The American Journal of Surgery 220 (2020) 830–835

Contents lists available at ScienceDirect

The American Journal of Surgery

journal homepage: www.americanjournalofsurgery.com

Featured Article

Significant morbidity is associated with proximal fecal diversion among high-risk patients who undergo colectomy: A NSQIP analysis

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ARTICLE INFO

Article history:
Received 22 February 2020
Received in revised form
5 May 2020
Accepted 7 May 2020

Keywords:
NSQIP
Colectomy
Diverting ileostomy
Morbidity
Anastomotic leak

ABSTRACT

Background: The value of proximal fecal diversion for patients undergoing colectomies is an ongoing debate. Previous studies have shown a benefit in decreased anastomotic leak rates and mitigation of the morbidity of a leak, especially in high-risk populations. However, more recent data suggests increased morbidity with fecal diversion, creating a complication with an unknown degree of anastomotic leak reduction. Therefore, we aimed to determine the impact on morbidity of a diverting loop ileostomy (DLI) in patients with a high risk of anastomotic leak.

Methods: The ACS-NSQIP database was queried (via CPT code) for adult patients (age ≥18 years) who underwent a colectomy only or colectomy with ileostomy (CWI) between Jan 2013 and Dec 2016. We compared thirty-day outcomes between a 3:1 propensity-matched colectomy only group to patients who had a CWI. We used risk factors for anastomotic leak as a basis of our propensity match which included preoperative smoking, steroid use, preoperative weight loss, preoperative transfusion, hypoalbuminemia, and leukocytosis; intraoperative match variables included indication for surgery, wound class, duration of operation, primary CPT code, elective vs. emergent, and inpatient vs. outpatient surgery.

Results: We identified 39,588 patients from the NSQIP database who had a colectomy only or a CWI. The colectomy only group was older (age 63 vs 52 years $p < 0.001$), overweight (BMI 34 vs 26.7, $p < 0.001$), more likely to be diabetic (16% vs 9.5%, $p < 0.001$) and hypertensive (49.3% vs 31.4%). However, the CWI group had higher steroid use (36.8% vs 10%, $p < 0.001$), preoperative sepsis (13.2% vs 2.5%, $p < 0.001$), smoking rate (25.7% vs 15.4%, $p < 0.001$), and preoperative weight loss (12.5% vs 4.9%, $p < 0.001$). Our propensity analysis matched 2274 colectomy only patients and 758 CWI patients. Baseline demographics were similar between groups. While the mortality rate was similar between groups (1.5% vs 1.8%, $p = 0.8$), CWI patients had longer length of stay (median 8 vs 7 days, $p < 0.001$), higher renal injury rates (3.2% vs 0.9%, $p < 0.001$), higher readmission rates (18.8% vs 11%, $p < 0.001$) and higher overall NSQIP morbidity (44.5% vs 37.6%, $p = 0.001$). The anastomotic leak rate was 3.8% in the CWI group and 5.1% in the colectomy only group ($p = 0.09$).

Conclusions: Significant thirty-day morbidity exists with a diverting ileostomy among high-risk colectomy patients with minimal benefit in anastomotic leak rates.

Introduction

An anastomotic leak is a major complication after colorectal surgery. A leak may be asymptomatic with minimal effect on the patient, but it may also result in fatal intraabdominal sepsis. In the literature, the incidence of an anastomotic leak ranges from 1 to 25% with higher rates for colorectal anastomoses.[1] Risk factors for an anastomotic leak include malnutrition, tumor stage, perioperative steroid use, age, obesity, history of pelvic radiation, and perioperative blood transfusions.[2,3] Traditionally, surgeons have created diverting loop ileostomies (DLI) to prevent or mitigate the clinical effects of anastomotic leaks. Typically DLI are created in the setting of low colorectal anastomoses or patients who are at high risk for leaks. Some studies advocate for DLI to reduce leaks with minimal ostomy related morbidity and ease of reversal.[4–9] More recent literature has challenged the benefit of DLI with significant

