Postoperative Recovery and Rehabilitation

28

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Contents

Abstract

Surgical recovery is a concept which has traditionally been poorly defined and poorly measured. The expectations of elderly patients with regards to their postoperative outcomes, including what they consider a success, may be very different when compared to the expectations of their younger counterparts or of their surgeons. In this chapter, the authors review the impact of surgery on a patient's functional status, on how they report their symptoms, and how they perceive their health and their quality of life. Important risk factors for a prolonged recovery, such as complications, malnutrition, and frailty, are described. Finally, strategies for optimizing recovery are discussed, starting with the preoperative period (comprehensive geriatric assessment, pre-habilitation), followed with hospitalization (enhanced recovery pathways, multidisciplinary intervention

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teams and programs), and finally with rehabilitation in the postoperative period.

Clinical Vignette

The surgery was a success, but. . .

Mrs. K is an 87-year-old woman who undergoes a laparoscopic anterior resection for sigmoid colon carcinoma. The surgery is uneventful, and she does quite well postoperatively "for someone her age." Her urinary catheter is kept in for 2 days because of a low urine output, which eventually resolves following several fluid boluses. During this time, she has become confused and uncooperative, most likely due to some degree of delirium. Consequently, she does not start ambulating until the fourth postoperative day when she is helped out of bed by a physiotherapist. She is eventually discharged home 8 days after surgery. She returns to the emergency department 4 days after discharge, when her niece reports that the patient has fallen, has difficulty feeding herself, and is generally too weak to manage on her own. The patient is readmitted until a bed is available in a specialized nursing care facility, where she "recovers" for 3 weeks, before returning home. Six months later, during a visit to her family doctor, the patient reports that she is still too weak to go to the shopping mall, to attend her usual weekly card games, or to travel to visit her family and friends.

Introduction

The satirical phrase "The surgery was successful, but the patient died" could well be rephrased to "The surgery was successful, but the patient was transferred to a specialized nursing care facility, became dependent, and never fully returned to his or her previous way of living." There is no doubt that, regardless of age, when discussing the success of a surgical procedure, traditional outcomes such as complications, length of stay, and mortality are now complemented by what some might call patient-centered or patient-reported outcomes, such as quality of life, functional status, and return to professional or social activities, to name a few. It is increasingly clear that these types of outcomes, which have a medium- to long-term impact, are of particular importance to elderly patients, a patient population that generally has very different goals and expectations when it comes to surgical recovery.

In the vignette above, the surgeon may have been quite satisfied with an uneventful surgery, with seemingly good oncological outcomes, and a patient discharged home in a very acceptable time frame. The patient, on the other hand, may have seen things in quite a different light. This is well illustrated by a study by Terri Fried et al. in which over 226 elderly patients with a severe medical illness (cancer, chronic heart failure, or chronic obstructive pulmonary disease) were asked how likely they would be to undergo a life-saving procedure if this procedure resulted in cognitive or functional impairment. As the risk of dependency increased, fewer patients chose the procedure. In fact, if the outcome was survival associated with functional impairment, 74% of patients chose death. As many as 89% of patients refused the life-saving procedure when the outcome was survival with severe cognitive impairment [1]. In a study of elderly patients considering orthopedic surgery, a list of all potential concerns was established in semi-structured patient interviews. 155 out of 164 concerns (70%) had to do with anticipating postoperative quality of life (mainly with respect to perceived threats to physical and social well-being) and their capacity to cope with surgery and the postoperative recovery. Perhaps not surprisingly, only a little over 50% of these concerns were addressed with the surgeon [2]. Considering the fact that 80% of studies in gastrointestinal surgery only report morbidity and mortality [3], it seems clear that there remains a significant disconnect between traditional surgical goals and the treatment preferences and expectations of functional preservation that are valued by elderly patients [4].

Understanding what can be expected after surgery following hospitalization is important to the

surgeon when he or she counsels the patients regarding perioperative outcomes. For patients and their caregivers, only with a true understanding of recovery is it possible to make a judgment on how the benefits of the procedure measure up to the risks. It allows them to align their expectations with realistic goals and to plan accordingly. A better understanding of recovery may be useful information for the surgeon or primary care physician in understanding when a patient has fallen off the normal recovery curve and at what point that deviation from normal may indicate the need for further investigations. In addition, from a professional development or physician-centered point of view, surgeons would likely benefit from recognizing and integrating the importance of longer-term functional outcomes in the context of personal practice audits, of measuring intervention effectiveness, or even in comparing new procedures or approaches. Finally, notwithstanding the impact on the patient and on the caregivers, loss of independence after surgery is independently associated with healthcare costs [5].

