



## National Surgical Quality Improvement Program analysis of unplanned reoperation in patients undergoing low anterior resection or abdominoperineal resection for rectal cancer ☆



Lily V. Saadat, MD<sup>a,\*</sup>, Adam C. Fields, MD<sup>a</sup>, Heather Lyu, MD<sup>a</sup>, Richard D. Urman, MD, MBA<sup>b,c</sup>, Edward E. Whang, MD<sup>a</sup>, Joel Goldberg, MD, MPH<sup>a</sup>, Ronald Bleday, MD<sup>a</sup>, Nelya Melnitchouk, MD, MSc<sup>a</sup>

<sup>a</sup> Department of Surgery, Brigham and Women's Hospital, Harvard Medical School, Boston, MA

<sup>b</sup> Department of Anesthesiology, Perioperative and Pain Medicine, Brigham and Women's Hospital, Harvard Medical School, Boston, MA; and

<sup>c</sup> Center for Perioperative Research, Brigham and Women's Hospital, Boston, MA

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### ABSTRACT

**Background:** The rate of unplanned reoperation for rectal cancer can provide information about surgical quality. We sought to determine factors associated with unplanned reoperation after low anterior resection and abdominoperineal resection for patients with rectal cancer and outcomes after these reoperations.

**Methods:** The American College of Surgeons National Surgical Quality Improvement Program database was used to conduct this retrospective study. Patients who underwent elective low anterior resection and abdominoperineal resection for rectal cancer from 2012–2014 were identified. The primary outcomes were 30-day reoperation rates and postoperative complications.

**Results:** A total of 454 low anterior resection patients (5.9%) and 289 abdominoperineal resection patients (8.1%) required reoperation within 30 days of their index operation. The most common reasons for reoperation were infection, bleeding, and bowel obstruction. Multivariate analysis revealed that male sex (odds ratio: 1.5,  $P = .001$ ), poor functional status (odds ratio: 2.2,  $P = .04$ ), operative time (odds ratio: 1.001,  $P = .01$ ), low preoperative albumin (odds ratio: 0.79,  $P = .04$ ), and lack of ostomy (odds ratio, 0.66,  $P = .005$ ) were independent risk factors for reoperation after low anterior resection. Smoking (odds ratio: 1.7,  $P = .001$ ), chronic obstructive pulmonary disease (odds ratio: 1.8,  $P = .03$ ), poor functional status (odds ratio: 2.1,  $P = .032$ ), operative time (odds ratio: 1.003,  $P < .001$ ), low preoperative albumin (odds ratio: 0.69,  $P = .007$ ), and open approach (odds ratio: 1.5,  $P = .02$ ) were independent risk factors for reoperation after abdominoperineal resection. Postoperative complication rates are high for those undergoing reoperation, often leading to non-home discharge ( $P < .001$ ) after reoperation.

**Conclusion:** Reoperation after low anterior resection and abdominoperineal resection for rectal cancer is not uncommon. This study highlights the indications for reoperation, potentially modifiable preoperative risk factors for reoperation, and the morbidity associated with such operations.

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### Introduction

Variation in surgical outcomes has been a topic of wide discussion and research in the setting of the rising cost of healthcare. Traditionally, metrics such as morbidity and mortality have been used as proxies for surgical quality.<sup>1</sup> Recent data have demon-

strated the utility of unplanned reoperation rates as a quality metric for monitoring quality across hospitals because they are discrete, easily tracked events.<sup>2–6</sup> Moreover, reoperations have clear implications for increased patient morbidity and healthcare costs.<sup>7,8</sup> For example, 1-year mortality after colorectal surgery has been shown to be independently predicted by reoperation.<sup>9</sup> Given its importance, several variables relating to unplanned reoperations were added to the American College of Surgeons (ACS) National Surgical Quality Improvement Program (NSQIP) database in 2012, allowing for closer examination of these patients and their overall outcomes.

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\* Corresponding author: Lily Saadat, MD, 75 Francis Street, Boston, MA 02108.  
E-mail address: [lsaadat@partners.org](mailto:lsaadat@partners.org) (L.V. Saadat).

Earlier studies have found that colorectal operations account for the greatest proportion of unplanned reoperations, with associated increases in overall hospital cost and mortality rates.<sup>3</sup> In colorectal cancer patients, reoperation in the early postoperative period has been further associated with worse long-term oncologic outcomes.<sup>10</sup> Merkow et al<sup>1</sup> demonstrated that 5.7% of colorectal patients required reoperations. Despite the clear implications of reoperation on overall patient outcomes and cost, there are no studies focused on unplanned reoperations in patients with rectal cancer undergoing abdominoperineal resection (APR) or low anterior resection (LAR) and risk factors associated with reoperation.