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https://doi.org/10.1016/j.amjsurg.2020.05.007
0002-9610/

morbidity (up to 28%) associated with readmissions due to dehydration, problems managing the stoma, and complications with reversal.[10–17] In addition, other studies have advocated selective DLI use due to it mitigating the effects of an anastomotic leak rather than preventing one.[18–21] Luglio et al. concluded that the benefit of creating a DLI benefit might outweigh the risk in patients who have a predicted postoperative complication rate of greater than 5% without diversion.[22]

Despite the number of studies on the use of DLI in colorectal surgery, most of the studies were single-center and retrospective in nature. Also, smaller sample sizes limited the ability to perform adequately powered subgroup analyses. In addition, the majority of the literature only examined the role of DLI for patients with low colorectal anastomoses. As a result, the surgeon perception of the protective ability of DLI persists, which is seen with high-risk patients. Our study aimed to examine population data using the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) to identify high-risk patients who underwent a colectomy only, excluding those who received a colorectal resection. Our primary objective was to examine the morbidity of a DLI in high risk patients who undergo a colectomy. Our secondary objective was to compare anastomotic leak rates among colectomy patients who have a DLI vs. those who do not.

Methods

We queried the ACS-NSQIP Participant Use Files (PUF) between 2013 and 2016 for colectomies with and without concomitant ileostomies. We identified colectomies by primary CPT codes of 44140, 44160, 44204, or 44205, and concomitant ileostomies by secondary CPT codes of 44187 or 44310. We merged the colectomy cases with the colectomy procedure targeted PUFs, and only included cases with procedure targeted data. We examined two patient groups: colectomy with ileostomy (CWI) and colectomy only. We excluded any protectomies due to the known benefit in DLI for this population.

We defined NSQIP morbidity as any of the following 30-day complications: mortality, any SSI (superficial, deep incisional, or organ/space), wound disruption, pneumonia, transfusion, urinary tract infection, unplanned intubation, ventilator-dependent > 48 h, sepsis, septic shock, renal failure, renal insufficiency, pulmonary embolism, deep vein thrombosis, cardiac arrest, myocardial infarction, or stroke.

We compared perioperative characteristics by the procedure group. For categorical variables, counts, and column percentages (%) were reported, while comparisons were made using chi-square and Fisher's exact tests. Continuous variables were tested for normality using the Shapiro-Wilk normality test, along with histograms. Normally distributed variables were reported using means and standard deviations (SD) and compared using one-way ANOVAs (t-tests for procedure targeted variables); otherwise, medians and first/third quartiles were reported (Q1 − Q3), and comparisons were made using Kruskal-Wallis tests (or Mann-Whitney U tests for procedure targeted variables).

We used propensity score matching to create a subsample of colectomy cases balanced by selected confounders. These variables were chosen after a review of the literature for risk factors of anastomotic leaks in colorectal patients. Propensity scores were estimated using a logistic regression model with ileostomy as the outcome variable and the following variables as main effects: age, BMI group, smoking status, steroid use, preoperative weight loss, medication for hypertension, bleeding disorder, transfer status, sepsis, albumin <3, WBC >11,000, ASA class, wound class, total operative time, primary CPT code, elective surgery status, outpatient status, and indication for surgery. These reflected not only risk factors for anastomotic leak, but also renal failure and readmission. A 3:1 non-ileostomy to ileostomy match was made using a nearest-neighbor matching algorithm with a caliper of size 0.20. The post-match balance was assessed using standardized mean differences (SMD), where variables with SMD values < 0.10 were considered to be balanced (all variables from Tables 1–3 had SMD < 0.1).

Statistical significance was defined to be $p < 0.05$. We excluded and reported missing observations on an analysis-by-analysis basis. All analyses were done in R programming language, version 3.5.1 (R Core Team; Vienna, Austria). Propensity score matching was done using the R package MatchIt, version 3.0.2.

