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ORIGINAL CONTRIBUTIONS

Impact of Bariatric Surgery on Outcomes of Patients with Inflammatory Bowel Disease: a Nationwide Inpatient Sample Analysis, 2004–2014

Prabin Sharma [1] · Thomas R. McCarty [2] · Basile Njei [3]

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Abstract

Purpose There is a paucity of data regarding the benefits of bariatric surgery in patients with inflammatory bowel disease (IBD). The primary aim of this study was to evaluate the role of bariatric surgery on clinical outcomes among hospitalized patients with IBD.

Materials and Methods The United States (US) National Inpatient Sample database was queried between 2004 and 2014 for discharges with co-diagnoses of morbid obesity and IBD. Hospitalizations with a history of prior-bariatric surgery were also identified. The primary outcome was in-hospital mortality. Secondary outcomes included renal failure, under-nutrition, thromboembolic events, strictures, fistulae, length of stay, and hospitalization costs. Using Poisson regression, adjusted incidence risk ratios (IRR) were derived for clinical outcomes in patients with prior-bariatric surgery compared to those without bariatric surgery.

Results Among 15,319 patients with a discharge diagnosis of IBD and morbid obesity, 493 patients (3.2%) had bariatric surgery. From 2004 to 2014, the proportion of obese IBD patients that underwent bariatric surgery declined (5.2 versus 3.1%). In a multivariable analysis, prior-bariatric surgery was associated with decreased IRR for renal failure, under-nutrition, and fistulae formation in morbidly obese IBD patients [(IRR 0.1; 95% CI 0.02–0.3; $P < 0.001$), (IRR 0.2; 95% CI 0.05–0.8; $P = 0.03$), and (IRR 0.1; 95% 0.2–08; $P = 0.03$), respectively]. Bariatric surgery did not influence mortality ($P = 0.99$).

Conclusions Despite a gradual increase in morbid obesity among patients with IBD, there has been a decrease in proportion of overall bariatric surgeries. Bariatric surgery appears to reduce morbidity in obese patients with IBD.

Keywords Inflammatory bowel disease (IBD) · Crohn's disease (CD) · Ulcerative colitis (UC) · Obesity · Bariatric surgery · Weight loss

Introduction

Within the last decade, epidemiologic studies have shown a parallel rise in the prevalence of obesity and immune-mediated conditions, including inflammatory bowel disease (IBD) [1–3]. While early data suggested that obesity was a rare finding among IBD patients as these individuals usually suffer from under-nutrition and weight loss, more recent studies point towards a similar increase in the incidence of obesity and IBD [4]. Although IBD is not considered a traditional obesity-related comorbidity, studies suggest that obesity, being a pro-inflammatory state, may itself play a role in pathogenesis of IBD [5–7].

Though this remains controversial at present, obesity-related inflammatory cytokines may induce or worsen IBD with higher hospitalization rates and disease activity [8–12]. While one study has demonstrated obesity to be a marker of less severe IBD disease course, there is mounting evidence to support the complex interaction between obesity and IBD [8–13]. Furthermore, the role of bariatric surgery in morbidly

Co-first authors PS and TRM contributed equally to this manuscript.

✉ Basile Njei
basile.njei@yale.edu

[1] Department of Internal Medicine, Yale-New Haven Health System - Bridgeport Hospital, Bridgeport, CT, USA

[2] Department of Internal Medicine, Yale University School of Medicine, New Haven, CT, USA

[3] Section of Digestive Diseases, Yale University School of Medicine, 333 Cedar St, New Haven, CT 06520, USA

obese patients with IBD is especially uncertain. Questions about nutrition, IBD-specific disease activity, metabolic syndrome-associated outcomes, and specific weight loss strategies persist.

Over the past decade, bariatric surgery has evolved with remarkable success in weight loss as well as reduction in obesity and metabolic syndrome-related complications [14]. These surgeries have also shown significant improvement in outcomes of some inflammatory conditions (e.g., gout, psoriasis, and lupus) [15–17]. Similarly, as obesity and IBD appear to share a common inflammatory pathogenesis, it is plausible that weight reduction surgery may result in improved outcomes in obese IBD patients.

Despite this notion, there is hesitation towards performing bariatric surgeries in morbidly obese IBD patients due to reports of higher rates of short- and long-term complications (e.g., fistulae, abscesses, strictures, anastomotic leaks, bowel obstructions, and neoplasms) [18–22]. More recent studies have shown that bariatric surgery is safe and effective in this unique patient population but requires patients to be carefully selected with a multidisciplinary approach [19]. At this time, there is no consensus on the preferred surgical method for patients with IBD though small bowel sparing surgeries such as sleeve gastrectomy and laparoscopic adjustable gastric banding are typically recommended in contrast to Roux-en-Y gastric bypass [19].

