

Postoperative Recovery in Frail, Pre-frail, and Non-frail Elderly Patients Following Abdominal Surgery

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Abstract

Background The objective of this study is to explore the association between frailty and surgical recovery over a 6-month period, in elderly patients undergoing elective abdominal surgery.

Methods A total of 144 patients were categorized as frail, pre-frail, and non-frail based on five criteria: weight loss, exhaustion, weakness, slowness, and low activity. Recovery to preoperative functional status (activities of daily living (ADL) and instrumental activities of daily living (IADL)), cognition, quality of life, and mental health was assessed at 1, 3, and 6 months postoperatively. A repeated measure logistic regression was used to analyze the effect of frailty on recovery over time. The effect of frailty on hospitalization outcomes was also evaluated.

Results Mean age was 78 ± 5 years with 17.4% of patients categorized as frail, 60.4% pre-frail, and 22.2% non-frail. At 6 months, the percent of patients who had recovered to preoperative values were: ADL 90%; IADL 76%; cognition 75.5%; mental health 66%; and quality of life 70%. While more frail patients experienced adverse hospitalization outcomes and fewer had recovered to preoperative functional status, these differences were not found to be statistically significant. Overall, frailty status was not significantly associated with the trajectory of recovery or hospitalization outcomes.

Conclusion Strong, institutional commitment to quality surgical care, as well as appropriate strategies for older patients, may have mitigated the impact of frailty on recovery. Further research is needed to examine the role of frailty in the surgical recovery process.

Introduction

Elderly patients aged 65 years and older represent a significant portion of individuals undergoing elective abdominal surgery [1]. This type of surgery has been shown to impact physiological function and patient autonomy in elderly patients [2]. These patients are often classified as frail, defined as “a biological syndrome with decreased physiological reserves across multiorgan systems which consequently reduces the ability to withstand stressors and increases the likelihood of poor outcomes” [3]. This syndrome has been associated with increased hospital length of stay (LOS), higher morbidity and

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mortality, greater risk of postoperative complications, and increased likelihood for readmission [4–7].

Most surgical studies investigating frailty focus on hospitalization outcomes, such as length of stay, occurrence of postoperative complications, and 30-day mortality [8–10]. However, the short-term nature of hospitalization outcomes captures limited information on patient health, poorly reflects what is considered important to elderly patients, and incompletely describes their recovery process. Recovery assessed by patient-centered outcomes, including functional status, cognition, mental health, and quality of life, has been shown to better characterize the full spectrum of patient recovery and present a relevant framework for reporting surgical recovery in elderly patients [11, 12]. The relationship between frailty and such recovery outcomes has been described mostly in the cardiac surgery population [13–16]. Among the few non-cardiac studies, only a limited subset of recovery outcomes has been examined [17–19].

The objective of this study is to explore the association of frailty and recovery of functional status, cognition, mental health, and perception of quality of life over the course of a 6-month follow-up period, in elderly patients undergoing elective abdominal surgery.

Methods

This study is a secondary analysis of data collected for a larger prospective study assessing the relationship between perioperative process-based quality indicators and recovery in elderly patients undergoing elective abdominal surgery at two university hospitals. Patient characteristics and hospitalization outcomes were collected retrospectively through chart review, and data pertaining to frailty criteria were determined by clinical assessments. Patients aged 70 years or older undergoing elective abdominal general surgery and requiring a postoperative hospitalization stay of at least one night were included in the study. The exclusion criteria were (1) inability to speak English or French, (2) surgery in the previous 6 months, (3) inability to ambulate, and (4) cognitive impairment or a Mini Mental State Examination (MMSE) [20] score of less than 18. All patients were assessed preoperatively and at 1 month, 3 months, and 6 months postoperatively at home or in hospital. The research team discontinued clinical assessments for patients who underwent subsequent surgeries within the 6-month follow-up period. Study data were collected in person at the hospital sites or at patient homes by three evaluators: a research nurse (DT), a surgical resident (MT), and a research assistant (TS) using a data management software on a laptop. Data were then transferred to a secure server within the hospital sites.

