Surgical Research Review

What does it really mean to "recover" from an operation?

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MANY NEW OPERATIVE TECHNIQUES AND INNOVATIONS are hypothesized to improve recovery. Much of the effectiveness data of these innovations, however, have focused all too often on audit measures, such as duration of hospital stay, morbidity, and mortality, or biologic or physiologic parameters, such as gut or pulmonary function. Audit outcomes are, at best, proxy measures of recovery, because duration of stay may be affected by external elements such socioeconomic, cultural, and institutional factors[1]; moreover, complications and mortality are relatively uncommon and often measured inconsistently.[2] These measures are of greatest interest to clinicians, but patients, ie, those who are actually "recovering," equate recovery to the absence of symptoms and the return of their ability to perform activities as they could before their operative treatment.[3] Biologic and physiologic outcomes are incomplete measures of recovery because they are unlikely to persist beyond the short term or may be confounded between disease-specific symptoms and those related to the operation and its potential complications.

Therefore, there is a need for a shift in the emphasis of outcome reporting from these audit measures to longer-term patient- and recovery-centric measures. The problem is that there is no consistent definition for postoperative recovery. Recovery may have different meanings for different stakeholders, such as administrators, doctors, nurses, and patients. This lack of a consistent definition is further complicated by the fact that postoperative recovery is a complex construct that encompasses multiple domains and timeframes. To be able to quantitate postoperative recovery using reliable and valid measures, the construct of recovery must first be well defined. Therefore, the purpose of this short research review is to introduce the reader to the concepts that are important to the construct of postoperative recovery and to identify areas where future research should be focused.

WHAT DOES POSTOPERATIVE RECOVERY MEAN?

Postoperative recovery is a complex and multidimensional process that involves multiple domains, including physical, physiologic, psychologic, social, and economic aspects. A comprehensive definition of recovery after surgery has been described by Allvin et al,[4] who identified the five defining attributes of recovery after surgery as: (1) an energy-requiring process; (2) a return to a state of normality and wholeness defined by comparative standards; (3) regaining control over physical, psychologic, social, and habitual functions; (4) returning to preoperative levels of independency/dependency in activities of daily living; and (5) regaining one's optimum level of well-being.[4]

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These definitions are not new. In 1958, Dr. Francis D. Moore, a giant of 20th-century surgery, wrote that convalescence or recovery includes "all the interlocking physical, chemical, metabolic, and psychological factors commencing with injury, or even slightly before the injury, and terminating only when the individual has return to normal physical well-being, social and economic usefulness, and psychological habitus."[5] He also wrote that "since convalescence must be said to terminate somewhere, we have chosen the criteria of the social and economic rehabilitation of an individual, that is, that he is psychologically and physiologically restored to full effectiveness."

These definitions emphasize the multidimensional aspect of "recovery." Assessment of any one dimension while ignoring the remainder will not fully capture the whole construct of recovery. For example, consider a physically active patient who undergoes an uncomplicated elective colectomy for cancer. At the 3-week postoperative visit, the patient reports no major physical symptoms, but is unable to resume normal sporting activities or work because of fatigue, which negatively affects the patient's psychologic, social, and economic domains. In this case, focusing only on the physical domain and ignoring the other domains will incorrectly describe this patient as "recovered" from surgery. The natural trajectory of recovery is also implicit in these definitions; recovery can be described a rapid decrease in functioning in all relevant domains immediately postsurgery and persistence in this postoperative state during the deterioration period, which will gradually "recover" or exceed the baseline value over the rehabilitation period (Fig 1).

In truth, there is no single definition of recovery, nor does there need to be. There are overlapping phases of recovery that are of interest to different stakeholders, and subsequently the outcomes of relevance may vary depending on the phase. It is important that researchers report the timeframe or phase of recovery of interest. Table provides a division of recovery into three distinct phases: early, intermediate, and late; each phase has its relevant outcomes of interests along with examples of validated generic instruments.[6-11] For example, anesthesiologists often refer to recovery as the time required for patients to sufficiently recover from anesthesia enabling discharge from the postanesthesia care unit to the surgical ward (early phase). Outcomes of interest during this phase of recovery generally are focused on biologic or physiologic processes. The intermediate phase of recovery occurs from the time after transfer to the surgical ward until discharge home. Traditionally, this phase has been the most relevant to clinicians. Outcomes of interest in this phase tend to be concentrated on symptoms and impairments in the ability to perform activities of daily living, and audit measures such as duration of hospital stay and morbidity. There is also a growing number of researchers investigating novel metabolic markers of recovery within the intermediate phase, such as insulin resistance,[12] immuno-modulators,[13] and other neuroendocrine markers,[14] among others.

