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Reducing Readmissions While Shortening Length of Stay: The Positive Impact of an Enhanced Recovery Protocol in Colorectal Surgery

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Abstract

Background—Hospital readmission rates are an increasingly important quality metric since enactment of the 2012 Hospital Readmissions Reduction Program. The proliferation of enhanced recovery protocols and earlier discharge raises concerns for increased readmission rates.

Objective—We evaluated the effect of enhanced recovery on readmissions and identified risk factors for readmission.

Design, Setting, Patients—A multidisciplinary enhanced recovery protocol was implemented for all elective colorectal surgery patients at a large academic medical center.

Intervention and Main Outcome Measure—This cohort study compared patients before and after enhanced recovery initiation, looking at 30-day readmission as the primary outcome. A multivariable logistic regression model identified predictors of 30-day readmission. Kaplan-Meier analysis identified differences in time to readmission.

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Results—707 patients underwent colorectal procedures between 2011 and 2015. 383 pre-enhanced recovery patients were compared to 324 patients following protocol implementation. Length of stay decreased from median 5 days to median 4 days pre and post-enhanced recovery implementation, respectively ($p < 0.0001$). Thirty-day readmission decreased from 19% (72/383) in the pre-enhanced recovery pathway to 12% (38/324) in the enhanced recovery pathway ($p = 0.009$). Twenty-one percent (21/99) of ileostomy patients were readmitted prior to enhanced recovery implementation compared to 19% (18/93) of ileostomy patients following enhanced recovery implementation ($p = 0.16$). Multivariable logistic regression identified ileostomy as increasing risk of readmission ($p = 0.04$), while enhanced recovery protocol decreased risk of readmission ($p = 0.006$).

Limitations—Single institution, before and after study design

Conclusion—These data suggest that use of a standardized enhanced recovery protocol significantly reduces length of stay and readmission rates in an elective colorectal surgery population. However, the presence of an ileostomy maintains a high association with readmission, serving as a significant burden to patients and providers alike. Ongoing efforts are needed to further improve the management of ileostomy patients in the outpatient setting following discharge to prevent readmissions.

Keywords

enhanced recovery; readmission reduction; colorectal surgery; ostomy

Introduction

Hospital readmission rates have become an increasingly important quality metric due to enactment of the Hospital Readmissions Reduction Program in 2012 as part of the Affordable Care Act.^{1,2} In the next calendar year, 2,600 institutions will pay over \$400 million in penalties to Centers for Medicare and Medicaid Services (CMS) related to excess readmissions. Readmission rates after colorectal surgery frequently exceed that of other surgical procedures and range in various series from 8% to 17%.^{1–3}

A series of prospective, randomized controlled trials and observational studies conducted over a period of more than two decades have demonstrated that enhanced recovery (ER) protocols substantially reduce hospital length of stay (LOS) and decrease health care costs.^{4–7} With the proliferation of ER protocols and earlier discharge, there are concerns of potentially increased readmission rates. We sought to evaluate the effect of ER on readmissions as the primary outcome and to identify risk factors for readmission within an ER protocol. We hypothesize that patients undergoing colorectal surgery within an ER program have similar rates of readmission when compared to traditional care patients.

Material and Methods

This is a retrospective analysis of a prospectively maintained database that included all consecutive adult (> 18 years) patients undergoing elective colorectal surgery before (August 4, 2011 – August 5, 2013) and after (August 6, 2013 – July 1, 2015) the implementation of an ER program. All procedures were performed by one of two board-certified colon and

rectal surgeons. The primary outcome was 30-day readmission, defined as an inpatient admission to any acute care facility within 30 days after the index operation. Secondary outcomes included time to and reason for readmission. Approval from the Institutional Review Board at the University of Virginia was granted.

