

Chapter 1

Surgery: Moving People, Improving Outcomes

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Abstract

Surgery aims to improve a patient's medical condition. However, surgery is a major life event with the risk of negative consequences, like peri- and postoperative complications, prolonged hospitalization and delayed recovery of physical functioning. One of the major common side effects, functional decline, before (in the "waiting" period), during and after hospitalization is impressive, especially in frail people.

Preoperative screening aims to identify frail, high-risk patients at an early stage, and advice these high-risk patients to start supervised preoperative home-based exercise training (prehabilitation) as soon as possible. Depending on the health status of the patient and his/her outcomes during the screening and the type of surgery, prehabilitation should focus on respiratory, cardiovascular and/or musculoskeletal parameters to prepare the patient for surgery. By improving preoperative physical fitness, a patient is able to better withstand the impact of

major surgery and this will lead to a both reduced risk of negative side effects and better short term outcomes as a result. Besides prehabilitation hospital culture and infrastructure should be inherently activating so that patients stay as active as can be, socially, mentally and physically.

In the first part of this chapter the concept of prehabilitation and different parameters that should be trained will be described. The second part focuses on the “Better in, Better out” (BiBo™) strategy, which aims to optimize patient’s pre-, peri- and postoperative physical fitness. Prehabilitation should comprise “shared decisions” between patient and physical therapist regarding experience and evidence based best options for rehabilitation goals, needs, and potential of the individual patient and his/her (in) formal support-system. Next, a case will describe the preoperative care pathway. This chapter will close with conclusions about how moving people before and after surgery will improve their outcomes.

Introduction

In recent decades, advances in surgery and anesthesia have greatly optimized surgical treatments and outcomes. However, surgery represents a major life event with the risk of negative consequences like peri- and postoperative complications, prolonged hospitalization and delayed recovery of daily life activities. One of the major common side effects, functional decline, before (in the “waiting” period), during and after hospitalization is impressive, especially in old and frail people [1]. For example, Cov-

insky et al. [2] showed that 43% of the patients waiting for surgery showed a decline in physical function. Also, 34% of the patients showed at discharge worse functional scores compared to baseline [2]. Postoperatively, bed rest contributes to a progressive loss of functional capacity via loss of (lower) extremity muscle strength, power and cardiorespiratory fitness. This impaired functioning as a result of the surgery is also called “hospitalization associated disability” [3]. Recently, hospitalization associated disability has been recognized as an iatrogenic but, more importantly, as a preventable disorder [4]. In order to avoid that patients enter the critical zone (their level of physical fitness is too low to recover successfully from surgery) leading to negative side effects after surgery, a detailed preoperative screening is essential. Patients with an impaired physical fitness are at high-risk of peri- and postoperative complications, and should therefore be advised during shared decision-making to start preoperative exercises training (prehabilitation) to improve their physical fitness [5].

Prehabilitation

Prehabilitation is defined as “the process on the continuum of care between establishing an indication for surgery, hospital admission and surgery”. It aims to improve physical fitness levels to optimize the patient’s physiological reserve, as well as creating a proactive culture in this continuum of care. By improving preoperative physical fitness, a patient can withstand the impact of the surgery

and will not enter the critical zone, with reduced postoperative complication risks and a better outcome as a result. Prehabilitation includes physical assessments that establish a baseline functional level, identifies impairments, and provides targeted preventive interventions that improve a patient's health and health-related functioning before surgery. Prehabilitation may thus be an opportunity to help patients return quickly to the highest level of functioning possible after surgery, thereby reducing surgery-related morbidity and/or mortality, decreasing the length of stay in the hospital and/or rehabilitation centers, and reducing readmissions (Figure 1). The main principle of prehabilitation is to change the passive “sit, wait and see approach” into an (pro)active “empowerment period” [1].

Prehabilitation aims to improve 1) respiratory, 2) cardiovascular, and 3) musculoskeletal fitness parameters to optimize patient's physiological reserves, and thereby their adaptation to surgical stress and handling of postsurgical functional recovery [6]. Furthermore, prehabilitation aims to create a continuum of care, in both its context and process, at home and even in the acute-care setting (Figure 2). It keeps both low- and high-risk patients as physically active as possible before, during and after hospitalization [1].

