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ORIGINAL CONTRIBUTIONS

# Effects of Chronic Corticosteroid and Immunosuppressant Use in Patients Undergoing Bariatric Surgery

Joshua Hefler[1,2] · Jerry Dang[1] · Aryan Modasi[1] · Noah Switzer[3] · Daniel W. Birch[1] · Shahzeer Karmali[1]

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## Abstract

**Background** Chronic immunosuppression can put surgical patients at additional risk for complications, particularly infection. This is not a contraindication for patients undergoing bariatric surgery. However, with the increasing prevalence of bariatric surgery, it is important to characterize the additional risks for immunosuppressed patients.

**Methods** The Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program (MBSAQIP) data registry was used to identify immunosuppressed patients who had undergone bariatric surgery. Patients undergoing primary bariatric surgery (laparoscopic Roux-en-Y gastric bypass or laparoscopic sleeve gastrectomy) at an accredited institution between 2015 and 2017 were included. A multivariable regression analysis was performed, controlling for age, sex, procedure, and several other comorbidities. Overall 30-day incidence of major complications was the primary outcome. A secondary analysis compared outcomes amongst immunosuppressed patients by procedure type using a propensity-matched analysis. Propensity matching was performed based on preoperative comorbidities and bariatric procedure.

**Results** A total of 430,936 patients were included in the study. Of these, 7214 (1.7%) were chronically immunosuppressed. Our multivariable regression analysis found statistically higher odds of 30-day major complications (OR 1.39, 95% CI 1.25–1.55; $p < 0.001$), bleed (OR 1.49, 95% CI 1.24–1.80; $p < 0.001$) and anastomotic leak (OR 1.38, 95% CI 1.02–1.87; $p = 0.037$) amongst immunosuppressed patients. However, there was no difference between 30-day mortality (OR 1.15, 95% CI 0.64–2.07; $p = 0.644$). Our secondary analysis found higher rates of 30-day major complications for immunosuppressed patients undergoing gastric bypass (9.6% vs. 5.0%; $p < 0.001$).

**Conclusion** Immunosuppressed patients are at higher risk of major complications when undergoing bariatric surgery, especially gastric bypass.

**Keywords** Immunosuppression · Steroids · 30-day complications · Roux-en-Y gastric bypass · Sleeve gastrectomy

## Introduction

Bariatric surgery has been shown to be an effective treatment of obesity and its associated medical comorbidities [1, 2]. The number of bariatric surgeries being performed worldwide is increasing from year to year [3]. The majority are done laparoscopically, minimizing post-operative pain and length of hospital stay. Particularly in high-volume centers, the complication profile is favorable, with low rates of mortality and major complications. As surgeons become more experienced

✉ Joshua Hefler
hefler@ualberta.ca

Jerry Dang
dang2@ualberta.ca

Aryan Modasi
modasi@ualberta.ca

Noah Switzer
nswitzer@ualberta.ca

Daniel W. Birch
dbirch@ualberta.ca

Shahzeer Karmali
shahzeer@ualberta.ca

[1] Department of Surgery, Faculty of Medicine & Dentistry, University of Alberta, Edmonton, Alberta, Canada

[2] Mackenzie Health Sciences Centre, c/ o Dvorkin Lounge Mailroom, 2G2 Walter C, 8440 - 112 ST NW, Edmonton, AB T6G 2B7, Canada

[3] Wexner Medical Center, The Ohio State University, Columbus, Ohio, USA

with these procedures, bariatric surgery is increasingly being offered to patients who would not have been considered previously, such as those with significant medical comorbidities or at the extremes of age.

The increased risks of surgery in patients requiring long-term immunosuppressant therapy are well known and make many surgeons appropriately wary [4–6]. Traditional immunosuppressants, such as steroids, methotrexate, azathioprine, and cyclosporine, increase risks of infection and interfere with healing, which in abdominal surgery translates to higher rates anastomotic leaks. Glucocorticoids, in particular, have long been used to treat a variety of autoimmune and inflammatory diseases, both acutely and over the long term. They have the additional effect of adrenal suppression with prolonged use, which necessitates continued use and may require stress dosing at the time of surgery [7]. Newer monoclonal antibodies (i.e., biologics) are increasingly being used to treat inflammatory conditions, as well as playing a role in therapies for specific malignancies. While they do not cause the same global immunosuppression as traditional therapies, their targeted effects can put surgical patients at increased risk of infection, to varying degrees [8].