The aim of this study was to determine the factors associated with unplanned reoperation after LAR and APR for patients with rectal cancer and to examine the outcomes after these reoperations using ACS NSQIP database. The goal is to provide recommendations for risk stratification based on preoperative characteristics that may improve overall patient outcomes.

## Methods

### Data source and patient selection

The ACS NSQIP is a validated, risk-adjusted, national program that provides data on patient demographics, medical comorbidities, operative variables, and postoperative events, which can be used for quality improvement. Further details of ACS NSQIP are described elsewhere.<sup>11</sup> Using the ACS NSQIP database, we identified 11,297 patients undergoing LAR or APR from 2012 through 2014. We utilized 2012–2014 data because these were the first years that unplanned reoperation was included in the NSQIP database. Patients were identified using Current Procedural Terminology codes for APR and LAR, including 45110, 44146, 44155, 44156, 55157, 44158, 44145, 44207, 44208. This study was reviewed by the Brigham and Women's Hospital Institutional Review Board (Boston, MA) and found to be exempt.

### Variables and outcomes

Demographic, preoperative, operative, and postoperative variables were obtained for analysis. Patient demographic variables included age, race, sex, body mass index (BMI), American Society of Anesthesiologists (ASA) class, and associated comorbidities. Metrics of patients' preoperative functional status, as defined by their ability to perform activities of daily living in the 30 days before surgery, were also collected. Use of chronic preoperative steroids within 30 days before the principle operative procedure or at the time of surgical consideration was also noted. Surgical procedures were categorized by type, approach (open versus laparoscopic), and wound class. All procedures were for rectal cancer, and patients undergoing emergency operations were excluded. Laboratory variables obtained included creatinine, albumin, hematocrit, and platelets. Postoperative complications were analyzed and included superficial, deep, and organ space infections and pulmonary complications such as pneumonia and pulmonary embolism, renal insufficiency, cardiac arrest or myocardial infarction, bleeding, deep vein thrombosis, sepsis, death, and readmission. We also analyzed discharge destination, which refers to home versus nonhome discharge.

The primary study outcome was unplanned reoperation within 30 days of the index procedure. Unplanned reoperation was defined by the NSQIP database as an "unplanned return to the operating room for a surgical procedure related to either the index or concurrent procedure performed ... [and] may occur at any hospital or surgical facility," including hospitals other than the facility where the index procedure was performed.<sup>12</sup> Secondary outcomes included postoperative complications.

## Statistical analyses

Bivariate exploratory analyses were carried out using Pearson  $\chi^2$  or Fisher exact tests for categorical variables and independent *t* tests for continuous variables. Multivariate logistic regression analysis was then performed to determine independent risk factors for reoperation. All lab values were expressed as mean values with standard deviations.  $P < .05$  was considered statistically significant for all tests run. All statistical analyses were calculated using SPSS software v 20.0 (IBM, Armonk, NY).

## Results

A total of 11,297 patients were identified; 7,714 patients underwent LAR and 3,583 patients underwent APR. A total of 454 LAR patients (5.9%) and 289 APR patients (8.1%) required reoperation within 30 days of their index operation.

### Patient characteristics and risk factors for reoperation

In the LAR group, patients who needed a reoperation compared with patients who did not need a reoperation were older (62.4 vs 60.9 years,  $P=.01$ ), more likely to have preoperative hypertension (53% vs 44.9%,  $P=.001$ ), use steroids (4.4% vs 2.6%,  $P=.03$ ), had worse functional status (3.08% vs 1.06%,  $P < .001$ ), and had a higher ASA class (61.6% vs 51.4%,  $P < .001$ , [Table 1](#)). Patients who were female (29% vs 42%,  $P < .001$ ) or white (68.7% vs 76.8%,  $P=.001$ ) were less likely to have a reoperation. Patients who had longer index operation times had higher rates of reoperation (250 minutes vs 236 minutes,  $P=.01$ ). Reoperation was more common in patients who did not have an ostomy at the time of the index surgery (46.9% vs 40.1%,  $P=.005$ ). High preoperative creatinine, low albumin, and low platelets were also associated with increased risk of reoperation ([Table 1](#)).