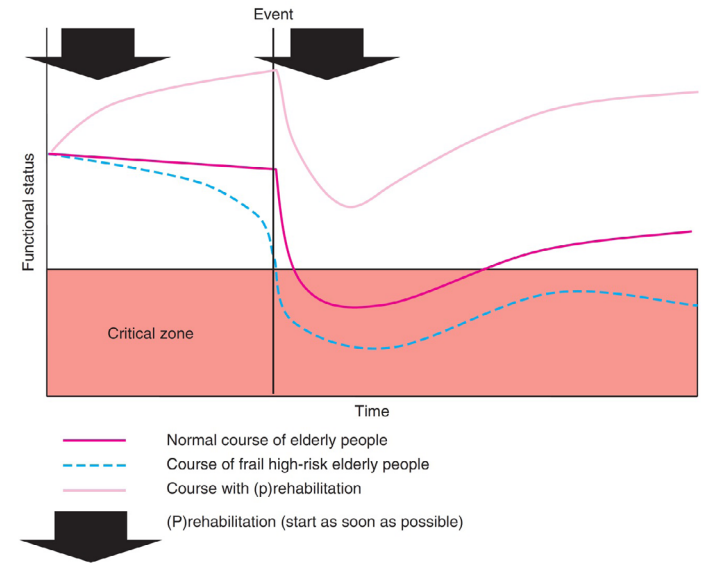


Figure 1: Elderly patients undergoing major elective surgery show a functional decline and recovery after surgery including the preoperative period. Many patients show a satisfactory functional recovery during the postoperative period because they have an adequate stress response and retain their prehospitalization level of functioning (middle line). In high-risk patients (lower dotted line), this “waiting” period may even worsen the decline in the critical zone recovery will take more time and may not be complete after surgery. Prehabilitation is thought to improve physical fitness before surgery in high-risk patients (upper line), preventing them to enter the critical zone [1].

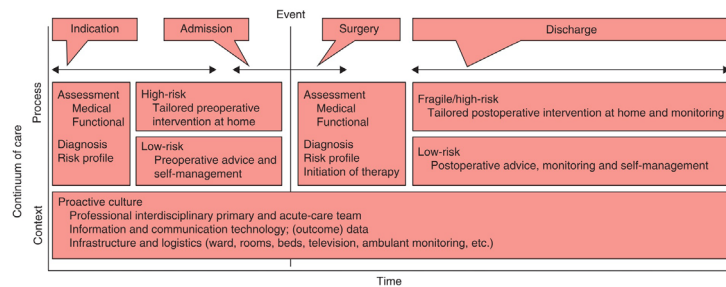


Figure 2: Overview of the continuum of care consisting of 1) process steps and 2) its context. The process starts with an assessment to identify high- and low-risk patients before and after elective surgery aiming to provide the best rehabilitation program. Contextual ingredients ((multidisciplinary) team, technology and infrastructure) provides a proactive culture where and when possible throughout the entire perioperative period [1].

Respiratory Exercise Training

Surgery negatively affects the respiratory system as a result of the effects of the location of the surgical incision, anesthetics and analgesia. These include changes in lung volumes, diaphragmatic dysfunction, a decrease in respiratory muscle strength, changes in ventilation pattern and alterations in gas exchange and response to carbon dioxide and oxygen concentrations. These changes make elderly patients more prone to developing postoperative pulmonary complications [7]. Postoperative pulmonary complications affect physical fitness negatively, increase hospital morbidity and hospital stay, contribute to additional healthcare costs and can even be life-threatening.

Preoperative identification of patients at high-risk of developing postoperative pulmonary complications can help clinicians to identify patients who may need additional preventive care or monitoring. Inspiratory muscle training is one form of prehabilitation. Inspiratory muscle training aims to increase inspiratory muscle strength and endurance by applying a resistive load to the inspiratory muscles to achieve a training effect. Respiratory muscle weakness is a risk factor for the development of postoperative pulmonary complications. Reductions in inspiratory and expiratory muscle strength have been demonstrated up to 12 weeks after surgery. Preoperative interventions to strengthen the inspiratory muscles improve post-operative recovery and reduce the incidence of postoperative pulmonary complications [1,7].

