Measurement of Recovery Within ERAS

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What Does It Mean to Recover?

Obtaining quality of recovery is an abstract construct that is the ultimate goal of each perioperative experience. Recovery assessment has progressed from the unidimensional historical construct focused purely on that which determined safe discharge from theater [1] to a multidimensional construct that encompasses functional recovery, symptomatology, cognitive function, and patient-reported outcomes (PROs). Historical indicators of poor recovery have primarily addressed that which is important for hospital discharge and resource utilization: basic functional assessment, the presence or absence of adverse symptomatology (pain, nausea, etc.) [2–8], emotional and psychological distress [6, 7, 9–11], or patient dissatisfaction [6, 7, 12–14]. Modern recovery, however, is best viewed as a multidimensional construct extending beyond the immediate postoperative period and is best defined by outcomes that are important to both clinician and patient.

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The Temporal Nature of Recovery

Integral to the concept of recovery within ERAS (Enhanced Recovery After Surgery) is the notion that recovery is a multidimensional and continuous process that occurs over sequential time periods [15–17]. The recovery trajectory commences with an abrupt decline from function (temporally associated with surgical injury or trauma), which precedes a time-dependent restitution of function and well-being toward a plateau that may be similar to, or different from, the patient's own preoperative baseline. Recovery assessment is thus inherently a comparison of a patient's postoperative function to that of a preoperative performance—ideally their own—with an assessment of the magnitude of this change to determine its clinical significance.

ERAS has traditionally defined three recovery time periods: early, intermediate, and late recovery [15]. Early recovery is defined as that which is important for safe discharge to the ward (restitution of physiological parameters); intermediate recovery as that which is essential for hospital discharge (presence of adverse symptomatology [pain, nausea], basic resumption of functional activities, self-care); and late recovery as that which occurs post-hospital discharge until such time as a patient has returned to "normal activity." The two former time periods are inherently provider and institution focused and assess recovery via surrogate performance indicators that also determine resource utilization [18, 19]. Patient-focused outcomes are only assessed within the latter recovery period. Alternatively, early, intermediate, and late recovery can be defined in terms of that which is important for hospital discharge (physiological function and absence of adverse symptomatology), successful return to home (nociceptive, emotive, functional, and cognitive recovery), and return to previous level of function (poor functional recovery, persistent pain, nausea, and cognitive decline), respectively [20]. Despite discrepancies in terminology used to temporally define recovery, it is essential that modern recovery assessment tools are multidimensional and validated for repeat measures, thus enabling extended assessment of

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patients along the recovery trajectory out beyond the immediate postoperative period.

Measurement of Recovery Within ERAS Programs

Recovery assessment within the scope of ERAS programs has traditionally focused on unidimensional outcomes important for patient discharge (length of hospital stay [LOS]) and resource utilization (hospital readmission). Two systematic reviews analyzing the efficacy of enhanced recovery after surgery pathways [18, 19] revealed LOS and the presence of complications as being almost universally reported within ERAS studies, whereas patient-centered outcomes were almost universally absent. This is important given that traditional unidimensional postoperative outcome measures lack patient focus and, when used in isolation, were found in two systematic reviews to have rarely improved patient outcomes [21, 22].

A systematic review of the outcome measures used to evaluate ERAS programs [19] identified 38 studies, 25 of which were randomized control trials. LOS was the most commonly reported outcome, being reported in all but one study, and was specifically defined as the primary outcome in 18 of the studies. Other commonly reported outcomes also pertained to the immediate in-hospital period—namely, physiological parameters (25 studies), pulmonary function (5 studies), and basic physical strength (3 studies). Fifty percent of studies included parameters that addressed basic functional status, most commonly in-hospital mobility; while this has been traditionally a surrogate for readiness for discharge, it has yet to be determined whether this correlates to successful resumption of daily activities once a patient has been discharged. Cognitive assessment was included in only one study—a significant omission due to the known interplay between impaired cognitive and non-cognitive recovery and increased patient morbidity and mortality [23–25]. Interestingly, quality of life (QoL) measures were included in seven studies, but only one of these used a validated health-related QoL-specific instrument. The time periods over which recovery was assessed were predominantly limited to the in-hospital and immediate discharge period. While all studies reported on the aforementioned in-hospital variables, only 17 studies reported on variables specifically confined to post-hospital discharge. A meta-analysis of enhanced recovery programs in 5099 surgical patients [18] reported ERAS pathways to be associated with a reduced length of hospital stay (−1.14, 95% CI −1.45 to −0.88) and 30-day mortality (RR 0.71, 95% CI 0.6–0.86) but was unable to detect additional benefits due to the included studies nonuniform study design, nonuniform definitions, and low power. One of these reviews [19] called on future reporting of ERAS pathways to include both patient-centered outcomes and data that could provide context to the traditional outcomes. These reviews, along with editorials [26, 27], highlighted that while traditional outcomes of LOS and readmission rates are essential components of recovery assessment as they have direct impact on resource utilization, they lack patient focus and do not fully address the multidimensional nature of modern recovery assessment.