In general, surgeons understand recovery to be the period of time following surgery during which patients return to or exceed their preoperative state. But because it is such a complex, multimodal concept that can be measured and interpreted in many different ways, there does not exist a uniformly accepted definition. Perhaps the best definition of recovery is that suggested by the surgical pioneer, Dr. Francis Moore, who, in 1958, wrote that recovery was "the interlocking physical, chemical, metabolic, and psychological factor commencing with the injury, and terminating only when the individual has returned to normal physical well-being, social, and economic usefulness, and psychological habitus." [6]

The outcomes used to describe recovery can be categorized using a pre-defined framework, the Wilson-Cleary model [7], which captures the elements of Moore's definition. It establishes a relationship between clinical interventions, biological and physiological impairment, and the resulting effects on four health status domains: symptom status, functional status, general health perception, and quality of life [8, 9]. This model underlines the shift in modern therapeutic goals from improving physiological impairment and survival to improving patient function and well-being [10, 11].

Table 1 Definition of health status domains and validated measures of recovery

Functional status: ***Ability to perform physical or cognitive tasks***
Katz index [12]
Abbreviated mental test [13]
Mini- Mental Status Exam [14]
Short physical performance battery [15]
Handgrip strength and gait speed [16]
Symptoms status: ***Perception of an abnormal feeling in the patient's body***
Visual analogue pain scale [17, 18]
Verbal descriptive pain scale [18]
General health perceptions: ***Subjective assessment of how patients view their overall health***
Geriatric Depression Scale [19]
Quality of life: ***Defined by Emerson as the "satisfaction of an individual's values, goals, and needs through the actualization of their abilities or lifestyle"*** [20]
Short Form 36 [21]

Definitions of the health domains and examples of measures of recovery which have been validated for use in elderly patients are found in Table 1. The following discussion focuses on the general outcomes of surgical recovery, as opposed to procedure-specific outcomes, such as limb function after orthopedic surgery or exercise capacity after cardiac surgery, for example, which are outside the scope of this chapter.

Functional Status

The idea of a return to preoperative functional status is central to the majority of surgical recovery studies. It is of particular clinical importance, being one of the health domains, that takes longest to return to baseline [22]. Examples of outcomes assessing functional status include the ability to perform basic physical activities independently or to perform a cognitive task. In this patient population, the most commonly used clinical tools to assess physical function and dependency are the activities of daily living

Table 2 Activities of daily living and instrumental activities of daily living

Activities of daily living	Instrumental activities of daily living
Feeding	Using the telephone
Continence	Shopping
Transferring	Preparing food
Toileting	Housekeeping
Dressing	Doing laundry
Bathing	Using transportation
	Handling medication
	Handling finances

(ADL) and instrumental activities of daily living (IADL), which are described in Table 2. Although some authors have shown that elderly patients can recover completely at 3 months following surgery [23], this seems to be the exception rather than the rule. In the general elderly surgical population, there is a persistent impairment in ADL in less than 10% of patients at 6 months [22, 24]. However, in the more vulnerable geriatric patients, such as those above the age of 80, there is 58% dependency in an equivalent time frame [25]. Similarly, a population-based study by Finlayson et al. of 6822 nursing home patients undergoing colon surgery for cancer demonstrated functional decline in 42% of patients at 3 months, 28% at 6 months, and 24% at 12 months [26]. Furthermore, there is considerable dependency in IADL noted in 19% of geriatric patients at 6 months following major abdominal surgery [22]. In elderly critically ill patients, most of which had undergone surgery, at a median follow-up of 21 months, 13% had increased their dependency, and an additional 4% had become completely dependent [27]. When using objective physical performance measures, such as timed walk, functional reach, and hand grip strength, as many as 58% of patients had not return to baseline after 6 months [22]. Such studies raise the important question of whether, in patients who have not yet returned to baseline at 6 months, 12 months, or 24 months, recovery is still actively progressing or whether it has reached a plateau and permanent disability has led to a new baseline state.

From a cognitive standpoint, there is a significant incidence of postoperative delirium, which varies between 5% and 40%, depending on the type of surgery. By definition, this is usually transient in nature and limited to the hospitalization period [28, 29]. In general, based on older studies, it was thought that approximately 8–10% of patients undergoing non-cardiac surgery suffered from cognitive dysfunction, detectable as early as 3–6 months after surgery and possibly persisting for several years [30, 31]. Postoperative cognitive dysfunction has been poorly defined and its etiology is unclear. It may simply represent a preexisting chronic state uncovered by the acute stress of surgery. More recent studies have reported an improvement in MMSE scores at 3–6 months, when compared to preoperative values, possibly related to the overall improvement in patients' medical status following surgery [22]. The data on this important topic are too conflictual and vague to effectively synthesize in order to properly counsel patients with regards to long-term cognitive risk. In general terms, it seems fair to say that, for the vast majority of patients, cognitive functional status seems to be preserved following surgery.