Cardiovascular Exercise Training

Physical inactivity affects both the central and peripheral components of the cardiovascular system and represents cardiac deconditioning. The heart muscle atrophies, stroke volume declines (up to 30%), heart rate increases at rest and during physical activity, and the individual's cardiac capacity to respond to any level of physical activity declines [8]. Cardiac deconditioning has been identified as a risk factor for cardiovascular disease and postoperative morbidity and mortality.

Regular endurance training programs are important to maintain a healthy cardiovascular function [8]. From a preventive perspective in prehabilitation, these exercise

programs must start as soon as possible in order to take advantage of the normally asymptotic response of the cardiovascular system upon physical exercise training in the short time-interval between diagnosis and surgery.

Musculoskeletal Exercise Training

Skeletal muscles play an important role in performing activities of daily life and active functioning. They respond directly to a decline in regular physical activity by atrophying, with an accompanying loss in contractility and strength [8]. Skeletal muscle strength declines 1–1.5 per cent per day during strict bed rest, and the decreases vary among muscle groups and muscle types. Decreases in slow-twitch fibers (type I) may account for the finding that antigravity muscles, which have a high density of type I fibers, appear to atrophy selectively as a result of immobilization compared with non-antigravity muscles. Consequently, selective atrophy is dependent on the location and function of the muscle as well as daily use of a specific muscle. This finding is important to healthcare providers because the muscle groups that lose strength most quickly as a result of immobilization, inactivity or bed rest are those involved with transferring position and ambulation [9]. Furthermore, the age-related phenomenon sarcopenia is characterized by muscle loss, muscle weakness and increased fatigability. Sarcopenia reduces the ability to produce and sustain muscular power which affects physical functioning. Moreover, aging is related to a reduction

in muscle mass caused by muscle fiber atrophy and/or loss of muscle fibers [10]. Due to a decline in physical activity, in particular for frail elderly and all the more so from surgical stress and bed rest, the musculoskeletal system is weakened in such a grade that these patients might enter the critical zone in a very short period of time after surgery. This will lead to negative consequences during post-operative recovery [1].

A review of Hoogeboom et al. [11] studying the effect of total-body prehabilitation (endurance and/or resistance training, preferably in the home and living context) showed that prehabilitation may improve physical function of high-risk patients during the preoperative period. After surgery, these patients had reduced pain and length of hospital stay, and an accelerated return to baseline physical function compared with controls [11].

General Considerations Prehabilitation

The following aspects regarding a (home-based) functional exercise training program with high-risk patients are important [12]:

- Exercise training should comprise “shared decisions” between the patient and physical therapist regarding short- and long-term goals, needs, and potential of the individual patient. Furthermore, the training should be directed to the physical fitness required for activities of daily life [13,14].

- Because physical fitness is closely related to lower leg muscle function, the functional activities in the training program should focus on these muscles. Also, preoperative training of patients' cardiorespiratory fitness prepares them for the increased metabolic demands after surgery [15].
- Patient-specific exercises should not only be progressed on intensity and repetitions, but on complexity and variability as well [16].
- The limited time before surgery requires a high-intensity training program to achieve short-term effects [17] and it should be targeted to elicit overload in order to improve physical functioning and cardiorespiratory fitness.
- The functional physical exercise program should be planned, structured, executed and monitored with the patient and within his or her own living situation, as frail elderly patients are less likely to participate in a clinic-based physical exercise program [18] than they are in a home-based physical exercise program [19].
- The training must be monitored by the patient as well as by their physical therapist using functional tests to direct and titrate exercise dosage [20]. Patients should take the lead to evaluate the therapy progress, test their own physical capacity and monitor the progress during training-episodes. This will improve their involvement and motiva-

tion and thereby therapy adherence and satisfaction.

Better in Better out™ (BiBo™)

The Better in Better out™ (BiBo™) strategy was developed in 1996 in order to reduce the risk of a complicated postoperative course through the optimization and professionalization of pre- and perioperative hospital care in a physically activating context. In addition to the concept of prehabilitation, the BiBo™ strategy goes one step further. BiBo™ includes four steps to optimize personalized health care inpatients scheduled for elective surgery. They are described in the following paragraphs in more detail.

