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Outcomes

Compliance to an enhanced recovery pathway among patients with a high frailty index after major gastrointestinal surgery results in improved 30-day outcomes

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ABSTRACT

Background: Enhanced recovery pathways have been shown to improve clinical outcomes after surgery. Concerns exist about the feasibility of implementing enhanced recovery pathways in frail patients, who are at a greater risk for adverse postoperative outcomes. This study evaluated compliance and outcomes after enhanced recovery pathway implementation in high-risk, abdominal surgery patients.

Methods: Patients entered into the American College of Surgeons National Surgical Quality Improvement Program database who underwent abdominal surgery after enhanced recovery pathway implementation at two Johns Hopkins Medical Institutions were included. Risk was assessed using the American College of Surgeons National Surgical Quality Improvement Program validated, modified 5-item frailty index. Primary outcomes included compliance with 14 enhanced recovery pathway standards and postoperative length of stay, major complications (Clavien-Dindo score II–IV), and 30-day readmission.

Results: This study included 646 patients who participated in our enhanced recovery pathway program and 65 patients with modified 5-item frailty index ≥ 2 before enhanced recovery pathway implementation. Overall, 325 patients (50.3%) were high compliers (>75% compliance) with enhanced recovery pathway standards, with similar proportions of patients with a modified 5-item frailty index ≥ 2 or < 2 achieving high compliance (51.6% vs 50.2%, $P = .89$, respectively). Examining causality for "low compliers" among patients with a high frailty score (modified 5-item frailty index ≥ 2) demonstrated significant less use of goal-directed therapy when compared with "high compliers" (43% vs 75%, $P = .01$). Low compliers were also less likely than high compliers to experience mobilization the day of surgery (43% vs 78%, $P = .01$), postoperative day 1 (43% vs 88%, $P < .01$), and postoperative day 2 (60% vs 100%, $P < .01$). In addition, low compliers were less likely than high compliers to have their diet advanced to solids on postoperative day 1 (17% vs 59%, $P < .01$) and have their Foley catheter removed on postoperative day 1 (45% vs 97%, $P < .01$). Comparing our pre-enhanced recovery pathway patients with our enhanced recovery pathway cohort with a high frailty score, enhanced recovery pathway patients had a significantly shorter length of stay (4.5 vs 6 days, $P = .04$). However, adjusted analysis demonstrated that high compliance, and not just the enhanced recovery pathway intervention among patients with a high frailty score, was independently associated with a decrease in length of stay (odds ratio 0.72, 95% confidence interval 0.63–0.82, $P < .01$) and a significant reduction in major complications (odds ratio 0.30, 95% confidence interval 0.14–0.65, $P < .01$.

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Conclusion: This study demonstrates that frail patients comply well with a robust enhanced recovery pathway protocol and subsequently experience improved outcomes. Targeted interventions that seek to maximize compliance with specific enhanced recovery pathway standards may further improve outcomes in this population.

Introduction

Enhanced recovery pathways (ERPs) seek to attenuate the physiologic stress of surgery and maintain the preoperative functional status of compliant patients.[1] These programs have been shown to reduce adverse 30-day outcomes after a variety of surgical procedures.[2–4] Recently, we have shown that patients ≥65 years of age undergoing major gastrointestinal procedures experience reductions in length of stay (LOS) and major complications when adhering to an ERP protocol.[5] However, because age alone has not been shown to be a strong predictor of perioperative risk, we wished to examine the effect of ERP implementation on 30-day outcomes in a more "well-defined" high-risk population of patients.[6,7]

Frailty is an indicator of reduced physiologic reserve and is associated with a diminished ability to respond to stress.[8] It is now recognized as an independent predictor of adverse postoperative outcomes, including major complications and mortality, LOS, and loss of independence, as indicated by discharge to a skilled or assisted-living facility.[9,10] Recognizing the utility of frailty in the context of preoperative risk stratification, the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) and the American Geriatrics Society (AGS), in their jointly published guidelines for optimal preoperative geriatric care, included the recommendation that a frailty assessment be performed in older surgical patients.[11] Fundamentally, the ACS/AGS guidelines aim to help physicians identify high-risk patients and make the necessary preoperative considerations about their care.

In an initial effort to understand the implications of frailty on postoperative outcomes in the era of enhanced recovery, we utilized a well-validated, 5-item modified frailty index (mFI)[12] embedded in the ACS-NSQIP registry to identify patients with a high frailty score undergoing major intestinal surgery. We sought to determine whether patients with a high frailty score comply with an ERP and whether compliance among this population of patients independently improves postoperative outcomes.

