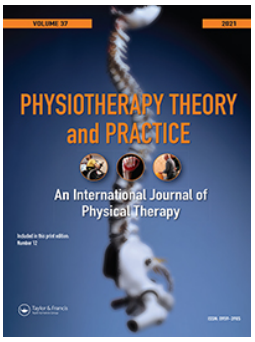

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Personalized community-based prehabilitation for a high-risk surgical patient opting for pylorus-preserving pancreaticoduodenectomy: a case report

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ABSTRACT

Introduction: Prehabilitation aims for an optimal physical functioning level before, during, and after hospitalization for major surgery. The purpose of this case report was to illustrate the care pathway of a high-risk patient who opted for pylorus-preserving pancreaticoduodenectomy, including preparation for this procedure by participating in a community-based exercise prehabilitation program. The report describes patient examination, evaluation in decision-making for surgery, the prehabilitation program, and outcomes within the context of the Hypothesis-Oriented Algorithm for Clinicians II.

Case Description: The patient was a 75-year-old woman with a history of several comorbidities and a polypoid mass in the descending segment of the duodenum. Based on the preoperative assessment, the level of physical functioning was expected to be insufficient to cope adequately with the stress of hospitalization and surgery.

Intervention: A 4-week prehabilitation program, including aerobic, resistance, and functional task training in a community-based physical therapy practice.

Outcomes: Prehabilitation had a beneficial impact on improving functional mobility preoperatively (timed up-and-go test score improved from 19.4 to 10.0 s, five times sit-to-stand test score improved from 30.1 to 10.1 s, and two-minute walk test distance improved from 55.0 to 107.0 m). Surgery and postoperative recovery proceeded without complications. She achieved independent physical functioning on postoperative day 6 and was discharged home on postoperative day 12.

Conclusion: Preoperative risk-assessment can support clinical decision-making in a high-risk patient opting for major abdominal surgery. Furthermore, a remarkable improvement in physical functioning can be achieved by community-based prehabilitation in a high-risk surgical patient.

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Preoperative training; Risk assessment; Surgery; Physical functioning; Pancreatic resection

Introduction

Surgical and anesthetic techniques have improved significantly in the last decades, trying to minimize the loss of a patient's medical condition during surgery. Still, the challenge remains to optimize the perioperative period and context, especially for frail patients who are at increased risk for delayed or permanent loss of physical functioning before, during, and after hospitalization and surgery (Covinsky, Pierluissi, and Johnston, 2011; Lawrence et al., 2004; Palleschi et al., 2014). Their increased risks can be counteracted by preoperatively challenging homeostatic and specifically allostatic mechanisms by supportive preoperative interventions (prehabilitation), enabling the patient to deal with the stressors of the diagnosis of their pathology, the preoperative 'waiting' period, hospital stay, and surgical intervention (Dronkers, Witteman, and van Meeteren, 2016; Hulzebos and van Meeteren, 2016). Modifiable patient factors, such as aerobic capacity, level of physical functioning, and nutritional status may determine the capacity of the patient's homeostatic and allostatic responses to these stressors and consequently their postoperative recovery (West, Wischmeyer, and Grocott, 2017).

Prehabilitation is advocated for patients with a high-risk profile. Hulzebos and van Meeteren (2016) described prehabilitation within a proactive perioperative care strategy aiming for an optimal level of physical functioning before, during, and after hospitalization, inspired by

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Hood's P4-medicine approach (Hood, 2013; Hulzebos and van Meeteren, 2016). Perioperative care would best be: 1) predictive (e.g. preoperatively screening a patient's individual risk factors); 2) preventive (e.g. offering preoperative interventions as physical exercise training, nutritional, and/or psychological support); 3) personalized (e.g. tailored inventions for the individual patient); and 4) participatory (e.g. encouraging the patient to actively participate in their treatment through active self-care and self-management) (Bongers, Punt, and van Meeteren, 2019).

Considering the importance of proactive perioperative management in relation to postoperative outcomes, the purpose of this case report was to illustrate the care pathway of a high-risk patient who opted for pylorus-preserving pancreaticoduodenectomy (PPPD), including preparation for this procedure by participating in a community-based prehabilitation program. The role of the patient and physical therapist, both part of the interdisciplinary team, in managing perioperative care in major abdominal cancer surgery is described with the application of the Hypothesis-Oriented Algorithm for Clinicians II (HOAC II) for clinical reasoning (Rothstein, Echternach, and Riddle, 2003). The HOAC II was combined with the ontology of the International Classification of Functioning (ICF), using the recently advised change of the WHO framework (Heerkens et al., 2018). This case report followed the CARE guidelines (Gagnier et al., 2013) for case reports and evaluated therapeutic validity using the CONTENT scale (Hoogeboom et al., 2012).