Data Collection

As a participant of the National Surgical Quality Improvement Project (NSQIP), data was abstracted for all procedures included in the colectomy and proctectomy modules in the Targeted Procedure Program. NSQIP definitions for all demographic and outcome data were strictly adhered to and can be found at http://www.facs.org/~media/files/quality%20programs/nsqip/nsqip_puf_userguide_2014.ashx. Additional data points specific to the project that were not collected by NSQIP were collected prospectively in a separate quality improvement database or through retrospective chart review. All patients were followed through 30 days to assure all readmissions to any care facility were captured. If the patient was readmitted more than once in the 30-day post-operative period, only the first readmission was included in the analysis. Reasons for readmission were categorized into nausea/emesis, infection, ostomy-related complications (including pouching difficulties, dehydration, acute kidney injury, or prolapse), or other. If a patient with an ostomy was admitted with an infection or nausea/emesis but was otherwise not having issues related to the ostomy, it was classified into the respective category as opposed to ostomy-related. Information on distance from the hospital was obtained using Google Maps (googlemaps.com) and was based on the zip code provided by the patient.

Management Strategies

The care protocols prior to and after implementation of our ER program have been described in detail elsewhere and will be summarized in brief.⁷ Prior to implementation of the ER protocol, patients were instructed to drink clear liquids the day before surgery and made *nil per os* (NPO) at midnight. A mechanical bowel preparation (MBP) was administered the evening prior to surgery. Perioperative pain management was dependent on the type of surgery but generally included a low thoracic epidural for open procedures and patient-controlled analgesia with intravenous opioids for laparoscopic procedures. Intra-operative fluid administration was left to the discretion of the anesthesiologist. The primary surgeon determined when a patient's diet was advanced and intravenous fluids discontinued.

On August 6, 2013, we implemented a standardized, multidisciplinary ER protocol for colorectal surgery patients. We utilized this opportunity to standardize every aspect of the perioperative care pathway from preadmission through discharge. (Table 1) Discharge criteria remained identical before and after ER protocol implementation (tolerating a diet, passing flatus or >500 cc in presence of ileostomy, ambulatory, pain well controlled on oral analgesia).

Statistical Analysis

Univariate analysis was performed to compare baseline demographic and clinical variables between patients in both care pathways and according to readmission status. Readmitted patients were further stratified on care protocol and demographic and clinical variables were

compared similarly. Distance from the University of Virginia was also compared using univariate analysis. Compliance with protocol elements is expressed in intraoperative and total opioid consumption (morphine equivalents), fluid balance (mL), administration of spinal (yes/no), consumption of preoperative Gatorade (yes/no), and ambulation the day of surgery (yes/no). Baseline data for opioid consumption and fluid balance are from the cohort of patients in the preceding six months prior to ER protocol implementation as presented in Thiele et al.⁷ Wilcoxon's Rank Sum was used to compare continuous variables while Chi-square and Fisher's exact test were used for categorical comparisons. Means and standard errors of the mean are used to describe normally distributed data, whereas medians and interquartile ranges describe non-normal data. 30-day readmission was treated as a dichotomous variable (yes or no).

Based on a baseline readmission rate of 20% in the Pre-ER patients, 174 patients were required to be 90% sure that the limits of a two-sided 90% confidence interval would exclude a difference between the two groups of more than 20%, based on an equivalence design. Unadjusted Kaplan-Meier analysis with log-rank test analyzed differences in time to readmission data. Lastly, a multivariable logistic regression model was developed to identify factors predictive of readmission. Variables with a p-value of less than 0.10 were included in a logistic regression model to determine independent associations with readmission. Statistical significance was set at $p < 0.05$. All statistical analyses were performed using SAS 9.4 (SAS Institute, Cary, NC) software.

Results

Between August 4, 2011 and July 1, 2015, a total of 707 patients were included in the elective colorectal surgery database; 383 (54%) prior to ER protocol implementation (Pre-ER) and 324 (46%) after ER protocol implementation (ER). Demographic and operative variables comparing these two groups are demonstrated in Table 2. There are no differences in age, race, sex, BMI, Diabetes, hypertension, smoking, ASA or wound classification. There is a higher rate of laparoscopic procedures in the ER group ($p < 0.0001$) although there is no difference in the rates of rectal surgery or ileostomy creation. Compliance with protocol elements is demonstrated in Table 3. We demonstrated a significant reduction in opioid consumption and fluid administration after ER protocol implementation. Compliance with consumption of Gatorade®, placement of spinal, and ambulation on the day of surgery were $> 70\%$. As previously demonstrated, ER patients have significantly shorter median LOS of 4 days (IQR 3–5), compared to median 5 days (IQR 4–7) for pre-ER patients ($p < 0.0001$). In addition, there was a significant reduction in the incidence of surgical site infection, bleeding requiring transfusion, and overall complications.