Concept Analyses and the Development of Modern ERAS Recovery Assessment

There has been significant discussion within the literature as to what best defines modern ERAS recovery. A concept analysis [28] concluded that the attributes that defined modern recovery were those of an energy-requiring process that culminated in the return of a patient to a relative state of normality, independence, optimal well-being, and self-efficacy. Recovery was thus defined in terms of the absence of unpleasant symptoms, re-establishing emotional well-being, and resumption of functional activities. Similarly, another concept study [29] also defined recovery in terms of absence of adverse symptomatology and restitution of basic bodily functions. A more recent concept analysis specifically addressing recovery within the ERAS framework [17] aimed to develop a conceptual framework with which to define, and hence assess, recovery post abdominal surgery. It first defined 22 recovery-related concepts, classified them according to the International Classification of Functioning, Disability and Health (ICF), and used this as the basis to determine the content validity of eight patient-reported outcome assessment tools. The four most important concepts of recovery (an energy-requiring process, an absence of pain, general physical endurance, and ability to carry out daily routine) were consistent with that reported in previous studies and emphasized recovery as the resumption of previous activities undertaken. These concept analyses are in keeping with the wider literature where patients define recovery not just in terms of restitution of basic physiological function but also in terms of their ability to return to a previous "normality," a resumption of previous life roles [30–33]. There is, however, often a disparity between traditional objective recovery assessment variables and that which is defined by the patient, as the latter is heavily influenced by each patient's individual internal cognitive framework (personality traits, coping mechanisms, and global sense of security) and knowledge regarding their expected recovery trajectory [31]. Thus, modern assessment of ERAS recovery must include both traditional parameters, such as restitution of physiological and physical function, as well as the broader nociceptive, emotive, social, satisfaction, and cognitive domains [31, 34].

Approaches to Recovery Assessment

Objective Versus Subjective Assessment

Modern postoperative recovery assessment faces the challenge of providing objective measurement of variables that by their nature are inherently subjective and of including in its breadth of assessment recovery domains that have tangible meaning to both patient and provider. Traditionally, recovery assessment was quantified using unidimensional objective measures. However, the multidimensional recovery construct has implications to both patient and provider and has required recovery assessment to include more subjective (and in particular patient-reported) outcomes.

The terms "objective" and "subjective" outcomes are entrenched within the medical literature yet lack unifying definitions. A systematic review [35] of 90 methodological publications and 200 clinical trials found there to be no unifying definition of either variable. It revealed, however, that common characteristics were associated with each. A subjective outcome was concluded to be that which is dependent in part upon an individual's judgment (be it either the patient or an observer), is patient-reported, or is a private phenomenon (measurable only by the patient). Conversely, an objective outcome was one that was independent of an individual's judgment (be it patient or an observer) and was reported and assessable without judgment by an observer other than the patient. Patient *centered* outcomes, which may be measured either objectively or subjectively, are those that hold intrinsic value to the patient [36–39]. In comparison, patient *reported* outcomes are inherently subjective as they are direct patient reports from the perspective of the patient without inference or judgment from an external observer [36, 40]. This distinction between objective and subjective variables has clinical ramifications, as subjective outcomes are by necessity unblinded and hence particularly susceptible to reporter bias and overexaggeration of treatment effect size and are influenced heavily by the patient-provider relationship [35, 41, 42].

Objective Outcomes

Clinical Performance Indicators

Recovery at the institutional and provider level has been traditionally by proxy through the use of clinical performance indicators (CPIs). The benefit of CPIs is that they are objective outcome measures that are easily reported and retrospectively audited (such as length of hospital stay) and reflect resource utilization. They have become linked to reward-based payment systems and are often used as a surrogate for quality of recovery [43, 44]. However, their utility is in detection of complications, clinical errors, and deviations from guideline adherence rather than a true measure of quality of recovery [44].