For patients who underwent APR, reoperation was similarly more common in older patients (63.5 vs 61.6 years,  $P=.02$ ). Reoperation was also higher in patients who had chronic obstructive pulmonary disease ([COPD] 8.3% vs 4.4%,  $P=.003$ ) or were active smokers (31.8% vs 20.3%). Patients with poor functional status (4.8% vs 2.1%,  $P=.005$ ) and high ASA class (69.5% vs 63.2%,  $P=.04$ ) were also at an increased risk of reoperation. Longer index operative time was again noted to be associated with reoperation (349 minutes vs 289 minutes,  $P < .001$ ). Low albumin was found to be associated with reoperation (3.72 g/dL vs 3.8,  $P=.003$ ); however, creatinine, hematocrit, and platelet level were not associated with reoperation in the APR cohort ([Table 2](#)).

Multivariate analysis was conducted, which revealed that male sex (odds ratio [OR]: 1.7, 95% CI: 1.35–2.23,  $P=.001$ ), poor functional status (OR: 2.2, 95% CI: 1.03–4.50,  $P=.04$ ), operative time (OR: 1.002, 95% CI: 1.001–1.008,  $P=.001$ ), low preoperative albumin (OR: 0.80, 95% CI: 0.63–0.99,  $P=.05$ ), and lack of ostomy during the index procedure (OR: 0.66, 95% CI: 0.52–0.89,  $P=.001$ ) were independent risk factors for reoperation after LAR ([Table 3](#)). Smoking (OR: 1.7, 95% CI: 1.2–2.4,  $P=.001$ ), COPD (OR: 1.8, 95% CI: 1.1–3.1,  $P=.03$ ), poor functional status (OR: 2.1, 95% CI: 1.1–4.3,  $P=.032$ ), operative time (OR: 1.003, 95% CI: 1.002–1.004,  $P < .001$ ), low preoperative albumin (OR: 0.69, 95% CI: 0.53–0.90,  $P=.007$ ), and open approach (OR: 1.5, 95% CI: 1.1–2.1,  $P=.02$ ) were independent risk factors for reoperation after APR.

### Indications for reoperation

The mean time to reoperation was 10.6 days and 13.1 days for LAR and APR, respectively. After LAR, the most common cause for reoperation was postoperative infection (20.3%, [Table 4](#)). Wound

**Table 1**  
Patient characteristics for LAR.

Demographics	No reoperation (7,260)	Reoperation (454)	P value
Age (years)	60.97 ± 12.76	62.49 ± 13.04	.01
Female	3,105 (42.77%)	133 (29.30%)	< .001
BMI (kg/m <sup>2</sup> )	28.29 ± 6.34	28.37 ± 6.13	.77
Race			
White	5,575 (76.79%)	312 (68.72%)	.001
Black	462 (6.36%)	45 (9.91%)	
Asian	328 (4.52%)	18 (3.96%)	
Other	895 (12.33%)	79 (17.40%)	
Comorbidities			
Diabetes	1,097 (15.11%)	73 (16.08%)	.58
HTN	3,264 (44.96%)	241 (53.08%)	.001
COPD	254 (3.50%)	20 (4.41%)	.31
Smoker	1,146 (15.79%)	83 (18.28%)	.16
Functional status	77 (1.06%)	14 (3.08%)	< .001
Steroid use	192 (2.64%)	20 (4.41%)	.03
Weight loss	287 (3.95%)	23 (5.07%)	.24
Procedure characteristics			
Laparoscopic	3,824 (52.67%)	225 (49.56%)	.2
Wound class 3/4	573 (7.89%)	53 (11.67%)	.004
ASA class 3/4	3,734 (51.43%)	280 (61.67%)	<.001
Operative time (min)	236.11 ± 112.16	250.38 ± 119.72	.01
Preoperative labs			
Creatinine (mg/dL)	0.90 ± 0.34	0.97 ± 0.46	.002
Albumin (g/dL)	3.97 ± 0.51	3.89 ± 0.54	.005
HCT (%)	39.02 ± 4.77	39.08 ± 5.34	.81
Platelet (× 10 <sup>3</sup> )	243.64 ± 78.18	235.40 ± 74.63	.03

HTN, hypertension.

