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Outcomes After Bowel Resection for Inflammatory Bowel Disease in the Era of Surgical Care Bundles and Enhanced Recovery

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Abstract

Objective To compare 30-day postoperative complications in patients with inflammatory bowel disease (IBD) undergoing colorectal resection before and after implementation of a hospital-wide surgical care bundle (SCB) to prevent surgical site infection (SSI) followed by enhanced recovery protocol (ERP).

Background Perioperative SCBs to prevent SSI after colectomy have evolved to include ERPs demonstrating reduced rates of SSI, ileus, and length of stay in colorectal surgical patients. IBD patients often present with more risk factors for postoperative complication like malnutrition or immunosuppression, and the impact of SCBs and ERPs in this population is understudied.

Methods Crohn's disease and ulcerative colitis patients undergoing elective bowel resection at a tertiary-level referral center from 2013 to 2018 were retrospectively evaluated. Postoperative complications at 30 days including SSI, ileus, and anastomotic leak were compared between pre-SCB/ERP, post-SCB, and post-SCB + ERP time periods using institutional ACS-NSQIP data. Pediatric (age $\leq$ 18 years) and emergent cases were excluded.

Results Out of 977 patients, 224 were pre-SCB/ERP, 517 post-SCB, and 236 post-SCB + ERP. Gender ($P = 0.01$), race ($P = 0.02$), body mass index ($P = 0.04$), immunosuppressant use ($P = 0.01$), wound classification ($P < 0.001$), malnutrition ($P < 0.001$), duration of procedure ($P = 0.04$), and procedure performed ($P = 0.01$) were significantly different between the three cohorts. A significant decrease in the rates of SSI (14.7% to 5.5%), ileus (20.1% to 8.9%), and anastomotic leak (4.7% to 0.0%) was demonstrated after implementation of SCB and ERP ($P \leq 0.01$). On multivariable regression, the risk for postoperative SSI and ileus decreased significantly post-SCB + ERP (OR 0.39, CI 0.19–0.82 and OR 0.45, CI 0.24–0.84, respectively).

Conclusion SCB and ERP implementation was associated with decreased rates of postoperative SSI, ileus, and anastomotic leak for IBD patients undergoing elective bowel resection.

Keywords Inflammatory bowel disease · Colorectal resection · Surgical care bundle · Surgical site infections · Postoperative ileus · Enhanced recovery protocol

Introduction

Postoperative surgical site infections (SSI) are frequent, serious complications that can affect up to 30% of colorectal resections and lead to worsened rates of morbidity, readmission, reoperation, and prolonged hospitalization.[1,2] Typical patient risk factors include a history of diabetes, obesity, and tobacco use while procedural risk factors include surgeries involving the colon and rectum as opposed to the small bowel, whether the procedure was performed in an open rather than minimally invasive fashion, longer operative time, and the need for performing surgery emergently.[3] The indication for undergoing surgery also affects the likelihood of a postoperative SSI or complication, and it is known that patients with inflammatory bowel disease (IBD) comprise a much higher-risk cohort when compared to non-IBD. The rate of postoperative SSI in this subpopulation has been reported to be as high as 47.1%, and this likely is due to their increased chance of presenting in an immunocompromised state with malnutrition, anemia, and worse wound classification.[4–8]

SSI prevention has been most effective when multiple risk factors are addressed. Surgical care bundles (SCBs) composed of evidence-based practices to prevent SSI have been implemented across the phases of perioperative care at several

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hospitals worldwide. The elements of an SCB typically include perioperative antibiotic prophylaxis, hair removal before surgery, perioperative normothermia, and normoglycemia.[3,9,10] These have led to reduced rates of colorectal SSI from 15 to as low as 4% in certain studies and have now been incorporated into standard perioperative care in most US institutions participating in the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP).[2,3,9–11]

Enhanced recovery pathways (ERPs) have now supplemented SCBs. In addition to a bundle of measures preventing SSI, ERPs are composed of evidence-based practices to reduce the physiologic stress of surgery and accelerate postoperative recovery. Components of an ERP may include lack of nasogastric tube utilization, early mobilization, early oral nutrition with early discontinuance of intravenous fluids, early removal of epidural, early removal of urinary catheter, and non-opioid analgesia. Numerous randomized trials have demonstrated that ERP implementation is associated with decreased lengths of hospital stay by up to 2.4 days and a 50% reduction of risk for 30-day postoperative complication when compared to conventional perioperative patient management.[12–15]

Although it is widely accepted that SCB and ERP implementation provides a significant benefit for colorectal surgical patients as a whole, the evidence looking at the outcomes for IBD alone has been limited. It is therefore unclear as to whether there is an advantage for SCB and ERP in this high-risk cohort of patients. For this reason, we sought to evaluate 30-day postoperative complications in IBD patients undergoing colorectal resection at our institution before and after the implementation of a hospital-wide SCB to prevent SSI followed by ERP.

