International Journal of Colorectal Disease (2024) 39:17
https://doi.org/10.1007/s00384-023-04588-2

RESEARCH

Short-term postoperative outcomes for obese versus non-obese inflammatory bowel disease patients undergoing bowel resection: a propensity score matched analysis

Lily Park[1,2] · Tyler McKechnie[1,2] · Yung Lee[1] · Léa Tessier[3] · Edward Passos[1,3] · Aristithes Doumouras[1,2,3,4] · Dennis Hong[1,3,4] · Cagla Eskicioglu[1,3,4]

Accepted: 21 December 2023

Abstract

Purpose Up to 40% of patients with inflammatory bowel disease (IBD) are obese. Obesity is a well-known risk factor for increased perioperative morbidity, but this risk has never been quantified in IBD patients undergoing abdominal surgery using the United States National Inpatient Sample (NIS) database. This study aims to compare postoperative morbidity between obese and non-obese patients undergoing bowel resection for IBD using recent NIS data.

Methods Adult patients who underwent bowel resection for IBD from 2015 to 2019 were identified in the NIS using ICD-10-CM coding. Patients were stratified into obese (BMI > 30 kg/m^2) and non-obese groups, then propensity score matched (PSM) for demographic, operative, and hospital characteristics. The primary outcome was postoperative in-hospital morbidity. Secondary outcomes included postoperative in-hospital mortality, system-specific postoperative complications, total admission healthcare costs, and length of stay (LOS). Univariable and multivariable regressions were utilized.

Results Overall, 6601 non-obese patients and 671 obese patients were identified. The PSM cohort included 659 patients per group. Obese patients had significantly increased odds of experiencing postoperative in-hospital morbidity (aOR 1.50, 95% CI 1.10–2.03, $p = 0.010$) compared to non-obese patients. Specifically, obese patients experienced increased gastrointestinal complications (aOR 1.49, 95% CI 1.00–2.24, $p = 0.050$), and genitourinary complications (aOR 1.71, 95% CI 1.12–2.61, $p = 0.013$). There were no differences in total admission healthcare costs (MD − $2256.32, 95% CI − 19,144.54–14,631.9, $p = 0.79$) or LOS (MD 0.16 days, 95% CI − 0.93–1.27, $p = 0.77$).

Conclusions Obese IBD patients are at greater risk of postoperative in-hospital morbidity than non-obese IBD patients. This supports targeted preoperative weight loss protocols for IBD patients to optimize surgical outcomes.

Keywords Inflammatory bowel disease · Ulcerative colitis · Crohn's disease · Colorectal surgery · Obesity

Introduction

Obesity has reached epidemic proportions as approximately 13% of the world's population and 33% of adults in the United States (U.S.) are considered obese with a body max index (BMI) greater than or equal to 30 kg/m^2 [1–3]. This trend is expected to continue, with 50% of the U.S. population projected to be obese by 2030 [4]. Despite the conventional association of inflammatory bowel disease (IBD) with malnourished and underweight patients, the prevalence of obese IBD patients has also been rising. Today, an estimated 10–40% of IBD patients are obese, with recent evidence suggesting that this number will continue to rise [5, 6].

Perioperative morbidity among obese surgical patients is higher than non-obese contemporaries [7–9]. Obesity is

Lily Park and Tyler McKechnie are joint first authors, and contributed equally

✉ Cagla Eskicioglu
eskicio@mcmaster.ca

1 Department of Surgery, Division of General Surgery, McMaster University, Hamilton, ON, Canada

2 Department of Health Research Methods, Evidence, and Impact, McMaster University, Hamilton, ON, Canada

3 Michael G. DeGroote School of Medicine, McMaster University, Hamilton, ON, Canada

4 Division of General Surgery, Department of Surgery, St. Joseph Healthcare, 50 Charlton Avenue East Hamilton, Hamilton, ON L8N 4A6, Canada

Published online: 09 January 2024

associated with a plethora of cardiovascular, pulmonary, and immunologic comorbidities [9]. Additionally, obesity represents a chronic pro-inflammatory state, which combined with the increased visceral adiposity can make surgery technically challenging [8]. Altogether, these factors contribute to worse perioperative outcomes including wound infections, anastomotic leaks, incisional hernias, and cardiopulmonary complications [7].

Currently, there is a lack of robust cohesive evidence regarding the impact of obesity specifically among IBD patients undergoing abdominal surgery, and existing evidence is conflicting [7]. A retrospective review of the American College of Surgeons National Surgical Quality Improvement Program database from 2005 to 2008 demonstrated increased short-term perioperative outcomes, which were mostly driven by surgical site infections (SSI) [10]. Another retrospective study involving 626 patients demonstrated increased operative time, conversion rate, and blood loss among obese IBD patients without worse perioperative outcomes as compared to non-obese IBD patients [11]. More recently, a systematic review and meta-analysis pooled these data and demonstrated significant increases in overall postoperative morbidity and infectious complications among obese IBD patients undergoing intra-abdominal surgery [12]. However, the majority of these previously published data are at high risk of bias due to confounding.

The National Inpatient Sample (NIS) is the largest public all-payer inpatient database in the U.S., which has yet to be analyzed for the purposes of this clinical question. With the prevalence of obese IBD patients on the rise, further investigations on the impact of obesity on perioperative outcomes are timely and would lay the foundation for targeted perioperative care for this unique population. Therefore, the objective of this study was to compare post-operative morbidity, mortality, length of stay (LOS), and hospitalization costs between propensity score matched obese and non-obese IBD patients undergoing bowel resections using 2015–2019 NIS data.

Methods

Data source

A retrospective population-based cohort study was performed utilizing the Healthcare Cost and Utilization Project (HCUP) NIS data from October 1st, 2015, to December 31st, 2019. This data was managed by the Agency for Healthcare Research and Quality (AHRQ). The timeline reflects the years that NIS started utilizing the International Classification of Diseases, 10th Revision, Clinical Modification (ICD-10-CM) codes. The NIS is the largest public all-payer inpatient database in the U.S. It approximates a 20% stratified sample of community hospital discharges and its included hospitals cover more than 97% of the population, providing a nationally representative sample of the patient population and hospital characteristics. The NIS records information on roughly 7 million hospitalizations annually, including weighted data to help make population estimates. Local ethics board approval was not required for this study.

Cohort selection

The NIS captures 30 admission diagnoses and 15 admission procedures through the ICD-10-CM codes. Corresponding ICD-10-CM codes were utilized to identify a cohort of adult patients (≥ 18 years of age) admitted with a primary diagnosis of IBD (i.e., Crohn's disease, ulcerat colitis, indeterminate colitis). Both male and female sexes, as identified by the NIS, were included. The study group was further narrowed by identifying only IBD patients who underwent either small bowel resection, colectomy, or proctectomy on the given admission. The diagnosis and procedure codes utilized were drawn from previous similar studies [13–15] Patients with missing data pertaining to age, sex, type of hospital admission (i.e., elective vs. emergent), mortality, LOS, and total in-hospital healthcare costs were excluded.

