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Correlation between precise and simple tests in recovery of dynamic balance function after intravenous sedation with midazolam in the elderly

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Short title:

Dynamic balance test after sedation in the elderly

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Abstract

Purpose. Assessing the recovery of dynamic balance after intravenous sedation in the elderly is important for ensuring safe discharge, especially by walking. A reliable, simple dynamic balance test would be useful in daily clinical practice. We observed the recovery of balance after intravenous sedation with midazolam using computerized dynamic posturography (CDP) and evaluated the correlation between the CDP and simple dynamic balance tests.

Methods. midazolam was administered in divided dose until the Wilson sedation score reached 3 in 18 elderly male volunteers. A dynamic balance test using CDP with perturbation stimuli was performed before and after sedation. As simple dynamic balance tests, the usual-speed walking (USW) and maximum-speed walking (MSW) tests

and the modified timed "Up & Go" (TUG) test (subjects stand up from a chair, walk 5 m forward and back with MSW, and sit down again) were performed.

Results. The recovery times, defined as the time until the significant difference between the value at each time point and the baseline value disappeared, in the dynamic balance test, USW test, MSW test, and TUG test, were 80, 40, 80, 80 minutes, respectively. There was a significant and strong positive correlation between the result of the dynamic balance test in CDP and the TUG test ($p < 0.01$, $r=0.70$).

Conclusion. The TUG test is a useful simple dynamic balance/motor test that can be used in daily clinical practice in the elderly.

Introduction

Intravenous sedation is sometimes used to relieve stress during surgery for the elderly patients [1-3]. Assessing the recovery of dynamic balance function involving movement of the center of gravity after intravenous sedation in the elderly, whose activities of daily life might be significantly decreased owing to falls or fractures, is important for ensuring safe discharge, especially by walking. Evaluation by means of computerized dynamic posturography (CDP) with unpredictable perturbation stimuli may be rational and objective for preventing falls [4, 5]; however, such assessment may be difficult in daily clinical practice owing to economic considerations and the duration of the test. Therefore, simple dynamic balance tests that are well correlated with CDP would be useful in daily clinical practice.

We observed the recovery process of postural control ability after intravenous sedation with midazolam using CDP with perturbation stimuli and simple dynamic balance tests, and evaluated the possible correlation between the precise and simple balance tests in elderly male volunteers.

Subjects and methods

After informed consent and the approval of the ethics committee of our institution were obtained, 18 elderly male volunteers were enrolled in this study. Hypertension was observed in 7 subjects, arrhythmia in 2, and diabetes mellitus and asthma in 1 each (more than 1 complication in some subjects). Long-term benzodiazepine users and those who suffered from liver, renal, or neuromuscular disorders were excluded from the study. Midazolam was administered in small, divided doses over 4 to 5 minutes until the Wilson sedation score reached 3 (the eyes are closed, but the subject responds to one or two calls) [6]. After the designated depth of sedation was achieved, no additional sedatives were administered. As an objective index of the sedation level, the bispectral index (BIS) was determined with a BIS monitor (A1050, Aspect Medical

Systems, Newton, MA, USA) during sedation.

A precise balance test and three simple dynamic balance tests were performed before (baseline) and 40, 60, 80, 100, and 120 minutes after administration of midazolam. A dynamic balance test using CDP with unpredictable perturbation stimuli (a Stability System, Biodex Medical, Shirley, NY, USA) was performed as described previously [5]. Briefly, in the dynamic balance test, an unstable platform tilts in all directions according to changes in body weight applied to the tip of the toes and the heels. On the basis of the results of our preliminary tests, we set platform stability at "level 7", as a moderate and safe level for the elderly. The subjects were asked to keep the platform horizontal for 20 seconds. The degree of platform tilt from the horizontal line in all directions during the test was expressed as the stability index. As simple dynamic balance tests, the usual-speed walking (USW) and maximum-speed walking (MSW) tests, in which the time required to walk 10 m at the usual and maximum speeds, respectively, were measured, and the modified timed "Up & Go" (TUG) test [7] were performed. In the TUG test, the subject sat on a pipe chair with his back in contact with the back of the chair, stood up, walked to a marker 5 m in front of the chair and returned to the chair at maximum walking speed, sat on the chair, and brought his back to the back of the chair. The time needed to complete these actions was measured with a stopwatch.