Readmissions

A total of 110 patients (16%) were readmitted during the entire study period. Reasons for readmission between Pre-ER and ER groups are delineated in Figure 1. One hundred patients had one 30-day readmission, 66 (17%) pre-ER and 34 (10%) ER. Nine patients had two 30-day readmissions, five Pre-ER (1%) and 4 ER (1%) patients. One pre-ER patient had 3 readmissions within 30 days. Of all readmitted patients, 19% (72/383) were Pre-ER and

12% (38/324) were ER patients ($p = 0.009$, Table 1). Reduction in readmissions for infection (primarily SSI) and nausea/emesis accounted for the lower rate of readmissions within the ER group. Prior to implementation of ER, 50 patients (13%) required readmission for either SSI or nausea/emesis compared to 24 (7%) following ER implementation. Additionally, readmissions were reduced by 50% in patients *without* an ileostomy; 18% (51/284) of Pre-ER patients *without* an ileostomy required readmission compared to 9% (20/231) of ER patients *without* an ileostomy ($p=0.003$). Twenty-one percent (21/99) of ileostomy patients required readmission prior to ER implementation compared to 19% (18/93) of ileostomy patients following ER implementation ($p=0.85$).

Demographic, clinical and procedural data for patients who were readmitted versus patients who were not are presented in Table 4. Enrollment into an ER protocol has an unadjusted OR of 0.59 (95% CI 0.37–0.88) with relation to readmission within 30 days. Creation of an ileostomy at the index operation was significantly associated with readmission ($p=0.03$) with an unadjusted OR of 1.59 (95% CI 1.04–2.46). Hospital LOS was significantly associated with readmission—patients with longer LOS were more likely to be readmitted ($p=0.008$). Finally, patients living closer to the University of Virginia Health System were significantly more likely to have a 30-day readmission ($p=0.05$).

A subgroup analysis was performed to evaluate readmitted patients. They were stratified based on pre-ER or ER protocol and relevant comparisons are outlined in Table 5. There are no differences between the two groups in regards to age, gender, distance from primary institution, and rates of rectal surgery. Although there was an absolute reduction in nausea/emesis and infection readmissions following ER implementation as demonstrated in Table 2, the relative proportions for the reason for readmissions were identical between groups. Similarly, while the readmission rate in ileostomy patients was identical between groups (21% vs. 19%), there were 50% less readmissions overall in ER patients without an ileostomy (18% vs. 9%). Therefore, patients with ileostomy represented a higher percentage of the readmitted patients in the ER group (47% versus 29%, $p=0.06$).

Kaplan-Meier curves for time to readmission is demonstrated in Figure 2, representing a small but significant difference in the proportion of patients readmitted between the two groups. 75% of all readmitted patients are readmitted by post-discharge day 9.5 (95% CI 8–13 days).

Lastly, a multivariable logistic regression model was created to identify variables predictive of readmission. After adjusting for protocol, hospital LOS, ileostomy, functional status, albumin, distance from UVA and laparoscopy, undergoing a colorectal procedure after initiation of ER protocol ($p=0.006$, adjusted OR 0.54, 95% CI 0.35–0.84) was associated with decreased risk of readmission. Presence of an ileostomy was associated with increased risk of readmission ($p=0.04$, adjusted OR 1.6, 95% CI 1.03–2.5) and functional status has marginal significance in association with readmission (Table 6). The C-statistic for the multivariable logistic regression model was 0.63.

