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ORIGINAL CONTRIBUTIONS

Early Postoperative Outcomes of Primary Bariatric Surgery in Patients on Chronic Steroid or Immunosuppressive Therapy

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Abstract
Background Previous research suggests that patients on chronic steroids may be at an increased risk of postoperative morbidity after major surgery. We aimed to evaluate the prognostic impact of chronic use of steroid or immunosuppression on 30-day morbidity and mortality rates after primary bariatric surgery.
Methods From American College of Surgeons-National Surgical Quality Improvement Program (ACS-NSQIP) database, we identified patients who underwent primary bariatric surgery between 2005 and 2013. Logistic regression was used to determine the prognostic impact of chronic use of steroid or immunosuppression on the 30-day postoperative outcomes.
Results One thousand two hundred seventy seven steroid/immunosuppressant-dependent (SD) and 112,892 non-dependent (ND) patients were analyzed. SD patients had a higher baseline risk profile compared to ND patients. Thirty-day mortality rates for SD and ND patients were 0.55 and 0.11 %, respectively ($P<0.001$) which corresponds to an adjusted odds ration (OR) of 6.85 (95 % confidence interval (CI) 1.95–24.12). SD patients had a higher 30-day major morbidity compared to ND patients (5.01 versus 2.54 %; $P<0.001$, respectively). After adjustment, this translated into an OR of 2.21 (95 % CI 1.29–3.79). Among SD patients, there was no significant difference in 30-day major morbidity after gastric bypass compared to sleeve gastrectomy (OR=0.36; 95 % CI 0.08–1.66).
Conclusions Chronic and active use of steroid or immunosuppressant medications is a strong predictor of 30-day postoperative morbidity and mortality following primary bariatric surgery. Among the steroid/immunosuppressant users, complication rates were similar for gastric bypass and sleeve gastrectomy patients. Further studies are needed to help guide the management or discontinuation of such medications in the perioperative period.

Keywords Bariatric surgery · Steroid · NSQIP · Morbidity · Mortality · Glucocorticoid · Immunosuppression · Gastric bypass · Sleeve gastrectomy

Introduction

Immunosuppressive medications inhibit activity of the immune system and include steroids, cytostatics, biologic modifiers, and other drugs used to suppress the body's immune response [1]. Notably, synthetic steroids are potent anti-inflammatory drugs widely used to attenuate the general immune response [2–4]. Steroids along with other immunosuppressive medications are used to treat chronic inflammatory conditions such as asthma, chronic obstructive pulmonary disease, sarcoidosis, and osteoarthritis in addition to autoimmune diseases like rheumatoid arthritis and systemic lupus erythematosus.

Despite their benefit, chronic immunosuppressant and steroid medications have been associated with severe complications including infections, cardiac and thromboembolic events, gastrointestinal bleeding, wound healing, and anastomotic leakage following a variety of surgical procedures [5–8]. A large multicenter study of 635,265 patients undergoing a variety of operations reported a two- to threefold higher postoperative infection rate and a fourfold increase in

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mortality rate among steroid users compared with nonusers [8]. Unfortunately for many patients, discontinuation of such medications is not feasible due to risk of disease relapse or exacerbation.

Given the rise in the incidence of severe obesity worldwide, there has been an increase in bariatric procedures due to its effectiveness in achieving weight loss and improvement of obesity-related comorbidities [9–11]. In addition, more patients on chronic immunosuppressants are being referred for and undergoing bariatric surgery, especially in the transplant-recipient or candidate population who are severely obese [12, 13]. However, the literature on the postoperative outcomes in patients on chronic steroid or other immunosuppressants following primary bariatric surgery is limited [14–16]. We thus aimed to compare the 30-day major morbidity and mortality among steroid/immunosuppressant-dependent (SD) and non-dependent (ND) patients following primary bariatric surgery.