To assess psychomotor function, the digit symbol substitution test (DSST) and the Trieger dot test (TDT) were performed before (baseline) and 50, 70, 90, 110, and 130 minutes after midazolam administration. The DSST was performed for 90 seconds using the Japanese version of the manual for the Wechsler Adult Intelligence Scale-Revised. In the TDT, a geometric figure was drawn by connecting a series of dots with a ball-point pen.

This study was designed to have 80% power for detecting a difference of 0.48 degree (this value is equivalent to 20% of the baseline value in a preliminary study) in stability index of Dynamic balance test between the baseline value and the value at each time point. The recovery time was defined as the time until the significant difference between the mean value at each time point and the mean baseline value disappeared. The recovery time was analyzed with Friedman's test, and subsequent multiple comparisons were performed with the Wilcoxon t-test with Bonferroni correction.

The relationship between CDP and the three simple dynamic balance tests with the change from the baseline value was assessed with Spearman's rank correlation coefficient. Differences with a P level less than 0.05 were considered significant.

Values are expressed as the mean (standard deviation.

Results

The mean age, height, body weight, and body mass index of the subjects were 68.2 (3.44 years (range, 61–72 years), 166.7 (4.8 cm (range, 156–175 cm), 65.6 (8.2 kg (range, 50–80 kg), and 23.7 (3.1 kg · m⁻² (range, 19.5–29.6 kg · m⁻²), respectively. The mean dose of midazolam was 0.042 (0.0085 mg · kg⁻¹ (range, 0.028–0.053 mg · kg⁻¹). At the end of administration (time of optimal sedation) the BIS was 74.5 (3.9, and following slight arousal stimulation 5, 15, 25, and 35 minutes after the administration of midazolam the BIS was 80.4 (4.6, 84.1 (5.5, 87.2 (5.4, and 93.1 (5.0, respectively. Serial changes in values of balance tests and psychomotor function tests are shown in Tables 1 and 2, respectively. The recovery times in the dynamic balance test, USW test, MSW test, TUG test, and simple psychomotor function tests were 80, 40, 80, 80, and 70 minutes, respectively.

There was a significant positive correlation between the results of the dynamic balance test and the simple dynamic balance tests ($p < 0.01$, $r=0.70$ in TUG test, $r=0.59$ in MSW test, $r=0.34$ in USW test) (Fig. 1).

Discussion

Monitored anesthesia care (MAC) is recognized by anesthesiologists as a useful anesthetic management method [8,9]. During MAC, the anesthesiologist provides a number of specific services including administration of sedatives, analgesics, hypnotics, anesthetic agents as necessary to ensure patient safety and comfort [8]. Intravenous sedation with midazolam is sometimes used in MAC for day-stay surgery with regional anesthesia to relieve stress during surgery for the elderly patients [1–3]. However, an increased risk of falls after administration of sedatives has been reported [10]. In the elderly, falls often cause fracture, associated inability to walk, and a decrease in activities of daily living. Therefore, precise evaluation of balance function after intravenous sedation is needed for safe discharge, particularly by walking. As the elderly tend to fall as a result of stumbling, the CDP with unpredictable perturbation stimuli used in the present study is an ideal method for the evaluation of balance [11]. This method has previously been proven to be a sensitive and reliable method for evaluating the balance-inhibiting effects of sedatives [5]. However, such assessment with CDP may be difficult in daily clinical practice owing to economic considerations and the duration of the test. Therefore, simple dynamic balance tests that are well correlated with CDP would be useful in

