Prehabilitation in Clinical Practice: A Review of Concepts and Implementation in Enhancing Post-operative Outcomes

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ABSTRACT

In the presence of globalization and advancing clinical knowledge, there is a paradigm shift from a single patient care sector to a multidisciplinary-collaborated health care team. In pursuit of favorable postoperative outcomes, reduced length of hospital stay, minimized complications and morbidity, and accelerated recovery, prehabilitation strategies assume a prominent role following preoperative assessment. Fundamental to prehabilitation are physical activity, nutrition, and psychological interventions, aimed at enhancing preoperative functional reserve through expert-designed program sessions spanning various specialties. Enhanced Recovery After Surgery (ERAS) serves as an intra- and postoperative strategy to facilitate the smooth return of patients to their baseline status post-operation by mitigating surgical stress. Integrating prehabilitation into ERAS protocols holds promise for optimizing postoperative outcomes. Protocols for prehabilitation across diverse patient groups have been proposed, paving the way for the routine incorporation of prehabilitation into patient care.

Keywords: Prehabilitation; perioperative; postoperative outcomes; enhanced recovery after surgery (ERAS); multidisciplinary; multimodal (Siriraj Med J 2024; 76: 646-654)

INTRODUCTION

In the midst of globalization and the expanding global population, particularly in the context of an aging demographic, the demand for healthcare, including hospitalization, has surged.[1,2] This increase is further accompanied by the prevalence of non-communicable diseases, emerging conditions, and chronic comorbidities, necessitating both medical and surgical interventions. To address these challenges, evidence-based guidelines for intraoperative and immediate postoperative care have been established. These guidelines aim to facilitate rapid recovery and mitigate postoperative complications, such as prolonged hospital stays, hospital readmissions, escalated healthcare costs, and elevated mortality rates.[3-5]

Optimizing perioperative care necessitates a multidisciplinary approach that integrates surgical and anesthesia standpoints. Comprehensive medical management spans from preoperative assessment through to patient discharge. However, the pivotal factor determining favorable postoperative outcomes lies in the patient's preoperative functional capacity. Limited functional capacity has been consistently linked to increased risks of 30-day mortality and postoperative complications. Consequently, various strategies have been devised to enhance and optimize preoperative functional status, particularly among vulnerable populations such as the elderly, frail individuals, and those suffering from malnutrition.[4,6,7] The preoperative phase is widely acknowledged as a

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Received 23 May 2024 Revised 28 June 2024 Accepted 28 June 2024
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https://doi.org/10.33192/smj.v76i9.269392

critical window for risk assessment, optimization, and meticulous patient preparation in anticipation of the physiological stress induced by surgical procedures.[8]

This review article underscores the significance of prehabilitation as a strategy for enhancing preoperative functional capacity by strengthening physiological and metabolic reserves in at-risk patients. It advocates for the integration of prehabilitation into routine anesthesia practice, emphasizing its potential benefits. The article also explores how prehabilitation can be integrated with Enhanced Recovery After Surgery (ERAS) within a framework of multidisciplinary collaboration, and introduces its implementation among various groups of specific patients.

Definition of prehabilitation

Prehabilitation, a term first proposed approximately two decades ago by Topp et al., pertains to a program aimed at enhancing functional capacity prior to admission to the intensive care unit (ICU).[9] Despite its original conceptualization, prehabilitation has undergone a paradigm shift, and is now viewed as a valuable strategic approach during preoperative preparation to mitigate surgery-induced stress.[10] The fundamental objective of prehabilitation is to minimize the risk of postoperative complications and expedite recovery through the proactive implementation of physical training, nutritional enhancement, and mental support, with the aim of reducing morbidity and mortality following surgery.