Reporting of clinical performance indicators is ubiquitous within the perioperative literature and the most common outcome reported in ERAS studies. However, an observational before-after study involving ERAS programs reported a disparity between LOS and the time a patient was deemed ready for discharge [45], with 87% of ERAS patients being discharged a median 1 day *after* discharge criteria were fulfilled. This highlights that even the dichotomous traditional outcome variable "LOS" was itself heavily influenced by social, cultural, institutional, and patient factors [46]. Of interest, a study demonstrated construct validity for "Time to Readiness for Discharge" as an alternative surrogate measure of short-term recovery [46], which aims to mitigate the impact of confounding influences on assessment of recovery. These studies emphasized the lack of collection of contextual variables (patient comorbidities and surgical complexity) with which to analyze these objective outcomes (length of stay) and recommended future studies to include these. Furthermore, a recent ERAS consensus statement advocated for traditional clinical outcomes to be routinely recorded with contextual variables such as patient case mix [47]. Another systematic review [17] concluded that unidimensional outcomes are beneficial in assessing adherence to clinical pathways and identification of sentinel events, but must be viewed in the context of confounding variables (differences in patient case mix, anesthetic and surgical complexity, measurement error or chance [43]). Importantly, when used in isolation, they are rarely associated with improved patient outcomes [21, 22]. Thus, while objective outcomes are easy to measure, only through their interpretation in a clinical context can they be true measures of the multifaceted nature of recovery [48].

Subjective Outcomes

Patient-Reported Outcomes

Patient-reported outcomes (PROs) are subjective measures that prioritize the patient's perspective as being that which is the most important at the time of assessment and are essential to the provision of high-level patient-centered care [26, 40, 49]. They are specifically adept in capturing the multidimensional and interrelated nature of recovery domains [40, 50], define recovery in terms of the patient as the key stakeholder, and ultimately optimize patient outcome through facilitating patient engagement in the recovery process [51]. PROs commonly aim to quantify more abstract concepts of recovery not traditionally assessed: postoperative quality of life, satisfaction, and personal experience of care [36]. However, PROs as surrogate measures of recovery are hindered by their inherent subjective nature, lack of validated assessment tools, and their susceptibility to response shift and recall bias [37, 40].

Patient-reported outcome measures (PROMs) are the means by which PROs are measured. PROMs were initially utilized in pharmacological and health service research but have now become commonplace in the clinical arena to the extent that they are embedded in regulatory requirements and routine clinical care reporting [36, 52, 53]. However, a systematic review identifying 22 unique PROMs for post abdominal surgery [40] reported 74% as displaying only fair or poor development methodology, with the majority being based on limited or unknown evidence. Importantly, no PROM adhered to the International Society for Quality of Life Research [38] minimum standards (internal consistency, reliability, content validity, hypothesis testing validity, or responsiveness), although the four recovery-specific PROMs did demonstrate sound content validity. In addition, PROMs were reported to be susceptible to the time delay between their reporting and the event being assessed, which directly impacted on the likelihood of both recall and response shift bias. In response, groups such as the Patient-Reported Outcomes Measurement Information System (PROMIS) and Oxford Patient-Reported Outcomes Group aim to calibrate and standardize contemporary PROMs for both clinical and research applications [38, 50, 54–56].

Response Shift and Recall Bias

Although not insurmountable, a major limitation of subjective outcomes is its susceptibility to measurement bias, in particular that due to response shift and error in patient recall. There is also the issue of from whose view the health state is measured. Recovery inherently infers that a comparison is made between a patient's postoperative state of health (or part thereof) and a preoperative control—ideally their own preoperative baseline. This "change" is a surrogate marker of recovery for that health domain being assessed, with subsequent assessment of the magnitude of this change to determine whether it is within what is expected for that recovery interval. However, change scores that are reported by the patient and those that are recorded by an observer are often disparate [37, 57]. This is in part due to recall and response shift bias.

When assessing change scores, three change scores are quantifiable, which differ in their primary state of reference and susceptibility to bias (Fig. 35.1). Conventional change (CC) scores are derived by comparison of the patient's postoperative (x_1) and preoperative (x_o) scores, with the latter being the score *actually recorded* by the patient preoperatively. CC scores infer that the most important perspective from which to measure the domain of interest is that at the time of each assessment (i.e., the preoperative score is derived from the patient preoperatively and the converse for the postoperative score). Its benefit is that it is immune to recall bias, but it is susceptible to bias due to response shift. In contrast, patient-perceived change (PPC) scores are