Results

During our study period from January 2013 to December 2016, we identified 39,588 patients from the ACS-NSQIP database who underwent colectomy only or CWI. On average, patients who underwent a colectomy were older (63 years, SD 15.9), had higher BMI (28.5, SD 6.6), lower tobacco use (15.4%), more likely to have preoperative hypertension (49.3) and less likely to have preoperative steroid use (10%) or weight loss (4.9%). In contrast, patients who underwent CWI were younger (52 years, SD 18.2), had higher ASA class, higher tobacco use (25.7%), and more likely to have preoperative steroid use (36.8%) and weight loss (12.5%). The discrepancy in preoperative nutritional status was notable in baseline laboratory results, where the CWI group had 29.2% of patients with albumin less than 3.0 mg/dL compared to 9.7% in the colectomy alone group. In addition, these patients were sicker, with 24.9% having a preoperative leukocytosis compared to the colectomy only group (9.4%). When examining procedure-related characteristics, diverticulitis was the most common operative indication for CWI compared to the colectomy only group (43.6% vs. 11.8%). In addition, preoperative steroid use was significantly higher (34.4% vs. 8.7%) in the CWI group (Table 1). We then performed our propensity matching which was successful in balancing the confounders we had selected. When comparing the demographics between the two procedure groups, there were no significant differences noted (Table 1b).

In terms of operative characteristics, a majority of the colectomy only group were performed electively (83.7) and had a wound classification of clean/contaminated (83.5%) when compared to the CWI group (elective - 58.7%, clean/contaminated − 46%). On average, patients in the CWI group also had a longer operative duration than the colectomy group (215 min vs. 166 min). (Table 2).

When we examined our unmatched cohort, the NSQIP outcome data demonstrated significant morbidity among patients who underwent CWI compared to the colectomy only group (45.4% vs 24.1%, $p < 0.01$). This was a result of higher unplanned readmissions (18.8% vs. 7.6%), SSI (16% vs. 8.6%), renal failure (3% vs 0.8%) and pulmonary embolism or deep vein thrombosis (3.9% vs 1.5%). Postoperatively, they required transfusions more often (14.8% vs. 8.2%) and were more likely to develop postoperative sepsis (11.4% vs. 3.9%). There was also a notable difference in the median length of stay (8 days vs. 5 days) but thirty-day mortality rate remained similar (1.1% vs 1.7%) (Table 3a). After performing the propensity matching, our subsample analysis demonstrated CWI patients continued to have a higher morbidity rate than colectomy only patients (44.5% vs 37.6%, $p < 0.01$). Specifically, they had a higher unplanned related admission rate (18.2% vs. 11%) and likelihood for developing renal failure (3.2% vs 0.9%). They had a slightly longer median length of stay (8 days vs. 7 days) and the mortality rate was similar at 1.5% vs 1.7% (Table 3b).

We then examined the overall anastomotic leak rate between our unmatched cohort and we noted a significant difference between the two (3.5% vs. 3.8%, p 0.01). There was a slightly higher

Table 1a
Patient characteristics stratified by procedure group (N = 41,450).