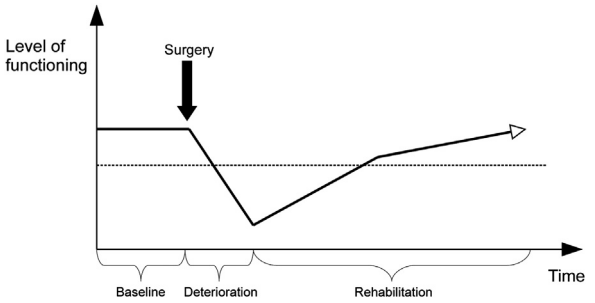

Fig 1. Expected trajectory of recovery. The *dotted line* represents the minimum level of functioning.

Finally, the late phase of recovery occurs from the time the patient is discharged from the hospital until the resumption of usual function or activities. In this phase, the relevant outcomes for recovery include functional status and health-related quality of life (QOL). The late phase often lasts much longer than expected by clinicians. Lawrence et al[15] studied 372 patients ages 60 years and older after a major elective abdominal operation by measuring physical ability, functional capacity, and cognitive function. At 6 months after surgery, fewer than 50% of patients had recovered to baseline levels of physical performance (handgrip strength, timed walk), and even more surprisingly, fewer than 20% of patients were able to perform the same activities of daily living as they had before surgery. Similarly, Mayo et al[16] reported that less than 60% of patients had returned to baseline walking capacity at 3 months after elective colorectal operation. Even after ambulatory laparoscopic cholecystectomy, more than 50% of patients had not yet reached baseline levels of physical activity by one-month after surgery.[6]

REFINING THE DEFINITON OF A RECOVERY MEASURE

Carli and Mayo[17] developed a causal pathway to evaluate the appropriateness of measures of operative outcomes (Fig 2). In this model, any short- or long-term outcome measure must be biologically

Table. Stages of recovery

Phase of recovery	*Definition*	*Time frame*	*Threshold*	*Outcomes*	*Examples of existing instruments*
Early	From OR to discharge from PACU	Hours	Safety (sufficiently recovered form anesthesia and safe to go to floor)	Physiologic and biologic	Aldrete Postanesthetic Recovery Score[9]
Intermediate	From PACU to discharge from hospital	Days	Self-care (able to care for self at home)	Symptoms and impairment in ADL	Quality of Recovery score[10] Abdominal Surgery Impact scale[8]
Late	From hospital discharge to return to usual function and activities	Weeks to months	Return to normal (baseline or population norms)	Function and health-related quality of life	Six-minute walk test[7] Community Health Activities Model Program for Seniors (CHAMPS)[6] Short Form-6D[11]

ADL, Activities of daily living; *OR*, operating room; *PACU*, postanesthesia care unit.

related to the intervention and should not be influenced by external factors. These outcomes must also be related to the short-term changes that occur after the operation. We have adopted this causal pathway in an attempt to develop a conceptual model for the construct of postoperative recovery. In addition to the obligatory relationships with the intervention and the short-term postoperative changes, any outcome measure of recovery must also assess the domains relevant to recovery, namely those elucidated by Moore[5] (physical, psychologic, social, and economic) and must correlate with the ability to perform activities of daily living.[4] Furthermore, this measure must be comparative to a baseline or population norm[4] and follow the expected trajectory of recovery, that is, a rapid decline from baseline ("deterioration"), followed by gradual improvement back to baseline or beyond ("rehabilitation"). The time frame has also been modified to reflect the phases of recovery described previously (Table).