Methods

Data Collection and Study Cohort

This retrospective cohort study was based on the data from the American College of Surgeons-National Surgical Quality Improvement Program (ACS-NSQIP) database. The ACS-NSQIP prospectively collects information on over 300 variables, including demographic variables, comorbidities, laboratory values, and 30-day postoperative mortality and morbidity outcomes for patients undergoing major surgical procedures in over 430 participating centers in North America by the end of 2013. The ACS-NSQIP utilizes several mechanisms to ensure that the data collected are of the highest consistency and reliability [17].

We identified patients ≥18 years old who had a body mass index (BMI) ≥35 kg/m^2 and underwent adjustable gastric banding (AGB), sleeve gastrectomy (SG), Roux-en-Y gastric bypass (RYGB), or biliopancreatic diversion-duodenal switch (BPD-DS) using their respective Current Procedural Terminology codes (AGB: 43770; SG: 43775; RYGB: 43644, 43645; BPD-DS: 43845). All operations were performed laparoscopically except for a small fraction of the BPD-DS procedures. We excluded patients who underwent a revisional bariatric procedure and procedures coded as emergent. Patients who had another surgery in the 30 days prior to the index bariatric surgery were also excluded. In order to further identify those patients that were at risk for a worse postoperative outcome, we excluded those with any evidence of preoperative sepsis, disseminated cancer, chronic dependence on dialysis, and American Society of Anesthesiology (ASA) class 5 (Moribund).

Covariates

The main exposure variable was chronic use of steroid or immunosuppressant medications. According to ACS-NSQIP variable definitions, we identified SD patients as those who were on a long course of steroid or immunosuppressant medications (defined by a duration >10 days) for a chronic medical condition (e.g., chronic obstructive pulmonary disease [COPD], asthma, rheumatologic disease, rheumatoid arthritis, inflammatory bowel disease), and within the 30 days prior to the principal operative procedure.

Independent demographic variables were age, sex, weight, BMI, race, and ethnicity. Examined comorbidities included diabetes (and insulin usage), hypertension, dyspnea, congestive heart failure (CHF), history of coronary artery disease ([CAD] binary variable representing angina, myocardial infarction, cardiac interventions, and cardiac surgeries), COPD, history of cerebrovascular diseases (binary variable representing transient ischemic attack and stroke), history of peripheral vascular disease (binary variable representing rest pain, gangrene, or need for revascularization or amputation), and bleeding disorder. Other baseline characteristics included were active smoking and functional status. Preoperative laboratory variables included serum hematocrit, albumin, bilirubin, and international normalized ratio. All variables are clearly defined in the ACS-NSQIP database user guide [17]. Operative variables considered were the ASA classification, type of bariatric surgery, and operation time.

End Points

The primary end points were 30-day postoperative mortality and major morbidity, which was defined as the presence of any of 14 major adverse events including organ/space surgical site infection, sepsis, septic shock, pneumonia, unplanned reintubation, failure to wean from mechanical ventilation beyond 48 hours from index operation, myocardial infarction, cardiac arrest, stroke, coma, venous thromboembolic event (VTE) including deep vein thrombosis (DVT) or pulmonary embolism (PE), need for transfusion, acute kidney injury, and wound disruption. We also considered any or infectious morbidities, VTE, postoperative bleeding requiring blood transfusion, 30-day return to operating room, unplanned 30-day readmissions, and length of stay (LOS) beyond 3 days as secondary outcomes.

Statistical Analysis

The estimates on the study parameters are expressed as mean ±standard deviation (SD) and number (%). Baseline, operative, and 30-day postoperative parameters between SD and ND patients were compared using the Pearson's chi-square

or Fisher's exact tests for the categorical variables and Student's *t* test or Wilcoxon rank-sum test for the continuous variables. Missing data is not tabulated since its consideration in the analyses did not change significance of the univariate analyses.