Case description

Patient history and system review

This case report is about a 75-year-old woman, living alone in a senior apartment and able to perform her activities of daily living (ADL) independently. Signed informed consent was obtained from the patient to present and publish the data as a case report. Her weekly physical activity consisted of walking to the supermarket (75 m). She would have preferred to be able to walk longer distances and in the past, she enjoyed recreational swimming (1h a week); however, because of complaints of dyspnea, probably due to her chronic obstructive pulmonary disease (COPD; GOLD II), she was not able to perform the latter activities anymore. For household cleaning activities, she had a cleaner once a week. She has one daughter and three grandchildren. Her medical history included right-sided total hip replacement and revision, uterus extirpation, appendectomy, COPD (GOLD II, Tiffeneau index of 69%), atrial fibrillation, left ventricular hypertrophy (left ventricular ejection fraction 50–55%) and moderate stage 3A renal failure (glomerular filtration rate 47 mL/min). She consulted her general practitioner with discomfort and the sensation of a lump behind her sternum after eating, as well as with itching complaints for 6 months. The lump behind her sternum was not painful and by drinking water, the discomfort disappeared. Her general practitioner referred her to the nearest general hospital for a gastroscopy and computed tomography (CT) scan. The CT scan of the abdomen showed a dilatation of the intrahepatic bile duct and the common bile duct with a polypoid mass in the descending segment (D2) of the duodenum. No lymphadenopathy or distant metastases were detected by the CT scan of the abdomen and thorax. A gastroduodenal endoscopy revealed a polyp in D2, occupying one-third of the lumen with probably the involvement of the ampulla of Vater. Pathological examination of the biopsy of the polyp revealed low-grade dysplasia without malignancy. After the diagnostic tests, the gastroenterologist explained that her esophagus and stomach were well; however, they discovered a large suspicious mass in her duodenum. The immediate reaction of the patient was: "That's like the ground falls out from beneath your feet! I was shocked." She was referred to the outpatient hepatopancreatobiliary (HPB) unit of Maastricht University Medical Center+ to discuss her treatment options. In Figure 1, the patient journey is presented, ordered on a timeline starting from the time of her complaints.

Qualitative and quantitative clinical impression I

During the multidisciplinary team meeting with the surgeon, gastroenterologist, radiologist, oncologist, and clinical nurse specialist, the results of the diagnostics tests (e.g. CT-scan, endoscopy, and pathology) and the treatment options for the patient were discussed. The multidisciplinary team concluded that the provisional diagnosis was a polypoid mass in D2, with suspicion of involvement of the ampulla of Vater. There was no proven malignancy based on the results of the pathology. However, the team concluded that the mass was still suspicious for malignancy. There was no possibility for endoscopic removal of the mass. Performing a pylorus preserving pancreaticoduodenectomy (PPPD) was decided as the best treatment option when she was able to withstand the stress of hospitalization and surgery. After the multidisciplinary team meeting, it was concluded that she might be 'frail' and at risk for adverse postoperative outcomes after

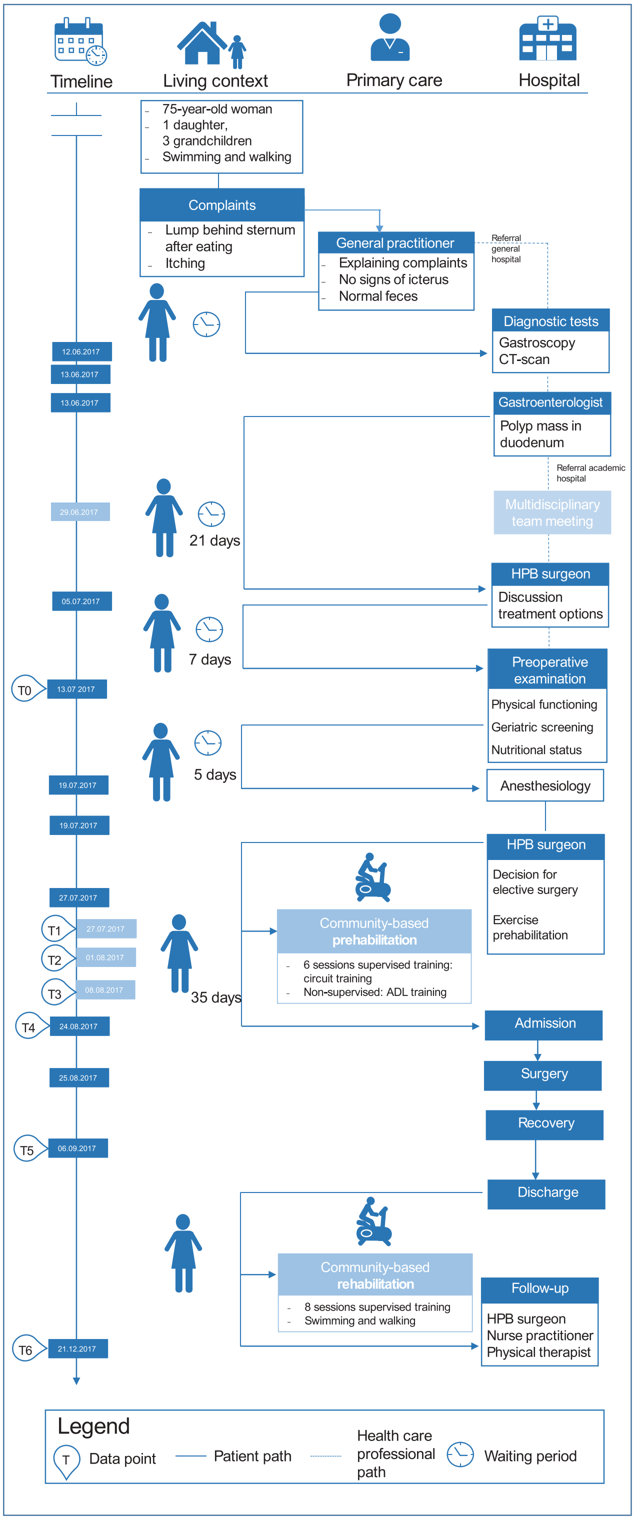


Figure 1. The patient journey listed on a timeline view ordered by start of the event.

Abbreviations: CT = computed tomography; HPB = hepatopancrea-tobi-liary.

a PPPD, based on several patient-related risk factors, such as age, COPD, cardiac problems, and functional dependence. Consequently, the patient was referred to the outpatient clinic 21 days after the diagnostic tests (Figure 1) to discuss her treatment options with the surgeon. Seven days later, a preoperative multidisciplinary risk assessment in support of decision-making was performed as well.

