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ORIGINAL ARTICLE

What is the real morbidity after emergency colectomy for Crohn's disease? A propensity score matched study

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Abstract

Background In the inflammatory bowel disease literature, emergency surgery for Crohn's disease (CD) is associated with worse postoperative outcomes as compared to elective surgery. Previous studies have compared heterogeneous groups only. We hypothesized that this association would be lost after matched analysis. We aimed to compare matched CD patients undergoing elective vs emergency surgery.

Methods The National Surgical Quality Improvement database (01/2005–12/2019) was utilized to identify adult CD surgical patients. Univariate and conditional logistic regression models were used to analyze unmatched and matched cohorts. Propensity-score matching was performed to match emergency to non-emergency patients 1:1. Our primary outcome was a composite of any complication. Our secondary endpoints were hospital readmission, unplanned reoperation and 30-day morbidity and mortality.

Results In the unmatched analyses ($n = 12{,}181/95.28\%$ elective and $n = 603/4.72\%$ emergency) of Crohn's patients undergoing colectomy, 20% of elective and 42% of emergency patients experienced a complication ($p < 0.001$). Over 20 outcomes measured including length of stay (LOS), readmission, infections and respiratory, cardiovascular and renal complications, were worse in the emergency cohort. In the matched analyses ($n = 400$ emergency/400 elective patients) only the categories of any complication (OR 1.44, 1.06–1.96 95% CI, $p = 0.02$), any surgical site infection (SSI, OR 1.53, 1.07–2.19 95% CI, $p = 0.02$), superficial SSI (OR 2.25, 1.14–4.44 95% CI, $p = 0.02$), organ space SSI (1.58 OR 1.04–2.4 95% CI, $p = 0.03$), unplanned intubation (OR 5.0, 1.45–17.27 95% CI, $p = 0.01$), ventilation > 48 h (OR 9.0, 1.4–38.79 95% CI, $p = 0.003$) and septic shock (OR 4.5, 1.86–10.9 95% CI, $p < 0.001$) were higher in the emergency cohort.

Conclusions Matching CD patients resulted in a loss of the observed increase in cardiovascular and renal complications, reoperation and LOS following emergency surgery; however, SSIs and respiratory complications remained increased despite matching.

Keywords Surgery · IBD · Crohn's · Colectomy · NSQIP · Morbidity

Introduction

Up to 50% of patients with Crohn's disease (CD) patients undergo small and/or large bowel resection within 10 years of diagnosis [1]. Approximately, 5–10% of these colectomies are performed emergently [2]. The inflammatory bowel disease (IBD) literature suggests that CD patients have worse outcomes after emergency surgery when compared to elective surgery. These outcomes include longer lengths of stay (LOS) and increased rates of return to the operating room, infections, and renal, pulmonary, and cardiovascular complications [2–5]. Previous studies on outcomes after emergency colectomy have used data from large national registries and

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the American College of Surgeons' National Surgical Quality Improvement Project (ACS-NSQIP) database; however, these studies are limited by comparing dissimilar, unmatched CD patients and, in some cases, included all surgical patients rather than IBD patients alone [2, 3, 5].

The ACS-NSQIP database is the largest and most well-known postoperative database of surgical patients. This database was proposed by a colorectal surgeon, Dr. Clifford Ko and has been collecting surgical data since 2005. Over 300 individual demographic, intraoperative, post-operative and 30-day outcome data points are available for collection by dedicated individuals in > 700 hospitals [6, 7].

In our center, we have not observed overall worse outcomes in CD patients who were operated on emergently versus electively. We hypothesized that the association between emergency surgery and worse outcomes observed in the current literature would be lost after matched analyses of emergency and elective CD patients. We aimed to confirm the current literature on emergency CD surgery suggesting increased complications using a large cohort of unmatched CD patients using the NSQIP database. We then aimed to determine if 30-day postoperative outcomes remain worse when emergency and elective CD are matched and compared. Our primary outcome was a composite of any complication. Our secondary endpoints were hospital readmission, unplanned reoperation, and 30-day morbidity and mortality.