daily clinical practice. Of the three simple dynamic balance tests, in the present study, the TUG test had results most strongly correlated with those of CDP with perturbation stimuli. The TUG test is a modified version of "Get-up and Go" test developed by Mathias [12] as a simple balance function test to predict falls in the elderly. In this original method, the subject stands up from an armchair, walks forward 3 m, returns to the chair at a comfortable pace, and sits down again. These actions are recorded on videotape, and the risk of falls is evaluated by medical professionals using a 5-grade scale, with a score of 1 = normal to 5 = severely abnormal. Podsiadlo et al. [13] quantified this method by measuring the time required to complete the actions. Shumway-Cook [14] used MSW instead of USW. Shimada [7] used MSW and extended the distance to 5 m, and we used it in the present study. The TUG test used in the present study possesses all advantages which is contained in MSW test as described previously [5], such as proven correlation with balance function [13-15], being a quantitative assessment, good reproducibility [12-14, 16], short measurement time, and low cost. Furthermore, this test possesses proven differences between fall and non-fall groups [7, 14-16], high sensitivity and specificity [14-16], applicability to the elderly [7, 12-16], and no requirement for wide space. In addition, This test requires rapid acceleration and deceleration, a turn during high-speed walking, and rapid sitting down with a turn, and, therefore, seems to be more suitable for assessing comprehensive motor function more closely associated with balance function than the MSW test.

There are no exact criteria showing what % recovery of the baseline value of the TUG test guarantees the recovery of balance. However, the criteria to attain 90% recovery or more of the baseline value that were used in this study may be relatively strict criteria. The test with maximum speed walking possesses probability of falling. However, if a patient does not recovered sufficiently, he or she will decrease walking speed intentionally. It may be safer to perform this test after recognizing recovery with Romberg's test, which is less reliable but safer than the dynamic balance test [17]. Good correlation between the results of the TUG test and the CDP does not necessarily indicate that the reliability of the TUG test for detecting the suppression of balance is close to that of the CDP. It is also risky to presume that complete evaluation can be done by one test type alone. However, the TUG test is still useful for evaluating the balance function because of its relative reliability and ease of performance.

Unlike general anesthesia, an intravenous overdose of a sedative, even if it is slight, can lead to serious complications endangering life. Excessive sedation, airway

obstruction, and respiratory failure may occur in elderly patients when the same dose of a benzodiazepine sedative as that needed for younger patients is administered, because the pharmacodynamics and/or pharmacokinetics of these drugs are different for the elderly and younger persons [18, 19]. Therefore, careful titration is needed to achieve an optimal sedation level in intravenous sedation, especially for the elderly [20, 21]. On this occasion, it is desirable to evaluate the sedation level objectively. In sedation with midazolam or propofol, the BIS is reported to be 75 to 89 at a sedation level that does not induce airway obstruction and allows responses to verbal commands [22, 23]. The BIS values during sedation in the present study were from 74.5 to 93.1, which suggests that recovery of dynamic balance from an adequate level of sedation could be evaluated here.

Before patients are discharged, the recovery of balance and psychomotor functions should be confirmed. To assess psychomotor function after general anesthesia or intravenous sedation, the DSST and TDT are frequently used [24, 25]. In the present study with the DSST and TDT, the recovery time of psychomotor function was 70 minutes. Thus, discharge by walking may be permitted 80 minutes after the administration of midazolam in the elderly. This result was similar to that in young adults in our previous study on dynamic balance recovery [5]. However, the interpretation of time agreement is tricky. First, we must consider the same sedation level not the same dosage, and second the amount of change, not the actual measurement value. The age-related decrease in dynamic balance function has been reported even without sedatives [26, 27]. Third, platform stability at "level 7" used in the present study is more stable than that in the younger subjects previously reported [5]. In the evaluation of recovery of balance from intravenous sedation, more careful attention is needed for the aged than for younger patients.