Discussion

Principle Findings

We found that use of a highly standardized ER protocol was associated with a significantly lower rate of readmission and decreased LOS in an elective colorectal surgery population. The reduction in readmission was associated with lower rates of SSI and nausea/emesis following ER implementation and had the greatest effect in patients without an ileostomy. The presence of an ileostomy and poor functional status is associated with a higher rate of 30-day readmission.

Strengths

To our knowledge, this is one of the largest reports focused *specifically* on readmission patterns within an ER protocol in patients undergoing colorectal surgery. ER protocols have been demonstrated by numerous studies to significantly reduce LOS, costs, and complication rates in patients undergoing a wide variety of surgical procedures.^{4–10} However, in the current pay for performance era, readmissions rather than LOS have become the focus of increasing scrutiny as a quality metric. This may serve as a barrier to the proliferation of enhanced recovery efforts to reduce LOS. Certainly, this was of concern when initiating our own protocol, as our baseline readmission rate of 19% put us in the 10th decile for risk adjusted outcomes according to NSQIP. However, our results would seem to alleviate some of these concerns in the context of proper preparation for shift of care from the inpatient to outpatient setting.

Limitations

Our study has important limitations, which should be delineated. First, we are limited by the before and after study design, which might introduce selection bias. These were consecutively enrolled patients and there were no demographic differences between the two groups. However, there was a higher rate of laparoscopic procedures in the ER group. Since this is a potential confounder, it was controlled for in the multivariable logistic regression model and was not found to be independently associated with readmission. Additionally, while we only demonstrate association as opposed to causation from the data, there were no other readmission efforts during the same time period within the institution.

Given that the rate of readmission was higher in the patients that live closer to the medical center, there is a chance that some readmissions were not captured, particularly for patients who were readmitted to outside facilities. All patients were rigorously followed to 30 days with either an outpatient clinic visit or follow-up phone call. Admission to any facility was closely monitored. Therefore, to the best of our ability, we have captured all readmissions. Finally, we are unable to discern which specific aspects of the protocol (early feeding, ambulation, multimodal analgesia, ileostomy algorithm, SSI prevention elements, etc.) contributed individually to the decreased rates of readmission.

Comparison to similar studies

The vast majority of all studies in the enhanced recovery literature include readmission as a secondary outcome.^{4–11} However, relatively few have demonstrated an *improvement* in

readmission rates or performed an in-depth analysis with readmissions as the primary outcome. Our data are similar to a study by Francis *et al*, which demonstrated a 12.7% readmission rate after the implementation of an ER protocol.⁹ Lawrence *et al*/similarly demonstrated reduction in LOS by employing an enhanced recovery protocol, without a concomitant increase in readmission rates in patients undergoing laparoscopic colorectal surgery.¹¹ The main reasons for readmission in both these studies as well the current study include dehydration, obstructive bowel symptoms, and surgical site infection. We previously noted a significant reduction in SSI with our ER protocol. This is likely related to standardization in care and specific elements within the ER protocol such as use of a separate fascial closure tray, switching from a second generation cephalosporin to a first generation cephalosporin with metronidazole for intravenous antibiotic prophylaxis, and initiation of preoperative chlorohexidine bathing.

Clinical Implications

The presence of an ileostomy has been associated with readmission rates up to 35%, due to dehydration, acute kidney injury, fluid and electrolyte imbalances and pouching difficulties.^{12–16} As expected, patients with an ileostomy in this study were more likely to be readmitted when compared to patients without an ostomy or a colostomy ($p=0.03$). Our baseline rate of readmission in patients with an ileostomy was 20%, which is comparable or lower than what has been reported in the literature. Our results demonstrate ileostomy-related readmissions did not increase following ERAS implementation as could potentially be expected by substantially reducing LOS in this vulnerable at risk population. This was due to a highly concerted effort focused on perioperative ostomy support at the time of ERAS implementation.

