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Evaluation of a Clinical Recovery Score after General Anesthesia

Christine L. Quinn, DDS, MS,* Joel M. Weaver, DDS, PhD,† and Mike Beck, DDS, MA‡
*Section of Oral Biology, UCLA School of Dentistry, Los Angeles, California; †Department of Oral Surgery and ‡Department of Diagnostic Services, The Ohio State University College of Dentistry, Columbus, Ohio

A clinical recovery score (CRS) assessing recovery after general anesthesia was compared with the Digit-Symbol Substitution Test (DSST), Trieger Test (TT), a patient-completed visual analogue scale for alertness (VAS), and an independent observer's evaluation of recovery. The CRS included ratings of the following parameters: activity, respiration, circulation, consciousness, ambulation, color, and nausea and vomiting. Forty patients requiring the removal of three or four third molars participated in the study. All patients received the same general anesthetic technique. Each patient was evaluated by the five methods preoperatively, on admission to the recovery room, and at 15-min intervals until discharge. The four recovery tests (CRS, DSST, TT, VAS) were evaluated using χ^2 analysis to determine if there was any overall difference among the tests using the observer's determination of home readiness as the standard for discharge. The CRS was significantly more in agreement with the observer's determination than were the paper and pencil tests. The recovery tests were also evaluated with regard to instances of early dismissal or prolonged retention of the patient, again using the observer's determination as the "gold standard." The CRS was the only recovery test devoid of early dismissals. We conclude that the CRS provides a valid, simple measure of recovery that can be readily used in offices providing outpatient anesthesia and in studies measuring clinical recovery from anesthesia or sedation.

It is increasingly common to deliver outpatient general anesthesia or deep sedation outside of the hospital operating room, in outpatient surgical centers and private offices. This trend is especially true in dentistry. Patients are considered to be recovered after anesthesia in a surgery center or hospital when they have achieved specific recovery criteria. In the dental office setting, however, the patient is typically discharged when the clinician makes a subjective evaluation of the patient's degree of recovery. Anesthetics should have the same standards for recovery and discharge whether done in a dental office, surgery center, or hospital.

Korttila defined three levels of recovery after general anesthesia: home readiness, street fitness, and complete recovery.[1] A variety of techniques, including psychomotor tests and subjective reports, have been used to determine recovery from anesthesia. Few of these have been compared to the assessment of home readiness used in clinical practice, ie, when the patient is able to be discharged in the care of a responsible adult. A patient who is home ready is oriented to person, place, and time, is able to ambulate without assistance, and has stable vital signs.[2] While it may be ideal medically to discharge a patient when recovery is complete, it is not practical. Complete recovery after an inhalation anesthetic may take more than 24 hr.[3]

Recovery tests range from a simple test measuring the patient's amount of sway to complex driving simulators.[4–12] Each method of evaluation is sensitive to different aspects of recovery. These tests, though worthwhile experimentally, are rarely used on a routine clinical basis, and the patient's recovery is ultimately determined by subjective opinion.

The purpose of this study was to compare several widely recognized recovery tests with an objective clinical recovery score and the determination of home readiness made by an unbiased dentist anesthesiologist.

METHODS

The study used 40 patient volunteers (15 males and 25 nonpregnant females) who required general anesthesia for the surgical removal of three or four impacted third molars. All patients were American Society of Anesthesiologists physical status I or II. No patient was currently

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Address correspondence to Dr. Christine Quinn, UCLA School of Dentistry, Center for the Health Sciences, Los Angeles, CA 90024.

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taking any centrally acting medication nor had any patient undergone a general anesthetic within the past year. The study was approved by The Ohio State University Human Subjects Review Committee, and written consent was obtained from each subject.