Symptoms Status

Symptoms are usually reported by the patient, and protracted symptoms represent the expression of the patient's underlying ill-being. These symptoms may include the perception of heightened pain, fatigue, or nausea. Generally, unless complications occur, resolution of pain or nausea following surgery will occur within days to weeks, sometimes even during hospitalization. The symptom which seems to persist for weeks or months is a patient's fatigue, even following relatively minor procedures. In several studies of elderly patients undergoing colorectal surgery, fatigue persisted for at least 1 month [23, 32, 33].

General Health Perception

The subjective perception of fatigue, pain, and depressive symptoms have been found to be important factors to acknowledge in elderly

patients undergoing surgery. In a study by Zalon et al., it was found that patients perceived to be 33% recovered at 1 month and 92% at 3 months [34]. They found that depression, along with symptoms of pain and fatigue, also improved, but persisted past 3 months. These symptoms contributed significantly to the patients' perception of their own health.

Quality of Life

Quality of life is highly correlated with the health domains describe above, with the addition of the concept of patient satisfaction. Although it seems intuitive that surgery would have an undeniable impact on quality of life, it seems to be minimal, usually with a mild attenuation in the first several weeks after surgery and a return to baseline within 3–6 months [24, 35]. This may be more related to the physical component of the quality of life construct, as the mental component does not seem to be affected negatively by surgery or by critical illness [27, 35]. In fact, some studies have shown that the mental component score of the Short Form 36 quality of life questionnaire may sometimes even surpass baseline scores [36, 37], which is a phenomenon that has also been described in a younger patient population. It is postulated that perhaps, beyond the physical manifestations of the recovery process, the satisfaction of having gone through the procedure, having survived, returned home and begun a life free of the morbidity that prompted the surgery, is enough to improve the patient's overall condition.

For any given outcome, a patient can be imagined to progress along the hypothesized recovery trajectory developed by Feldman et al. [10] and reproduced in Fig. 1. The patient starts at their baseline or preoperative state. When surgery occurs, the surgical trauma and resultant hospitalization begin the deterioration phase, in which the curve of the outcome in question slopes down. This usually takes place during hospitalization. Eventually, usually as the patient returns home and starts reintegrating their pre-procedural life, the rehabilitation phase begins. This can last anywhere between a few weeks and several months. As suggested by Moore, recovery ends when the patient has returned or exceeded their preoperative state [6]. In this figure, the dotted line represents the minimum level of functioning. Protracted recovery can occur when the baseline curve starts at a lower level than expected or is oriented downwards as might be the case in someone who becomes sedentary because of progressive leg pain while awaiting vascular surgery. Conversely, a patient on a pre-habilitation program may benefit from an upward baseline curve. Similarly, the deterioration curve may be steeper than expected in a patient who is not well mobilized after surgery. That same curve would be made less steep if a patient was recruited to an enhanced recovery pathway. Finally, the rehabilitation curve may be modified negatively by a patient with chronic pain after surgery

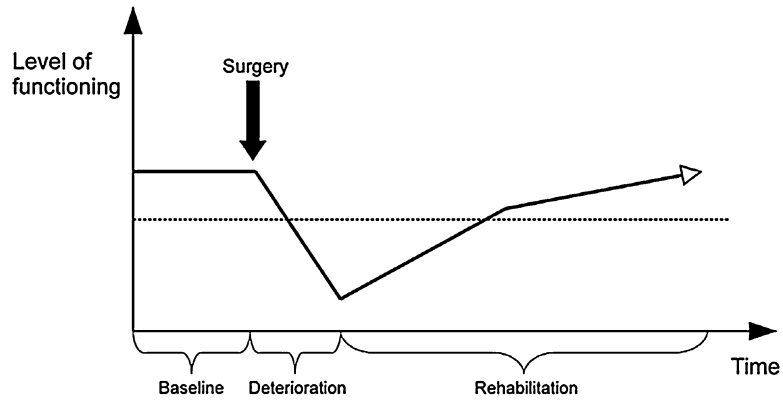

Fig. 1 The hypothesized trajectory of recovery [10]

or positively if undergoing rehabilitation after discharge. Some of the more important risk factors for protracted recovery as well as the strategies to optimize recovery are discussed below.