Methods

Data source

Participants' data were obtained from the ACS NSQIP database. This database and the variables included in this database have been described extensively elsewhere.[13] This study was approved by the Johns Hopkins University Institutional Review Board (Baltimore, MD).

Participants

Patients from Johns Hopkins Hospital (JHH) and the Johns Hopkins Bayview Medical Center (JHBMC) who underwent major gastrointestinal surgery on our colorectal and gastrointestinal services between December 15, 2014, at JHH and July 1, 2015, at JHBMC through June 15, 2017, and participated in our ERP were identified in the ACS NSQIP database. Procedures included were defined by the primary Current Procedural Terminology (CPT) codes and All Patients Refined Diagnosis Related Groups (APR-DRG) 220-221 for major abdominal procedures or ICD-9 Procedure Codes (any position) 435, 436, 4389, and 4382. Patients <18 years of age and those whose procedures were emergent were excluded.

For comparison of 30-day outcomes among our ERP patients with a high frailty score defined as mFI ≥2, a cohort of patients were identified in ACS NSQIP from January 1, 2013, through December 14, 2014, (JHH) and June 30, 2015, (JHBMC) before ERP implementation who met the inclusion criteria. Because JHBMC did not join NSQIP until April 2015, patients were identified from hospital claims data and missing data points from this cohort were obtained through manual abstraction from the electronic medical record (EMR) by the ACS NSQIP nurse abstractors to provide consistency.

ERP protocol

Our health system ERP protocol was established in collaboration with the specific enhanced recovery standards outlined in ACS NSQIP, and all perioperative practices were implemented concurrently on December 14, 2015, at JHH and on July 1, 2015, at JHBMC. Implementation at both medical centers occurred within 6 months of migration to a new electronic medical record—EPIC—throughout the health system. This included the use of new preoperative and postoperative gastrointestinal ERP order sets. Our ERP standards were based on a multimodal approach that captures preoperative, intraoperative, and postoperative components of patient-centered care, which are specified for major intestinal surgery. Additional best practices performed at JHH and JHBMC included in the ERP protocol but not included in this analysis were as follows: standardized mechanical bowel preparation with oral antibiotics, preoperative cleansing by the patients with chlorhexidine wipes, and extended postoperative venous thromboembolism prophylaxis for patients with a Caprini score >5. None of the following medications were added to the protocol to prevent ileus (alvimopan, Entereg) or limit postoperative pain (injectable liposomal bupivacaine, Exparel) because these medications are not on the institutional formulary for use in this patient population.

Compliance measurements

To quantify compliance with our ERP after implementation, we prospectively collected patient data for the 14 Enhanced Recovery in NSQIP (ERIN) standards that correspond to our institutional practices, as previously described and outlined in Table I.[13] Compliance was assessed by two metrics: ERIN standard compliance and individual compliance. ERIN standard compliance was defined for each standard as the percentage of patients whose care met the standard definition. The denominator (total patients) used to calculate ERIN standard compliance was adjusted to exclude those patients prohibited from complying with that standard because of factors such as operative approach or being deemed "high-risk" per NSQIP data definitions. Individual compliance was defined for each patient as the percentage of the 14 ERIN standards

Table I
Observed ERIN variable compliance rates among high risk for frailty patients stratified by individual compliance (high versus low)

Variable- n/N^* (%)	High compliance (>75%) $N = 32$ (%)	Low compliance (≤74%) $N = 30$ (%)	*P*
Preoperative processes			
Preadmission counseling	27/32 (84.4)	22/30 (73.3)	.52
Allow clear liquids up to 3hours before induction†	27/32 (84.4)	21/30 (70.0)	.35
Day of surgery processes			
Use of multimodal pain management	32/32 (100)	30/30 (100)	1.00
Use of regional anesthetic‡	16/23 (69.6)	12/22 (54.5)	.37
Normal Temperature upon arrival to PACU	31/32 (96.9)	28/30 (93.3)	1.00
Use of goal-directed fluid therapy	24/32 (75.0)	12/30 (42.9)	.01
Use of antiemetic prophylaxis	31/32 (96.9)	29/30 (96.7)	1.00
Postoperative processes			
Mobilization on POD 0	25/32 (78.1)	13/30 (43.3)	.01
Patient was given clear liquids on POD 0	30/32 (93.8)	25/30 (83.3)	.25
Intravenous fluids discontinued POD 0	25/32 (78.1)	18/30 (60.0)	.17
Mobilization BID POD 1	28/32 (87.5)	12/30 (42.9)	< .01
Solids given POD 1	19/32 (59.4)	5/30 (16.7)	< .01
Foley removed on/before POD 1§	28/29 (96.6)	13/29 (44.8)	< .01
Mobilization BID POD 2	32/32 (100)	18/30 (60.0)	< .01
Overall mean compliance	(86.0)	(62.8)	