Patient characteristics

Age, sex, height, weight, the presence of cancer, and other comorbidities including chronic heart failure, chronic obstructive pulmonary disease, diabetes, and stroke were retrieved from the hospital charts of all patients. Comorbidity was measured by the Charlson Comorbidity Index (CCI), a weighted score ranging from 0 (no comorbidities) to 6 (death) including age and the following chronic conditions: myocardial infarction, congestive heart failure, peripheral vascular disease, cerebrovascular disease, dementia, chronic pulmonary disease, ulcers, liver disease, diabetes, hemiplegia, the presence of tumors (non-metastatic or metastatic), cancer, and AIDS [21]. High CCI scores have been associated with increased likelihood of adverse outcomes. Body mass index (BMI) was calculated using height and weight.

Frailty assessment

Preoperative frailty was assessed according to five frailty domains as outlined by Fried et al. [3]. Individuals exhibiting three or more frailty criteria were categorized as frail, one or two frailty criteria as pre-frail, and no criteria as non-frail [3].

1. Weight loss and nutritional status: Unintentional weight loss of 5% or more [3], mild to severe malnourishment, or a BMI less than 22 [22, 23].
2. Exhaustion: Self-reported usual energy level of the past month [24, 25].
3. Weakness: For women: BMI \leq 23 and hand grip strength (HGS) \leq 17 kg, 23 < BMI \leq 26 and HGS \leq 17.3 kg, 26 < BMI \leq 29 and HGS \leq 18 kg, or 29 < BMI and HGS \leq 21 kg. For men: BMI \leq 24 and HGS \leq 29 kg, 24 < BMI \leq 26 and HGS \leq 30 kg, 26 < BMI \leq 28 and HGS \leq 30 kg, or 28 < BMI and HGS \leq 32 kg [3]. The Jamar dynamometer was used for all HGS measurements [26].
4. Slowness: A gait speed less than 0.6 m/s [27].
5. Self-reported frequency and intensity of physical activity [28, 29].

Hospitalization outcomes

Patient charts were reviewed to obtain the following perioperative and postoperative information over the 6-month follow-up period: surgery type (colorectal, hernia, hepatopancreaticobiliary, esophagogastric, and small bowel); surgical approach (open or laparoscopic); length of hospital stay; discharge destination; mortality; readmission; occurrence of emergency department (ED) visit; number of postoperative outpatient clinic visits; and occurrence and

type of postoperative complications [30, 31]. The Comprehensive Complication Index was used to score the extent of a patient's complication on a scale of 0 (no complications) to 100 (death) [32].

Recovery outcomes

Recovery for functional status, cognition, mental health, and quality of life was assessed at each visit during the follow-up period. Patients were categorized at each study visit as having recovered for an outcome if their current status was at, or better than, their preoperative value.

Activities of daily living (ADL) (bathing, dressing, toileting, transferring, continence, and feeding) and instrumental activities of daily living (IADL) (shopping, meal preparation, housekeeping, laundry, transportation, telephone use, medication use, and finances) are measured by the Katz Index [33] and the Older American Resources and Services (OARS) scale [34], respectively, validated tools for measuring functional status in the geriatric population [33, 34]. We defined two measures of functional status that were used to determine recovery: the percentage of ADL tasks each patient was able to perform and the percentage of applicable IADL tasks each patient was able to perform.

Cognitive status was evaluated using the Montreal Cognitive Assessment (MoCA) [35], a validated tool for detecting mild cognitive impairment in the elderly. The score was adjusted for educational level [35].

Mental health was assessed with the Geriatric Depression Scale (GDS) [36], which has high reliability and validity for identifying depression in elderly patients.

Quality of life was measured using the EQ-5D-3L (EQ) [37], a composite score ranging from 0 (death) to 1 (perfect health) including five descriptive domains (mobility, self-care, usual activities, pain or discomfort, and anxiety or depression) and a measure of overall self-reported health [38].