Examination strategy

Rational for preoperative examination

The HOAC II and the recently revised WHO framework of the ICF were used to structure and organize the patient history and clinical status, as well as to develop hypotheses prior to the preoperative examination and development of the plan of care (Figure 2). The aim of the preoperative medical and functional examination 29 days after the diagnostic tests (Figure 1) was to identify whether the patient was able to cope with the mental and physical stress of the pathology, hospitalization, and surgical stress response. The physiological response to stress can be described with the concepts of allostasis and allostatic load (McEwen and Wingfield, 2010). Allostasis is the process in which physiological systems adapt to excessive stressors to remain homeostasis. The cumulative effect of an allostatic state is an allostatic load (McEwen and Wingfield, 2010). If additional load of unpredictable events (e.g. pathology, hospitalization, and surgery) is superimposed on the already existing allostatic load (e.g. comorbidities), and the patient is not able to cope with this increased load, it may lead to allostatic overload, resulting in adverse health outcomes such as complications and a decline in physical functioning (McEwen and Wingfield, 2010).

Content of the preoperative examination

The aim of the outpatient preoperative examination was to assess the patient's medical condition and level of physical functioning to examine the patient's physiological reserve capacity (e.g. respiratory, cardiovascular, and physical functioning parameters, and nutritional and cognitive status) (Figure 2). The anesthesiologist assessed the general medical condition. The hospital physical therapist aimed to evaluate her level of physical functioning using performance-based tests to estimate her: aerobic capacity (steep ramp test [SRT]); muscle strength (handgrip strength [HGS]); and functional mobility (timed up-and-go [TUG] test, two-minute walk test [2MWT], and five times sit-to-stand [FTSTS] test). In addition, the physical therapist aimed to evaluate her perception of her functional capacity to perform activities of daily living using two questionnaires (veterans-specific activity questionnaire [VSAQ] and Duke activity status index [DASI]). The nurse specialist evaluated the nutritional and cognitive status of the patient by performing a short nutritional assessment, including

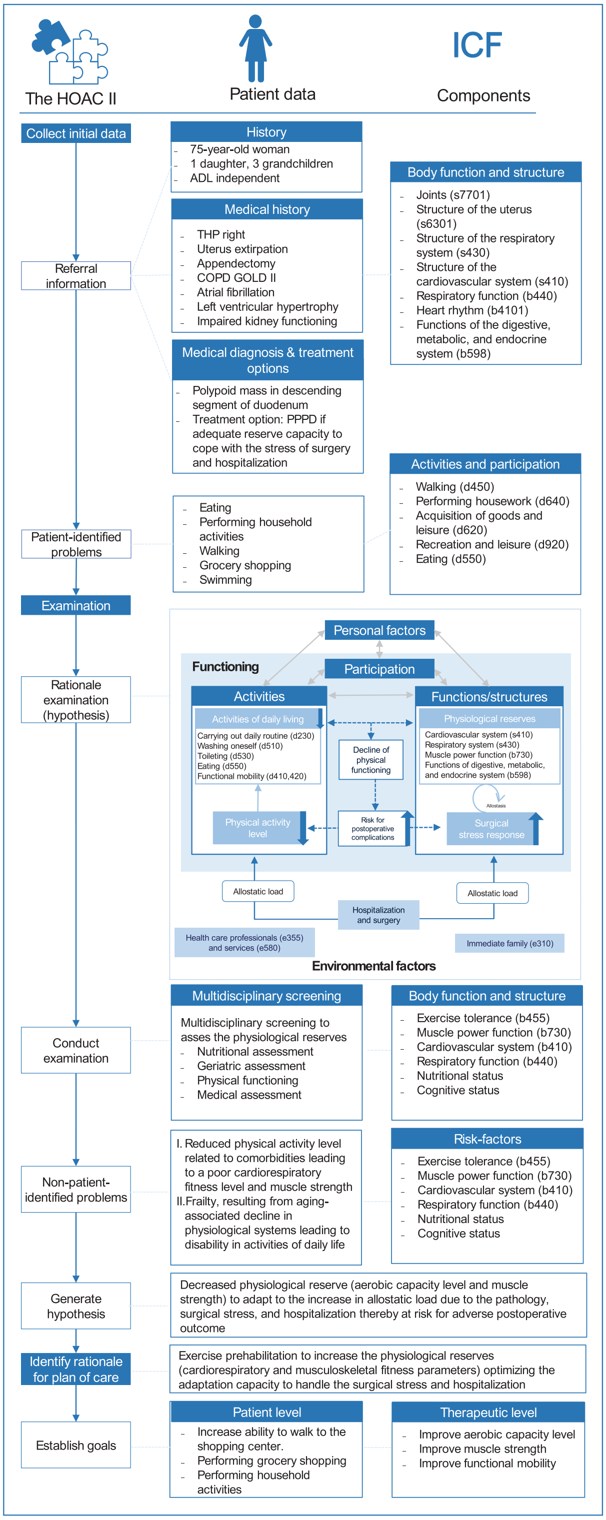


Figure 2. The step of the hypothesis-oriented-algorithm for clinicians II expanded with the international classification of functioning framework.

Abbreviations: ADL = activities of daily life; COPD = chronic obstructive pulmonary disease; PPPD = pylorus-preserving pancreaticoduodenectomy; THP = total hip replacement.

anthropometric measurements (e.g. body height, body mass, circumference of the mid-upper arm, triceps skinfold). An extensive description of the examination strategy of the physical therapist and clinical nurse specialist can be found in the Appendix.