Prognostic impact of chronic dependence on steroid or other immunosuppressant medications was examined using multivariate logistic regression. In order to adequately control for confounding, we included all potential and empiric confounders of the relation between steroid/immunosuppressant use and 30-day postoperative outcome using a stepwise approach. The confounders were included in the regression model if they exerted a minimum of a 2 % change in either direction for the odds ratio (OR) of the main exposure variable [18]. A separate multivariate logistic regression was carried out within the subgroup of SD patients comparing the two most common bariatric procedures (SG and RYGB) in terms of 30-day postoperative outcomes. OR (and 95 % confidence intervals [CI]) was used as a measure of magnitude of association. Statistical analyses were carried out using the STATA software (Stata Corp, Texas, USA) version 12. Inference is based on a two-sided 5 % level.

Results

The study cohort consisted of 114,169 patients who underwent primary bariatric surgeries between 2005 and 2013. We identified 1277 (1.12 %) SD patients. The proportion of SD patients to all patients who had primary bariatric surgery increased from 1.44 % (N=15) in 2005 to 1.76 % (N=359) in 2013.

Compared to ND patients, the mean age of the SD patients was higher (44.76 versus 48.96 years old; P<0.001). Mean BMI was 47.02 kg/m^2 in SD patients and was significantly higher than a mean of 46.37 kg/m^2 in ND patients (P=0.003). Diabetes mellitus, hypertension, COPD, cardiac, cerebrovascular, and bleeding disorders were significantly more prevalent among SD patients (P<0.001). SD patients had significantly lower mean preoperative hematocrit and serum albumin levels compared to ND patients (P<0.001). The complete list of baseline characteristics of the study cohort is described in Table 1.

The frequencies of AGB placement were similar between the SD (21.14 %) and ND patients (22.87 %; P=0.144). The frequency of SG was higher in the SD (26.47 %) compared to ND patients (18.34 %; P<0.001) and the frequency of RYGB was higher in the ND (57.46 %) compared to SD patients (50.35 %; P<0.001). Higher proportion of SD patients underwent BPD-DS (2.04 %) compared to ND patients (1.33 %; P=0.028). Operation times for AGB, SG, and RYGB were significantly longer among SD patients (P≤0.013). Table 2 shows the operative characteristics of the study cohort.

Table 3 demonstrates the 30-day postoperative outcomes stratified on the chronic use of steroid/immunosuppressant medications. Thirty-day mortality rate for SD patients was significantly higher (0.55 %) compared to the ND patients (0.11 %; P<0.001). SD patients had a higher 30-day major composite morbidity compared to ND patients (5.01 versus 2.54 %; P<0.001). Similar frequencies for 30-day return to the operating room were found for SD patients (2.58 %) and ND patients (2.02 %; P=0.152). However, unplanned 30-day readmissions were higher among SD patients (8.58 %) as compared to ND patients (4.77 %; P<0.001). SD patients also had a longer mean length of stay compared to ND patients (2.41 versus 1.99 days; P<0.001).

Table 4 lists the adjusted OR for the chronic use of steroid/immunosuppressant medications corresponding to the primary and secondary end points. With respect to 30-day mortality, SD patients had an adjusted OR of 6.85 (95 % CI 1.95–24.12; c-statistic=0.89). Chronic steroid/immunosuppressant use was also an independent prognostic factor for 30-day major morbidity (OR=2.21; 95 % CI 1.29–3.79; c-statistic=0.68). Chronic use of steroid/immunosuppressant drugs was not found to be an independent predictor of 30-day postoperative bleeding requiring transfusion, return to the operating room, and unplanned readmission.

Table 5 shows the subgroup multivariate regression analysis comparing RYGB to SG in the SD patients only. Due to small number of events within the SD subgroup, no OR were reported for mortality and unplanned readmission. After adjustment, there was no significant difference in 30-day major morbidity after RYGB compared to SG (OR=0.36; 95 % CI 0.08–1.66). LOS beyond 3 days was found to be significantly higher in patients who underwent RYGB compared to SG (OR=5.43; 95 % CI 1.05–28.07).

Discussion

We found that the 30-day postoperative mortality rate among patients dependent on chronic use of steroid/immunosuppressant after primary bariatric surgery was near sevenfold higher than that for ND patients. The occurrences of any, any major, and any infectious morbidity in the 30-day postoperative period were also over twofold higher in the SD compared to the ND patients. Diabetes mellitus, hypertension, COPD, cardiac, cerebrovascular, and bleeding disorders were significantly more prevalent at baseline among SD patients. However, the substantial prognostic effect of the chronic steroid use was observed after accounting for several confounders including the comorbidities at baseline.