At present, there is a paucity of data regarding bariatric surgery and relevant clinic outcomes in obese patients with IBD. Current available data is limited to small case series and studies with small patient populations. The primary aim of this study was to assess the impact of bariatric surgery on clinical outcomes in morbidly obese hospitalized patients with IBD. We hypothesized that bariatric surgery would be associated with improved outcomes in this select patient population.

Methods

Data Source and Study Population

The study sample originated from the National Inpatient Sample database, which includes hospitalized patients in the United States (US) during the 2004 to 2014 period. This registry is part of the Healthcare Cost and Utilization Project, sponsored by the Agency for Healthcare Research and Quality [23]. The National Inpatient Sample is a database of hospital inpatient stays derived from billing data submitted by hospitals to statewide data organizations across the US. Inpatient data includes clinical and resource use information typically available from discharge abstracts. Each discharge is coded with a principal diagnosis for that specific hospitalization in addition to the potential for 14 secondary diagnoses and 15 associated procedures. The Nationwide Inpatient Sample is the largest US inpatient care database, encompassing hospitals from a total of 46 states, which serve 97% of the US population.

Inclusion and Exclusion Criteria

Patients were included if they had a primary or secondary diagnosis of IBD and morbid obesity. These conditions were identified using the International Classification of Diseases, Ninth Edition, Clinical Modification (ICD-9-CM) codes. IBD was defined based upon ICD-9-CM codes for ulcerative colitis (UC)—556.0, 556.1, 556.2, 556.3, 556.4, 556.5, 556.6, 556.8, and 556.9—and Crohn's disease (CD)—555.0, 555.1, 555.2, and 555.9. Morbid obesity was defined by ICD-9-CM codes 278.01, V85.35, V85.36, V85.37, V85.37, V85.38, V85.39, V85.40, V85.41, V85.42, V85.43, V85.44, and V85.45.

Bariatric Surgery Assessment

Among the included patients with morbid obesity and IBD, hospitalizations with a history of prior-bariatric surgery (Roux-en-Y, gastric band, and sleeve gastrectomy) were identified using the following ICD-9-CM codes: laparoscopic or open Roux-en-Y gastric bypass (ICD-9-CM 44.31, 44.38, and 43.39), laparoscopic adjustable gastric band (ICD-9-CM 44.95), and laparoscopic sleeve gastrectomy (ICD-9-CM 43.82).

Outcomes

The primary outcome was in-hospital mortality. Secondary outcomes included renal failure, under-nutrition, thromboembolic events, strictures, fistulae, length of stay, and hospitalization costs.

Covariates

The covariates included demographic data (age, gender, and race/ethnicity) as well as characteristics related to metabolic syndrome and IBD-specific outcomes including strictures and fistulae. Hospitalization data such as day of admission (weekday or weekend), route of admission, mean length of hospital stay, hospitalization charges, and primary payer source was also included. Details on the covariates are highlighted in Appendix 1.

Statistical Analysis

Characteristics, both demographic and clinical, were compared between patients with and without a history of bariatric surgery. Categorical variables were presented as counts and proportions and differences tested using Pearson's Chi-square test. Continuous variables were presented as mean (standard deviation), and differences between groups were tested using the t test. The age-adjusted mortality rate was calculated for each year of study by summing the product of age-specific mortality rates by the age-specific weights. For population trends, the total number of cases was standardized per 100,000 based upon total population derived from the US census data for specific years (2004 to 2014) [24]. The weights used in the age adjustment of the data were the proportion of the year 2000 standard US population within each age group [25].

Secular trends in mortality rates were assessed using linear Poisson regression models. The models were used to investigate the effect of the period of diagnosis (independent variable) on the in-hospital mortality rate (dependent variable), while controlling for other variables (i.e., adjusting for age, sex, race, income, insurance status, type of admission, and modified Elixhauser Comorbidity Index including diabetes, hypertension, hyperlipidemia, coronary artery disease, and obstructive sleep apnea). Risk estimates and 95% confidence intervals (CIs) were calculated for all independent variables in the final model. Poisson regression with robust (Huber–White) standard errors was also used to determine incident risk ratios (IRR) for predictors of in-hospital mortality. Prior to our analysis, we tested the Poisson models for over-dispersion using a Pearson goodness-of-fit test. Models were not over-dispersed; thus, Poisson regression was then used to determine IRR for clinical outcomes in patients with prior-bariatric surgery compared to those without bariatric surgery.