Risk Factors for Protracted Recovery

Postoperative complications have consistently been shown to be predictors of a slower recovery [26, 38]. This was described by Tahiri et al. who reported that the greater number and severity of complications increased the time to recovery in elderly patients undergoing abdominal surgery. Using the short physical performance battery, an objective measure of functional capacity, the deterioration curve was deeper for those with complications as compared to those without. 58% and 74% of patients who did not suffer postoperative complications had recovered at 1 and 6 months, respectively, compared to 34% and 58% of patients who had experienced complications [39]. In patients above the age of 80 undergoing colorectal procedures, one study found that elective surgeries were associated with a return to premorbid functional status in 83% of patients, whereas this number was as low in 53% of patients undergoing emergency colorectal surgery. This difference was mainly attributable to the higher number of complications in the emergency group. Finally, in a multivariate analysis, the development of postoperative complications was associated with an odd ratio of 24.5 of not returning to premorbid function, far surpassing in importance every other factor included in the analysis [40].

Malnutrition has been shown to be related to poorer traditional outcomes, but there is also good data to suggest that it has a significant impact on recovery of longer-term functional outcomes. This is of particular importance in elderly patients who are at greater risk of malnutrition [41]. Six months after major abdominal surgery, increased dependency in daily activities was seen in 80% of malnourished patients as opposed to 30% of those who were well nourished. [25] In a study of elderly hip fracture patients, Goisser et al. measured the daily oral intake of patients during postoperative hospitalization. Regardless of their preoperative functional status, patients who ate smaller amounts had significantly lower ADL scores up to 6 months after surgery, and a greater percentage of them had long-term mobility loss [42]. Bastow et al. demonstrated the potential impact of preoperative tube feeding in a randomized controlled of 744 women with femoral neck fractures, stratified in 3 groups according to the level of nutrition: well nourished, thin, and very thin. Independent mobility was achieved at postoperative days 10, 12, and 23 days, respectively, and postoperative tube feeding in the thin and very thin patients reduced the time to full recovery to 10 and 16 days, respectively [43]. Despite these data and although nutritional screening is recommended for all hospitalized, medical or surgical, and elderly patients, there is still debate as to whether or not early optimization with parenteral or enteral nutrition improves postoperative recovery [44].

Frailty is a multidimensional syndrome that reflects a state of decreased physiologic reserves and vulnerability to stressors [45]. Currently available risk scores capture only a snapshot of a patient's health status at the time of the preoperative evaluation, which is heavily focused on comorbidities [46, 47]. They fail to capture the multitude of subclinical impairments that progressively accumulate with age and that ultimately determine the patient's physiologic reserve, which will be called upon at the time of major stress, such as the perioperative period [48]. These subclinical impairments may be responsible for the heterogeneity that is seen in older patients and may be better measured by the clinical frailty phenotype: slowness, weakness, weight loss, low physical activity, exhaustion, cognitive impairment, and mood disturbance [49, 50]. However, frailty may also be characterized by an accumulation of deficits that can encompass diverse signs, symptoms, comorbidities, as well as disabilities [51–53]. In a prospective study of almost 600 elderly patients undergoing elective surgery, Makary et al. demonstrated that frail patients were significantly more likely to have a prolonged hospital stay, more complications, and more often

be discharged to skilled or assisted living facilities [54], findings corroborated by others [55]. Although these studies do not make a direct link between frailty and recovery, the higher incidence of complications and subsequent functional decline observed in this group serve as satisfying evidence that recovery is indeed impaired in frail individuals.

When the impact of poor baseline functional status is studied on its own, the data are more convincing and provide validation to the concept of pre-habilitation, which is discussed in the next section. Low preoperative physical function independently predicts slower recovery of ADL and IADL scores [22]. Finlayson et al. reported that in elderly patients undergoing surgery for colon cancer, preoperative functional decline was one of the most important predictors of postoperative functional decline [26]. A population-based study by Oresanya et al. paints a grim picture of the impact of baseline function. In a particularly functionally dependent population of over 10,000 nursing home patients with extensive vascular disease, 64% of patients experienced functional decline 1 year following lower extremity revascularization. At that time, among those that were ambulatory prior to surgery, 63% had become non-ambulatory or suffered a fatal event. Among those that were non-ambulatory at baseline, 89% had remained non-ambulatory or died. [56]

Strategies for Optimizing Recovery

Preoperative Care

Comprehensive Geriatric Assessment

The comprehensive geriatric assessment (CGA) is "a multidisciplinary diagnostic and treatment process that identifies medical, psychosocial, and functional capabilities of older adults to develop a coordinated plan to maximize overall health with aging." [57] In surgery, such a tool is useful for risk stratification, for preoperative optimization of modifiable risk factors, for informed decision-making, and for planning postoperative strategies and treatments to minimize age-specific complications. The domains that are evaluated by the CGA are summarized in Table 3 [58].