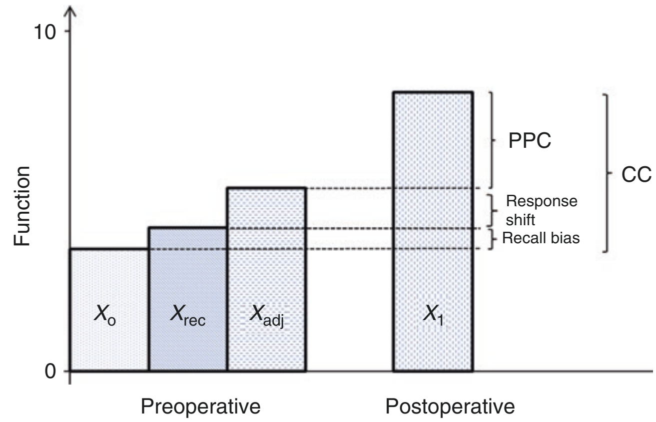

Fig. 35.1 Relationship between conventional change (CC) scores and patient-perceived change (PPC) scores. X_o, preoperative score actually recorded by patient; X_{rec}, preoperative score a patient recalls having recorded; X_{adj}, preoperative score recorded by the patient from the post-operative perspective; X_1, postoperative score recorded by the patient

derived by comparison of the patient's postoperative score (x_1) to the preoperative score that they would *now* give, *given their current postoperative perspective* (x_{adj}). PPC scores thus infer that the most important perspective from which to measure the domain of interest is from one time point (i.e., the postoperative time point is the most suitable time for the patient at which to determine *both* postoperative and preoperative scores). Its benefit is that it is immune to bias due to response shift (as both pre- and postoperative events are assessed in the context of the postoperative experience), but it is susceptible to recall bias.

Recall bias is defined as the difference between what the patient *recalls* having scored preoperatively (x_{rec}) and what they *actually* had documented (x_o). Thus, a third change score, the PPC score adjusted for recall bias (PPC_{adj}), was described [37] and is the sum of the PPC and recall bias. Similarly, response shift can be quantified as the difference between the CC and PPC_{adj} (which is the difference between the patient's x_{adj} and x_{rec} preoperative scores). This retrospective assessment of a preoperative event (i.e., how the patient rates their preoperative function from the perspective of their postoperative state) infers that past events are best compared in the context of subsequent events (the postoperative period) and from the perspective of those experiencing them (the patient). It also enables quantification of both recall and response shift bias.

Response shift was initially described within the domain of educational research and management science and was subsequently applied to the clinical arena [58] in order to quantify the normal adaptive changes that occur within a patient's internal framework in response to the passage of time and the experience of major life stressors (such as surgery of significant illness). Response shift is the alteration in a patient's cognitive framework as a result of a stressor such that subsequent events are assessed through an altered perspective [39]. For a postoperative patient, a catalyst (surgery, trauma, or major illness) challenges a patient's internal mechanisms by which he or she accommodates the catalyst (internal behaviors, cognitive and affective processes) such that the fundamental meaning of a target construct (i.e., what it means to recover) is altered for that patient [39, 59, 60]. The mechanisms by which this alteration occurs are by one or more of recalibration (change in internal standards of measurement used to define recovery), reprioritization (change in values associated with recovery), or reconceptualization (redefinition of what it means to recover) [59, 60]. When assessing a patient's quality of recovery using CC scores, this results in measurement bias in that the same construct (quality of life, recovery) is being measured pre- and postoperatively by the *same patient* using *different (cognitive) measurement* tools. This is mitigated when the same construct is calculated using PPC scores.

Response shift thus impacts on the reliability, validity, and responsiveness of a PROM tool [58, 61, 62]. Construct validity is impacted as it assumes constant correlation between two domains of interest—a phenomenon that does not occur when two patients experience vastly different recovery experiences. Reliability is impacted as it requires that all patients share a common (and constant) frame of reference and experiences through which to view the recovery domain of interest. Thus, measurement error results when subjective outcomes are compared between disparate groups (i.e., treatment vs. control) or in the one patient but from differing perspectives (i.e., patient vs. caregiver vs. family member), as both the baseline cognitive framework and magnitude of response shift differ among patient, caregivers, and providers as a result of differences in an individual's experience, fear, focus, or internal standards [39]. Interestingly, when correcting for the effect of response shift on health-related outcome measures, there is often an increase in the treatment effect detected and a reclassification of the mechanism by which this change occurs [63].