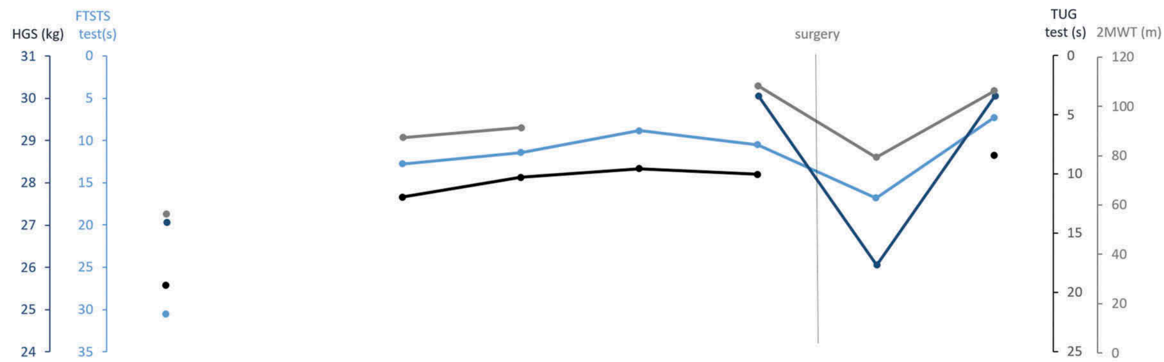
Results of preoperative examination

The anesthesiologist independently classified the patient with an American Society of Anesthesiologist (ASA) grade III and concluded that she was able to perform activities on an activity level of 4 metabolic equivalents of task (METs). Results of the additional cardiac and respiratory examination are shown in Table 1. Results of the preoperative examination of the physical functioning of the patient are presented in Figure 3 at time point T0. Nutritional assessment revealed an increase in body mass of 5 kg during the last 6 months. Moreover, no severe sarcopenic or cachexic state was observed by the nurse specialist. A comprehensive geriatric assessment was not recommended by the nurse specialist, despite a score <14 on the Geriatric 8. The rationale here was that the patient's low Geriatric 8 score could be entirely attributed to her age, medications, and functional mobility.

Table 1. Results of the medical, nutritional, and geriatric assessment.

Anesthesiologist	
General	
ASA classification	III
Mallampati	1
TMA	Normal
Physical fitness level (MET)	4
Cardiac evaluation	
Electrocardiagram	Sinus rhythm, LAD, LVH
Echocardiogram	LVEF 45–50%
Pulmonary evaluation	
Spirometry	FEV_1/FVC 69%; FEV_1 76%; DLCO 55% of predicted
Blood tests	
Hemoglobin (mmol/L)	6.2
Clinical nurse specialist	
Short nutritional assessment procedure	
Body height (m)	1.71
Body mass (kg)	85.0
Figure	Large
BMI (kg/m^2)	29.07
Body mass loss (kg)	+ 5.00
Arm circumference (cm)	34.00
Triceps skinfold (mm)	43.00
Muscle area upper arm (cm^2)	33.41
Fat area upper arm (cm^2)	58.58
Handgrip strength (kg)	27
Cognitive screening	
G-8	12

Abbreviations: ASA = American Society of Anesthesiologists; DLCO = diffusing capacity of carbon monoxide; FEV_1 = forced expiratory volume in 1 s; FVC = forced vital capacity; G-8 = Geriatric 8; LAD = left axis deviation; LVEF = left ventricular ejection fraction; LVH = left ventricular hypertrophy; MET = metabolic equivalent of task; TMA = thyroid-mandible angle.



	Reference value	T0 13.07.2017	T1 27.07.2017	T2 01.08.2018	T3 08.08.2017	T4 24.08.2017	T5 06.09.2017	T6 21.12.2017
HGS (kg)	21.40	27.00	-	-	-	30.00	26.00	30.00
FTSTS test (s)[a]	12.60	30.50	12.75	11.42	8.84	10.50	16.79	7.27
TUG test (s)[a]	9.20	19.41	11.96	10.29	9.55	10.03	-	8.44
2MWT (m)	140.9	55.00	86.00	90.00		107.0	78.00	105.0
VSAQ (METs)		2.0						
DASI (METs)		3.9						
		Preoperative screening	Prehabilitation			Admission	Discharge	Follow-up

[a] Lower scores on these tests are related to better performance.

Figure 3. Results of the performance-based tests during the pre- and postoperative period.
Abbreviations: DASI = Duke activity status index; FTSTS = five times sit-to-stand; HGS = handgrip strength; TUG = timed up-and-go; VSAQ = veterans-specific activity questionnaire; 2MWT = two-minute walk test.