Our study uses data collected by the Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program (MBSAQIP) to compare 30-day outcomes for immunosuppressant therapy-dependent patients undergoing bariatric surgery. Our primary outcomes are major complications. Secondary outcomes include mortality, post-operative leak, and post-operative bleed.

## Methods

### Data Source and Study Population

The MBSAQIP is a national accreditation program for centers performing bariatric surgery that is maintained by the American College of Surgeons (ACS) and the American Society for Metabolic & Bariatric Surgery (ASMBS) [9]. Outcome data is collected from 810 accredited centers within the USA and Canada and stored in a central database that is available to members of the associated institutions. The data set includes information on patient demographics, comorbidities, intraoperative details, and 30-day post-operative events. This study included data from 2015 to 2017, inclusive. Patients included in the MBSAQIP database had met eligibility criteria for elective bariatric surgery, which was performed at an accredited center in the USA or Canada. This study only included patients undergoing laparoscopic Roux-en-Y gastric bypass (LRYGB) or laparoscopic sleeve gastrectomy (LSG) as these are the two most common bariatric procedures performed. Patients undergoing revisional or emergency surgery were also excluded [10].

### Baseline Characteristics

Baseline characteristics included patient demographics (age, sex, race), body mass index (BMI), functional status, smoking status, American Society of Anesthesiologists (ASA) Physical Status Classification, medical comorbidities (diabetes mellitus (DM), cardiac disease, chronic obstructive pulmonary disease (COPD), renal impairment, history of venous thromboembolism (VTE)) and procedure type (LRYGB or LSG). Note that the MBSAQIP does not distinguish between patients on chronic steroids and those on other immunosuppressants.

### Outcomes

The primary outcome was major complication within the first 30 days post-operatively. This included any cardiac complications, pneumonia, acute renal failure, VTE, cerebral vascular accident (CVA), sepsis, unplanned intubation, coma for > 24 h, deep surgical site infection (SSI), wound disruption, any post-operative bleed or leak, and the need for reoperation or reintervention within 30 days. Secondary outcomes included mortality, anastomotic leak, and bleed within 30 days.

### Statistical Analysis

Stata 15.1 software, licensed from StataCorp LLC (College Station, TX, USA), was used for statistical analysis. The primary analysis used a multivariable logistic regression analysis to determine the odds ratio of major complications between immunosuppressed and non-immunosuppressed patients. Variables controlled for included age, sex, race, BMI, smoking status, functional status, ASA category, medical comorbidities (gastroesophageal reflux disease (GERD), hypertension, hyperlipidemia, DM, COPD, obstructive sleep apnea (OSA), oxygen dependency, chronic kidney disease (CKD), dialysis, venous stasis, history of myocardial infarction (MI), previous percutaneous coronary intervention (PCI), history of VTE, preoperative therapeutic anticoagulation), and procedure performed. A purposeful selection algorithm was used. Variables with a $p < 0.10$ on univariate screen were included in the multivariable model. The threshold for significance was set at $p < 0.05$. The Brier score was then used to assess calibration and discrimination of the model. A purposeful selection multivariable regression analysis was also done for secondary outcomes—mortality, leak, and post-operative bleed.

A secondary analysis was done including only immunosuppressed patients, which compared those undergoing LRYGB with LSG using a propensity matched algorithm [11]. Propensity scores were calculated using the same variables included in the above analysis. Immunosuppressed patients were matched 1-to-1 with patients who do not take immunosuppressants, using their propensity scores within a specified caliper distance of 0.2 standard deviations. This

resulted in two groups with similar baseline characteristics, eliminating approximately 99% of variation due to potential confounders [12]. Univariate analysis (Pearson's $\chi^2$ test or Student's $t$ test as appropriate) was then applied to compare differences in outcomes between the two groups.

