

# Development and Feasibility of a Scale to Assess Postoperative Recovery

## *The Post-operative Quality Recovery Scale*

Colin F. Royse, M.D.B.S.,\* Stanton Newman, D.Phil.,† Frances Chung, M.D., F.R.C.P.C.,‡ Jan Styggall, M.Sc.,§ Rachel E. McKay, M.D.,|| Joachim Boldt, M.D.,# Frederique S. Servin, M.D.,\*\* Ignacio Hurtado, M.D.,†† Raafat Hannallah, M.D.,‡‡ Buwei Yu, M.D.,§§ David J. Wilkinson, M.B.B.S., F.R.C.A.||||

### ABSTRACT

**Background:** Good postoperative recovery is increasingly recognized as an important outcome after surgery. The authors created a new Post-operative Quality Recovery Scale (PQRS) that tracks

multiple domains of recovery from immediate to long-term time periods in patients of varying ages, languages, and cultures.

**Methods:** The parameters of importance to both clinicians and patients were identified. After an initial pilot study of 133 patients, the PQRS was refined. It consists of six domains (physiologic, nociceptive, emotive, activities of daily living, cognitive, and overall patient perspective). An observational study of 701 patients was performed with the refined PQRS to assess its capacity to evaluate and track recovery and to discriminate between patients. It was conducted in eight countries and in five languages, involving patients more than or equal to 6 yr undergoing elective surgery with general anesthesia. Recovery was assessed before surgery and at multiple time periods postoperatively. Recovery was defined as return to baseline values or better.

**Results:** Seven hundred one patients completed the PQRS. Mean completion time was 4.8 (SD 2.8) min. Recovery scores improved with time. Physiologic recovery was complete in 34% of subjects by 40 min. By the third postoperative day, complete recovery was obtained in 11% of cases (all domains): 48.7% nociceptive, 81.8% emotive, 68.8% activities of daily living, and only 33.5% cognitive. Overall, 95.8% of the patients reported that they were “satisfied or totally satisfied” with their anesthetic care.

**Conclusion:** The scores on the PQRS demonstrated an improvement over time, consistent with an expected recovery after surgery and anesthesia, and an ability to discriminate between individuals. Many patients had incomplete recovery by the third postoperative day.

\* Associate Professor, Anaesthesia and Pain Management Unit, Department of Pharmacology, University of Melbourne, Melbourne, Victoria, Australia, and Consultant Anaesthetist, Department of Anaesthesia and Pain Management, The Royal Melbourne Hospital, Melbourne, Victoria, Australia. † Professor of Health Psychology and Honorary Consultant, § Senior Research Fellow, Unit of Behavioural Medicine, University College London, London, United Kingdom. ‡ Professor, Department of Anaesthesia, University Health Network, University of Toronto, Toronto, Ontario, Canada. || Associate Professor, Department of Anesthesia and Perioperative Care, University of California, San Francisco, San Francisco, California, and Attending Anesthesiologist, University of California, San Francisco Medical Center, San Francisco, California. # Professor of Anaesthesia and Intensive Care Medicine, Head of Department of Anaesthesia and Intensive Care Medicine, Klinikum der Stadt, Ludwigshafen, Ludwigshafen, Germany. \*\* Consultant Anaesthetist, Department d'Anesthesiologie, Assistance Publique-Hôpitaux de Paris, Hôpital Bichat, Paris, France. †† Cardiovascular Anesthesiologist, Associate Professor, Universidad Autonoma de Mexico, Mexico City, Mexico, and Director, Anesthesia Department, American British Cowdray Medical Center, Mexico City, Mexico. ‡‡ Professor of Anesthesiology and Pediatrics, The George Washington University Medical Center, Washington, D.C., and Division of Anesthesiology, Children's National Medical Center, Washington D.C. §§ Professor and Chairman, Department of Anesthesiology, Ruijin Hospital, Shanghai, China, and Shanghai Jiao Tong University, School of Medicine, Shanghai, China. ||| Emeritus Consultant Anaesthetist, Boyle Department of Anaesthesia, St. Bartholomew's Hospital, London, United Kingdom, and Chair, Post-operative Quality Recovery Scale (PQRS) Advisory Board, London, United Kingdom.

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Address correspondence to Dr. Royse: Department of Pharmacology, University of Melbourne, 245 Cardigan Street, Carlton, Victoria, 3053, Australia. colin.royse@unimelb.edu.au. This article may be accessed for personal use at no charge through the Journal Web site, www.anesthesiology.org.

### What We Already Know about This Topic

- ❖ Multiple domains of recovery, including physiologic, cognitive, and functional recovery, are important to patients and their caregivers, yet a single and simple assessment tool to include these domains has not been validated

### What This Article Tells Us That Is New

- ❖ In more than 700 postoperative patients in eight countries, a Post-operative Quality Recovery Scale was applied, and recovery was distinguished among individuals across multiple domains

**A**NESTHESIOLOGISTS have frequently sought to evaluate the quality of anesthesia care that they provide. In the early years, specialty efforts were focused on the assessment of mortality, with the development of national surveys.<sup>1,2</sup> These surveys were initially based on voluntary reporting but later evolved into compulsory national studies, which in recent years have been focused on specific surgical areas.<sup>3,4</sup> As the science in the delivery of anesthesia improved and the rate of anesthetic-related mortality and morbidity declined, it became difficult to demonstrate improvements using these outcomes.<sup>5</sup>

With the development of ambulatory surgery, recovery from anesthesia has focused on a return to acceptable physiologic parameters, and simple scoring systems have been devised to denote readiness for discharge from hospital.<sup>6-9</sup> It has become increasingly evident, however, that to capture the broader and potentially long-term impact of anesthesia and surgery, these recovery scales are limited.<sup>10</sup>

At the start of this century, Myles *et al.* examined the concept of the functional quality of recovery. The approach adopted was to use patient ratings as the key to assessing the quality of recovery. This was followed by the increase in the use of patient-reported outcomes in recent years.<sup>11</sup> Although the reports given by patients are an important approach in assessing recovery, other crucial aspects are in dimensions likely or known to be influenced by surgery and anesthesia but which may not fall within the patient's conscious experience. For example, the patient-reported scales do not address the important issue of cognitive recovery.<sup>12-15</sup> The importance of neurocognitive decline after cardiac surgery has been identified for many years.<sup>16</sup> There is also a controversy that neurocognitive decline can also occur after noncardiac surgery and that it may be related to anesthesia delivery. This has raised new interest in recovery as a possible measure of the quality of anesthesia care and a target toward which innovation and improvement can be directed.<sup>17-19</sup> Other scales have been developed to assess postoperative recovery, some of which have focused on particular forms of surgery and others have approached this in a more general way.<sup>10</sup>

In 2007, a group of anesthesiologists with an interest in recovery commenced the development of a brief measurement tool to assess multiple domains of recovery, including cognition, over time. It was also intended for the tool to be applicable to patients with a wide age range, diverse languages, cultures, and physical abilities. The intention was to produce an instrument for assessment of recovery for multiple time periods to assess early and long-term recovery. This report describes the development and the initial feasibility study of the Post-operative Quality Recovery Scale (PQRS).