Before surgery each patient completed all of the recovery tests, had vital signs recorded, and walked along a straight line 6 ft in length. Monitors were placed before the induction of general anesthesia: intermittent noninvasive blood pressure (Dinamap 1846 SX, Critikon, Tampa, FL), pulse oximeter (Biox Pulse Oximeter, Ohmeda, Boulder, CO), electrocardiogram (Lifepak 6 EKG, Physiocontrol, Redmond, WA), and precordial stethoscope. Intravenous access was obtained with a 20-ga catheter. Before the induction of general anesthesia each patient received 1 mg/kg meperidine hydrochloride intravenously. General anesthesia was induced with 3 mg/kg sodium methohexital. An additional 25% of the induction dose of methohexital was given if the initial dose was not adequate to produce a satisfactory hypnotic state. All patients received 0.8 mg/kg succinylcholine chloride to facilitate nasoendotracheal intubation. Anesthesia was maintained with minimal titrated amounts of enflurane in 67% nitrous oxide and 33% oxygen. The percentage of enflurane administered to the patient was recorded every 5 min. Every patient received infiltration/nerve block local anesthesia with 7.2 mL of 0.5% bupivacaine with 1:200,000 epinephrine to provide pain control in the postoperative period. All anesthetic and surgical procedures were performed by practitioners skilled in airway management, general anesthesia, and resuscitative techniques.

The patients' recovery and vital signs were evaluated on admission to the recovery room and at 15-min intervals thereafter until the patients were cleared for discharge in the usual subjective manner by the dentist anesthesiologist.

Patients were assessed by four recovery tests during the recovery period. The tests used were as follows: (1) the Trieger Dot Test (TT), a variation of the Bender-Gestalt test in which the patient is asked to connect a series of dots arranged in a specific pattern. Points are subtracted for missing a dot and for the distance that the dot is missed; (2) the Digit-Symbol Substitution Test (DSST), a subtest of the Weschler Adult Intelligence Scale (WAIS). It is a timed test in which the patient is required to match the appropriate symbol to the number, after a short practice session; (3) the Visual Analogue Scale (VAS), a 100-mm line ranging from barely awake to wide awake, along which the patient draws a hatch mark, to make a subjective evaluation of alertness; and (4) the Clinical Recovery Score (CRS), a modification of Aldrete's postanesthetic recovery score[4] with the addition of a component for nausea and vomiting. The CRS assessed the following parameters: activity, circulation, respiration, consciousness, ambulation, color, and nausea and vomiting (Table 1). Patients could earn from 0 to 2 points in each of the first six categories, with an overall maximum of 12 points. Up to 2 points could be subtracted if nausea and/or vomiting were present.

A nonbiased observer determined when the patient could be discharged. This person was an experienced dentist anesthesiologist who would observe the patient before each testing period and determine the patient's ability to be safely discharged. The observer was allowed to minimally interact with the patient before making the determination. The observer's determination of recovery was used as the "gold standard" to allow for comparison of the different recovery tests.

In order to evaluate the clinical utility of the various recovery tests, each test was compared with the observer's evaluation of home readiness. For each test a cut score was determined to minimize the total number of disagreements with the observer. In addition a separate cut score was chosen to minimize the number of early dismissals, defined as instances in which the cut score for

Table 1. Components of the Clinical Recovery Score

Category	*Points*	*Criteria*
Activity	0	Unable to sit up
	1	Able to sit without assistance
	2	Able to stand without assistance
Respiration	0	Apnea
	1	Depressed from preoperative rate
	2	Same as or more than the preoperative rate
Circulation	0	More than 50% decrease below the preoperative systolic blood pressure
	1	A 20%–50% decrease below the preoperative systolic blood pressure
	2	Less than 20% below the preoperative systolic blood pressure
Consciousness	0	Unresponsive to verbal stimulation
	1	Responsive to verbal stimulation
	2	Fully awake
Ambulation	0	Unable to walk
	1	Able to walk with assistance
	2	Able to walk without assistance heel to toe along a line 6 ft in length
Color	0	Cyanotic mucous membranes
	1	Pale mucous membranes
	2	Normal coloration
Nausea and Vomiting	−2	Vomiting
	−1	Nausea
	0	Minimal dizziness

Total scores may range from −2 to 12.

the recovery test was attained but the patient was not ready for discharge according to the observer.