All the analyses accounted for clustering and sampling weights. The Healthcare Cost and Utilization Project National Inpatient Sample has a two-stage cluster design incorporating clustering at the hospital level and discharge level. The weighting of discharges is based on the hospital type and volume of discharges relative to the sampling region. Analyses were performed using Stata version 13.0 (StataCorp LP, College Station, TX). All P values were based on two-sided tests and were considered statistically significant at P value < 0.05.

Results

Patient Characteristics

A total of 15,319 patients with a discharge diagnosis of morbid obesity and IBD were included in our study, of which $n = 493$ (3.2%) had prior-bariatric surgery. A majority of the study population was Caucasian (82.2%) and female (84.2%). A total of $n = 9704$ (63%) patients carried a diagnosis of CD while $n = 5672$ (37%) had UC—a ratio of 1.7:1. The mean age of included patients was 45.9 ± 14.6 years. The baseline demographic and hospitalization characteristics of patients as stratified by bariatric surgery status are presented in Table 1. Obese IBD patients with a history of bariatric surgery were more likely to have a documented history of polycystic ovarian syndrome ($P < 0.001$). Patients without bariatric surgery were more likely to have a diagnosis of coronary artery disease ($P = 0.03$).

Trends in Obesity and Bariatric Surgery Use

Trends of obesity among IBD patients as adjusted for the proportion of discharges demonstrated a percent annual change of + 0.5% from 2004 to 2014 (Fig. 1). The overall number of bariatric surgeries in morbidly obese IBD patients increased almost 3.4 times the original number of procedures performed from 2004 ($n = 24$) to 2014 ($n = 82$) (Table 2). Trends in overall bariatric surgery as adjusted for the proportion of discharges with bariatric surgery demonstrated a percent annual change of + 0.24% from 2004 to 2014 (Fig. 2). With regard to specific weight loss surgeries, both the number of laparoscopic gastric band and gastric sleeve procedures increased while that of the Roux-en-Y procedure decreased (Table 2). Over the same period, the proportion of patients with Roux-en-Y procedures declined at an adjusted rate of − 0.07% per year (Fig. 3). During this same time period, the utilization of laparoscopic gastric banding decreased at an adjusted rate of − 0.1% per year, whereas the use of laparoscopic sleeve gastrectomy significantly increased with an adjusted annual percent increase of + 3.4% per year (Figs. 4 and 5, respectively).

Clinical Outcomes

In a multivariable analysis, compared to patients with no history of a surgical weight loss procedure, there was no significant in-hospital mortality difference for IBD patients with bariatric surgery ($P = 0.99$) (Table 3). Renal failure, undernutrition, and fistulae were significantly lower in obese IBD patients with a history of prior-bariatric surgery [(IRR 0.1; 95% CI, 0.02–0.3; $P < 0.001$), (IRR 0.2; 95% CI, 0.05–0.8; $P = 0.03$), and (IRR 0.1; 95% CI, 0.02–0.8; $P = 0.03$), respectively]. In a subgroup analysis, rates of renal failure were lower for both CD and UC [(IRR 0.1; 95% CI, 0.01–0.5; $P = 0.006$) and (IRR 0.6; 95% CI, 0.01–0.42; $P = 0.01$), respectively]. Strictures were significantly higher in UC patients with a history of prior-bariatric surgery (IRR 2.3; 95% CI, 1.4–3.7; $P = 0.001$); however, this was not the case for CD patients (IRR 1.1; 95% CI, 0.7–1.6; $P = 0.71$). Regardless of type, overall IBD patients did not have a significant difference in strictures with or without a history of bariatric surgery (IRR 1.3; 95% CI, 0.9–1.8; $P = 0.11$).

Morbidly obese IBD patients with a prior history of bariatric surgery as compared to no weight loss surgery had a lower hospitalization cost and shorter length of hospital stay [(41,239 ± 32,264 versus 44,964 ± 64,557; $P < 0.001$) and

Table 1 Characteristics of hospitalized patients with morbid obesity and inflammatory bowel disease