PACU, postoperative anesthesia care unit; *BID*, twice daily.
* *N* reflects the total number of patients not prohibited from complying with a variable per the following criteria.
† Total excludes high-risk patients for impaired gastric emptying, per NSQIP data definition.
‡ Total reflects open cases only.
§ Total excludes high-risk patients with concurrent urinary tract procedures, per NSQIP data definition.

that were successfully completed for that patient. For ease of analysis, we dichotomized individual compliance rates into "high" and "low" compliance. Based on our earlier work and that of others that suggest 70%–75% compliance is sufficient to improve postoperative outcomes after colorectal surgery, we set the benchmark for high individual compliance at ≥75%, or ≥11 of 14 of ERIN standards.[5,13–15]

5-item modified frailty index

Risk for adverse health outcomes was evaluated using a previously described 5-item modified frailty index (mFI).[12] The mFI comprises 5 conditions commonly comorbid with frailty: (1) history of chronic obstructed pulmonary disease, (2) congestive heart failure within 30 days before surgery, (3) functional health status before surgery (defined as partially dependent or totally dependent), (4) hypertension requiring medication, and (5) diabetes mellitus requiring oral agents or insulin. A calculation of the total mFI score for each patient is performed by tallying the number of these 5 variables present for that patient, with each variable denoting 1 point for a possible score of 0–5 points. Other authors have suggested a score of ≥2 as sufficient for predicting adverse outcomes among patients.[16] In the present study, participants were thus stratified by mFI scores of < 2 and ≥ 2, with mFI ≥2 indicating a high frailty score. We assessed the influence of a high frailty score on ERP compliance and on 30-day postoperative outcomes.

Outcomes measure

The 30-day postoperative outcomes were defined as occurrences observed after the index operation to 30 days postoperation, irrespective of the patient's disposition. Postoperative outcomes of interest included LOS, major complications assessed by the Clavien-Dindo (CD) grading system, and rate of readmission. LOS is defined as the postoperative time interval recorded in days from the date of operation to the day of discharge from inpatient acute hospital care. Postoperative complications were stratified using the CD grading system.[17] Readmissions—following the ACS NSQIP definition—is admission to any hospital related to the primary procedure within 30 days from the date of discharge.

Statistical analysis

Patient-level characteristics, procedure, risk indices, and overall morbidity were compared between patients with mFI < 2 or ≥ 2, using the Student *t* test with unequal variances for means, the Mann-Whitney *U* test for medians, and the χ^2 and Fisher exact tests for continuous and categorical variables, respectively. Pearson and Spearman correlation was used to assess correlation. Compliance rates were compared in a similar manner, and variable selection was based on clinical and scientific knowledge of factors that influence postoperative outcomes (age, sex, race, surgery classification and approach, and risk assessment) and Akaike information. Analyses were risk adjusted using the Physiological and Operative Severity Score for the enumeration of colorectal Mortality and Morbidity (CR-POSSUM), based on 12 physiologic and preoperative variables routinely collected during the hospital admissions process.[18] To identify patient-level characteristics of compliance with ERP, univariate logistic regression was performed and reported as odds ratios (ORs) and 95% confidence intervals (CIs). The relationship between the mFI versus compliance with the protocol and 30-day postoperative outcomes (LOS, CD, and readmission) were assessed using the Poisson regressions with quasi likelihood. The results are presented as incidence rate ratios (IRR) and OR with their corresponding 95% CI. A $P < .05$ was considered statistically significant in all analyses. All analyses were performed using STATA v 14.0 (StataCorp, College Station, TX).