Total number of patients (%)	Overall	Procedure Group		P-value
		Colectomy only	Colectomy with Ileostomy	
	41,450 (100)	38,764 (93.5)	824 (2.0)	
Mean age (SD), years	62 (16.2)	63 (15.9)	52 (18.1)	<0.0001
Missing data	N = 1	N = 1	N = 0	
Male, N (%)	19,701 (47.5)	18,409 (47.5)	403 (48.9)	0.7095
Mean BMI (SD), kg/m^2	28.3 (6.7)	28.5 (6.6)	26.4 (6.9)	<0.0001
Missing data	N = 248	N = 243	N = 5	
BMI > 30, N (%)	13,757 (33.4)	13,137 (34.1)	219 (26.7)	<0.0001
Missing data	N = 248	N = 243	N = 5	
BMI group, N (%)				<0.0001
<18.5	1152 (2.9)	1059 (2.7)	93 (11.4)	
18.5–24.9	11759 (29.7)	11,468 (29.8)	291 (35.5)	
25.0–29.9	13073 (33)	12,857 (33.4)	216 (26.4)	
30.0–34.9	7736 (19.5)	7611 (19.8)	125 (15.3)	
35.0–39.9	3399 (8.6)	3341 (8.7)	58 (7.1)	
40.0 +	2221 (5.6)	2185 (5.7)	36 (4.4)	
Missing data	N = 248	N = 243	N = 5	
ASA Class, N (%)				<0.0001
I–II	17880 (45.2)	17,574 (45.4)	306 (37.2)	
III	19617 (49.6)	19,145 (49.5)	472 (57.4)	
IV–V	2020 (5.1)	1976 (5.1)	44 (5.4)	
Missing data	N = 71	N = 69	N = 2	
Treatment for diabetes, N (%)	6275 (15.9)	6197 (16.0)	78 (9.5)	<0.0001
Smoking, N (%)	6175 (15.6)	5963 (15.4)	212 (25.7)	<0.0001
Dyspnea, N (%)	2990 (7.6)	2938 (7.6)	52 (6.3)	0.0415
Partially/totally dependent functional status, N (%)	869 (2.2)	852 (2.2)	17 (2.1)	<0.0001
Missing data	N = 131	N = 130	N = 1	
Ventilator use pre-op, N (%)	13 (0)	11 (0.0)	2 (0.2)	<0.0001
History of COPD, N (%)	1956 (4.9)	1912 (4.9)	44 (5.3)	0.7943
Ascites, N (%)	202 (0.5)	189 (0.5)	13 (1.6)	<0.0001
History of CHF, N (%)	464 (1.2)	460 (1.2)	4 (0.5)	0.1772
Med. for hypertension, N (%)	19355 (48.9)	19,096 (49.3)	259 (31.4)	<0.0001
Renal failure preop, N (%)	51 (0.1)	51 (0.1)	0 (0.0)	0.0685
Currently on dialysis, N (%)	228 (0.6)	223 (0.6)	5 (0.6)	0.3782
Disseminated cancer, N (%)	2678 (6.8)	2608 (6.7)	70 (8.5)	<0.0001
Wound infection preop, N (%)	427 (1.1)	396 (1.0)	31 (3.8)	<0.0001
Steroid use, N (%)	4171 (10.5)	3868 (10.0)	303 (36.8)	<0.0001
Preop weight loss > 10% within 6 months of procedure, N (%)	2002 (5.1)	1899 (4.9)	103 (12.5)	<0.0001
Bleeding disorder, N (%)	1281 (3.2)	1233 (3.2)	48 (5.8)	<0.0001
Transfusion preop, N (%)	1062 (2.7)	1037 (2.7)	25 (3.0)	0.0002
Sepsis preop, N (%)	1080 (2.7)	971 (2.5)	109 (13.2)	<0.0001

proportion of patients who underwent a colectomy only who required a reoperation for their leak (1.8% vs 1.2%). However, less severe leaks that did not required an intervention but not a reoperation were more common in the CWI group (1.7% vs 0.7%) (Table 3a). After propensity matching for high risk patients, the overall anastomotic leak rate was slightly higher in the colectomy only group compared to the CWI group (5.1% vs 3.8%, p = 0.9). More colectomy only patients also required a reoperation for their anastomotic leak (3% vs 1.3%). However, there was no difference between groups if the patient had a subclinical leak that did not require treatment or one that required intervention without a reoperation.