To our knowledge, this is the largest multi-center study to show a highly negative prognostic impact of the chronic use of steroid/immunosuppressant medications on the 30-day postoperative morbidity and mortality following primary bariatric

Table 1 Baseline characteristics of the study cohort

Patient characteristic	Study cohort *N*=114,169	SD *N*=1277	ND *N*=112,892	*P* value
Age (year)—mean±SD	44.81±11.62	48.96±10.83	44.76±11.62	*<0.001*
Sex (male)—*N* (%)	23,880 (20.92)	236 (18.48)	23,644 (20.94)	0.072
Weight (kg)—mean±SD	128.47±26.08	128.46±27.07	128.47±26.06	0.987
BMI (kg/m^2)—mean±SD	46.37±7.82	47.02±8.86	46.37±7.81	*0.003*
Race—*N* (%)				*<0.001*
White	83,971 (73.55)	898 (70.32)	83,073 (73.59)	
Black	17,211 (15.08)	243 (19.03)	16,968 (15.03)	
Ethnicity—*N* (%)				0.160
Non-Hispanic	98,620 (86.38)	1,123 (87.94)	97,497 (86.36)	
Hispanic	9041 (7.92)	96 (7.52)	8945 (7.92)	
Dependent functional status—*N* (%)	518 (0.45)	23 (1.80)	495 (0.44)	*<0.001*
Smoker—*N* (%)	12,732 (11.15)	139 (10.88)	12,593 (11.15)	0.760
DM—*N* (%)	31,121 (27.26)	447 (35.00)	30,674 (27.17)	*<0.001*
On insulin	10,723 (9.39)	216 (16.91)	10,507 (9.31)	*<0.001*
HTN—*N* (%)	59,768 (52.35)	850 (66.56)	58,918 (52.19)	*<0.001*
Dyspnea—*N* (%)				*<0.001*
On exertion	22,820 (19.99)	319 (24.98)	22,501 (19.93)	
At rest	401 (0.35)	15 (1.17)	386 (0.34)	
CHF—*N* (%)	164 (0.14)	10 (0.78)	154 (0.14)	*<0.001*
CAD[a]—*N* (%)	2424 (2.12)	39 (3.05)	2385 (2.11)	*<0.001*
TIA/CVA[b]—*N* (%)	1082 (0.95)	20 (1.57)	1062 (0.94)	*<0.001*
PVD[c]—*N* (%)	195 (0.17)	2 (0.16)	193 (0.17)	0.905
COPD—*N* (%)	1841 (1.61)	102 (7.99)	1739 (1.54)	*<0.001*
Bleeding disorder—*N* (%)	1592 (1.39)	47 (3.68)	1545 (1.37)	*<0.001*
Preoperative blood test				
Hematocrit (%)—mean±SD	40.22±3.64	39.78±3.92	40.23±3.64	*<0.001*
Albumin (g/dL)—mean±SD	4.10±0.42	4.03±0.41	4.10±0.42	*<0.001*
Total bilirubin (mg/dL)—mean±SD	0.52±0.57	0.50±0.44	0.52±0.57	0.242
INR—mean±SD	1.02±0.21	1.05±0.40	1.02±0.21	*<0.001*

The italicized numbers represent the statistically significant results

SD steroid/immunosuppressant dependent, *ND* steroid/immunosuppressant non-dependent, *BMI* body mass index, *DM* diabetes mellitus, *HTN* hypertension, *CHF* congestive heart failure, *CAD* coronary artery disease, *TIA* transient ischemic attack, *CVA* cerebrovascular accident, *PVD* peripheral vascular disease, *COPD* chronic obstructive pulmonary disease, *INR* international normalized ratio

[a] This is a binary variable representing the occurrence of any history of angina within 1 month before index surgery, history of myocardial infarction within 6 months before surgery, any previous percutaneous cardiac intervention, or any previous cardiac surgery

[b] This is a binary variable representing any history of transient ischemic attacks or any cerebrovascular accidents irrespective of the presence of any neurological deficit

[c] This is a binary variable representing any history of revascularization or amputation for peripheral vascular disease, or the presence of rest pain or gangrene

surgery. Our results are consistent with other large multicenter studies showing that chronic steroid use is associated with significant postoperative adverse events following a variety of surgical procedures mainly colorectal surgeries [4, 8, 19].