## Materials and Methods

The use of the PQRS protocol was approved by the relevant human research ethics committees of each participating center, and written informed consent was obtained from all patients.

## Research Group

The research group comprised nine anesthesiologists and two neuropsychologists, and it was assisted by a statistician. The project was funded by a research grant from Baxter Healthcare (Deerfield, IL). The first group meeting occurred in March 2007. This was followed by regular face-to-face meetings, several times per year, and teleconference and e-mail communication.

## Development of the Tool

The group recognized that adoption of a tool would be related to its perceived value, ease of use, and brevity. At the first meeting, the group defined its objective to develop a measurement tool to evaluate postoperative recovery that could be performed by minimally trained staff and be suitable for repeated measurements that would be brief yet sufficiently complex to measure recovery in these multiple domains. The process of the development of the PQRS and arrival at the final scale is displayed in table 1.

**Table 1.** The Process of the Development of the PQRS

Stage	Process
1	Consisted of a comprehensive literature review to identify current postoperative recovery scales and to determine their limitations
2	Identified through a Delphi process the domains considered relevant for both patient and clinicians to be included in the scale
3	Defined recovery as return to baseline or better
4	Developed and agreed relevant items to determine recovery in each of the domains through a Delphi process and compiled a Pilot Scale
5	Identified and agreed to time points for the assessment
6	Translated the pilot tool into multiple languages
7	Determined the training requirements and wrote support documents required for the PQRS
8	Wrote a protocol and conducted a pilot study to determine the feasibility of the initial assessment tool on 133 patients
9	Based on the pilot study, revised the tool on the basis of the time taken to complete testing, and identified any obvious items that may have "floor" or "ceiling" effects
10	Defined the final PQRS and the assessment procedure and timings and performed the translation into multiple languages
11	Conducted Pilot Validation Study on 701 participants

PQRS = Post-operative Quality Recovery Scale.

**Table 2.** Six Domains of Recovery Included in the Post-operative Quality Recovery Scale

Domain	Recovery Parameters Measured	Comment
Physiology	Systolic blood pressure, heart rate, temperature, respiratory rate, and oxygen saturation constitute physiologic recovery. Airway control, level of agitation, level of consciousness, and activity on command relate to emergence and airway safety.	This domain is tested in the immediate and early period. It is principally designed to assess physiologic safety and “home readiness” for day-stay surgery.
Nociceptive	Patient assesses of pain and nausea at the time of testing.	1–5 Likert Rating Scale use a “faces” pictorial display to aid ease of response. Scoring as for nociceptive domain.
Emotional	Patient assesses of feelings of anxiety and depression at the time of measurement.	
Activities of daily living	Assesses physical return to normalcy through activities of daily living. Ability to stand, walk and dress without assistance, and ability to eat and drink.	Scored as 3—easily, 2—with difficulty, and 1—not at all.
Cognitive	Five tests assess orientation, verbal memory, executive functioning, attention, and concentration.	Tests produce performance scores. The tests are derived from validated and extensively used neurocognitive tests.
Overall patient perspective	Patients rate of their recovery with respect to their activities of daily living, clarity of thought, ability to work, and satisfaction with anesthetic care.	Reported on a 5-point scale in the same manner as nociceptive. Return to work is only applied to those who currently work and intend to return after surgery. This domain differs from the others because there are no baseline measurements. It is complimentary to the other “recovery domains” but is not included in analysis of return to baseline.

### The PQRS Tool

An example of the PQRS tool data collection sheet is shown in the appendix. Six domains of recovery (physiologic, nociceptive, emotive, activities of daily living (ADL), cognitive, and overall patient perspective) are described in table 2. Each domain comprised a series of questions. Nociceptive, emotive, ADL, and overall patient perspective contain observations that can be scored in a categorical fashion. In the cognitive domain, tasks receive a performance score. In the physiologic domain, values are transformed and categorized as acceptable, somewhat or far outside of the desirable boundaries, based on normative population data.

The multiple time points allow the assessment of recovery over time and at periods of critical clinical decision-making. Baseline testing in all domains is performed between 1 and 14 days preoperatively. Time zero ( $T_0$ ) was defined as the point after which anesthesia is no longer required. This is a complex definition as it is not the same for all operations. Five criteria were defined for the user to choose from. These include last skin stitch or painful stimulus, plaster dressing set, removal of endoscopic device, removal of intravascular device and completion of arterial compression, or application of final dressing. The immediate time point postoperatively is performed at 15 min ( $T_{15}$ ) and is principally designed to assess issues reflective of physiologic recovery, with relevance to patient safety and triage. The extent of early recovery has significant impact on perioperative workflow,

respiratory complications, and rare adverse events.<sup>20–23</sup> Early measurement is performed at 40 min ( $T_{40}$ ) and is principally designed to assess recovery at the point of discharge from the postoperative anesthesia care unit. Late recovery refers to the measurements performed in the first week after surgery, and in the current study, it was performed at 1 and 3 days postoperatively ( $D_1$  and  $D_3$ ). Long-term recovery, not reported in this article, is assessed at 3 months postoperatively ( $M_3$ ). In late and long-term measurements, the focus changes from physiologic and home-readiness recovery to cognitive recovery and return to previous or expected level of functioning at home or workplace.

After an initial pilot study of 133 patients, the PQRS was revised. This process identified that some aspects of recovery could not be satisfactorily performed at  $T_{15}$  and  $T_{40}$ . These included the ADL and overall patient perspective items. Equally, after hospital discharge, the physiologic domain was meaningless. Accordingly, the assessments were constrained with the physiologic domain being tested at  $T_{15}$  and  $T_{40}$ , and the ADL and overall patient perspective domains from  $D_1$  onward. A number of items, including one cognitive test (letter deletion test), that were both time consuming and difficult to complete, were removed. The ADL tests were decreased from eight to four items to reduce duplication. The group considered that a reasonable minimum age to answer the PQRS questions would be 6 yr, subject to pilot and feasibility studies. Experience from the pilot study showed that children as young as 6 yr could answer the ques-

tions satisfactorily, although a greater incidence of failure to complete the questionnaire occurred in this group in the early time periods.

**Scoring the Tool**

Baseline measurements are critical to the use of the tool as the definition of recovery adopted by the PQRS group is “return to baseline values or better.” The overall patient perspective has no baseline measure and is not included in the assessment of recovery. It is a patient-reported outcome and as such mirrors previous work that attempted to assess recovery.<sup>13–15</sup> Measurements at each time point in the five other domains are scored and compared with values assessed before surgery. This is a conservative definition of recovery in the cognitive domain, as repeated measurement may enhance performance through learning effects.<sup>24</sup> This definition required further refinement in the physiologic domain as physiologic variables have broadly defined normal values. Recovery in this domain was classified into three levels that were scored at baseline and at all subsequent time points. They were scored as 3 if their values fell into accepted ranges, 2 if the values were abnormal, and 1 if they were extremely abnormal. (These levels were derived from the literature and are displayed in the appendix.<sup>25–34</sup>)