**Table 2**  
Patient characteristics for APR.

Demographics	No reoperation (3,294)	Reoperation (289)	P value
Age (y)	63.56 ± 12.72	61.66 ± 13.62	.02
Female	1,337 (40.59%)	101 (34.95%)	.06
BMI (kg/m <sup>2</sup> )	27.65 ± 6.35	28.10 ± 7.03	.26
Race			
White	2,554 (77.53%)	212 (73.36%)	.001
Black	274 (8.32%)	44 (15.22%)	
Asian	109 (3.31%)	8 (2.77%)	
Other	357 (10.84%)	25 (8.65%)	
Comorbidities			
Diabetes	526 (15.97%)	52 (17.99%)	.37
HTN	1,622 (49.24%)	137 (47.40%)	.55
COPD	146 (4.43%)	24 (8.30%)	.003
Smoker	669 (20.31%)	92 (31.83%)	<0.001
Functional status	72 (2.19%)	14 (4.84%)	.005
Steroid use	113 (3.43%)	10 (3.46%)	.98
Weight loss	245 (7.44%)	23 (7.96%)	.75
Procedure characteristics			
Laparoscopic	1,136 (34.49%)	75 (25.95%)	.003
Wound class 3/4	490 (14.88%)	52 (17.99%)	.16
ASA class 3/4	2,083 (63.24%)	201 (69.55%)	.04
Operative time (min)	289.65 ± 125.88	349.13 ± 167.40	< .001
Ostomy	3,404 (46.9%)	182 (40.1%)	.005
Preoperative labs			
Creatinine (mg/dL)	0.92 ± 0.48	0.97 ± 0.92	.34
Albumin (g/dL)	3.84 ± 0.52	3.72 ± 0.56	.003
HCT (%)	37.90 ± 4.67	37.46 ± 5.14	.14
Platelet (× 10 <sup>3</sup> )	245.40 ± 85.53	250.58 ± 88.99	.33

HTN, hypertension.

disruption (9.7%), bleeding complications (7.5%), and obstruction (6.6%) were other causes for reoperation in the immediate postoperative period. Genitourinary complications, ostomy complications, ischemic colitis, and perforation were also found to be associated with reoperation in this cohort. Similarly, after APR, the most common cause for reoperation was postoperative infection (17.3%) followed by wound disruption (15.6%), obstruction (9.7%), and bleed- ing complication (8.7%).

#### Postoperative complications

In the LAR cohort, the risk of all complications was higher in the reoperation cohort, except for cerebrovascular accident where there was no statistical difference between the reoperation and the no reoperation cohort (Table 5). For patients undergoing APR, reoperation was associated with higher rates of superficial, deep, and organ space infections; dehiscence; pneumonia; failure to wean

**Table 3**  
Multivariate analysis.

Independent risk factors for reoperation after APR	OR	95% CI	P value
Smoking	1.7	1.2–2.4	.001
Functional status	2.1	1.1–4.3	.032
COPD	1.8	1.1–3.1	.03
Operative time	1.003	1.002–1.004	< .001
Albumin	0.69	0.53–0.90	.007
Open surgery	1.5	1.1–2.1	.02
Independent risk factors for reoperation after LAR	OR	95% CI	P value
Male	1.7	1.35–2.23	.001
Functional status	2.2	1.03–4.50	.04
Operative time	1.002	1.001–1.008	.001
Albumin	0.80	0.63–0.99	.05
Ostomy	0.66	0.52–0.89	.001

**Table 4**

Indications for reoperation.

Reoperation causes in APR (289 cases)	Mean days to reoperation
Postop infection (50)—17.3%	13.1 ± 8.4
Wound disruption (45)—15.6%	
Obstruction (28)—9.68%	
Bleeding complication (25)—8.65%	
Ostomy complication (17)—5.89%	
GU complication (12)—4.15%	
Reoperation causes in LAR (454 cases)	Mean days to reoperation
Postop infection (92)—20.3%	10.62 ± 7.49
Wound disruption (44)—9.7%	
Bleeding complication (34)—7.5%	
Obstruction (30)—6.6%	
GU complication (21)—4.6%	
Ostomy complication (20)—4.4%	
Ischemic colitis (11)—2.4%	
Perforation (8)—1.8%	

GU, Genitourinary.

from ventilator; bleeding; deep vein thrombosis (DVT); sepsis; septic shock; death; and readmission (Table 6). Of note, patients who underwent reoperation for either LAR or APR were significantly more likely to have a nonhome discharge ( $P < .001$ ; Tables 6 and 5).