Materials and methods

The American College of Surgeons National Quality Improvement Project Participant User File (NSQIP PUF) was used to identify all adult CD patients who underwent a colectomy between 01/2005 and 12/2019. Patient characteristics, intraoperative details, perioperative outcomes, and 30-day outcomes were recorded and analyzed. Patients who already had a stoma in situ at the time of surgery and/or who underwent any procedure that did not involve excision of part or all of the colon (i.e. proctectomy alone, defunctioning ostomy, perianal surgery) were excluded. The ACS-NSQIP and the hospitals participating in the ACS-NSQIP are the source of the data used herein; they have not verified and are not responsible for the statistical validity of the data analysis or the conclusions derived by the authors.

Univariate and multivariate logistic regression models were used to examine the association between emergency surgery and complications in the unmatched cohort. All relevant patient characteristics, operative and postoperative data are presented as mean (standard deviation), median [min, max] or frequency (percent). Student's *t*-test or non-parametric Wilcoxon rank sum tests were used for continuous factors. The Chi-square test and Fisher exact test were used to compare categorical variables between emergency versus surgery groups. Backward stepwise selection was used to build the final multivariate regression model with all preoperative and perioperative characteristics included except those with > 20% missing data. The Firth correction was applied to solve the separation issue. All data are incorporated into the article.

A logistic regression model was used to assign a propensity score to each patient using emergency surgery as the outcome. Emergency patients were matched to elective patients on a 1:1 basis. The probability of emergency surgery based on these factors was used as the propensity score. A greedy matching algorithm was used to find the best controls matches for each case. A Love plot was used to show the covariate balance between the emergency group before and after matching. Patients were matched on all demographic and clinical factors except those with more than 20% missing data. Specifically, matching was performed according to age ± 5 years, sex, body mass index (BMI), race, ethnicity, steroid use, weight loss, smoking, dyspnea with moderate exertion, American Society of Anesthesiologists (ASA) score, wound classification, operation time, number of comorbidities, surgical approach, open wound/wound infection, preoperative transfusion of red blood cells in 72 h prior to surgery, bleeding disorders, diabetes mellitus, hypertension requiring medication, systemic inflammatory response syndrome (SIRS)/sepsis, serum sodium, blood urea nitrogen (BUN), serum creatinine, white blood cell (WBC) count, hematocrit, platelet count, transfer status, any concurrent procedure, any other procedure, bleeding and transfusions. Differences in matched groups are presented as standardized mean difference (SMD) with a smaller SMD correlating with greater similarity between the groups. A SMD < 0.2 represents balanced groups. Conditional logistic regression was used to evaluate the association between outcomes and an emergency colectomy on the matched samples. Covariates with standardized mean difference over 0.2 were also adjusted in the model to remove residual confounding. All comparisons were made at a significance level of 0.05. All analyses were performed with R version 4.0.2.

Emergency resections are defined as occurring within 12 h of admission per NSQIP coding. Also according to NSQIP definitions, hypertension is defined by the requirement for medication. The diagnosis of 'dyspnea' is with moderate exertion. Current smokers are smokers within 1 year of admission. Preoperative transfusion is defined as a transfusion of ≥ 1 unit of whole/packed red blood cells within 72 h prior to surgery. Weight loss is defined as 10% body weight loss in the 6 months preceding surgery.