Our multifaceted strategy to prevent ileostomy-related readmissions centered around preoperative planning, enhancement of inpatient education in the immediate postoperative period (including the weekends) and close outpatient follow-up. Prior to surgery, patients meet with an enterostomal therapist and attend a class for all new ostimates. Following surgery, a dedicated enterostomal therapist provides stomal support and education during their inpatient stay. Patients are not discharged unless the ileostomy output is greater than 500 mL but less than 1500 mL over a 24-hour period. To avoid delays in discharge for patients undergoing surgery at the end of the week, changes in personnel were necessary to provide stomal support on the weekends. An algorithm was generated for patients to guide the titration of stool thickening medications immediately following discharge as demonstrated in Figure 3. We encouraged patients to consume isotonic electrolyte-balanced solutions and limit high intake of hypotonic fluids. Home health is arranged for a majority of the patients although few agencies have a dedicated enterostomal therapist. Patients were encouraged to contact our office with questions during the day. After hours calls were taken by the housestaff, who were educated on the ileostomy algorithm. Finally, a dedicated outpatient clinic was established with a goal to see all new ileostomy patients within a week of discharge. Our experience is similar to Nagle *et al*/who describe an ileostomy pathway incorporating early patient “ownership” of the ileostomy with active learning principles, in addition to preoperative counseling and written educational materials.¹⁶

Suggestions for future study

These data suggest that the use of a highly standardized ER protocol significantly reduces readmission rates in addition to LOS in an elective colorectal surgery population. However, the presence of an ileostomy remains the most significant risk factor for readmission in colorectal surgery, serving as a significant burden to patients and providers alike. Ongoing efforts are needed to further improve the management of ileostomy patients in the outpatient setting following discharge to prevent readmissions.

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References

1. Lucas DJ, Ejaz A, Bischof DA, Schneider EB, Pawlik TM. Variation in readmission by hospital after colorectal cancer surgery. *JAMA Surg.* 2014; 149:1272–1277. [PubMed: 25337956]
2. Kulaylat AN, Dillon PW, Hollenbeak CS, Stewart DB. Determinants of 30-d readmission after colectomy. *J Surg Res.* 2015; 193:528–535. [PubMed: 25438957]
3. Kelly KN, Iannuzzi JC, Aquina CT, et al. Timing of discharge: a key to understanding the reason for readmission after colorectal surgery. *J Gastrointestinal Surg.* 2015; 19:418–428.
4. 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. [PubMed: 24368573]
5. Miller TE, Thacker JK, White WD, et al. Reduced length of hospital stay in colorectal surgery after implementation of an enhanced recovery protocol. *Anesth Analg.* 2014; 118:1052–1061. [PubMed: 24781574]
6. ERAS Compliance Group. The impact of enhanced recovery protocol compliance on elective colorectal cancer resection: results from an international registry. *Ann Surg.* 2015; 261:1153–1159. [PubMed: 25671587]
7. Thiele RH, Rea KM, Turrentine FE, et al. Standardization of care: impact of an enhanced recovery protocol on length of stay, complications, and direct costs after colorectal surgery. *J Am Coll Surg.* 2015; 220:430–443. [PubMed: 25797725]
8. Zhao J-H, Sun J-X, Gao P, et al. Fast-track surgery versus traditional perioperative care in laparoscopic colorectal cancer surgery: a meta-analysis. *BMC Cancer.* 2014; 14:607. [PubMed: 25148902]
9. Francis NK, Mason J, Salib E, et al. Factors predicting 30 day readmission after laparoscopic colorectal cancer surgery within an enhanced recovery programme. *Colorectal Dis.* 2015; 17:148–154.
10. Debarros M, Steele SR. Perioperative protocols in colorectal surgery. *Clin Colon Rectal Surg.* 2013; 26:139–145. [PubMed: 24436664]
11. Lawrence JK, Keller DS, Samia H, et al. Discharge within 24 to 72 hours of colorectal surgery is associated with low readmission rates when using enhanced recovery pathways. *J Am Coll Surg.* 2013; 216:390–394. [PubMed: 23352608]
12. Messaris E, Sehgal R, Deiling S, et al. Dehydration is the most common indication for readmission after diverting ileostomy creation. *Dis Colon Rectum.* 2012; 55:175–180. [PubMed: 22228161]
13. Tyler JA, Fox JP, Dharmarajan S, et al. Acute health care resource utilization for ileostomy patients is higher than expected. *Dis Colon Rectum.* 2014; 57:1412–1420. [PubMed: 25380008]
14. Paquette IM, Solan P, Rafferty JF, Ferguson MA, Davis BR. Readmission for dehydration or renal failure after ileostomy creation. *Dis Colon Rectum.* 2013; 56:974–979. [PubMed: 23838866]

