



Open versus minimally invasive small bowel resection for Crohn's disease: a NSQIP retrospective review and analysis

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Abstract

Introduction Many patients with Crohn's Disease will require surgical resection. While many studies have described outcomes following ileocecectomy, few have evaluated surgical resection of other portions of small bowel. We sought to compare open and minimally invasive surgery (MIS) approaches for small bowel resection excluding ileocecectomy of patients with Crohn's Disease using the National Surgical Quality Improvement Program (NSQIP) database.

Methods The NSQIP database was queried for patients with Crohn's disease or complications related to Crohn's disease who underwent segmental small bowel resection utilizing open or minimally invasive approaches between 2012 and 2018. Patients requiring ileocecectomy or diagnosed with ascites, disseminated cancer, pre-operative sepsis, ASA class 5, and patients requiring mechanical ventilation were excluded. The association of pre-operative variables including patient demographic information and comorbidities with surgical approach were examined using Fishers exact test. Intraoperative, and 30-day post-operative outcomes were compared between the groups using both univariate and multivariate logistical regression models. SAS was used for data analysis with $p < 0.05$ considered significant.

Results After exclusions, we found 1697 patients with Crohn's disease who underwent segmental small bowel resection, 1252 of whom underwent open surgery and 445 of whom underwent MIS. After adjusting for possible confounders with multivariable analysis, patients who underwent MIS had a lower incidence of wound events (surgical site, organ space, or deep wound infection, or dehiscence), post-operative bleeding, need for return to the operating room, and shorter total hospital length of stay despite longer operative times compared with open surgery.

Conclusions This retrospective review of NSQIP shows that minimally invasive small bowel resection is associated with equivalent or improved morbidity over open surgery in select patients with small bowel Crohn's Disease. We show that in select patients minimally invasive small bowel resection can be safe and performed for patients with isolated small bowel Crohn's disease.

Keywords Small bowel · Crohn's disease · Minimally invasive surgery

Crohn's disease (CD) is a chronic inflammatory bowel disease with unclear etiology and insidious onset that can

affect any part of the gastrointestinal (GI) tract from mouth to anus. It is characterized by inflammatory skip-lesions along the lining of the digestive system that can cause transmural inflammation, resulting in a range of GI pathologies including intestinal thickening, abscesses, fistulas, strictures, bowel obstruction, and bowel perforation. Despite advances

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in medical therapy and preference to avoid surgery, approximately 33% of Crohn's patients will require surgery 5 years after initial diagnosis with almost 50% requiring surgery at 10 years [1].

Appropriate operative intervention for CD depends on both surgical indication and location. Common surgical procedures include endoscopic dilation, strictureplasty, or bowel resection. Despite the preference for bowel-sparing techniques, some patients will ultimately require bowel resection for definitive treatment which has been associated with significantly improved quality of life for certain patients [2]. With respect to resection, there is still controversy regarding the appropriateness of a minimally invasive approach to treat patients with CD. Often patients can present in extremis, requiring an urgent or emergent operation in which laparoscopy may not be the most appropriate initial approach. Additionally, technical challenges of laparoscopic bowel resection in Crohn's patients can include difficulty manipulating inflamed bowel that may be adherent to other structures as well as dissection of thickened mesentery with increased vascularity without injury [3].

On the other hand, given that a significant proportion of patients with CD will require reoperation at some point in their lifetime, a minimally invasive approach may be of particular benefit to this patient population. Recently, minimally invasive surgery (MIS) has grown in popularity to address CD [4–6]. Advantages of MIS for Crohn's patients have been highlighted by several studies and include reduced morbidity, faster recovery, and lower cost of surgery as well as fewer small bowel obstructions and incisional hernias compared to patients undergoing open surgery [4–9]. Additionally, despite concerns of high recurrence due to potentially overlooking areas of diseased bowel requiring resection with MIS, no studies have shown a difference in rates of reoperation comparing open and MIS approaches [10, 11].