Results

Unmatched cohort

A total of 16,790 patients were included in the unmatched analyses: 12,181 (95.28%) elective and 603 (4.72%)

emergency CD patients (Tables 1 and 2). Mean LOS was significantly longer in the emergency cohort (9.5 [7,16] vs 5 [4, 8] days, $p < 0.001$, Table 2). Overall, 21% of all patients experienced a complication. The rate was doubled

Table 1 Demographics of the unmatched Crohn's cohort ($n = 12,784$)

	All $n = 12,784$	Elective $n = 12,181$	Emergency $n = 603$	p
Age < 39 years	6288 (49.2%)	5983 (49.1%)	305 (50.7%)	0.49
Sex: female	**6814 (53.3%)**	**6522 (53.5%)**	**292 (48.4%)**	**0.02**
BMI kg/m^2, mean ± SD	**25.5 (6.22)**	**25.5 (6.22)**	**24.9 (6.35)**	**0.02**
Non-white race	**1305 (11.3%)**	**1236 (11.2%)**	**69 (15.9%)**	**0.003**
Steroid use for chronic condition	**7680 (60.1%)**	**7366 (60.5%)**	**314 (52.1%)**	**< 0.001**
Weight loss	**1122 (8.78%)**	**1042 (8.55%)**	**80 (13.3%)**	**< 0.001**
Current smoker	**2837 (22.2%)**	**2679 (22.0%)**	**158 (26.2%)**	**0.02**
Dyspnea	257 (2.01%)	243 (1.99%)	14 (2.32%)	0.68
Open wound/wound infection	383 (3.00%)	367 (3.01%)	16 (2.65%)	0.70
Preoperative transfusion	**144 (1.13%)**	**107 (0.88%)**	**37 (6.14%)**	**< 0.001**
Bleeding disorders	**280 (2.19%)**	**253 (2.08%)**	**27 (4.48%)**	**< 0.001**
Diabetes mellitus	427 (3.34%)	408 (3.35%)	19 (3.15%)	0.88
Hypertension	2076 (16.2%)	1981 (16.3%)	95 (15.8%)	0.78
SIRS/sepsis	**930 (7.27%)**	**675 (5.54%)**	**255 (42.3%)**	**< 0.001**
Any comorbidity	**10,199 (79.8%)**	**9670 (79.4%)**	**529 (87.7%)**	**< 0.001**
Number of comorbidities, median (IQR)	**1.00 [1.00;2.00]**	**1.00 [1.00;2.00]**	**2.00 [1.00;2.00]**	**< 0.001**
Serum sodium ≥ 139 mEq/L	**6923 (58.9%)**	**6674 (59.8%)**	**249 (41.8%)**	**< 0.001**
BUN ≥ 11 mg/dL	6400 (55.6%)	6076 (55.6%)	324 (57.3%)	0.66
Serum creatinine ≥ 0.78 mg/dL	**5991 (50.9%)**	**5683 (50.8%)**	**308 (51.9%)**	**< 0.001**
Serum albumin < 3 g/dL	**1695 (13.3%)**	**1520 (12.5%)**	**175 (29.0%)**	**< 0.001**
Total bilirubin ≥ 0.4 mg/dL	**5786 (59.8%)**	**5397 (59.1%)**	**389 (71.6%)**	**< 0.001**
WBC ≥ 8.1 × 109/L	**5774 (48.0%)**	**5377 (47.0%)**	**397 (66.2%)**	**< 0.001**
Hematocrit ≥ 37.6%	**6579 (54.3%)**	**6332 (55.0%)**	**247 (41.2%)**	**< 0.001**
Platelet count ≥ 139 × 10^9/L	6923 (58.9%)	6674 (59.8%)	249 (41.8%)	0.24
INR ≥ 1.1	**2911 (52.1%)**	**2620 (50.4%)**	**291 (75.2%)**	**< 0.001**
Procedure: ileocolic resection	**8584 (67.2%)**	**8224 (67.6%)**	**360 (59.7%)**	**< 0.001**
Total abdominal colectomy with ileostomy	**3 (0.02%)**	**2 (0.02%)**	**1 (0.17%)**	
Partial colectomy	**1 (0.01%)**	**1 (0.01%)**	0 (0.00%)	
Proctocolectomy	**3008 (23.5%)**	**2798 (23.0%)**	**210 (34.8%)**	
Low anterior resection	**568 (4.45%)**	**551 (4.53%)**	**17 (2.82%)**	
Low anterior resection with stoma	**8 (0.06%)**	**8 (0.07%)**	**0 (0.00%)**	
Total abdominal colectomy	**603 (4.72%)**	**588 (4.83%)**	**15 (2.49%)**	
Stoma	**1806 (14.1%)**	**1629 (13.4%)**	**177 (29.4%)**	**< 0.001**
Approach: laparoscopic	**7267 (56.8%)**	**7105 (58.3%)**	**162 (26.9%)**	**< 0.001**
Conversion to open	**1036 (8.10%)**	**996 (8.18%)**	**40 (6.63%)**	
Open	**4481 (35.1%)**	**4080 (33.5%)**	**401 (66.5%)**	
Transfer status	**759 (5.94%)**	**650 (5.34%)**	**109 (18.1%)**	**< 0.001**
Wound classification:				**< 0.001**
Clean contaminated	**10,606 (83.0%)**	**10,272 (84.3%)**	**334 (55.4%)**	
Dirty/infected	**2178 (17.0%)**	**1909 (15.7%)**	**269 (44.6%)**	
ASA classification 3–5	**5085 (39.8%)**	**4738 (38.9%)**	**347 (57.5%)**	**< 0.001**