Patient and institution characteristics

Patient characteristics that were included for analyses included age, sex, race (White, Black, Hispanic, Asian or Pacific Islander, and others), body mass index (BMI) class (≤ 30, 30–40, ≥ 40), insurance status (Medicare, Medicaid, Private Insurance, Self-pay, and others), and income quartile. Comorbidities were assessed with the Charlson Comorbidity Index software for ICD-10-CM for each individual patient. The operative approach (i.e., minimally invasive, open), operative setting (i.e., emergent versus elective), and specific type of inflammatory bowel disease (i.e., Crohn's disease, ulcerative colitis, indeterminate colitis) were recorded for each included patient. The institution characteristics that were included for analysis were teaching status, rural status, region (Northeast, Midwest, South, West), and bed size (small, medium, large).

Outcomes

The primary outcomes were overall postoperative in-hospital morbidity. Postoperative morbidity was identified with ICD-10-CM diagnosis and procedure codes that explicitly identified individual postoperative outcomes. For postoperative morbidity that was not identifiable by individual ICD-10-CM codes, the AHRQ Patient Safety Indicators were used [16].

The secondary outcomes included post-operative mortality, system-specific postoperative morbidity, postoperative length of stay, total in-hospital healthcare cost, and discharge disposition. System-specific complications were grouped and recorded according to respiratory, cardiovascular, gastrointestinal, genitourinary, and infectious complications using previously utilized methods [17, 18]. Healthcare utilization resources (i.e., length of stay, cost) are recorded in the HCUP NIS and thus were extracted directly from the database. Discharge disposition was categorized into home, short-term hospital, skilled-nursing facility, home healthcare, and others. Due to the nature of the NIS database not having patient identifiers or linkage with other administrative databases, only in-hospital outcomes could be captured.

Statistical analyses

Patient characteristics were presented as frequencies (%) for categorical variables and means (standard deviations) or medians (interquartile ranges (IQR) for continuous variables. Statistical analyses for categorical and continuous unmatched baseline variables were performed using the Chi square test and two sample *t*-test, respectively. McNemar and paired *t*-tests were performed for matched baseline categorical and continuous baseline variables, respectively. Propensity score matching was performed with a 1:1 matching ratio for obese and non-obese patients. Propensity scores were computed by modeling a logistic regression with the dependent variable being the odds of experiencing the exposure of interest (i.e., surgery) and the independent variables as age, sex, year of treatment, emergent surgery, type of inflammatory bowel disease, Charlson Comorbidity Index, operative approach, type of operation, income quartile, hospital bed size, and hospital region [19]. Patients were matched with nearest neighbor matching without replacement [20]. Patients who did not match were excluded from further analyses. The degree of baseline variable balance was assessed with standardized differences. A high degree of balance was assumed to be achieved with a standardized difference of less than 10% [21]. Univariable and multivariable logistic regression models were fit for the primary outcomes and dichotomous secondary outcomes according to obesity status. Univariable and multivariable linear regression models were fit for the continuous secondary outcomes according to obesity status. All multivariable models were determined a priori by experts in the field on the basis of clinical importance of the covariate. For each independent variable in the models, the variation inflation factor (VIF) was calculated with no evidence of multicollinearity. A sensitivity analysis with a BMI cut-off of 35 kg/m^2 was performed. All statistical tests were two-sided with the threshold for significance set at $p < 0.05$. Discharge-level weight provided by HCUP was used to calculate national estimates. All statistical analysis was performed using STATA (StataCorp version 18; College Station, TX).

Results

Unmatched patient demographics and hospital characteristics

Demographic and in-hospital characteristics of the overall NIS sample and the propensity score matched sample are reported in Table 1. The NIS sample population included 6601 non-obese IBD patients (mean age 43.8 [18.6], % female 50.4) and 671 obese IBD patients (mean age 48.3 [18.6], % female 61.5). There were significantly more female ($p < 0.001$) and older ($p < 0.001$) patients in the obese cohort. This group also had significantly greater proportion of patients with Crohn's disease ($p = 0.007$), less comorbidities according to the Charlson Comorbidity Index ($p < 0.001$), and underwent fewer proctectomies ($p < 0.001$) compared to the obese group. Significantly more non-obese patients underwent emergent surgery ($p = 0.003$). There were no differences in the rate of laparoscopic ($p = 0.370$) or open ($p = 0.410$) operative approaches between the obese and non-obese patients. Figure 1 demonstrates the increasing prevalence of obese surgical IBD patients from 2016 to 2019 ($p = 0.049$).

Matched patient demographics and hospital characteristics

Following 1:1 propensity score matching, 659 patients were left in both arms. Standardized differences were 10% or less across all baseline patient, treatment, and hospital characteristics, suggesting adequate matching (Table 1). The majority of patients had Crohn's disease (non-obese 60.2%, obese 61.5%), had a Charlson Comorbidity Index of three or less (non-obese 59.5%, obese 60.1%), were undergoing open surgery (non-obese 62.7%, obese 63.9%), were undergoing colectomy (non-obese 81.9%, obese 82.9%), and were undergoing elective surgery (non-obese 67.7%, obese 66.3%).

Postoperative morbidity

Total postoperative in-hospital morbidity occurred in 24.3% and 32.2% of non-obese and obese patients, respectively. Adjusted analysis demonstrated significantly higher odds of in-hospital morbidity in the obese group (aOR 1.50, 95% CI 1.10–2.03, $p = 0.010$). Analysis of the individual components of the composite outcome demonstrated statistically significant increases in gastrointestinal (aOR 1.49 95% CI 1.0–2.3, $p = 0.05$) and genitourinary (aOR 1.71 95% CI 1.12–2.61, $p = 0.013$) complications in the obese group.