Methods

Our data source was composed of patients undergoing small bowel and colorectal resection from January 2013 to December 2018 at the Mount Sinai Hospital using institutional ACS-NSQIP Procedure Targeted Colectomy data. Cases were statistically sampled according to Current Procedural Terminology (CPT) code and ACS-NSQIP inclusion/exclusion criteria. This sampling method has been validated in previous studies and provides a valid representation of our institutional case-mix without the requirement for a 100% capture rate.[16,17] Our institution also serves as one of the pilot sites for the Agency for Healthcare Research and Quality (AHRQ) Safety Program for Improving Surgical Care and Recovery (ISCR), which seeks to improve clinical outcomes by supporting hospitals in the implementation of evidence-based ERPs as part of a national collaborative. The ACS-NSQIP Procedure Targeted Colectomy program includes colectomy and proctectomy cases as captured by CPT code and collects additional clinical data relevant to colectomy and proctectomy.

The overall study time period was divided into three consecutive time points at our hospital based on the implementation of an SCB for colectomy intended to reduce SSI, which was then supplemented with an ERP to accelerate postoperative recovery. The interventions that comprise SCB and ERP and their time periods are listed in Table 1. Pre-SCB was from January 2013 to September 2014; post-SCB October 2014 to October 2017, and post-SCB + ERP was from November 2017 to December 2018.

Patients were included in the analyses if their complete ACS-NSQIP measure data had been entered; their diagnosis was Crohn's disease or ulcerative colitis based on International Classification of Disease (ICD) 9 or 10 code, and if they underwent elective colorectal resection, as defined by the following CPT codes: 44005, 44120, 44125, 44130, 44140, 44141, 44143, 44144, 44145, 44146, 44147, 44150, 44151, 44155, 44156, 44157, 44158, 44160, 44180, 44187, 44202, 44204, 44205, 44206, 44207, 44210, 44211, 44212, 44227, 44310, 44316, 44320, 44615, 44620, 44625, 44626, 44640, 44650, 45110, 45111, 45112, 45113, 45119, 45121, 45123, 45136, 45395, 45397, 45499, 49000. Emergent and pediatric cases aged $\leq$ 18 years were excluded. Additionally, all patients with ostomy creation were excluded for the anastomotic leak analysis.

The primary outcomes of interest were 30-day postoperative complications including SSI, ileus, and anastomotic leak. Secondary outcomes of interest included death/serious morbidity, readmission, unplanned reoperation, and length of hospital stay. Clinical data including patient demographics, surgical risk factors, intraoperative factors, and 30-day postoperative outcomes were collected according to standardized definitions by trained, audited abstractors at our hospital. Thirty-day postoperative outcomes were determined from the medical record and via direct communication with patients. Compliance data to SCB and ERP interventions were captured by nursing staff during each patient's hospital admission. This data was then compiled, tracked, and summarized in an ongoing database for quality improvement at our institution.

Wound classifications were based on Center for Disease Control National Health and Safety Network criteria (CDC NHSN).[18] SSIs included superficial, deep, and organ space infections. The ACS-NSQIP defines Ileus as "prolonged nil per os (NPO) status or nasogastric tube (NGT) use for suctioning or decompression more than 3 days postop or reinsertion of NGT or reinstating NPO status any time postoperative day 4 or later within 30 days". An anastomotic leak was defined as a "leak of endoluminal contents through an anastomosis".[19]

Descriptive statistics were used to compare the demographic, preoperative, and intra-operative variables and clinical

Table 1 Surgical care bundle and enhanced recovery protocol components

	SCB	ERP
Date of implementation	October 2014	November 2017
Preoperative	• Patient education on SSI prevention	• Patient education on ERP
	• Clear liquid diet on day prior	• Reduced fasting[a]
	• Chlorhexidine shower	
	• Oral antibiotics taken at 1 pm, 2 pm, and 11 pm on day before surgery	• Carbohydrate loading[b]
	• Mechanical bowel prep is optional	
Immediate preoperative	• Glucose control for diabetics [c]	• Glucose control for all[c]
	• Hair clipping	• Multi-modal anesthesia[d]
Intraoperative	• Antibiotics given within 15 min prior to incision with re-dosing.	• Multi-modal anesthesia[e]
	• Wound classification	
	• At closing, gowns and glove are changed. A separate closing tray with normal saline irrigation, wound protector, and antimicrobial sutures is used. The surgical field is prepared again. All suction and e lectrocautery is changed.	
Postoperative		• Early ambulation[f]
		• Minimize IV fluids[g]
		• Early alimentation[h]
		• Nutritionist consult[i]
		• Multimodal anesthesia and medication for PONV[j]
		• Glucose control[c]