Results

Study population demographics and procedure characteristics

From December 15, 2014, until June 15, 2017, a total of 646 patients at JHH and JHBMC met the inclusion criteria. Overall, 376

Table II
Demographic, clinical, and operative characteristics for ERP patients stratified by the mFI

Characteristic	Total ERP $N = 646$	mFI 0-1 $n = 584$	mFI ≥ 2 $n = 62$	*P value	Pre ERP mFI ≥ 2 $n = 65$	†P value
Age (years) - median (IQR)	59 (49, 69)	59 (48, 68)	66 (59, 76)	< .01	66 (57, 74)	.36
Sex- *n* (%)						
Male	329 (51)	292 (50)	37 (60)	.18	31 (48)	.21
Female	317 (49)	292 (50)	25 (40)		34 (52)	
Race- *n* (%)						
White	484 (75)	445 (76)	39 (63)	.02	44 (68)	.82
Black	96 (15)	79 (14)	17 (27)		16 (25)	
Others‡ /unknown	66 (10)	60 (10)	6 (10)		5 (8)	
Current smoker- *n* (%)	76 (12)	68 (12)	8 (13)	.68	9 (14)	1.0
Disseminated malignancies- *n* (%)	43 (7)	37 (6)	6 (10)	.29	3 (5)	.32
BMI (kg/m^2)- median (IQR)	27 (23, 31)	26 (23, 30)	30 (26 37)	< .01	31 (27,35)	.93
CR-POSSUM- median (IQR)	1.9 (1.0,3.6)	1.9 (1.0,3.6)	3.1 (1.3,5.0)	< .01	3.6 (2.4,5.0)	.18
mFI Variables- *n* (%)						
Diabetes	73 (11)	19 (3)	54 (87)	< .01	51 (78)	.24
Hypertension	244 (38)	183 (31)	61 (98)	< .01	65 (100)	.49
History of COPD	16 (3)	8 (1)	8 (13)	< .01	12 (79)	.39
History of CHF	1 (0.2)	0 (0)	1 (2)	.10	5 (7.7)	.28
Partially/totally dependent	2 (0.3)	1 (0.2)	1 (2)	.18	3 (5)	.62
Operative approach- *n* (%)						
Open	356 (55.1)	323 (55.3)	33 (53.2)	.79	47 (62)	.03
Laparoscopic	290 (44.9)	261 (44.7)	29 (46.8)		18 (38)	
Procedure type- *n* (%)						
Colectomy	375 (58.0)	330 (56.5)	45 (72.6)	.01	42 (64.5)	< .01
Proctectomy	195 (30.2)	186 (31.9)	9 (14.5)		22 (34)	
Other§	76 (11.8)	68 (11.6)	8 (12.9)		1 (1.5)	
New ostomy	—	—	14 (23)		19 (29)	.42
Postoperative outcomes						
LOS (days)- median (IQR)	4 (3, 7)	4 (3,7)	4.5 (3,9)	.13	6 (5,10)	.04
Complications -CD *n* (%)						
0-I	543 (84)	495 (85)	48 (77)	.14	51 (78)	1.0
II-IV	103 (16)	89 (15)	14 (23)		14 (22)	
Readmissions- *n* (%)	98 (15)	89 (15)	9 (15)	1.00	13 (20)	.49

ERP, enhanced recovery pathway; *COPD*, chronic obstructive pulmonary disease; *CHF*, congestive heart failure.
* Comparison of ERP patients with mFI < 2 and mFI $\geq$ 2.
† Comparison of pre-ERP patients to ERP patients with mFI $\geq$ 2.
‡ Asian, Native Hawaiian/Pacific Islander, American Indian/Alaska Native, or unknown.
§ Gastrectomy and proctopexy.

patients (58.2%) had an mFI of 0, 208 (32.2%) had an mFI of 1, 61 (9.4%) had an mFI of 2, and 1 (0.2%) had an mFI of 3. No patients had a mFI > 3. Patient level demographic and operative characteristics for the cohort are delineated in Table II. Stratifying the patients by mFI scores, patients with mFI $\geq$ 2 ($n = 62$) tended to be older, non-white, have a higher BMI, have a greater CR-Possum physiological score and predicted mortality risk, as compared with patients with mFI < 2. There was no 30-day mortality among the 646 patients studied.

Before ERP implementation in December of 2014, a total of 65 patients were identified with an mFI $\geq$ 2 and served as our pre-ERP cohort. These patients had similar characteristics to our ERP cohort with a high frailty score; however, in the pre-ERP cohort more patients underwent an open procedure and had a proctectomy (Table II). We observed no difference in the rate of new ostomy formation between the pre-ERP cohort and the ERP cohort (29% vs 23%, $P = .42$, Table II).

