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Review Article

Postoperative recovery and outcomes – what are we measuring and for whom?

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Summary

Recovery is an abstract quantity the definition of which varies according to the pre-dilection of individual institutions, clinicians or patients. While traditionally focused on immediate postoperative restitution of function and readiness for discharge, recovery assessment has progressively expanded its focus to include other clinically relevant time periods, each of which is influenced by specific factors. Assessment tools have progressed from assessing one dimension of recovery, such as physiological variables, to multidimensional assessment of physical, nociceptive, emotive, functional and cognitive performance. They should be validated ideally for repeat measures and should provide real-time recovery data, as recovery can be viewed as a continuous process.

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Recovery time periods – relevance, influences and focus

Postoperative recovery is complete when function is restored and adverse symptoms have resolved. Function and symptoms can be assessed at time points considered significant by the patient, clinician or institution.

The outcomes of the 'enhanced recovery after surgery' pathways were initially determined by clinicians rather than patients, and emphasised what happened in hospital – length of hospital stay, complications and early organ dysfunction [1]. However, reductions in length of hospital stay and complications associated with the enhanced recovery pathway are of limited interest to patients [2, 3]. Patients rarely achieve normal levels of function and are usually symptomatic on discharge after major surgery, the timing of which is influenced by organisational factors and correlates poorly with longer term recovery [1, 2].

Postoperative enhanced recovery, as a process and as an endpoint, is now assessed during three stages: from the end of surgery to discharge from the postanaesthetic care unit; from then until hospital discharge; and, finally, until normal function has been restored. Simple physiological variables predominantly influence the first stage. The second and third stages are predominantly influenced by pain, more complex physiology and function.

Tools generated by clinicians from various specialties, rather than just surgery, also define recovery over three phases, their cumulative duration exceeding that of the surgically-focused enhanced recovery pathway [4]. The recovery phases described by these tools can be categorised as early, intermediate and late. The early postoperative recovery phase has been defined as the first 24 h [5, 6] or the first seven days [7–9]. The speed and extent of recovery in the early phase is influenced most by pain, nausea, peri-operative medications and delirium [10]. The intermediate phase of postoperative recovery has been defined as the first 28 [11] or 60 [12] days. The extent of recovery in the intermediate phase is influenced most by pain, anxiety and depression, physical impairment and cognitive dysfunction. The late postoperative recovery phase has been defined as the first six weeks [13] or three months [14]. Symptoms that afflict the early and intermediate phases of recovery can persist into this extended period.

How measurement tools assess recovery has been influenced by the interests of the authors. Tools generated by authors interested in modern ambulatory surgery focus principally on patients' recovery at 24 h [5, 6] and up to seven postoperative days [7–9]. Authors interested in recovery after major surgery have had to generate tools that reliably measure the same variables on many occasions up to three postoperative months that include measurements of cardiovascular status, pain and cognition [8, 12, 14].

Recovery assessment tools

The recovery of health and function means different things to different people. This may be because they have had different operations, but it may also be because different things constitute health and function, for instance for a sedentary octogenarian, a young athlete and a self-employed electrician with four children. Hence, recovery assessment tools differ in their derivation, validation, timing of administration and breadth of assessment. Tools validated for gauging postoperative recovery have been derived in non-surgical populations [7], or have been derived in other surgical populations [5, 6, 12, 15] or are new [8, 9, 11, 14, 16].

The 'general symptom distress scale/functional status questionnaire' (GSDS/FSQ) [7] was developed to assess non-surgical populations. It has been used to assess peri-operative patient distress and the resumption of activities of daily living, despite its components having been validated for the domiciliary care of non-surgical patients (GSDS) [14] and patients with chronic illness (FSQ) [15]. Assessments that extend existing tools include the '24 h functional ability questionnaire' (24 h FAQ) [6], and the 40-item and 15-item 'quality of recovery scores' (QoR-40 [5], QoR-15 [12]). The 24 h FAQ was derived to assess the use of anaesthetic agents and other resources, but has been validated to assess satisfaction and recovery 24 h after ambulatory surgery, the realisation of pre-operative expectations, symptoms and activities of daily living. The QoR-40 and QoR-15 were derived from a patient quality of recovery score. They have been validated after inpatient and ambulatory surgery. They assess recovery in five dimensions 24 h after surgery (emotional state, physical comfort, psychological support, physical independence and pain).