Optimizing the preoperative patient status necessitates a multidisciplinary collaboration involving perioperative clinicians, surgeons, anesthesiologists, geriatricians, nurses, physiotherapists, nutritionists, and various other pertinent healthcare professionals. This endeavor is often referred to as "pre-surgical conditioning", representing measures aimed at enhancing the functional and mental status of patients before surgery, improving disease manifestations, and preventing potential adverse events through the adoption of prehabilitation principles.[11]

Implementation of preoperative prehabilitation approaches

The effectiveness of treatment extends beyond the surgical procedure alone; it also relies on the speed of recovery and the restoration of pre-surgery functional capacities. Implementing carefully planned physical activity programs, initiated 4-6 weeks before scheduled surgery, has been shown to enhance fitness levels.[12] Additionally, as previously mentioned, integrating nutritional interventions, psychological support, and cessation of smoking and alcohol consumption is imperative and should be incorporated into the multimodal prehabilitation regimen.

Physical exercises

One of the core components of prehabilitation is physical exercise, which encompasses a variety of activities proven to enhance functional capacity. These include aerobic exercise, resistance training, muscle strengthening, balance training, and flexibility exercises. The design of physical exercise programs is tailored to align with patients' baseline physical abilities, as assessed by measures such as the 6-minute walk test (6MWT), oxygen consumption in the aerobic threshold (AT), and peak exercise capacity (VO_2 max).[11] Typically, the recommended total exercise duration is 2.5 hours per week, consisting of 2-3 sessions of 30-40 minutes of aerobic exercise per week. The target heart rate for each exercise session should range between 50-80% of the maximum age-related heart rate, calculated as 220 minus the individual's age in years. Strengthening exercises targeting daily-life muscles are recommended twice a week, alternating with sessions of flexibility and balance exercises.[4,13] To tailor an appropriate exercise program for each individual, common assessments of preoperative functional capacity[14-31] are conducted as outlined in Table 1.

Nutritional optimization

The concept of nutrition in prehabilitation extends beyond merely replenishing deficit calories. Nutritional support is envisioned proactively, encompassing both the preoperative and postoperative periods.[32] It is recommended that all patients, especially those with malnutrition and those undergoing gastrointestinal or cancer surgery, be encouraged to receive nutritional support. Enteral nutrition is prioritized for patients scheduled for major surgical interventions, with an intake of 1.2-1.5 g/kg of body weight of protein for approximately 7-14 days. Protein supplementation is suggested within 1 hour following physical activity to optimize muscle protein synthesis. Consumption of 140 g of carbohydrates around 3 hours prior to exercise is encouraged to enhance muscle and liver glycogen storage.[33-36]

Psychological wellness

Mental health holds equal significance to physical well-being, particularly in the context of surgery. Preoperative stressors such as fear, anger, depression, and anxiety, if left unaddressed, can accumulate and negatively impact recovery, treatment outcomes, and overall quality of life. Various strategies are proposed to alleviate psychological

TABLE 1. Preoperative functional capacity assessments[14-31]

Assessments	Details	Interpretation
Cardiopulmonary Exercise Testing (CPET)[14-18]	The gold standard for measuring functional capacity and the capability to achieve metabolic demands. Requires significant time and resources. Involves estimating cardiopulmonary function and cellular respiration by assessing physiological responses to exercise and cardiorespiratory performance. Includes the monitoring of electrocardiogram (EKG), minute ventilation, heart rate, O_2 uptake, and CO_2 output.	The scoring system ranges from 0 to 20, where scores of 0-5 indicate normal reference levels, while scores > 5 signify escalating risk factors. These include: a ratio between pulmonary ventilation and CO_2 production (VE/VCO_2) slope of ≥ 34 = 7 points; heart rate recovery (HRR) of ≤ 16 beats/min = 5 points; O_2 uptake efficiency slope (OUES) of ≤ 1.4 = 3 points; end tidal CO_2 partial pressure ($PETCO_2$) of < 33 = 3 points; and peak O2 consumption (VO_2 max) of ≤ 14 ml/kg/min = 2 points. Peak VO_2 < 15 ml/kg/min corresponds to metabolic equivalents (METS) < 4, resulting in postoperative complications. Peak VO_2 > 20 ml/kg/min indicates a low risk of postoperative mortality. The level of O_2 uptake at which lactate begins to increase in the circulation (anaerobic threshold, AT) < 9-11 ml/kg/min is related to postoperative complications and mortality.
The Duke Activity Status Index (DASI)[14,19-21]	Utilization of a 12-item questionnaire to determine the capacity of physical tasks performance. DASI score spans from 0 to 58.2 and possesses predictive capability for estimating the VO_2 max as expressed by the formula: VO_2 max = (0.43 x DASI score) + 0.96.	DASI > 34 indicates a predicted VO_2 max > 15 ml/kg/min. DASI < 34 is associated with an increased risk of 30-day mortality or experiencing moderate to severe postoperative complications among patients vulnerable to myocardial infarction or undergoing major surgery. DASI < 31.95 signifies low functional capacity among patients with preexisting stroke.
The 6-minute walk test (6MWT)[14,22-24]	A sub-maximal exercise assessment wherein a patient walks back and forth on a level surface between 2 designated markers. The final walking distance is reported in meters (m).	The 6MWT values of 427 m and 563 m indicate a low AT of < 11 ml/kg/min and a high AT of > 11 ml/kg/min, respectively. A 6MWT result of < 350 m is associated with an increased risk of 12-month disability following surgery. A 6MWT result of 400 m corresponds to New York Heart Association (NYHA) classification 2.