Table 1 Univariate comparison of baseline patient, disease, and hospital characteristics between obese and non-obese inflammatory bowel disease patients undergoing bowel resection, Nationwide Inpatient Sample September 2015–December 2019

	Overall cohort			***Propensity matched cohort***		
n (sample size)	**Non-obese**	**Obese**	***p***	**Non-obese**	**Obese**	***Standardized difference***
N (weighted population estimate)	***n* = 6601**	***n* = 671**		***n* = 659**	***n* = 659**	
	***N* = 33005**	***N* = 3355**		***N* = 3295**	***N* = 3295**	
Patient characteristics, *n* (%)						
Female sex	3324 (50.4)	413 (61.5)	<0.001*	401 (60.8)	406 (61.6)	0.016
Age (mean [SD])	43.77 (18.60)	48.25 (15.25)	<0.001*	48.85 (18.23)	48.30 (15.28)	0.033
Disease						
Ulcerative colitis	1334 (20.2)	156 (23.2)	0.063	132 (20.0)	154 (23.4)	0.081
Crohn’s disease	4395 (66.6)	412 (61.4)	0.007*	397 (60.2)	405 (61.5)	0.025
Indeterminant colitis	872 (13.2)	103 (15.4)	0.179	130 (19.7)	100 (15.2)	0.10
Race			0.200			0.10
White	5073 (80.4)	517 (83.0)		532 (83.4)	511 (83.4)	
Black	624 (9.9)	54 (8.7)		49 (7.7)	53 (8.6)	
Hispanic	345 (5.5)	36 (5.8)		31 (4.9)	33 (5.4)	
Asian or pacific islander	83 (1.3)	3 (0.5)		10 (1.6)	3 (0.5)	
Others	185 (2.9)	13 (2.1)		16 (2.5)	13 (2.1)	
Insurance			0.200			0.10
Medicare	1336 (20.3)	161 (24.0)		185 (28.1)	159 (24.1)	
Medicaid	920 (13.9)	85 (12.7)		67 (10.2)	82 (12.4)	
Private insurance	3985 (60.4)	395 (58.9)		377 (57.2)	388 (58.9)	
Self-pay	167 (2.5)	14 (2.1)		16 (2.4)	14 (2.1)	
Others	188 (2.9)	16 (2.4)		14 (2.1)	16 (2.4)	
Residential income			0.064			0.087
First quartile (lowest)	1439 (21.8.7)	164 (24.4)		149 (22.6)	152 (23.1)	
Second quartile	1593 (24.1)	166 (24.7)		185 (28.1)	166 (25.2)	
Third quartile	1810 (27.4)	196 (29.2)		174 (26.4)	196 (29.7)	
Fourth quartile (highest)	1759 (26.6)	145 (21.6)		151 (22.9)	145 (22.0)	
Charlson Comorbidity Index (median [IQR])	0 (0, 2)	1 (0, 3)	<0.001*	1 (0, 3)	1 (0, 3)	−0.036
3 ≥	4559 (69.1)	404 (60.2)	<0.001*	392 (59.5)	396 (60.1)	
4–6	1693 (25.6)	222 (33.1)	<0.001*	228 (34.6)	220 (33.4)	
≥ 7	349 (5.3)	45 (6.7)	0.120	39 (5.9)	43 (6.5)	
Treatment characteristics, *n* (%)						
Year treated						0.084
2015	411 (6.2)	28 (4.2)	0.033*	31 (4.7)	27 (4.1)	
2016	1533 (23.2)	152 (22.7)	0.740	153 (23.2)	148 (22.5)	
2017	1508 (22.8)	148 (22.1)	0.640	134 (20.3)	147 (22.3)	
2018	1586 (24.0)	155 (23.1)	0.590	169 (25.6)	152 (23.1)	
2019	1563 (23.7)	188 (28.0)	0.012*	172 (26.1)	185 (28.1)	
Surgical approach						
Open	4103 (62.2)	428 (63.8)	0.410	413 (62.7)	421 (63.9)	0.025
Minimally invasive	2497 (37.8)	242 (36.1)	0.370	244 (37.0)	237 (36.0)	0.022
Surgical procedure						
Small bowel resection	933 (14.1)	82 (12.2)	0.170	83 (12.6)	81 (12.3)	0.0092
Colectomy	5519 (83.6)	557 (83.0)	0.690	540 (81.9)	546 (82.9)	0.024
Proctectomy	989 (15.0)	140 (20.0)	<0.001*	133 (20.2)	138 (20.9)	0.019
Emergent surgery	2608 (39.6)	225 (33.6)	0.003*	213 (32.3)	222 (33.7)	0.033
Hospital characteristics, *n* (%)						

Table 1 (continued)

	Overall cohort			*Propensity matched cohort*		
n (sample size)	**Non-obese**	**Obese**	***p***	**Non-obese**	**Obese**	***Standardized difference***
N (weighted population estimate)	***n* = 6601**	***n* = 671**		***n* = 659**	***n* = 659**	
	***N* = 33005**	***N* = 3355**		***N* = 3295**	***N* = 3295**	
Hospital bed size						0.031
Small	872 (13.2)	91 (13.6)	0.800	85 (12.9)	91 (13.8)	
Medium	1543 (23.4)	149 (22.2)	0.490	153 (23.2)	147 (22.3)	
Large	4186 (63.4)	431 (64.2)	0.680	421 (63.9)	421 (62.9)	
Teaching status						0.0086
Non-teaching	807 (12.2)	75 (11.2)	0.430	66 (10.0)	72 (10.9)	
Teaching	5598 (84.8)	571 (85.1)	0.840	564 (85.6)	562 (85.3)	
Not reported	196 (3.0)	25 (3.7)	0.293	29 (4.4)	25 (3.8)	
Hospital location						0.031
Urban	6405 (97.0)	646 (96.3)	0.280	630 (95.6)	634 (96.2)	
Rural	196 (3.0)	25 (3.7)	0.280	29 (4.4)	25 (3.8)	
Hospital region						
Northeast	1393 (21.1)	136 (20.3)	0.610	144 (21.9)	134 (20.3)	0.037
Midwest	1784 (27.0)	223 (33.2)	0.001*	193 (29.3)	220 (33.4)	0.088
South	2354 (35.7)	223 (33.2)	0.210	230 (34.9)	218 (22.1)	0.038
West	1070 (16.2)	89 (13.3)	0.047*	92 (14.0)	87 (12.3)	0.022

All *n* are analytic sample; *N* are survey-weighted to reflect national estimates. Percentages may not add up to 100% due to rounding

*$p < 0.05$

The obese cohort experienced a greater absolute percentage of outcomes across all these complications sub-categories and demonstrated a statistically significant increased risk of developing AKI (Table 2).