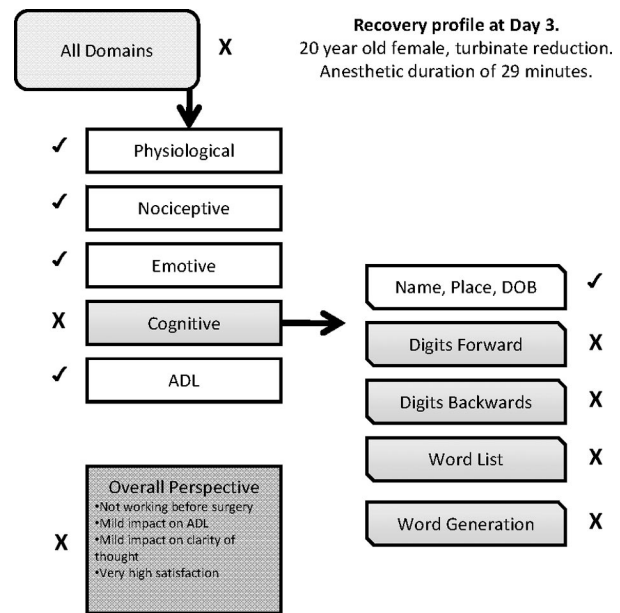
For each patient, values at each measurement time point are compared with baseline values as either recovered (return to baseline values or better) or not recovered. This is scored for all test items and then grouped by domain or by all domains. Any failure to recover for any questions within a domain renders the whole domains as “not recovered.” An example of this is shown in figure 1.

Fundamental to the design of the PQRS tool is that it is a flexible instrument. The assessment of recovery can be expanded or collapsed from a simplistic indicator of recovery (return to baseline values in all tests and all domains) or identify the failure of recovery in particular domains. Alternatively, it can be used to probe deeper and identify which aspect of a domain is problematic or even assess severity indicators within each domain. In addition, the timing of the assessments can be adjusted to the focus of interest. The PQRS is not a summative score, but is rather indicative of whether patients have either recovered or not recovered. This may apply for all domains, or by domains, depending on the research question. Comparisons can be made between groups on the incidence of recovery.

**Feasibility Study**

A prospective observational study of 701 patients was conducted to measure recovery with the PQRS for repeated time periods and provide the initial feasibility and “face validity” data on its use. One of the purposes of the study was to establish the feasibility of assessing patients over the repeated time points. Eight centers in Australia, Canada, China, France, Germany, Mexico, the United Kingdom, and the United States were involved.

The PQRS was used by research staff trained in its conduct, who were not responsible for the direct care of the



**Fig. 1.** Example of a recovery profile for a patient after turbinate reduction on Day 3 compared with baseline values. Recovery (return to baseline values or better) is indicated by clear boxes and ✓, and failure to recovery by shaded boxes and crosses. Only the cognitive domain shows failure to recover, and it occurs in four of the five tests. Overall patient perspective is not designated as a recovery domain as there are no baseline values. Rather, it provides additional subjective experience on the recovery process. ADL = activities of daily living; DOB = date of birth.

patients. Patients were included if they were 6 yr or older, undergoing elective surgery with general anesthesia, and able to complete the PQRS testing in the provided language at baseline. Patients were not enrolled if they had any current psychiatric disturbance or were undergoing neurosurgery that could impair their ability to participate with the assessment. Sampling was “convenience sampling” with patients being recruited from the member institutions of the PQRS group and when research staff were available to conduct the testing.

Baseline measurement of the PQRS was conducted up to 14 days before surgery. Baseline demographic and intraoperative data were recorded by the attending anesthesiologist. After anesthesia was no longer required, the PQRS was repeated at 15 min, 40 min, first day, third day, and 3 months postoperatively. The 3-month dataset is not reported here and will be the subject of a subsequent publication. The PQRS was conducted face-to-face for baseline, T<sub>15</sub>, T<sub>40</sub>, and at D<sub>1</sub> and D<sub>3</sub> if the patient was still in hospital; otherwise it was conducted *via* telephone interview once the patient was discharged. This approach has been used with other assessments.<sup>35</sup> To help standardize the telephone assessment, the “faces” diagrams pertaining to questions were supplied to the patients to use at home. The questions and answers were read from the prescribed PQRS script. Data were recorded and scored according to the definitions and rating scales used in the PQRS (appendix; table 2).



If patients were unable to complete all or part of the PQRS, the missing data were scored as patient refusal, assessor unable to initiate, or patient unavailable. In a number of cases, the assessors were unavailable to complete all the time points of the assessments. These data were excluded from the respective time-point analyses for each domain, and the numbers completing the assessments at each time point are displayed in the relevant tables. We considered this to be reflective of the feasibility of gathering data at all the time points. If a patient attempted a question in the cognitive domain but was unable to answer, then a score of 0 was assigned. This article presents the initial descriptive analyses of the data of 701 patients up to 3 days postanesthesia and surgery.

### Statistical Methods

Data were collected and verified at each participating center before submission to the data manager for analysis. Data are presented as mean and SD or range and percent, and univariate analyses were conducted using chi-square analysis or Fisher exact test where appropriate and were analyzed using SPSS version 14.0 for Windows (SPSS Inc, Chicago, IL).

### Results

From April 2008 to January 2009, 701 patients from eight countries were enrolled and participated using the PQRS (Australia, 92; Canada, 242; France 40, Germany, 143; Mexico, 89; United Kingdom, 46; United States, 42; and China, 7). Baseline and demographic details of the cohort are shown in table 3.

The time taken to complete the scale, rate of refusal, and those unable to complete testing are shown in table 4. The percentage of patients unable to answer at least 50% of the questions within each domain and categorized by age bands, gender, and language, for each time point is shown in table 5.

The percentage of patients returning to baseline or better (recovery) is shown for each test within domains in table 6. The percentage returning to baseline by domain and on the full PQRS is displayed in figure 2. The responses for overall patient perspective are shown in figure 3. Note that this measure did not have a baseline.

To determine the scale's ability to distinguish between individuals experiencing good *versus* poor recoveries, specific cases were examined. Examples of individual patient's performance demonstrating differences in good and bad recovery are shown in figure 4.

An example of the discriminant ability of the PQRS was examined by determining the relationship between the duration of surgery and the various subscale performances and is shown in figure 5. For this purpose, the duration of surgery was divided into three ranges based on the tertiles of data (< 60 min, 60–120 min, and > 120 min). By using the agreed definition of return to baseline or better, each test within each domain's score was dichotomously characterized

**Table 3.** Baseline Demographic and Operative Variables

	Range	Mean (SD)
Age, yr	6–95	48.17 (18.8)
Education, yr	1–25	12.78 (3.8)
Weight, kg	19–174	75.3 (19.1)
Height, cm	120–203	168.36 (11.1)
Alcohol, standard units	0–30	1.72 (4.2)
Duration of anesthetic, min	4–600	119.98 (99.6)
	Frequency	Percent
Gender, male	355	50.6
Nonsmoker	405	60.2
Ex-smoker	151	22.4
Current smoker	117	17.4
Missing (smoking status)	28	
Employment		
Not employed	302	44.3
Not-ill health-to return	39	5.7
Not-ill health-no return	15	2.2
Employed—to return	277	40.6
Employed—not return	49	7.2
Missing (employment status)	19	
American Society of Anesthesiologists Status		
1	276	39.5
2	280	40.1
3	141	20.2
4	1	0.1
Missing	3	
Inpatient	479	68.3
Surgery type		
General	177	25.2
Orthopedic	136	19.4
Ear, nose, and throat	162	23.1
Urologic	77	10.9
Cardiac	35	5.0
Gynecologic	49	7.0
Ophthalmology	19	2.7
Vascular	9	1.3
Bariatric	2	0.3
Maxillo-facial	1	0.1
Plastics	21	3.0
Dental	1	0.1
Neurosurgical	8	1.1
Oncologic	1	0.1
Thoracic	3	0.4