BMI body mass index; *SIRS* systemic inflammatory response syndrome; *BUN* blood urea nitrogen; *WBC* white blood cell count; *INR* international normalized ratio; *ASA* American Society of Anesthesiologists

Bold represents statistically signficant values

Table 2 Outcomes of the unmatched Crohn's cohort ($n = 12{,}784$)

	All $n = 12{,}784$	Elective $n = 12{,}181$	Emergency $n = 603$	p
Length of total hospital stay, data, median (IQR)	**5.00 [4.00; 9.00]**	**5.00 [4.00; 8.00]**	**9.50 [7.00; 16.0]**	**< 0.001**
Discharged home	**12,398 (97.2%)**	**11,862 (97.5%)**	**536 (89.6%)**	**< 0.001**
Operation time ≥ 162 min	**5718 (44.7%)**	**5528 (45.4%)**	**190 (31.5%)**	**< 0.001**
Any readmission	1535 (12.0%)	1461 (12.0%)	74 (12.3%)	0.89
Return to OR	**563 (4.40%)**	**513 (4.21%)**	**50 (8.29%)**	**< 0.001**
Known death	**39 (0.31%)**	**30 (0.25%)**	**9 (1.49%)**	**< 0.001**
Any complication	**2690 (21.0%)**	**2436 (20.0%)**	**254 (42.1%)**	**< 0.001**
Any infection	**1946 (15.2%)**	**1753 (14.4%)**	**193 (32.0%)**	**< 0.001**
Any SSI	**1491 (11.7%)**	**1356 (11.1%)**	**135 (22.4%)**	**< 0.001**
Superficial SSI	**549 (4.29%)**	**508 (4.17%)**	**41 (6.80%)**	**0.003**
Deep incisional SSI	**83 (0.65%)**	**72 (0.59%)**	**11 (1.82%)**	**0.002**
Organ space SSI	**947 (7.41%)**	**853 (7.00%)**	**94 (15.6%)**	**< 0.001**
Wound disruption	**68 (0.53%)**	**60 (0.49%)**	**8 (1.33%)**	**0.014**
Pneumonia	**153 (1.20%)**	**134 (1.10%)**	**19 (3.15%)**	**< 0.001**
Unplanned intubation	**95 (0.74%)**	**77 (0.63%)**	**18 (2.99%)**	**< 0.001**
Pulmonary embolism	58 (0.45%)	54 (0.44%)	4 (0.66%)	0.35
Ventilator > 48 h	**98 (0.77%)**	**76 (0.62%)**	**22 (3.65%)**	**< 0.001**
Acute renal failure	**30 (0.23%)**	**25 (0.21%)**	**5 (0.83%)**	**0.012**
Urinary tract infection	160 (1.25%)	152 (1.25%)	8 (1.33%)	1.00
CVA/stroke with neurological deficit	**6 (0.05%)**	**4 (0.03%)**	**2 (0.33%)**	**0.029**
Cardiac arrest requiring CPR	**17 (0.13%)**	**13 (0.11%)**	**4 (0.66%)**	**0.007**
Myocardial infarction	**28 (0.22%)**	**24 (0.20%)**	**4 (0.66%)**	**0.041**
Bleeding transfusions	**891 (6.97%)**	**808 (6.63%)**	**83 (13.8%)**	**< 0.001**
DVT/thrombophlebitis	185 (1.45%)	173 (1.42%)	12 (1.99%)	0.33
Sepsis	**707 (5.53%)**	**611 (5.02%)**	**96 (15.9%)**	**< 0.001**
Septic shock	**136 (1.06%)**	**101 (0.83%)**	**35 (5.80%)**	**< 0.001**
Clostridium difficile colitis*	97 (1.06%)	93 (1.06%)	4 (0.95%)	1.00

