psychomotor test batteries or driving simulators. However, we do not suggest that the Balance Master test would replace more traditional measures of home readiness, such as the PADS system, after ambulatory anesthesia. This test may not be suitable for obtaining clinical criteria because it is difficult to identify which scores would correlate with home-readiness. Also, these scores are sensitive to minor postural disturbances, and a patient may not need to wait for a fully resumed balance function before discharge home. In addition, this test requires patients to be measured multiple times, it is cumbersome and time-consuming, and patients may not cooperate.

In conclusion, a computerized force platform provided a sensitive and objective assessment of balance function in terms of postural stability. Patients undergoing minor surgical procedures who have met the clinical discharge criteria (judged with PADS score) shortly after general anesthetics may still have impaired balance function. Finally, a desflurane-based anesthetic seemed to be associated with less vestibular disturbance than a propofol-based anesthetic in the early recovery period.

References

1. White PF, ed. Ambulatory anesthesia and surgery. London: WB Saunders, 1997.
2. Van Hemelrijck J, Smith I, White PF. Use of desflurane for outpatient anesthesia: a comparison with propofol and nitrous oxide. Anesthesiology 1991;75:197–203.
3. Raeder JC, Mjaland O, Aasbo V, et al. Desflurane versus propofol maintenance for outpatient laparoscopic cholecystectomy. Acta Anaesthesiol Scand 1998;42:106–10.
4. Korttila K, Ghoneim MM, Jacob L, Lakes RS. Evaluation of instrumental force platform as a test to measure residual effects of anesthetics. Anesthesiology 1981;55:625–30.
5. Gupta A, Ledin T, Larsen LE, Odkvist M. Computerized dynamic posturography: a new method for the evaluation of postural stability following anaesthesia. Br J Anaesth 1991;66: 667–72.
6. Hiller A, Pyykko I, Saarnivaara L. Evaluation of postural stability by computerised posturography following outpatient paediatric anesthesia: comparison of propofol/alfentanil/N_2O anesthesia with thiopental/halothane/N_2O anesthesia. Acta Anaesthesiol Scand 1993;37:556–61.
7. Chung F, Chen VW, Ong D. A post-anesthetic discharge scoring system for home readiness after ambulatory surgery. J Clin Anesth 1995;7:500–6.
8. NeuroCom International, Inc. Balance Master version 6.1 operator's manual. Clackamus, OR: NeuroCom, 1998:C-1.
9. Steward DJ, Volgyesi G. Stabilometry: a new tool for the measurement of recovery following general anesthesia for outpatients. Can Anaesth Soc J 1978;25:4–6.
10. Xiaoshong L, Hamdy R, Sandborn W, et al. Long-term effects of antidepressants on balance, equilibrium, and postural reflexes. Psychiatry Res 1996;63:191–6.
11. Cyr DG, Moore GF, Moller CG. Clinical application of computerized dynamic posturography. Ear Nose Throat J 1988; 9(Suppl):36–47.
12. Brouwer B, Culbam EG, Liston RA, Grant T. Normal variability of postural measures: implications for the reliability of relative balance performance outcomes. Scand J Rehabil Med 1998;30: 131–7.
13. Liston RA, Brouwer BJ. Reliability and validity of measures obtained from stroke patients using the Balance Master. Arch Phys Med Rehabil 1996;77:425–30.
14. Shumway-Cook A, Horak FB. Assessing the influence of sensory interaction on balance. Phys Ther 1986;66:1548–50.
15. Ledin T, Gupta A, Tytor M. Postural control after propofol anesthesia in minor surgery. Acta Otolaryngol Suppl 1995;520: 313–6.
16. Eriksen J, Jansen J, Larsen RE, Olesen MB. Postanaesthetic postural stability following thiopental or propanidid anaesthesia. Acta Anaesthesiol Scand 1978;22:323–6.