Variable	Bariatric surgery (*N* = 493; 3.2%)	No bariatric surgery (*N* = 14,826; 96.8%)	*P* value
Demographic characteristics			
Age (years)[a]	45.9 (14.6)	52.7 (11.2)	< 0.001
Male gender	78 (15.8)	4239 (28.6)	<0.001
Race/ethnicity)			0.003
White	351 (82.2)	10,539 (80.2)	
Black	34 (8.0)	1695 (12.9)	
Hispanic	21 (4.9)	566 (4.3)	
Other	21 (4.9)	346 (2.6)	
Hypertension	238 (48.3)	6648 (44.8)	0.13
Coronary artery disease	IS[b]	392 (2.6)	0.03
Hyperlipidemia	114 (23.1)	3131 (21.1)	0.3
PCOS	15 (3.0)	101 (0.7)	< 0.001
UC	245 (49.7)	5427 (36.6)	< 0.001
CD	248 (50.3)	9456 (63.8)	< 0.001
CCI[a]	6.4 (2.5)	7.8 (3.2)	< 0.001
Hospital-related characteristics			
Elective admission	452 (92.2)	3158 (21.4)	< 0.001
Weekend admission	IS[b]	2936 (19.8)	< 0.001
Primary payer source			<0.001
Private insurance	82 (16.8)	6175 (41.7)	
Medicaid	36 (7.4)	1991 (13.5)	
Medicare	340 (69.5)	5736 (38.8)	
Other payment source	19 (3.9)	527 (3.6)	
Self-pay	IS[b]	54 (0.4)	
No charge	11 (2.2)	312 (2.1)	
LOS			
Overall LOS[a]	2.4 (2.8)	6.0 (6.5)	< 0.001
LOS UC[a]	2.5 (3.2)	6.4 (6.9)	< 0.001
LOS CD[a]	2.3 (2.2)	5.8 (6.3)	< 0.001
Total costs			
Overall total costs[a]	41,239 (32264)	44,964 (64557)	< 0.001
Total costs UC[a]	40,866 (36740)	50,103 (68683)	< 0.001
Total costs CD[a]	41,607 (27202)	42,030 (61778)	< 0.001

Data are counts (percentage)

PCOS polycystic ovarian syndrome, *UC* ulcerative colitis, *CD* Crohn's disease, *CCI* Charlson comorbidity index, *LOS* length of stay, *IS* information suppressed

[a] Mean (SD)

[b] NOTE. According to the data user agreement, any individual table cell counts of 10 or fewer cannot be presented to preserve patient confidentiality. In such instances, data are suppressed

(2.4 ± 2.8 versus 6.0 ± 6.5; $P < 0.001$), respectively]. Even when stratifying by IBD type, both patients with UC and CD showed a significantly lower hospitalization cost and shorter length of stay [(hospitalization cost: UC 40866 ± 36,740 versus 50,103 ± 68,683; $P < 0.001$, and CD 41607 ± 27,202 versus 42,030 ± 61,778; $P < 0.001$) and (length of stay: UC 2.5 ± 3.3 versus 6.4 ± 6.9; $P < 0.001$, and CD 2.3 ± 2.2 versus 5.8 ± 6.3; $P < 0.001$), respectively] (Table 1).

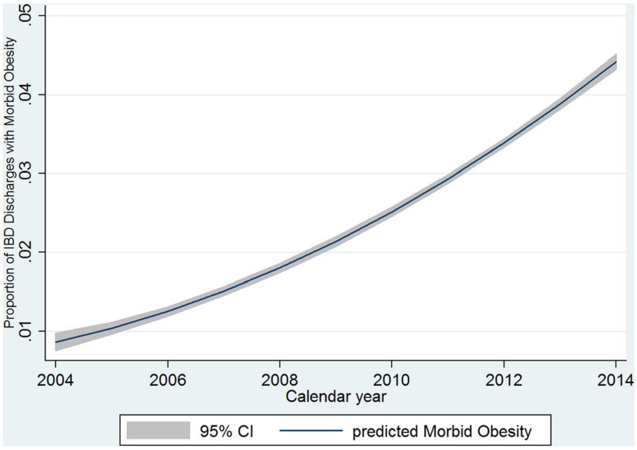

Fig. 1 Proportion of morbidly obese IBD patients, 2004–2014

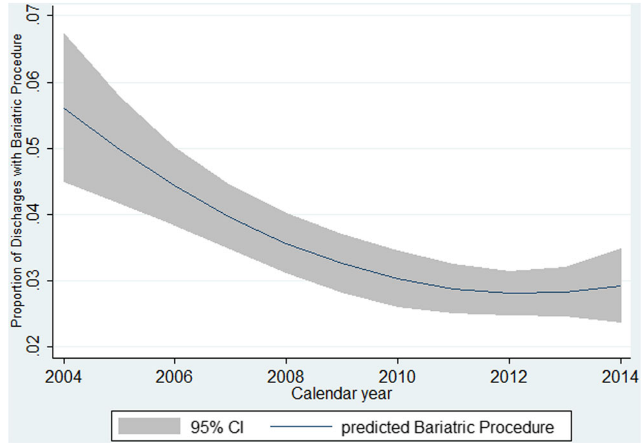

Fig. 2 Proportion of morbidly obese IBD patients with bariatric surgery, 2004–2014

Discussion

In our study, we utilized the Nationwide Inpatient Sample database to examine trends in bariatric surgery and report clinically relevant outcomes in a hospitalized population of 15,319 patients with morbid obesity and IBD. Although prior studies have reported conflicting outcomes, our results demonstrate that weight loss surgery does not affect mortality for morbidly obese IBD patients. While bariatric surgery does not affect mortality in this select patient population, prior-bariatric surgery is associated with a decreased risk of renal failure, under-nutrition, fistulae formation, and lower hospitalization cost. From these results, bariatric surgery appears to reduce morbidity in obese patients with IBD.