Satisfaction

Satisfaction is a subjective PRO that has intrinsic value and is central to the modern concept of patient-centered care [64] but must not be used as a surrogate for quality of recovery. Quality of recovery is a multidimensional construct that assesses the postoperative experience using both objective and subjective measures [65, 66]. While satisfaction may be assessed as a component of quality of recovery, it is a discrete entity, which is inherently solely subjective and influenced by external events, patient expectation, sociodemographic variables, and internal patient characteristics [12, 37, 64, 67]. Satisfaction as an outcome measure is hindered by its inherently subjective nature and the paucity of validated assessment tools and lack of a suitable comparator [68–71]. Satisfaction is heavily influenced by the provider-patient relationship, being improved with empathetic care, provision of individualized health information, realistic patient expectation, shared decision-making, emotional engagement, and perceived responsiveness of the patient's treating team [59, 60, 67, 68, 72–74]. It is, in, part, correlated to objective measures of recovery, with high satisfaction being associated with reduced early readmission rates [75] and low satisfaction being correlated with persistent adverse symptomatology and postoperative complications [6, 71, 76, 77]. Thus, while satisfaction has intrinsic value as an outcome in its own right, it must not be used as a surrogate for quality of care or recovery and must be measured using a validated tool assessing satisfaction in specific areas of care [68, 70].

Quantifying Recovery

Recovery fundamentally assesses a patient's postoperative performance to that of a preoperative comparator, with subsequent inference as to whether the magnitude of this difference is clinically significant. However, recovery assessment tools differ in their method by which they assess a patient's postoperative performance and, importantly, the preoperative baseline performance to which they compare.

Composite Change Scores

Recovery and its fundamental physiological processes exist along a continuum. Hence, recovery assessment begins with assigning a mathematical value to a patient's postoperative performance in a health domain of interest. These commonly take the form of Likert or visual analogue scales, where a patient's performance is assigned an integer value by either the patient or an independent observer, with 1 and 10 (or 5) being the minimum and maximum scores, respectively. Each domain is assessed using one or more health-related questions or "items." In multidimensional recovery assessment, scores from each item are then summated to produce a single postoperative score (composite score) for each patient. This score is then compared to a preoperative baseline score, with this latter score being either the patient's *own* baseline performance or, more commonly, the *average* preoperative performance of a group (either the group to which the patient belongs or a historical group). This conventional change score is referred to as a composite change score. The significance of this score can then be assessed in two ways (Fig. 35.2): either by comparison of the difference between two groups' mean change scores to determine whether different clinical pathways infer a benefit or by comparing an individual patient's change score to a predetermined threshold in order to determine whether a patient's performance is in keeping with what would be expected for "normal recov-

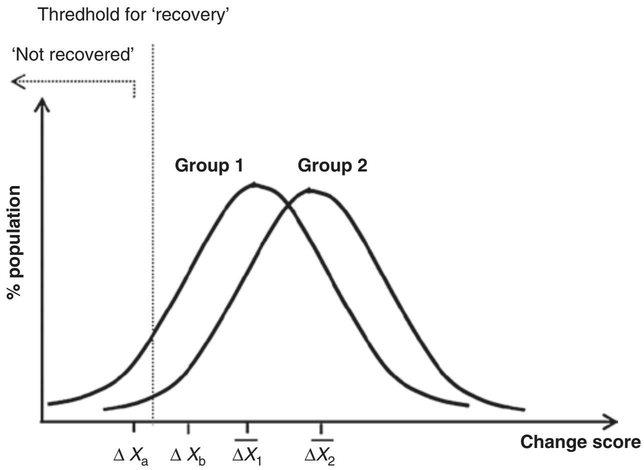

Fig. 35.2 Composite change scores. Δ(Delta)x_a, individual change score for patient a; Δ(Delta); x_b, individual change score for patient b; Δ(Delta) x_1, group 1 mean change score; Δ(Delta) x_2, group 2 mean change score

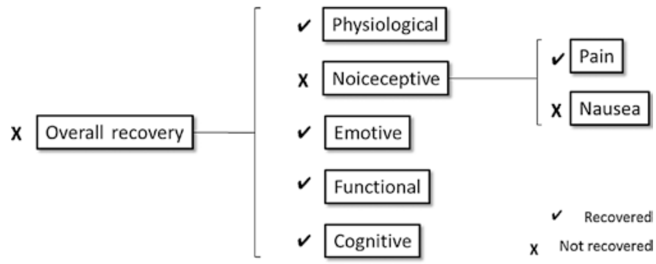

Fig. 35.3 Dichotomous recovery score. In this example, the patient has not recovered overall, due to failure to recover in the nociceptive domain due to persistent nausea (but no pain)

ery." In both assessments, a statistical significance is inferred to have clinical significance.