## Discussion

This is the first study in the literature to analyze factors associated with reoperation and outcomes after reoperation in patients undergoing LAR or APR for rectal cancer. Understanding predictive factors for reoperations can help risk-stratify patients and focus efforts to improve overall outcomes. Early identification of patients who are at high risk for reoperation can additionally help operative planning and patient counseling. In this study, we showed that 8.1% of APR patients and 5.9% of LAR patients required reoperation within 30 days of the index operation for management of infection, bleeding, and bowel obstruction. Operative time, poor nutritional status, and poor functional status were major risk factors for reoperation.

Earlier studies on reoperation rates after all colorectal surgery have reported rates ranging from 1.8% to 14%<sup>1,3–5</sup>; there are no studies looking specifically at rectal cancer surgery, which is technically more difficult and carries a higher complication rate.<sup>13</sup> The timing of complications after APR or LAR for rectal surgery is also not well defined in the literature. One study in patients undergoing laparoscopic or open colectomy analyzed the rate of anastomotic leak in colorectal surgery and timing to detection of this complication. This study concluded that the mean time after index operation for anastomotic leak was 9.8 days.<sup>14</sup> In our study, the mean time to reoperation was 10.6 days and 13.1 days for LAR and APR,

**Table 5**  
Postoperative complications after LAR.

	No reoperation (7,260)	Reoperation (454)	P value
Surgical complications			
Superficial infection	350 (4.82%)	46 (10.13%)	< .001
Deep wound infection	51 (0.70%)	29 (6.39%)	< .001
Organ space infection	288 (3.97%)	206 (45.37%)	< .001
Bleeding	585 (8.06%)	92 (20.26%)	< .001
Dehiscence	33 (0.45%)	38 (8.37%)	< .001
Medical complications			
PNA	85 (1.17%)	48 (10.57%)	< .001
Pulmonary embolism	35 (0.48%)	15 (3.30%)	< .001
Failure to wean from vent	30 (0.41%)	51 (11.23%)	< .001
Renal insufficiency	98 (1.35%)	23 (5.07%)	< .001
Renal failure	37 (0.51%)	17 (3.74%)	< .001
UTI	225 (3.10%)	33 (7.27%)	< .001
CVA	10 (0.14%)	1 (0.22%)	.65
Cardiac arrest	21 (0.29%)	11 (2.42%)	< .001
MI	29 (0.40%)	15 (3.30%)	< .001
DVT	56 (0.77%)	21 (4.63%)	< .001
Sepsis	155 (2.13%)	104 (22.91%)	< .001
Septic shock	34 (0.47%)	60 (13.22%)	< .001
Death	38 (0.52%)	17 (3.74%)	< .001
Readmission	819 (11.28%)	183 (40.31%)	< .001
Discharge destination	388 (5.34%)	85 (18.72%)	< .001

CVA, Cerebrovascular accident; PNA, Pneumonia; UTI, Urinary tract infection.

**Table 6**  
Postoperative complications after APR.

	No reoperation (3,294)	Reoperation (289)	P value
Surgical complications			
Superficial infection	297 (9.02%)	44 (15.22%)	.001
Deep wound infection	121 (3.67%)	65 (22.49%)	< .001
Organ space infection	138 (4.19%)	46 (15.92%)	< .001
Bleeding	657 (19.94%)	102 (35.29%)	< .001
Dehiscence	80 (2.43%)	50 (17.30%)	< .001
Medical complications			
PNA	78 (2.37%)	19 (6.57%)	< .001
Pulmonary embolism	21 (0.64%)	7 (2.42%)	.006
Failure to wean from vent	37 (1.12%)	19 (6.57%)	< .001
Renal insufficiency	24 (0.73%)	5 (1.73%)	.08
Renal failure	12 (0.36%)	5 (1.73%)	.009
UTI	178 (5.40%)	17 (5.88%)	.73
CVA	5 (0.15%)	1 (0.35%)	.4
Cardiac arrest	17 (0.52%)	0 (0%)	.39
MI	25 (0.76%)	4 (1.38%)	.29
DVT	28 (0.85%)	9 (3.11%)	.002
Sepsis	129 (3.92%)	43 (14.88%)	< .001
Septic shock	24 (0.73%)	13 (4.50%)	< .001
Death	28 (0.85%)	7 (2.42%)	.02
Readmission	401 (12.17%)	114 (39.44%)	< .001
Discharge destination	410 (12.45%)	70 (24.22%)	< .001

CVA, Cerebrovascular accident; PNA, Pneumonia; UTI, Urinary tract infection.

respectively. These data may allow providers to predict timing of morbid complications in the postoperative period.