ERIN standard compliance

Overall, 325 ERP patients (50.3%) were "high compliers" or achieved compliance with greater than 11 of the 14 standards, with similar proportions of patients with an mFI $\geq$ 2 or < 2 achieving high individual compliance ($n = 32$, 51.6% vs $n = 293$, 50.2%, $P = .89$, respectively).

When examining causality for low individual compliance among our patients with a high frailty score, compliance rates for each of the 14 standards were compared between "high compliers" and "low compliers" (Table I). We noted similar rates of compliance for all preoperative standards; however, compliance declined for the day of surgery and postoperative standards. Among the "low compliers," there was significantly less use of goal-directed therapy compared with "high compliers" (43% vs 75%, $P = .01$). Low compliers were also less likely than high compliers to experience mobilization the day of surgery (43% vs 78%, $P = .01$), postoperative day (POD) 1 (43% vs 88%, $P < .01$), and POD 2 (60% vs 100%, $P < .01$). In addition, low compliers were less likely than high compliers to have their diet advanced to solids on POD 1 (17% vs 59%, $P < .01$) and have their Foley catheter removed on POD 1 (45% vs 97%, $P < .01$).

On adjusted analysis of all ERP patients (*data not presented*), high compliance was independently predicted by age (OR: 1.00, 95% CI: [1.00–1.01], $P < .01$), female sex (OR: 1.74, 95% CI: [1.64–1.85], $P < .01$), and laparoscopic approach (OR: 1.66, 95% CI: [1.19–2.31], $P < .01$), and being non-white predicted a reduced likelihood of achieving high compliance (OR: 0.76, 95% CI: [0.74–0.78], $P < .01$). High frailty scores had no significant effect on the likelihood of achieving high individual compliance (OR: 1.05, 95% CI: [0.95–1.18], $P = .34$).

Analysis of 30-day postoperative outcomes

Among all ERP patients, in unadjusted analysis, there was no significant difference between patients with an mFI < 2 and those

Table III
Risk-adjusted analysis: Factors associated with 30-day outcomes of LOS, complications (CD II-IV), and readmissions among all ERP patients ($n = 646$)

Variable	LOS		CD (II-IV)		Readmission	
	IRR (95% CI)	*P*	OR (95% CI)	*P*	OR (95% CI)	*P*
High compliance	0.85 (0.59–1.23)	.39	0.33 (0.12–0.91)	.03	0.72 (0.62–0.83)	<.01
Frailty index score						
mFI 0-1	Ref		Ref		Ref	
mFI ≥ 2	0.98 (0.78–1.22)	.84	1.55 (0.70–3.44)	.29	0.92 (0.75–1.12)	.38
Age	1.00 (0.99–1.00)	.85	1.02 (1.01–1.02)	<.01	1.00 (0.99–1.00)	.51
Sex						
Male	Ref		Ref		Ref	
Female	1.07 (0.98–1.16)	.14	1.13 (0.73–1.75)	.59	0.85 (0.64–1.14)	.29
Race						
White	Ref		Ref		Ref	
Black/Other*	1.24 (1.12–1.38)	<.01	1.05 (0.82–1.35)	.68	0.83 (0.67–1.02)	.08
BMI	1.03 (1.00–1.05)	.02	1.01 (0.99–1.04)	.24	0.99 (0.99–1.00)	.07
CR-POSSUM risk	1.00 (0.99–1.00)	.37	1.00 (0.99–1.01)	.50	1.03 (1.02–1.04)	<.01
Operative approach						
Open	Ref		Ref		Ref	
Laparoscopic	0.63 (0.60–0.66)	<.01	0.76 (0.63–0.92)	<.01	0.95 (0.64–1.40)	.78

Age and BMI were analyzed as continuous variables.
* Asian, Native Hawaiian/Pacific Islander, American Indian/Alaska Native, or unknown.

Table IV
Risk-adjusted analysis: Factors associated with 30-day outcomes of LOS, complications (CD II-IV), and readmissions among vulnerable (mFI ≥ 2) ERP patients ($n = 62$).