Preoperative Risk Stratification

When a patient is scheduled for major elective surgery, a hospital physical therapist screens the patient to identify those patients that are at high risk of a complicated postoperative course. Preoperative screening includes physical fitness and physical activity level, as well as personal and medical factors such as age, BMI, mental health and comorbidities (e.g., diabetes or heart failure). Predictive risk factors for delayed functional recovery vary, based on the surgical procedure and the local context. In general, preoperative cardiorespiratory fitness, muscle strength and performance of physical activities proved to be independent risk factors for postoperative complications, recovery of physical functioning and morbidity and mortality in major abdominal and cardiothoracic surgery [21]. These

factors are indicators of the adaptive capacity of the patient (homeostasis and adequacy of responses to allostatic load) to cope with the psychophysiological consequences of major surgery [15].

For example, patients undergoing major elective abdominal surgery with a low cardiorespiratory fitness (ventilatory threshold <11 mL/kg/min or oxygen uptake at peak exercise <18 mL/kg/min) as measured objectively during cardiopulmonary exercise testing are generally considered as high-risk patients [21]. In clinical practice, cardiorespiratory fitness can also be estimated by use of less sophisticated (maximal) exercise tests (e.g. steep ramp test, walking tests) that do not include respiratory gas analysis. Moreover, other parameters of physical fitness (e.g. hand grip strength, chair rise time) are associated with postoperative mortality and discharge destination [22].

Preoperative Education

All patients are educated and motivated about the importance of physical fitness and physical activity before and after surgery for adequate post-surgical functional recovery. Knowing that bed rest is detrimental to one's physical fitness – and should be avoided as much as possible [11] – the therapist emphasizes the importance of postoperative fast-track mobilization [23] and physical activity [4,12]. Moreover, high-risk patients with a low physical fitness should receive the advice to start with preoperative exercise therapy to better cope with the consequences of

the surgery, including anesthesiological procedures, and postoperative nowadays still mostly bed- and sedentary habits oriented hospitalization.

Preoperative Exercise Therapy of High-Risk Patients (Prehabilitation)

During the preoperative period, high-risk patients train in collaboration with a trained physical therapist via a home-based functional exercise training program in order to keep patients as physically active as possible. The overall goal of this prehabilitation program is to improve the respiratory, cardiovascular and musculoskeletal system to objectively optimize the patients' reserves and thereby their adaptation to surgical stress and handling of postsurgical recovery of physical functioning [6] (see chapter 2.1-2.3).

Postoperative Mobilization and Functional Exercise Therapy

Postoperatively, hospital culture and infrastructure should stimulate the patient to be physically active. However, in most hospitals health care is entirely organized around the patient's bed. This system invites patients to lie in bed, even when there is no medical reason [24]. It is highly important that the hospital environment stimulates and facilitates physical activity and postoperative mobilization as early and as much as possible. For example, in case of fast-track surgery, patients are constantly in an environment where their peers are “up and running” and

participating in all sorts of household and leisure activities amongst each other. Thereby patients are implicitly, or even explicitly if necessary, recommended getting out of bed, even within a couple of hours after surgery [23]. Patients themselves monitor their immediate rehabilitation progress and anticipate in going home as soon as fit and functional as possible. Postoperative physical therapy care should exceed one-size-fits-all principles, in which the protocol demands that the physical therapist treats every patient with the same frequency and amount of time. However, in some situations three or four times therapy is warranted, while other patients only need one quick screening session for risks [12].

Postoperative recovery should be focused on reaching objective functional milestones (e.g. supine to sitting on the edge of the bed, sit to stand, walking, stair climbing), which serve as to be (self) monitored indicators of postoperative complications, independent physical functioning and discharge from hospital to home or elsewhere.

High-risk patients continue home-based functional physical exercise training after discharge in order to reach their functional milestones. Preferably, a patient has pre- and postoperatively – if indicated the same specialized physical therapist at home. Low-risk patients receive postoperative advice about the monitoring of their physical fitness progress and suggestions for self-management of rehabilitation. When the functional milestones have been achieved and the patient is able to fulfill his or her par-

ticipatory duties, the BiBo™ health care process is finished [12].