Recovery assessment tools developed for postoperative patients include the 'post-anaesthesia short-term quality of life tool' (PASQOL) and the 'postdischarge surgical recovery scale' (PSR) [11]. The PASQOL is a 40-item questionnaire that assesses functional, physical and psychological domains. The PSR was designed to assess postoperative recovery in ambulatory anaesthesia. It addresses health status, activity, fatigue, ability to work and patient expectations once within 4 days of surgery.

Tools have been developed to detect small changes in each recovery domain to observe their changes with time and with interventions, including the 'functional recovery index' (FRI) [8], the 'surgical recovery index' (SRI) [12] and the 'postoperative quality of recovery score' (PQRS) [14]. The FRI assesses pain, social interaction, lower limb movement and physical activity at multiple time points over the first postoperative week. The SRI assesses overall pain, pain with common activities, overall health and daily activity over the first postoperative month. The 'surgical recovery scale' (SRS) [12], derived from a non-surgical population, has been validated to assess emotional and functional recovery at 3, 7, 30 and 60 postoperative days. The PQRS (the acronym now renamed as PostopQRS) was specifically developed to assess short and long-term recovery in multiple domains and at multiple time points. An additional benefit of the SRS, FRI and PostopQRS is that they assess patient recovery in relation to individual baseline performance, with the latter two also assessing individual patient, as well as group, recovery.

Assessing whether a patient has recovered

Recovery may be viewed and assessed as an endpoint or a process. Recovery may also be viewed as absolute or relative. Therefore, it is not necessarily obvious whether a patient has 'recovered' from their operation as the definition of 'recovered' can vary.

Scores for each recovery characteristic can be summated for an individual, the value of which is analysed as a continuous variable, either in reference to the individual's baseline – the 'change score' – or a population norm [5–9, 11, 12, 14–16]. The recovery of a cohort is quantified as their mean change score – the less the change, the better the recovery. An individual's change score may be compared with the cohort's mean change score, or it may be compared with an historical control or tested against a pre-determined value defining a recovery endpoint (Fig. 1).

The summation of different variables into a composite recovery score suffers from the generic problems faced by any composite score. For instance, different recovery characteristics are treated as mathematically equivalent, with the resolution of nausea being considered as important as the recovery of cognitive function. Composite scores are dominated by the most common component, symptom or dysfunction, and may be unduly biased by patients with extremes of recovery, i.e. patients who remain incapacitated, or those who recover completely and rapidly [17]. Recovery can be categorised as complete once a threshold composite value has been exceeded. However, threshold values lose much of the information contained within the scores, as all values above the threshold are considered equivalent, as are all values below the threshold. Threshold values that are validated in some way in one population might be invalid in another population.

Using thresholds to define recovery

A threshold implies that a patient has recovered if their postoperative score matches or exceeds a pre-deter-

