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Recovery of dynamic balance after general anesthesia with sevoflurane in short-duration oral surgery

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Abstract

Purpose. Recovery of dynamic balance, involving adjustment of the center of gravity, is essential for safe discharge on foot after ambulatory anesthesia. The purpose of this study was to assess the recovery of dynamic balance after general anesthesia with sevoflurane, using two computerized dynamic posturographies.

Methods. Nine hospitalized patients undergoing oral surgery of less than 2 h duration under general anesthesia (air-oxygen-sevoflurane) were studied. A dynamic balance test, assessing the ability of postural control against unpredictable perturbation stimuli (Stability System; Biodex Medical), a walking analysis test using sheets with foot pressure sensors (Walk Way-MG1000; Anima), and two simple psychomotor function tests were performed before anesthesia (baseline), and 150 and 210 min after the emergence from anesthesia.

Results. Only the double-stance phase in the walking analysis test showed a significant difference between baseline and results at 150 min. None of the other variables showed any differences among results at baseline and at 150 and 210 min.

Conclusion. The recovery times for dynamic balance and psychomotor function seem to be within 150 min after emergence from general anesthesia with sevoflurane in patients undergoing oral surgery of less than 2-h duration.

Key words Dynamic balance · General anesthesia · Sevoflurane · Computerized dynamic posturography · Oral surgery

Introduction

Recovery of postural balance is one of the essential criteria for safe and appropriate discharge after ambulatory anesthesia [1]. Korttila [2] identified different levels of recovery after outpatient anesthesia: home readiness, street fitness, and complete recovery. Home readiness is a term that is used for patients who can be safely discharged with an escort and can recover from residual impairment at home [3], while street fitness indicates that the patients can safely walk on the street [4]. The definition of street fitness is controversial. Some studies equate it with home readiness [5,6], some classify it somewhere between home readiness and complete recovery [1,2], while others equate it with complete recovery [3]. The usual walking or standing tests that are generally used in clinical practice are adequate indicators of home readiness. However, the ability to walk straight without staggering in a hospital setting, i.e., home readiness, does not guarantee that a patient can safely walk outside, because unpredictable perturbation stimuli might occur [1]. Therefore recovery of higher levels of motor and balance functions must be assessed by computerized dynamic posturography (CDP), which measures motor and balance functions by changing the subject's center of gravity, enabling us to obtain fundamental data for assessing the criteria for safe discharge on foot after ambulatory anesthesia. Although there are a few studies that have evaluated the process of recovery of dynamic balance by CDP after general anesthesia [7–9], no precise evaluation of dynamic balance and motor function with multiple CDPs has ever been reported.

The purpose of the present study was to investigate the recovery of the ability of postural control against perturbation stimuli and the ability to walk, after general anesthesia with sevoflurane, using two types of CDPs.

Patients and methods

After obtaining the approval of the ethics committee of our institution and informed consent from the patients, nine hospitalized patients, American Society of Anesthesiologists (ASA) class 1, who underwent

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short-duration oral surgeries (within 2 h) were enrolled. Patients received either no premedication or only an H_2-blocker on the night or morning before surgery. Anesthesia was induced with 1.5 $\mu g \cdot kg^{-1}$ fentanyl and 2.0 $mg \cdot kg^{-1}$ propofol IV, and the trachea was intubated after the administration of 0.1 $mg \cdot kg^{-1}$ vecuronium IV. No subsequent doses of vecuronium were administered after induction. Anesthesia was maintained with air-oxygen-sevoflurane. Local anesthetics were injected in the oral mucosa of all patients. Fentanyl 1 $\mu g \cdot kg^{-1}$ was injected intravenously just before starting surgery. The concentration of sevoflurane for the maintenance of anesthesia was limited to 3.0%.

Two CDPs and two simple psychomotor function tests were performed before anesthesia (baseline), and 150 and 210 min after the emergence from general anesthesia. The dynamic balance test, in which responses to unpredictable perturbation stimuli were tasked, was performed using the Stability System (Biodex Medical, Shirley, NY, USA) as previously reported [10]. Briefly, an unstable platform tilted in all directions according to changes in body weight applied by the tips of the toes and heels. The subjects were asked to maintain the platform horizontal for 20 s. The degree of tilt from the horizontal in all directions during the test was expressed as the stability index. Walking analysis test at a normal speed was carried out using sheets with foot pressure sensors (Walk Way-MG1000; Anima, Tokyo, Japan). The following four variables were measured: stride width-step length ratio, walking speed, stride length, and double-stance phase. Stride width is the distance between both heels in the frontal plane, while step length is the distance between the heel of the current footprint to that of the previous footprint of the opposite foot (i.e., a step) in the sagittal plane. The stride width-step length ratio is obtained by dividing the stride width by the step length. Stride length is the distance between the heels of two consecutive footprints of the same foot (i.e., two steps) in the sagittal plane. Double-stance phase is the period when both feet are on the floor, there being two such periods during a gait cycle time. Double-stance phase is expressed as a percentage after dividing the mean of the two periods by the gait cycle time. For psychomotor function tests, the digit symbol substitution test (DSST) and Trieger dot test were performed, as previously reported [11].

Recovery time after the emergence from anesthesia was defined as the earliest time when the difference between the value at each time point and the baseline value was not significant. An increase in each variable (except for the walking speed, stride length, and DSST) indicated a reduction in function. The actual measured values, not including those obtained by applying division methods, were analyzed by repeated-measures analysis of variance (ANOVA), and subsequent multiple comparisons were performed by the Bonferroni method. Other variables were assessed by Friedman's test, and subsequent multiple comparisons were performed by the Wilcoxon *t*-test with Bonferroni correction. The level of significance was set at 5%. Data values are presented as means ± SD, or as medians (ranges).