Assessing recovery as a composite change score is not without its limitations. Firstly, while composite scores allow for assessment of recovery in multiple domains, it assigns equal weight to each scale, which may not reflect their clinical implications; i.e., a score of 7/10 for each on the pain and nausea scales, while mathematically equal and contributing to the final composite score to the same degree, may have different clinical implications. Secondly, each domain is commonly assessed using more than one response item, but the number of response items per domain may not be equal; i.e., the nociceptive domain may be assessed using three response items, while the cognitive domain may have only one. This biases the overall composite score to reflect the domain that is assessed by the most number of response items; i.e., in the previous example, a patient with poor postoperative pain will score a worse composite score compared to a patient that may have severe cognitive dysfunction but excellent pain control. Thirdly, composite scores have the potential to "mask" poor postoperative function—demonstrable failure by a patient in one domain may be compensated for by their above-average performance in the remaining domains [78, 79]. Finally, a composite change score that is deemed to be reflective of poor recovery does not identify *in which domain* a patient's performance is suboptimal but only that is occurring.

Dichotomized Recovery Scores

An alternative method of recovery assessment is dichotomization of each domain, such that each recovery domain is assessed independently from all others. This mitigates bias due to differences in the number of items used to assess each domain, as well as that due to a patient's failure in one domain being obscured by their excellent recovery in the remaining domains. At an individual patient level, a patient is deemed to have recovered on a recovery item if their postoperative performance is equal to, or exceeds, a predetermined value (ideally their own preoperative performance). Domain recovery requires that a patient scores as "recovered" in all the items pertaining to that domain. Overall recovery mandates that a patient is deemed to have recovered in all of the domains assessed (Fig. 35.3). Group recovery is assessed by comparison of recovery prevalence rates, either overall or for each domain. Dichotomizing recovery assessment thus has direct clinical utility, as it identifies not only *in which* patients poor recovery is occurring (this patient "has recovered" vs. "has not recovered") but *in which domain*s (they have recovered in the emotive, functional domains and cognitive domains but not the nociceptive domain). This allows for targeted intervention to be given to those patients who would most benefit (physiotherapy assessment to patients with poor functional recovery and psychological review for those with poor emotive recovery). A perceived limitation of dichotomized recovery is that data richness is lost and that it identifies only the patient who has not recovered but not the magnitude by which they failed to do so. This is mitigated by recording continuous variables in their raw form, thus enabling a "drill down" of domains with poor recovery to identify its severity.

The Importance of Using the Patient's Own Baseline as the Comparator

It is essential that the comparator to which a patient's postoperative performance is assessed is the patient's *own* baseline (preoperative) performance. When ordinal scales are summated, it is assumed that there is not only mathematical equivalence *between* scales (the increments within the pain scale are identical to that on the nausea scale) but *within* each scale (i.e., the difference between 1 and 2 on the nausea scale is the same as 9 to 10) and *between patients* (each patient assigns the same weight to each increment on the nausea scale as he or she does to the pain scale). However, as each patient differs in his or her internal cognitive framework from which he or she assesses the quality of his or her experiences, so too will he or she differ in the relative magnitude that he or she assigns to the increments *within* each scale and *between* scales. This has direct implications when a patient's postoperative performance is compared to *anything other than their own*, as in this instance the internal framework assigning value to each of the recovery scales postoperatively (the patient's) is not the same internal framework that is assigning value to the scales preoperatively (either a person other than the patient or even a group average). For example, a patient may be more likely to report a lower postoperative pain score if he or she is undergoing curative surgery compared to a patient who has undergone a palliative procedure. Similarly, a patient who has previously experienced debilitating postoperative nausea may assign a greater significance to a single increment in nausea compared to a patient who has not. In addition, by using a patient's own preoperative baseline *for each* individual perioperative event, response shift and recall bias is further reduced as it minimizes the time delay between postoperative and preoperative assessments. As each perioperative journey is assessed independent upon previous, or future, events, this minimizes the bias due to changes in a patient's internal cognitive framework as a result of chronic illness or trauma.

When assessing objective measures, comparison of a patient's postoperative performance to that *other than their own preoperative baseline* is also biased when the patient differs significantly from the reference population in regard to the recovery item being assessed. The fundamental building block of recovery assessment is comparison of a patient's postoperative performance to a preoperative reference (traditionally this being an average performance of a reference preoperative group), with subsequent assessment as to whether this difference is in keeping with what would be expected for that particular time in a patient's recovery course. A threshold difference in performance must therefore be determined, below which suboptimal recovery is deemed to be occurring. This is usually defined using common statistically significant thresholds (i.e., a change that is greater than 1 or 2 standard deviations from a reference population's average performance) that is inferred to have clinical significance.