Discussion

This study is the first large study examining the ACS-NSQIP database for a high-risk patient population undergoing a colectomy. We have demonstrated that in a propensity-matched analysis of these patients, DLI offers minimal benefit in anastomotic leak rates for colectomies. In our unmatched analysis, while there was statistical significance between the anastomotic leak rate of the CWI and colectomy only group, the difference in rate was only 0.3%. When we examined the anastomotic leak rate after our propensity matching, that rate difference increased to 1.3%. Our expectation was that among high risk patients, not performing a DLI for a colectomy would lead to higher anastomotic leak rates. One consequence of this is noted in the reoperation rates. Colectomy only patients had three times the reoperation rate for an anastomotic leak when compared to the CWI patients (3% vs 1.3%). This may reflect the more severe nature of leaks that occur without diversion which must be addressed with a second operation. However, postoperative sepsis and unplanned reoperation rates did not differ between groups. The question then becomes whether a 1% higher leak rate among high risk patients who do not undergo diversion is clinically significant. We argue that it is not and surgeons should not shy away from performing an anastomosis without diversion. Of note, our study focused only on colectomies and excluded proctectomies because the literature has strongly supported proximal fecal diversion due to the higher risk of a colorectal anastomotic leak.

Our propensity analysis matched groups based on known predictors of anastomotic leak but they also represent the strongest predictors of other outcomes. In particular, ASA class, approach (embedded in CPT code), elective surgery, albumin, BUN, COPD, BMI, and indication for surgery are all balanced in the propensity analysis and comprise eight of the top ten risk factors for general morbidity in the 2019 NSQIP colectomy model. In addition, the top 10 NSQIP predictors of renal failure after colectomy in 2019 were

Table 1b
Patient characteristics stratified by procedure group among the propensity-matched subsample of colectomy cases (N = 3032).

Total number of patients (%)	Overall	Procedure Group		P-value
		Colectomy Alone	Colectomy with Ileostomy	
	3032 (100)	2274 (75.0)	758 (25.0)	
Mean age (SD), years	53 (18.4)	53 (18.6)	53 (17.9)	0.6692
Male, N (%)	1528 (50.4)	1161 (51.1)	367 (48.4)	0.2239
Mean BMI (SD), kg/m^2	27.0 (7.0)	27.1 (7.0)	26.7 (6.8)	0.2014
BMI > 30, N (%)	855 (28.2)	645 (28.4)	210 (27.7)	0.7619
BMI group, N (%)				0.9756
<18.5	287 (9.5)	214 (9.4)	73 (9.6)	
18.5–24.9	1054 (34.8)	787 (34.6)	267 (35.2)	
25.0–29.9	836 (27.6)	628 (27.6)	208 (27.4)	
30.0–34.9	473 (15.6)	352 (15.5)	121 (16.0)	
35.0–39.9	240 (7.9)	185 (8.1)	55 (7.3)	
40.0 +	142 (4.7)	108 (4.7)	34 (4.5)	
ASA Class, N (%)				0.1864
I–II	1233 (40.7)	942 (41.4)	291 (38.4)	
III	1626 (53.6)	1198 (52.7)	428 (56.5)	
IV–V	173 (5.7)	134 (5.9)	39 (5.1)	
Treatment for diabetes, N (%)	348 (11.5)	271 (11.6)	77 (10.2)	0.2113
Smoking, N (%)	757 (25.0)	569 (25.0)	188 (24.8)	0.9421
Dyspnea, N (%)	190 (6.3)	141 (6.2)	49 (6.5)	0.8626
Partially/totally dependent functional status, N (%)	76 (2.5)	61 (2.7)	15 (2.0)	0.3485
Missing Data	N = 3	N = 2	N = 1	
Ventilator use pre-op, N (%)	4 (0.1)	2 (0.1)	2 (0.3)	0.2616
History of COPD, N (%)	148 (4.9)	106 (4.7)	42 (5.5)	0.3811
Ascites, N (%)	39 (1.3)	28 (1.2)	11 (1.5)	0.7801
History of CHF, N (%)	28 (0.9)	24 (1.1)	4 (0.5)	0.2730
Med. for hypertension, N (%)	1008 (33.2)	760 (33.4)	248 (32.7)	0.7553
Renal failure preop, N (%)	3 (0.1)	3 (0.1)	0 (0.0)	0.5779
Currently on dialysis, N (%)	13 (0.4)	10 (0.4)	3 (0.4)	0.9999
Disseminated cancer, N (%)	241 (7.9)	175 (7.7)	66 (8.7)	0.4156
Wound infection preop, N (%)	103 (3.4)	76 (3.3)	27 (3.6)	0.8621
Steroid use, N (%)	1015 (33.5)	755 (33.2)	260 (34.3)	0.6093
Preop weight loss > 10% within 6 months of procedure, N (%)	346 (11.4)	258 (11.3)	88 (11.6)	0.8951
Bleeding disorder, N (%)	137 (4.5)	100 (4.4)	37 (4.9)	0.6500
Transfusion preop, N (%)	102 (3.4)	80 (3.5)	22 (2.9)	0.4853
Sepsis preop, N (%)	295 (9.7)	213 (9.4)	82 (10.8)	0.2727