Postoperative mortality

In-hospital mortality rates were low in both groups (Table 2). There were 5 (0.8%) deaths in the non-obese cohort and 2

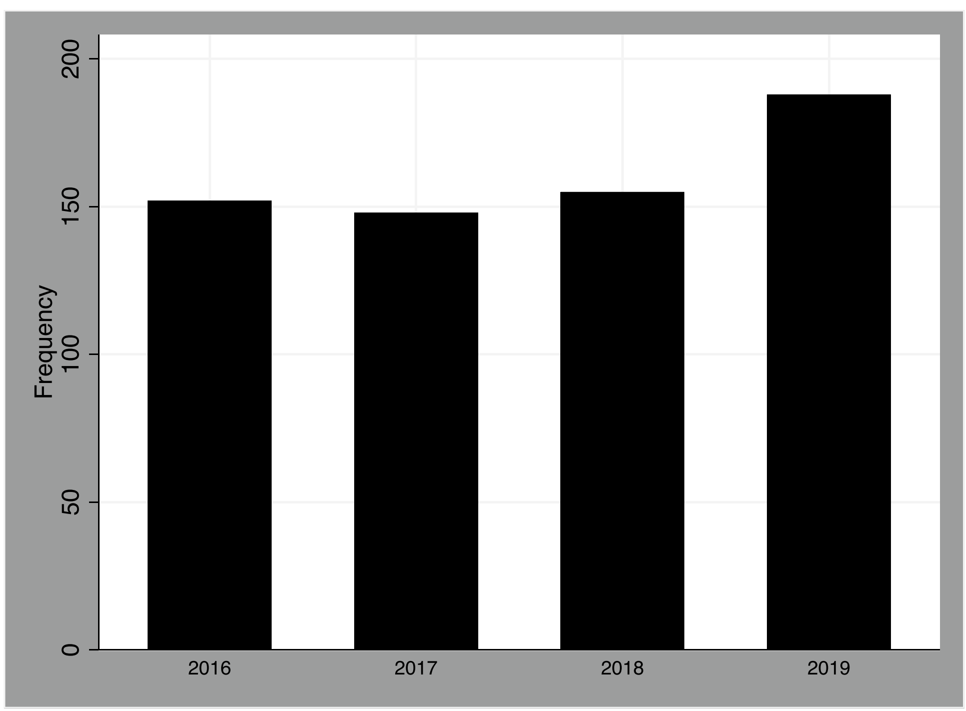

Fig. 1 Increasing prevalence of obese patients presenting for surgical management of inflammatory bowel disease across the September 2016–December 2019 Nationwide Inpatient Sample

Table 2 In-hospital mortality and morbidity based on obesity-status in a propensity score matched cohort, Nationwide Inpatient Sample September 2015–December 2019

n (sample size) *N* (weighted population estimate)	**Non-obese** ***n* = 659** ***N* = 3295**	**Obese** ***n* = 659** ***N* = 3295**	**Unadjusted OR (95% CI)**	***p***	**Adjusted OR** (95% CI)**	***p***
In-hospital mortality, *n* (%)	5 (0.8)	2 (0.3)	0.40 (0.052–3.08)	0.38	0.48 (0.046–5.01)	0.54
Post-operative ICU admission, *n* (%)	18 (2.7)	40 (6.1)	2.30 (1.15–4.61)	0.019*	2.52 (1.24–5.11)	0.01*
Composite system-specific complications, *n* (%)						
Any	160 (24.3)	212 (32.2)	1.48 (1.10–1.99)	0.01*	1.50 (1.10–2.03)	0.01*
Respiratory	20 (3.0)	19 (2.9)	0.95 (0.44–2.06)	0.89	1.12 (0.51–2.48)	0.78
Pneumonia	10 (1.5)	7 (1.1)	0.70 (0.21–2.34)	0.56	0.75 (0.24–2.38)	0.63
Cardiovascular	1 (0.2)	5 (0.8)	5.03 (0.35–72.61)	0.24	5.38 (0.47–61.83)	0.18
Stroke	1 (0.2)	0 (0.0)	-	-	-	-
MI	0 (0.0)	4 (0.6)	-	-	-	-
Gastrointestinal	69 (10.5)	99 (15.0)	1.51 (1.01–2.26)	0.044*	1.49 (1.001–2.25)	0.05
Ileus	56 (8.5)	70 (10.6)	1.28 (0.81–2.01)	0.29	1.27 (0.80–2.03)	0.31
Anastomotic leak	33 (5.0)	53 (8.0)	1.66 (0.94–2.92)	0.079	1.63 (0.93–2.86)	0.086
Postoperative bowel obstruction	127 (1.9)	16 (2.4)	1.24 (0.70–2.21)	0.45	1.25 (0.70–2.24)	0.45
Genitourinary	64 (9.7)	97 (14.7)	1.60 (1.07–2.40)	0.022	1.71 (1.12–2.61)	0.013*
Acute kidney injury	20 (3.0)	44 (6.7)	2.29 (1.18–4.44)	0.015*	2.57 (1.31–5.03)	0.006*
Urinary retention	25 (3.8)	31 (4.7)	1.25 (0.64–2.44)	0.51	1.26 (0.64–2.48)	0.50
Urinary tract infection	22 (3.3)	31 (4.7)	1.43 (0.72–2.83)	0.30	1.53 (0.76–3.11)	0.24
Infectious	40 (6.1)	49 (7.4)	1.24 (0.74–2.09)	0.41	1.24 (0.74–2.10)	0.42
Wound	7 (1.1)	14 (2.1)	2.02 (0.65–6.24)	0.22	2.02 (0.68–6.06)	0.21
Post-procedural shock	3 (0.5)	3 (0.5)	1.00 (0.14–7.21)	1.00	0.75 (0.13–4.21)	0.74
Discharge disposition, *n* (%)						
Home	425 (64.5)	399 (60.5)	0.84 (0.65–1.09)	0.20	0.81 (0.62–1.07)	0.14
Short-term hospital	1 (0.2)	4 (0.6)	4.02 (0.26–61.13)	0.32	6.31 (0.38–105.02)	0.20
Skilled nursing facility	40 (6.1)	44 (6.7)	1.11 (0.65–1.88)	0.71	1.50 (0.81–2.76)	0.20
Home healthcare	186 (28.2)	208 (31.6)	1.17 (0.89–1.54)	0.25	1.18 (0.89–1.56)	0.24
Other	6 (0.9)	4 (0.6)	0.66 (0.14–3.22)	0.61	0.78 (0.14–4.40)	0.77

All *n* are analytic sample; all % and means (SD) are survey-weighted to reflect national estimates

*$p < 0.05$; **Adjusted by age, Charlson Comorbidity Index, type of inflammatory bowel disease (i.e., Crohn's vs. ulcerative colitis), type of operation (i.e., small bowel resection, colectomy, proctectomy), operative approach (i.e., minimally invasive vs. open), insurance status, income quartile, hospital bed size, and location of hospital (i.e., urban vs. rural)

deaths (0.3%) in the obese cohort. There were no significant differences between the two on adjusted analyses (aOR 0.48 95% CI 0.046–5.01, $p = 0.54$).

Length of stay

The mean hospital LOS in the non-obese and obese groups were 8.39 (SD 9.89) and 8.57 (SD 7.51) days, respectively (Table 3). There were no statistically significant differences in LOS between the two groups on adjusted analyses (MD 0.16 days, 95% CI − 0.94–1.27, $p = 0.77$).

Cost

The mean total hospitalization costs for the non-obese and obese groups in U.S. dollars (USD) were $105,139.37 (SD 177,167.59) and $102,244.65 (SD 94,041.78), respectively (Table 3). There were no significant differences in hospitalization costs between the two groups on adjusted analyses (MD − $2256.32, 95% CI − $19,144.54–14,631.90, $p = 0.79$).