Case Description

A 71-year-old female (height 1.67 m, weight 56 kg, BMI 20.1 kg/m²) was diagnosed with pancreatic cancer and underwent removal of the head of the pancreas (pylorus preserving pancreaticoduodenectomy (PPPD)). In addition, the patient decided to receive the advised five cycles of adjuvant chemotherapy. This patient also decided to have a screening preoperatively by a hospital physical therapist.

During the preoperative screening, the patient and therapist jointly assessed the patient's functional capacity perceptions, cardiorespiratory fitness, muscle strength, and functional performance. These tests were performed six weeks prior to surgery.

Perception of Functional Capacity

Perception of functional capacity was measured using the Duke Activity Status Index (DASI) and the Veteran's Specific Activity Questionnaire (VSAQ). Both are self-administered symptom questionnaires linked to a metabolic equivalent (MET) score based on the compendium of physical activities [25-27].

Cardiorespiratory Fitness

The steep ramp test (SRT, using a ramp of 25 W every 10 seconds), a short-time maximal exercise test without

respiratory gas analysis measurements, was used [28-30]. The primary outcome of this test is the achieved maximal work rate (WR_{peak}, W). To provide the patient insight in his cardiorespiratory fitness level, the relative VO_{2peak} was predicted from the SRT outcome (WR_{peak}) using prediction equations¹ [29].

Muscle Strength

To evaluate muscle strength of the lower extremities, the five times sit to stand test (FTSTST) was performed. The FTSTST measures the time (seconds) required to rise from a chair five times in a row. Furthermore, hand-grip strength (HGS) of the dominant hand was measured to assess general muscle strength using a hand held dynamometer [31]. The highest score out of three trials was used for analysis and decision support.

Functional Performance

The two-minute walk test (2MWT) was used as a practical, simple, and quick sub maximal exercise test measuring walking endurance [32,33].

Finally, the timed up and go test (TUG) evaluates the functional mobility of the patient by measuring the time the patient needs to get up out of a chair, walk three meters and return to the chair. The TUG is a clinically relevant tool in assessing the risk for postoperative complications in a population with onco-geriatric surgical advice [34].

¹absolute VO_{2peak} (L/min)=(0.0067 × WR_{peak} SRT) + 0.358 and
relative VO_{2peak} (mL/kg/min)=(absolute VO_{2peak} (L/min) × 1000)
/ body mass (kg)

Results Preoperative Screening

This patient scored 5 METs at the VSAQ and 18.95 points at the DASI, which corresponds with a perceived activity level score of 5 METs. This indicates that the therapist infers that she should be able to perform activities with a moderate intensity. Using the SRT, the patient's WR_{peak} was 68 W. The calculated VO_{2peak} based on the SRT was 14.5 mL/kg/min (4.1 METs). Age- and sex-related norm values for VO_{2peak} indicate a value between 28 mL/kg/min and 29 mL/kg/min for this patient [35]. Thus, the cardiorespiratory fitness of our patient is indicated as 'poor' and based on this insight the patient and the care-team should be aware that the patient's condition preoperatively points towards high risk of postoperative complications and all the more so might hamper postoperative recovery of physical functioning and might increase the length of stay.

The patient was able to ambulate 125 m without walking aid during the 2MWT, which is 86% of predicted [33]. This indicates that walking endurance was moderately compromised. The TUG score of the patient was 8.6 s, which is 93% of predicted [36]. FTSTST performance was 16.25 s, which is 129% of predicted [37]. The patient's HGS was 20 kg, which is 87% of predicted (see Table 1) [38]. Both FTSTST and HGS indicate that the patient's muscle strength was suboptimal.

Preoperative Exercise Therapy

These results classified her as a high-risk patient for postoperative complications and delayed post-surgical functional recovery. She decided to perform preoperative nine home-based functional exercise training sessions at home, together with her partner/relatives, supervised by one of the dedicated and specifically trained physical therapists during six weeks. The training was tailored to the patient's abilities, potential, and participatory needs. Training sessions focused at improving cardiorespiratory fitness and muscle strength in activities that are relevant for this specific patient and in her own living context, both inside as well as outside. She performed combinations of exercises such as stair climbing, walking, shopping and household activities. Moreover, she was strongly advised to stay physically active between training sessions, preferably with one of her relatives. An advice that was followed up by her together mostly with her 76-years old husband and her 49-years old daughter. Her muscle strength and functional mobility were measured weekly during this preoperative period and demonstrated progression throughout these six weeks of prehabilitation (overall progression: HGS: 23 kg, +13%; FTSTS: 12.3 s, -31%; 2MWT: 142 m, +11%; TUG: 6.6 s, -21%, see Table 1).