OR operating room; *SSI* surgical site infection; *CVA* cerebrovascular accident; *CPR* cardiopulmonary resuscitation; *DVT* deep vein thrombosis

*9163 patients had clostridium difficile result recorded

Bold represents statistically signficant values

in the emergency cohort (42% vs 20%, $p < 0.001$). The rate of any surgical site infection (SSI) was also doubled in the emergency cohort (22.4% vs 11.1%, $p < 0.001$). Other large significant differences were found in the categories of: return to the operating room (4.2% elective vs 8.3% emergency patients, $p < 0.001$), sepsis (5% vs 15.9%, $p < 0.001$), septic shock (0.83% vs 5.8%, $p < 0.001$) and death (0.25% vs 1.49%, $p < 0.001$). Similarly, superficial SSI, deep SSI, organ space SSI, pneumonia, discharge other than home, wound disruption, unplanned intubation, ventilation > 48 h, acute renal failure (ARF), cerebrovascular event (CVA), myocardial infarction (MI) and cardiac arrest were all higher in the emergency cohort.

Matched cohort

After propensity matching, 400 emergency and 400 elective Crohn's patients were analyzed (Table 3). In the propensity matched CD analyses, the category of 'any complication' was significantly higher in the emergency cohort (OR 1.44, 1.06–1.96, 95% CI, $p = 0.02$, Table 4). Additionally, any SSI (OR 1.53, 1.07–2.19 95% CI, $p = 0.02$), superficial SSI (OR 2.25, 1.14–4.44, 95% CI, $p = 0.02$), organ space SSI (1.58 OR 1.04–2.4, 95% CI, $p = 0.03$), unplanned intubation (OR 5.0, 1.45–17.27 95% CI, $p = 0.01$), ventilation > 48 h (OR 9.0, 1.4–38.79, 95% CI, $p = 0.003$) and septic shock (OR 4.5, 1.86–10.9, 95%

Table 3 Demographics and operative factors of the propensity matched Crohn's cohort ($n=800$)