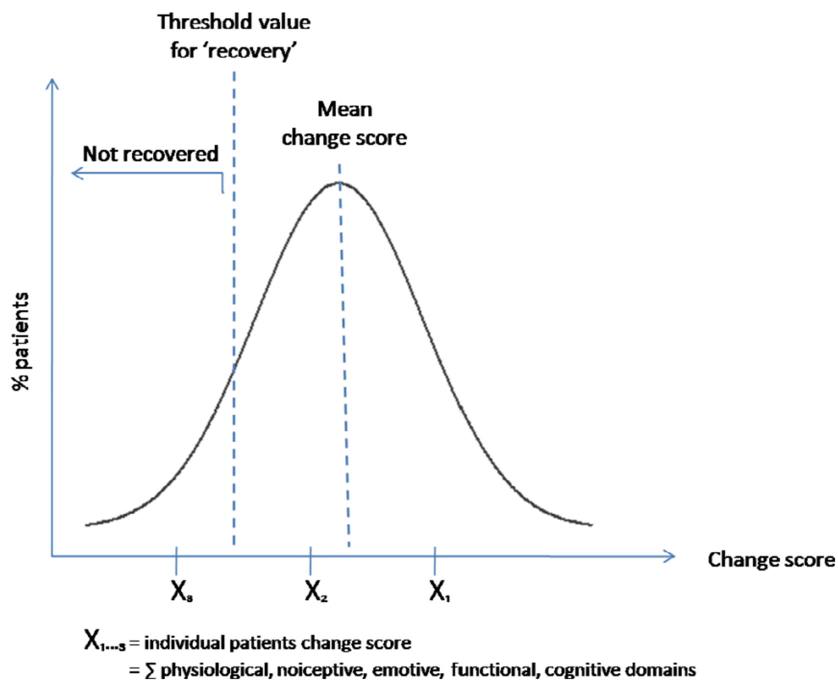

Figure 1 Recovery may be assessed as a continuous variable (change from the pre-operative norm), or as an outcome that is or is not achieved (threshold value). Patient X_1 is considered 'recovered', patient X_3 has not recovered and patient X_2 might be considered to have recovered based upon the threshold value, but has not recovered as well as the mean change score for the cohort.

mined threshold, ideally their pre-operative value. The proportion of patients in each group whose composite or domain-specific recovery reaches their individual thresholds can be compared, allowing one to distinguish which recovery characteristics are responsible for differences between groups. Recovery can be assessed globally or in more detail (Fig. 2): complete recovery; domain-specific recovery; recovery of characteristics within each domain, such as needing help to eat in the domain 'activities of daily living'; and the severity of the problem indicated by the number of characteristics within each domain that have not recovered.

Recovery thresholds are invalid if their use loses important information [18]. However, clinical decisions are always based around thresholds, below which one course of action is followed and above which a different course of action is followed. While underlying processes of recovery may progress along a continuum, clinical decisions and their outcomes are binary – 'has this patient recovered adequate physical and gastrointestinal function to be safely discharged' (institutional focus) or 'has this patient the cognitive function to read the newspaper' (patient focus)? Recovery thresholds can reveal important clinical effects for individual patients that are not immediately apparent when comparing differences in change scores. Similarly, the mean change score for a cohort may be statistically significant but may or may not represent a clinically relevant change; when recovery is defined using a clinically important threshold a difference in the rate of recovery is clearly important.

Perhaps the best solution is to determine whether the process of recovery has progressed beyond an acceptable threshold (dichotomous analysis) and then to determine how much beyond the minimum threshold recovery has progressed (continuous analysis). Retention of continuous measures of recovery allows one to recalibrate the definition of recovery, as the same dataset can be dichotomised multiple times using different threshold values.

Objective vs subjective testing

Subjective assessment is limited by impaired postoperative patient insight, cognition or satisfaction [5, 13, 19, 20]. Self-reported deficits and dysfunction correlate poorly with objective neurological function [21–23], as do satisfaction and professional competence [24]. Dysfunction becomes familiar with time and can become accepted. Patients can recalibrate what it means to be recovered, can reassign the importance of different aspects of recovery and can change their concepts of what it means to be recovered [25]. Patients might not recover from curative surgery if they experience mild but persistent pain, whereas the same patient might consider themselves recovered if they have less pain when the operation was palliative. Nevertheless, recovery is in the eye of the patient, as is the degree of residual dysfunction, so the subjectivity of assessments does not make them subordinate to objective measures, as long as the patient acts as their own perioperative control.