Demographic and operative variables for the 701 patient validation study cohort. Employment status: not employed—at the time of surgery and included students; not-ill health-to return are those who are not working because of their current illness, but plan to return to work; not-ill health-no return are those not working due to the current illness but do not plan to return to work; “employed” means currently employed despite the illness and either plan to return to work or not when recovered. Inpatient means at least one overnight stay in hospital.

as having returned to baseline or not. The resulting score of the number of tests returning to baseline was used to compare recovery in relation to the three durations of surgery and anesthesia. Analysis was performed at each time of assessment to account for the differing numbers of participants at each assessment point.

**Table 4.** Time Taken to Perform Assessments, Refusal Rates, and Unable to Complete Testing Rates

	Baseline	T <sub>15</sub>	T <sub>40</sub>	D <sub>1</sub>	D <sub>3</sub>
Time taken to perform assessments, s	315 (227)	263 (162)	280 (141)	324 (175)	269 (138)
Refusal to participate	1 (0.1)	8 (1.1)	4 (0.6)	48 (6.8)	73 (11.1)
Unable to complete	0 (0)	284 (41)	229 (32.6)	43 (6)	67 (9.6)

Time taken to complete testing is shown as mean (SD) in seconds. Number of patients (%) refusing to complete or unable to complete any part of the Post-operative Quality Recovery Scale questionnaire for the 701 patient dataset. Testing periods are baseline (performed up to 14 days presurgery), T<sub>15</sub>, T<sub>40</sub>, D<sub>1</sub>, and D<sub>3</sub> are the time points measured at 15 and 40 min, and 1 and 3 d after anesthesia was no longer required.

The physiologic domain consists of nine items. Chi-square analyses were conducted to examine the relationship between recovery and the three categories of anesthetic duration. A significant relationship between recovery and anesthetic duration was apparent at both time points where physiology was assessed, T<sub>15</sub>: chi-square = 34.4 (df = 12), *P* < 0.001 and T<sub>40</sub>: chi-square = 37.1 (df = 10), *P* < 0.001. Figure 5 shows this relationship for T<sub>40</sub>. The nociceptive and emotional domains showed a trend toward improved recovery with shorter durations of anesthesia and surgery at each time point. These were statistically significant at the day 1 assessment of the nociceptive domain, chi-square = 18.11 (df = 4), *P* = 0.001 and the emotive domain, chi-square =

22.9 (df = 4), *P* < 0.001 (fig. 5). ADLs were assessed at days 1 and 3, and both time points showed significant differences between the extent of recovery and the anesthetic duration, day 1: chi-square = 60.8 (df = 8), *P* < 0.001 and day 2: chi-square = 54.15 (df = 8), *P* < 0.001 (fig. 5 indicates the day 1 relationship). In the cognitive domain, the assessment of orientation showed limited ability to discriminate between individuals. Consequently, the cognitive domain was assessed using the remaining four tests, and this indicated a significant difference in cognitive recovery in relation to the duration of anesthesia and surgery for all measurements except T<sub>15</sub>, T<sub>40</sub>: chi-square = 57.06 (df = 8), *P* < 0.001; day 1: chi-square = 16.37 (df = 8), *P* = 0.037; day 3: chi-square =

**Table 5.** Percentage of Patients Unable to Attempt at Least 50% of Questions per Domain

	All Patients	6-10 yr	11-15 yr	16-25 yr	26-65 yr	>65 yr	M	F	English	German	French	Spanish	Chinese
N	701	17	7	83	456	138	355	346	422	143	40	89	7
Physiological													
T <sub>15</sub>	1.3	0	0	0	1.1	2.3	1.7	0.9	2.1	0	0	0	0
T <sub>40</sub>	0.3	0	0	0	0	1.4	0	0.8	0.5	0	0	0	0
Nociceptive													
T <sub>15</sub>	25	47	57	20	20	36	26	23	30	25	30	0	86
T <sub>40</sub>	7.7	224	14	3.6	5.3	16	7.9	7.5	12	5	1.4	0	0
D <sub>1</sub>	0.7	6.5	0	0	0.9	0	0.6	0.9	1.2	0	0	0	0
D <sub>3</sub>	0.9	6.2	0	0	0.9	0.7	0.8	0.9	1.2	0	2.6	0	0
Emotive													
T <sub>15</sub>	34	65	57	27	30	44	36	32	40	34	55	0	86
T <sub>40</sub>	12	36	29	4.8	8.3	22	11	12	16	4.4	22	1.1	0
D <sub>1</sub>	0.7	5.9	0	0	0.9	0	0.6	0.9	1.2	0	0	0	0
D <sub>3</sub>	0.9	5.8	0	0	0.9	0.7	0.8	0.9	1.2	0	2.5	0	0
ADL													
D <sub>1</sub>	3.7	12	0	0	3.3	6.5	3.9	3.5	4.0	0.7	10.0	0	57
D <sub>3</sub>	1.0	5.9	0	0	1.1	0.7	1.1	0.9	1.2	0.7	0	0	0
Cognitive													
T <sub>15</sub>	20	88	71	24	15	25	23	17	27	5.6	35	0	86
T <sub>40</sub>	10	65	29	7.2	7.2	15	11	9.8	15	14	0.7	0	14
D <sub>1</sub>	0.9	5.9	0	1.2	0.9	0.7	1.1	0.8	1.4	0.7	0	0	0
D <sub>3</sub>	1.3	5.9	0	1.2	0.7	2.9	1.4	1.2	1.2	0.7	7.5	0	0
Overall perspective													
D <sub>1</sub>	1.0	5.8	0	0	0.9	1.4	0.8	1.1	1.7	0	0	0	0
D <sub>3</sub>	1.6	5.9	0	0	1.1	3.6	2.0	1.2	1.9	0.7	0.5	0	0

The percentage of patients who were unable to attempt at least 50% of the questions within each domain, for each of the testing periods is shown. These data do not include failures where the staffs were not present to conduct the tests, or if there was a logistic reason (rather than patient reason) for failure to complete testing. Testing periods are baseline (performed up to 14 days presurgery), T<sub>15</sub>, T<sub>40</sub>, D<sub>1</sub>, and D<sub>3</sub> are measured at 15 and 40 minutes, and 1 and 3 days after anesthesia was no longer required. ADL = activities of daily living; F = female; M = male.