	All $n=800$	Elective $n=400$	Emergency $n=400$	Standardized mean difference
Age: < 39 years	409 (51.1%)	212 (53.0%)	197 (49.2%)	0.08
Sex: female	383 (47.9%)	193 (48.2%)	190 (47.5%)	0.02
BMI kg/m^2	25.0 (6.51)	24.9 (6.69)	25.0 (6.34)	0.01
Non-white race	124 (15.5%)	61 (15.2%)	63 (15.8%)	0.01
Steroid use for chronic condition	423 (52.9%)	217 (54.2%)	206 (51.5%)	0.06
Weight loss	115 (14.4%)	56 (14.0%)	59 (14.8%)	0.02
Current smoker	235 (29.4%)	119 (29.8%)	116 (29.0%)	0.02
Dyspnea	19 (2.38%)	9 (2.25%)	10 (2.50%)	0.02
Open wound/wound infection	26 (3.25%)	14 (3.50%)	12 (3.00%)	0.04
Preoperative transfusion	51 (6.38%)	27 (6.75%)	24 (6.00%)	0.03
Bleeding disorders	45 (5.62%)	20 (5.00%)	25 (6.25%)	0.05
Diabetes mellitus	22 (2.75%)	7 (1.75%)	15 (3.75%)	0.12
Hypertension	139 (17.4%)	66 (16.5%)	73 (18.2%)	0.05
SIRS/sepsis	377 (47.1%)	193 (48.2%)	184 (46.0%)	0.05
Number of comorbidities	1.87 (1.30)	1.87 (1.36)	1.88 (1.25)	0.004
Serum sodium > 139	301 (37.6%)	143 (35.8%)	158 (39.5%)	0.08
BUN > 11	463 (57.9%)	228 (57.0%)	235 (58.8%)	0.04
Serum creatinine: > 0.78	414 (51.7%)	203 (50.7%)	211 (52.8%)	0.04
WBC > 8.1	535 (66.9%)	263 (65.8%)	272 (68.0%)	0.05
Hematocrit: > 37.6	327 (40.9%)	155 (38.8%)	172 (43.0%)	0.09
Platelet count: > 308	408 (51.0%)	213 (53.2%)	195 (48.8%)	0.09
Surgery: ileocolic resection	474 (59.2%)	236 (59.0%)	238 (59.5%)	0.03
Total abdominal colectomy	19 (2.38%)	10 (2.50%)	9 (2.25%)	
Proctocolectomy	288 (36.0%)	145 (36.2%)	143 (35.8%)	
Low anterior resection	19 (2.38%)	9 (2.25%)	10 (2.50%)	
Surgical approach				
Laparoscopic	192 (24.0%)	102 (25.5%)	90 (22.5%)	0.08
Conversion to open	46 (5.75%)	21 (5.25%)	25 (6.25%)	
Open	562 (70.2%)	277 (69.2%)	285 (71.2%)	
Stoma created	260 (32.5%)	127 (31.8%)	133 (33.2%)	0.03
Transfer status	182 (22.8%)	95 (23.8%)	87 (21.8%)	0.05
Operation time: > 162	253 (31.6%)	127 (31.8%)	126 (31.5%)	0.005
Any concurrent procedures	66 (8.25%)	35 (8.75%)	31 (7.75%)	0.04
Any other procedure	400 (50.0%)	192 (48.0%)	208 (52.0%)	0.08
Bleeding transfusions	117 (14.6%)	57 (14.2%)	60 (15.0%)	0.02
Wound classification				0.07
Clean, contaminated	436 (54.5%)	225 (56.2%)	211 (52.8%)	
Dirty/infected	364 (45.5%)	175 (43.8%)	189 (47.2%)	
ASA classification 3–5	431 (53.9%)	213 (53.2%)	218 (54.5%)	0.03

BMI body mass index; *SIRS* systemic inflammatory response syndrome; *BUN* blood urea nitrogen; *WBC* white blood cell count; *INR* international normalized ratio; *ASA* American Society of Anesthesiologists grade

CI, $p<0.001$) were higher in the emergency cohort. Reoperation, readmission, mortality, any infection, wound disruption, and pneumonia were not significantly different between the two cohorts.