Table 3 Comprehensive geriatric assessment domains and tests [58]

Domain	Tests
Functional status	ADL and IADL Objective performance tests
Socioeconomic status	Income and housing Social support Transport
Comorbidities	Cumulative Index Rating Scale Revised Cardiac Risk Index
Cognitive Function	Mild cognitive impairment or dementia Depression and anxiety Risk of delirium
Nutritional Status	Mini nutritional assessment Nutritional global assessment Recent weight loss
Polypharmacy	Medication reconciliation
Geriatric syndromes	Frailty Incontinence Pressure ulcers Falls

There are few studies comparing CGA to regular care and even fewer looking at the long- to medium-term impact of this type of intervention. A recent systematic review by Partridge et al. showed that the use of the CGA in older persons scheduled to undergo elective surgery was associated with reductions in the number of cancelled surgeries and in length of hospital stay, with one study demonstrating fewer postoperative complications [59]. Despite there being no direct evidence of the CGA improving recovery, intuitively, identifying the factors that affect recovery, such as poor functional status, for example, and potentially modifying them to minimize their impact and avoiding complications, is a reasonable strategy to entertain in selected individuals.

Pre-habilitation

In the last decade, preoperative exercise therapy, or "pre-habilitation," has been investigated across several surgical fields, including general surgery, colorectal surgery, hepatobiliary surgery, orthopedic surgery, thoracic surgery, and gynecological surgery [60–71]. The goal is to

maintain or possibly enhance the physical functioning and capacity of an individual to withstand the physiological stressors associated with a surgical intervention, thereby improving the baseline segment of the recovery trajectory [72]. A randomized controlled trial comparing pre-habilitation to rehabilitation in patients undergoing colorectal surgery showed that a greater percentage of patients in the pre-habilitation group had recovered to their baseline exercise capacity levels at 8 weeks (84% vs. 62%) [64]. Similarly, pre-habilitation programs for elderly patients undergoing colorectal surgery were reported to be associated with better postoperative performances on the 6-min walk test when compared to controls [66]. Although there remains many questions with respect to patient selection, exercise program design, and overall compliance and effectiveness, pre-habilitation seems to be a very promising strategy for optimization of recovery.

Hospitalization

Enhanced Recovery Pathways

Enhanced recovery pathways are multimodal evidence-based protocols, which span the entirety of the surgical experience, from preoperative patient preparation and nutrition, to intraoperative fluid and pain management, to early postoperative feeding and mobilization. Significant benefits have been demonstrated when enhanced recovery pathways are successfully implemented, such as shorter length of stay and fewer complications [73–76]. Many believe that these strategies are becoming the gold standard of care in many areas of abdominal surgery [77], although there has been uptake in other surgical disciplines as well. Contrary to what the term enhanced recovery would suggest, the great majority of the literature on the topic is quite limited when it comes to demonstrating or even studying the impact of these pathways on mid- to long-term outcomes or patient-centered outcomes, such as return to preoperative functional status [11, 78]. Nevertheless, a small number of studies in patients of all ages would suggest that enhanced recovery pathways are associated with improved quality of life and a quicker return to baseline function [79–81].

It seems intuitive that elderly patients, with their greater vulnerability to surgical stressors and decreased physiologic reserve, would have more to gain from the improved quality of surgical care that comes with these pathways [82]. In the context of enhanced recovery pathways, an early landmark study published in 1995 had demonstrated that enhanced recovery pathways provided effective postoperative pain relief, thus enabling earlier mobilization, reducing length of stay, and avoiding functional impairment in elderly surgical patients [83]. Following this, though, very little has been reported with regard to the impact on enhanced recovery pathways on functional recovery in this population. The few studies that exist are limited to short-term, traditional outcomes, such as length of stay and morbidity [84].

Multidisciplinary Intervention Team

The goal of multidisciplinary intervention teams is to ensure that care is delivered according to best known practices across a variety of complementary fields, in particular geriatrics, nursing, social work, physiotherapy, and occupational therapy. The key to the success of such teams is having (i) a shared, as opposed to competing vision; (ii) coordinated planning of interventions; (iii) effective communication; (iv) the ability of all team members to understand the purpose of the other members; and (v) proper completion and follow-through of tasks [85]. Unfortunately, most models of geriatric care that broadly implemented comprehensive groups of best practice processes did so in medical, rather than surgical patient populations. In fact, in a recent systematic review of geriatric co-management systems for in-hospital patients, only one high-level surgical study was included. There were conflicting results with respect to functional status improvement, with some studies showing mainly short-term improvement over

standard care, while others showed no difference at all. [86] Several successful surgical programs are discussed below.