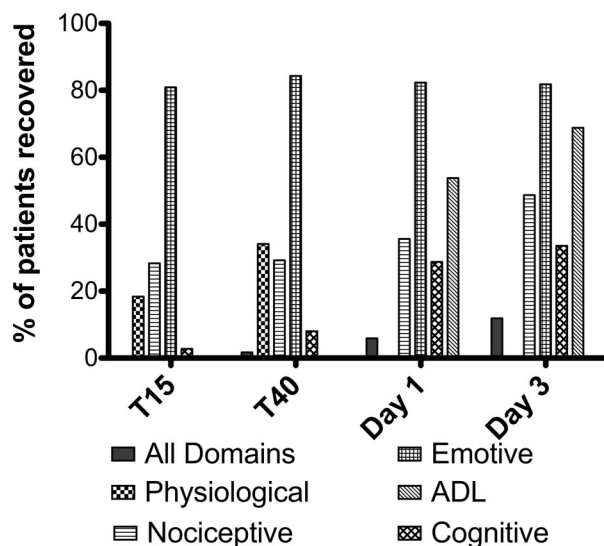
**Table 6.** Percentage of Patients Recovered on All Items of the Post-operative Quality Recovery Scale

Domains	T <sub>15</sub>	T <sub>40</sub>	D <sub>1</sub>	D <sub>3</sub>
All domains	0.3	1.7	5.9	12
Physiological	18	34	—	—
Blood pressure	85%	86%	—	—
Heart rate	545/643	564/658	—	—
Ventilation rate	81%	77%	—	—
Temperature	100%	100%	—	—
SpO <sub>2</sub>	626	634	—	—
Airway	84%	91%	—	—
Agitation	566/671	626/689	—	—
Consciousness	89%	95%	—	—
Response	596/671	654/690	—	—
Nociceptive	81%	88%	—	—
Pain	534/661	603/682	—	—
Nausea	33%	62%	—	—
Emotive	222/669	424/688	—	—
Depressed	58%	84%	—	—
Anxious	386/667	577/687	—	—
Activities of daily living	28	29	35	49
Ability to stand	34%	36%	39%	53%
Ability to walk	169/502	225/634	246/627	306/579
Ability to eat	73%	76%	82%	88%
Ability to dress	362/499	484/634	525/638	525/597
Cognitive	81	84	82	81
Name, date, place	86%	87%	85%	85%
Digits forward	371/434	529/607	538/633	501/592
Digits backward	92%	94%	94%	93%
Word list	400/435	568/604	593/628	545/589
Word generation	—	—	54	64
Ability to stand	—	—	67%	81%
Ability to walk	—	—	404/602	480/591
Ability to eat	—	—	67%	79%
Ability to dress	—	—	400/598	465/588
Cognitive	—	—	90%	94%
Name, date, place	—	—	546/604	557/591
Digits forward	—	—	67%	80%
Digits backward	—	—	405/602	471/588
Word list	2.7	8.0	29	34
Word generation	64%	91%	99%	99%
Name, date, place	343/537	559/618	616/621	567/571
Digits forward	24%	46%	77%	77%
Digits backward	128/532	279/603	475/616	442/568
Word list	26%	41%	76%	75%
Word generation	137/528	246/599	464/612	425/565
Name, date, place	19%	36%	61%	68%
Digits forward	101/524	216/599	374/614	386/566
Digits backward	18%	32%	65%	70%
Word list	95/525	192/599	400/612	392/563
Word generation	—	—	—	—

Data are presented as % recovery (return to baseline values or better) for individual tests within each domain. The number recovered/number where tests were completed is shown below the % recovered. Testing periods are baseline (performed up to 14 days presurgery), T<sub>15</sub>, T<sub>40</sub>, D<sub>1</sub>, and D<sub>3</sub> are measured at 15 and 40 min, and 1 and 3 days after anesthesia was no longer required.

SpO<sub>2</sub> = oxygen saturation.

### Recovery by domains

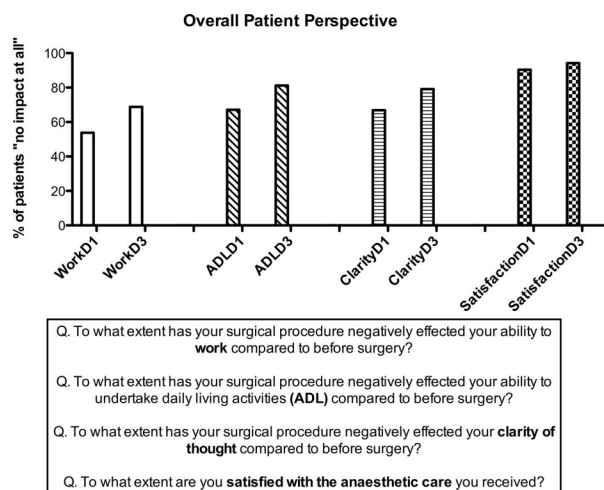


**Fig. 2.** The percentage of patients showing overall recovery and recovery by domains for 701 patients. Recovery is defined as return to baseline values and shown for measurements performed after cessation of anesthesia at 15 min (T<sub>15</sub>), 40 min (T<sub>40</sub>), day 1 (D<sub>1</sub>), and day 3 (D<sub>3</sub>). ADL = activities of daily living.

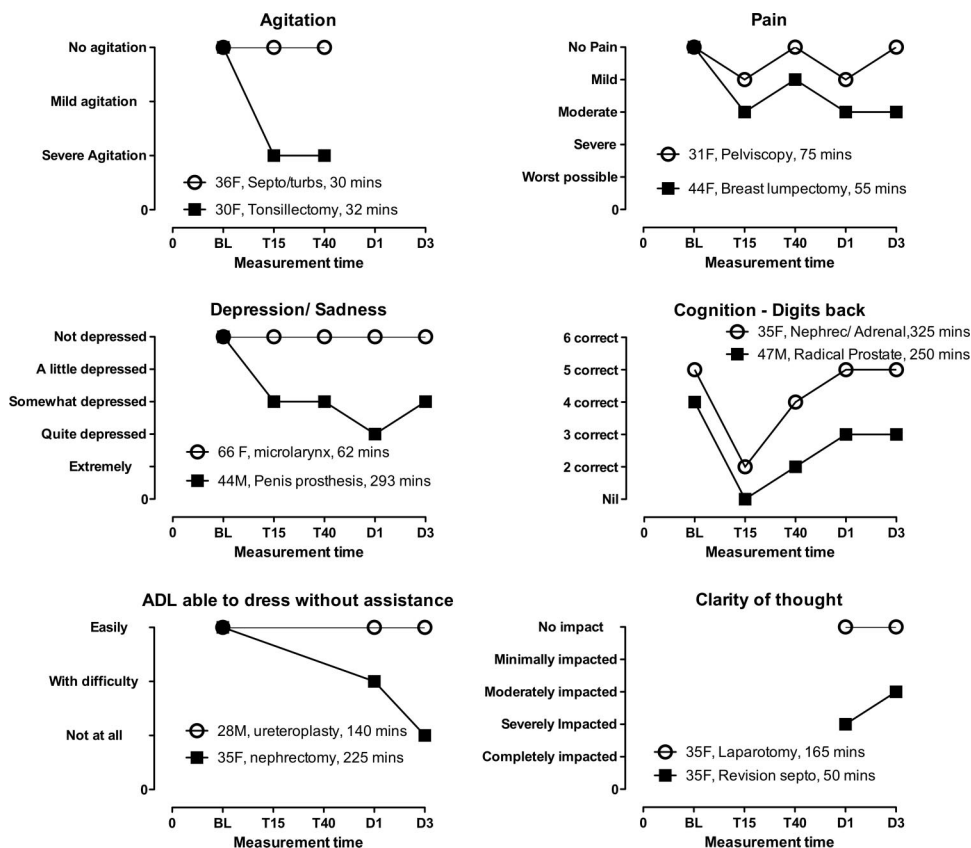
19.82 (df = 8), *P* = 0.011, and T<sub>15</sub>; *P* = 0.51 (day 1 is shown in fig. 5).