The correlations among the various recovery tests were evaluated using Kendall's coefficient of concordance. A χ^2 analysis was used to determine if there was any overall difference among the tests using the observer's determination of home readiness as the standard for discharge. Student's *t*-test was used to evaluate differences in anesthesia parameters and recovery scores between the patients experiencing nausea and vomiting and those without nausea and vomiting. A *P* value of 0.05 was considered statistically significant.

RESULTS

The mean anesthesia time was 30.4 min ± 16.5 min (mean ± standard deviation), with a mean enflurane exposure of 0.85% ± 0.35%. Females had a significantly lower exposure to enflurane than did male patients (P = 0.003). Six males and eight females experienced nausea and vomiting. Patients experiencing postoperative nausea and vomiting had a significantly greater anesthesia time, 39.3 min versus 25.6 min (P = 0.01), but there was no significant difference in total exposure to enflurane. Patients spent, on average, 40.5 min in recovery before discharge. The presence of nausea and vomiting significantly increased the time spent in recovery: 49.3 min versus 35.2 min (P = 0.004, Figure 1). There was no difference in the length of the recovery room stay with regard to patients' sex. Recovery progressed in a similar fashion with the four tests, from a preoperative high score to a low score on admission to the recovery room and then a gradual approach to the preoperative score during the recovery period (Figure 2). The mean recovery scores ± standard deviations are shown in Table 2. The recovery tests were all statistically correlated (Table 3); however, only the r^2 value for the TT vs DSST was above 0.5.

Cut scores for the pencil and paper recovery tests (DSST, TT, VAS) indicating home fitness were calculated as a percentage of the subjects' baseline scores. A score of 92% baseline minimized instances of disagreement with the observer. A cut score of 11 for the CRS minimized both disagreement with the observer and early dismissal errors. Instances of disagreement with the observer are tabulated in Tables 4 and 5. With regard to total errors (ie, disagreements) the CRS had the fewest, less than half that of the VAS (Table 4). With the exception of the CRS, full recovery to baseline was required to minimize early dismissals. Even then, only the CRS totally avoided early dismissal errors, using the cut score of 11 (Table 5). Significant increases in prolonged retention occurred with the other recovery tests when the cut score was optimized to avoid early dismissals. There were 17 patients who would have been kept longer than necessary using the CRS criteria, but of these only four had not attained a score of 11 or 12 by the next evaluation period (15 min later).

The four recovery tests were evaluated using χ^2 analysis to determine if there was any overall difference among the tests using the observer's determination of

Figure 1. Percentage of patients recovered as a function of time in recovery. Recovery in patients with nausea (n = 14) was significantly delayed (P = 0.004, Student's *t*-test) in comparison to patients without nausea (n = 26).

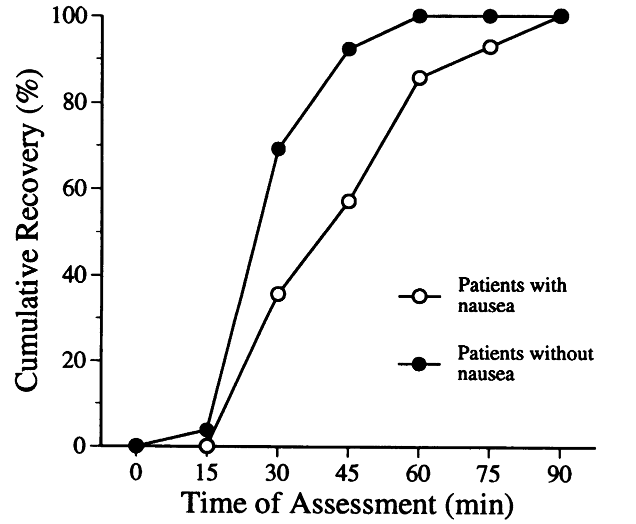

Figure 2. Adjusted recovery scores at each evaluation period. All values were adjusted so that the preoperative value (preop) = 100 and the score on admission to recovery (admit) = 0. The values at the different time intervals indicate the mean percentage of return toward the preoperative score. Abbreviations: TT = Trieger Test; DSST = Digit-Symbol Substitution Test; VAS = Visual Analogue Scale; CRS = Clinical Recovery Score; OBS = Nonbiased Observer.