Hospital Elder Life Program (HELP)

The Hospital Elder Life Program consists of systematically putting into practice key processes to mitigate the effects of hospitalization in elderly patients, specifically functional decline, nutritional depletion, and delirium. Initially developed for a medical population, Chen et al. studied its impact on elderly patients undergoing a variety of abdominal surgical procedures. A single nurse carried out mobilization and rehabilitation, oral care and dietary education, and cognitive stimulation following surgery. The authors found that in the control group, 68% of patients who were pre-frail had transitioned to frailty, whereas in the HELP group, only 18% became frail, with another 18% actually becoming non-frail. Overall, at discharge, 19% of HELP group patients were frail as compared to 65% in the control group. This difference did not persist at 3 months, at which point 17–23% of patients were considered frail. [87] This intervention also reduces the rate of delirium from 15% to 7% and reduces length of hospital stay by 2 days [88]. The CareWell in Hospital program, based on HELP, reported more modest results in their mostly surgical patient population, in part because of the very variable adherence to the large number of processes that had been implemented during the study period [89].

Proactive Care of Older People Undergoing Surgery (POPS)

The POPS team consists of a geriatrician, a geriatric nurse, a physiotherapist, an occupational therapist, and a social worker. Eligible patients benefit from supervised care throughout the preoperative, hospitalization, and postoperative phases. This includes a CGA, planning of discharge needs; education on recovery, including counselling on physical activity, nutrition, and pain management; in-hospital assistance to the surgical team with mobilization; and prevention of population-specific complications, followed by postoperative ambulatory visits to address any outstanding or residual medical problems. POPS was studied in various surgical disciplines. In orthopedic surgery, the program demonstrated better pain control, less short-term dependency, and a shorter length of stay [90]. In elderly patients undergoing elective abdominal aortic aneurysm repair or limb revascularization, even when only the preoperative arm of the POPS program was implemented, a randomized clinical trial demonstrated a shorter length of stay, less delirium, and less dependency at discharge [91]. Finally, in urology, although reductions in length of stay and complications were observed, the impact on functional status was not examined. [92]

Acute Care for Elders (ACE)

ACE units have been studied almost exclusively in medical patients. Results have shown successful prevention of functional decline, reduced length of hospital stay, and reduced rates of delirium. A small pilot study in a surgical patient population admitted to a specific unit, where surgical and geriatric nurses carried out all interventions, showed only a modest improvement in ADLs when comparing the Katz score before surgery and at the time of discharge, as well as no documented falls and very minimal use of restraints [93].

Geriatric Surgery Service (GSS)

Tan et al. reported the benefits of a "dedicated collaborative transdisciplinary geriatric surgery service," which was involved in all aspects of the pre- and postoperative care of elderly surgical patients. This group consisted of a surgeon, a nurse clinician, an anesthetist, a geriatrician, a cardiologist, a physiotherapist, a dietician, a social worker, a pharmacist, and a "befriender" (an individual who would provide cognitive stimulation or "food for the soul" by conversing with the patient). 85% of elderly colorectal surgery patients in this program recovered to their baseline ADL level as early as 6 weeks [94, 95]. When pre-habilitation was added to the GSS, 100%

of patients (of which 26% were frail) had recovered to their preoperative functional levels by 6 weeks [96].

Post Hospital Care

Rehabilitation

Elderly patients are predisposed to a state of decreased physiologic reserves and stressor vulnerability [45]. The decreased physiologic reserves seen in geriatric patients are believed to be a result of predisposing molecular and disease-related triggers, compounded by the socioeconomic environment, immobilization, malnutrition, and numerous comorbidities, which in turn lead to multiple physiologic impairments. The impaired physiologic systems are centered around the dysregulation of the immune, hormonal, and endocrine systems, resulting in an upregulation of inflammatory cytokines and insulin resistance [97, 98]. This dysregulation leads to a catabolic milieu, which consequently results in a progressive decline in muscle mass and strength known as sarcopenia [99]. As skeletal muscle is the principal reservoir for amino acids [100], a decline in muscle mass impedes the body's capability to mobilize amino acids that are needed for protein synthesis [101], which are needed during periods of stress to promote immune function, wound healing, and acute phase reactants. The end result is a perpetual catabolic cycle that results in deconditioning, prolonged recovery, perioperative morbidity, and mortality [102, 103]. On the other hand, exercise has been shown to improve skeletal muscle blood flow, pulmonary gas exchange, and cardiopulmonary fitness and tolerance and have an upregulating effect on hundreds of genes that play a role in tissue maintenance and homeostasis [104, 105]. Counteracting the state of decreased physiologic reserve forms the rationale for surgical rehabilitation.