Sensitivity analysis

After propensity score matching patients above and below a BMI cut-off of 35 kg/m^2, there were 377 patients included in each arm (Table 4). Standardized mean differences suggested that the groups were well matched aside from year of treatment (standardized mean difference: 19.6%) and insurance group (standardized mean difference 17.6%).

Total postoperative in-hospital morbidity occurred in 27.3% and 32.4% of patients below and above a BMI of 35 kg/m^2, respectively. Adjusted analysis demonstrated that

Table 3 Healthcare utilization outcomes based on obesity-status in a propensity score matched cohort, Nationwide Inpatient Sample September 2015–December 2019

n (sample size) *N* (weighted population estimate)	**Non-obese** ***n* = 659** ***N* = 3295**	**Obese** ***n* = 650** ***N* = 3295**	**Unadjusted mean difference (95% CI)**	***p***	**Adjusted mean difference** (95% CI)**	***p***
Cost, mean (SD), USD	105,139.37 (177,167.59)	102,244.65 (94,041.78)	−2,894.73 (− 21,720.20 to + 15,930.75)	0.76	−2,256.32 (− 19,144.54 to 14,631.90)	0.79
Total length of stay, mean (SD), days	8.39 (9.89)	8.57 (7.51)	+0.18 (− 1.01 to + 1.38)	0.77	+0.16 (− 0.94 to + 1.27)	0.77

All *n* are analytic sample; all % and means (SD) are survey-weighted to reflect national estimates

IQR interquartile range; *USD* United States dollars

*$p < 0.05$; **Adjusted by age, Charlson Comorbidity Index, type of inflammatory bowel disease (i.e., Crohn's vs. ulcerative colitis), type of operation (i.e., small bowel resection, colectomy, proctectomy), operative approach (i.e., minimally invasive vs. open), insurance status, income quartile, hospital bed size, and location of hospital (i.e., urban vs. rural)

postoperative in-hospital morbidity was not significantly different between groups (aOR 1.29, 95% CI 0.94–1.78, $p = 0.12$). Respiratory complications were significantly greater in the patients with a BMI greater than 35 kg/m^2 (aOR 2.68, 95% CI 1.05–6.84, $p = 0.039$). Otherwise, there were no significant differences in system-specific morbidity (Table 5). In-hospital postoperative mortality was extremely low in both groups.

Mean hospital LOS was 8.35 days (SD 7.21) and 8.97 days (SD 8.55) for the patients below and above the cut-off, respectively (Table 6). Mean cost of hospitalization was $96,716.10 (SD 79,071.80) and $105,849.64 (SD 109,324.98) for the patients below and above the cut-off, respectively. There were no significant differences for either outcome on adjusted analyses (Table 6).

Discussion and conclusions

This nationwide retrospective matched cohort study is the first analysis of NIS data investigating the impact of obesity on IBD patients undergoing intraabdominal surgery. Obese IBD patients were found to be at increased risk of experiencing postoperative in-hospital complications, specifically gastrointestinal and genitourinary complications. There were no significant differences in index LOS, total hospitalization costs, or postoperative mortality. With the increasing rates of obese IBD patients seemingly outpacing existing evidence, this is an important addition to this area of study.

Previous studies utilizing other large databases, namely NSQIP and local hospital-based data, have demonstrated conflicting evidence on this topic [10, 11]. Both have reported significantly increased operative times and rates of conversion from laparoscopic to open procedures. Yet, postoperative data in the NSQIP study by Causey et al., which involved 379 obese and 1940 non-obese Crohn's disease patients, demonstrated significantly increased wound infections in the obese group [10]. These findings were not replicated in one of the larger single-center studies by Krane et al., which included 85 obese and 541 non-obese IBD patients [11]. The study herein is a propensity score matched study involving 659 IBD patients per group, allowing for greater confidence that the results were less influenced by important confounding variables. Like the NSQIP study, there were increased post-operative complications seen in the obese group, but the greatest system-specific contributors of post-operative complications were gastrointestinal and genitourinary outcomes. Increased wound complications, as seen in the NSQIP study, were not seen here likely due to the limitation of NIS capturing in-hospital data only [10].

Although obesity is a well-known risk factor for complications from surgery, there remains several gaps in the understanding of obesity as it specifically relates to surgical patients with IBD [7]. This is likely a result of the recent shift in IBD patient demographics from the classic underweight, malnourished profile. There are several theories to explain this demographic shift. It has been proposed that obesity can predispose a patient to IBD development or contribute to its severity [22]. Others suggest that obesity may be a result of dysmetabolism from IBD or from steroid use as part of their treatment regimen [7, 23, 24]. By extension, some believe that this is a function of improved overall management of IBD such that they can retain nutrition and gain weight [10]. This is supported by the shift toward increased elective over emergency surgical interventions for refractory IBD [10]. Nonetheless, the study herein demonstrates that obesity is a risk factor for poor surgical outcomes, and the above theoretical frameworks provide potential areas for further study to improve operative outcomes.

The study findings suggest that there are fundamental differences between obese and non-obese IBD patients that require consideration prior to surgical intervention. The

Table 4 Propensity score matched cohort inflammatory bowel disease patients undergoing bowel resection above and below a body mass index cut-off of 35 kg/m^2, Nationwide Inpatient Sample September 2015–December 2019