SD = standard deviation. There were no missing data unless otherwise noted.

Table 2
Operative characteristics stratified by procedure group.

Total number of patients (%)	Overall	Procedure Group		P-value
		Colectomy only	Colectomy with Ileostomy	
	39,588 (100)	38,764 (93.5)	824 (2.0)	
Mean operative duration (SD), minutes	165 (82.6)	166 (80.7)	215 (105.2)	<0.0001
Missing data	N = 3	N = 3	N = 0	
Primary CPT, N (%)				<0.0001
44140	7731 (19.5)	7440 (19.2)	291 (35.3)	
44160	6073 (15.3)	5753 (14.8)	320 (38.8)	
44204	16653 (42.1)	16,531 (42.6)	122 (14.8)	
44205	9131 (23.1)	9040 (23.3)	91 (11.0)	
Elective, N (%)	32934 (83.2)	32,451 (83.7)	483 (58.7)	<0.0001
Missing data	N = 14	N = 13	N = 1	
Outpatient, N (%)	182 (0.5)	182 (0.5)	0 (0.0)	<0.0001
Wound class, N (%)				<0.0001
Clean	383 (1)	380 (1.0)	3 (0.4)	
Clean/contaminated	32754 (82.7)	32,375 (83.5)	379 (46.0)	
Contaminated	4158 (10.5)	3959 (10.2)	199 (24.2)	
Dirty/infected	2293 (5.8)	2050 (5.3)	243 (29.5)	
Primary indication for surgery, N (%)				<0.0001
Colon cancer	23908 (60.4)	23,707 (61.2)	201 (24.4)	
Chronic diverticular disease	6440 (16.3)	6323 (16.3)	117 (14.2)	
Crohn's disease	4926 (12.4)	4567 (11.8)	359 (43.6)	
Colon cancer with obstruction	2333 (5.9)	2263 (5.8)	70 (8.5)	
Acute diverticulitis	1981 (5)	1904 (4.9)	77 (9.3)	

Table 3a
Thirty-day outcomes stratified by procedure group.