Evaluation

Quantitative clinical impression II

The examination supported the clinical impression that this patient had several risk factors that might be associated with adverse peri- and postoperative outcomes. Her advanced age (75 years), body mass index ≥25 kg/m^2, COPD (Gold II), cardiovascular disease (atrial fibrillation, left ventricular hypertrophy), American Society of Anesthesiologists (ASA) grade III, and her impaired functional mobility performance at baseline (Figure 3) are all independently associated with postoperative 30-day morbidity after pancreaticoduodenectomy (De Oliveira et al., 2006; Greenblatt et al., 2011; Schneider et al., 2012; Venkat et al., 2011; Wiltberger et al., 2016). An ASA grade ≥III is associated with severe (Clavien-Dindo grade IV or V) postoperative complications (odds ratio [OR] of 1.496; 95% confidence interval [CI] of 1.186 to 1.887; *P*= .001) (Schneider et al., 2012) and higher risk for postoperative pulmonary complications (OR of 3.12; 95% CI of 2.17 to 4.48) (Smetana, Lawrence, and Cornell, 2006). The results of the spirometry revealed moderate COPD grade II (Tiffeneau index <70%; 50%< FEV_1 <80% of predicted). Although respiratory distress is a predictor for postoperative complications, mild-to-moderate COPD is not independently and directly associated with an increased risk for postoperative pulmonary complications after abdominal surgery (Wagner et al., 2016). The risk factors for development of pulmonary complications depend not solely on the patient's respiratory comorbidity (COPD), but also on procedure-related factors (e.g. respiratory consequences of surgery and anesthesia) (Licker et al., 2007) and context-related factors (e.g. early mobilization after surgery) (Haines, Skinner, and Berney, 2013). The dyspnea (e.g. shortness of breath and wheezing) noticed by the patient during ADL is typical for COPD patients and was noticed during the examination of her functional mobility performance. Consequently, this could explain the comprised walking distance on the 2MWT and the long duration at the TUG test. A TUG test score >20 s is an independent predictor for postoperative delirium (hazard ratio of 4.8; 95% CI of 1.5 to 15.6; *P*= .009) (Brouquet et al., 2010), major postoperative complications (OR of 3.43; 95% CI of 1.13 to 10.36; *P*= .03) (Huisman et al., 2014), and an increased length of stay of >7 days (OR of 4.21; 95% CI of 1.14 to 15.58; *P*= .003) (Huisman et al., 2014) in elderly undergoing surgery. In addition, the aerobic capacity of the patient was indicated as 'poor' based on her inability to perform the modified SRT (10 W/10 s) and low MET values on the VSAQ (2.0 METs) and DASI (3.9 METs) questionnaires. A patient's aerobic capacity is associated with postoperative time to recovery of physical functioning, complications, length of stay, and mortality in major abdominal surgery (Heldens et al., 2017; Moran et al., 2016b). Above findings support the limitations the patient experiences in ambulation, in walking long distances, and in performing household activities. These results correspond with the results of her self-reported physical activity level (VSAQ and DASI) and the estimated MET score of 4 METs by the anesthesiologist. Therefore, we expected that she was only able to perform activities with a light intensity (<4 METs).

Furthermore, approximately 30% of the patients >70 years develop a disability between the onset of their illness and their hospitalization or during their hospitalization resulting in a loss in adequate performance of activities of daily living (Covinsky, Pierluissi, and Johnston, 2011). The development of disability depends on several factors; preexisting frailty, severity of the illness, and the hospital culture and infrastructure (Covinsky, Pierluissi, and Johnston, 2011). Physical inactivity and immobilization, due to augmented bed rest during hospitalization, are associated with impairments in transfers and walking due to loss of muscle mass (Ikezoe et al., 2015). Therefore, the patient's preoperative functional mobility should be sufficient to prevent her from entering a critical zone postoperatively, which might lead to a delayed recovery of physical functioning, permanent loss of physical functioning, morbidity, and/or mortality (Hulzebos and van Meeteren, 2016). In conclusion, the patient's age, comorbidities, impaired functional mobility, and low aerobic capacity were considered risk factors for not being able to withstand the stress of hospitalization and surgery and, consequently, for having a higher risk for postoperative complications and an impaired recovery of physical functioning.

Plan of care

The results of the medical and functional preoperative assessment and the identified risk factors were discussed directly after the examination with the patient by the anesthesiologist, physical therapist, and clinical nurse specialist. Subsequently, the surgeon discussed the risks and benefits of performing a PPPD (e.g. postoperative complications, mortality, potential malignancy, and disease progression). Besides, she was educated about the importance of an adequate physical functioning level in relation to postoperative recovery of physical functioning and complications. Eventually, she opted for exercise prehabilitation to preoperatively improve her aerobic capacity, muscle strength, and functional mobility level, and thereby to reduce her risk for a delayed recovery or even permanent loss of physical functioning, morbidity, and mortality after surgery. There were no signs or symptoms for the need of nutritional or cognitive interventions. Although the patient did not like to perform exercise training (see quote), the patient and her surgeon agreed that she would benefit from participation in a prehabilitation program in order to reduce her perioperative risks and improve her recovery of physical functioning. Therefore, she decided to start preoperative exercise training at a community physical therapy practice in her neighborhood in order to preoperatively improve her level of physical functioning. The patient indicated: "*The surgeon told me that if he would operate on me in my current health status, I would not leave the operation theater alive. I needed more resilience and more reserves; he meant that I have to perform physical exercises. I thought, bah, I hate all that equipment.*"

Intervention

Prehabilitation has shown to be beneficial in patients with a higher risk for postoperative complications by preoperatively improving their low aerobic capacity that might decrease their risk for postoperative complications (Moran et al., 2016a; Thomas et al., 2019). A personalized prehabilitation program consisting of motivational interviewing, promotion of daily physical activity, and a supervised high-intensity training program in patients undergoing major elective abdominal surgery resulted in an increase in preoperative aerobic capacity and was found to be protective for the risk of postoperative complications (relative risk of 0.5; 95% CI of 0.3–0.8; $P < .001$) (Barberan-Garcia et al., 2018). Besides the fact that the prehabilitation program should be personalized, training intensity should be high enough to protract substantial progression in a relatively short period before surgery, improving her physical functioning shifting her preoperative health status from a high-risk profile to a low-risk profile. The physical exercise training program should focus on functional task exercises required for the patient's ADL (de Vreede et al., 2005), and training progression should not only consist of increasing the number of repetitions and intensity, but on increasing complexity and variability as well. Frequent monitoring of progression by patients (self-monitoring) and their physical therapist using functional exercise tests is important to assess the patient's response to the prehabilitation program. The latter is an interventional procedure known as 'titration', aiming to use the maximal potential for improvement of a patient (Glasziou, Irwig, and Mant, 2005). Target levels should be established at the start of the physical exercise training program and monitoring intervals should be short in the beginning to adequately record the expected asymptotic improvement in physical functioning following training sessions (e.g. law of diminishing returns) (Glasziou, Irwig, and Mant, 2005; Hoffman, 2014). When test results are within reasonable predicted limits, the monitoring intervals may become longer. However, when the predicted and expected asymptotic curvature of training gains fails to appear (aspects of a non-responding patient), CONTENT-issues (Hoogeboom et al., 2012) as prognosis and training parameters have to be reconsidered.