Discussion

Rates of surgery in the CD population are high at 18.7%, 28.0% and 39.5% at 1, 5, and 10 years after diagnosis. Risk of a subsequent resection is greater than 30% at 10 years [1]. Therefore, the prediction of the incidence and nature of complications in this cohort is key to preoperative planning and

Table 4 Association between group (emergency vs elective) and outcomes with matched sample Crohn's cohort ($n = 800$)

Outcome	Odds ratio	95% CI	*p*
Any complication	**1.44**	**1.06–1.96**	**0.02**
Known death	4.5	0.97–20.83	0.051
Any reoperation	1.78	1–3.17	0.053
Any readmission	0.91	0.62–1.33	0.63
Return to OR	1.78	1–3.17	0.053
Any infection	1.26	0.91–1.74	0.16
Any SSI	**1.53**	**1.07–2.19**	**0.02**
Superficial SSI	**2.25**	**1.14–4.44**	**0.02**
Deep incisional SSI	0.5	0.15–1.66	0.26
Organ space SSI	**1.58**	**1.04–2.4**	**0.03**
Wound disruption	6	0.72–49.84	0.1
Pneumonia	1.71	0.67–4.35	0.26
Unplanned intubation	**5**	**1.45–17.27**	**0.01**
Pulmonary embolism	0.8	0.21–2.98	0.74
Ventilator > 48 h	**9**	**2.09–38.79**	**0.003**
Urinary tract infection	0.67	0.19–2.36	0.53
DVT/thrombophlebitis	1.5	0.53–4.21	0.44
Sepsis	0.98	0.66–1.45	0.92
Septic shock	**4.5**	**1.86–10.9**	**< 0.001**

CI confidence interval; *OR* operating room; *SSI* surgical site infection; *DVT* deep vein thrombosis

Bold represents statistically signficant values

counselling. In the present study, we confirmed previously published outcomes from unmatched CD patients undergoing colectomy in a large cohort. We then present the first analysis of matched CD patients undergoing elective versus emergency surgery. These cohorts are matched according to over 30 demographic and operative details providing very similar groups for comparison.

To address our first aim, our unmatched analyses confirmed the published data demonstrating worse outcomes in unmatched CD patients undergoing emergency versus elective surgery. These data include a 2020 meta-analysis of 22 Crohn's studies by Udholm et al.demonstrating a 40-fold increase in overall complications in patients undergoing emergency surgery compared to elective patients [8]. Similar to our unmatched analysis, emergency surgery patients were more likely to experience postoperative complications, longer lengths of stay and return to the operating room. Mullen et al. evaluated reported results on 173,643 NSQIP patients undergoing general surgery who were categorized into elective (75%), emergency (13.0%) and non-elective and nonemergency (12.0%). Similar to our unmatched analysis, non-elective surgery was associated with slightly increased odds of experiencing any complication (OR, 1.38–1.65) and of mortality (OR 2.32; 95%-2.91). Surgical procedures performed urgently had a 12.3% morbidity rate of morbidity a 2.3% rate of mortality [5]. However, this study was not exclusive to IBD or even colorectal patients. Hajirawala et al. also used NSQIP data and analyzed approximately 150,000 elective, urgent and emergency surgical patients. Elective mortality was 0.4% vs 2.5–4.1% in emergency patients. The mortality rate was 1.49% for CD [3]. A Danish national registry data inclusive of 2889 IBD undergoing total colectomy demonstrated a 30-day mortality was 5.3% versus 1% for elective cases. Their highest mortality (8.1%) was in emergency Crohn's patients. For the elective cohort, 30-day mortality was 1.5% for CD. Comorbidities and age were associated with worse outcomes [4]. Our elective mortality was similar to Hajirawala's study at 0.25%; however, our emergency mortality was much lower at 0.38%. This may be due to our inclusion of only patients who underwent a colectomy.

Our propensity matched analysis provides important and novel data. Addressing our second aim by analyzing this matched cohort, we demonstrated that only the category of any complication and SSIs, respiratory complications (unplanned intubation, ventilation > 48 h) and septic shock were significantly higher in the emergency cohort. There was no difference in rates of reoperation, death, any infection, wound disruption and pneumonia between the two cohorts. These data are different to previous studies because they used heterogeneous populations in which, understandably, the emergency cohort was more comorbid, older and had undergone different surgical procedures when compared to the elective cohort. We eliminated this heterogeneity with propensity matching to ensure the populations we compared were the same age and gender and had similar comorbidities and surgical procedures. Unlike previous analyses, we purposely excluded patients with a stoma already in situ. We wanted to determine the rate of stoma creation in our cohorts. Additionally, the presence of a stoma preoperatively may affect surgical approach and outcomes. Interestingly, 13.4% vs 29.4% of our unmatched elective and emergency patients underwent stoma formation during their colectomy.