Early recovery from anesthesia allowing transfer out of the recovery room is best measured through biologic and physiologic parameters. The intermediate phase that occurs before the patient is discharged from hospital is best described with symptoms, such as gastrointestinal function, pain, and nausea, as well as mobility and the ability to perform basic activities of daily living, because these are criteria that assess the ability to be safely discharged. Long-term recovery or the late phase that occurs in the weeks and months after discharge from hospital is best estimated with measures of functional status and health-related QOL because these measures have been shown to remain impaired in the postoperative period and take the greatest time to recover.[15]

In addition, functional capacity measures, such as the 6-minute walk, shuttle, and timed up and go tests, correlate well with the ability to perform activities of daily living, physical and mental health-related QOL, and the ability to perform activities of daily living.[18] The 6-minute walk test has also been validated specifically in the context of postoperative recovery.[7] In addition to measures of functional capacity, physical activity can be estimated through the administration of validated questionnaires.[19]

The ideal time point at which to perform the assessment is also clearly dependent on the research question and the course of the disease or intervention under investigation. For example, QOL after cholecystectomy remained poor at 1 month after surgery,[6] but was improved compared to baseline by 3 months.[20] Timing is also dependent on the type of measure, as reported by Lawrence et al,[15] who found that after major abdominal surgery in the elderly, functional and physical capacity measures remained significantly below baseline at 6 weeks, but by 6 months had mostly recovered back to baseline values, whereas QOL had mostly improved by 6 weeks.

Currently, there is no single instrument that evaluates both functional capacity and all of the relevant domains of postoperative recovery. Kluivers et al[21] performed a systematic review on existing specific instruments to measure recovery

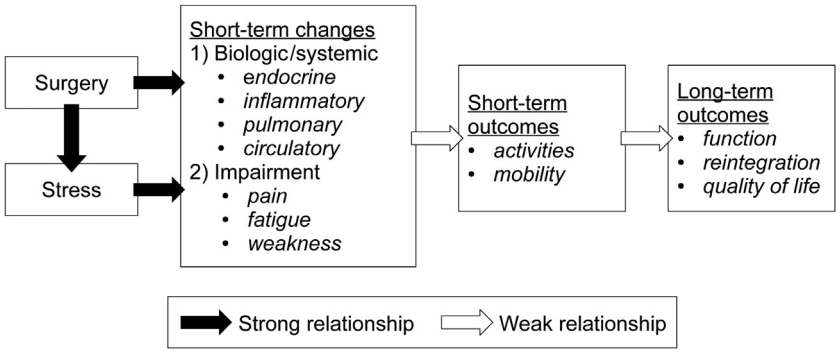

Fig 2. Causal model for measuring outcomes after surgery proposed by Carli and Mayo.[12]

and found that none of the 12 identified instruments was fully validated for the construct of postoperative recovery. For example, QOL instruments have failed to demonstrate a difference in both short- and long-term QOL after laparoscopic compared to open colectomy,[22] despite the assumption of a "faster recovery" for the laparoscopic approach. These results suggest that either laparoscopy confers no benefits or perhaps the QOL instruments that were used do not adequately measure the construct of recovery. In addition, QOL is affected by external factors[23] and may also experience response shift,[24] which makes their interpretation difficult.

Therefore, it is important to use instruments that have validity evidence to measure the construct of recovery from operation. Several instruments, such as the Surgical Recovery Score[25] and the Abdominal Surgery Impact Score,[8] have been specifically developed in this context but have preliminary validity evidence. It is unknown whether these instruments are sensitive enough to detect subtle differences, such as between laparoscopy versus open, or traditional compared with enhanced recovery perioperative management.

Until a single, comprehensive instrument is developed, the best approach may be to use a combination of complementary instruments to account for all of the suggested criteria. In a study investigating recovery after laparoscopic donor nephrectomy, Bergman et al[26] used a combination of the 6-minute walk test, which measured functional exercise capacity, visual analog scales for symptoms such as pain, and the Short-Form (SF)-36, which measured mental and physical health-related QOL in an attempt to more objectively describe the recovery profile.

This stopgap approach has definite limitations because few instruments have been specifically validated in the context of postoperative recovery. This approach also runs the risk of over-burdening patients and may decrease compliance to prospective study protocols, especially if multiple instruments that are used overlap and repeatedly measure similar aspects or domains; patient compliance will prove to be problematic. Furthermore, the ability to design studies to investigate interventions that are hypothesized to improve recovery is limited if the clinically relevant changes for each instrument are not known.