A patient with a preoperative baseline performance significantly greater than that of the reference population is biased to be deemed to have recovered, even in the event that their postoperative function is demonstrably less than their own (high) preoperative baseline. This is as a result of the fact that the absolute value above which recovery is deemed to have occurred is based on population parameters (the average group baseline score and the accepted "normal" group variation above and below this) that may not mathematically model the individual patient's performance. A patient with high preoperative baseline is biased to be recovered irrespective of whether they experience a normal *or* demonstrable decline in postoperative function *compared to their own* preoperative baseline (Fig. 35.4). As the population-based preoperative reference is less than the patient's own baseline performance, these patients' postoperative function must decline by a larger magnitude (compared to a patient with "average" baseline function) for it to fall below the population-based threshold defining incomplete recovery. For example, a patient with high cognitive baseline may be able to recall nine out of ten words at baseline (compared to a population's whose average is six and a standard deviation of two) but only six postoperatively. If the threshold that defines poor recovery is a change score greater than -1SD from baseline, this patient would be deemed to be recovered when assessed using population parameters, but not necessarily when assessed to their own preoperative baseline. In this instance, they would be required to score less than four (a demonstrable decline from

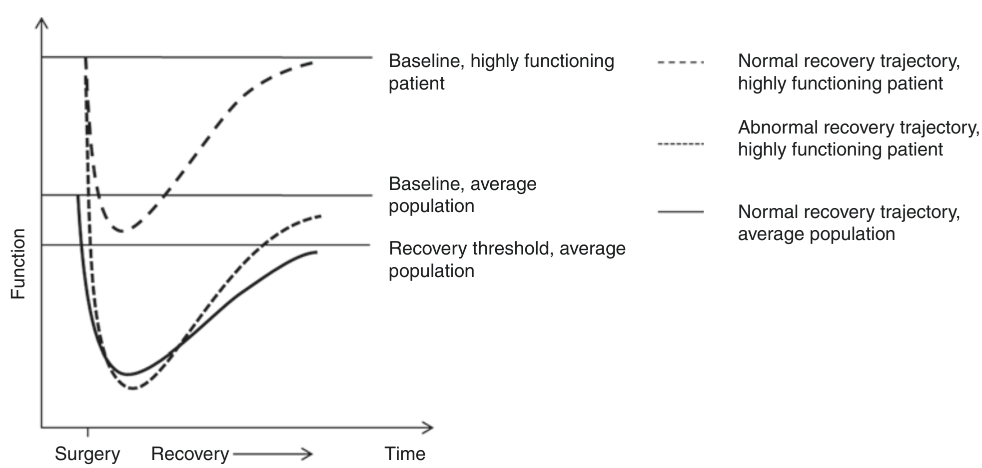

Fig. 35.4 The effect of comparing a patient's postoperative performance to their own (vs. group average) preoperative baseline

their own baseline) for them to be deemed "not recovered." It is only by using each patient as their own comparator is this measurement bias minimized.

Contextual Real-Time Recovery: The Future of Modern Recovery Assessment

Recovery assessment is complimentary to, but distinct from, traditional perioperative risk models. Perioperative risk assessments aim to predict patients in whom perioperative compilations (i.e., suboptimal recovery) may occur in order to rationalize resources to the patients who would benefit the most. Modern risk reduction tools utilize predictive analytics and patients' electronic metadata in order to drive clinical decision and improve patient outcomes [80, 81]. They are beneficial at the institutional and provider level to anticipate resource utilization. At the individual patient level, population-based risk parameters are applied to determine a risk band for each patient's perioperative event. Perioperative risk stratification does, in part, correlate with postoperative outcomes [82, 83] but requires all patients within a population (high-risk patients) to all be given a treatment in order to prevent adversity in a proportion of them and fails to address the perioperative issues (poor recovery) that may occur in a proportion of patients a priori classified as low perioperative risk. Thus, while traditional perioperative risk models predict patient *populations at risk* of suboptimal recovery (and hence resource utilization), they do not identify *individual patients in whom this actually occurs* in entirety [84].

Real-time recovery (RTR) assessment is complementary to traditional risk assessment as it identifies individual patients in whom suboptimal recovery is *actually* occurring *at the time* that it is occurring. RTR has the potential to improve patient outcome by minimizing the time delay between identification of suboptimal recovery and implementation of a corrective measure [85–92] as well as through improved patient engagement and promotion of self-efficacy [93–95].