Total number of patients (%)	Overall	Procedure Group		P-value
		Colectomy only	Colectomy with Ileostomy	
	39,588 (100)	38,764 (93.5)	824 (2.0)	
Prolonged postoperative NPO or NGT use, N (%)	5054 (12.8%)	4864 (12.5)	190 (23.1)	<0.0001
Unknown	N = 78	N = 78	N = 0	
Median hospital length of stay (Q1 − Q3), days	5.0 (3.0–8.0)	5.0 (3.0–7.0)	8.0 (5.0–13.0)	<0.0001
Missing data	N = 24	N = 24	N = 0	
NSQIP morbidity, N (%) (any of the following)	9711 (24.5)	9337 (24.1)	374 (45.4)	<0.0001
Mortality	448 (1.1)	434 (1.1)	14 (1.7)	<0.0001
Unplanned reoperation	1639 (4.1)	1598 (4.1)	41 (5)	0.0003
Unplanned related readmission	3109 (7.9)	2954 (7.6)	155 (18.8)	<0.0001
Any SSI	3451 (8.7)	3319 (8.6)	132 (16)	<0.0001
Superficial	1702 (4.3)	1646 (4.2)	56 (6.8)	0.0005
Deep incisional	324 (0.8)	305 (0.8)	19 (2.3)	<0.0001
Organ/space	1593 (4)	1529 (3.9)	64 (7.8)	<0.0001
Wound disruption	289 (0.7)	282 (0.7)	7 (0.8)	0.8588
Pneumonia	713 (1.8)	698 (1.8)	15 (1.8)	0.0755
Transfusion	3305 (8.3)	3183 (8.2)	122 (14.8)	<0.0001
Urinary tract infection	718 (1.8)	695 (1.8)	23 (2.8)	<0.0001
Unplanned intubation or ventilator use > 48 h	696 (1.8)	672 (1.7)	24 (2.9)	0.0009
Sepsis or septic shock	1609 (4.1)	1515 (3.9)	94 (11.4)	<0.0001
Renal failure or insufficiency	325 (0.8)	300 (0.8)	25 (3)	<0.0001
Pulmonary embolism or deep vein thrombosis	624 (1.6)	592 (1.5)	32 (3.9)	<0.0001
Cardiac arrest, myocardial infarction, or stroke	471 (1.1)	436 (1.1)	12 (1.5)	0.6190
Anastomotic leak, N (%)				0.0139
No definitive diagnosis of leak	38,209 (96.5)	37,416 (96.5)	793 (96.2)	
Leak, treated with reoperation	708 (1.8)	698 (1.8)	10 (1.2)	
Leak, treated with intervention	274 (0.7)	260 (0.7)	14 (1.7)	
Leak, treated with non-operative, non-intervention means	180 (0.5)	175 (0.5)	5 (0.6)	
Leak, no intervention documented	87 (0.2)	85 (0.2)	2 (0.2)	
Unknown	N = 130	N = 130	N = 0	

ASA class, Creatinine, primary CPT code, diabetes, preoperative sepsis, hypertension, gender, ascites, low WBC, and albumin; these were all balanced in the propensity analysis already run. Similarly, 14 of the 15 top predictors of colectomy readmission were balanced as well.

While CWI patients had a small decrease in anastomotic leak rates, ileostomies are not without their complications. Fish et al. performed a single-center study that examined postoperative complications related to ileostomy creation and found a 28% readmission rate within a 60-day window. The most common

Table 3b
Thirty-day outcomes stratified by procedure group among the propensity-matched subsample of colectomy cases (N = 3040).