The study was approved by the ethics review board of two hospitals affiliated with the McGill University Health Center, in Montreal, Canada.

Statistical analysis

For the recovery outcomes measured at multiple time points, the trajectory of recovery was modeled using a repeated measure multivariate logistic regression, which adjusted for possibly confounding variables such as age, gender, BMI, comorbidities (CCI), a cancer diagnosis, surgical approach, type of surgery, and the preoperative outcome value used in determining recovery. Time was included as a continuous covariate in the model. Both the main effect of frailty status and its interaction with time were included in the model, in order to estimate the impact

of frailty both on average recovery and on the trajectory of recovery over the 6-month follow-up period.

The hospitalization outcomes were modeled to determine the effect of frailty, adjusting for all previously mentioned covariates. LOS and the number of outpatient visits were modeled using a negative binomial distribution; the occurrence of a complication, readmission, and visit to the ED were modeled with a logistic regression. The Comprehensive Complication Index was modeled for those with a postoperative complication using a normal distribution. Effect estimates for the logistic models are presented as odds ratios (OR) and for the negative binomial models as incidence rate ratios (IRR).

Finally, preoperative patient and surgical characteristics as well as postoperative outcomes of subjects who completed the 6-month follow-up and subjects who voluntarily withdrew from the study were compared to assess potential bias due to loss of follow-up.

All analyses were performed using SAS software version 9.4 (SAS Institute Inc., Cary, NC).

Results

A total of 351 patients were identified and screened to participate in the study across both institutions; 71 patients did not meet the inclusion criteria, 88 patients refused to participate in the study, and 21 patients were unable to be reached by the research assistants. Overall, 280 patients were eligible for the study, of which 171 patients agreed to participate, resulting in a recruitment rate of 61.1%. Following enrollment, 27 patients were excluded from the analysis, most often due to the cancelation of their surgery, leading to a final study size of 144 patients. During the follow-up period, 125 patients were assessed at 1 month, 113 patients at 3 months, and 106 patients at 6 months. Thirty-eight patients (26.4%) withdrew from the study during the 6-month follow-up period, due to subsequent surgeries ($n = 5$), lack of motivation ($n = 10$), fatigue ($n = 8$), unavailable due to traveling ($n = 4$), loss to follow-up ($n = 6$), and death ($n = 5$). Data that were collected on these patients until their withdrawal remained in the analysis. No differences were observed between patients who withdrew or remained in the study.

Preoperative and surgical characteristics

The preoperative and surgical characteristics of 144 patients are provided in Table 1. At the preoperative visit, 17.4% were classified as frail, 60.4% as pre-frail, and the remaining 22.2% as non-frail (Table 1). Patients characterized as frail were older, were less capable of performing instrumental activities of daily living, had a lower