Hospital Admission

After surgery the patient spented three days on the recovery due to an iatrogenic fluid overload. At postop-

erative day (POD) 3 she developed a systemic inflammatory response syndrome reaction with respiratory insufficiency as a result of fluid overload. Therefore, she was admitted to the Intensive Care Unit (ICU). After one day at the ICU, the patient was admitted to the ward with four-liter oxygen. At POD 8 the patient was discharged home in a good medical and functional condition.

The patient started with physical therapy at POD 1. The short-term goal was to optimize respiratory gas-exchange using the active cycle breathing technique including deep inspiration, huffing, and coughing. The patient had minimal secretions but had difficulties with deep inspiration due to the pain from the incision making her at risk for atelectasis. An upright position was advised for the intervention because the diaphragm muscle excursion was maximal and the work of breathing will be reduced in this position. In the next days, mobilisation was started which turned out to be unsuccessful. The patient only tolerated an upright position in bed. When the patient was admitted to the ward at POD 4, mobilization was expanded. At POD 8 the patient achieved functional independency based on the modified Iowa level of assistance scale [39]. Reassessment of the functional fitness was performed at POD 7 (Table 1). During hospitalisation HGS was 12 kg, a reduction of 11 kg compared to the preoperative assessment. She performed the FTSTST within 22.0 s. For the TUG she scored 11.0 s and she was able to ambulate 102 meter during the 2MWT without walking aids. At discharge, the patient received the advice to start

postoperative exercise training in the home-based setting in order to attain former levels of physical fitness.

Table 1: Results functional test during pre- and perioperative period.

		Reference value	Preoperative (% pred)		Admission (% pred)		POD 7	
SRT	WRpeak (W)	NA	68	(NA)	-	-	-	-
	Estimated VO ₂ peak (ml/kg/min)	28-29	14.5	(51%)	-	-	-	-
	METs	8	4.1	(51%)	-	-	-	-
FTSTST (s)*		12.6	16.2	(129%)	12.3	(98%)	22.0	(175%)
HGS (kg)		23	20	(87%)	23	(100%)	12	(52%)
2MWT (m)		145.9	125	(86%)	142	(97%)	102	(70%)
TUG (s)*		9.2	8.6	(93%)	6.6	(72%)	11.8	(128%)

Conclusion

People that decide upon advise for major elective surgery should be aware that being physically active before, as well as after surgery will positively influence their functional recovery. Particularly in frail (high risk) people, physical inactivity might lead to delayed functional recovery, increased incidence of peri- and postoperative complications, prolonged hospitalization, and delayed recovery of daily life activities.

According to the “Better in, Better out” (BiBo™) concept, preoperative screening of physical functioning is essential to identify and advise patients at high-risk of a complicated postoperative course. These patients, but also low-risk patients, have the right to be adviced at a proper time about the importance of physical activity before,

during and after hospitalization for optimal post-surgical functional recovery. In addition, high-risk patients should be provided the choice to involve in home-based exercise therapy in order to improve their preoperative physical fitness. The idea is that, with improved physical fitness, a patient can more actively and there for better deal with the impact of the surgery. During hospitalization, but also after discharge, patients should be assisted to be as physically active as possible with the aim to reach their objective functional milestones. The role of the patient him- or herself is of utmost importance. Patients should be technically and socially supported and motivated to take the lead to evaluate the therapy progress, test their own physical capacity, and monitor the progress during training-episodes. This will activate their involvement and motivation and thereby therapy adherence and satisfaction. An additional benefit of the BiBo™ concept is that direct health care cost will decrease (e.g. reduced length of stay, fewer complications). Moreover, additional costs for home care or even admission to a nursing home will decrease.

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