Earlier studies have suggested that demographic factors have little impact on postoperative outcomes and frequency of postoperative procedures after colorectal surgery.<sup>5</sup> Other studies have concluded that patient characteristics, such as age, comorbidities, and acuity of surgery, were associated with postoperative outcomes and are more predictive than other metrics including annual colorectal surgical volume.<sup>15</sup> We identified several patient characteristics that predicted a higher risk for reoperation. Poor functional status and low preoperative albumin were found to have a significant association with reoperation after both APR and LAR. Low preoperative albumin can provide information about a patient's overall nutritional status before surgery and can be predictive of wound healing potential. This is supported by a study that analyzed prognostic nutritional index, a measure calculated based on the serum albumin concentration and peripheral blood lymphocyte count and its ability to predict postoperative outcomes in colorectal cancer.<sup>16</sup> They found that a low preoperative nutritional index was associated with an increase in overall postoperative complications and poor survival. Moreover, overall functional status may serve as a proxy for a patient's overall fitness and ability to recover postsurgically. These findings suggest that a patient's nutritional and functional optimization before elective rectal cancer surgery may improve outcomes and reduce the rates of reoperation.

Our study also demonstrated that longer operative time was linked to reoperation in both APR and LAR. Longer operative time may be a marker for case difficulty, which could explain its association with an increased number of reoperations. A series of smaller studies have defined an association between longer operative duration and infection risk.<sup>17–19</sup> Although there is no consensus on the exact etiology of this association, some have proposed that longer operations increase anesthesia dose, increase the risk of hypothermia and electrolyte derangements, and prolong overall physiologic stress, which can have implications for wound healing and recovery.<sup>20</sup> As the majority of reoperations in this series were secondary to infection, minimizing operative time may be one way to reduce need for reoperation and improve overall outcomes.<sup>21</sup> Improvement in technical skills is one way to reduce complications intraoperatively and risk of postoperative complications. Appropri-

ate and meticulous preoperative planning may also lead to more efficient intraoperative care.

Patients with a history of smoking or COPD were found to have a high risk for reoperation after APR. This association has been highlighted in earlier studies, including one study that analyzed more than 40,000 plastic surgery patients and found that smokers had a higher risk for wound complications or dehiscence and for surgical wound infections.<sup>22</sup>

For patients undergoing LAR, the presence of an ostomy is protective of reoperation in this series. As the most common cause for reoperation after LAR is postoperative infection (20.3%) with organ space infection accounting for the majority of these infections (45.37%), it is logical that patients who are diverted during their index procedure may be less likely to develop anastomotic leaks or deep pelvic infections, requiring further procedure. An earlier study by Michaels et al.<sup>21</sup> reviewing elective colorectal resection, found that anastomotic leak was associated with 22% of reoperations. They also concluded that return to OR for anastomotic leak was more common in the elective surgery population after colorectal surgery (1.5% vs 0.7%). Of interest, this study found that 57% of patients who did not receive an ostomy at their index procedure underwent ostomy creation at the time of reoperation.<sup>21</sup> The implication of this finding is that cases at high risk for complications secondary to difficult dissection may benefit from closer consideration of fecal diversion at the index procedure.

Postoperative complications are particularly prevalent in patients who underwent reoperation after LAR or APR. Earlier studies have found that technical problems, such as inadequate hemostasis, wound dehiscence, and anastomotic leaks, led to most reoperations.<sup>21,23,24</sup> In our study, the rate of superficial, deep wound, and organ space infection were found to be the most common reasons for reoperation after both LAR and APR. This is consistent with earlier work, including one study from Khoury et al,<sup>10</sup> which found that indications for reoperation were most commonly anastomotic leak or abscess, massive bleeding, bowel obstruction, and wound complications.<sup>10</sup> Although it is difficult to surmise whether these unplanned returns to the operating room were preventable, attention to minimizing risk of infection through measures, such as enforcement of sterile techniques and preoperative antibiotics, is critical. Although our data demonstrate a clear association between infection and reoperation, further studies will be necessary to determine the etiology and extent of these wound infections

to determine whether future cases can be prevented. Furthermore, the NSQIP data are limited in that they do not include other procedures, such as percutaneous abscess drainage by interventional radiology. Therefore, it does not capture all potential procedures that may be indicated and subsequently add to overall postsurgical morbidity.