Table 1 Preoperative patient characteristics by frailty group

	Total sample (<i>N</i> = 144)	Frail (<i>n</i> = 25)	Pre-frail (<i>n</i> = 87)	Non-frail (<i>n</i> = 32)
Age, mean (SD)	77.8 (5.0)	81.3 (6.0)	77.4 (4.7)	76.2 (3.4)
Male gender, <i>n</i> (%)	79 (54.9)	15 (60.0)	47 (54.0)	17 (53.1)
Body mass index mean (SD)	27.7 (5.1)	26.4 (5.6)	28.0 (5.1)	27.6 (4.7)
Frailty markers, <i>n</i> (%)				
Weight loss	38 (26.4)	15 (60.0)	23 (26.4)	0 (0)
Exhaustion	23 (16.0)	16 (64.0)	7 (8.1)	0 (0)
Weakness	81 (56.3)	24 (96.0)	57 (65.5)	0 (0)
Slowness	14 (9.8)	9 (36.0)	5 (5.8)	0 (0)
Low physical activity	47 (32.9)	19 (79.2)	28 (32.2)	0 (0)
Living alone at home, <i>n</i> (%)	45 (31.3)	10 (40.0)	29 (33.3)	6 (18.8)
Charlson Comorbidity Index, median (IQR)	3.0 (2.0–6.0)	3.0 (2.0–6.0)	4.0 (2.0–6.0)	3.0 (2.0–6.0)
Cancer diagnosis, <i>n</i> (%)	98 (68.1)	18 (72.0)	57 (65.5)	23 (71.9)
Laparoscopic surgery, <i>n</i> (%)	40 (27.8)	5 (20.0)	24 (27.6)	11 (34.4)
Procedure type, <i>n</i> (%)				
Colorectal	81 (56.3)	16 (64.0)	44 (50.6)	21 (65.6)
Hernia	22 (15.3)	3 (12.0)	16 (18.4)	3 (9.4)
Hepatopancreaticobiliary	20 (13.9)	2 (8.0)	13 (14.9)	5 (15.6)
Esophagogastric	13 (9.0)	2 (8.0)	9 (10.3)	2 (6.25)
Small bowel	5 (3.5)	1 (4.0)	3 (3.5)	1 (3.1)
Other	3 (2.1)	1 (0.04)	2 (2.3)	0 (0.0)
Preoperative percentage of ADL ^a tasks performed, mean (SD)	99.3 (3.3)	99.3 (3.3)	99.0 (3.9)	100 (0)
Preoperative percentage of IADL ^b tasks performed, mean (SD)	92.1 (15.1)	83.2 (19.8)	93.3 (13.4)	96.0 (13.2)
Preoperative MoCA ^c score, mean (SD)	23.0 (3.5)	22.1 (3.9)	22.9 (3.6)	23.9 (3.0)
Preoperative GDS ^d score, mean (SD)	3.0 (2.6)	4.4 (3.2)	2.9 (2.3)	2.3 (2.3)
Preoperative EQ ^e score, mean (SD)	0.84 (0.14)	0.75 (0.15)	0.85 (0.13)	0.89 (0.11)

^aActivities of daily living

^bInstrumental activities of daily living

^cMontreal Cognitive Assessment

^dGeriatric Depression Scale

^eEQ-5D-3L for quality of life perception

proportion of laparoscopic surgery, had higher depression scores, and had lower quality of life scores, compared to patients who were characterized as pre-frail or non-frail.

Descriptive statistics on hospitalization procedures and outcomes

Patients underwent the following general surgery procedures: 81 with colorectal procedures (colon resection (*n* = 64, 44.4%), rectal resection (*n* = 14, 9.7%), Hartman's reversal (*n* = 2, 1.4%), rectopexy (*n* = 1, 0.69%); 20 with hepatobiliary procedures (Whipple (*n* = 8, 5.5%), hepatectomy (*n* = 4, 2.8%), distal pancreatectomy (*n* = 6, 4.2%), radiofrequency ablation of liver lesion (*n* = 1, 0.69%), ampullary resection (*n* = 1, 0.69%); 22 (15.3%) with incisional hernias; 13 with esophagogastric

procedures (hiatal hernia repair (*n* = 10, 6.9%), gastrectomy (*n* = 3, 2.1%); 5 with small bowel procedures (small bowel resection (*n* = 3, 2.1%) and ileostomy reversal (*n* = 2, 1.4%); 2 (1.4%) with splenectomy; and 1 (0.7%) with sarcoma resection (Table 1). Thirty-five percent (*n* = 50) of patients had one or more complication, with a median Comprehensive Complication Index score of 22.6 (IQR 8.7–26.2) (Table 2). The median length of hospital stay was 7.0 (IQR 4.0–9.0) days, and 93.1% (*n* = 134) were discharged to their home. Within the 6-month follow-up period, 18.8% (*n* = 27) of patients were readmitted to the hospital, 32.6% (*n* = 47) visited the ED, and the median number of outpatient visits was 5.5 (IQR 2.0–13.0) visits. Frail and pre-frail patients had a 2-day longer median LOS compared to non-frail patients. A greater proportion of frail patients had postoperative complications