TABLE 1. Preoperative functional capacity assessments[14-31] (Continue)

Assessments	Details	Interpretation
The incremental shuttle walk test (ISWT)[14,25,26]	Walking on a flat surface between 2 points with acceleration. ISWT is associated with VO_2 max measurement. The final walking distance is reported in meters (m).	The ISWT result > 360 m corresponds with VO_2 max > 15 ml/kg/min and AT > 11 ml/kg/min.
Brain natriuretic peptide (BNP) and N-terminal pro-brain natriuretic peptide (NT-pro BNP)[14,27,28]	The preoperative plasma levels of BNP and NT-pro BNP may be relevant to both mortality and cardiac complications following non-cardiac surgery.	A BNP level ≥ 92 pg/ml and an NT-pro BNP level ≥ 300-450 pg/ml may serve as predictors of postoperative morbidity within 30 days.
High-sensitivity cardiac troponin T (hs-cTnT)[29,30]	The preoperative level of plasma hs-cTnT can aid in predicting peri-operative myocardial injury/infarction.	A cutoff of ≥ 14 pg/ml designates an abnormal level of hs-cTnT, which predicts perioperative coronary artery adverse events.
Growth differentiation factor-15 (GDF-15)[29,31]	The preoperative plasma level of GDF-15 can predict the risk of myocardial injury after non-cardiac surgery and also enhance cardiac risk evaluation by 30% compared to the Revised Cardiac Risk Index (RCRI) alone.	The risk of myocardial injury after non-cardiac surgery is 12% when the GDF-15 level is between 1,000-1,500 pg/ml, and 34% when > 3,000 pg/ml.

Abbreviations: 6MWT: The 6-minute walk test; AT: Anaerobic threshold; BNP: Brain natriuretic peptide; CO_2: Carbon dioxide; CPET: Cardiopulmonary exercise testing; DASI: The Duke Activity Status Index; EKG: Electrocardiogram; GDF-15: Growth differentiation factor-15; hs-cTnT: High-sensitivity cardiac troponin T; ISWT: The incremental shuttle walk test; kg: Kilogram; m: Meter; METS: Metabolic equivalents; min: Minute; ml: Milliliter; NT-pro BNP: N-terminal pro-brain natriuretic peptide; NYHA: New York Heart Association; O_2: Oxygen; OUES: Oxygen uptake efficiency slope; $PETCO_2$: End tidal carbon dioxide partial pressure; pg: Picogram; RCRI: Revised Cardiac Risk Index; VCO_2: Carbon dioxide production; VE: Pulmonary ventilation

stress, including deep breathing techniques, meditation, muscle relaxation, yoga, cognitive training, and potentially seeking consultation with a psychologist.[37] An integrated exercise and nutrition plan can be incorporated into the program to provide psychological relief, motivating and encouraging patients to engage in prompt mental and physical preparation before their planned surgery.