RTR is a concept originating from information technology and organizational literature but is directly applicable to the concept of recovery as that which occurs along a time-dependent predictable trajectory. RTR is the ability of a system to detect and recover from a deviation from an expected norm in a time frame that minimizes system losses. In regard to patient recovery, RTR requires first identification of individual patients and in which domains suboptimal recovery is occurring and then implementation of a clinical corrective treatment aimed at the cause of this suboptimal recovery. RTR is thus ideally measured using a dichotomous recovery tool with contemporaneous collection and analysis of data. This real-time individualized data assessment *is in addition to*, and contrasts sharply from, traditional assessments of recovery, which have been limited to retrospective assessment of recovery between groups (rather than between individual patients).

The infrastructure and tools required for RTR assessment are already well established within the medical and surgical fields. These include data detection devices (either automated biometric technology or electronic apps collecting recovery specific parameters) and digitized analytic platforms. Automated biometric technology includes items of clothing and jewelry that provide a continuous, or high frequency, individualized biometric setting (cardiorespiratory and basic physiological variables) from which to view other measures of recovery [96]. Recovery-specific parameters range from PROMs (pain, anxiety) to procedure-specific outcomes (return of bowel function, ability to flex knee). Data is transmitted to digitized platforms either by automatic uploads through the device itself, via external hybrid devices, or by manual entry by the patient into recovery-specific smart apps. Thus, each individual patient's recovery data is assessed in context of their individual biometric profile and ideally in reference to their own preoperative baseline.

Digitized platforms are ideally tailored to the clinical context to which they are applied. For example, a recovery assessment may be tailored to include operation-specific items that a surgeon has deemed important to measure or to what has been defined by the patient as important for a successful surgical outcome. Smart devices have high population penetrance and patient familiarity [96–99], biometric technology has high patient acceptability [96], and the use of smart devices for the collection of recovery data has demonstrated proof of concept [100, 101]. Through contemporaneous collection, uploading, and analysis of data and the use of automated alerts, a clinician can be alerted at the time to a patient who is experiencing suboptimal recovery, irrespective of the geographic location of the patient (inpatient versus outpatient). In addition, by inclusion of the patient into the alert, patients are kept informed of their own recovery progress, an integral component of patient-centered care and engagement.

The Postoperative Quality of Recovery Scale (PostopQRS)

The Postoperative Quality of Recovery Scale (PostopQRS) is a dichotomous multidimensional recovery assessment tool, which has an established digitized analytic platform with real-time scoring of recovery. Recovery assessment may be tailored to the user (patient or clinician) and encompasses both basic physiological variables and the nociceptive, emotive, functional, and cognitive domains. In addition, it compares each patient's postoperative performance to their own preoperative baseline, thus minimizing measurement bias. It has both clinical and research applications, as automated alerts can identify patients in whom suboptimal recovery is occurring at the time it is occurring (and in which domains) and retrospective assessment of data can analyze the prevalence of recovery within a clinician's patient population. It has been validated in heterogeneous patient populations, includes a cognitive domain that is based on formal neuropsychological tests and that has been calibrated for repeated assessments, and has been calibrated for assessment either face-to-face or via telephone [6, 102–104]. These attributes are essential for a tool to assess individualized patient recovery at multiple time points, both in the immediate postoperative period and post-hospital discharge.

The PostopQRS has been designed for multiple purposes, including the ability to engage patients as well as connecting them with their providers. However, other stakeholders in the health industry with interest in patient improvement can use the PostopQRS as an audit or research tool to benchmark recovery, institute health service changes, and measure the effect of interventions. This concept is illustrated in Fig. 35.5.

Fig. 35.5 Patient and stakeholder uses of the Postoperative Quality of Recovery Scale (PostopQRS) to enhance recovery

Conclusion

Modern recovery has progressed from a unidimensional to multidimensional construct, is defined as occurring along a predictable time trajectory, and extends beyond the traditional immediate postoperative period. The most commonly reported outcome measures used to evaluate ERAS pathways were length of stay and 30-day readmission rates. There is a call for measurement of recovery within ERAS programs to be extended beyond the use of these traditional surrogate markers of patient recovery and to include both patient-centric outcomes and contextual variables in a multidimensional assessment. Recovery assessment variables may be objective or subjective and are prone to bias due to lack of context or susceptibility to response shift, respectively. Recovery assessment infers a comparison of a patient to a preoperative comparator, ideally their own preoperative baseline. Ideally, recovery is assessed using a multidimensional dichotomous recovery assessment tool that has the infrastructure to provide recovery data to both patient and clinician in real time.

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