15. Hayden DM, Pinzon MCM, Francescatti AB, et al. Hospital readmission for fluid and electrolyte abnormalities following ileostomy construction: preventable or unpredictable? *J Gastrointest Surg.* 2013; 17:298–303. [PubMed: 23192425]
16. Nagle D, Pare T, Keenan E, Marcet K, Tizio S, Poylin V. Ileostomy pathway virtually eliminates readmissions for dehydration in new ostomates. *Dis Colon Rectum.* 2012; 55:1266–1272. [PubMed: 23135585]

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Figure 1.
Reasons for readmission separated by protocol type

Figure 2.
Kaplan-Meier analysis of time to readmission, stratified by protocol group.

- **Drink 10-12 glasses of fluids daily, including electrolyte enhanced beverages**
- **Measure your fluid intake and ileostomy output. Use your “hat” as you were taught in the hospital to collect and measure the ileostomy drainage.**
- **Record the volume on your log sheet. Every morning, add up the total for the last 24 hours and follow the instructions on the chart below:**

Step 1: Loperamide, 1 tablet before breakfast and dinner

Step 2: Loperamide, 1 tablet before breakfast, lunch, dinner, and bedtime

Step 3: Loperamide, 2 tablets before breakfast, lunch, dinner, and bedtime

Figure 3.

Algorithm to guide titration of stool thickening medications for ileostomy patients

Table 1

University of Virginia Enhanced Recovery Protocol	
<i>Preoperative</i>	
<ul style="list-style-type: none"> - The ER protocol and the patients' role in their recovery are described in detail including checklists to be completed with the nursing staff. - Patients are given a goal of discharge on the second to third postoperative day - The ER protocol patients are flagged in the electronic medical record and on the operative schedule - The night before surgery, patients receive a MBP consisting of 4L of GoLyteLy®, as well as erythromycin (1 gm × 3), neomycin (1 gm × 3), and metoclopramide (10 mg × 3). Regular diet ceases at 6 PM, after which clear liquids can be consumed ad libitum until 2 hours prior to surgery. - Chlorohexidine is provided for showering prior to surgery 	
<i>Day of Surgery</i>	
<ul style="list-style-type: none"> - Patients are asked to consume 20 ounces of Gatorade® Thirst Quencher G Series, two hours prior to induction. - Patients receive 200 mg celecoxib, 600 mg gabapentin, and 975 mg oral acetaminophen unless contraindicated prior to surgery - Alvimopan is administered preoperatively and twice daily for up to seven days - Patients receive antibiotic prophylaxis with cefazolin and metronidazole - A morphine spinal (250 ucg) is administered - 5,000 U unfractionated heparin is administered immediately after placement of the spinal - N-Methyl-D-aspartate (NMDA) antagonists are used with induction (magnesium 30 mg/kg, ketamine 0.5 mg/kg) and throughout surgery (ketamine 10 ucg/kg/min). - IV lidocaine is infused during surgery (40 ucg/kg/min) and for 48 hours after the procedure (1 mg/min) - Intraoperative fluid management is guided by a goal-directed fluid algorithm utilizing the Masimo "Pleth Variability Index" (PVI) to guide fluid responsiveness - A separate clean fascial closure tray is utilized at the end of the case - Patients get out of bed in PACU to be weighed, and are out of bed the night of surgery - Clear fluids are administered in PACU 	
<i>Postoperative</i>	
<ul style="list-style-type: none"> - Intravenous fluids are continued at 40 cc/hr on the night of surgery and discontinued at 08:00 on the first postoperative day. - A soft diet begins on the first postoperative day - Patients are placed on scheduled acetaminophen and celecoxib. The primary post-operative opioid analgesic agent is oral oxycodone (q4h on the day of surgery, scheduled daily at 6 AM on the first postoperative day for the open cases) 	
<i>Following Discharge</i>	
<ul style="list-style-type: none"> - Patients are called within 72 hours following discharge - New ostomates are referred for home health and seen within one week in the enterostomal therapy clinic 	