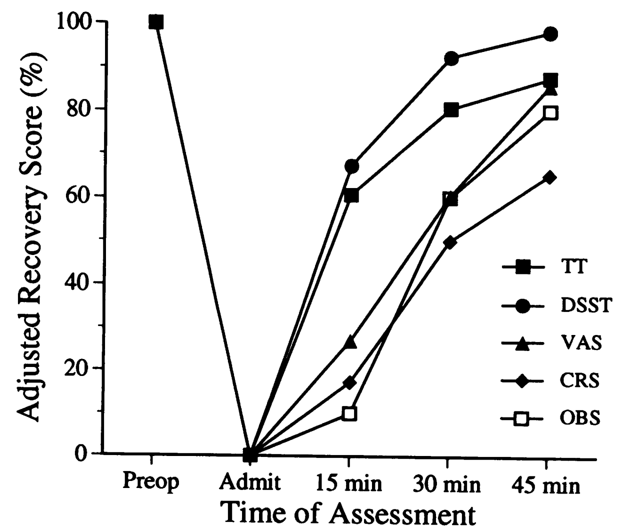

Table 2. Recovery Test Scores at Each Evaluation Period[a]

Recovery Test	*Preop*	*Admission*	*15 min*	*30 min*	*45 min*
CRS	12 ± 0	7.4 ± 1.1	8.2 ± 1.2	9.7 ± 1.8	10.4 ± 1.5
TT	−2 ± 2.5	−30.7 ± 10.3	−13.3 ± 8.9	−7.6 ± 6.9	−5.6 ± 5.5
DSST	62 ± 11	10 ± 14	45 ± 17	58 ± 15	61 ± 16
VAS	85 ± 16	22 ± 22	39 ± 22	60 ± 20	76 ± 17
OBS[b]	2 ± 0	0 ± 0	0.2 ± 0.4	1.2 ± 1.0	1.6 ± 0.8

Abbreviations: CRS = Clinical Recovery Score; TT = Trieger Test; DSST = Digit-Symbol Substitution Test; VAS = Visual Analogue Scale; OBS = Nonbiased Observer.

[a] Values represent the mean ± standard deviation.

[b] Observer scores were 0 = not recovered; 1 = equivocal recovery; 2 = home fit.

home readiness as the standard for discharge. The CRS was significantly better than the other tests in terms of agreement with the observer's determination (P = 0.004). The CRS was also significantly different from the other tests when evaluating agreement with the observer's clinically important decisions (P = 0.016). When patients were separated in terms of presence or absence of nausea and vomiting, the CRS was better in patients with nausea and vomiting (P = 0.03) and had a tendency toward being better in the absence of nausea and vomiting (P = 0.19).

DISCUSSION

The object of this study was to determine if a standardized system for evaluating clinical recovery was a useful means for gauging a patient's recovery to "home readiness." A CRS that, unlike paper and pencil tests, does not require patient cooperation is a more realistic means of deciding when a patient is ready for discharge. The scoring system could also be very useful in mentally and physically challenged individuals, since it measures a return to preoperative physical and mental states without requiring the patient to perform tasks that may not be suited for that individual's disability.

The 15-min testing intervals used here were more frequent than had been used in other studies, in which the recovery tests were given on admission to the recovery room and 1 hr later.[13,14] This study showed that patients often return to their baseline values on recovery tests and are ready for discharge within the first hour after waking from anesthesia.

The results of this study agree with earlier studies pertaining to the length of time required to achieve baseline scores on the paper and pencil tests after an anesthetic. Results also indicate that the TT and the DSST, two measures of psychomotor recovery, assess patients in a similar fashion. The DSST and the TT have been previously shown as not being sensitive to changes in psychomotor performance after the first hour of recovery.[1,15] This study showed that they cannot be considered reliable to evaluate recovery to "home readiness" as demonstrated by the number of early dismissals that would have occurred if they were used as the only criteria for discharge. An additional shortcoming of paper and pencil tests as determinants of home readiness is that the motivation of the patient to complete the test can greatly influence the results.[15] Motivation was not a problem in this study; subjects were college students and quite competitive in completing the tests.