Variable	LOS		CD (II-IV)		Readmission	
	IRR (95% CI)	*P*	OR (95% CI)	*P*	OR (95% CI)	*P*
High compliance	0.72 (0.63–0.82)	<.01	0.30 (0.14–0.65)	<.01	1.68 (0.92–3.07)	.09
Age	1.00 (0.98–1.01)	.89	1.08 (0.99–1.17)	.07	1.10 (1.09–1.12)	<.01
Sex						
Male	Ref		Ref		Ref	
Female	0.98 (0.72–1.32)	.87	0.43 (0.18–0.99)	.05	0.63 (0.13–2.95)	.55
Race						
White	Ref		Ref		Ref	
Black/Other*	0.95 (0.83–1.08)	.43	1.39 (0.08–2.48)	.82	1.31 (1.23–1.39)	<.01
BMI	0.96 (0.93–0.99)	.02	1.05 (0.90–1.23)	.53	1.07 (0.94–1.21)	.32
CR-POSSUM risk	0.96 (0.94–0.98)	<.01	0.92 (0.22–3.81)	.91	1.04 (0.99–1.09)	.07
Operative Approach						
Open	Ref		Ref		Ref	
Laparoscopic	0.72 (0.53–0.98)	.04	0.74 (0.26–2.15)	.58	0.63 (0.24–1.66)	.35

Age and BMI were analyzed as continuous variables.
* Asian, Native Hawaiian/Pacific Islander, American Indian/Alaska Native, or unknown.

with an mFI ≥ 2 in postoperative LOS, rate of major complications, and rate of 30-day readmissions (Table II). However, when comparing patients with a high frailty score in our pre-ERP cohort with our ERP cohort, frail ERP patients had a significantly shorter LOS (4.5 vs 6 days, $P = .04$; Table II).

On adjusted analysis, among all ERP patients, high compliance with the ERP standards was independently associated with a reduction in major complications (OR 0.33, 95% CI 0.12–0.91, $P = .03$) and 30-day readmission (OR 0.72, 95% CI 0.62–0.83, $P < .01$; Table III). Similarly, having a laparoscopic procedure was also independently associated with a reduction in major complications (OR 0.76, 95% CI 0.63–0.92, $P < .01$) and LOS (IRR 0.63, 95% CI 0.60–0.66, $P < .01$). However, non-white patients and patients with a higher BMI were more likely to have an increased LOS. A high frailty score was not associated with a significant risk for poor postoperative outcomes.

Among the subgroup ERP patients with a high frailty score (62 patients), adjusted analysis confirmed that high compliance and not just the ERP intervention was independently associated with a decrease in LOS (OR 0.72, 95% CI 0.63–0.82, $P < .01$) and a significant reduction in major complications (OR 0.30, 95% CI 0.14–0.65, $P < .01$; Table IV). Similarly, having a laparoscopic procedure was independently associated with a decrease LOS (IRR 0.72, 95% CI 0.53–0.98, $P = .04$). Other findings also include an associated between higher BMI and a decrease in LOS (IRR 0.96, 95% CI 0.93–0.99, $P = .02$) and being non-white increased the likelihood of readmission within 30 days after surgery (OR 1.31, 95% CI 1.23–1.39, $P < .01$).

Discussion

Other studies have demonstrated that frailty is associated with poor 30-day outcomes for patients undergoing a variety of surgical procedures.[9,10] Similarly, a number of studies have demonstrated that implementation on an ERP improves 30-day outcomes after a variety of surgical procedures.[2–4] This study is the first study to our knowledge that examined the compliance rate of patients with a high frailty score to an ERP after major abdominal surgery and determined the effect of this compliance on outcomes. Similar to our earlier work, which demonstrated that elderly patients can comply with an ERP and have improved 30-day outcomes, this study demonstrated that high compliance with a robust ERP

independently accounted for improved 30-day outcomes, both overall and specifically among patients with a high frailty score. Overall, high ERP compliance independently accounted for significant reductions in our readmission rate and complication rate, as poor compliers had a 1.39-fold increased odds of being readmitted and had 3 times greater odds of developing postoperative complications. High ERP compliance among patients with a high frailty score decreased the odds of developing complications by more than 3-fold and predicted a nearly 30% reduction in LOS. Of note, this highlights the practical feasibility of improving outcomes among higher risk, frail patients by utilizing an ERP and justifies the need to allocate resources to improve compliance to meet the unique needs of this patient population.