Table 2

Demographic and clinical comparison of pre-ER and ER patients

Variable (n, %)+	Pre-ER (n=383)	ER (n=324)	p-Value
Patient Demographics			
Age (mean, SEM ¹)	57.1	58.3	0.83
Sex, male	182	147	45%
Race			0.83
Asian	1	2	-
Black	33	46	12%
White	329	284	88%
Other	6	6	2%
Diabetes	59	43	13%
Hypertensive	177	132	41%
Smoking	62	66	20%
BMI [*] (median, IQR ²)	27	23.4, 31.3	27
Diagnosis			0.29
Neoplasm	224	59%	194
IBD ^{††}	68	18%	53
Diverticular	47	12%	48
Other	43	11%	24
ASA ^{***}			0.88
1	2	--	1
2	179	47%	159
3	194	51%	158

Variable (n, %)+	Pre-ER (n=383)	ER (n=324)	p-Value
4	8	5	2%
Laparoscopic	119	175	54% <0.0001 ++
Rectal Surgery	158	128	41% 0.52
Ostomy			0.66
None	245	197	61%
Colostomy	39	34	10%
Ileostomy	99	93	29%
Clinical Outcomes			
Index median LOS (IQR [†])	5	4, 7	4, 3, 5 <0.0001
Reoperation within 30 days	23	13	4% 0.23
Surgical site infection	68	25	8% 0.0001
Superficial/deep	43	13	4% 0.0004
Organ space	25	12	4% 0.12
Pneumonia	6	4	1% 0.76
Thromboembolism	9	7	2% 1.0
Acute Renal Failure	0	2	1% 0.21
Urinary Tract Infection	17	13	4% 1.0
Bleeding/Transfusion	42	21	7% 0.05
Any Complication	125	71	22% 0.002
30-day Mortality	0	3	1% 0.10
Discharged to a facility	20	24	7% 0.27

Variable (n, %) [†]	Pre-ER (n=383)	ER (n=324)	p-Value
Readmissions			
30-Day Readmission	72	38	12% 0.009
Readmitted due to:			
Nausea/Emesis	23	11	3%
Infectious	27	13	4%
Ostomy Related	11	5	2%
Other	11	7	2%

[†] unless otherwise noted
[†] standard error of the mean
^{††} significance at p<0.05
[†] inter-quartile range
^{*} body mass index
^{**} American Society of Anesthesiologists
^{††} Inflammatory bowel disease

Table 3

Compliance with Enhanced Recovery Protocol Elements

	Pre ER protocol baseline (98) [*]	Post ER Protocol (N=324)	P value
Intraoperative morphine equivalents (mean, SEM) [†]	20 (13,28)	0.1 (0.1,2.)	0.0001 ⁺⁺
Received spinal analgesia	--	73.4%	n/a
Total morphine equivalents (mean, SEM)	150 (80,299)	40 (15,81)	0.0001 ⁺⁺
Intraoperative net fluid balance (mean, SEM)	2500 (1750,3300)	500 (276,944)	0.0001 ⁺⁺
Total net fluid balance (mean, SEM)	4536 (1866,7132)	207 (-1600,1896)	0.0001 ⁺⁺
Gatorade	--	84.0%	n/a
Ambulate Day of Surgery	--	74.88%	n/a

[†] standard error of the mean

⁺⁺ Significance at p<0.05

^{*} Baseline data is from original cohort of patients undergoing surgery 6 months prior to ER implementation.