## Results

Of 430,936 patients undergoing bariatric surgery at an MBSAQIP accredited site between 2015 and 2017, only 1.7% (7214) were immunosuppressed. Table 1 shows the baseline characteristics for immunosuppressed and non-immunosuppressed patients. With the exception of smoking ($p = 0.452$), the prevalence of all recorded comorbidities was significantly higher in the immunosuppressed group. Immunosuppressed patients were also older (48.5 ± 11.5 vs. 44.5 ± 12.0 years old, $p < 0.001$). A smaller proportion of immunosuppressed patients underwent LRYGB compared with non-immunosuppressed patients (24.0% vs. 27.2%, $p < 0.001$).

Table 2 shows the unadjusted outcomes for immunosuppressed and non-immunosuppressed patients. Several complications were significantly higher in the immunosuppressed group, including the rate of major complications within 30 days (5.6% vs. 3.5%; $p < 0.001$). The rates of several infectious complications, including pneumonia (0.4% vs. 0.2%; $p = 0.001$) and superficial (0.8% vs. 0.4%; $p < 0.001$) and deep SSI (0.4% vs. 0.3%; $p = 0.003$), were significantly higher in the immunosuppressed group. However, rates of sepsis were equal between groups (0.1% vs. 0.1%; $p = 0.965$). The 30-day mortality for immunosuppressed patients was also significantly higher (0.2% vs. 0.1%; $p = 0.035$).

Multivariable regression analysis controlled for all of the potential confounders is listed in Table 1. The odds of 30-day major complications were significantly higher amongst immunosuppressed patients, with an odds ratio of 1.39 (95% CI 1.25–1.55; $p < 0.001$). The odds of post-operative bleed and anastomotic leak were also higher in the immunosuppressed group, with odds ratios of 1.49 (95% CI 1.24–1.80; $p < 0.001$) and 1.38 (95% CI 1.02–1.87; $p = 0.037$), respectively. The odds of death, however, were not significantly increased, with an odds ratio for 30-day mortality of 1.15 (95% CI 0.64–2.07; $p = 0.644$) after adjusting for confounders.

Secondary analysis looked at immunosuppressed patients stratified by procedure type. Table 3 shows the baseline characteristics of these patients, before and after propensity-score matching. The matched groups showed no statistical difference between the majority of their baseline characteristics. Comparing outcomes for the matched groups (Table 4), the rate of major complications was higher for patients undergoing LRYGB (9.6% vs. 5.0%; $p < 0.001$). Within major complications, rates of 30-day reoperation, reintervention, readmission, acute kidney injury, and deep SSI were significantly

