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Modified frailty index predicts high-risk patients for readmission after colorectal surgery for cancer

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ABSTRACT

Background: Modified frailty index (mFI) has been proposed as a reliable tool in predicting postoperative outcomes after surgery. This study aims to evaluate whether mFI could be utilized to predict readmissions after colorectal resection for patients with cancer by using nationwide cohort.

Methods: Patients undergoing elective abdominal colorectal resection for colorectal cancer were reviewed from the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) procedure-targeted database (2010–2012). A previously described mFI was calculated. Demographics, comorbidities, and 30-day postoperative complications were compared between patients who were readmitted or not after colorectal surgery.

Results: A total of 7337 patients were identified with a mean age of 65.8(±13.6) years. Eight hundred seventy-one (11.8%) patients were readmitted at least once within 30 days. Age, gender, BMI, and other comorbidities were comparable between the groups. O approach, current smoking, mFI(>3/11), disseminating cancer, bleeding disorder and longer operative time were found to independently associated with readmission.

Conclusions: An 11-point modified frailty index as measured in NSQIP correlates with readmissions after colorectal resection in patients with colon and rectal cancer.

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Introduction

Readmission following colorectal surgery for cancer is associated with one-year mortality.[1] In addition, high readmission rates following colorectal surgery causes a significant financial burden on the healthcare system. Recently, it has been reported that 11.4% of the patients who underwent colorectal surgery were readmitted with a mean cost of each readmission of $8885.[2] Unfortunately efforts to predict individual patient readmission, and reduce overall readmission rates have not reduced these numbers.

There are ongoing efforts to develop risk prediction indices.[3] The impact of frailty index has been studied in various surgical procedures such as urological,[4] thoracic,[5] orthopedic,[6] vascular,[7] bariatric,[8] and colorectal[9] surgeries to determine the risk of postoperative mortality, morbidity and readmission.

Fried et al.[10] described five criteria of physical frailty phenotype: unintentional weight loss, self-reported exhaustion, weakness, slow walking speed and low physical activity. Another phenotype of frailty is the multi-domain phenotype such as the Canadian Study of Health and Aging Frailty Index (CSHA-FI) including 70 items.[11] More recently, the CSHA-FI has been modified into the mFI which consists of 11 items. It has been noted that the mFI can predict postoperative mortality and morbidity.[12,13] Unfortunately the association between 11 item mFI and readmission is unknown yet.

This study aims to evaluate whether mFI is associated with readmission rates after colorectal resection for patients with cancer by using nationwide cohort. We hypothesized that frail patients may have a high risk for hospital readmission following colorectal resection for colorectal cancer.

Material and methods

Patients undergoing elective abdominal colorectal resection for colorectal cancer were reviewed from the American College of Surgeons National Surgical Quality Improvement Program (ACS-

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NSQIP) procedure-targeted database (2010–2012) according to their primary procedure Current Procedural Terminology (CPT) codes.

An mFI score was calculated for each patient by dividing the count of the number of factors a patient had by the total number possible. The eleven factors that make up the mFI score are[12]:

[1] dependent functional status[2]; history of diabetes mellitus[3]; history of chronic obstructive pulmonary disease or pneumonia[4]; history of congestive heart failure[5]; history of myocardial infarction[6]; history of percutaneous coronary intervention, stenting, or angina[7]; history of hypertension requiring medication[8]; history of peripheral vascular disease or ischemic rest pain[9]; history of transient ischemic attack or cerebrovascular event,[10] history of cerebrovascular accident with neurologic deficit,[11] history of impaired sensorium.

Demographics, comorbidities, 30-day postoperative complications were evaluated and compared between patients who were readmitted or not after surgery. Univariate and multivariate analyses using logistic regression analysis were conducted for predicting factors for readmission.

Univariate analyses were conducted between patient characteristics. Pearson's chi square or Fisher's exact test were used for categorical variables and ANOVA was used for continuous variables. MFI score was divided into two groups (low and high) at a cutoff value for each multivariable model below. Multiple cutoff values were assigned and the one that resulted with the maximal odds ratios was selected (3/11). The grouped versions of mFI used in each multivariate analysis was included in the univariate analyses along with continuous mFI.

Multivariable logistic regression models were fit to predict readmission based on mFI score. A stepwise selection procedure was used with alpha = 0.1 entry and alpha = 0.05 stay criteria. Variables considered for selection into each model were based on clinical relevance and univariate significance. For the readmission model, operative time, surgical procedure, surgical approach, smoke, disseminating cancer, bleeding disorder, preoperative chemo/radiotherapy, and ASA Class were considered. The cutoff value that resulted in the highest odds ratio for mFI was used for each model. Only this grouped version of mFI was included in the multivariable analyses. All analyses were performed using SAS (version 9.4, The SAS Institute, Cary, NC) and a $p < 0.05$ was considered statistically significant.