Preoperative education is advocated in conjunction with psychological interventions. Such education, encompassing information pertaining to surgery and anesthesia, perioperative management, and pain control, has been demonstrated to mitigate anxiety and enhance patient satisfaction.[38] The multimodal prehabilitation approaches[4,11,13,33-37] are outlined in Table 2.

Prehabilitation for specific groups of patients

Strengthening the functional reserve prior to surgery constitutes the core principle of prehabilitation. It is essential to note that while specific interventions primarily target patient cohorts vulnerable to surgical stress, certain individuals, particularly those identified as such, may require tailored prehabilitation interventions to optimize their surgical outcomes.

Frail surgical patients

Frailty denotes the age-related process encompassing both functional and cognitive decline, which subsequently elevates the risk of 30-day postoperative complications and 1-year mortality.[39] Despite the absence of a standardized universal prehabilitation regimen for frailty,[40] adopting a multimodal prehabilitation strategy could be beneficial. Such a program for frail patients may include[41]:

1. Moderate to intense aerobic exercise and resistance training targeting muscles essential for daily functioning, such as the upper and lower limbs, for 75-90 minutes, twice per week

TABLE 2. The multimodal prehabilitation approaches.[4,11,13,33-37]

Components of multimodal prehabilitation		
1) Physical exercise intervention		
Aerobic exercise: 30 min/day, 2-3 times/week, maintaining the target heart rate of 50-80% of age-adjusted maximal heart rate, such as: walking cycling running hiking swimming etc.	Resistance exercise: 8-15 repetitions/set for 1-2 sets, 2 times/week, targeting the strengthening of muscles essential for daily activities including arms, shoulders, chest, abdomen, back, and legs. Examples of exercises include: push-ups weight lifting abdominal curls etc.	Flexibility and balance: 2-3 times/week, holding each position for 20-30 sec, including: standing on one leg lateral thigh lift single-leg squat stretching yoga etc.
2) Nutritional intervention	**3) Psychological intervention**	
Enteral nutrition is prioritized, with a protein intake of 1.2-1.5 g/kg supplemented by an additional 20-30 g of protein following aerobic exercise. An intake of 140 g of carbohydrates is recommended 3 hours before exercise to support glycogen storage in the muscles and liver. Arginine and omega-3 fatty acids are supplemented to enhance immune function.	A 60-min session with a psychological expert is recommended to reduce anxiety and negative mood effects. Psychological support also enhances patient motivation and compliance with the prehabilitation program. Examples of techniques for psychological support include: mindfulness meditation deep breathing muscle relaxation positive thinking etc.	

Abbreviations: min: Minute; sec: Second

2. Dietary adjustments tailored to body weight and composition, aiming for an intake of 25-30 kcal/kg and protein intake of 1.5 g/kg, initiated 4 weeks prior to surgery and supplementation with arginine and omega-3 fatty acids to enhance immune function

3. Psychological prehabilitation coupled with patient education

Overall, the implementation of multimodal prehabilitation interventions in frail patients is strongly recommended (1B-1C recommendation) to enhance postsurgical outcomes.[40]

Cancer patients

Multimodal prehabilitation remains a mainstream practice, with recent systematic reviews focusing on exercise training programs for cancer patients. These programs typically include a warm-up period of 5-10 minutes, followed by a 30-minute session comprising aerobic and resistance exercises or aerobic training alone, concluding with a 5-10-minute cool-down period. Sessions are typically conducted 3-4 times per week over a span of 4 weeks. As a consequence of the limited number of studies and low sample size, the benefit of exercise prehabilitation in cancer patients is not apparent. However, there is a tendency towards the advantages of prehabilitation for reductions in the length of hospital stay and postoperative complications.[42]