Mechanisms of Obesity, IBD, and Bariatric Surgery

Though the interaction between obesity and IBD is complex, it appears to be largely driven by the inflammatory cascade. Previous studies have demonstrated that obesity itself may play a role in the pathogenesis of IBD [5, 6]. This has been further supported by demonstration of over-expression of adipokines (e.g., leptin, resistin, adiponectin), cytokines (e.g., interleukin [IL]-6 and tumor necrosis factor [TNF]-alpha), and neuropeptides (e.g., substance P) in the mesentery of IBD patients [26, 27]. Adipokines are bioactive molecules synthesized by adipocytes and have been proposed to drive the inflammatory process of IBD [26–28].

In one study examining a pediatric population, 20% of children with CD and 33% of children with UC were found to be obese or overweight with these obese children having a more severe disease course as reflected by increased need for IBD-related surgery [4]. In regards to obese adults with IBD, studies have associated obesity with increased peri-anal disease and higher rates of IBD-related surgery [9, 18]. It has also been suggested that obesity in patients with IBD leads to maceration and secondary bacterial infections as a result of friction and sweating between skin folds [9]. Additionally, obese IBD patients have a larger pharmacological volume of distribution and may have a lower response to IBD chemotherapeutics, thus leading to more aggressive disease [18]. Therefore, management of obesity involving surgical weight loss modalities may be key to improving IBD-specific disease activity.

Table 2 Trends in bariatric surgery among patients with morbid obesity and inflammatory disease

Bariatric surgery procedures	Number of each procedure per year											
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total
Bariatric surgery	24	21	23	27	53	51	39	41	52	80	82	493
Roux-en-Y	22	13	14	11	24	23	14	11	14	17	13	176
Laparoscopic gastric banding	IS[a]	IS[a]	IS[a]	IS[a]	21	18	11	IS[a]	IS[a]	IS[a]	IS[a]	87
Sleeve gastrectomy	IS[a]	IS[a]	IS[a]	IS[a]	IS[a]	11	15	21	35	60	69	233
No bariatric surgery	436	492	501	705	901	1153	1419	2179	2132	2344	2564	14,826
Total no. of patients	460	513	524	732	954	1204	1458	2220	2184	2424	2646	15,319

IS information suppressed

[a] NOTE. According to the data user agreement, any individual table cell counts of 10 or fewer cannot be presented to preserve patient confidentiality. In such instances, data are suppressed

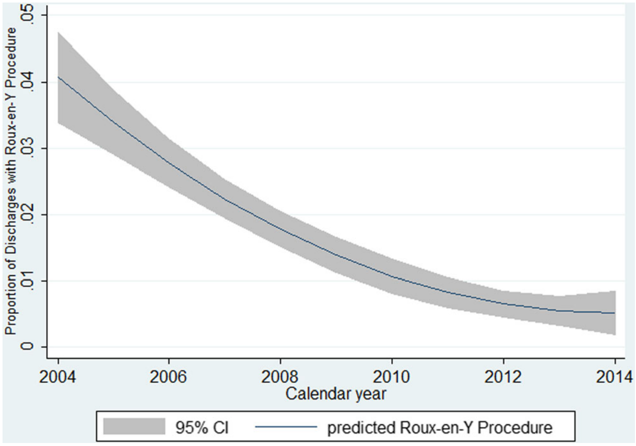

Fig. 3 Proportion of morbidly obese IBD patients with Roux-en-Y gastric bypass, 2004–2014

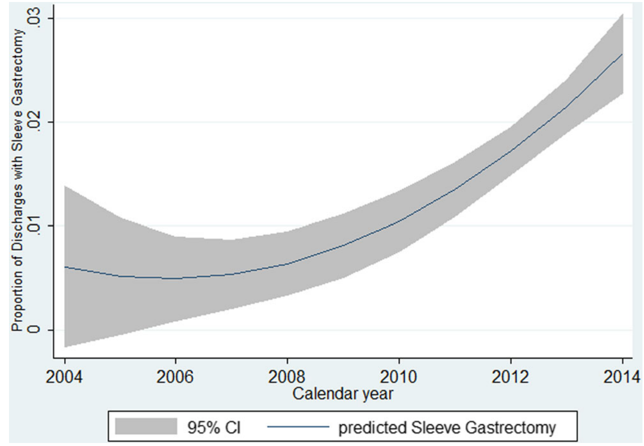

Fig. 5 Proportion of morbidly obese IBD patients with sleeve gastrectomy, 2004–2014