SCB surgical care bundle, *ERP* enhanced recovery pathway, *SSI* surgical site infection, *IV* intravenous, *PONV* postoperative nausea and vomiting

Patients ≤ 18 years of age undergoing elective bowel surgery, or who are likely to require incision into the large or small bowel intra-operatively are enrolled into the SCB program. Bariatric and transplant cases excluded. All patients enrolled into SCB program were enrolled into ERP program starting November 2017

[a] Intake of solids until 8 h prior to induction and intake of clear liquids until 2 h prior to induction unless delayed gastric emptying is documented

[b] 12–24 oz. of carbohydrate-rich fluid > 2 h prior to induction on night before or morning of surgery

[c] Glucose controlled for diabetic patients in SCB and for all patients in ERP, beginning immediately preop and continuing until discharge with insulin sliding scale to prevent hyperglycemia. Patients receive a fingerstick to check glucose prior to surgery and an endocrine consult as appropriate

[d] Gabapentin 600 mg PO (default), gabapentin 300 mg PO for age > 70 or renal insufficiency, acetaminophen 975 mg PO, scopolamine 1.5 mg patch (contraindicated for glaucoma patients)

[e] For laparoscopic cases, regional anesthesia via transverse abdominis plane block or rectus sheath block with bupivacaine 0.25% mixed with lidocaine 2%. For open cases, thoracic epidural catheter with bupivacaine 0.1% mixed with fentanyl 2 mcg/cc

[f] Out of bed to chair on postop day 0 and early mobilization with patients walking by postop day 1

[g] < 5 mL/kg/h of ideal body weight to be discontinued on postop day 1 after the patient tolerates fluids

[h] Clear liquid diet started on postop day 1. Solid diet started after first flatus or bowel movement at the discretion of the surgeon

[i] Nutritionist visit by postoperative 3

[j] Postop day 0–1: acetaminophen 1000 mg IV every 6 h for four doses. Postop day 1–2: acetaminophen 1000 mg PO every 6 h, gabapentin 600 mg PO at bedtime. Postop day 2–3: ketorolac 30 mg IV every 6 h pending surgical approval and earlier if surgeon consents. Lidocaine peri-incisional patches are used × 3 for 12 h on followed by 12 h off

comorbidities of all patients in the three consecutive time periods. Continuous variables were compared with analysis of variance (ANOVA) tests and are reported as mean with standard deviation. Categorical variables were compared using Pearson X^2 or Fisher's exact tests, as appropriate, and are expressed as percentages. Variables for which $P < 0.2$ were included in the multivariable logistic regression model. The two-sided $P < 0.05$ was considered statistically significant for multivariable model. Data analyses were done using the SAS Statistical Software (Version 9.4, North Carolina).

Results

Baseline Characteristics

A total of 977 patients with Crohn's disease or ulcerative colitis that underwent colorectal resection were included in the study: 224 patients were pre-SCB, 517 post-SCB, and 236 post-SCB + ERP. The demographic and clinical characteristics for all three cohorts are summarized in Table 2. The three cohorts were similar in terms of age, race, American

Table 2 Patient characteristics

	Pre-SCB/ERP ($N=224$)	Post-SCB ($N=517$)	Post-SCB + ERP ($N=236$)	P value
Demographics				
Age (years, mean, std. dev)	41.0 ± 15.4	40.2 ± 14.7	40.5 ± 16.0	0.7873
Female gender	124 (55.4%)	253 (48.9%)	96 (40.7%)	0.01
Race				
White	192 (85.7%)	396 (76.6%)	179 (75.9%)	0.02
Non-white	13 (5.8%	43 (8.3%)	15 (6.4%)	
Unknown/not reported	19 (8.5%)	78 (15.1%)	42 (17.8%)	
Clinical characteristics				
ASA Classification				
I	2 (0.9%)	1 (0.2%)	1 (0.4%)	0.3872
II	157 (70.1%)	363 (70.2%)	154 (65.3%)	
III	63 (28.1%)	150 (29.0%)	77 (32.6%)	
IV	2 (0.9%)	3 (0.6%)	4 (1.7%)	
BMI, kg/m^2, mean, std. dev	23.9 ± 5.0	23.5 ± 5.3	22.8 ± 4.6	.04
Diabetes mellitus	5 (2.2%)	15 (2.9%)	10 (4.2%)	0.44
Disseminated cancer	2 (0.9%)	0 (0.0%)	0 (0.0%)	0.0524
Dependent functional health status	1 (0.5%)	8 (1.6%)	5 (2.1%)	0.3048
Dyspnea				0.9637
At rest	0 (0.0%)	1 (0.2%)	0 (0.0%)	
Moderate exertion	2 (0.9%)	8 (1.6%)	3 (1.3%)	
No	222 (99.1%)	508 (98.3%)	233 (98.7%)	
COPD	0 (0.0%)	4 (0.8%)	0 (0.0%)	0.1817
Hypertension requiring medication	24 (10.7%)	58 (11.2%)	25 (10.6%)	0.9599
Steroid/immunosuppressant use for chronic condition	149 (66.5%)	284 (54.9%)	147 (62.3%)	0.0075
Currently requiring dialysis	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Smoker	16 (7.1%)	35 (6.8%)	22 (9.3%)	0.4556
Wound classification				< 0.0001
Clean	3 (1.3%)	3 (0.6%)	0 (0.0%)	
Clean/contaminated	205 (91.5%)	268 (51.8%)	113 (47.9%)	
Contaminated	12 (5.4%)	187 (36.2%)	86 (36.4%)	
Dirty/infected	4 (1.8%)	59 (11.4%)	37 (15.7%)	
10% loss of body weight	11 (4.9%)	68 (13.2%)	51 (21.6%)	< 0.0001