The future of recovery – active assessment and immediate treatment

The typical recovery trajectory is characterised by an initial abrupt decline in function, followed by progressive resolution towards the original state or a new equilibrium [1, 26]. The assessment of recovery as it happens depends on automated data analysis, so that clinicians are alerted immediately to patients whose

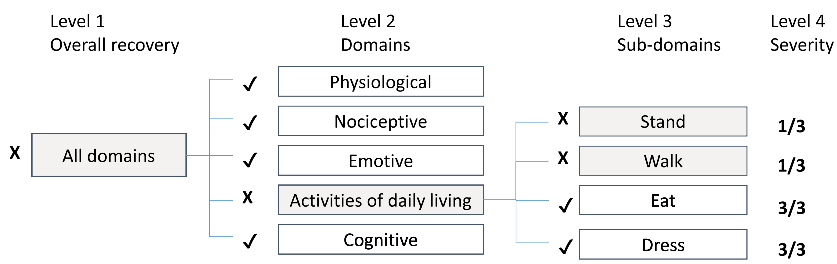

Figure 2 Using thresholds to define recovery at different levels of detail. In this example, the patient has not recovered (level 1) due to failure to recover activities of daily living (ADL, level 2), which in turn was due to failures to stand and walk (level 3), quantified in level 4.

recovery trajectory fails. Patients with acceptable recovery trajectories receive fast-track care and do not unnecessarily consume resources they do not need. Traditional research into recovery has been retrospective, so that interventions to improve recovery can only be applied to a later population, not the patients who were under study. Real-time recovery can be used for research: an individual's postoperative deviation from the desired trajectory is identified, the patient is treated, the 'effect' is analysed, the treatment might be modified, the modification is given to the next patient who needs treatment, and so on [27]. It is analogous to dosing research that uses an 'up-down' methodology, with the next patient's dose being adjusted in the light of the effect of the dose given to the previous patient.

Real-time recovery assumes the principle that rapid correction of pathology prevents harm. This principle has been proven for ST-elevation myocardial infarction, for which mortality is halved by early detection and rapid intervention [28, 29]. Other examples proving the benefit of early intervention are head injury [30] and trauma, whether intra-abdominal [27], thoracic [31] or general [32]. Pre-operative risk stratification can identify patients' risks of postoperative death, functional decline and reduced life-expectancy [33–36]. The personalised postoperative care that real-time recovery can realise can therefore anticipate which patients might most benefit from timely intervention, even before they deteriorate, by taking note of pre-operative risk stratification and intra-operative events.

Interventions should be targeted to whichever aspect of recovery has failed in a particular patient, which is often best served by domain-specific dichotomous measures of recovery, rather than a composite score. Failure in one domain is often accompanied by failure in another domain. For instance, a patient may fail to recover cognitively because they have been in pain and subsequently received opioid analgesia.

Cognitive function

Cognition is potentially permanently worse after surgery, particularly in older patients [37–40]. Postoperative cognitive impairment includes acute delirium and cognitive dysfunction, both of which compare patient performance to population norms. In contrast, 'cognitive recovery' compares patient performance to their own pre-operative baseline. Cognitive and non-cognitive recovery are associated with one another [41, 42]. Both short- and long-term cognitive impairment are also associated with long-term mortality. For instance, cognitive dysfunction at discharge is associated with mortality three months later and cognitive dysfunction at three months is associated with mortality nine months later [43]. The older the patient, the more persistent the cognitive impairment. Cognitive recovery should be assessed ideally at multiple postoperative time points, to help both prognostication and treatment.

Conclusions

The assessment of postoperative recovery has developed from a single measurement at a single point in time to measurements of many variables at multiple time points. More recent assessment tools aim to target the right patients at the right time by detecting specific deficits in their recovery trajectories, whether due to pain, cognitive dysfunction, physical dysfunction or some other characteristic. A promising development is the automated detection and immediate treatment of individual recovery trajectories that deviate outside pre-determined safe limits.

Competing interests

CR is the Chair of the 'postoperative recovery scale' scientific committee. No other competing interests declared.

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