IMPLICATIONS FOR FUTURE RESEARCH

Therefore, future research on postoperative recovery should first focus on identifying all instruments that are currently used to measure recovery and determine their validity for the context of recovery within specific populations of operative patients. To date, the choice of instruments appears somewhat arbitrary. Although generic instruments such as the SF-36 have been validated across a wide spectrum of diseases, its psychometric properties have yet to be investigated for many specific surgical populations. Yet, the SF-36 continues to be one of the most commonly used instruments despite the fact that it may not be sensitive enough to detect changes between operative patients (for example, between laparoscopic and open colectomy).[22]

It will be essential to determine whether these instruments are specifically validated for the patient population and setting in which they are used because often validity information based on patients with other diagnoses are juxtaposed onto the new setting under study.[27] It also will be important to determine the clinically relevant changes for these instruments so that future studies may be adequately powered to detect meaningful changes. Clinically relevant change refers to the minimal change in a measure that is considered meaningful, which can be from the point-of-view of the patient or related to another outcome.

Sample size calculations for "hard outcomes" in randomized studies are heavily scrutinized to ensure that studies are adequately powered to detect a relevant change; however, there are no data that report the relevant changes for existing measures of recovery. Elucidation of the clinically relevant changes in recovery measures will provide data to perform the adequate power calculations for studies investigating interventions hypothesized to improve recovery.

For instances in which no valid measure of recovery exists, a valid patient-reported measure should be developed that satisfies the definition and trajectory and takes into account multiple stakeholders. An ideal measure of recovery needs to be phase-specific (Table), multidimensional, responsive to the expected trajectory of recovery (Fig 1), and able to discriminate between other important outcomes of interest (for example patients with and without complications). We recommend the use of modern psychometric methods, such as item-response theory or Rasch measurement theory, to develop, calibrate, and validate an item bank from existing instruments that capture the key health aspects of recovery.[28] Traditional psychometric methods of instrument development often result in a collection of items that are scored on an ordinal scale (for example a 5-point Likert scale: 1 "strongly disagree" to 5 "strongly agree") that are weighted to form a total score; however, this approach has several limitations in that the assumption of "equal differences" between ordinal levels may not hold true. For example, consider the example of another ordinal scale such as cancer staging (graded from I to IV), one does not assume that the difference between stages I and II is the same as the difference between stages III and IV, yet this assumption, which is mathematically incorrect, is made for many of these instruments.[29]

Also, administration of the entire instrument is required because these instruments are based on a total score, which, given the length of time needed to fill out many of these instruments, may limit their practicality.[30] In contrast, both item-response and Rasch measurement theories estimate the degree to which items related to an underlying construct hierarchically fit on a unidimensional, linear continuum (in this case, the trajectory of recovery). Therefore, patients may be situated along a calibrated linear continuum using fewer items, thereby improving validity and ease of administration. Nevertheless, this approach still requires that the resulting instrument be validated for its intended population and setting.

Another potential roadblock is the confounding between changes related to the operation and those related to the disease. For example, a visual analog scale to assess pain may not be an entirely useful instrument to measure recovery after surgery to address symptoms of pain because how does one specifically measure improvement in pain due to the surgery and differentiate it from the pain from the surgery itself? Also, recovery after oncologic surgery is further complicated by potential changes due to adjuvant therapy. Therefore, we recommend that initial validation of a measure of recovery be performed in a population of asymptomatic or healthy patients undergoing elective surgery, such as laparoscopic donor nephrectomy or colonic resection of asymptomatic polyps found on routine colonoscopic screening. With this method, there should be minimal confounding between surgery-related and disease-related changes given the asymptomatic baseline. Subsequent validation along with the determination of the specific clinically relevant change in other patient cohorts should then be performed.

Finally, we also recommend that future studies be specific as to which part of the continuum of recovery is under study (Table). The exact measures of interest will differ depending on the type of surgery and population under study, but this framework may improve comparability between studies if the timeline of recovery can be standardized.

In summary, "recovery" after surgery is an important outcome that is often measured inaccurately and inconsistently because of the lack of a clear definition. We have divided recovery into three distinct phases along with their relevant outcomes of interests. Furthermore, we argue that the recovery construct should be a patient-centric model that is multidimensional and must include the physical, psychologic, social, and economic domains; should have a comparative standard (either through baseline or population norms); and should conform to the expected trajectory of immediate deterioration, followed by rehabilitation. Any instrument used to measure postoperative recovery must also be related to the intervention or disease process and the immediate postoperative changes, and should be evaluated at time points relevant to the disease or intervention in question. Finally, we propose a research agenda to guide future efforts in this field. An instrument that is fully validated for this construct will be of immense utility as an outcome measure of recovery after surgery.

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