	Prospensity matched cohort		
n (sample size)	**BMI < 35**	**BMI > 35**	***Standardized difference***
N (weighted population estimate)	***n*** **= 377 N=1885**	***n*** **= 377 N=1885**	
Patient characteristics, *n* (%)			
Female sex	236 (62.6)	241 (63.9)	0.028
Age (mean [SD])	47.27 (17.83)	47.62 (15.30)	−0.021
Disease			
Ulcerative colitis	79 (21.0)	81 (21.5)	−0.013
Crohn's disease	237 (62.9)	231 (61.3)	0.033
Indeterminant colitis	61 (16.2)	65 (17.2)	0.021
Race			0.10
White	302 (84.4)	289 (82.3)	
Black	24 (6.7)	34 (9.7)	
Hispanic	21 (5.9)	19 (5.4)	
Asian or pacific islander	3 (0.8)	1 (0.3)	
Others	8 (2.2)	8 (2.3)	
Insurance			0.18
Medicare	97 (25.7)	103 (27.3)	
Medicaid	35 (9.3)	53 (14.1)	
Private insurance	226 (59.9)	206 (54.6)	
Self-pay	10 (2.7)	6 (1.6)	
Others	9 (2.4)	9 (2.4)	
Residential income			0.09
First quartile (lowest)	107 (28.4)	97 (25.7)	
Second quartile	99 (26.3)	103 (27.3)	
Third quartile	95 (25.2)	115 (30.5)	
Fourth quartile (highest)	76 (20.2)	62 (16.4)	
Charlson Comorbidity Index (median [IQR])	1 (0, 3)	1 (0, 2)	0.029
3 ≥	231 (61.3)	227 (60.2)	
4–6	115 (30.5)	125 (33.2)	
≥ 7	31 (8.2)	25 (6.6)	
Treatment characteristics, *n* (%)			
Year treated			0.20
2015	29 (7.7)	16 (4.2)	
2016	74 (19.6)	92 (24.4)	
2017	72 (19.1)	83 (22.0)	
2018	97 (25.7)	87 (23.1)	
2019	105 (27.9)	99 (26.3)	
Surgical approach			
Minimally invasive	120 (31.8)	128 (34.0)	−0.045
Surgical procedure			
Small bowel resection	51 (13.5)	42 (11.1)	0.073
Colectomy	302 (80.1)	316 (83.8)	−0.097
Proctectomy	75 (19.9)	69 (18.3)	0.040
Emergent surgery	252 (66.8)	245 (65.0)	0.039
Hospital characteristics, *n* (%)			
Hospital bed size			0.029
Small	51 (13.5)	54 (14.3)	
Medium	85 (22.5)	87 (23.1)	
Large	241 (63.9)	236 (62.6)	

Table 4 (continued)

	Prospensity matched cohort		
n (sample size) *N* (weighted population estimate)	**BMI < 35** ***n*** **= 377 N=1885**	**BMI > 35** ***n*** **= 377 N=1885**	***Standardized difference***
Teaching status			0.029
Non-teaching	45 (11.9)	47 (12.5)	
Teaching	318 (84.4)	314 (83.3)	
Not reported	14 (3.7)	16 (4.2)	
Hospital location			0.027
Urban	363 (96.3)	361 (95.8)	
Hospital region			0.042
Northeast	71 (18.8)	76 (20.2)	
Midwest	118 (31.3)	120 (31.8)	
South	137 (36.3)	133 (35.3)	
West	51 (13.5)	48 (12.7)	

All *n* are analytic sample; *N* are survey-weighted to reflect national estimates. Percentages may not add up to 100% due to rounding

*$p < 0.05$

Table 5 In-hospital mortality and morbidity based on sensitivity analysis (body mass index cut-off of 35 kg/m^2), Nationwide Inpatient Sample September 2015–December 2019

n (sample size) *N* (weighted population estimate)	**BMI < 35** ***n*** **= 377** ***N*** **= 1885**	**BMI > 35** ***n*** **= 377** ***N*** **= 1885**	**Unadjusted OR (95% CI)**	***p***	**Adjusted OR** (95% CI)**	***p***
In-hospital mortality, *n* (%)	0	2 (0.5)	-	-	-	-
Post-operative ICU admission, *n* (%)	14 (3.7)	23 (6.1)	1.68 (0.85–3.32)	0.13	1.83 (0.91–3.68)	0.092
Composite system-specific complications, *n* (%)						
Any	103 (27.3)	122 (32.4)	1.27 (0.93–1.74)	0.13	1.29 (0.94–1.78)	0.12
Respiratory	7 (1.9)	17 (4.5)	2.49 (1.02–6.09)	0.044*	2.68 (1.05–6.84)	0.039*
Pneumonia	3 (0.8)	5 (1.3)	1.68 (0.40–7.06)	0.48	1.91 (0.43–8.39)	0.39
Cardiovascular	1 (0.3)	5 (1.3)	5.05 (0.59–43.46)	0.14	7.14 (0.74–68.53)	0.089
Stroke	1 (0.3)	0 (0.0)	-	-	-	-
MI	0 (0.0)	4 (1.1)	-	-	-	-
Gastrointestinal	47 (12.5)	52 (13.8)	1.12 (0.74–1.72)	0.59	1.13 (0.73–1.73)	0.59
Ileus	37 (9.8)	38 (10.1)	1.03 (0.64–1.66)	0.90	1.04 (0.64–1.69)	0.88
Anastomotic leak	25 (6.6)	25 (6.6)	1.00 (0.56–1.77)	1.00	0.99 (0.55–1.77)	0.98
Genitourinary	45 (11.9)	54 (14.3)	1.23 (0.87–1.89)	0.33	1.26 (0.81–1.95)	0.31
Acute kidney injury	16 (4.2)	27 (7.2)	1.74 (0.92–3.29)	0.087	1.92 (0.99–3.73)	0.054
Urinary retention	14 (3.7)	16 (4.2)	1.15 (0.55–2.39)	0.71	1.13 (0.54–2.36)	0.75
Urinary tract infection	17 (4.5)	18 (4.8)	1.06 (0.54–2.09)	0.86	1.06 (0.53–2.12)	0.86
Infectious	27 (7.2)	33 (8.8)	1.24 (0.73–2.11)	0.42	1.26 (0.73–2.15)	0.41
Wound	3 (0.8)	8 (2.1)	2.70 (0.71–10.27)	0.14	2.97 (0.77–11.50)	0.12
Post-procedural shock	2 (0.5)	1 (0.3)	0.50 (0.045–5.52)	0.57	0.25 (0.014–4.34)	0.34
Discharge disposition, *n* (%)						
Home	243 (64.5)	221 (58.6)	0.78 (0.58–1.04)	0.10	0.77 (0.56–1.05)	0.10
Short-term hospital	2 (0.5)	3 (0.8)	1.50 (0.25–9.05)	0.66	1.50 (0.23–9.61)	0.67
Skilled nursing facility	22 (5.8)	32 (8.5)	1.50 (0.85–2.63)	0.16	1.95 (1.03–3.67)	0.040*
Home healthcare	109 (28.9)	117 (31.0)	1.11 (0.81–1.51)	0.53	1.11 (0.80–1.53)	0.53
Other	1 (0.3)	4 (1.1)	4.03 (0.45–36.24)	0.21	4.17 (0.44–39.45)	0.21

All *n* are analytic sample; all % and means (SD) are survey-weighted to reflect national estimates

*$p < 0.05$; **Adjusted by age, Charlson Comorbidity Index, type of inflammatory bowel disease (i.e., Crohn's vs. ulcerative colitis), type of operation (i.e., small bowel resection, colectomy, proctectomy), operative approach (i.e., minimally invasive vs. open), insurance status, income quartile, hospital bed size, and location of hospital (i.e., urban vs. rural)