Results

A total of 7337 patients were identified with a mean age of 65.8 (±13.6) years [3524 (48.1%) female]. Eight hundred seventy-one (11.8%) patients were readmitted at least once within 30 days. The cutoff value that resulted in the highest odds ratio for mFI was 3/11.

Univariate analyses are summarized in Table 1. Age ($p = 0.25$), gender ($p = 0.81$), BMI ($p = 0.21$), and other comorbidities ($p < 0.05$) were comparable between the groups. Variables found to be related to readmission were ASA score, mFI, preoperative smoking, bleeding disorder, preoperative dyspnea, disseminated cancer, preoperative chemo/radiotherapy, rectal cancer, having a stoma and surgical approach.

After multivariate logistic regression analysis, open approach, current smoking, mFI (>3/11), disseminating cancer, bleeding disorder and longer operative time were found to independently be associated with readmission (Table 2). There was a significant increase in readmission for patients with an mFI score of 3/11 or greater [OR: 1.4 (1.1, 1.8), p: 0.005].

Discussion

Our study has shown that mFI is a quick and simple tool that defines a cohort of patients undergoing elective abdominal colorectal resection for cancer who are at high risk for readmission. There is a significant increase in readmission for patients with a high mFI score. In addition to a mFI of >3/11, an open surgical approach, current smoking, disseminating cancer, bleeding disorder and longer operative time were independently associated with early readmission following colorectal surgery for cancer.

Colorectal cancer is one of the most common cancer causing significant morbidity and mortality. Frequently surgical resection is required to improve survival. Despite the improvement of surgical technology and treatment options, readmission after surgery still remains as a concern.

Greenblatt et al.[1] conducted a study including 43,903 patients who were diagnosed with primary colon adenocarcinoma to determine the relationship between early readmission and 1-year mortality. It has been stated that the most common readmission reasons are gastrointestinal complications (28.3%) such as bowel obstruction and ileus, surgical site infection (7.6%), respiratory complications (7.1%), bleeding and anemia (6.9%), and sepsis (5.1%). They have also emphasized that readmission is strongly associated with 1-year mortality ($p < 0.0001$). The 1-year mortality rate for readmitted and non-readmitted patients were 26.6% and 11%, respectively. They stated that the most important factors causing this result were advanced stage disease and older age.

Predicting early readmission with high precision would be beneficial for both patients, payors and health care systems, such that it might give a targeted opportunity to reduce the significant associated mortality and financial burden on the healthcare system.

Pandit et al.[14] analyzed a total of 53,652 patients with colon cancer underwent elective surgery identified from the National Inpatient Sample database. They used a 9-item mFI to predict adverse outcomes among patients with colon cancer underwent surgery. The variables assessed as part of the 9-item mFI were: diabetes mellitus, congestive heart failure, chronic lung disease, peripheral vascular disease, hypothyroidism, depression, mental illness history, blood loss anemia and weight loss. They emphasized that frail patients are significantly associated with adverse outcomes in terms of postoperative complications, discharge disposition and length of stay.

Keller et al.[9] conducted a study to examine frailty as a predictor of patients who might fail early discharge. They used the 11-item mFI and stated that mFI is strongly associated with length of hospital stay. According to their results, patients with >2 mFI variables were less likely to successfully achieve early discharge. Also, different studies which used the 11-item mFI, have shown that patients with high mFI were associated with increased postoperative complications, 30-day mortality.[15] Also, the 11 item mFI was used to predict intensive care unit (ICU)-level complications and postoperative mortality in patients who underwent colectomy.[16] In addition our study has shown that patients with high mFI were associated with readmission.

Recently, a 5-item modified frailty index has been studied in predicting early outcomes after colorectal surgery. The variables were diabetes mellitus, congestive heart failure, chronic obstructive pulmonary disease, hypertension, and non-independent functional status. The authors stated that there is a significant association between 5- item mFI (mFI ≥ 2) and hospital readmission.[17]

Subramaniam et al.[18] conducted a study comparing the predictive ability of the 5-item mFI with that of the 11-item mFI. They emphasized that neither was a good predictor of early readmission as incompatible with our study. While we reviewed patients undergoing elective abdominal colorectal resection for colorectal

Table 1
Readmission summary.