The proposed mechanism by which bariatric surgery may improve outcomes in IBD patients is likely explained by a common pro-inflammatory state of both obesity and IBD. Increased visceral mesenteric adipose tissue in patients with IBD is linked to increased inflammatory mediators that may play a role in pathogenesis of IBD and increased disease activity [28–30]. It is thus very likely that reduction in adipose tissue via weight loss may negate the pro-inflammatory state reducing the disease severity and IBD-associated complications. Another possible mechanism by which bariatric surgery may result in positive IBD-specific outcomes in obese patients involves reduction in the pharmacological volume of distribution as a result of lowering of the body mass index (BMI) [31]. This will in turn reduce the required dose of IBD medications and their potential for associated adverse effects.

Trends in Bariatric Surgery Among IBD Patients

Bariatric-specific trends as reported in our study highlight that morbid obesity has been rising over the past 10 years among

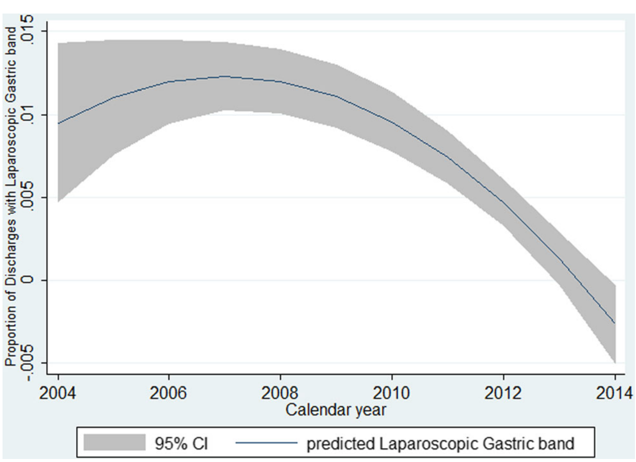

Fig. 4 Proportion of morbidly obese IBD patients with laparoscopic gastric band, 2004–2014

IBD patients. This study further demonstrates that rates of bariatric surgery among morbidly obese IBD patients remain low at 3.2%. Furthermore, the annual adjusted rate of these surgeries (e.g., Roux-en-Y gastric bypass and laparoscopic adjustable gastric band) has decreased in the past decade while rates of sleeve gastrectomy have risen during this same time period.

Obesity is a global epidemic, and its epidemiologic increase appears to parallel the increase in the incidence of IBD. Not surprisingly, there is a trend towards rising obesity in the IBD patient population [8]. This was also demonstrated in our study with a percent annual change of + 0.5% for obesity from 2004 to 2014 among hospitalized IBD patients. Whether obesity leads to IBD or IBD is a potential cause of obesity remains unclear. However, the interaction between the two as discussed above suggests both are chronic inflammatory states possibly sharing a common pathogenic mechanism. At present, the estimated prevalence of obesity among IBD patients, specifically CD, is 15 to 20%—with some estimates suggesting as high as 30% [4, 7, 13, 18, 21, 30]. With such a significant portion of the IBD disease population having concomitant obesity concerns, it makes sense to treat these patients with available weight loss therapies.

Obesity is generally associated with higher rates of surgical complexities and surgery-associated complications. These technical limitations and complications are further enhanced in obese patients with IBD. Obese patients with IBD who undergo surgery have previously been demonstrated to have longer operating times as well as high rates of morbidity in the post-operative course [32]. There are very few reports and limited data on these patients regarding outcomes of bariatric surgery. There are some reports of IBD flares and new diagnoses of IBD after undergoing bariatric surgery in obese IBD patients [33–36]. More recent studies contradict these findings and suggest that bariatric surgeries can safely be performed in IBD patients after a careful patient selection [19, 31, 37].