SCB surgical care bundle, *ERP* enhanced recovery pathway, *ASA* American society of anesthesiologists, *BMI* body mass index, *COPD* chronic obstructive pulmonary disease

Society of Anesthesiologists (ASA) classification, body mass index (BMI), diabetes mellitus, chronic obstructive pulmonary disease (COPD), hypertension, and smoking status. They differed significantly in terms of gender ($P = 0.01$), race ($P = 0.02$), body mass index (BMI) ($P = 0.04$), steroid or immunosuppressant use for chronic condition ($P < 0.01$), wound classification ($P < 0.001$), and ≥ 10% loss of body weight ($P < 0.001$).

Operative Characteristics

Operative characteristics are depicted in Table 3. The pre-SCB/ERP, post-SCB, and post-SCB + ERP cohorts were similar in terms of the percentage of patients undergoing minimally invasive surgery (64.3% vs 67.7% and 72.9%, respectively, $P = 0.13$). The operative times decreased significantly (174.5 ± 87.7 min, 165.4 ± 90.0 min, 154.3 ± 84.5 min, $P = 0.13$), and the make-up of the surgical procedures performed was significantly different with the most common procedure being a partial colectomy ($P = 0.01$).

Postoperative Outcomes

Postoperative outcomes are depicted in Table 4. The SSI rates pre-SCB, post-SCB, and post-SCB + ERP were 14.7%, 9.1%, and 5.5%, respectively ($P = 0.003$). The rate of ileus was

Table 3 Operative characteristics

	Pre-SCB/ERP (*N* = 224)	Post-SCB (*N* = 517)	Post-SCB + ERP (*N* = 236)	*P* value
Operative approach				
Open	80 (35.7%)	167 (33.2%)	64 (27.1%)	0.1337
Minimally invasive	144 (64.3%)	350 (67.7%)	172 (72.9%)	
Duration of surgical procedure (minutes, mean, std. dev)	174.5 ± 87.7	165.4 ± 90.0	154.1 ± 80.0	0.04
Procedures performed				0.01
Small bowel resection including lysis of adhesion	44 (19.6%)	52 (10.1%)	22 (9.3%)	
Partial colectomy	88 (39.3%)	208 (40.2%)	91 (38.6%)	
Total abdominal colectomy	26 (11.6%)	59 (11.4%)	40 (17.0%)	
Total proctocolectomy	17 (7.6%)	38 (7.4%)	19 (8.1%)	
Proctectomy	22 (9.8%)	73 (14.1%)	27 (11.4%)	
Stoma reversal	27 (12.1%)	87 (16.8%)	37 (15.7%)	