The implications for reoperation are sizable. Earlier data have concluded that compared with nonreoperated patients, those who underwent reoperation in the early postoperative period had worse long-term oncologic outcomes.<sup>10</sup> Of note, in our series, in both patients who underwent LAR or APR, death was also more common in the patients who underwent reoperation. Finally, patients who underwent reoperation were more likely to be discharged to a nonhome discharge destination. Earlier studies analyzing predictors of unplanned readmission after colorectal surgery have found that discharge to any destination other than home after index hospital admission was associated with unplanned readmission.<sup>25</sup> Readmissions have implications for overall healthcare costs. The cost to Medicare has been estimated to be \$17.4 billion annually.<sup>26</sup> This has prompted hospital penalties for preventable readmissions within 30 days. More concerning, unplanned hospital readmissions have also been associated with greater 1-year mortality in patients after colectomy.<sup>27</sup>

Our study identifies risk factors associated with unplanned reoperation after surgery for rectal cancer. To improve outcomes, patients with risk factors for reoperation should undergo more extensive assessment preoperatively. Based on their preoperative characteristics, patients may benefit from increased nutritional optimization or a more rigorous preoperative fitness protocol before operative intervention. Because many of these procedures for management of rectal adenocarcinoma are performed electively, using preoperative time to optimize patients would be valuable. Prehabilitation programs are an example of one such approach that may help patients optimize their fitness in preparation for surgery. In addition, intraoperative and postoperative resources could be individualized for patients deemed high risk based on their preoperative characteristics. Some of these resources include use of wound protection devices intraoperatively, more rigorous antiseptic protocols, and strict adherence to anticoagulation guidelines for patients at high risk for rebleeding. Furthermore, early preoperative risk stratification may help determine which patients may benefit from novel postoperative fast-track recovery protocols such as Enhanced Recovery After Surgery.

This study is not without limitations. First, this study primarily highlights data provided in NSQIP, which only follows patients up to 30 days after the index procedure. We chose to evaluate data from the first several years after the inclusion of reoperation in the NSQIP database. Furthermore, smaller secondary procedures, which may not have required operative intervention, are not captured. In addition, the specific etiology for reoperation cannot be determined from the NSQIP database; however, regardless of the nature of their subsequent operative procedures, the trends in overall patient outcomes, mortality, and discharge planning remain true. Next, the ACS NSQIP database is biased toward including larger hospitals, potentially making the data less generalizable to all hospitals. We are unable to comment on whether the reoperations were performed by the surgeon who performed the index operation, and thus there may be variability in the threshold for reoperative surgery. We were unable to include data on patients' neoadjuvant treatment, including radiation or chemotherapy, which may impact their wound healing potential. Finally, we did not control for several factors that impact wound healing after APR, such as omental flaps and gracilis flaps.

In conclusion, strategies to reduce the incidence of reoperations are necessary to improve overall patient outcomes. In our study, we identified a series of patient characteristics that can be opti-

mized before elective surgery for rectal cancer. We also have highlighted risk factors that may be targeted in quality improvement projects to reduce the incidence of reoperations.