Table 6 Healthcare utilization outcomes based on sensitivity analysis (body mass index cut-off of 35 kg/m^2), Nationwide Inpatient Sample September 2015–December 2019

n (sample size) *N* (weighted population estimate)	**Non-obese** ***n* = 659** ***N* = 3295**	**Obese** ***n* = 650** ***N* = 3295**	**Unadjusted mean difference (95% CI)**	***p***	**Adjusted mean difference** (95% CI)**	***p***
Cost, mean (SD), USD	105,139.37 (177,167.59)	102,244.65 (94,041.78)	9133.54 (−4538.79 to 22,805.87)	0.19	8990.11 (−4383.07 to 22,363.38)	0.19
Total length of stay, mean (SD), days	8.39 (9.89)	8.57 (7.51)	0.62 (−0.52 to 1.74)	0.29	0.60 (−0.50 to 1.70)	0.28

All *n* are analytic sample; all % and means (SD) are survey-weighted to reflect national estimates

IQR interquartile range; *USD* United States dollars

*$p < 0.05$; **Adjusted by age, Charlson Comorbidity Index, type of inflammatory bowel disease (i.e., Crohn's vs. ulcerative colitis), type of operation (i.e., small bowel resection, colectomy, proctectomy), operative approach (i.e., minimally invasive vs. open), insurance status, income quartile, hospital bed size, and location of hospital (i.e., urban vs. rural)

aforementioned increase in elective operations may generate a window of opportunity for pre-operative optimization. Early involvement of registered dieticians, exercise regimens, and careful coordination of medication regimens could optimize nutrition while also potentially promoting weight loss. Similar preoperative optimization programs have been successfully implemented in patients undergoing surgery for colorectal cancer, hepatobiliary disease, esophagogastric malignancies, and more [25–27]. This could potentially reduce the technical challenge of surgery in obese patients, which may, in turn, reduce complications like anastomotic leaks [28–30]. Specific post-operative protocols can be developed for the obese IBD patient to avoid complications identified in this study such as AKI, urinary retention, UTI, and ileus, through specific fluid resuscitation and Foley management protocols as well as increased supports for early mobilization. Moreover, an understanding of the increased odds of postoperative morbidity for these patients can heighten postoperative monitoring and lower the threshold for investigating potential postoperative complications [31].

Sensitivity analysis with a BMI cut-off of 35 kg/m^2 demonstrated that patients with BMI greater than 35 kg/m^2 were only at increased risk of respiratory complications, and that the significant differences demonstrated between the obese and non-obese groups in the main analyses in terms of overall in-hospital morbidity, gastrointestinal complications, and genitourinary complications were lost. This may have been a result of reduced statistical power as the overall cohort size with the sensitivity analysis was halved. It is also possible that these data indicate that a BMI cut-off of 30 kg/m^2 is most appropriate for risk stratifying these patients. Further data are required to explore an optimal BMI cut-off, especially in the context of pre-operative optimization; however, for the time being, a cut-off of 30 kg/m^2 appears appropriate for these patients.

The strengths of this study include its novelty, statistical power, and the propensity score matching. However, there remain several limitations. Firstly, this study is limited by its retrospective design and reliance on large population-level data that inherently increase the risk for selection bias. Secondly, there is significant risk of residual confounding in the present study due to the number of variables that are important to the care of surgical IBD patients that the NIS does not capture. For example, IBD severity, steroid use, biologic use, and age of IBD onset are all important variables that can predict postoperative morbidity and healthcare utilization data that are not captured by the NIS. The NIS also does not collect post-discharge postoperative data. Thus, delayed postoperative outcomes such as anastomotic leaks and SSIs may have been underreported in the present cohort. This is important to consider while interpreting the results of our study, as there's an increased risk of SSI among patients with IBD, which may commonly manifest post-discharge especially with the use of perioperative immunosuppressants [32–34]. This could be further exacerbated by obesity, which independently, and in the context of IBD, has been demonstrated to be a risk factor for SSI [12, 35, 36]. Altogether, the lack of post-discharge postoperative data may have led to underestimation of the morbidity effect size. Moreover, important long-term postoperative outcomes such as disease recurrence and incisional hernia could not be captured. Lastly, due to the nature of the ICD-10-CM coding, errors in identifying patients based on diagnosis and procedural codes are possible and may impact the accuracy of these findings.

This large retrospective matched cohort study of NIS data contributes to the growing body of evidence that obesity is a risk factor for worse postoperative outcomes in IBD patients undergoing abdominal surgery. Although there are no differences in LOS, hospital costs, and mortality, the significant differences in postoperative complications support the development of targeted perioperative management protocols for this unique patient population. Future studies should aim to evaluate perioperative interventions aimed at improving postoperative outcomes in obese surgical IBD patients.

Author contribution Study concept and design – all authors Acquisition of data – McKechnie, Lee Analysis and interpretation of data – all authors Drafting and revision of manuscript – all authors Approval of the final version of the manuscript – all authors All authors have approved of the final draft submitted.

Data availability The data that support the findings of this study are openly available in the National Inpatient Sample.

Data sharing The data are publicly available.

Declarations

Ethics approval This project did not require local ethics board approval.

Competing interests The authors declare no competing interests.