The most commonly affected location of disease in Crohn's patients is the terminal ileum and cecum (55%) and therefore strong evidence has favored MIS ileocecectomy compared to open surgery. However, CD has been reported to show a pattern of isolated small bowel disease that can affect 11–48% of patients, with operative rates for isolated ileal disease described at approximately 50% at 5 years and 70% at 10 years [3, 12–14]. For these patients who may not have involvement of the ileocecal valve or who cannot undergo bowel-sparing techniques such as strictureplasty, segmental bowel resection may be the most appropriate surgical management option. Despite this, no randomized or well-powered retrospective studies have evaluated outcomes of patients requiring segmental bowel resection for CD isolated to the small bowel. In this study, we sought to examine overall outcomes of this patient population as well as the impact of operative approach comparing open surgery to MIS on 30-day outcomes using the American College of

Surgeons National Surgical Quality Improvement Program (NSQIP) database.

Methods

We retrospectively reviewed patients utilizing data from the main NSQIP database. Because the data from NSQIP is de-identified, this study was deemed exempt from our Institutional Review Board. We included patients with a diagnosis of CD (ICD10 codes K50.0, K50.9 or ICD9 codes 555.0, 555.9) who underwent either open small bowel resection (CPT code 44120, 44125, 44130) or minimally invasive small bowel resection (CPT code 44202) between 2012 and 2018. The patients were then divided into groups based on the operative approach: open small bowel resection and minimally invasive small bowel resection based on the CPT code. Patients who underwent conversion to an open procedure from MIS were included in the MIS cohort as part of an intention-to-treat analysis. Patients with ascites, disseminated cancer, sepsis, those who were ventilator-dependent, and those who were ASA class 5 were excluded. Additionally, as our intention was to evaluate patients who underwent small bowel resection only, patients who underwent ileocecectomy were excluded from analysis.

Patient demographics that were compared between the two operative groups included age, average BMI, sex, race, independent functional status, and ASA class. Additionally, past medical history including history of diabetes, smoking, chronic obstructive pulmonary disease (COPD), congestive heart failure (CHF), hypertension, requirement for dialysis, pre-operative diagnosis of sepsis, pre-operative use of corticosteroids, bleeding pre-disposition, obesity, requirement for dialysis, anemia, and serum albumin < 3.5 were compared. Procedural characteristics such as wound class and classification of the procedure as emergent were also compared. Perioperative and 30-day post-operative outcomes were collected from the NSQIP database and analyzed to compare benefits or disadvantages of the two operative approaches. Outcomes of interest included cardiac events (cardiac arrest, MI), renal events (acute kidney injury, dialysis), pulmonary events (pneumonia, prolonged intubation, reintubation), post-operative sepsis (including septic shock), venous thromboembolism wound events (superficial surgical site infection, deep wound infection, organ space infection, dehiscence), stroke, urinary tract infection, *Clostridium difficile* infection, return to OR, 30-day mortality, mean operative time, and total hospital length of stay.

We examined associations of pre-operative variables and outcomes with procedure (Open vs MIS) using Fishers Exact test. Binary outcome associations with procedure were examined in multivariable logistic regression models. We eliminated covariates with $p > 0.20$ since these would have

had minimal effects as confounds, but reduced degrees of freedom, thereby reducing power unnecessarily. SAS (Version 9.4, Cary, NC) was used for data analysis, with $p < 0.05$ considered significant.

Results

After exclusions, there were 1697 cases meeting inclusion criteria, 445 (26%) of which underwent MIS approach, 1252 (76%) an open approach. Demographic data are summarized in Table 1. The overall mean age of patients was 44.6 ± 16 years old, and mean BMI was 25 ± 6 . 47% of all patients were female. 79% of all patients were White, 7% Black, 3% Hispanic, 2% Asian, and 9% unknown race. Surgical approaches differed significantly on several pre-operative variables. Patients who received MIS were slightly younger (41.5 ± 15.8 vs. 45.7 ± 15.9 ; $p < 0.0001$),

more likely to have independent functional status (99.8% vs. 98.5%; $p = 0.037$) and less likely to have pre-op infection (2.0% vs. 4.9%; $p = 0.008$), low serum albumin (25.8% vs. 36.8%; $p < 0.0001$), anemia (26.1% vs. 37.4%; $p < 0.0001$), or to have emergency surgery (4.0% vs. 6.8%; $p = 0.038$). The overall NSQIP computed morbidity and mortality probabilities were higher in patients who received open surgery as well (8.3% vs 16.7% and 0.3% vs 0.8%, respectively; $p < 0.0001$). There were no significant differences between approaches in terms of sex, BMI, race, history of diabetes, smoking, dyspnea, COPD, CHF, HTN, pre-operative use of steroids, pre-operative weight loss, bleeding pre-disposition, pre-operative abnormal WBC count, or pre-operative ASA class. A specific breakdown of minimally invasive approaches is listed in Table 2. 343 (77%) of patients had procedures coded as laparoscopic only while 83 (19%) of patients had procedures coded as lap-assisted (including both “laparoscopic with hand assist” and “laparoscopic