Elderly patients

Among the elderly population aged over 65 years, baseline health can be stratified into three groups: good health, pre-frail (experiencing normal aging), and frail (exhibiting pathological presentation). Regardless of initial health status, a decline in functional capacity is typically observed after surgery, with recovery to the baseline preoperative level often taking several months.[43] With the implementation of moderate to intense aerobic and resistance exercise aiming for 80% of the maximum heart rate, 1.2-1.5 g/kg/day of protein intake with the supplementation of 20-30 g whey protein after aerobic exercise, and an anxiety relief program, an increase in muscle strength, muscle power, and VO_2 max is observed.[44]

Prehabilitation and Enhanced Recovery After Surgery (ERAS)

ERAS has been recommended in the intraoperative care plan to promote early recovery and prevent adverse outcomes.[45-52] However, there are a limited number of studies investigating the beneficial association between prehabilitation and the ERAS protocol. While ERAS has the potential to independently mitigate surgical stress and optimize surgical outcomes, some research has demonstrated an expedited return to baseline functional status, referred to as surgical resilience, among patients who undergo preoperative prehabilitation followed by ERAS intervention. Patients undergoing a multimodal prehabilitation plan demonstrated superior preservation of muscle mass and walking capacity, as determined by the 6MWT after surgery, compared to those who received only the ERAS protocol.[53,54] Collectively, prehabilitation serves as a complement to ERAS by targeting the reduction of surgical stress through the enhancement of preoperative functional reserve. Nevertheless, the effectiveness of prehabilitation relies on both the baseline functional capacity and adherence to multimodal interventions.

The independent factors contributing to adverse postoperative outcomes include advanced age (≥ 75 years), smoking, hypertension, kidney disease requiring dialysis, body mass index (BMI) ≥ 30 kg/m², chronic steroid use, and American Society of Anesthesiologists (ASA) physical status classification ≥ 3.[55] These risks for adverse postoperative outcomes are largely attributed to old age and frailty, characterized by a decline in the functional capacity and performance of organ systems, as well as cognitive function. Therefore, the implementation of prehabilitation for elderly and frail patients, as previously discussed in this context, is required.

While prehabilitation is not novel in the fields of surgery and anesthesia, its integration into ERAS protocols for ensuring optimal recovery and reducing postoperative complications is not widely practiced in routine clinical settings, particularly in Thailand. A concise overview is provided in this article regarding prehabilitation and its interaction with personalized protocols tailored to individual patients, aiming to enhance clinical outcomes and mitigate adverse postoperative events. The integration scheme[4,53,54,56] of prehabilitation and ERAS targeting favorable postoperative outcomes is demonstrated in Fig 1.

Integrating prehabilitation into clinical practice through a multidisciplinary collaboration

Prehabilitation necessitates multifaceted collaboration among various healthcare professionals. Commencing with the mutual agreement between surgeons and patients regarding the forthcoming operation, the subsequent step involves preoperative screening for risk stratification and patient optimization, typically conducted in the preoperative clinic. The responsible team comprises clinicians from diverse specialties, nurses, and notably