SCB surgical care bundle, *ERP* enhanced recovery pathway

Table 4 Postoperative outcomes

	Pre-SCB/ERP (*N* = 224)	Post-SCB (*N* = 517)	Post-SCB + ERP (*N* = 236)	*P* value
Hospital length of stay (days, mean, std. dev)	7.8 ± 5.6	6.9 ± 6.6	6.7 ± 5.1	0.08
Surgical site infection	33 (14.7%)	47 (9.1%)	13 (5.5%)	0.003
Ileus	45 (20.1%)	44 (8.5%)	21 (8.9%)	< 0.0001
Anastomotic leak	8 (4.7%)	12 (2.6%)	0 (0.0%)	0.01
30-day unplanned return to OR	15 (6.7%)	29 (5.6%)	12 (5.1%)	0.7471
Return to OR related to procedure	15 (6.7%)	28 (5.4%)	12 (5.1%)	0.7203
Still in hospital 30 days	1 (0.5%)	5 (1.0%)	0 (0.0%)	0.3682
Postop acute renal failure	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Postop CVA	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Postop cardiac arrest	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Postop myocardial infarction	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Postop ventilator 48 h	0 (0.0%)	2 (0.4%)	1 (0.4%)	1
Postop pneumonia	0 (0.0%)	2 (0.4%)	1 (0.4%)	0.5340
Postop progressive renal insufficiency	0 (0.0%)	1 (0.2%)	1 (0.4%)	0.7202
Postop PE	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Postop sepsis	5 (2.2%)	16 (3.1%)	3 (1.3%)	0.3151
Postop septic shock	1 (0.5%)	2 (0.4%)	0 (0.0%)	0.7968
Postop transfusion	9 (4.0%)	29 (5.6%)	14 (5.9%)	0.6020
Postop UTI	4 (1.8%)	4 (0.8%)	0 (0.0%)	0.0749
Postop unplanned intubation	0 (0.0%)	2 (0.4%)	0 (0.0%)	1
Postop wound disruption	4 (1.8%)	3 (0.6%)	1 (0.4%)	0.2308
Readmissions likely related	26 (11.6%)	51 (9.9%)	20 (8.5%)	0.5310
Readmissions within 30 days	26 (11.6%)	55 (10.6%)	21 (8.9%)	0.6225
Death within 30 days	0 (0.0%)	0 (0.0%)	1 (0.9%)	0.1308
Postoperative seath > 30 days after procedure	0 (0.0%)	0 (0.0%)	0 (0.0%)	

SCB surgical care bundle, *ERP* enhanced recovery pathway, *std. dev* standard deviation, *OR* operating room, *CVA* cerebrovascular accident, *PE* pulmonary embolism, *UTI* urinary tract infection

Table 5 Multivariable analysis of surgical care bundle and enhanced recovery protocol on colorectal resections in inflammatory bowel disease

	Odds ratio	95% confidence interval
Surgical site infection		
Post-SCB vs Pre-SCB	0.60	0.34–1.03
Post-SCB + ERP vs Pre-SCB	0.39	0.19–0.82
Post-SCB + ERP vs Post-SCB	0.66	0.34–1.26
Ileus		
Post-SCB vs Pre-SCB	0.41	0.24–0.68
Post-SCB + ERP vs Pre-SCB	0.45	0.24–0.84
Post-SCB + ERP vs Post-SCB	1.11	0.63–1.96
Anastomotic leak		
Post-SCB vs Pre-SCB	0.67	0.24–1.83
Post-SCB + ERP vs Pre-SCB	< 0.001	< 0.001 to > 999.99[a]
Post-SCB + ERP vs Post-SCB	< 0.001	< 0.001 to > 999.99[a]

Adjusted for gender, race, body mass index, immunosuppressant use, wound classification, > 10% loss of body weight, operative time, and procedure performed

SCB surgical care bundle, *ERP* enhanced recovery pathway

[a] Sample size inadequate

20.1%, 8.5%, and 8.9% ($P < 0.0001$) and the rates of anastomotic leak were 4.7%, 2.6%, and 0.0% ($P = 0.01$). There was a downward trend, although not statistically significant, for the length of hospital stay ($P = 0.08$), rates of postoperative readmission ($P = 0.53$), reoperation ($P = 0.74$), sepsis ($P = 0.31$), and wound disruption ($P = 0.23$). There were no significant differences in the rates of acute renal failure, cerebrovascular accident, cardiac arrest, myocardial infarction, prolonged use of ventilator, pneumonia, pulmonary embolism, septic shock, transfusion, urinary tract infection, unplanned intubation, and mortality. The results after multivariable regression adjusting for gender, race, BMI, immunosuppressant use, wound classification, ≥ 10% loss of body weight, operative time, and type of procedure performed are depicted in Table 5. After the implementation of SCB and ERP, the risk for postoperative SSI and ileus was reduced by 61% and 55%, respectively.

Compliance to SCB and ERP Measures

The compliance to SCB measures by the end of the post-SCB time period ranged from 76 to 100% preoperatively and 80 to 100% intraoperatively (Table 6). Compliance at the end of the post-SCB + ERP time period ranged from 38 to 82% for preoperative measures, 78 to 100% for intraoperative measures, and 16 to 82% for post-operative measures. The pre-operative ERP measures with the lowest compliance included patient education (38%) and carbohydrate-rich fluids > 2 h before surgery (38%), while postoperatively the measures with lowest compliance included discontinuation of intravenous fluids before postoperative day 2 (16%) and starting multimodal anesthesia on postoperative days 1–3 with acetaminophen, gabapentin, and ketorolac (23–28%).