Even with robust data collection, any retrospective study using a large database has fundamental limitations. For NSQIP, all patients who underwent surgery more than 12 h after being admitted were categorized in the "elective" group based on the NSQIP definition of "emergency status [6]." Therefore, we are comparing true emergency resections vs all other resections. The number of variables included per patient varies by institution and year. Additionally, patients are randomly assigned for inclusion in the database [7]. Therefore not all resections in all institutions are captured. Preoperative blood tests are not ordered at a standard time.

IBD medication and bowel preparation regimens vary by institution. Several institutions provide bowel preparation and antibiotics to their elective cases. This may contribute to outcomes in terms of infections and is not captured. Other factors that are not recorded that can contribute to outcomes include operative difficulty, particularly in reoperative CD surgery. However, case status (i.e. clean vs contaminated) and length can provide some information.

With propensity score matching, 33% emergency cases were dropped due to missing data. However, sensitivity analysis shows that there is no significant difference in covariates between the overall study sample and complete cases, meaning using complete cases to represent whole sample is acceptable.

Conclusions

The majority of categories of poorer outcomes seen when unmatched emergency and elective patients are compared are not actually significantly different when comparing matched or like cohorts. In particular, in the matched cohorts, rates of reoperation, readmission, mortality, any infection, wound disruption and pneumonia were not significantly different between the emergency and elective cohorts.

Matching resulted in a loss of the observed increase in cardiovascular and renal complications, reoperation and LOS following emergency surgery; however, SSIs and respiratory complications remained increased despite matching.

Author contributions All authors have given substantial contributions to the conception, design, analysis and interpretation of data for the work as well as drafting the work and final approval of the version to be published and are in agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Declarations

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

Ethical approval This is NSQIP data which is a national, anonymized database and does not require institutional ethical approval.

References

1. Tsai L, Ma C, Dulai PS et al (2021) Contemporary risk of surgery in patients with ulcerative colitis and Crohn's disease: a meta-analysis of population-based cohorts. Clin Gastroenterol Hepatol 19(10):2031-2045 e2011
2. Patel SS, Patel MS, Goldfarb M et al (2013) Elective versus emergency surgery for ulcerative colitis: a National Surgical Quality Improvement Program analysis. Am J Surg 205(3):333–337 (**discussion 337–338**)
3. Hajirawala L, Leonardi C, Orangio G et al (2021) Carries a higher morbidity and mortality than elective surgery. J Surg Res 268:394–404
4. Tottrup A, Erichsen R, Svaerke C et al (2012) Thirty-day mortality after elective and emergency total colectomy in Danish patients with inflammatory bowel disease: a population-based nationwide cohort study. BMJ Open 2(2):e000823
5. Mullen MG, Michaels AD, Mehaffey JH et al (2017) Risk associated with complications and mortality after urgent surgery vs elective and emergency surgery: implications for defining "quality" and reporting outcomes for urgent surgery. JAMA Surg 152(8):768–774
6. Eisenstein S, Stringfield S, Holubar SD (2019) Using the national surgical quality improvement project (NSQIP) to perform clinical research in colon and rectal surgery. Clin Colon Rectal Surg 32(1):41–53
7. Surgeons. TACo. (2021) https://www.facs.org/quality-programs/acs-nsqip. Accessed April 5, 2022.
8. Udholm LS, Rasmussen SL, Madsboll TK et al (2021) A systemic review and metaanalysis of postoperative outcomes in urgent and elective bowel resection in patients with Crohn's disease. Int J Colorectal Dis 36(2):253–263

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