## References

1. Merkow RP, Bilimoria KY, Cohen ME, Richards K, Ko CY, Hall BL. Variability in reoperation rates at 182 hospitals: A potential target for quality improvement. *J Am Coll Surg.* 2009;209:557–564.
2. Ansari MZ, Collopy BT. The risk of an unplanned return to the operating room in Australian hospitals. *Aust N Z J Surg.* 1996;66:10–13.
3. Birkmeyer JD, Hamby LS, Birkmeyer CM, Decker MV, Karon NM, Dow RW. Is unplanned return to the operating room a useful quality indicator in general surgery? *Arch Surg.* 2001;136:405–411.
4. Isbister WH. Unplanned return to the operating room. *Aust N Z J Surg.* 1998;68:143–146.
5. Morris AM, Baldwin LM, Matthews B, Dominitz JA, Barlow WE, Dobie SA, et al. Reoperation as a quality indicator in colorectal surgery: A population-based analysis. *Ann Surg.* 2007;245:73–79.
6. Ploeg AJ, Lange CP, Lardenoye JW, Breslau PJ. The incidence of unplanned returns to the operating room after peripheral arterial bypass surgery and its value as indicator of quality of care. *Vasc Endovascular Surg.* 2008;42:19–24.
7. Khuri SF, Daley J, Henderson W, Barbour G, Lowry P, Irvin G, et al. The National Veterans Administration Surgical Risk Study: Risk adjustment for the comparative assessment of the quality of surgical care. *J Am Coll Surg.* 1995;180:519–531.
8. Leape LL, Brennan TA, Laird N, Lawthers AG, Localio AR, Barnes BA, et al. The nature of adverse events in hospitalized patients. Results of the Harvard Medical Practice Study II. *N Engl J Med.* 1991;324:377–384.
9. van Westreenen HL, Ijpmma FF, Wevers KP, Afzali H, Patijn GA. Reoperation after colorectal surgery is an independent predictor of the 1-year mortality rate. *Dis Colon Rectum.* 2011;54:1438–1442.
10. Khoury W, Lavery IC, Kiran RP. Impact of early reoperation after resection for colorectal cancer on long-term oncological outcomes. *Colorectal Dis.* 2012;14:e117–e123.
11. ACS NSQIP Participant Use Data File. <https://www.facs.org/quality-programs/acs-nsqip/participant-use>.
12. User Guide for the 2012 ACS NSQIP Participant Use Data File. <https://www.facs.org/quality-programs/acs-nsqip/participant-use>.
13. Kirchoff P, Clavien PA, Hahnloser D. Complications in colorectal surgery: Risk factors and preventive strategies. *Patient Saf Surg.* 2010;4:5.
14. Feo LJ, Jrebi N, Asgeirsson T, Dujovny N, Figg R, Hoedema R, et al. Anastomotic leaks: Technique and timing of detection. *Am J Surg.* 2014;207:371–374 discussion 374.
15. Zingmond D, Maggard M, O'Connell J, Liu J, Etzioni D, Ko C. What predicts serious complications in colorectal cancer resection? *Am Surg.* 2003;69:969–974.
16. Mohri Y, Inoue Y, Tanaka K, Hiro J, Uchida K, Kusunoki M. Prognostic nutritional index predicts postoperative outcome in colorectal cancer. *World J Surg.* 2013;37:2688–2692.
17. Campbell Jr DA, Henderson WG, Englesbe MJ, Hall BL, O'Reilly M, Bratzler D, et al. Surgical site infection prevention: the importance of operative duration and blood transfusion—Results of the first American College of Surgeons-National Surgical Quality Improvement Program Best Practices Initiative. *J Am Coll Surg.* 2008;207:810–820.
18. Culver DH, Horan TC, Gaynes RP, Martone WJ, Jarvis WR, Emori TG, et al. Surgical wound infection rates by wound class, operative procedure, and patient risk index. National Nosocomial Infections Surveillance System. *Am J Med.* 1991;91:152S–157S.
19. Haley RW, Culver DH, Morgan WM, White JW, Emori TG, Hooton TM. Identifying patients at high risk of surgical wound infection. A simple multivariate index of patient susceptibility and wound contamination. *Am J Epidemiol.* 1985;121:206–215.
20. Kurosawa S, Kato M. Anesthetics, immune cells, and immune responses. *J Anesth.* 2008;22:263–277.
21. Michaels AD, Mullen MG, Guidry CA, Krebs ED, Turrentine FE, Hedrick TL, et al. Unplanned reoperation following colorectal surgery: Indications and operations. *J Gastrointest Surg.* 2017;21:1480–1485.
22. Goltsman D, Munabi NC, Ascherman JA. The association between smoking and plastic surgery outcomes in 40,465 patients: An analysis of the American College of Surgeons National Surgical Quality Improvement Program Data Sets. *Plast Reconstr Surg.* 2017;139:503–511.
23. Feldman L, Barkun J, Barkun A, Sampalis J, Rosenberg L. Measuring postoperative complications in general surgery patients using an outcomes-based strategy: Comparison with complications presented at morbidity and mortality rounds. *Surgery.* 1997;122:711–719 discussion 719–20.
24. Gawande AA, Thomas EJ, Zinner MJ, Brennan TA. The incidence and nature of surgical adverse events in Colorado and Utah in 1992. *Surgery.* 1999;126:66–75.
25. Li LT, Mills WL, White DL, Li A, Gutierrez AM, Berger DH, et al. Causes and prevalence of unplanned readmissions after colorectal surgery: A systematic review and meta-analysis. *J Am Geriatr Soc.* 2013;61:1175–1181.
26. Jencks SF, Williams MV, Coleman EA. Rehospitalizations among patients in the Medicare fee-for-service program. *N Engl J Med.* 2009;360:1418–1428.
27. Greenblatt DY, Weber SM, O'Connor ES, LoConte NK, Liou JI, Smith MA. Readmission after colectomy for cancer predicts one-year mortality. *Ann Surg.* 2010;251:659–669.