### Discussion

Defining “recovery,” after surgery and anesthesia, is a necessary step in the development of a recovery scale. The definition of recovery used in the PQRS is the concept of return to the presurgical state or even improvement. It is expected that patients will deviate from their presurgical state and then progressively recover over time. Integral to using this defini-



**Fig. 3.** The percentage of patients who rated their overall perspective of the operative procedure as “no impact at all” at day 1 (D<sub>1</sub>) and day 3 (D<sub>3</sub>) postsurgery. The questions rated are shown.



**Fig. 4.** Examples of individual patients showing good *versus* bad recovery. The recovery tests are shown, and the age, gender, operation, and duration of anesthesia for and after cessation of anesthesia at 15 min (T<sub>15</sub>), 40 min (T<sub>40</sub>), day 1 (D<sub>1</sub>), and day 3 (D<sub>3</sub>) are also shown. ADL = activities of daily living; BL = baseline; F = female; M = male.

tion is the requirement to perform baseline testing before surgery. Postoperative values are then compared with baseline values to determine whether recovery has occurred. This definition caters to the wide range of baseline scores that will occur between patients. Many of the recovery scales developed to date do not include any assessment before surgery and anesthesia.

To establish face validity, the PQRS was developed over a period of time by a consensus of experts with diverse backgrounds and amended on the basis of empirical data to remove overlapping items and items that had floor or ceiling effects. Face validity means that the scale should show changes that are known and expected from clinical experience. The scale and its constituent parts demonstrated improved recovery over time, which is consistent with clinical experience.

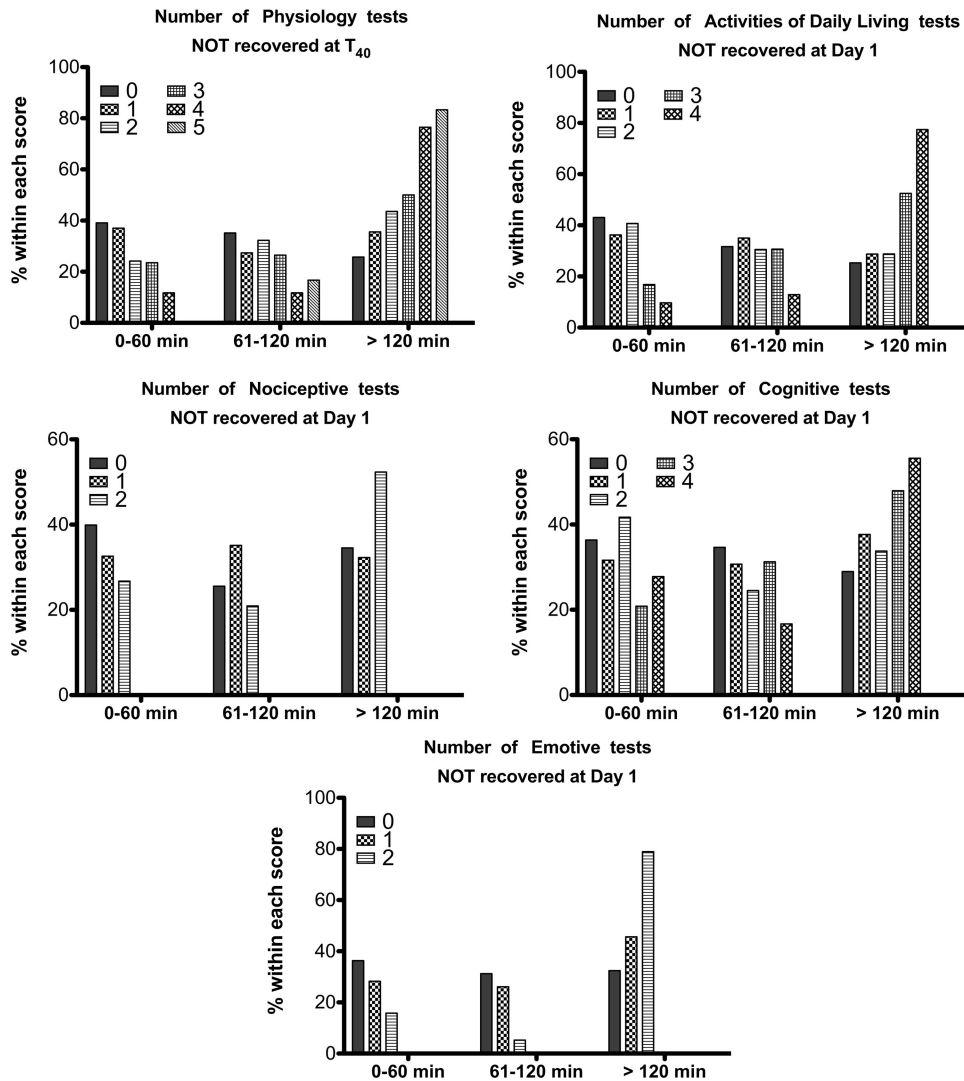
This study shows that the PQRS is able to track recovery in multiple domains over time, in a wide age range of patients, and in multiple languages. With minimal additional training, researchers are able to perform the testing in a relatively brief time, and the use of face-to-face and telephone interviews provided minimal disruption to both patient and staff time.

One of the strengths of the PQRS is that it is a brief test to apply (approximately 5 min), making it feasible to use in many environments. It is acceptable to patients across a wide range of ages, languages, and types of surgery and has a low

patient refusal rate. The percentage of patients unable to attempt the scale was very low for all time points other than the first time point T<sub>15</sub>. This demonstrates the feasibility of performing the test. Other than the very young patients, there were no major differences in the usability of the test across ages, gender, and languages. In contrast to older children, very young patients (6–10 yr) were most likely to be unable to answer questions at T<sub>15</sub> and T<sub>40</sub>. The usability in very young children needs more research to identify the optimal minimal age, as these data are small in number and predominantly from one institution conducting ear, nose, and throat surgery, where emergence agitation in young children is common. Further comparisons between languages are also necessary, but it requires more homogeneous cohorts, as the current dataset is too heterogeneous for meaningful comparisons between languages and cultures, other than to demonstrate that the PQRS can be completed in languages other than English.