**Table 1** Baseline characteristics of immunosuppressed and non-immunosuppressed patients undergoing bariatric surgery

| Patient characteristic | Non-immunosuppressed 423,722 (98.3%) | Immunosuppressed 7214 (1.7%) | $p$ value |
|---|---|---|---|
| Age | | | |
| mean ± SD | 44.5 ± 12.0 | 48.5 ± 11.2 | < 0.001 |
| < 18 | 685 (0.2) | 13 (0.2) | < 0.001 |
| 18–30 | 49,742 (11.7) | 378 (5.2) | |
| 30–40 | 108,603 (25.6) | 1246 (17.3) | |
| 40–50 | 122,533 (28.9) | 2203 (30.5) | |
| 50–60 | 93,684 (22.1) | 2196 (30.4) | |
| ≥ 60 | 48,475 (11.4) | 1178 (16.3) | |
| Female | 336,099 (79.3) | 5922 (82.1) | < 0.001 |
| Race | | | |
| White | 309,870 (73.1) | 5293 (73.4) | < 0.001 |
| Black | 74,382 (17.5) | 1352 (18.7) | |
| Other | 39,470 (9.3) | 569 (7.9) | |
| BMI | | | |
| mean ± SD | 45.4 ± 7.9 | 45.2 ± 7.9 | 0.041 |
| 30–35 | 14,035 (3.3) | 259 (3.6) | 0.001 |
| 35–40 | 93,937 (22.3) | 1748 (24.3) | |
| 40–45 | 129,685 (30.8) | 2100 (29.2) | |
| 45–50 | 86,860 (20.6) | 1441 (20.1) | |
| 50–60 | 74,663 (17.7) | 1265 (17.6) | |
| >60 | 21,612 (5.1) | 369 (5.1) | |
| Functional status | | | |
| Independent | 419,436 (99.0) | 7035 (97.5) | < 0.001 |
| Partially dependent | 2604 (0.6) | 142 (2.0) | |
| Fully dependent | 1682 (0.4) | 37 (0.5) | |
| ASA classification | | | |
| I-II | 97,448 (23.1) | 968 (13.5) | < 0.001 |
| III | 309,374 (73.4) | 5802 (80.6) | |
| IV-V | 14,914 (3.5) | 429 (6.0) | |
| Current smoker | 36,354 (8.6) | 637 (8.8) | 0.452 |
| Diabetes | | | |
| No | 312,136 (73.7) | 4969 (68.9) | < 0.001 |
| Non-insulin | 75,380 (17.8) | 1295 (18.0) | |
| Insulin dependent | 36,206 (8.5) | 950 (13.2) | |
| COPD | 6698 (1.6) | 587 (8.1) | < 0.001 |
| $O_2$ dependency | 2781 (0.7) | 253 (3.5) | < 0.001 |
| Anticoagulant use | 10,525 (2.5) | 488 (6.8) | < 0.001 |
| CKD | 2544 (0.6) | 219 (3.0) | < 0.001 |
| Dialysis dependent | 1212 (0.3) | 77 (1.1) | < 0.001 |
| GERD | 129,498 (30.6) | 3182 (44.1) | < 0.001 |
| Hyperlipidemia | 101,032 (23.8) | 2367 (32.8) | < 0.001 |
| Hypertension | 204,052 (48.2) | 4450 (61.7) | < 0.001 |
| OSA | 160,499 (37.9) | 3417 (47.4) | < 0.001 |
| Previous MI | 5355 (1.3) | 166 (2.3) | < 0.001 |
| Previous PCI | 8399 (2.0) | 285 (4.0) | < 0.001 |
| Previous VTE | 9411 (2.2) | 387 (5.4) | < 0.001 |
| Venous stasis | 4187 (1.0) | 134 (1.9) | < 0.001 |
| Procedure type | | | |
| LRYGB | 115,426 (27.2) | 1733 (24.0) | < 0.001 |
| LSG | 308,296 (72.8) | 5481 (76.0) | |

*BMI*, body mass index; *ASA*, American Society of Anesthesiologists; *COPD*, chronic obstructive pulmonary disease; *CKD*, chronic kidney disease; *GERD*, gastroesophageal reflux disease; *OSA*, obstructive sleep apnea; *MI*, myocardial infarction; *PCI*, percutaneous coronary intervention; *VTE*, venous thromboembolism; *LRYGB*, laparoscopic Roux-en-Y gastric bypass; *LSG*, laparoscopic sleeve gastrectomy

**Table 2** Perioperative outcomes for immunosuppressed patients undergoing bariatric surgery

| Outcome | Non-immunosuppressed 423,722 (98.3%) | Immunosuppressed 7214 (1.7%) | *p* value |
|---|---|---|---|
| Mortality | 384 (0.1) | 12 (0.2) | 0.035 |
| Major complication | 14,663 (3.5) | 405 (5.6) | < 0.001 |
| Leak | 1743 (0.4) | 44 (0.6) | 0.009 |
| Bleed | 3826 (0.9) | 120 (1.7) | < 0.001 |
| Reoperation | 5069 (1.2) | 129 (1.8) | < 0.001 |
| Reintervention | 5479 (1.3) | 145 (2.0) | < 0.001 |
| Readmission | 16,046 (3.8) | 409 (5.7) | < 0.001 |
| Cardiac event | 277 (0.1) | 8 (0.1) | 0.136 |
| Pneumonia | 815 (0.2) | 27 (0.4) | 0.001 |
| AKI | 541 (0.1) | 37 (0.5) | < 0.001 |
| VTE | 1103 (0.3) | 27 (0.4) | 0.061 |
| Deep SSI | 1071 (0.3) | 31 (0.4) | 0.003 |
| Wound disruption | 198 (0.1) | 7 (0.1) | 0.052 |
| Sepsis | 418 (0.1) | 7 (0.1) | 0.965 |
| Unplanned intubation | 579 (0.1) | 28 (0.4) | < 0.001 |
| Coma > 24 h | 10 (0.0) | 1 (0.0) | 0.055 |
| CVA | 45 (0.0) | 4 (0.1) | < 0.001 |
| Superficial SSI | 1737 (0.4) | 54 (0.8) | < 0.001 |
| Length of stay (days) | 85.3 ± 46.7 | 85.7 ± 48.0 | 0.476 |
| Operative time (minutes) | 1.7 ± 1.5 | 2.0 ± 2.0 | < 0.001 |