Factor	Total (n = 7337)	Readmission (−) (n = 6466)		Readmission (+) (n = 871)		p-value
		n	Statistics	n	Statistics	
mFI	0.09 ± 0.09	6466	0.09 ± 0.09	871	0.10 ± 0.10	0.013[a]
Age	65.8 ± 13.6	6466	65.8 ± 13.5	871	65.3 ± 13.7	0.25[a]
Height	66.4 ± 4.2	6385	66.4 ± 4.2	865	66.7 ± 4.2	0.051[a]
Weight	177.8 ± 48.7	6431	177.5 ± 48.4	868	180.6 ± 51.3	0.072[a]
BMI	28.1 ± 7.1	6431	28.1 ± 7.0	868	28.4 ± 7.4	0.21[a]
Operation Time	189.8 ± 107.5	6466	186.9 ± 105.0	871	211.2 ± 122.4	<0.001[a]
mFI ≥ 3/11	597(8.1)	6466	505(7.8)	871	92(10.6)	0.005[c]
Gender		6462		869		
female	3524(48.1)		3103(48.0)		421(48.4)	
male	3807(51.9)		3359(52.0)		448(51.6)	0.81[c]
Surgical Approach		6466		871		
Open	4193(57.1)		3640(56.3)		553(63.5)	
laparoscopic surgery	3144(42.9)		2826(43.7)		318(36.5)	<0.001[c]
Smoke	1092(14.9)	6466	925(14.3)	871	167(19.2)	<0.001c
Disseminating Cancer	586(8.0)	6466	491(7.6)	871	95(10.9)	<0.001c
Bleeding Disorder	224(3.1)	6466	184(2.8)	871	40(4.6)	0.005c
ASAClass		6466		871		
1	149(2.0)		135(2.1)		14(1.6)	
2	2973(40.5)		2664(41.2)		309(35.5)	<0.001[c]
3	3854(52.5)		3366(52.1)		488(56.0)	
4	361(4.9)		301(4.7)		60(6.9)	

Statistics presented as Mean ± SD, Median [P25, P75], Median (min, max) or N (column %).p-values: a = ANOVA, b = Kruskal-Wallis test, c = Pearson's chi-square test, d = Fisher's Exact test.

cancer from NSQIP database between 2010 and 2012, they collected data of 9 surgical subspecialties using NSQIP database for only 2012. In the subgroup analysis of their study, 11-item mFI was not a strong predictive value for general surgery.

Current scoring systems such as ASA score and Charlson Comorbidity Index (CCI) could predict adverse postoperative outcomes. However CCI is a more detailed, quite complex scoring system with 19 diagnoses score.[19] Although univariate analyses showed that the ASA classification is associated with readmission, the score assignment is widely variable due to its subjectivity.[20] Nevertheless, it could be a useful adjunct to mFI to predict readmission in patients who underwent colorectal surgery for cancer.

There is no doubt that major abdominal surgery challenges the physiological reserve of patients with cancer and it is no surprise that frailty is associated with poorer outcomes. Enhanced recovery after stay in patients undergoing elective colorectal surgery,[21] however patients with high mFI are likely to have poor outcomes evan after the implementation of ERAS after surgery. Recent data suggest that pre-habilitation may provide additional benefit for patients undergoing surgery,[22,23] however further studies are needed to delineate the specifics of what is required.

Our study has several limitations that are usually present in large database studies. First, despite the fact that the use of a large database allows a broad view of national trends, it has a potential risk for bias as a result of coding and tracking errors. In addition there was no way to determine some informations such as the experience of surgeons, intraoperative complexities and nutritional status of patients. Despite these limitations, this study reflects a large pool of colorectal surgery patients.

Table 2
Multivariable logistic regression for readmission.

Effect	OR (95% CI)	p-value
mFI ≥ 3/11	1.4 (1.1, 1.8)	0.005
Operation time	1.00 (1.00, 1.00)	<0.001
Surgical_approach	1.3 (1.09, 1.5)	0.002
Current Smoke	1.4 (1.1, 1.6)	0.001
Dissemimating cancer	1.3 (1.06, 1.7)	0.014
Bleeding disorder	1.6 (1.1, 2.3)	0.009

OR: odds ratio; CI: confidence interval.

Conclusion

We have shown that mFI (>3/11), open approach, current smoking, disseminating cancer, bleeding disorder and longer operative time were independent predictors of early readmission following colorectal surgery for cancer. Strategies to reduce the modifiable components of frailty may improve surgical outcomes and reduce readmission rates.

Declaration of competing interest

The authors have no conflicts of interest or financial ties to disclose.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.amjsurg.2019.11.016.

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