Table 2 Postoperative outcomes by frailty group

	Total sample (<i>N</i> = 144)	Frail (<i>n</i> = 25)	Pre-frail (<i>n</i> = 87)	Non-frail (<i>n</i> = 32)
Length of stay, median (IQR)	7.0 (4.0–9.0)	7.0 (6.0–12.0)	7.0 (4.0–9.0)	5.0 (4.0–8.5)
Postoperative complications, <i>n</i> (%)	50 (34.7)	9 (36.0)	33 (37.9)	8 (25.0)
Comprehensive Complication Index ^a , median (IQR)	22.6 (8.7–26.2)	20.1 (8.7–22.6)	22.6 (8.7–29.6)	23.2 (8.7–36.8)
Discharged to home ^b , <i>n</i> (%)	134 (93.1)	21 (84.0)	83 (95.4)	30 (93.8)
Mortality, <i>n</i> (%)	5 (3.5)	1 (4.0)	3 (3.4)	1 (3.1)
Readmission ^c , <i>n</i> (%)	27 (18.8)	5 (20.0)	19 (21.8)	3 (9.4)
ED visits ^c , <i>n</i> (%)	47 (32.6)	9 (36.0)	30 (34.5)	8 (25.0)
Number of outpatient visits, median (IQR)	5.50 (2.0–13.0)	4.0 (2.0–11.0)	5.0 (2.0–12.0)	4.0 (2.0–11.0)

^aComprehensive Complication Index score of those with postoperative complications

^bNumber of patients admitted from home and discharged to their home

^cNumber of patients with at least one or more visit to the emergency department

(36% vs. 25%), readmissions (20% vs. 9%), occurrence of ED visits (36% vs. 25%), and fewer discharges to home (84.0% vs. 93.8%) compared to non-frail patients.

Descriptive statistics on recovery at 6 months

At the end of 6-month postoperative period, 90% of all patients had recovered to preoperative ADL status, 76% had recovered to preoperative IADL status, 75.5% had recovered to preoperative MOCA scores, 66% had recovered to preoperative GDS scores, and 70% had recovered to preoperative EQ scores. When comparing the rate of recovery by frailty group, we found that only 70% of frail patients had recovered to preoperative ADL status compared to 92% among pre-frail and 100% among non-frail (Fig. 1). In terms of IADL status, a similar trend was observed with 65% of frail patients having recovered to preoperative IADL status compared to 78% among pre-frail and 81% among non-frail. Recovery for MoCA at 6 months was similar across frailty groups, ranging from 70 to 73%. We observed, however, higher 6-month recovery for GDS among frail patients (79%) compared to pre-frail (67%) and non-frail patients (52%), while pre-frail patients showed higher recovery for EQ (77%) than frail (60%) and non-frail (54%).

Statistical modeling results

Overall, adjusted models for trajectories of recovery showed no statistically significant differences across frailty groups for ADL, IADL, MoCA, or GDS (Table 3). Only one significant difference was found in the trajectory of recovery for EQ between pre-frail and non-frail patients ($p = 0.02$). No association was observed between frailty and the hospitalization outcomes: postoperative