The occurrence of nausea and/or vomiting reported in

Table 3. Correlation Among Recovery Tests

Recovery Comparison	*Correlation Coefficient (r)*	r^2
CRS vs TT	0.693	0.480
CRS vs DSST	0.665	0.442
CRS vs VAS	0.697	0.485
TT vs DSST	0.833	0.693
TT vs VAS	0.579	0.335
DSST vs VAS	0.574	0.329

Correlation coefficients were determined by the Kendall Rank Test. All r values are significantly greater than 0 ($P < 0.05$). Abbreviations: CRS = Clinical Recovery Score; TT = Trieger Test; DSST = Digit-Symbol Substitution Test; VAS = Visual Analogue Scale.

Table 4. Recovery Disagreements with Observer Using Recovery Scores Chosen to Minimize the Total Number of Disagreements

Recovery Test	*Early Dismissal*		*Prolonged Retention*	
	n^a	*% error*	n^a	*% error*
CRS	0	0	17	12
TT	19	13	12	8
DSST	13	9	9	6
VAS	12	8	25	17

Abbreviations: CRS = Clinical Recovery Score; TT = Trieger Test; DSST = Digit-Symbol Substitution Test; VAS = Visual Analogue Scale.

[a] Number of disagreements out of a total of 147 decisions.

Table 5. Recovery Disagreements with Observer Using Recovery Scores Chosen to Minimize Early Dismissals

Recovery Test	Early Dismissal		Prolonged Retention	
	n[a]	*% error*	*n*[a]	*% error*
CRS	0	0	17	12
TT	5	3	31	21
DSST	8	5	20	14
VAS	10	7	31	21

Abbreviations: CRS = Clinical Recovery Score; TT = Trieger Test; DSST = Digit-Symbol Substitution Test; VAS = Visual Analogue Scale.

[a] Number of disagreements out of a total of 147 decisions.

this study (35%) is higher than has been previously reported with a similar anesthetic technique.[16] The higher rate of nausea and vomiting is most likely related to the inclusion of meperidine in the anesthetic regimen. Other contributors could be that participants were asked to complete paper and pencil tests during the recovery period and were required to undergo positional changes rather than remaining supine. Nausea and vomiting, which can occur without central nervous system depression, frequently prolongs a recovery room stay. In this study, patients with nausea and vomiting had a significantly longer recovery room stay than those not experiencing nausea and vomiting during the recovery period. The CRS differs from the psychomotor tests in that it takes into account the presence of nausea and vomiting and in that way is similar to the trained observer who may also use nausea and vomiting as a criterion for delaying discharge.

When considering recovery from anesthesia it is desirable to have a highly specific test (small number of false positives, ie, early dismissals). In order to achieve a highly specific test there is some loss in sensitivity, which in this situation equates to patients being kept in recovery longer than necessary. The loss in sensitivity is not considered crucial because error on the side of prolonged retention is more of an inconvenience than a threat to safety. An early dismissal is unacceptable because of the risk of death or serious injury if a patient is prematurely discharged after anesthesia. The CRS was the only method of evaluation used that had no early dismissals.

The CRS has potential for use in a dental office where sedation or general anesthesia is being performed. It is a system comparable to evaluation methods used in hospital recovery rooms. As more and more patients are being treated in the outpatient setting, it is important to develop a system for evaluating recovery that can determine when a patient may be safely discharged in the care of a responsible adult. In this study all of the recovery tests were compared with the decisions of a nonbiased, experienced dentist anesthesiologist. Not all persons recovering patients in an outpatient setting are equally trained and qualified to make the judgments that were made here by the dentist anesthesiologist. Using the CRS, though, would permit a lesser trained individual to safely evaluate a patient's recovery to home readiness by providing a quantitative method that is usable in a clinical setting. The CRS would also be useful in clinical trials of anesthetic drugs where a standardized measure of recovery is needed.

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