The recovery time of the USW test was faster than the CDP with perturbation stimuli and the correlation coefficient between the two tests was low in the present study. Therefore, there is no guarantee that a patient can safely walk outside, where unpredictable perturbation stimuli occur, only because he or she can walk straight at normal speed in the hospital. In Japan, medical institutes establishing a system of day stay anesthesia have been increasing [28, 29]. Some patients might need to have sufficient recovery of balance function confirmed before discharge, depending on method they will use to return home such as by walking or physiological factor such as aging, in MAC or general anesthesia for day surgery. The TUG test can contribute to safe post anesthetic management for such patients.

In conclusion, the TUG test is strongly correlated with reliable CDP with perturbation

stimuli and can be used in daily clinical practice for assessment of recovery of dynamic balance from sedation in the elderly.

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Figure legend

Fig. 1 Correlation between the dynamic balance test in CDP and three simple dynamic balance tests

CDP, computerized dynamic posturography; TUG, timed up and go; MSW, maximum speed walking; USW, usual speed walking.

There was a relatively strong correlation between the dynamic balance test and the TUG test ($r=0.70$). Δ (delta) means that the value at each time point minus the baseline value.

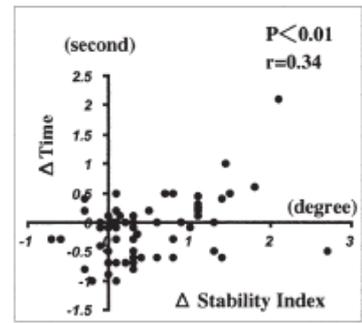
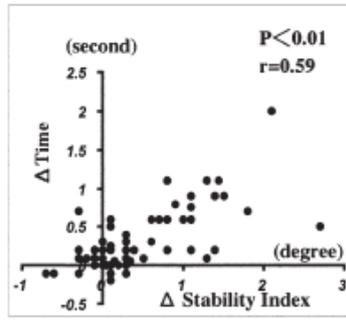
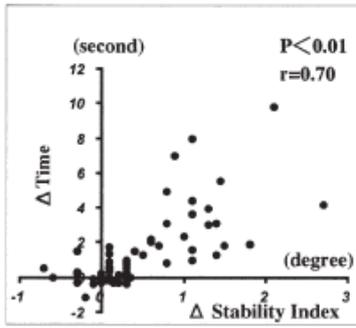


Table 1. Serial changes in values of CDP and simple dynamic balance tests after administration of midazolam (mean±SD; n=18)

Test	Measurement (units)	Baseline	40 min after	60 min after	80 min after	100 min after	120 min after	Recovery time
CDP								
Dynamic balance test	Stability Index (degrees)	2.44±0.60	3.61±0.89**	2.74±0.65**	2.62±0.74	2.46±0.55	2.45±0.56	80 min
Simple dynamic balance tests								
TUG test	Time (s)	9.66±0.90	13.47±3.02**	10.62±1.49**	9.80±1.22	9.66±1.02	9.59±0.91	80 min
MSW test	Time (s)	5.19±0.48	5.89±0.83**	5.48±0.58**	5.28±0.55	5.23±0.51	5.20±0.50	80 min
USW test	Time (s)	6.71±0.73	6.89±1.04	6.62±0.84	6.38±0.89**	6.37±0.86**	6.36±0.86**	40 min

Abbreviations: CDP, computerized dynamic posturography; TUG, timed up and go; MSW, maximum speed walking; USW, usual speed walking

*p<0.05; **p<0.01 (vs baseline)

Table 2. Serial changes in values of simple psychomotor function tests after administration of midazolam (mean±SD; n=18)

Test	Measurement	Baseline	50 min after	70 min after	90 min after	110 min after	130 min after	Recovery time
DSST	Number of correct answers	49.4±10.7	45.1±9.0*	50.2±9.9	51.9±10.8	53.1±11.1	52.4±10.6	70 min
TDT	Number of dots left outside the drawn line	8.2±4.7	10.6±4.5*	8.0±4.0	7.7±4.2	7.8±4.2	7.9±3.9	70 min

Abbreviations: DSST, digit symbol substitution test; TDT, Trieger dot test

*p<0.05 (vs baseline)