Concerns have been expressed about the ability of frail patients to adhere to an ERP protocol. A recent systematic review by Bagnall et al[19] highlighted the benefits and feasibility of using an ERP in elderly patients; however, the review sited 13 studies in which patients with high-risk characteristics, including an elevated ASA (class 4 or 5), intensive care unit stay, or cognitive impairment were excluded from the ERP. Feroci et al[20] examined adherence to an ERP in patients undergoing colorectal surgery and identified age >75 years, male sex, and an ASA score of 3 to 4 as independent predictors of poor compliance with postoperative ERP standards. In a more recent study, Keller et al[21] examined the predictive value of frailty measures on outcomes in patients on an ERP. In this study, the 11-item ACS NSQIP frailty index (of which the mFI used in this study is based) was utilized. The authors demonstrated that frailty as measured by this index predicted prolonged length of stay and failure to achieve early discharge. However, this group did not report compliance rates with the ERP for frail or non-frail patients. Recently, we reported our findings on outcomes in our elderly patient population undergoing major abdominal surgery and demonstrated that 47% of our patients ≥65 years were highly compliant (≥75%) with the ERIN standards and that high compliance was associated with a 30% decrease in LOS and a 60% decrease in major complications.[5] Because age alone has been shown to be a poor predictor of compliance to an ERP and 30-day postoperative outcomes,[5,13] in this study, we examined compliance with an ERP among patients with a high frailty score and determined the effect of their compliance on 30-day postoperative outcomes. This study demonstrated that frail patients can comply with an ERP at similar rates to nonfrail patients and that high compliance to the ERP is associated with a significant decrease in LOS and in the likelihood of having a major complication.

There are several limitations to this study. Although our study included 646 patients undergoing surgery on an ERP, only 62 (9.6%) of our patient population were considered frail, which limited the strength of our analysis when examining our frail population alone. However, this is in keeping with most other studies where the prevalence of frailty among older patients undergoing major abdominal procedures ranged from 10% to 28%, independent of the method used to determine frailty.[9,10,21] There have been numerous frailty assessments developed during the past 20 years, the vast majority of which ascribe to either one of two prevalent models of frailty: the “frailty phenotype” model, first described by Fried et al[22] as a collection of phenotypes that include unintentional weight loss, weakness (grip strength), self-reported exhaustion, slow gait, and low physical activity levels; and the “accumulation of deficits” model, which quantifies vulnerability by scoring the number of various accumulated health “deficits” or comorbidities a patient demonstrates. Both of these models have been validated as appropriate means of defining and assessing risk in the operative setting.[23–25] Of most significance in this study is the use of the mFI, which examined frailty solely from an “accumulations of deficits” model and may not accurately identify the frail phenotype but rather those patients with high medical comorbidities. Given this concern, quality registries, such as the ACS NSQIP, should consider including a frailty assessment that identifies the frailty phenotype and the assessments currently embedded into the database.

Inherent biases exist when including two or more hospitals in a study; however, both of these hospitals are part of an integrated health system, and the ERP was standardized across institutions. For this reason, data from both institutions were included. In performing this study, we were unable to obtain complete compliance data on all patients because some patients were included in a period when ACS NSQIP was providing clarity to some of the ERIN standards and there was a lapse noted in documentation as the clinical reviewers gained expertise in this area. The majority of patients lacking data were young, non-frail patients, and we did not believe this greatly altered our outcome.

In conclusion, although frail patients have reportedly worse postoperative outcomes, we demonstrate here that they can adhere to and benefit from an ERP because high compliance is associated with improved outcomes. The incorporation of assessments into the preoperative clinical workflow aiding in early identification of frail patients may allow for implementation of interventions focused on achieving high ERP compliance, which may be most beneficial to this population.