Table 1 Pre-operative variables

Pre-operative variable	MIS ($n = 445$)	Open ($n = 1252$)	<i>p</i>
Age	41.5 ± 15.8	45.7 ± 15.9	< 0.0001
Sex: female	214 (48.1%)	588 (47.0%)	0.6990
Average BMI	25.2 ± 5.8	24.7 ± 5.9	0.13
Race			
White	364 (81.8%)	970 (77.5%)	0.0595
Black	29 (6.5%)	94 (7.5%)	0.5247
Hispanic	15 (3.4%)	43 (3.5%)	1.0000
Asian	10 (2.3%)	19 (1.5%)	0.2942
Other/missing	27 (5.9%)	126 (10.0%)	
Independent functional status	444 (99.8%)	1233 (98.5%)	0.0368
History of diabetes	12 (2.7%)	49 (3.9%)	0.2990
History of smoking	77 (17.3%)	255 (20.4%)	0.1650
History of dyspnea	7 (1.6%)	27 (2.2%)	0.5568
History of COPD	10 (2.3%)	21 (1.7%)	0.4166
History of CHF	0 (0%)	2 (0.2%)	1.0000
History of HTN	69 (15.5%)	214 (17.1%)	0.4600
Pre-operative infection	9 (2.0%)	61 (4.9%)	0.0080
Pre-operative steroid use	251 (56.4%)	653 (52.2%)	0.1353
Pre-operative weight loss	30 (6.7%)	115 (9.2%)	0.1382
Bleeding pre-disposition	8 (1.8%)	20 (1.6%)	0.8286
Serum albumen < 3.0	115 (25.8%)	461 (36.8%)	< 0.0001
WBC > 11.5	117 (26.3%)	376 (30.0%)	0.1447
Anemia	116 (26.1%)	468 (37.4%)	< 0.0001
ASA class 1 or 2	441 (99.0%)	1239 (99.0%)	1.0000
ASA class 3 or 4	4 (1.0%)	13 (1.0%)	1.0000
Emergency surgery	18 (4.0%)	85 (6.8%)	0.0376
NSQIP morbidity probability	8.3% (7.9–8.6%)	16.7% (16.3–17.0%)	< 0.0001
NSQIP mortality probability	0.3% (0.27–0.43%)	0.8% (0.73–0.97%)	< 0.0001

Values given are *N* (column %) or Mean \pm Standard Deviation. For NSQIP probability estimates, mean (95% confidence interval) are shown

Significant *p* values are in bold

Table 2 Breakdown of minimally invasive approaches

Surgical approach	Number of patients
Laparoscopic only	343
Lap-assisted	83
Lap with unplanned conversion	7
Robotic only	5
Robotic-assisted	5
Robotic with unplanned conversion	2
Total	445

with open assist”. A minority of patients underwent robotic surgery (3%).

Results of univariable analysis are seen in Table 3. The conversion rate was approximately 2%, and 12 patients in the open cohort required an enterostomy. MIS was associated with a significantly lower rate of post-operative sepsis (3.8% vs. 7.0%; $p=0.021$), wound events (8.3% vs. 16.7%; $p<0.0001$), bleeding complications (4.3% vs. 11.5%; $p<0.0001$), and return to OR (3.8% vs. 7.0%; $p=0.016$), with a trend level significance for pulmonary events (0.9% vs 2.5%; $p=0.051$). MIS was also associated with a significantly shorter total hospital length of stay (5.94 ± 4.65 days vs. 9.67 ± 9.31 days; $p<0.001$), but a longer mean operative time (177.7 ± 98.3 min vs. $153.3+69.6$ min, $p<0.001$).