Our results following primary bariatric surgery are in contrast to a recent cohort study by Gribsholt et al. using the Danish nationwide medical database which evaluated the postoperative infection and bleeding rates in 325 current and 365 recent steroid users following RYGB from 2006 to 2012 [15]. Gribsholt et al. showed that current use of steroid is associated with a slightly increased but not significant risk of postoperative bleeding (2.8 versus 1.6 %) translating into an adjusted OR of 1.5 and virtually no difference in risk of infection (1.9 versus 1.7 %) [15]. This difference in rate of infectious complications with our results could partly be

Table 2 Operative characteristics of the study cohort

Variable	Study cohort *N*=114,169	SD *N*=1277	ND *N*=112,892	*P* value
ASA class[a]—*N* (%)				*<0.001*
2—Mild disturbance	37,146 (32.54)	209 (16.37)	36,937 (32.72)	
3—Severe disturbance	73,842 (64.68)	989 (77.45)	72,853 (64.53)	
4—Life-threatening	2544 (2.23)	78 (6.11)	2466 (2.18)	
Operation type[b]—*N* (%)				
AGB	26,087 (22.85)	270 (21.14)	25,817 (22.87)	0.144
SG	21,048 (18.44)	338 (26.47)	20,710 (18.34)	*<0.001*
RYGB	65,509 (57.38)	643 (50.35)	64,866 (57.46)	*<0.001*
BPD-DS	1525 (1.34)	26 (2.04)	1499 (1.33)	*0.028*
Operation time (min)—mean±SD				
AGB	69.58±32.37	75.62±40.41	69.51±32.27	*0.002*
SG	96.30±47.33	102.63±45.78	96.20±47.35	*0.013*
RYGB	135.33±56.22	144.57±64.04	135.23±56.13	*<0.001*
BPD-DS	182.40±93.58	188.73±115.29	182.29±93.20	0.728

The italicized numbers represent the statistically significant results

SD steroid/immunosuppressant dependent, *ND* steroid/immunosuppressant non-dependent, *ASA* American Society of Anesthesiology, *AGB* adjustable gastric banding, *SG* sleeve gastrectomy, *RYGB* Roux-en-Y bypass, *BPD-DS* biliopancreatic diversion-duodenal switch, *SD* standard deviation

[a] Patients categorized as ASA class 5 (Moribund) at the time of the index surgery have been excluded from the study cohort; ASA class 1 (No Disturbance) is not tabulated here

[b] All surgical procedures were primary operations performed laparoscopically; only some of BPD-DS operations (CPT code: 43845) may have been performed via laparotomy

explained by the small sample size of the SD patients in the Danish study with a study cohort unique to a single Scandinavian country. But the difference could also be in part due to different definitions used in various studies and the lack of information on baseline comorbidities that could necessitate chronic steroid/immunosuppressant therapy in the ACS-NSQIP database such as systemic lupus erythematosus, asthma, or inflammatory bowel disease. Adjusting for such chronic diseases could likely blunt the magnitude of the effect measures in our study.

We also found that chronic steroid/immunosuppressant use is not an independent predictor of postoperative bleeding requiring transfusion, return to operating room, or unplanned readmission. Yet we showed that chronic steroid use is an independent predictor of 30-day postoperative DVT, and despite the lack of statistical significance, there was high trend toward a higher occurrence of 30-day VTE in the SD patients. This finding is consistent with another large ACS-NSQIP study on risk factors of postoperative symptomatic thromboembolism after nine common general, vascular, and orthopedic surgeries that after adjustment showed a 1.5- to 2-fold increase in 30-day VTE and PE directly attributed to chronic corticosteroid use [20]. Furthermore, we found that chronic steroid use was also an independent predictor of prolonged LOS defined as >3 days for a primary bariatric surgery which, given the associated increase in 30-day postoperative morbidity is not surprising.