*AKI*, acute kidney injury; *VTE*, venous thromboembolism; *SSI*, surgical site infection; *CVA*, cerebrovascular accident

higher in the LRYGB group. Concordantly, length of stay was significantly higher in this group (2.4 days vs 1.90 days; $p < 0.001$). Operative time was also higher for the LRYGB group (121.7 min vs 76.0 min; $p < 0.001$).

## Discussion

Crude data showed higher rates of certain complications for immunosuppressed patients undergoing bariatric surgery including pneumonia, superficial SSI, and deep SSI. Our adjusted analysis similarly found a higher incidence of major complications in the first 30 days post-operatively, including bleeding and anastomotic leaks. However, 30-day mortality was similar after adjusting for confounders. We also found higher complications in immunosuppressed patients undergoing LRYGB.

The higher rate of complications in immunosuppressed individuals can be explained by the effects of immunosuppressants in decreasing the immune response, impairing healing, and predisposing to infection. This is of particular concern for patients undergoing abdominal surgery where bowel anastomoses are required. This has been well described in other patient populations, particularly for traditional immunosuppressants, such as glucocorticoids. A meta-analysis by Subramanian and colleagues included seven studies that compared complications between steroid-dependent and non-steroid-dependent patients with inflammatory bowel disease undergoing surgery [13]. Their pooled analysis found the odds of total complications were 41% higher and infectious complications 68% higher in the steroid-dependent group. Similarly, in a retrospective analysis of the National Surgical Quality Improvement Program (NSQIP) database, Sims et al. reported higher rates of 30-day mortality (5.7% vs. 3.4%) and morbidity (35.4% vs. 29.0%) for immunosuppressed patients undergoing surgery for colorectal cancer [14].

The only case were surgical patients may benefit from being on steroids is in patients with COPD. Lee and colleagues reported decreased post-operative pulmonary complications for COPD patients on steroids undergoing elective abdominal surgery, with an adjusted OR of 0.036 [15]. Non-pulmonary complications did remain higher in the steroid group, though they did not conduct a multivariable analysis for this outcome. It is not known how this applies to bariatric surgery. The number of immunosuppressed patients in the MSBAQIP database would be too small to stratify by COPD and it could not be determined if immunosuppression was in the form of steroids for COPD or whether was for some other condition.

Literature addressing surgical complications in patients requiring immunosuppressant agents, other than steroids, is less

**Table 3** Baseline characteristics of immunosuppressed patients, stratified by procedure type, shown before and after propensity-score matching