The patient participated in a partly supervised prehabilitation program at a nearby community physical therapy practice supplemented with functional task exercises she could perform at home. The four-week training program consisted of one-hour training sessions, which she attended twice per week. The aim of the preoperative physical exercise training program was to improve her aerobic capacity, muscle strength, and functional mobility using exercises in relation to ADL of relevance for her. The supervised training consisted of one-hour circuit training, including cycling, treadmill walking, resistance training, and functional task exercises, each lasting 15 min. For cycling, aerobic interval training on a cycle ergometer was performed, starting with three 4-min intervals in the beginning of the training, which progressed to two 7-min intervals in the last week. The initial work rate on the cycle ergometer was aimed to reach a Borg score 6–7 (0–10 Borg scale) for perceived exertion (Horowitz, Littenberg, and Mahler, 1996). For the interval training at the treadmill, the average walking speed on the 2MWT was determined, as examined at the start of each new training week. Hence, she started with an average walking speed of 2.6 km/h (2MWT distance of 86 m). The interval training at the treadmill consisted of three 4-min intervals at that walking speed. Intensity was verified with the 0–10 Borg scale (6–7) for perceived exertion. The resistance-training program included several exercises performed on weight-training machines: leg press focused on quadriceps, hamstrings, gluteus, and calf muscles; leg extension (quadriceps); lat-pull down focused on latissimus dorsi and trapezius; chest press focused on pectoralis minor and major; and triceps pulley (triceps). The intensity of the resistance training was set between 60% and 80% of the one repetition maximum based on the Oddvar-Holten diagram, and the patient performed three sets of 8–12 repetitions, according to the Dutch guideline for resistance training in patients with chronic obstructive pulmonary disease (Gosselink et al., 2008). Based on the 0–10 Borg scale for rating of perceived exertion, which should be 6 or 7, resistance-training intensity was progressed in order to maintain a sufficient training stimulus. Five functional task exercises were performed by the patient each week (sit-to-stand, weight carrying with bottles of water or groceries, side-step, walking with walker, and stair climbing). These exercises were also the patient's homework exercises for the non-supervised part of the prehabilitation program. Every new training session at the beginning of the week her progression was objectively measured using the TUG test, FTSTS test, and the 2MWT.

Outcome

Prehabilitation

The patient attended six preoperative exercise-training sessions. The adherence of the supervised training sessions was 75% (6/8 training sessions attended). The community physical therapist reported that the patient was highly motivated to participate in the personalized prehabilitation program. "*For regular physical therapy in the past, she did not always complete her exercises; however, that was not the case this time, as she really wanted to undergo surgery and she knew she had to improve her level of physical functioning preoperatively*". She improved on all tests of functional mobility including TUG test performance (from 19.41 to 10.03 s), FTSTS test performance (from 30.05 to 10.05 s), and 2MWT performance (from 55.0 to 107.0 m), thereby slightly showing an asymptotic training response curve (T1-T4) (Figure 3). In the last week of the prehabilitation program, she was not able to continue the two last supervised training sessions due to nausea. She continued her training the last week in her own living context. The perspective of the patient after 3 weeks of training was: "*I noticed that I experienced less fatigue when performing ADL than before. Actually, I started to enjoy exercising, because I felt fitter. Consequently, I called the nurse specialist to ask when the surgery will be executed. It took me long enough to wait for surgery, while knowing it is going to happen anyway.*"

Peroperative procedure and characteristics

Four weeks after the initiation of the prehabilitation program, the patient was scheduled for her surgical procedure, a PPPD. A right subcostal incision was made to open the abdomen and the peritoneal cavity was searched for metastases. No peritoneal metastases were detected and intraoperative ultrasound showed no liver metastases. Peroperatively, a local excision of the duodenum polyp at the papillary of Vater was performed because of an *à vue* benign appearance, which was confirmed intra-operatively with frozen section investigation. For postoperative pain control, a wound catheter with continues infiltration of local anesthetic (bupivacaine 0.125%, 8 mL/h) was placed in combination with patient-controlled morphine analgesia. Peroperative blood loss was 400 mL, and the total duration of surgery was 3 h and 34 min. The polyp was sent for examination to the department of pathology. A tubulovillous adenoma with multifocal high-grade dysplasia was diagnosed.

Postoperative recovery and follow-up

Postoperatively, the patient was sent deliberately to the intensive care unit because of her medical history. Physical therapy was initiated as of postoperative day (POD) 1, starting with optimizing respiratory gas-exchange using the active cycling breathing technique. She positioned herself in an upright position, under the supervision of the physical therapist, to increase the diaphragm excursion and to decrease the work of breathing. At POD 2, she was discharged to the HPB ward and she started to participate in functional task training (e.g. practicing transfers and walking). The physical therapist visited the patient once or twice a day, depending on her performance and level of exhaustion. At POD 6, she achieved functional independency based on the modified Iowa level of assistance scale without climbing stairs, as the latter was not relevant to her living status at home. At POD 7, functional mobility and muscle strength were re-assessed using the 2MWT, FTSTS test, and HGS (T5) (Figure 3). The patient showed a decrease in her functional mobility compared to her post-prehabilitation (T4) scores (2MWT distance of 78 m [−27.1%], FTSTS test of 16.79 s [+59.9%], and HGS of 26 kg [−13.3%]). The hospitalization period was extended with 4 days because of a preexistent staggering fluid balance; during these days, the patient remained functionally active and independent. The patient was discharged home at POD 12. At home, she resumed the physical exercise training program at the community physical therapy practice twice a week for 4 weeks. The aim of this supervised rehabilitation program was to regain physical functioning to the patient's level experienced and measured before diagnosis, focusing on aerobic and resistance training. The same training principles of the prehabilitation program were also applied for the rehabilitation program. After the supervised rehabilitation program, she picked up swimming again (once or twice a week), accompanied with more walking activities. These activities were not monitored by the community physical therapist. Three months after surgery the practical performance based-tests were performed by the hospital physical therapist to re-assess her level of physical functioning and self-reported perceived level of physical functioning. She performed at the same level as preoperatively measured after the prehabilitation program (T6) (Figure 3).