References

1. Ng M, Fleming T, Robinson M, Thomson B, Graetz N, Margono C et al (2014) Global, regional and national prevalence of overweight and obesity in children and adults 1980–2013: a systematic analysis. Lancet Lond Engl 384(9945):766–781
2. Blüher M (2019) Obesity: global epidemiology and pathogenesis. Nat Rev Endocrinol 15(5):288–298
3. Flegal KM, Carroll MD, Ogden CL, Curtin LR (2010) Prevalence and trends in obesity among US adults, 1999–2008. JAMA 303(3):235–241
4. Ward ZJ, Bleich SN, Cradock AL, Barrett JL, Giles CM, Flax C et al (2019) Projected U.S. state-level prevalence of adult obesity and severe obesity. N Engl J Med 381(25):2440–50
5. Pringle PL, Stewart KO, Peloquin JM, Sturgeon HC, Nguyen D, Sauk J et al (2015) Body mass index, genetic susceptibility, and risk of complications among individuals with Crohn's disease. Inflamm Bowel Dis 21(10):2304–2310
6. Nic Suibhne T, Raftery TC, McMahon O, Walsh C, O'Morain C, O'Sullivan M (2013) High prevalence of overweight and obesity in adults with Crohn's disease: associations with disease and lifestyle factors. J Crohns Colitis 7(7):e241-248
7. Singh S, Dulai PS, Zarrinpar A, Ramamoorthy S, Sandborn WJ (2017) Obesity in IBD: epidemiology, pathogenesis, disease course and treatment outcomes. Nat Rev Gastroenterol Hepatol 14(2):110–121
8. Tjeertes EEKM, Hoeks SSE, Beks SSBJC, Valentijn TTM, Hoofwijk AAGM, Stolker RJ (2015) Obesity – a risk factor for postoperative complications in general surgery? BMC Anesthesiol 15(1):112
9. Ri M, Aikou S, Seto Y (2017) Obesity as a surgical risk factor. Ann Gastroenterol Surg 2(1):13–21
10. Causey MW, Johnson EK, Miller S, Martin M, Maykel J, Steele SR (2011) The impact of obesity on outcomes following major surgery for Crohn's disease: an American College of Surgeons National Surgical Quality Improvement Program Assessment. Dis Colon Rectum 54(12):1488–1495
11. Krane MK, Allaix ME, Zoccali M, Umanskiy K, Rubin MA, Villa A et al (2013) Does morbid obesity change outcomes after laparoscopic surgery for inflammatory bowel disease? Review of 626 consecutive cases. J Am Coll Surg 216(5):986–996
12. Jiang K, Chen B, Lou D, Zhang M, Shi Y, Dai W et al (2022) Systematic review and meta-analysis: association between obesity/overweight and surgical complications in IBD. Int J Colorectal Dis 37(7):1485–1496
13. Hwang F, Crandall M, Smith A, Parry N, Liepert AE (2022) Small bowel obstruction in older patients: challenges in surgical management. Surg Endosc
14. DeAngelis EJ, Zebley JA, Ileka IS, Ganguli S, Panahi A, Amdur RL et al (2022) Trends in utilization of laparoscopic colectomy according to race: an analysis of the NIS database. Surg Endosc
15. Edigin E, Asotibe J, Eseaton PO, Busari OA, Achebe I, Kichloo A et al (2021) Coexisting psoriasis is associated with an increased risk of hospitalization for patients with inflammatory bowel disease: an analysis of the National Inpatient Sample database. J Investig Med 69(4):857–862
16. Quan H, Drösler S, Sundararajan V, Wen E, Burnand B, Couris CM et al (2008) Adaptation of AHRQ patient safety indicators for use in ICD-10 administrative data by an international consortium. In: Henriksen K, Battles JB, Keyes MA, Grady ML, editors. Advances in patient safety: new directions and alternative approaches (Vol 1: Assessment) [Internet]. Rockville (MD): Agency for Healthcare Research and Quality; [cited 2022 Dec 17]. (Advances in Patient Safety). Available from: http://www.ncbi.nlm.nih.gov/books/NBK43634/
17. Storesund A, Haugen AS, Hjortås M, Nortvedt MW, Flaatten H, Eide GE et al (2019) Accuracy of surgical complication rate estimation using ICD-10 codes. Br J Surg 106(3):236–244
18. LaPar DJ, Bhamidipati CM, Mery CM, Stukenborg GJ, Jones DR, Schirmer BD et al (2010) Primary payer status affects mortality for major surgical operations. Ann Surg 252(3):544–50; discussion 550–551
19. Becker SO, Ichino A (2002) Estimation of average treatment effects based on propensity scores. Stata J 2(4):358–377
20. Geldof T, Popovic D, Van Damme N, Huys I, Van Dyck W (2020) Nearest neighbour propensity score matching and bootstrapping for estimating binary patient response in oncology: a Monte Carlo simulation. Sci Rep 10(1):964
21. Austin PC (2009) Balance diagnostics for comparing the distribution of baseline covariates between treatment groups in propensity-score matched samples. Stat Med 28(25):3083–3107
22. Khalili H, Ananthakrishnan AN, Konijeti GG, Higuchi LM, Fuchs CS, Richter JM et al (2015) Measures of obesity and risk of Crohn's disease and ulcerative colitis. Inflamm Bowel Dis 21(2):361–368
23. Karmiris K, Koutroubakis IE, Xidakis C, Polychronaki M, Voudouri T, Kouroumalis EA (2006) Circulating levels of leptin, adiponectin, resistin, and ghrelin in inflammatory bowel disease. Inflamm Bowel Dis 12(2):100–105
24. Berthon BS, MacDonald-Wicks LK, Wood LG (2014) A systematic review of the effect of oral glucocorticoids on energy intake, appetite, and body weight in humans. Nutr Res N Y N 34(3):179–190
25. Li C, Carli F, Lee L, Charlebois P, Stein B, Liberman AS et al (2013) Impact of a trimodal prehabilitation program on functional recovery after colorectal cancer surgery: a pilot study. Surg Endosc 27(4):1072–1082
26. Dagorno C, Sommacale D, Laurent A, Attias A, Mongardon N, Levesque E et al (2022) Prehabilitation in hepato-pancreato-biliary surgery: a systematic review and meta-analysis. A necessary step forward evidence-based sample size calculation for future trials. J Visc Surg 159(5):362–72
27. Bolger JC, Loughney L, Tully R, Cunningham M, Keogh S, McCaffrey N et al (2019) Perioperative prehabilitation and rehabilitation in esophagogastric malignancies: a systematic review. Dis Esophagus Off J Int Soc Dis Esophagus 32(9):doz058
28. Post IL, Verheijen PM, Pronk A, Siccama I, Houweling PL (2012) Intraoperative blood pressure changes as a risk factor for anastomotic leakage in colorectal surgery. Int J Colorectal Dis 27(6):765–772

29. Geiger TM, Muldoon R (2011) Complications following colon rectal surgery in the obese patient. Clin Colon Rectal Surg 24(4):274–282
30. Panteleimonitis S, Popeskou S, Harper M, Kandala N, Figueiredo N, Qureshi T et al (2018) Minimally invasive colorectal surgery in the morbid obese: does size really matter? Surg Endosc 32(8): 3486–3494
31. Haahr-Raunkjær C, Meyhoff CS, Sørensen HBD, Olsen RM, Aasvang EK (2017) Technological aided assessment of the acutely ill patient – the case of postoperative complications. Eur J Intern Med 1(45):41–45
32. Bhakta A, Tafen M, Glotzer O, Ata A, Chismark AD, Valerian BT et al (2016) Increased incidence of surgical site infection in IBD patients. Dis Colon Rectum 59(4):316–322
33. Liang H, Jiang B, Manne S, Lissoos T, Bennett D, Dolin P (2018) Risk factors for postoperative infection after gastrointestinal surgery among adult patients with inflammatory bowel disease: findings from a large observational US cohort study. JGH Open Open Access J Gastroenterol Hepatol 2(5):182–190
34. Law CC, Bell C, Koh D, Bao Y, Jairath V, Narula N (2020) Risk of postoperative infectious complications from medical therapies in inflammatory bowel disease. Cochrane Database Syst Rev 2020(10):CD013256
35. Winfield RD, Reese S, Bochicchio K, Mazuski JE, Bochicchio GV (2016) Obesity and the risk for surgical site infection in abdominal surgery. Am Surg 82(4):331–336
36. Meijs AP, Koek MBG, Vos MC, Geerlings SE, Vogely HC, de Greeff SC (2019) The effect of body mass index on the risk of surgical site infection. Infect Control Hosp Epidemiol 40(9):991–996