| Patient characteristic | Unmatched cohort | | *p* value | Matched cohort | | *p* value |
|---|---|---|---|---|---|---|
| | LSG 5481 (76.0%) | LRYGB 1733 (24.0%) | | LSG 1725 (50.0%) | LRYGB 1725 (50.0%) | |
| Age | | | | | | |
| mean ± SD | 48.2 ± 11.3 | 49.3 ± 10.9 | 0.001 | 49.7 ± 11.1 | 49.3 ± 10.9 | 0.296 |
| < 18 | 12 (0.2) | 1 (0.1) | 0.006 | 4 (0.2) | 1 (0.1) | 0.539 |
| 18–30 | 301 (5.5) | 77 (4.4) | | 63 (3.7) | 75 (4.4) | |
| 30–40 | 977 (17.8) | 269 (15.5) | | 275 (15.9) | 269 (15.6) | |
| 40–50 | 1692 (30.9) | 511 (29.5) | | 495 (28.7) | 509 (29.5) | |
| 50–60 | 1622 (29.6) | 574 (33.1) | | 565 (32.8) | 572 (33.2) | |
| ≥ 60 | 877 (16.0) | 301 (17.4) | | 323 (18.7) | 299 (17.3) | |
| Female | 4492 (82.0) | 1430 (82.5) | 0.596 | 1438 (83.4) | 1424 (82.6) | 0.526 |
| Race | | | | | | |
| White | 4010 (73.2) | 1283 (74.0) | 0.256 | 1251 (72.5) | 1276 (74.0) | 0.089 |
| Black | 1048 (19.1) | 304 (17.5) | | 348 (20.2) | 303 (17.6) | |
| Other | 423 (7.7) | 146 (8.4) | | 126 (7.3) | 146 (8.5) | |
| BMI | | | | | | |
| mean ± SD | 44.9 ± 7.7 | 46.3 ± 8.4 | < 0.001 | 46.1 ± 8.6 | 46.3 ± 8.4 | 0.562 |
| 35–40 | 1399 (25.7) | 349 (20.2) | < 0.001 | 377 (21.9) | 349 (20.2) | 0.225 |
| 40–45 | 1652 (30.3) | 448 (25.9) | | 483 (28.0) | 448 (26.0) | |
| 45–50 | 1030 (18.9) | 411 (23.8) | | 355 (20.6) | 410 (23.8) | |
| 50–60 | 919 (16.9) | 346 (20.0) | | 329 (19.1) | 345 (20.0) | |
| > 60 | 252 (4.6) | 117 (6.8) | | 124 (7.2) | 117 (6.8) | |
| Functional status | | | | | | |
| Independent | 5354 (97.7) | 1681 (97.0) | 0.266 | 1663 (96.4) | 1673 (97.0) | 0.519 |
| Partially dependent | 100 (1.8) | 42 (2.4) | | 47 (2.7) | 42 (2.4) | |
| Fully dependent | 27 (0.5) | 10 (0.6) | | 15 (0.9) | 10 (0.6) | |
| ASA classification | | | | | | |
| I-II | 810 (14.8) | 158 (9.1) | < 0.001 | 159 (9.2) | 158 (9.2) | 0.946 |
| III | 4358 (79.7) | 1444 (83.4) | | 1433 (83.1) | 1439 (83.4) | |
| IV-V | 300 (5.5) | 129 (7.5) | | 133 (7.7) | 128 (7.4) | |
| Current smoker | 491 (9.0) | 146 (8.4) | 0.495 | 126 (7.3) | 145 (8.4) | 0.229 |
| Diabetes | | | | | | |
| No | 3914 (71.4) | 1055 (60.9) | < 0.001 | 1058 (61.3) | 1051 (60.9) | 0.441 |
| Non-insulin | 932 (17.0) | 363 (21.0) | | 380 (22.0) | 361 (20.9) | |
| Insulin dependent | 635 (11.6) | 315 (18.2) | | 287 (16.6) | 313 (18.1) | |
| COPD | 408 (7.4) | 179 (10.3) | < 0.001 | 157 (9.1) | 179 (10.4) | 0.206 |
| $O_2$ dependency | 166 (3.0) | 87 (5.0) | < 0.001 | 82 (4.8) | 87 (5.0) | 0.693 |
| Anticoagulant use | 369 (6.7) | 119 (6.9) | 0.846 | 119 (6.9) | 119 (6.9) | 1.000 |
| CKD | 170 (3.1) | 49 (2.8) | < 0.001 | 46 (2.7) | 49 (2.8) | 0.755 |
| Dialysis dependent | 64 (1.2) | 13 (0.8) | 0.140 | 15 (0.9) | 13 (0.8) | 0.704 |
| GERD | 2275 (41.5) | 907 (52.3) | < 0.001 | 894 (51.8) | 903 (52.4) | 0.759 |
| Hyperlipidemia | 1718 (31.3) | 649 (37.5) | < 0.001 | 634 (36.8) | 647 (37.5) | 0.647 |
| Hypertension | 3279 (59.8) | 1171 (67.6) | < 0.001 | 1195 (69.3) | 1165 (67.5) | 0.272 |
| OSA | 2414 (44.0) | 1003 (57.9) | < 0.001 | 1029 (59.7) | 1001 (58.0) | 0.333 |
| Previous MI | 120 (2.2) | 46 (2.7) | 0.260 | 45 (2.6) | 46 (2.7) | 0.915 |
| Previous PCI | 204 (3.7) | 81 (4.7) | 0.076 | 89 (5.2) | 80 (4.6) | 0.478 |
| Previous VTE | 299 (5.5) | 88 (5.1) | 0.543 | 88 (5.1) | 87 (5.0) | 0.938 |
| Venous stasis | 94 (1.7) | 40 (2.3) | 0.111 | 45 (2.6) | 40 (2.3) | 0.583 |