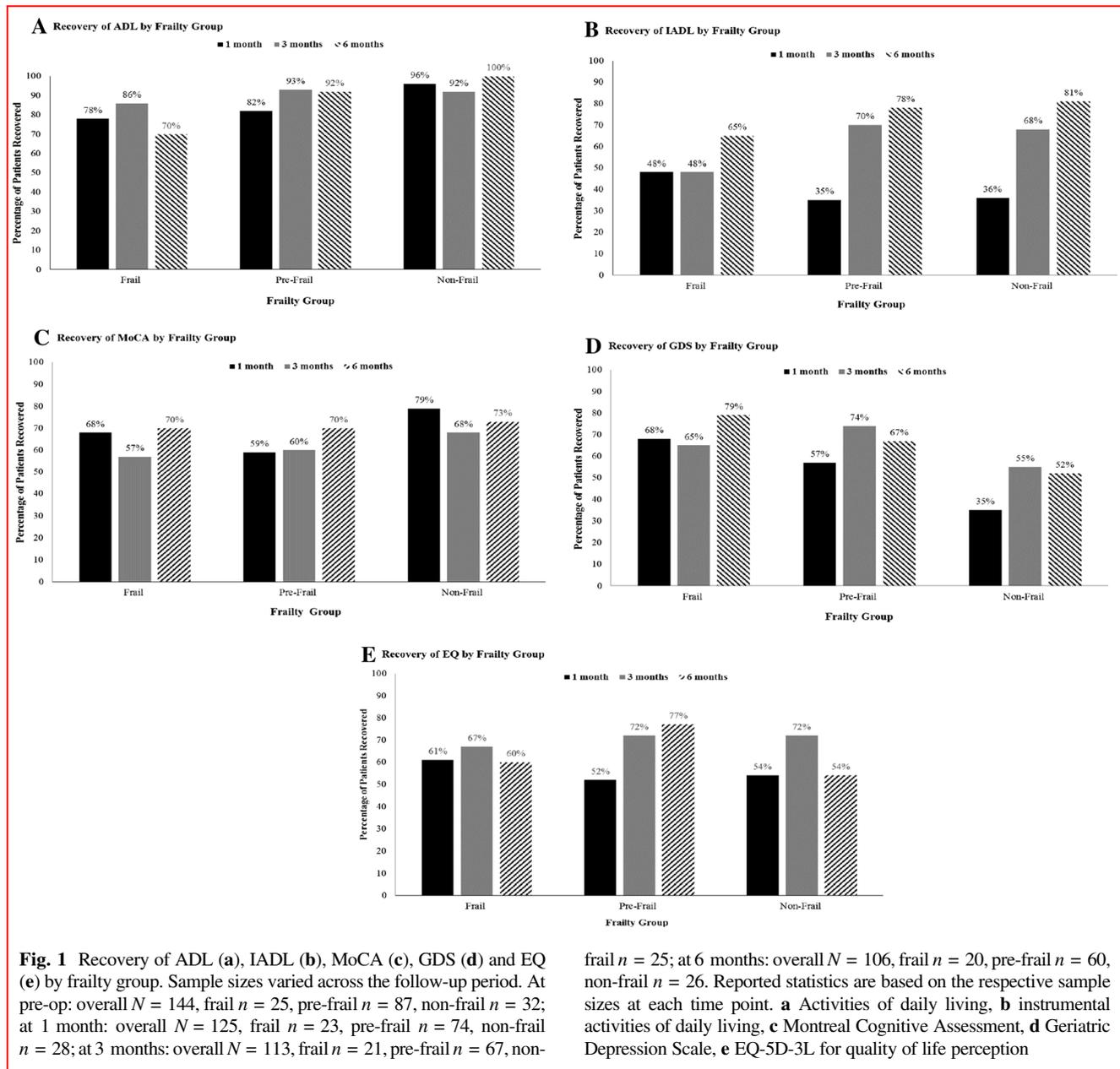
complications, readmissions, occurrence of ED visits, number of outpatient visits, and being discharged to somewhere other than home (Table 4).

Discussion

This study found that 6 months after surgery, a significant number of patients had not yet fully recovered to their preoperative levels. Frail patients demonstrated trends toward greater complications, longer length of stay, and higher postoperative readmissions and ED visits. Nevertheless, across frail, pre-frail, and non-frail individuals, the majority of the recovery trajectories did not show any statistically significant differences.

The cohort of patients in this study (significant comorbidity and 17% frail) is comparable to those found in other studies on surgical recovery in elderly patients [19, 39–41]. In our study, at 6 months, recovery of ADL and IADL was observed in 90% and 76% of patients, respectively. Recovery for cognition, mental health, and quality of life was seen in 66–76% of patients. In comparison, others have reported 76–90% ADL recovery and 81% IADL recovery at 6–12 months [42–44]. In addition, recovery for cognition has been reported in 73–92% of patients, in 70% for quality of life, and in 50–90% for mental health [41, 45, 46].