Total number of patients (%)	Overall	Procedure Group		P-value
		Colectomy only	Colectomy with Ileostomy	
	3032 (100)	2274 (75.0)	758 (25.0)	
Median hospital length of stay (Q1 − Q3), days	7.0 (5.0–12.0)	7.0 (5.0–12.0)	8.0 (5.0–13.0)	<0.0001
Missing data	N = 1	N = 1	N = 0	
NSQIP morbidity, N (%) (any of the following)	1192 (39.3)	855 (37.6)	337 (44.5)	0.001
Mortality	47 (1.6)	34 (1.5)	13 (1.7)	0.7990
Unplanned reoperation	191 (6.3)	152 (6.7)	39 (5.1)	0.1544
Unplanned related readmission	389 (12.8)	251 (11.0)	138 (18.2)	<0.0001
Any SSI	472 (15.6)	357 (15.7)	115 (15.2)	0.7724
Superficial	189 (6.2)	137 (6.0)	52 (6.9)	0.4610
Deep incisional	57 (1.9)	39 (1.7)	18 (2.4)	0.3156
Organ/space	253 (8.3)	202 (8.9)	51 (6.7)	0.0748
Wound disruption	39 (1.3)	33 (1.5)	6 (0.8)	0.2264
Pneumonia	79 (2.6)	65 (2.9)	14 (1.8)	0.1669
Transfusion	408 (13.5)	299 (13.1)	109 (14.4)	0.4244
Urinary tract infection	76 (2.5)	55 (2.4)	21 (2.8)	0.6874
Unplanned intubation or ventilator use > 48 h	90 (3.0)	68 (3.0)	22 (2.9)	0.9999
Sepsis or septic shock	295 (9.7)	220 (9.7)	75 (9.9)	0.9155
Renal failure or insufficiency	45 (1.5)	21 (0.9)	24 (3.2)	<0.0001
Pulmonary embolism or deep vein thrombosis	83 (2.7)	55 (2.4)	28 (3.7)	0.0827
Cardiac arrest, myocardial infarction, or stroke	41 (1.4)	29 (1.3)	12 (1.6)	0.6499
Anastomotic leak, N (%)				0.0922
No definitive diagnosis of leak	2882 (95.2)	2153 (94.9)	729 (96.2)	
Leak, treated with reoperation	78 (2.6)	68 (3.0)	10 (1.3)	
Leak, treated with intervention	40 (1.3)	28 (1.2)	12 (1.6)	
Leak, treated with non-operative, non-intervention means	19 (0.6)	14 (0.6)	5 (0.7)	
Leak, no intervention documented	7 (0.2)	5 (0.2)	2 (0.3)	
Unknown	N = 6	N = 6	N = 0	

reasons were dehydration, intra-peritoneal infections, and extraperitoneal infections. Our study demonstrated a lower readmission rate, but DLI patients were also more prone to develop acute kidney injuries postoperatively. Another study, a large meta-analysis by Chow et al., reviewed 48 studies on the morbidity surrounding DLI reversal and identified an overall rate of 17.3%. Postoperative complications included small bowel obstruction after closure, wound infections, and anastomotic leak of the ostomy closure. One final study by Sharma et al. examined NSQIP data on elective ileostomy closure and found a total complication rate of 17.7% (major 9.3%, minor 8.4%). While their average LOS was around five days, patients who suffered a major complication had a significant increase in their LOS (13.9 days).[23]

In addition to these clinical limitations of a DLI, there is an added financial burden. These include the cost of the complications, increased length of stay, readmissions, opportunity cost, etc. Furthermore, there is the cost of a second operation to reverse the ileostomy, which requires another hospitalization where the average length of stay is around 5.1 days. As healthcare costs continue to rise, surgeons need to consider the economics of our clinical care decisions in a changing reimbursement landscape.

While this study utilized a standardized national database, there are a few limitations. First, data collection is dependent on the quality of documentation of each NSQIP center and the accuracy of CPT reporting of the operating surgeon. Also, hospitals must choose to participate in the database, which may introduce selection bias in the patients represented. Second, due to the NSQIP database, we were unable to differentiate between a left and a right colectomy. Left colectomies have a higher anastomotic leak rate, so this would be a relevant differentiation to make in our data. Finally, while NSQIP is tracking patients who followed an enhanced recovery after surgery (ERAS) protocol, this is not currently available in public use files. ERAS was developed and popularized in Europe in the early 2000s before recently being adopted by academic centers in the United States. As more American hospitals develop their own ERAS protocols to improve their quality measures, this will be an important variable to account for in a study. The CWI group had a higher proportion of emergent operations, so those patients would not have benefitted from being in such a protocol and thus had worse outcomes as a result.

Conclusion

The impact of an anastomotic leak can be devastating, especially in a deconditioned, high-risk patient. Current dogma among surgeons is to create a DLI with these high-risk colectomy patients, but our study argues that the morbidity of an ileostomy outweighs any benefit in anastomotic leak reduction among patients who undergo a colectomy only.

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