Our study was not designed to identify the mechanism by which steroids or other immunosuppressant medications lead to such adverse early postoperative outcomes. Nonetheless, corticosteroids are involved in the regulation of various physiological processes maintaining homeostasis [21]. At supraphysiologic levels with exogenous use, they may suppress immune activity, proliferation and protein synthesis, and alter metabolism [5, 22] which can subsequently interfere with postoperative healing processes and recovery. In addition, steroids may mask the early symptoms of postoperative complications leading to a delay in diagnosis and treatment.

Regardless of the mechanism, given the strong negative prognostic effect of chronic steroid/immunosuppressant use on the 30-day postoperative morbidity and mortality after primary bariatric surgery, and the elective nature of weight loss procedures, all efforts must be made to help make these procedures safer. One such effort could be the cessation of the steroid/immunosuppressive therapy when clinically possible prior to the bariatric surgery in a supervised setting and to resume it after a short convalescent time interval. Unfortunately, no clear consensus exists regarding the need and optimum time for withholding therapy before surgery; likewise, clinicians are often uncertain of the appropriate time to resume therapy after the procedure [5]. Perhaps if the stability and course of the chronic disease permits, a 30 to 90-day preoperative window would be a reasonable interval to withhold the steroid/immunosuppressive therapy in a supervised setting.

Table 3 Thirty-day postoperative outcomes stratified on the chronic use of steroid/immunosuppression

Variable	Study cohort *N*=114,169	SD *N*=1277	ND *N*=112,892	*P* value
Mortality—*N* (%)	128 (0.11)	7 (0.55)	121 (0.11)	*<0.001*
Morbidity—*N* (%)				
Any[a]	5013 (4.39)	98 (7.67)	4915 (4.35)	*<0.001*
Major[b]	2926 (2.56)	64 (5.01)	2862 (2.54)	*<0.001*
Infectious[c]	3508 (3.07)	70 (5.48)	3438 (3.05)	*<0.001*
Surgical site infection				
Superficial	1497 (1.31)	21 (1.64)	1476 (1.31)	0.292
Deep incisional	181 (0.16)	3 (0.23)	178 (0.16)	0.490
Organ/space	590 (0.52)	12 (0.94)	578 (0.51)	*0.034*
UTI	806 (0.71)	22 (1.72)	784 (0.69)	*<0.001*
Sepsis	548 (0.48)	16 (1.25)	532 (0.47)	*<0.001*
Septic shock	206 (0.17)	3 (0.23)	203 (0.18)	0.644
Wound disruption	100 (0.09)	6 (0.47)	94 (0.08)	*<0.001*
Pneumonia	457 (0.40)	8 (0.63)	449 (0.40)	0.198
Unplanned reintubation	361 (0.32)	8 (0.63)	353 (0.31)	*0.047*
Ventilatory support >48 h	285 (0.25)	6 (0.47)	279 (0.25)	0.113
Cardiac arrest	75 (0.07)	5 (0.39)	70 (0.06)	*<0.001*
Myocardial infarction	68 (0.06)	1 (0.08)	67 (0.06)	0.782
Bleeding[d]	911 (0.80)	16 (1.25)	895 (0.79)	0.066
CVA	24 (0.02)	1 (0.08)	23 (0.02)	0.156
Coma	4 (0.01)	0	4 (0.01)	0.832
AKI	249 (0.22)	6 (0.47)	243 (0.22)	0.052
VTE	427 (0.37)	10 (0.78)	417 (0.37)	*0.016*
DVT	280 (0.25)	7 (0.55)	273 (0.24)	*0.028*
PE	192 (0.17)	4 (0.31)	188 (0.17)	0.203
Return to OR—*N* (%)	2310 (2.02)	33 (2.58)	2277 (2.02)	0.152
Unplanned Readmission[e]—*N* (%)	2586 (4.83)	63 (8.58)	2523 (4.77)	*<0.001*
LOS (day)—mean±SD	2.00±2.35	2.41±2.34	1.99±2.35	*<0.001*