Table 3 Univariable analysis of post-operative outcomes by approach

Outcome	MIS ($n=445$)	Open ($n=1252$)	Fisher p
Patients with enterostomy	–	12 (1%)	–
Conversion to open procedure	9 (2.0%)	–	–
Cardiac event	0	2 (0.2%)	0.99
Renal event	1 (0.2%)	14 (1.1%)	0.14
Pulmonary event	4 (0.9%)	31 (2.5%)	0.051
Venous thromboembolism	3 (0.7%)	22 (1.8%)	0.11
Post-operative sepsis	17 (3.8%)	87 (7.0%)	0.021
Wound event	37 (8.3%)	209 (16.7%)	< 0.0001
Bleeding complication requiring transfusion	19 (4.3%)	144 (11.5%)	< 0.0001
Return to OR	17 (3.8%)	88 (7.0%)	0.016
Total length of stay (days)	5.94 ± 4.65	9.67 ± 9.31	< 0.001
Mean operative time (min)	177.7 ± 98.3	$153.3+69.6$	< 0.001
30-day mortality	1 (0.2%)	6 (0.5%)	0.68

Values given are N (column %) or Mean \pm Standard Deviation

NA too few events to calculate

Significant p values are in bold

There were no significant differences in cardiac or renal events, venous thromboembolism, or 30-day mortality.

Results of multivariable regression analysis are seen in Table 4. After adjusting for possible confounding variables, open surgery was associated with significantly higher odds of wound events (OR 1.97; CI 1.36–2.87; $p=0.004$), bleeding complications requiring transfusion (OR 2.27; CI 1.37–3.77; $p=0.02$), and return to operating room (OR 1.73; CI 1.01–2.96); $p=0.046$). No significant differences were found in cardiac, renal, or pulmonary events as well as post-operative venous thromboembolism, sepsis, or 30-day mortality.

Discussion

We believe ours is the first evaluation of open and minimally invasive approaches to address segmental bowel resection for isolated small bowel CD in the literature. We found that MIS for isolated small bowel resection in patients with CD was safe with comparable or improved perioperative morbidity compared to open surgery in select patients. In our study, MIS was associated with a statistically significant decrease in incidence of the most common complications including wound events, bleeding requiring transfusion, and return to operating room as well as significantly shorter total hospital length of stay despite longer mean operative time. MIS also had a reduced incidence of post-operative sepsis and trended toward reduced incidence of pulmonary events, after controlling for rates of pre-operative infection in multivariable analysis.

With regards to the rate of wound events, it is particularly remarkable that the wound complication rate was significantly lower for MIS compared to open surgery given the similarly high (> 50%) rate of steroid use in both cohorts

Table 4 Multivariable regression analysis for post-operative outcomes by approach

Outcome	Adjusted OR for open (95% CI)	p
Cardiac event	NA	–
Renal event	4.49 (0.58–34.63)	0.15
Pulmonary event	1.97 (0.68–5.74)	0.21
Venous thromboembolism	2.55 (0.76–8.61)	0.13
Post-operative sepsis	1.52 (0.88–2.62)	0.13
Wound event	1.97 (1.36–2.87)	0.0004
Bleeding complication	2.27 (1.37–3.77)	0.002
Return to operating room	1.73 (1.01–2.96)	0.046
30-day mortality	1.21 (0.14–10.62)	0.87

OR odd's ratio, CI confidence interval, NA too few events to estimate an OR

Significant p values are in bold

and even after controlling for a slightly higher number of pre-operative infections in the open surgery cohort in multivariable analysis. These results are in concordance with other work comparing open and MIS with respect to wound infections for IBD and suggest that MIS independently is associated with decreased wound infection rates regardless of these other confounding factors [5, 16].

It is reported that 30–70% of all patients who receive surgery for CD will require repeat operations, and so these patients may particularly benefit from a minimally invasive approach due to the theoretical decrease in intraabdominal adhesions after MIS compared with open surgery [15]. Laparoscopic bowel resection for CD, however, can be technically demanding for several reasons. During the course of laparoscopic resection, the surgeon may encounter an inflammatory mass associated with the small bowel, unexpected abscess, internal fistula, thickened mesentery, enlarged lymph nodes, or multi-site disease [13]. If able to be addressed laparoscopically, these challenging situations likely explain the longer operative time we saw in MIS compared with open surgery. Ultimately, it may be easier to address these situations by converting to an open procedure and delivering the bowel into the wound to facilitate resection which may be the safest option for the patient.