Disclosures

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References

1. Kehlet H. Multimodal approach to control postoperative pathophysiology and rehabilitation. *Br J Anaesth*. 1997;78:606–617.
2. Greco M, Capretti G, Beretta L, Gemma M, Pecorelli N, Braga M. Enhanced recovery program in colorectal surgery: A meta-analysis of randomized controlled trials. *World J Surg*. 2014;38:1531–1541.
3. Nelson G, Ramierz PT, Ljungqvist O, Dowdy SC. Enhanced recovery program and length of stay after laparotomy on a gynecologic oncology service: A randomized controlled trial. *Obstet Gynecol*. 2017;129:1139.
4. Ljungqvist O, Scott M, Fearon KC. Enhanced recovery after surgery: A review. *JAMA Surg*. 2017;152:292–298.
5. Oluwafemi O, Hampton J, Bettick D, et al. High compliance to an enhanced recovery pathway for patients ≥ to 65 years undergoing major small and large intestinal surgery is associated with improved postoperative outcomes. *Ann Surg*; 2018 Jun 19. https://doi.org/10.1097/SLA.0000000000002872.
6. Braga M, Pecorelli N, Scatizzi M, et al. Enhanced recovery program in high-risk patients undergoing colorectal surgery: Results from the perioperative Italian Society Registry. *World J Surg*. 2017;41:860–867.
7. Polanczyk CA, Marcantonio E, Goldman L, et al. Impact of age on perioperative complications and length of stay in patients undergoing noncardiac surgery. *Ann Intern Med*. 2001;134:637–643.
8. Partridge JS, Harari D, Dhesi JK. Frailty in the older surgical patient: A review. *Age Ageing*. 2012;41:142–147.
9. Revenig L, Canter D, Taylor M, et al. Too frail for surgery? initial results of a large multidisciplinary prospective study examining preoperative variables predictive of poor surgical outcomes. *J Am Coll Surg*. 2013;217:665–670.
10. Makary MA, Segev DL, Pronovost PJ, et al. Frailty as a predictor of surgical outcomes in older patients. *J Am Coll Surg*. 2010;210:901–908.
11. Chow WB, Rosenthal RA, Merkow RP, Ko CY, Esnaola NF. Optimal preoperative assessment of the geriatric surgical patient: A best practices guideline from the American College of Surgeons National Surgical Quality Improvement Program and the American Geriatrics Society. *J Am Coll Surg*. 2012;215:453–466.
12. Chimukangara M, Helm MC, Frelich MJ, et al. A 5-item frailty index based on NSQIP data correlates with outcomes following paraesophageal hernia repair. *Surg Endosc*. 2017;31:2509–2519.

13. Sateri S, Azefor T, Ouanes JP, et al. Real time compliance monitoring with NSQIP: Successful method for enhanced recovery pathway implementation. *Perioperative Care and Operating Room Management*. 2017;8:6–11.
14. Gustafsson UO, Hausel J, Thorell A, Ljungqvist O, Soop M, Nygren J. Adherence to the enhanced recovery after surgery protocol and outcomes after colorectal cancer surgery. *Arch Surg*. 2011;146:571–577.
15. Pisarska M, Pedziwiatr M, Malczak P, et al. Do we really need the full compliance with ERAS protocol in laparoscopic colorectal surgery? A prospective cohort study. *Int J Surg*. 2016;36:377–382.
16. Chen SY, Stem M, Cerullo M, et al. The effect of frailty index on early outcomes after combined colorectal and liver resections. *J Gastrointest Surg*. 2018;22:640–649.
17. Clavien PA, Barkun J, de Oliveira ML, et al. The Clavien-Dindo classification of surgical complications: Five-year experience. *Ann Surg*. 2009;250:187–196.
18. Tekkis PP, Prytherch DR, Kocher HM, et al. Development of a dedicated risk-adjustment scoring system for colorectal surgery (colorectal POSSUM). *Br J Surg*. 2004;91:1174–1182.
19. Bagnall NM, Malietzis G, Kennedy RH, Athanasiou T, Faiz O, Darzi A. A systematic review of enhanced recovery care after colorectal surgery in elderly patients. *Colorectal Dis*. 2014;16:947–956.
20. Feroci F, Lenzi E, Baraghini M, et al. Fast-track surgery in real life: How patient factors influence outcomes and compliance with an enhanced recovery clinical pathway after colorectal surgery. *Surg Laparosc Endosc Percutan Tech*. 2013;23:259–265.
21. Keller DS, Bankwitz B, Nobel T, Delaney CP. Using frailty to predict who will fail early discharge after laparoscopic colorectal surgery with an established recovery pathway. *Dis Colon Rectum*. 2014;57:337–342.
22. Fried LP, Tangen CM, Walston J, et al. Frailty in older adults: Evidence for a phenotype. *J Gerontol A Biol Sci Med Sci*. 2001;56:M146–M156.
23. Robinson TN, Wu DS, Pointer L, Dunn CL, Cleveland JC, Moss M. Simple frailty score predicts postoperative complications across surgical specialties. *Am J Surg*. 2013;206:544–550.
24. Li G, Thabane L, Ioannidis G, Kennedy C, Papaioannou A, Adachi JD. Comparison between frailty index of deficit accumulation and phenotypic model to predict risk of falls: Data from the global longitudinal study of osteoporosis in women (GLOW) Hamilton cohort. *PLoS One*. 2015;10:e0120144.
25. Rockwood K, Song X, MacKnight C, et al. A global clinical measure of fitness and frailty in elderly people. *CMAJ*. 2005;173:489–495.