An inability to answer questions at T<sub>15</sub> should not be seen as an inability to use the test at an early time period, but rather it is reflective of the state of recovery at the time. In a number of cases at this very early time period, many patients were unconscious at 15 min postsurgery (for example, the 35 patients undergoing cardiac surgery). The time points for assessment used in this feasibility study are not proscriptive but were chosen to assess recovery at time periods relevant to





**Fig. 5.** Within each domain, the number of tests at 40 min (T<sub>40</sub>) or day 1 (D<sub>1</sub>) that did not show recovery is shown for duration of anesthesia. Zero indicated full recovery, and the maximum number in each graph denotes failure of recovery for all tests within the domain. Duration of anesthesia is categorized as 0–60 min, 61–120 min, and more than 120 min. Percent within each score is the proportion of patients across anesthesia durations that achieved a particular score.

clinical recovery, such as emergence, postanesthesia care unit discharge, and return to home. It is recommended that researchers using this tool choose time periods that are practical and appropriate to the surgical cohort and research question. For example, T<sub>15</sub> and T<sub>40</sub> are very important for ambulatory surgery but meaningless for recovery after cardiac surgery where patients may still be intubated.

Some scales have examined internal consistency and structure by performing tests to examine the relationship between items and to ensure that items cohere around meaningful constructs.<sup>9,14</sup> The approach adopted in the development of the PQRS was to exclude items that demonstrated significant correlation with each other within domains, so as to get maximum diversity and retain the brevity of the scale.

The inclusion of both face-to-face or telephone interviews was a deliberate attempt to increase the ability of the tool to capture time points after hospital discharge, without the addi-

tional burden and cost to patients of attending in person to perform the tests. This technique follows the development of other brief assessments that have also used a telephone or mail assessment for patients no longer easily accessible.<sup>13–15,35–38</sup>

The richness of data captured by the PQRS differentiates it from other recovery scales. The multiple aspects of recovery from both clinician and patient perspectives allow for a far more complex assessment of recovery processes than is currently available in other scales of recovery.<sup>6,9,13–15,36–38</sup> These other scales most notably lack the formal assessment of cognition. Although it is only possible to perform a limited screening test of cognition in this brief assessment of recovery, the relatively high incidence of patients failing to recover by day 3 in the cognitive domain was surprising to us. Only a third of the patients returned to baseline values in all cognitive tests by day 3, although recovery on individual tests occurred in approximately two thirds of attempts. It is im-

portant for us to emphasize that the cognitive tests in the PQRS are not formally assessing postoperative cognitive decline (POCD), but rather cognitive recovery. POCD is a formal definition using a comprehensive battery of neurocognitive tests and with defined limits of deviation from baseline values to define whether POCD exists.<sup>18,19</sup> It is possible that delayed cognitive recovery, especially at the D<sub>3</sub> time period, may be a harbinger of POCD.<sup>17,39</sup> These data are consistent with other publications associating duration of anesthesia with recovery parameters or morbidity indicators and adds to the face validity of the PQRS. In the International Study of Postoperative Cognitive Dysfunction-1, there was a modest but significant increase in POCD with each additional hour of anesthesia at 1 week.<sup>40</sup> In volunteers subjected to 2, 4, or 8 h of anesthesia, performance on cognitive tests was better in the first 2 h of recovery with the shorter anesthetic duration.<sup>41</sup> Other studies have shown association with duration of anesthesia and pain,<sup>42</sup> nausea,<sup>43</sup> and physiologic recovery and safety.<sup>44</sup> Further, prospective research with defined cohorts is required to elucidate whether impaired recovery is because of the anesthetic or the type of surgery, as the current dataset is too heterogeneous for that level of analysis.

The four postoperative time periods were designed to capture recovery over time. The specific timing was designed to capture rate of recovery and maximize differences in recovery. It is also broadly aligned with clinical decision making such as discharge from the postanesthesia care unit, return to work, and long-term issues of cognitive function and return to normalcy. It is clear from the data that capturing all patients at all time points does place a significant burden on the assessors and requires a dedicated person to perform the assessments.

The recovery data described in this study will reflect the patient cohorts and surgical case load. In general, there was a bias toward outpatient and ear, nose, and throat surgery, younger and fitter, and with most patients discharged home by D<sub>3</sub>. For many clinicians, once the patients are discharged, their recovery is not further evaluated. The potential value of the PQRS is reinforced by the number of patients who demonstrate a failure to recover. Forty-seven percent of patients still reported pain at D<sub>3</sub>, 12% still reported nausea, 36.2% had not returned to full ADL, and 66.5% of patients had not returned to baseline cognitive function on all tests. Emotive recovery was high and occurred early, although it is possible that the emotive domain may have greater deviations from baseline in more acute or major procedures. Despite failure to recovery in many aspects, patient satisfaction with their operative experience was very high. Some other assessments of recovery assume that assessed cognition will reflect subjective reports of cognition or understanding and assume that individuals have insight into their cognition or changes in cognition.<sup>13</sup> Other data assessing postsurgery have demonstrated that there is a poor correlation between subjective report and objective assessment of cognitive decline,<sup>45,46</sup> and the former seems to reflect mood state rather than any insight into cognitive performance.

It is important to identify some limitations of this article. First, the definition of recovery involves forcing a binary outcome based on preoperative assessment. Where patients score very low values at baseline, then by definition, they are likely to demonstrate recovery. Our recommendation is that researchers using the PQRS with this definition of recovery will need to identify whether these patients should be included in their trial. Poor baseline performance may be an exclusion criterion to enrollment or reason for *post hoc* exclusion.

The data reported do not analyze performance over time as at this stage not all data were collected on all participants at each time point. At this stage of development of the scale, it was intended to demonstrate its applicability to assess recovery and to assess the capacity to perform assessments at each time point. The findings suggest that the intensity of measurement may not be applicable in all studies of specific forms of surgery. For short anesthesia and minor surgery, the earlier assessments may be applicable, but for more major surgery (*e.g.*, cardiac surgery), the later assessments may be more important.

The patient sampling was “by convenience” as the primary focus of the study was to assess feasibility and face validity. This produces a heterogeneous group of patients, which has restricted the extent of data analysis that can be performed. Hypotheses relating to causation of failed recovery are the subject of specific future studies, which are more tightly controlled or randomized, depending on the question being asked. The analysis investigating anesthesia duration and cognitive recovery was used to illustrate the potential of the PQRS to discriminate between what may be considered the “severity” of the procedure. This study was not intended to comprehensively define causation of failed recovery. The findings of this analysis should be considered as hypothesis generating, and the basis for future research, rather than hypothesis proving.

There are many forms of validation that can apply to a new scale, of which feasibility and face validation have been primarily addressed in this article. In the ideal setting, any new scale would be compared against “a gold standard.” Unfortunately, there is no gold standard for measuring recovery, which was the impetus for the group to develop a more sophisticated scale. Current tests, such as the Aldrete Scale, have never been validated. Despite this, the Aldrete Scale, which was developed from an observational study, and published without validation, has been widely adopted.<sup>6</sup>

A number of future studies are planned in the development of the PQRS. Studies are currently under way to examine discriminant validity, validate interview methods, provide nonoperative data, and test–retest reliability data. Comprehensive validation of the tool is a process rather than a single entity. Larger scale use of the PQRS by other researchers will investigate hypothesis-driven research on the causation, management, or prevention of poor recovery. It is envisaged that the PQRS will primarily be for research and specific audits, rather than applied as a routine audit tool, as it is still sufficiently time consuming for individual practitio-

ners to complete while conducting their anesthetic practice. It is better suited to having a dedicated person completing the testing. Once the group has completed the further validation studies, however, the aim was to investigate the concept of a shortened version PQRS for the purpose of individual audit.