Table 4

Comparison of demographic variables for readmitted patients

Variable (n, %)+	Categories	Readmitted (n=110)	Not Readmitted (n=597)	P- Value
Age (mean, SEM) [‡]		55.2	58.1	0.62
		0.13		
Sex	Male	48	281	47%
		0.51		
Race	Asian	0	3	0.5%
	Black	17	62	10%
	White	90	253	88%
	Other	3	9	3%
		0.28		
Diabetes		15	287	15%
		0.80		
Hypertensive		50	259	43%
		0.69		
Smoking	Smoker	23	105	18%
		0.41		
BMI (mean, SEM)		27.2	28.3	0.29
		0.14		
Functional Status	Independent	105	588	98%
		0.04 ^{**}		
Albumin (median, IQR [§])		4	3.7, 4	3.8, 4.2
		0.04 ^{**}		
Creatinine (median, IQR)		0.8	0.7, 1.0	0.7, 1.0
		0.67		
Procedure	Laparoscopic	40	34%	254
	Rectal	43	41%	243
		0.23	43%	0.62
Diagnosis	Neoplasm	59	55%	359
	IBD	27	25%	94
	Diverticular	13	12%	82
	Other	9	8%	58
		0.15	61%	0.15

Variable (n, %) ⁺	Categories	Readmitted (n=110)	Not Readmitted (n=597)	p- Value
Ileostomy		39	35% 153	25% 0.03 ^{***}
ASA	1	0	-- 4	1% 0.61
	2	49	45% 289	49% 49%
	3	58	53% 294	49% 49%
	4	3	3% 10	2% 2%
Contamination				0.69
	Clean	1	1% 3	0.5% 0.5%
	Clean- Contaminated	91	83% 519	87% 87%
	Contaminated	14	13% 58	10% 10%
	Dirty/Infected	4	4% 17	3% 3%
Distance from UVA ^{††}(Median, IQR)	Miles	39.9	22, 107	59.1 32, 103 0.05 ^{***}
Initial Hospital Discharge to Facility		7	6% 37	6% 1.0
Initial Hospital LOS (median, IQR)		5	4,7 4	3,7 0.008 ^{***}
ER Protocol		38	35% 286	48% 0.01 ^{***}

⁺ unless otherwise noted

[†] standard error of the mean

^{††} University of Virginia

^{*} interquartile range

^{***} significant at p<0.05 level

Table 5

Details of readmission stratified by protocol

Variable	Pre-ER (N=72)	ER (N=38)	p-Value
Reason for readmission			0.94
Nausea/Emesis	23	11	31%
Infectious	27	13	36%
Ostomy Related	11	5	14%
Unrelated	11	7	19%
Required Reoperation during readmission	13	5	13%
			0.51
Days to readmission (Median, IQR [*])	5	2, 9.5	6
			3, 11
			0.48
Distance traveled (median, IQR)	37.3	20.5, 43.4	25.5, 99
		110.5	0.47
Ileostomy	21	29%	18
			47%
			0.06
Age (mean, SEM [†])	54.5	1.8	56.4
			2.5
			0.49
Male	29	40%	19
			50%
			0.28
Rectal Surgery	26	38%	17
			50%
			0.41
Laparoscopy	26	36%	14
			37%
			0.94
Diagnosis			0.45
Neoplasia	35	49%	24
			65%
IBD	20	28%	7
			19%
Diverticular	10	14%	3
			8%
Other	6	8%	3
			8%
Initial Hospital LOS (median, IQR)	5	4, 7	4, 5
			3, 7
			0.017 [‡]

* interquartile range

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standard error of the mean
significance at $p < 0.05$

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Table 6

Variables included in multivariable logistic regression

Variable	p-Value	Odds Ratio	95% Confidence Interval
ER Protocol	0.006 *	0.54	0.35–0.84
Presence of Ileostomy	0.04 *	1.61	1.03–2.54
Functional Status	0.05 *	3.18	0.99–10.24
Distance from UVA	0.20	0.99	0.98–1.01
Length of Stay	0.90	0.99	0.95–1.05
Albumin	0.11	0.65	0.39–1.10
Laparoscopy	0.72	0.92	0.58–1.46

* significance at $p < 0.05$