Despite the particular difficulties that operating on patients with CD may carry, the conversion rate we found was exceedingly low at 2% (Tables 2, 3). In our search of the literature, we were unable to find any studies that described conversion rates for isolated small bowel resection alone that did not also include a majority of patients who underwent ileocecal resection. Therefore, although we cannot make comparisons between existing rates of conversion for small bowel resection, for laparoscopic ileocectomy, reported conversion rates have a wide range from 2 to 40% [9, 16–24]. Our reported conversion rate of 2% is consistent with many studies reporting a similar low conversion rate [18–25]. The low conversion rate could also be due to the fact that the small bowel is not adherent to the pelvic sidewall, unlike the cecum, and therefore is much easier to resect laparoscopically compared to the ileocecal region, even in Crohn's patients. Put together, these results suggest that it may be possible to perform isolated small bowel resection for CD laparoscopically with a low and acceptable conversion rate.

Despite operative challenges in patients with CD, success with laparoscopy has been widely described for CD as it relates to the ileocecal region. Our results are similar to the work of others describing decreased rate of complications following ileocectomy. A well-powered retrospective review of NSQIP by Lee et al. additionally showed that laparoscopic ileocectomy was associated with reduction in both major and minor complications [5]. Additionally, a Cochrane review performed by Dasari et al. which

comprised two randomized controlled trials including 120 patients also showed that laparoscopic ileocectomy led to fewer wound infections and shorter length of stay despite longer operative time; however, no differences were found with respect to other post-operative complications including leak and intraabdominal abscess as well as similar 30-day reoperation rates [16]. Consistent with the results of our study of isolated small bowel disease, these results highlight the safety of MIS with resection of the ileocecal region in patients with CD.

This study does have some limitations. First, this is a retrospective review that is prone to selection bias that may affect the initial decision of surgical approach and the threshold for converting to an open approach. We were also unable to assess history of abdominal surgery which would obviously greatly affect the choice of surgical approach and would lead to significant selection bias. Selection bias was likely also affected by surgeon-specific factors not reported in NSQIP such as length in surgical practice, experience with MIS techniques, and history of fellowship training. We additionally could not control for all possible confounds (i.e. pre-operative differences between patients who received each procedure). Furthermore, NSQIP only reports 30-day outcomes, and therefore we were unable to assess long-term complications or recurrence. Additional limitations of the study were that we could not evaluate long-term recurrence rates requiring operation which have been reported to be up to 44% for small bowel disease [26]. We additionally had no way of determining the length of resection performed. A major limitation of this study is that definitions of what surgeons would consider to be an “MIS” approach may vary significantly in this study, especially with regards to differences between laparoscopic-assisted cases (including laparoscopic hand-assisted cases and laparoscopic with open assist) and an open case. We therefore decided to group all of these cases together to perform an intention-to-treat analysis. Also due to the limitations of NSQIP, we could not determine how many patients may have undergone intracorporeal anastomosis though most evidence suggests that there is no significant difference between anastomotic techniques [27].

Unfortunately, all studies evaluating outcomes comparing open and MIS small bowel resection for Crohn's patients that we found in the literature also included patients who underwent ileocectomy, and therefore results specific to patients who only underwent segmental small bowel resection were not described in those studies. Additionally, though laparoscopic small bowel resection overall has shown improved outcomes compared to open resection for patients without CD, it is difficult to compare results in patients with and without CD due to the associated comorbidities and particular difficulties of operating on Crohn's patients [28, 29]. Therefore, a significant limitation of this study is that it is difficult to contextualize our results by comparing them to

similar studies. Despite this, we believe that our results are concordant with the substantial amount of evidence supporting laparoscopy for CD requiring other types of bowel resection. We hope that in the future additional studies on this topic will be performed to provide further evidence for the benefits of laparoscopy for patients with CD.

Conclusions

Our goal was to increase the literature in surgical experience in the USA describing segmental resection for CD isolated to the small bowel. In summary, this large retrospective review of NSQIP demonstrates that select patients undergoing segmental small bowel resection for CD have equivalent or improved morbidity compared with open resection for the most common post-operative complications including wound complications, post-operative bleeding requiring transfusion, return to the operating room, and length of stay despite longer operating times. Our results show that laparoscopy can be performed safely for segmental resection in Crohn's patients and should be offered to select patients by surgeons with expertise in minimally invasive techniques.

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Declarations

Conflict of interest Dr. Vincent J. Obias was a consultant for Intuitive, Medtronic, and Medrobotics. Dr. Michael L. Horsey, Dr. Debra Lai, Aalap Herur-Raman, Dr. Richard Amdur, Dr. Matthew Chandler, and Dr. Matthew Ng report have no conflicts of interest or financial ties to disclose.

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