Table 3 Multivariable regression analysis for outcomes with prior bariatric surgery versus no bariatric surgery in patients with morbid obesity and inflammatory bowel disease

Outcome	Bariatric surgery (%)	No bariatric surgery (%)	*P* value	IRR[a] (95% CI)	*P* value
Overall					
Renal failure	0.6	12.4	< 0.001	0.1(0.02–0.3)	< 0.001
Malnutrition	0.4	3.2	< 0.001	0.2(0.05–0.8)	0.03
Thromboembolism	0.2	0.3	0.76	1.6(0.2–12.1)	0.44
Strictures	12.0	8.0	0.002	1.3 (0.9–1.8)	0.11
Fistulae	0.2	2.2	0.003	0.1(0.02–0.8)	0.03
Mortality	IS[b]	IS[b]	0.99	–	–
UC					
Renal failure	0.8	14.4	< 0.001	0.6 (0.01–0.4-2)	0.01
Malnutrition	0.4	3.7	0.006	0.20 (0.03–1.5)	0.11
Thromboembolic event	0.4	0.4	0.94	3.2 (0.4–26.7)	0.29
Strictures	9.8	4.4	< 0.001	2.3 (1.4–3.7)	0.001
Fistulae	0.4	1.0	0.38	0.6 (0.1–4.4)	0.62
Mortality	IS	IS	0.98	–	–
CD					
Renal failure	0.4	11.2	< 0.001	0.1(0.01–0.5)	0.006
Malnutrition	0.4	2.9	0.02	0.2 (0.03–1.4)	0.11
Thromboembolic event	IS[b]	IS[b]	0.99	–	–
Strictures	14.1	10.1	0.04	1.1 (0.7–1.6)	0.71
Fistulae	IS	IS	0.98	–	–
Mortality	IS	IS	0.98	–	–

CI confidence interval, *UC* ulcerative colitis, *CD* Crohn's disease, *IRR* incident risk ratios, *IS* information suppressed

[a] Incident risk ratios adjusted for age, sex, race, income, insurance status, type of admission, modified Elixhauser Comorbidity Index including diabetes, hypertension, hyperlipidemia, coronary artery disease, and obstructive sleep apnea

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With a surge in data on safety and efficacy of bariatric procedures, the total number of bariatric procedures increased in the USA overall in the past decade mirroring the rising trends of bariatric procedures performed worldwide over the same period [38, 39]. In spite of the total increase in number of procedures, the proportion of morbidly obese IBD patients with bariatric surgery has declined from 2004 to 2014. This observation may be in fact due to hesitance among surgeons to surgically treat these patients as a result of prior reports of higher short- and long-term post-surgical complications among IBD patients who underwent surgery.

Bariatric surgery provides the most significant improvement in weight loss and weight-related comorbidities compared to other available methods—achieving weight loss of approximately 66% with sleeve gastrectomy, 62% with Roux-en-Y gastric bypass, and 41% with laparoscopic adjustable gastric band [40–42]. In obese patients with IBD, sleeve gastrectomy and laparoscopic adjustable gastric band are preferred as they spare the small intestine in comparison to Roux-en-Y gastric bypass, which includes the lower part of the gut. Small bowel-sparing surgeries are recommended especially in IBD patients with small bowel disease as prior data suggests a potential risk of IBD (particularly small bowel CD) flares and higher risk of strictures, fistulae, and abscesses after gastric bypass surgeries [9].

In a systematic review by Shoar et al. that included six studies, the most commonly performed bariatric surgery for obese IBD patients was sleeve gastrectomy (55.8%), followed by Roux-en-Y gastric bypass (23.2%), and laparoscopic adjustable gastric band (11.6%). Our results were consistent with this prior report with the procedure rates of sleeve gastrectomy (47.2%), Roux-en-Y gastric bypass (35.6%), and laparoscopic adjustable gastric band (17.2%) [43]. In the past decade, rates of sleeve gastrectomy have increased while the other procedures declined at the same time likely related to increased experience of surgeons and availability of more data on safety and efficacy of this procedure.

Clinical Implications

For all patients with IBD, bariatric surgery had a significant role in reducing renal failure, under-nutrition, and fistulae without significantly affecting rates of strictures and thromboembolic events. This contradicts previous data that suggested IBD as well as weight reduction surgery may cause intestinal malabsorption leading to increased rates of nephrolithiasis, nephropathy, and under-nutrition [34, 35, 44]. Our results, however, support more recent data and novel evidence that demonstrates bariatric surgery may have a positive impact on renal function—diminishing rates of decline in renal function and increasing glomerular filtration rate in patients with hyperfiltration and renal impairment, respectively [45, 46]. The exact mechanism by which bariatric surgery may reduce these complications in our study population remains unclear and warrants further exploration in future studies.

We also examined the outcome of bariatric surgery individually for CD and UC patients. Prior bariatric surgery was shown to reduce renal failure in both groups, but under-nutrition and fistulae rates were not statistically significant. Complications of fistulae and strictures are common findings in patients with CD and are not traditionally associated with UC [47]. However, data comparing CD and UC in terms of complications after bariatric surgery, particularly strictures, are lacking. In this study, we found that the UC patients with prior-bariatric surgery were more likely to develop colonic strictures. This may suggest a need for a closer monitoring and follow-up among UC patients after bariatric surgery for early diagnosis and management of this complication.