Discussion

Patients with IBD are at greater risk for postoperative morbidity compared to those without because of their frequent presentation with malnutrition, immunosuppression, anemia, as well as intra-abdominal abscesses, fistulas, and bowel obstruction. While the benefits of SCB and ERP implementation have been demonstrated in colorectal surgical patients as a whole, their effect on IBD patients is not well described. We analyzed the postoperative morbidity rates of IBD patients undergoing elective bowel resection and compared the results before and after the implementation of a hospital-wide SCB followed by ERP. Our analysis showed that SCB and ERP implementation was associated with significantly reduced rates of SSI, ileus, and anastomotic leak at 30 days after surgery with a decreasing trend in the length of hospital stay and rates of re-admission, reoperation, sepsis, and wound disruption.

The postoperative outcomes in IBD patients before and after implementation of SCB and ERP are not well described, although studies comparing IBD to non-IBD within the setting of an ERP have been published recently. Ban et al. performed a retrospective registry-based cohort study with 4620 patients who underwent elective colectomy for neoplasm, diverticulitis, and IBD in the era of ERP.[20] Their analysis revealed that patients undergoing colectomy for IBD were more likely to have prolonged length of stay (OR, 1.98; 95% CI, 1.46–2.69), death/serious morbidity (OR, 1.62; 95% CI, 1.13–2.32), and readmission (OR, 1.54; 95% CI, 1.15–2.08) compared with patients with neoplasm. IBD patients took longer than patients with neoplasm or diverticulitis to achieve per os pain control (mean, 4.2 days vs 3.4 and 3.5 days, $P < 0.001$) and tolerate a diet (mean, 4.1 days vs 3.7 and 3.5 days ($P < 0.001$), but there was no statistically significant difference in outcomes between patients with neoplasm and diverticulitis.[20] Dai et al. performed a retrospective, single-institution analysis comparing patients with 184 patients with IBD and 250 with colorectal cancer undergoing resection in the setting of an ERP with the primary endpoint being postoperative ileus.[21] They demonstrated that IBD patients had higher incidence of postoperative ileus 28.8% vs 14.8% ($P < 0.001$) and that difference remained significant after propensity score matching.[21] The results from these two studies bring to light the question as to whether there is any benefit to SCB and ERP for IBD patients in the first place.

ERPs cannot simply be implemented and forgotten, but require a continuous audit process in place to guide compliance and improve quality.[22–24] At our institution, the rate of compliance to wound class increased from 67% pre-SCB to 100% post-SCB, which may explain the large difference in contaminated cases recorded in the pre-SCB time period where

Table 6 Compliance to surgical care bundle and enhanced recovery protocol measures

	Pre-SCB/ERP	Post-SCB	Post-SCB + ERP
Preoperative measures			
Education	22%	80%	38%
Chlorhexidine shower	22%	82%	69%
Clear liquid diet day before surgery	–	86%	74%
Last time you ate solids? (> 8 h)	–	–	82%
Carb-rich fluids > 2 h before surgery?	–	–	38%
Oral antibiotics	–	76%	64%
Diabetic testing	–	100%	77%
Gabapentin, tylenol, and scopolamine given after arriving at hospital?	–	–	57%
Intraoperative Measures			
Local, regional, or thoracic epidural used?	–	–	78%
Chlorhexidine cleaning in OR	–	89%	93%
Antibiotics with re-dosing	56%	100%	100%
Wound class verified	67%	100%	100%
Separate sterile field setup and closing tray	78%	99%	99%
Gowns/gloves changed at closing	33%	93%	90%
Prep field closing	33%	95%	95%
Change suction and bovie	22%	91%	92%
Wound protector	–	80%	86%
Irrigation	–	84%	97%
Anti-microbial sutures	–	–	92%
Postoperative Measures			
Early ambulation	–	–	65–77%
IV fluids discontinued before POD 2	–	–	16%
Clear liquid diet on POD 1	–	–	82%
Nutritionist visit on POD 1	–	–	51%
POD0–1: acetaminophen IV (4 doses)	–	–	44%
POD1–2: acetaminophen PO every 6 h and gapapentin PO	–	–	23%
POD2–3: ketorolac 30 mg IV Q6H	–	–	28%
Lidocaine patches × 3 12 h on 12 h off	–	–	77%

SCB surgical care bundle, *ERP* enhanced recovery pathway, *OR* operating room, *POD* postoperative day, *IV* intravenous, *PO* per os

contaminated cases may have been incorrectly classified as clean-contaminated. Dirty/infected cases, which include patients presenting with abscess or phlegmon common in IBD, may also have been classified inaccurately in the pre-SCB time period which could explain the increase in dirty/infected cases in the post-SCB and post-SCB + ERP time periods.