This study demonstrated a numerical trend consisting of frail and pre-frail individuals having higher lengths of stay, postoperative complications, readmissions, and visits to the ED, when compared to non-frail individuals. Similarly, less frail patients were discharged to home when compared to the pre-frail and non-frail groups. Nevertheless, these observed differences were not statistically significant. Several surgical studies have demonstrated an association



of frailty with increased length of stay [10], mortality [40, 47], readmissions [48], postoperative complications [10, 49], and decreased likelihood of being discharged to home [19]. Many of these studies have looked only at a subset of outcomes or at the evolution of outcomes over a shorter timeframe.

For patient-centered recovery outcomes at 6 months, there was no statistically significant difference in trajectories of recovery between frailty groups for functional status, cognition, and mental health. These findings are similar to a recent study of elderly patients undergoing colorectal surgery [41]. Finally, while others have shown that frailty is associated with a postoperative decline in

cognition [50, 51], the data on postoperative cognitive impairment after non-cardiac surgery are inconsistent and difficult to interpret.

While the results did not reach statistical significance, we did observe consistent trends showing slower recovery among frail subjects. Specifically, for functional status, we observed the lowest proportion of recovery among individuals categorized as frail compared to pre-frail and non-frail groups. Recovery to preoperative functional status is clinically relevant in re-establishing autonomy following surgery [44]. Furthermore, this is one aspect of recovery that can be potentially optimized, as demonstrated by a study, showing that pre-rehabilitation programs with

Table 3 Association between frailty and the trajectory of recovery

	ADL ^a			IADL ^b			MoCA ^c			GDS ^d			EQ ^e		
	OR	95% CI	p value	OR	95% CI	p value	OR	95% CI	p value	OR	95% CI	p value	OR	95% CI	p value
Interaction between time and pre-frail versus non-frail status ^f	1.00	(0.98, 1.01)	0.67	1.00	(0.99, 1.01)	0.52	1.00	(1.00, 1.01)	0.51	1.00	(0.99, 1.00)	0.47	1.01	(1.00, 1.02)	0.02*
Interaction between time and frail versus non-frail status ^g	0.99	(0.97, 1.00)	0.07	0.99	(0.98, 1.00)	0.19	1.00	(0.99, 1.01)	0.77	1.00	(0.99, 1.01)	0.71	1.00	(0.99, 1.01)	0.85
Time	1.01	(1.00, 1.02)	0.12	1.01	(1.01, 1.02)	<0.01*	1.00	(0.99, 1.01)	0.98	1.00	(1.00, 1.01)	0.08	1.00	(0.99, 1.01)	0.82
Pre-frail versus non-frail status ^h	0.38	(0.06, 2.21)	0.28	0.79	(0.30, 2.04)	0.62	0.42	(0.17, 1.05)	0.06	2.97	(0.95, 9.34)	0.06	0.516	(0.18, 1.45)	0.22
Frail versus non-frail status ⁱ	0.70	(0.08, 5.84)	0.74	1.15	(0.32, 4.08)	0.83	0.42	(0.14, 1.29)	0.13	1.64	(0.32, 8.43)	0.56	0.67	(0.16, 2.84)	0.59

Model estimates adjusted for age, gender, body mass index, comorbidities, cancer diagnosis, and the preoperative outcome value

**p* < 0.05 are statistically significant

^aActivities of daily living

^bInstrumental activities of daily living

^cMontreal Cognitive Assessment

^dGeriatric Depression Scale

^fDifference in trajectory of recovery of pre-frail group compared to non-frail group over 6-months

^gDifference in trajectory of recovery of frail group compared to non-frail group over 6-months