We did not note a significant in-hospital mortality difference from bariatric surgery in this study population. It may, however, be possible that weight loss surgery has influence in long-term mortality in these patients and studies with longer duration of follow-up are needed to explore this. While no mortality benefit was observed, our data suggests that morbidly obese patients with IBD with prior-bariatric surgery have a shorter hospital stay and lower costs of hospitalizations. This further supports the need of educating the physicians and patients with promotion of bariatric procedures selectively in this group in order to reduce complications and overall health care expenditure.

Strengths and Limitations

The main limitations to our study are the retrospective and observational collection of data inherent to the database study design. Using National Inpatient Sample database, we are able to assess in-hospital outcomes but this data source lacks long-term outcomes upon discharge. Similarly, studies using a database like National Inpatient Sample are subject to potential bias due to coding errors. While discrepancies may occur, previous studies using the Nationwide Inpatient Sample database have reliably used ICD-9 codes for both IBD and bariatric surgery ensuring accuracy for both diagnoses used to identify this unique patient population [42, 48]. In addition, to determine complications of bariatric surgery, surrogate end points including renal failure, under-nutrition, thromboembolic events, strictures, fistulae, length of stay, and hospitalization costs were utilized. However, the lack of directly attributable surgical complications were not able to be obtained based upon the study design. Using this national database, we are unable to determine the temporal sequence in the occurrence of IBD and the bariatric surgery procedure. There is also a possibility of residual confounding as some important covariates (i.e., percent excess weight loss and BMI) were not available in the database.

Additional limitations of our study are related to heterogeneity between the surgical and non-surgical IBD cohorts in this study. Patients with no history of bariatric surgery were significantly older and more ethnically/racially diverse. The Nationwide Inpatient Sample database does not contain data regarding the severity of an individual patient's IBD at the time of admission [48]. Furthermore, it is possible that those individuals with IBD that did not undergo surgery were not surgical candidates based upon factors not readily able to be collected from our study design. Many individuals who qualify for bariatric surgery may choose not to pursue it, further limiting the generalizability of these results to a bariatric surgery population. These factors may affect outcomes and lead to poor quality of recovery and prolonged outcomes not captured by our findings. Based upon this study design, other limitations include an inability to determine long-term outcomes for patients post discharge. The heterogeneity of these two cohorts and inability to determine post-discharge outcomes may prevent this study's findings from being generalized to a more broad IBD population.

Our study has several strengths despite these limitations. To our knowledge, this study is the largest study evaluating these trends and outcomes over a period of 10 years. This study includes the largest number of patients from a national population-based sample including several racial/ethnic groups. This minimizes the possible biases that may be seen in single-center studies and also provides strong data to generalize our observations to clinical practice in the US. Furthermore, we have included a vast array of relevant outcomes (i.e., renal failure, strictures, fistulae, thromboembolic events, under-nutrition) that would reliably indicate a response to bariatric surgery above and beyond percent weight loss and change in BMI.

Conclusion

In conclusion, the role of bariatric surgery in a population of patients with IBD has become a topic of significant interest. Results from our population-based study suggest that bariatric surgery appears to be associated with decreased complications and health resource utilization among individuals with morbid obesity and IBD. These results highlight the potential clinical importance of weight loss in the therapeutic approach to morbidly obese IBD patients, early in the course of the condition. This also suggests that efforts should be made to improve the low uptake of bariatric surgery among IBD patients who fail to lose weight through lifestyle modifications and pharmacologic therapies, especially given the observed decline in the proportion of IBD patients undergoing bariatric surgery during the 2004 to 2014 period.

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Compliance with Ethical Standards

Conflicts of Interest The authors declare that they have no conflicts of interest.

Appendix 1

International Classification of Diseases, Ninth Edition, Clinical Modification (*ICD-9-CM*) Codes Used to Define Conditions

Myocardial Infarction: 410.0–410.9
Malnutrition: 263.9
Strictures: 560.9
Fistulae: 569.81
Acute renal failure: 584.5–584.9
Cerebrovascular accident or transient ischemic attack: 434.91, 435.9
Diabetes mellitus: 249.00–249.31, 249.40–249.91, 250.00–250.33, 250.40–250.93
Hypertension: 401.0, 401.1, 402.00, 402.01, 402.10, 405.0, 405.01, 405.09, 405.11, 405.19, 405.91, 405.99
Hyperlipidemia: 272.0–272.4
Obstructive sleep apnea: 327.23
Polycystic ovarian syndrome: 256.4

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