The inclusion of baseline data is integral to the concept of recovery used in the PQRS. It provides individual patient change data and is much more robust than current scales. It is, however, a clear limitation of the ease with which the scale could be used in a busy clinical environment. The logistics required to perform the PQRS in this way could interfere with the workflow of a busy anesthesiologist. The balance between brevity and richness of data is a delicate balance and to exclude baseline data would negate the ability for the scale to account for individual changes and the variety of performance of individuals. It is likely, therefore, that for many anesthesiologists, someone will have to be allocated to perform these assessments.

## Conclusion

The PQRS is a brief tool that enables the assessment of recovery in multiple domains and over multiple time periods. It requires preoperative assessments that form the basis of later assessments and the scale demonstrates good face validity. It is of note that the data in this study demonstrated that recovery improves over time, but many patients still have delayed recovery by the third day postsurgery.

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Appendix

**T<sub>0+15m</sub> Patient Questionnaire**

This assessment must be completed at T<sub>0+15m</sub> or as close to T<sub>0+15m</sub> as possible.

Physiological Factors	
<i>P1 Blood Pressure</i> Please record the patient's systolic blood pressure	3= 90-140; 2=70-89 or 141-180; 1= <70 or >180
<i>P2 Heart Rate</i> Please record the patient's heart rate	3= 45-100; 2= 35-44 or 101-139; 1= <35 or >140
<i>P3 Temperature</i> Please record the patient's temperature	<i>Method 1. Sublingual 2. Tympanic 3. Other</i> 3=36-37.6; 2=35-35.9 or 37.7-38.9; 1=<35 or >39
<i>P4 Respiration</i> Please record the patient's respiratory rate	3= 10-20; 2= 5-9 or 21-30; 1=<5 or >30
<i>P5 Oxygen use to maintain Sp<sub>o</sub><sub>2</sub></i> Please record oxygen requirement 3. Oxygen administered by protocol or not required 2. Any SpO <sub>2</sub> <95% requiring oxygen as an intervention 1. Any SpO <sub>2</sub> <90% requiring oxygen as an intervention	
<i>P6 Airway</i> Please record the number corresponding to the actual assessment 3. Self-maintenance of airway 2. Maintenance of airway with support 1. Device <i>in situ</i>	
<i>P7 Agitation</i> Please record the number corresponding to the actual assessment 3. Shows no sign of agitation 2. Patient shows occasional agitation 1. Patient shows severe agitation	
<i>P8 Consciousness</i> Please record the number corresponding to the actual assessment 3. Fully awake 2. Rousable on auditory or physical stimulation 1. Not rousable	
<b><i>P9 Please touch your nose or please lift your head?</i></b> Please record the number corresponding to the actual assessment 3. Patient follows command completely 2. Patient responds purposely but is unable to complete request 1. No patient response or purposeless movement	
Nociceptive Factors	
<b><i>N1 I am going to show you a series of faces and I would like you to indicate which face, number, or description most accurately describes your level of pain at the moment.</i></b> Please show the appropriate face chart to the patient and record the number corresponding to the actual response (1 - 5). If the patient is unable to sit-up to read the chart please read out the responses to the patient by saying, <b>I would like you to tell me which of the following descriptions of level of pain best describes how you are feeling at the moment.</b> Read out the text on the chart and record response (1-5).	
<b><i>N2 I am going to show you a series of faces and I would you to indicate which face, number, or description most accurately describes your level of feeling nauseous or vomiting at the moment.</i></b> Please show the appropriate face chart to the patient and record the number corresponding to the actual response (1 - 5). If the patient is unable to sit-up to read the chart please read out the responses to the patient by saying, <b>I would like you to tell me which of the following descriptions of level of nausea or vomiting best describes how you are feeling at the moment.</b> Read out the text on the chart and record response (1-5).	

<b>Emotional Factors</b>	
<b>E1 I am going to show you a series of faces and I would like you to indicate which face, number, or description most accurately describes to what extent you feel sad, low, or depressed at the moment.</b>	Please show the appropriate face chart to the patient and record the number corresponding to the actual response (1 - 5). If the patient is unable to sit-up to read the chart please read out the responses to the patient by saying, <b>I would like you to tell me which of the following descriptions of extent of sadness or depressed mood best describes how you are feeling at the moment.</b> Read out the text on the chart and record response (1-5).
<b>E2 I am going to show you a series of faces and I would like you to indicate which face, number, or description most accurately describes to what extent you feel anxious or nervous at the moment.</b>	Please show the appropriate face chart to the patient and record the number corresponding to the actual response (1 - 5). If the patient is unable to sit-up to read the chart please read out the responses to the patient by saying, <b>I would like you to tell me which of the following descriptions of extent of anxiousness or nervousness best describes how you are feeling at the moment.</b> Read out the text on the chart and record response (1-5).
<b>Cognitive Factors</b>	
<b>C1 Please tell me your name, the city we are in and your date of birth.</b>	Please record the number of correct responses (1 – 3)
<b>C2 I am going to read you a list of numbers. Listen carefully, then when I am finished, I would like you to repeat them back to me in the same order that I read them. So, for example, if I said 1,2,3, you would say 1,2,3.</b>	Read out the digits given at the rate of one per second. Stop after failure at any point. Please record the item number of the last line correctly recalled.  1                    6, 7 2                    2, 5, 3 3                    6, 3, 8, 2 4                    5, 7, 3, 6, 1 5                    4, 3, 9, 5, 2, 8 6                    1, 7, 9, 5, 3, 2, 4
<b>C3 I am going to read you some more numbers, but this time when I stop I would like you to say them in reverse order. So, for example, if I said 1,2,3 you would say 3,2,1.</b>	Read out the digits given at the rate of one per second. Stop after failure at any point. Please record the item number of the last line correctly recalled.  1                    5, 6 2                    3, 7, 4 3                    5, 9, 1, 3 4                    7, 6, 8, 2, 4 5                    3, 6, 1, 5, 9, 2 6                    1, 4, 8, 6, 3, 9, 2
<b>C4 I am going to read out a list of words. Please listen carefully as when I have finished I would like you to repeat back to me as many of the words as you can remember. You can say them in any order and if you are not sure if you have said a word, say it just in case.</b>	Read the words to the patient at about 1 per second. Please record the number of correct responses.  DRUM, CURTAIN, BELL, COFFEE, SCHOOL, PARENT, MOON, GARDEN, HAT, FARMER, NOSE, TURKEY, COLOR, HOUSE, RIVER
<b>C5 I am going to name a letter and I would like you to state as many words as you can in 30 seconds that begin with this letter, try to avoid proper nouns, such as peoples' names, names of countries etc, numbers or the same word with a different ending such as long, longer, longish. The letter is "C." Time for 30 seconds using a stopwatch and stop patient at this time point.</b>	Please record the number of words correctly given in the 30 second time period.

Examples of the PQRS questions are shown for the T<sub>15</sub> time period. The cognitive tests have different sequences; memory lists or test letters to reduce the effect of learning for each repeated test.  
PQRS = Post-operative Quality Recovery Scale