*LRYGB*, laparoscopic Roux-en-Y gastric bypass; *LSG*, laparoscopic sleeve gastrectomy; *BMI*, body mass index; *ASA*, American Society of Anesthesiologists; *COPD*, chronic obstructive pulmonary disease; *CKD*, chronic kidney disease; *GERD*, gastroesophageal reflux disease; *OSA*, obstructive sleep apnea; *MI*, myocardial infarction; *PCI*, percutaneous coronary intervention; *VTE*, venous thromboembolism

robust. Elli and colleagues conducted a study examining the outcomes of sleeve gastrectomy in transplant patients who were maintained on calcineurin inhibitors [16]. While they did not report any significant complications for these patients, their findings are difficult to interpret as the study only included 10 transplant patients (6 renal, 2 liver, 2 pancreas), several of whom were lost to follow-up by 12 months.

Kaplan et al. conducted a similar study looking at all immunosuppressed patients undergoing bariatric surgery using data from the NSQIP database [17]. Compared with our study, they reported a similar prevalence of immunosuppression in patients undergoing bariatric surgery, with 1.6% of patients undergoing LRYGB and 1.1% of patients undergoing LSG being steroid dependent. However, they found much higher rates of both mortality and major complications, with odds ratios of 3.4 and 2.0, respectively. This may be explained by surgeon experience, as the hospitals included in NSQIP are not necessarily accredited bariatric surgery centers. As well,

**Table 4** Perioperative outcomes for immunosuppressant-dependent patients undergoing bariatric surgery, stratified by procedure type

| Outcome | Unmatched cohort | | *p* value | Matched cohort | | *p* value |
|---|---|---|---|---|---|---|
| | LSG 5481 (76.0%) | LRYGB 1733 (24.0%) | | LSG 1725 (50.0%) | LRYGB 1725 (50.0%) | |
| Mortality | 7 (0.1) | 5 (0.3) | 0.152 | 2 (0.1) | 5 (0.3) | 0.256 |
| Major complication | 239 (4.4) | 166 (9.6) | < 0.001 | 86 (5.0) | 166 (9.6) | < 0.001 |
| Leak | 27 (0.5) | 17 (1.0) | 0.023 | 10 (0.6) | 17 (1.0) | 0.176 |
| Bleed | 82 (1.5) | 38 (2.2) | 0.048 | 30 (1.7) | 38 (2.2) | 0.327 |
| Reoperation | 71 (1.3) | 58 (3.4) | < 0.001 | 22 (1.3) | 58 (3.4) | < 0.001 |
| Reintervention | 81 (1.5) | 64 (3.7) | < 0.001 | 28 (1.6) | 64 (3.7) | < 0.001 |
| Readmission | 270 (4.9) | 139 (8.0) | < 0.001 | 92 (5.3) | 137 (7.9) | 0.002 |
| Cardiac event | 5 (0.1) | 3 (0.2) | 0.372 | 3 (0.2) | 3 (0.2) | 1.000 |
| Pneumonia | 14 (0.3) | 13 (0.8) | 0.003 | 8 (0.5) | 13 (0.8) | 0.274 |
| AKI | 15 (0.3) | 22 (1.3) | < 0.001 | 9 (0.5) | 22 (1.3) | 0.019 |
| VTE | 16 (0.3) | 11 (0.6) | 0.042 | 7 (0.4) | 11 (0.6) | 0.345 |
| Deep SSI | 17 (0.3) | 14 (0.8) | 0.006 | 2 (0.1) | 14 (0.8) | 0.003 |
| Wound disruption | 7 (0.1) | 0 (0.0) | 0.137 | 3 (0.2) | 0 (0.0) | 0.083 |
| Sepsis | 5 (0.1) | 2 (0.1) | 0.778 | 1 (0.1) | 2 (0.1) | 0.564 |
| Unplanned intubation | 15 (0.3) | 13 (0.8) | 0.005 | 6 (0.4) | 13 (0.8) | 0.107 |
| Coma > 24 h | 1 (0.0) | 0 (0.0) | 0.574 | 0 (0.0) | 0 (0.0) | 1.000 |
| CVA | 2 (0.0) | 2 (0.1) | 0.224 | 1 (0.1) | 2 (0.1) | 0.564 |
| Length of stay (days) | 1.8 ± 1.6 | 2.4 ± 2.8 | < 0.001 | 1.9 ± 1.6 | 2.4 ± 2.8 | < 0.001 |
| Operative time (minutes) | 74.3 ± 38.2 | 121.8 ± 56.9 | < 0.001 | 76.0 ± 38.8 | 121.7 ± 56.9 | < 0.001 |