The italicized numbers represent the statistically significant results

SD steroid/immunosuppressant dependent, *ND* steroid/immunosuppressant non-dependent, *UTI* urinary tract infection, *CVA* cerebrovascular accident, *AKI* acute kidney injury, *VTE* venous thromboembolic event, *DVT* deep vein thrombosis, *PE* pulmonary embolism, *OR* operating room, *LOS* length of stay

[a] This is a composite binary variable representing the occurrence of any of the 30-day postoperative morbidities, including superficial and deep wound infection, organ/space surgical site infection, sepsis, septic shock, urinary tract infection, pneumonia, acute kidney injury, unplanned reintubation, failure to wean from mechanical ventilation beyond 48 h from index operation, myocardial infarction, cardiac arrest, stroke, coma, deep vein thrombosis, pulmonary embolism, need for transfusion, and wound disruption

[b] This is a composite binary variable representing the occurrence of any major postoperative morbidity, which excludes urinary tract, superficial and deep wound infections

[c] This is a composite binary variable representing the occurrence of any infectious postoperative morbidity, which includes superficial and deep wound infections, organ/space surgical site infection, sepsis, septic shock, urinary tract infection, and pneumonia

[d] This variable represents the need for any transfusion of packed red blood cells or whole blood given from the time the patient leaves the operating room up to and including 72 h postoperatively

[e] Information on the 30-day readmissions has been collected since 2011; virtually all readmissions were unplanned for both SD and SND patients (98 and 99 %), respectively

Support for the preoperative timing of drug cessation comes from a large population-level study by Ostenfeltd et al. which showed that, among 3966 SD patients from a total of 34,641 who underwent colorectal surgery for cancer, active SD patients had a 30 % higher 30-day mortality rate compared to non-users. Former users who did not take steroids in the 90-day period prior to the index operation did not have an increased mortality compared to the non-users [4]. Moreover,

Table 4 Adjusted odds ratios of preoperative chronic use of steroid/immunosuppressant on 30-day postoperative outcomes

30-day postoperative outcome	SD OR (95 % CI)
Mortality	*6.85 (1.95–24.12)*
Morbidity	
Any	*2.15 (1.42–3.27)*
Major	*2.21 (1.29–3.79)*
Infectious	*2.20 (1.36–3.57)*
VTE[a]	2.56 (0.77–8.55)
DVT	*3.71 (1.11–12.41)*
Bleeding	2.17 (0.67–7.07)
Return to OR	1.74 (0.88–3.46)
Unplanned readmission	1.83 (0.76–4.44)
LOS >3 days	*1.60 (1.19–2.15)*

Logistic regression models were based on empirical confounders that exerted a minimum of a 2 % change in the estimates of the main exposure variable toward the 30-day postoperative outcomes. The italicized numbers represent the statistically significant results

SD steroid/immunosuppressant dependent, *OR* odds ratio, *CI* confidence interval, *VTE* venous thromboembolic event, *DVT* deep vein thrombosis, *OR* operating room, *LOS* length of stay

[a] This is a composite binary variable representing the occurrence of any deep vein thrombosis or pulmonary embolism

the study by Gribsholt et al. also showed no increased risk of 30-day postoperative infection or bleeding in the recent steroid users who did not receive any steroids in the 60-day period leading up to the RYGB [15].