In the future, perioperative care pathways may be tailored specifically to different institutions with unique case mixes or to different patient populations such as IBD. For example, prior to the implementation of their SCB to prevent SSI, Weiser et al. designed their own Memorial Sloan Kettering colorectal SSI prediction tool to reflect their unique cancer-based practice. This was used to stratify their patient population into groups at low, intermediate, and high risk for SSI. After implementation of the SSI prediction tool, it was found that the rate of wound closure modification increased for all three risk groups which led to overall SSI rates post-SCB being significantly lower than pre-SCB at 4.1% vs 11.0% ($P = 0.001$). Intermediate- and high-risk groups had significantly lower SSI rates post-SCB than pre-SCB 4.7% vs 10.3% ($P = 0.006$) and 2% vs 19% ($P < 0.001$), respectively. The median length of hospital stay was significantly shorter post-SCB (6 (i.q.r. 5–9) vs 7 (5–10) days ($P = 0.002$)), and the intermediate- and high-risk groups' median length of stay was significantly lower 6 (5–8) vs 7 (5–10) days ($P = 0.006$) and 6 (5–9) vs 8 (6–12) days ($P < 0.001$), respectively. The results from this study indicate that SCB implementation not only reduces SSI rates and length of hospital stay, but also that institutional and patient-specific factors can affect the outcomes of SCB implementation.[25]

The limitations for our study include the single-institutional, retrospective design using ACS-NSQIP data. An overall national dataset encompassing multiple institutions was not possible because SCB and ERPs were implemented at the hospitals at varying time points. Additionally, the elements of each institutional SCB and ERP protocol would differ, and the compliance to their individual elements would be difficult to measure from a multi-institutional standpoint. Another limitation to our analysis is the use of ACS-NSQIP data, which in its current state is inadequate in capturing the unique risk factors affecting IBD patients. For example, the use of preoperative steroid, immunologic, and biologic medications is not categorized separately. The use of CPT procedure codes for ileal pouch anal anastomosis also does not distinguish between whether or not a diverting ileostomy was created. Finally, although the ACS-NSQIP sampling methodology has been validated, it does not capture all IBD patients undergoing surgery, and this may lead to some level of bias in our data. Despite these limitations, Mount Sinai is a tertiary level center for IBD and also one of the pilot centers for the AHRQ Safety Program. We thus were able to analyze a large sample of patients with IBD before and after implementation of SCB and ERP. Additionally, the compliance was well above 50% for a majority of the perioperative interventions, thus indicating a good correlation between bundle elements and patient outcomes.

Conclusion

SCBs and ERPs support the reduction of postoperative SSIs, ileus, and anastomotic leak in IBD patients undergoing bowel resection. Future studies that explore ERPs tailored more specifically for IBD may improve outcomes in this high-risk population of patients. Further analysis distinguishing between the types of immunosuppressant use and ostomy creation is also warranted.

Authors' Contribution All authors (APD, PK, RM, PS, and CMD) made substantial contribution to the conception and design of the work, acquisition and analysis of the data, and drafting and revising the work for important intellectual content. Everyone provided final approval of the version to be published.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