*LSG*, laparoscopic sleeve gastrectomy; *LRYGB*, laparoscopic Roux-en-Y gastric bypass; *AKI*, acute kidney injury; *VTE*, venous thromboembolism; *SSI*, surgical site infection; *CVA*, cerebrovascular accident

the time period of their study (2011–2013) was earlier than ours (2015–2017) so it is possible that surgical technique and post-operative care have improved.

The effect of bariatric surgery on obesity-related diseases has been well described. Some immunosuppressed patients may have additional benefit, depending on the indication for immunosuppression. A recent systematic review of literature by Gallo et al. concluded that weight loss achieved through bariatric surgery was associated with a reduction in inflammatory markers and reduction in the use of immunosuppressants (including steroids) in patients with rheumatic conditions (rheumatoid arthritis, systemic lupus erythematous, etc.) [18]. This fits with our understanding of the association between obesity and a chronic inflammatory state [19]. This may factor into the discussion for such patients, as though they are at increased risk in the immediate post-operative period, they may stand to gain more in the long term.

Our secondary analysis, stratified by procedure type, showed lower complications for patients undergoing LSG compared with LRYGB. A similar analysis that included all patients in the MBSAQIP database found similar conclusions [20]. Weight loss outcomes are generally considered comparable between the two procedures, as demonstrated by two recent randomized multicenter trials [21, 22]. Given this finding, it may be preferable to offer LSG rather than LRYGB to steroid-dependent patients to minimize post-operative risk.

A major advantage of our study is the size of the database, which was necessary to examine this small subgroup (1.7%) of patients. Having data only from accredited bariatric centers was also helpful in limiting the impact of variation in surgeon skill. The short duration of follow-up (30 days) was one of the limitations of the study. With the available data, we are unable to tell whether immunosuppressed patients experienced high rates of long-term complications or whether the increased rate of short-term complications impacted the expected benefits of bariatric surgery. In addition, the data does not distinguish between glucocorticoids and other immunosuppressants, which may have varying degrees of immunosuppression and other secondary effects. Given that glucocorticoids are associated with more severe side effects than new medications, our findings may underestimate the risk of bariatric surgery in these patients specifically.

## Conclusion

Immunosuppression-dependent patients have an increased risk of major complications from bariatric surgery, overall, and specifically have an increased risk of post-operative bleeds and anastomotic leak. The risk of complications is lower after LSG compared with LRYGB. An understanding of the risk of bariatric surgery in this high-risk population is important for informed decision making between the surgeon and the patient.

### Compliance with Ethical Standards

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

**Informed Consent** For this type of study, formal consent was not required.

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