The goals of rehabilitation in the geriatric population are to (a) maintain and improve fitness, (b) assist and accelerate recovery, (c) improve range of motion, and (d) reduce pain after surgery. The rehabilitation process can be divided into several stages [106].

1. *Initial assessment*: An assessment focused mainly on physical function can be performed by a physiotherapist, or alternatively, information may be derived from a more global assessment performed by a geriatrician. This may be done prior to surgery by identifying the existing disabilities or after surgery by analyzing the physical impact that surgery has had on the patient (i.e., how far below baseline they now are).
2. *Planning*: In collaboration with the patient, goals of care are set, taking into account several facets, which may include, but are not limited to, physical disability. These facets include a positive goal (e.g., the ability to attend a future family event), a social goal (the ability to continue living independently at home), a functional goal (completing IADL without assistance), and a health-related goal (survival).
3. *Treatment*: Exercise-based interventions or therapies are implemented to reduce disability following surgery. Treatment is usually different for the deterioration (or hospitalization) and the rehabilitation (or at home) phases of recovery. In the former, the primary goal is to bring the patient from a state of physical dependency to one of physical autonomy, wherein the patient is able to leave the hospital safely. Traditionally, this was achieved somewhat passively through the use of incentive spirometry devices and breathing exercises to prevent cardiopulmonary complications. This has now progressed to a more proactive focus on early mobilization, facilitated by enhanced recovery pathways (early feeding, pain control, avoidance of tubes and drains, etc.). In this phase, rehabilitation protocols may be supervised by physiotherapists, nurses, or physicians. The goal of treatment in the rehabilitation phase (following discharge) becomes return to baseline physical function, or, if this is not deemed possible, return to a function which would allow the patient the greatest autonomy and quality of life possible. This is usually achieved through gradual

endurance and muscle building programs. These are less often supervised and may involve outpatient physiotherapy or personal training services, either in the home or at the gym. There exist several postoperative rehabilitation protocols that are tailored to the patient and specific surgery being performed, but there is little consensus on which are most effective at helping patients return to their preoperative state. Table 4 summarizes the Oxford University Hospitals rehabilitation program [107]. This structured program can be carried out throughout hospitalization and then at home, following discharge, does not require any special equipment or expertise, and is low-cost.

4. *Re-evaluation*: The effectiveness of the interventions is evaluated in the context of the goals which were established at the onset of the process. If needed, the program is modified to reorient the therapy toward the desired outcomes.
5. *Management of disability*: If permanent disability ensues, additional care and

Table 4 Oxford University Hospitals postoperative rehabilitation program [107]

A. Immediately postop
Breathing exercises (3–6 deep breaths and then rest. Repeat these exercises 3–4 times an hour) 1. While sitting upright, relax your shoulders and upper chest 2. Take a slow, deep breath in to fill your lungs as fully as you can 3. Hold this breath for 3 s 4. Breathe out slowly through your mouth
Sitting out of bed The nursing and physiotherapy staff will help you sit out of bed either on the first morning after your operation or on the same day. They will continue to help you until you are able to do this yourself. You should sit out of bed twice a day, at first for 1 h and then gradually increasing the time each day
Walking The nursing or physiotherapy staff will help you until you can walk safely on your own. Once you can do so, you will be responsible for walking regularly and increasing the distance that you can go. You should aim to walk once every hour if able. You may also be taken to try climbing stairs with nursing or physiotherapy staff or alone when comfortable
Exercises *1. Ankles*: Bend and stretch your ankles up and down firmly and quickly. Repeat 10 times *2. Knees*: Tighten your thigh by pushing the back of your knee down against the bed. Hold for 5 s. Repeat 5 times with each leg. Then, pull your toes/foot up, tighten your thigh muscle, and lift and straighten one leg. Hold for 5 s and slowly relax. Repeat 5 times with each leg *3. Buttocks*: Tighten your buttocks regularly to relieve pressure from your bottom *4. Abdomen*: Lie flat with back on bed, lying your head on a pillow and your knees bent and flat on bed. Gently place your hands on lower tummy or hips. Breathe in through your nose, and as you breathe out, gently pull your tummy down toward your spine. Feel muscles tighten. Hold for a count of 3 and then relax. Breathe in and out normally. Do 5 times, 3 times a day *5. Pelvis*: Lie flat with back on bed, lying your head on a pillow and your knees bent and flat on bed. Place your hands in the hollow of your back. Tighten your tummy, flatten your lower back onto your hands, and tilt your bottom up and back toward your chest. Breath normally and hold for 3 s and release gently. Do 5 times, 3 times a day *6. Knee Rolling*: Lie flat with back on bed, lying your head on a pillow and your knees bent and flat on bed. Tighten your tummy and gently lower both knees to one side as far as possible. Bring them back to the middle and relax. Repeat to the other side. Do 5 times, 3 times a day.
B. At home
Weeks 1–3: After being at home for a few days, you can build strength and stamina by having a short walk each day. Start with 5–10 min and gradually try to add to your distance each day. It is safe for you to go up and down stairs from the day you go home. By the second week, you can start to carry out light chores, such as cooking, wiping, and dusting. Increase your walking time and distance each week
Weeks 4–6: You can gradually do more household jobs such as ironing and cooking. Break tasks
down into smaller parts and ask other people to help. Aim to be walking between 30 and 45 min by 6 weeks. You must still avoid heaving lifting and standing for long periods of time
Weeks 6–12: You can begin more strenuous tasking such as vacuuming so that by week 12 you are back to normal