References

1. Perencevich E, Sands K, Cosgrove S, Guadagnoli E, Meara E, Platt R (2003) Health and economic impact of surgical site infections diagnosed after hospital discharge. Emerg Infect Dis 9:196–203
2. Keenan J, Speicher P, Thacker J, Walter M, Kuchibhatla M, Mantyh C (2014) The preventive surgical site infection bundle in colorectal surgery: an effective approach to surgical site infection reduction and health care cost savings. JAMA Surg 149:1045–1052
3. Cima R, Dankbar E, Lovely J, Pendlimari R, Aronhalt K, Nehring S, Hyke R, Tyndale D, Rogers J, Quast L, Colorectal Surgical Site Infection Reduction Team (2013) Colorectal surgery surgical site infection reduction program: a national surgical quality improvement program–driven multidisciplinary single-institution experience. J Am Coll Surg 216:23–33
4. Alves A, Panis Y, Bouhnik Y, Pocard M, Vicaut E, Valleur P (2007) Risk factors for intra-abdominal septic complications after a first ileocecal resection for Crohn's disease: a multivariate analysis in 161 consecutive patients. Dis *Colon rectum* 50:331–336
5. Hu T, Wu X, Hu J, Chen Y, Liu H, Zhou C, He X, Zhi M, Wu X, Lan P (2018) Incidence and risk factors for incisional surgical site infection in patients with Crohn's disease undergoing bowel resection. Gastroenterol Rep (Oxf) 6:189–194
6. Heuschen U, Allemeyer E, Hinz U, Lucas M, Herfarth C, Heuschen G (2002) Outcome after septic complications in J pouch procedures. Br J Surg 2002:2
7. Madbouly K, Senagore A, Remzi F, Delaney C, Waters J, Fazio V (2006) Perioperative blood transfusions increase infectious complications after ileoanal pouch procedures (IPAA). Int J Colorectal Dis 21:807–813
8. Bhakta A, Tafen M, Glotzer O, Ata A, Chismark A, Valerian B, Stain S, Lee E (2016) Increased Incidence of Surgical Site Infection in IBD Patients. Dis *Colon rectum* 59:316–322
9. Lutfiyya W, Parsons D, Breen J (2012) A colorectal "care bundle" to reduce surgical site infections in colorectal surgeries: a single-center experience. Perm J 16:10–16
10. Tanner J, Padley W, Assadian O, Leaper D, Kiernan M, Edmiston C (2015) Do surgical care bundles reduce the risk of surgical site infections in patients undergoing colorectal surgery? A systematic review and cohort meta-analysis of 8,515 patients. Surgery 158:66–77
11. Waits S, Fritze D, Banerjee M, Zhang W, Kubus J, Englesbe M, Campbell DJ, Hendren S (2014) Developing an argument for bundled interventions to reduce surgical site infection in colorectal surgery. Surgery 155:602–606
12. Lv L, Shao Y, Zhou Y (2012) The enhanced recovery after surgery (ERAS) pathway for patients undergoing colorectal surgery: an update of meta-analysis of randomized controlled trials. Int J Colorectal Dis 27:1549–1554
13. Adamina M, Kehlet H, Tomlinson G, Senagore A, Delaney C (2011) Enhanced recovery pathways optimize health outcomes and resource utilization: a meta-analysis of randomized controlled trials in colorectal surgery. Surgery 149:830–840
14. Tan S, Zhou F, Yui W, Chen Q, Lin Z, Hu R, Gao T, Li N (2014) Fast track programmes vs. traditional care in laparoscopic colorectal surgery: a meta-analysis of randomized controlled trials. Hepatogastroenterology 61:79–84
15. Fearon K, Ljungqvist O, Von Meyenfeldt M, Revhaug A, Dejong C, Lassen K, Nygren J, Hausel J, Soop M, Andersen J, Kehlet H (2005) Enhanced recovery after surgery: a consensus review of clinical care for patients undergoing colonic resection. Clin Nutr 24:466–477
16. ACS NSQIP. ACS NSQIP Participant Use Data File - User Guide 2017 [Available from: https://www.facs.org/quality-programs/acs-nsqip/participant-use.
17. Shiloach M, Frencher SJ, Steeger J, Rowell K, Bartzokis K, Tomeh M, Richards K, Ko C, Hall B (2010) Toward robust information: data quality and inter-rater reliability in the American College of Surgeons National Surgical Quality Improvement Program. J Am Coll Surg 210:6–16

18. Center for Disease Control National Healthcare Safety Network (NHSN). Patient Safety Component Manual 2019 [Available from: https://www.cdc.gov/nhsn/pdfs/pscmanual/pcsmanual_current.pdf.
19. American College of Surgeons. ACS NSQIP Participant Use Data File 2018 [Available from: https://www.facs.org/quality-programs/acs-nsqip/participant-use.
20. Ban K, Berian J, Liu J, Ko C, Feldman L, Thacker J (2018) Effect of Diagnosis on Outcomes in the Setting of Enhanced Recovery Protocols. Dis *Colon rectum* 61:847–853
21. Dai X, Ge X, Yang J, Zhang T, Xie T, Gao W, Gong J, Zhu W (2017) Increased incidence of prolonged ileus after colectomy for inflammatory bowel diseases under ERAS protocol: a cohort analysis. J Surg Res 212:86–93
22. Bakker N, Cakir H, Doodeman H, Houdijk A (2015) Eight years of experience with Enhanced Recovery After Surgery in patients with colon cancer: Impact of measures to improve adherence. Surgery 157:1130–1136
23. McLeod R, Aarts M, Chung F, Eskicioglu C, Forbes S, Conn L, McCluskey S, McKenzie M, Morningstar B, Nadler A, Okrainec A, Pearsall E, Sawyer J, Siddique N, Wood T (2015) Development of an Enhanced Recovery After Surgery Guideline and Implementation Strategy Based on the Knowledge-to-action Cycle. Ann Surg 262:1016–1025
24. Ahmed J, Khan S, Lim M, Chandrasekaran T, MacFie J (2012) Enhanced recovery after surgery protocols - compliance and variations in practice during routine colorectal surgery. Colorectal Dis 14:1045–1051
25. Weiser M, Gonen M, Usiak S, Pottinger T, Samedy P, Patel D, Seo S, Smith J, Guillem J, Temple L, Nash G, Paty P, Baldwin-Medsker A, Cheavers C, Eagan J, Garcia-Aguilar J, Memorial Sloan Kettering Multidisciplinary Surgical-Site Infection Reduction Team (2018) Effectiveness of a multidisciplinary patient care bundle for reducing surgical-site infections. Br J Surg 105:1680–1687