Discussion

This case report illustrates the identification of risks and therapeutic opportunities for prehabilitation with a patient with several risk factors for a complicated postoperative recovery. Using concepts as the HOAC II, ICF, and the CONTENT scale on the one hand, and evidence like the strong relation between preoperative physical functioning and postoperative outcomes (Heldens et al., 2017; Moran et al., 2016a), the importance of preoperative risk-stratification (Moran et al., 2016a), as well as the beneficial effects of prehabilitation (Barberan-Garcia et al., 2018; Moran et al., 2016a) on the other hand, the patient and her (in)formal caregivers as a team were able to improve her preoperative physical functioning in a real-life clinical context. Upon this prehabilitation trajectory, no postoperative complications and a fairly rapid recovery of physical functioning (6 days) occurred, followed by a continued improvement of her physical functioning after hospital discharge. The peroperative risk for morbidity and mortality during the surgical procedure was, in our opinion, only marginally determined by the change from a PPPD to a local resection of the ampulla of Vater, given that the preparation and anesthesiology were completed for a PPPD. Postoperatively, the risks for a delayed recovery or permanent loss of physical functioning, morbidity, and mortality are certainly slightly reduced after this procedure compared to a PPPD. Given the preparation with abdominal mobilization and the risk of leakage of pancreatic fluids, this procedure should still be classified as an abdominal surgical procedure with high risk for delayed or permanent loss of physical functioning, morbidity, and eventually mortality.

Identification of a patient's preoperative risk profile often relies on a classification system with conventional factors, such as age, ASA score, and comorbid conditions (De Oliveira et al., 2006; Greenblatt et al., 2011; Venkat et al., 2011; Wiltberger et al., 2016). However, adding variables of aerobic capacity, muscle strength, and functional mobility to conventional prediction models significantly improves the predictive value of postoperative outcomes (Ausania et al., 2012; Dronkers, Chorus, van Meeteren, and Hopman-Rock, 2013; Wijeysundera et al., 2018). In our case, the modified SRT to estimate aerobic capacity was not possible due to dyspnea complaints.

However, the additional practical performance-based tests seemed to be able to provide insight into her physiological reserve capacity. Although literature addressing practical performance-based tests of physical functioning in relation to postoperative outcomes in patients undergoing a pancreaticoduodenectomy is limited, measurements of functional mobility in terms of ADL performance are important and related to the postoperative course in patients undergoing major abdominal surgery (Dronkers, Chorus, van Meeteren, and Hopman-Rock, 2013; Hayashi et al., 2017; Heldens et al., 2017; Van Beijsterveld et al., 2019). Frequently performing these tests during the prehabilitation trajectory by the patient, their (in)formal caregivers, as well as the physical therapist should be encouraged to monitor progression and ensure optimal exercise dosage. Additionally, repeated monitoring progression might have beneficial motivational effects in responders; however, training should be adapted in case of non-responders because it might exert discouraging effects.

As presented in this case report, a short-term preoperative physical exercise training program is feasible and effective in a high-risk frail patient opting for major abdominal surgery. The exercise training provided in this case report can be considered therapeutically valid, since it contained seven out of nine items on the CONTENT scale. Previous reports about prehabilitation programs in patients undergoing major abdominal surgery show heterogeneous designs in terms of: patient selection; modalities (e.g. aerobic training, resistance training, inspiratory muscle training, or a combination); intensity (e.g. low to high training intensity); context (e.g. home, community, and/or hospital-based); and duration of training (Berkel et al., 2018). The use of resistance training in the training program focusing on individual muscle groups is debatable since functional task training involves training of these muscle groups as well. Functional task training has been reported to be more effective in the improvement of ADL in elderly compared to resistance training (de Vreede et al., 2005) and feasible in highly compromised elderly (Siemonsma et al., 2018). The patient improved in her physical functioning in which the greatest improvement was seen in the first 2 weeks after the preoperative assessment. This could be due to a suboptimal performance during the assessment in the hospital or because the patient became more physically active after her preoperative examination.

In order to preserve and to optimally make use of the effects of prehabilitation, a physically activating culture and infrastructure in both its context and processes in the hospital is a prerequisite to regain and preserve independent physical functioning in ADL as soon as possible after surgery (Hulzebos and van Meeteren, 2016). Sedentary behavior is however provoked, as the dominant hospital recovery strategy is still bed-centered care. A case report like this has the potential to address these issues and enables to discuss 'habits' in care processes and procedures. Improvement of the hospital clinical context at hand here may potentiate the recovery of the physical functioning of patients during hospitalization in the future. Furthermore, by evaluating single cases over time with scientific evidence, a multidisciplinary learning community could be developed, improving clinical practice and facilitating and evaluating health-care innovations ensuring research, quality and value-adding improvements in real-life clinical practice.