interventions may be needed to alleviate and reduce the consequences of the disability. Occupational therapists have expertise in person-environment interactions within the home and work environment and may provide recommendations for the integration of assistive technologies and environmental modifications. Assistive technology may include bathroom or self-care aids, prosthetics, or mobility aids, such as canes, crutches, walkers, or wheelchairs. Environmental modifications use methods to minimize the effects of one's environment in exacerbating disability and promote ease of access. Finally, social workers may be useful in introducing coping strategies for patients, family, and caregivers to address the psychosocial issues that may arise secondary to the disability.

In surgery, the benefits of postoperative rehabilitation are evident in specific fields, mainly cardiac and orthopedic surgery, in which it has been shown to improve physical function, to reduce pulmonary complications, to decrease length of stay, and to lower hospitalization costs [108–111]. Furthermore, postoperative physiotherapy has reduced postoperative pulmonary complications and reduced length of stay in hospital in other heterogeneous cohorts of hospitalized patients [112, 113]. Following hospitalization, postoperative rehabilitation may be delivered in a variety of facilities, including the home, outpatient physiotherapy services, and inpatient rehabilitation services. The optimal setting will depend on the individual needs of the patient and the resources available in their milieu, but it would seem that inpatient rehabilitation services may be superior in improving functional independence when compared to skilled nursing facilities delivering physiotherapy services [114, 115].

Evidence-based practices for postoperative rehabilitation in abdominal surgery are sparse. Houborg et al. showed that postoperative physical training had no effect on physical function in patients undergoing colorectal surgery; however, the study may not have been adequately powered for this endpoint. [23] The benefits of enhanced recovery programs and the focus on encouraging early mobilization and exercise-based physiotherapy are increasingly recognized and integrated into practice; however, it is unclear what the contribution of the exercise therapy is to the overall benefit seen in programs with several other simultaneous interventions. Given the paucity of evidence, it is difficult to make any strong recommendations, although most would agree that early mobilization following surgery, whether assisted or not, is important and should be carried out in most patients. In-hospital rehabilitation programs may have some value in achieving this goal, although this is a resource which may not be available in all centers and certainly not always at the intensity needed to make an impact. Although data is lacking on whether post-hospitalization rehabilitation centers improve recovery, they may nevertheless be useful in providing a bridge between the ward and the home, during which function can be optimized, and the support can be provided to the patients who would otherwise not have access to it at home.

Conclusion

Surgical recovery in the elderly is poorly defined and poorly studied. It seems to revolve mainly around the return to preoperative functional status, although other domains are sparingly reported, including cognition, fatigue, and quality of life. Depending on the measure that is used, recovery may take up to 6 months, and sometimes longer, in a significant number of elderly individuals. Major risk factors for prolonged recovery include frailty, or at least a poor baseline functional status, malnutrition, and the occurrence of surgical complications. To optimize recovery, several strategies have shown success. The preoperative identification of higher-risk individuals using the CGA may help better address modifiable patient characteristics, leading to fewer complications and a quicker return to functional independence. Pre-habilitation protocols are in their infancy, but show promise in improving preoperative functional status in order to better withstand

the stressors of surgery. Several postoperative strategies, such as enhanced recovery pathways and multidisciplinary programs, share a common goal: to minimize the functional deterioration that is characteristic of hospitalization following surgery, by improving the adherence to best-practice processes, thereby promoting early mobilization and independence. Finally, following discharge, rehabilitation programs, which come in all shapes and sizes, should intuitively promote a faster return to the preoperative state, although the data are lacking. Overall, the fields of recovery and rehabilitation in elderly surgical patients suffer from a lack of knowledge. As the population continues to age, it is crucial to recognize the relevance of the surgical experience which occurs after discharge and to actively include elderly patients in surgical trials addressing the issues discussed in this chapter.

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