Even though the literature investigating the impact of chronic steroid/immunosuppressant use on postoperative outcomes after bariatric surgery is lacking, most surgeons assume SD patients to be higher-risk candidates. In addition to consulting with the respective specialists to withhold such medications preoperatively, surgeons may be more inclined to offer such patients a SG as a potentially less morbid operation. Since SG and RYGB are currently the two most commonly performed primary bariatric surgeries in North America, we carried out a subgroup multivariate analysis in the SD patients only to compare the 30-day postoperative adverse outcomes between these two procedures. We found that, after accounting for various baseline and operative confounders, RYGB did not pose a higher risk than SG in terms of 30-day postoperative morbidity. This is an important finding since the ultimate goal of bariatric surgery is to achieve weight loss along with improvement of metabolic and obesity-related comorbidities [9, 11, 23, 24] and RGYB may be more suitable than SG in some SD patients.

Table 5 Multivariate analysis comparing SG and RYGB in the SD patients

30-day postoperative outcome	RYGB[a] OR (95 % CI)
Morbidity	
Any	0.58 (0.16–2.07)
Major	0.36 (0.08–1.66)
Infectious	0.96 (0.18–5.07)
Return to OR	1.43 (0.15–13.76)
LOS >3 days	5.43 (1.05–28.07)

Logistic regression was used to evaluate the impact of procedure type on 30-day postoperative outcomes. Due to small number of events within the SD subgroup, no odds ratios were reported for mortality and unplanned readmission

SD steroid/immunosuppressant dependent, *RYGB* Roux-en-Y gastric bypass, *OR* odds ratio, *CI* confidence interval, *OR* operating room, *LOS* length of stay

[a] The reference procedure category used is the SG. Only SG and RYGB were evaluated since they are currently the two most common bariatric procedures

In addition, understanding the prevalence and pattern of early postoperative adverse events in this population will help surgeons to have a heightened awareness for early signs of complications in these patients and address them in a timely fashion when they occur. Once the patient is beyond the early postoperative phase, the bariatric and metabolic benefits of the surgery may result in improvements in the underlying indication for immunosuppressant medication and may even allow decrease in steroid/immunosuppressant use [13, 14]. A recent study on bariatric surgery outcomes in patients with systemic lupus erythematosus with a mean follow-up time of 3 years reported that, despite a higher prevalence of early postoperative complications among those patients on immunosuppressive therapy, 42 % had a reduction in their medication dose and over 19 % were completely off their immunosuppressants by the end of the follow-up period [25].

Certain limitations need to be taken into consideration when interpreting our results. First, these analyses are limited by the retrospective study design. Another limitation is that we were unable to differentiate between steroid and other classes of immunosuppressants. Furthermore, the worsened outcomes in the SD group may be a consequence of the underlying disease requiring the chronic steroid/immunosuppressant use. However, the chronic use of steroid/immunosuppressant could be a proxy for such unknown baseline comorbidities.

There are also inherent limitations when the ACS-NSQIP database is used that can introduce both selection and misclassification bias. ACS-NSQIP captures only a sample of all procedures from each participating center and does not collect data unique to bariatric surgery patients (preoperative comorbidities such as obstructive sleep apnea, pulmonary hypertension, and history of venous thromboembolism) or unique bariatric postoperative complications such as anastomotic leaks. Furthermore, not all baseline comorbidities that could necessitate steroid/immunosuppressant therapy are captured in the ACS-

NSQIP database such as systemic lupus erythematosus, rheumatoid arthritis, or asthma. In addition, the database only includes immediate postoperative outcomes up to day 30, which can lead to under-estimation of real risk of early adverse outcomes and has been suggested to be set at 90 days for other general surgical procedures [26]. In addition, long-term postoperative adverse events such as decrease in bone density and osteoporosis in patients with chronic steroid use after bariatric surgery may be missed [27].

Conclusions

In conclusion, we demonstrated that chronic and active use of steroid or immunosuppressant medications is a strong predictor of 30-day postoperative morbidity and mortality following primary bariatric surgery. Among the steroid/immunosuppressant users, RYGB and SG had a similar risk profile. Further studies are needed to help guide the management of such medications in the perioperative period.

Compliance with Ethical Standard

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

Disclaimer Since this study was performed using de-identified nationwide data, informed consent was not obtained for the purposes of this research. The American College of Surgeons National Surgical Quality Improvement Program 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.

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