^hAverage recovery of pre-frail group compared to non-frail

ⁱAverage recovery frail group compared to non-frail group

Table 4 Association between frailty and hospitalization outcomes

	Length of stay			Occurrence of complications			Severity of complications		
	IRR	95% CI	<i>p</i> value	OR	95% CI	<i>p</i> value	Effect estimate	95% CI	<i>p</i> value
Pre-frail versus non-frail status ^a	1.17	(0.94, 1.46)	0.16	1.63	(0.62, 4.27)	0.32	− 2.63	(− 17.25, 12.00)	0.72
Frail versus non-frail status ^b	1.31	(0.98, 1.74)	0.07	0.99	(0.28, 3.58)	0.99	− 7.58	(− 27.46, 12.30)	0.45
	Occurrence of readmissions			Occurrence of ED visits			Number of outpatient visits		
	OR	95% CI	<i>p</i> value	OR	95% CI	<i>p</i> value	IRR	95% CI	<i>p</i> value
Pre-frail versus non-frail status ^a	4.05	(0.48, 34.30)	0.20	2.03	(0.77, 5.37)	0.15	1.07	(0.71, 1.61)	0.76
Frail versus non-frail status ^b	4.06	(0.36, 46.00)	0.26	2.10	(0.57, 7.67)	0.26	1.08	(0.64, 1.83)	0.78

Model estimates adjusted for age, gender, body mass index, comorbidities, and cancer diagnosis

^aPostoperative outcomes of pre-frail group compared to non-frail

^bPostoperative outcomes of frail group compared to non-frail group

physical conditioning improved functional recovery in frail patients undergoing colorectal surgery compared to elderly patients who were provided conventional surgical care [52].

Contrary to the limited surgical literature on the impact of frailty on surgical outcomes and recovery, we found no association between frailty and surgical recovery in our study [17–19]. Several reasons may explain this contradictory finding including differences in the operational definitions of frailty, specific outcomes, and the surgical population studied. The small portion of patients categorized as frail may have limited the statistical power to detect differences in the trajectories of recovery across outcomes. On the other hand, it may be that strong institutional commitment to quality surgical and geriatric care in the two study hospitals has limited the impact of frailty on surgical recovery. Proactive, preoperative preparation of elderly patients, sensitive to the needs and expectations of older persons, with referrals to comprehensive geriatric assessments for the most vulnerable, may help minimize adverse outcomes. Engagement of a multidisciplinary team of healthcare professionals, including social workers, physiotherapists, occupational therapists, and pharmacists, as well as education strategies, thorough discharge planning, and appropriate home support, has been crucial in addressing the variety of medical and psychosocial issues encountered by this population.

This study is not without limitations. Patient withdrawals during the follow-up due to reasons of fatigue or inability to travel may have been linked to poor functional status which would create a selection bias in the analysis of ADL/IADL outcomes. The study may have been underpowered for some outcomes. For hospitalization outcomes, the confidence intervals were generally wide and may include clinically meaningful effects that could have been detected with a larger sample. Confidence intervals for the

recovery outcomes, on the other hand, were very narrow, implying that power was not a limitation for these outcomes. While we included an overall index of comorbidity, data on individual comorbidities were not available.

In conclusion, this study is important in its effort to characterize postoperative recovery in frail, pre-frail, and non-frail patients by evaluating a comprehensive set of hospitalization and patient-centered outcomes, at multiple time points over the recovery period. Overall, it demonstrated that many elderly patients had still not fully recovered 6 months after surgery and that this trajectory did not statistically differ across frailty groups. Therefore, we suggest that frailty should not be considered a contraindication for surgery. Future studies should explore the possible benefits of surgical prehabilitation and optimization of perioperative care in the older surgical population.

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Compliance with ethical standards

Conflict of interest Ms. Sikder, Dr. Maimon, Ms. Sourial, Dr. Tahiri, Ms. Teasdale, Dr. H. Bergman, Dr. S. Bergman, and Dr. Demyttenaere have no conflicts of interest or financial relationships to disclose. Dr. Fraser is a preceptor for Covidien and Bard Canada.

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