Results

The age, height, body weight, and body mass index of the patients were 30.4 ± 12.1 years, 172.1 ± 8.2 cm, 64.0 ± 8.9 kg, and 21.8 $kg \cdot m^{-2}$ (17.5–26.5 $kg \cdot m^{-2}$), respectively. Concentrations of sevoflurane for the maintenance of the early and middle periods of general anesthesia were 2% or under in five patients and 2%-3% in four patients. Reversal of vecuronium was done with neostigmine in eight patients. Surgery and anesthesia times were 84.4 ± 26.9 min and 129.4 ± 27.2 min, respectively.

Serial changes in the values of the CDPs and the simple psychomotor function tests are shown in Table 1. None of the values in the CDPs (except for the double-stance phase) or in the psychomotor function tests at 150 and 210 min after emergence from anesthesia showed significant differences from the baseline.

Discussion

As a result of this study, we found that there were no significant changes at any time points compared to baseline in the two CDPs, except for the double-stance phase at 150 min in the walking analysis test. The magnitude of the difference between the double-stance phase at baseline and 150 min was, however, only 1%, the walking speed at 150 min being the same as that at baseline (i.e., not the careful, slow-paced walk of incomplete recovery). Hence, dynamic balance function was deemed to have recovered within 150 min after emergence from general anesthesia with sevoflurane. This result indicates that recovery of dynamic balance in short-duration oral surgery takes significantly less time than complete recovery, which takes 24 h or more and includes recovery of the ability to drive a car [12,13].

The dynamic balance test used in the present study is reported to detect the residual inhibitory effects of midazolam with greater sensitivity than computerized static posturography (CSP) [10]. This test also seems to be appropriate for the evaluation of balance for safe discharge on foot, because unpredictable perturbation stimuli from all directions, which are tasked in this test, can potentially induce falling. The walking analysis test, using sheets with foot pressure sensors, may detect careful and slow walking, signifying incomplete recov-

Table 1. Serial changes in values of the two CDPs and two psychomotor function tests after the emergence from general anesthesia with sevoflurane

Test	Measure (unit)	Baseline	At 150 min after emergence	210 min after
CDPs				
Dynamic balance test	Stability index (°)	1.80 (1.55–2.53)	1.85 (1.33–3.03)	1.75 (1.5–3.25)
Walking analysis test	Stride width-step length ratio	0.12 (0.07–0.28)	0.15 (0.06–0.2)	0.13 (0.03–0.21)
	Walking speed ($cm \cdot s^{-1}$)	119 ± 20.1	113.9 ± 26.2	119 ± 24.8
	Stride length (cm)	122.9 ± 22.2	120.7 ± 21.5	123.4 ± 21.3
	Double-stance phase (%)	10.8 (7.7–13.6)	12.0 (7.8–14.0)*	10.2 (8.9–13.4)
Psychomotor function tests				
DSST	Number of correct answers	74.7 ± 14.1	68.7 ± 14.6	74.6 ± 16.0
Trieger dot test	Number of error dots	2.5 ± 1.6	4.0 ± 2.6	4.1 ± 3.3

* $P < 0.05$ (vs baseline)
Values are means ± SD, or medians (ranges); $n = 9$
CDP, Computerized dynamic posturography; DSST, digit symbol substitution test

ery after general anesthesia, as indicated by an increase in the stride width-step length ratio, prolongation of the double-stance phase, or a decrease in walking speed. Hence, we selected these CDPs in the present study.

Evaluation of psychomotor function also occupies an important role in the assessment of recovery from general anesthesia. With regard to the criteria for home readiness, recovery of the fundamental function of orientation in person, place, and time is considered to be adequate [14]. However, for safe discharge on foot, higher psychomotor functions, such as judgment and attention, also need to recover. Although the degree of recovery of psychomotor function that is required for safe discharge on foot is not clearly known, a person may be considered as having the ability required for such discharge if a psychomotor function test which is known to be generally reliable shows adequate recovery. The DSST is considered to be a more useful and sensitive psychomotor function test than the critical Flicker Fusion Test [15] and is, therefore, frequently used for the evaluation of recovery of psychomotor function after general anesthesia [16]. The recovery time of the DSST in the present study was 150 min, similar to that of the CDPs. Therefore, the time to recovery of dynamic balance and psychomotor function after general anesthesia in patients undergoing oral surgery of less than 2-h duration seems to be 150 min.

Although many discharge criteria after ambulatory anesthesia advocate the presence of an escort to accompany the patient home [13,14,17], some patients anesthetized with short-acting drugs may be able to go home safely without an escort after a sufficient recovery period. The degree of recovery of cognition, psychomotor, and memory function that is required for discharge without an escort, however, has not yet been revealed, necessitating further investigations.

Time to home readiness is reported to be acquired about 2 h after ambulatory surgery [18], and the recovery of dynamic balance is reported to take 20 min more than that of static balance after intravenous sedation with midazolam [10]. Therefore, in the present study we set the time points of measurement as 150 and 210 min after emergence from general anesthesia. However, we did not clarify whether there was a difference between the times required to home readiness and recovery of dynamic balance. It is also possible that the number of patients investigated in the present study was too small to clarify statistically significant differences between values at baseline and 150 min. Further studies with investigations at earlier time points after termination of anesthesia and with larger sample sizes than in the present study are, therefore, still required.

In conclusion, for ambulatory oral surgical procedures (within 2 h), the time to recovery of dynamic balance and psychomotor function for safe discharge on foot seems to be within 150 min after the emergence from general anesthesia with sevoflurane.

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