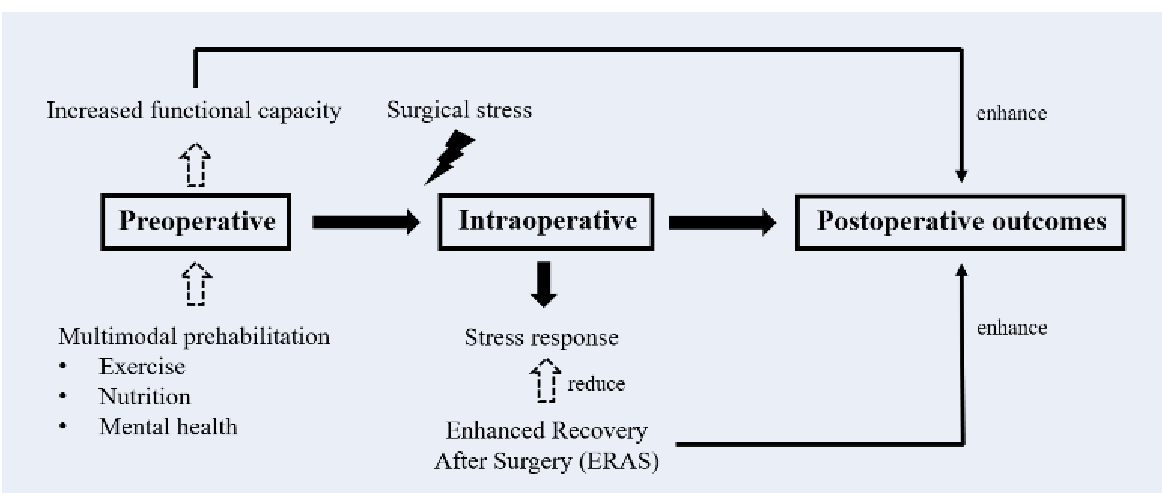

Fig 1. Integration of prehabilitation and ERAS in surgical care to improve postoperative outcomes[4,45,46,54]

anesthesiologists, who conduct preoperative evaluations in the preanesthetic clinic. After preoperative evaluation, the baseline functional assessments are determined by the prehabilitation team, which includes physiotherapists, exercise trainers, nutritionists, pharmacists, psychologists, smoking and alcohol cessation counselors, and other pertinent healthcare personnel. Prehabilitation interventions are implemented. This thorough preoperative evaluation and the subsequent prehabilitation program serve as a preparatory platform for elective surgery patients before their scheduled procedures.[4,57]

Future directions in prehabilitation

Several studies have investigated the implementation of prehabilitation programs for patients undergoing various surgical procedures. These multimodal interventions have shown promising results in enhancing patients' functional capacity and reducing postoperative complications.[18,40,42] However, despite the documented benefits of multimodal prehabilitation in improving functional capacity, there remains limited effectiveness among vulnerable patients with low baseline functional reserve and poor adherence to interventions. Previous studies on prehabilitation have shown variations in study design, sample size, and outcome measurement. Furthermore, adherence to prehabilitation protocols varies widely across studies, ranging from 16% to 97%.[58] Therefore, there is room for improvement in the form of prudent preoperative risk prediction, involving mutual decision-making among multidisciplinary care teams to tailor personalized prehabilitation interventions. Given the association of cognitive decline with aging, frailty, and malignancy, there is growing interest in integrating cognitive stimulation training into prehabilitation programs alongside exercise, nutrition, and psychological approaches, which are the cornerstones of the prehabilitation concept.[59,60]

CONCLUSION

Multimodal prehabilitation represents a preoperative strategy aimed at mitigating the stresses associated with subsequent surgery and anesthesia. Integrating prehabilitation with ERAS protocols can enhance functional capacity and fortify surgical resilience, thereby reducing complications during and after the operation. While exercise intervention plays a prominent role in the efficacy of prehabilitation, the significance of nutritional and psychological support is less apparent. A possible application to current perioperative practice is the integration of a preoperative prehabilitation program for indicated patients, emphasizing individualized care aimed at enhancing functional capacity in parallel with the intraoperative ERAS protocol. However, a knowledge gap exists that future research needs to address to refine interventions and establish clear outcome measures, thereby fully exploring the potential of prehabilitation as a multidisciplinary approach to improving postoperative outcomes.

ACKNOWLEDGEMENTS

The authors wish to express their gratitude for the insightful suggestions provided by Assoc. Prof. Dr. Arunotai Siriussawakul and for the administrative support from Mr. Pichanon Choosaeng, Department of Anesthesiology, Faculty of Medicine Siriraj Hospital, Mahidol University. Additionally, the authors extend their appreciation to Mr. Graeme Kay for his invaluable assistance with the English-language editing of this manuscript.

Author Contributions

PS was responsible for conceptualization, data curation, manuscript writing, and the review of the final manuscript. AJ contributed to data curation and the writing of the initial draft. NN managed data curation. All authors have read and approved the final manuscript.

DECLARATION

Funding

No funding was received for conducting this study.

Conflicts of interest

The authors declare that there are no conflicts of interest.

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