In the light of a gradual transition of stratified care to personalized health care, studying the perioperative trajectory and results of, in this case, an embedded prehabilitation phase in a single patient should be seen as a first step. This case report grants the opportunity to carefully and explicitly learn from practice and intertwined research. Moreover, in-depth analysis of a single case provides clinicians and researchers with detailed information on how all diagnostic and therapeutic interventions are executed and how their social, physical, and psychological responses unfold in real-life practice (Harris, 2019). With the use of the HOAC II for clinical reasoning, the ontology of the ICF, the CARE guidelines, and the CONTENT scale, an effort has been made to increase the internal validity and provide transparency and options for replicating the study and critical evaluation of the cause-effect considerations. Nevertheless, case studies are known for their scarce external validity (Lillie et al., 2011) and should therefore be replicated in order to be able to draw conclusions for the population addressed in the study. By combining multiple single case studies, the variability of patient responses to a certain intervention can be explored in its clinical or real-life variability.

This case report demonstrates how preoperative risk assessment can support clinical decision-making in coalition with a high-risk patient opting for major abdominal surgery and shows the feasibility and effects of preoperative physical exercise training in this high-risk patient. Furthermore, this case report illustrates how perioperative care can be improved by discussing evidence and reflecting on 'standard' perioperative care interventions in a single high-risk patient.

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Declaration of interest

The authors declare no conflicts of interest.

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Appendix

Description of the examination strategy of the physical therapist and clinical nurse specialist

Examination Physical Therapist

Self-Reported Physical Activity Level

The patient's perception of her functional capacity in performing activities of daily living was measured using the veterans-specific activity questionnaire (VSAQ) and the Duke activity status index (DASI). Both questionnaires consist of a list of activities linked to a particular metabolic equivalent of task (MET) score.[1–3] The VSAQ has a good intra- (ICC of 0.88; 95% CI of 0.76 to 0.94) and inter-rater reliability (ICC of 0.90; 95% CI of 0.80 to 0.95).[4] Both VSAQ (VO_{2peak}, ICC of 0.57, standard errors of estimate 7.63 mL/kg/min, $P < .0001$) and the DASI (VO_{2peak}, spearman correlation coefficient of 0.81) correlate moderate to good with aerobic capacity.[1,5]

Functional Mobility

Functional mobility was measured using the timed up-and-go (TUG) test (in s), two-minute walk test (2MWT, in m), and the five times sit-to-stand (FTSTS) test (in s). The TUG test measures the ability to rise from an arm chair (43 to 47 cm in height), walk a short distance (3 m), return to the chair, and sit down again, all as quickly as possible.[6] The TUG test is associated with time to recovery of physical functioning (odds ratio [OR] of 1.274; 95% CI of 0.975 to 1.664; $P = .008$) scored on the modified Iowa level of assistance scale (mILAS) in patients undergoing colorectal surgery.[7] During the 2MWT, patients have to walk as far as they can in 2 min over a length of 15 m with their customary walking aid, if applicable. The test has shown to have a good test–retest reliability (intraclass correlation coefficient (ICC) of 0.82; 95% CI of 0.76 to 0.87) in healthy adults between 18 and 85 years.[8] The FTSTS test is a performance-based functional test evaluating the combination of functional mobility, balance, and lower leg muscle strength.[9,10] Patients are asked to stand up and sit down from a chair (43 to 47 cm in height) as quickly as possible for five times with their arms folded across their chest. The FTSTS test is easy to perform in clinical practice and is reliable in community-dwelling older people (ICC of 0.89; 95% CI of 0.79 to 0.95).[10]

Muscle Strength

Evaluation of handgrip strength (HGS, in kg) of the dominant hand was performed to provide insight in general muscle strength using a hand-held dynamometer (JAMAR® Hydraulic Hand Dynamometers, JAMAR, Patterson, Medical Holdings, Inc., Ilinois, USA). Impaired preoperative HGS is related to increased postoperative morbidity, mortality, and prolonged hospital stay following surgery.[11–13]

Aerobic Capacity

To estimate aerobic capacity a steep ramp test (SRT) was performed. The SRT is a short-time maximal exercise test performed on a cycle ergometer (Lode Corival Rehab, Lode BV, Groningen, the Netherlands), in which the attained peak work rate (WR_{peak}, in W) is the primary outcome parameter. A modified incremental ramp protocol (10 W/10 s instead of the original 25 W/10 s) was used, as the duration of the test should be long enough to ensure sufficient involvement of the aerobic energy system. De Backer et al. found a strong correlation between aerobic capacity (VO_{2peak}, in mL/min) attained during a cardiopulmonary exercise test and the achieved WR_{peak} at the original SRT protocol ($r = 0.82$; $P < .001$).[14] In pancreatic cancer surgery, patients with a low aerobic capacity (oxygen uptake at the ventilatory anaerobic threshold (<10 mL/kg/min)) were found to be at an increased risk of postoperative complications (pancreatic fistula ($P = .028$)) and major intra-abdominal abscesses ($P = .042$), as well as an increased hospital length of stay (hazard ratio of 1.74; 95% CI of 1.14 to 2.64; $P = .010$).[15]

Examination Clinical Nurse Specialist

The clinical nurse specialist used two time-efficient screening methodologies to identify whether the patient was vulnerable and whether a referral for a comprehensive geriatric assessment and full nutritional assessment was necessary.

Geriatric Screening

The G-8 screening tool consists of eight questions concerning age (years), nutritional status, loss of body mass (in kg), body mass index (BMI, in kg/m^2), motor skills, psychological status, number of medications, and self-perception of health.[16–18] The G-8 is considered to be the most sensitive (ranges from 65% to 92%) screening tool for frailty in older cancer patients.[19]

Nutritional Status

The short nutritional assessment procedure (SNAP) is able to identify and monitor patients with a low-fat free mass index and low muscle strength.[20] The SNAP consists of the following anthropometric measurements: body height, body mass, circumference of the mid-upper arm, triceps skinfold, and HGS. Based on these measurements, BMI (kg/m^2), muscle area upper arm (cm^2), and fat area of the upper arm (cm^2) can be calculated.

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