Obesity Surgery (2020) 30:4899–4904
https://doi.org/10.1007/s11695-020-05013-1

ORIGINAL CONTRIBUTIONS

Outcomes of Bariatric Surgery After Solid Organ Transplantation

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Received: 4 August 2020 / Revised: 22 September 2020 / Accepted: 24 September 2020 / Published online: 30 September 2020
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Abstract

Purpose Obesity is prevalent after orthotopic solid organ transplant mainly due to immunosuppressive therapy, decreased physical activity, and unbalanced diet, which leads to development or worsening of other comorbidities, such as hypertension and type 2 diabetes mellitus. Morbid obesity increases the risk of graft loss and has negative effects on postoperative morbidity and patient survival. The aim of this study was to assess the safety and effectiveness of bariatric surgery after organ transplant.

Material and Methods A retrospective analysis of patients who underwent bariatric surgery after organ transplant between July 1, 2010, and June 30, 2019, was performed. Demographics, surgical data, immunosuppressive treatment, postoperative adverse events, and weight loss were collected.

Results Thirty-eight patients met inclusion criteria. The median (range) time between transplant and bariatric surgery was 54.3 (10.0–253.0) months. Laparoscopic sleeve gastrectomy and robotic Roux-en-Y gastric bypass were performed in 28 and 10 patients, respectively. Only 1 conversion to open procedure was required. Median length of stay was 2 days, with a 30-day adverse event rate of 23.7%. No leaks were documented. At 12-month follow-up, mean (SD) percentage excess body weight loss was 58.54 (21.91) and 68.74 (23.13) after sleeve gastrectomy and Roux-en-Y gastric bypass, respectively. Comorbidity-related medications were decreased in most patients, while transplant organ rejection occurred in 2 patients.

Conclusion Bariatric surgery after organ transplant enables considerable postoperative weight loss and improvement of obesity-related comorbidities; however, it presents with higher morbidity.

Keywords Bariatric surgery · Gastric bypass · Organ transplantation · Sleeve gastrectomy

Introduction

Obesity is a major health concern as it affects 39.6% of the US adult population [1]. In patients undergoing orthotopic solid organ transplant (OSOT), obesity prevalence rises from 5.6% before transplant to 11.5% 1 year after [2]. It is a multifactorial condition usually related to immunosuppressive treatment, decreased physical activity, unbalanced diet, and endocrine and metabolic changes [3]. Morbid obesity increases the risk of graft loss and delayed graft function and decreases patient survival [2, 4].

Bariatric surgery is the most effective treatment for morbid obesity in the long term [5], also helping achieve better control of obesity-related comorbidities, such as hypertension and diabetes mellitus [6]. However, its safety and efficacy in patients after OSOT have not been well established. Most studies in the literature are case reports or small case series about sleeve gastrectomy [7, 8], with little data regarding long-term outcomes [9]. The main concerns in this population are a higher rate of adverse events due to immunosuppressive state and prolonged corticosteroid use [10] and the effect bariatric surgery may have in the absorption of medications and, consequently, graft function.

Management of patients with OSOT presents a number of challenges to the bariatric surgeon. Concerns include increased risk of morbidity and mortality than in the general population [10], a more complex operation with longer operative time and length of hospital stay [11], and postoperative changes in medication absorption and immunosuppressive state [12, 13].

Presented at the 24th International Federation for the Surgery of Obesity and Metabolic Disorders World Congress, Madrid, Spain, September 3-7, 2019.

Portions of this manuscript have been published in abstract form: Diaz Vico T, Elli EF. O-126 Minimally invasive bariatric surgery for obese patients after solid organ transplantation: safety and feasibility. Obes Surg 2019;29:150.

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The aim of this study was to assess the safety and efficacy of bariatric surgery after OSOT by evaluating adverse event rates, graft rejection, weight loss, and comorbidity control.

Methods

After institutional review board approval, patients who underwent bariatric surgery at the Mayo Clinic in Jacksonville, Florida, from July 1, 2010, to June 30, 2019, were retrospectively identified based on billing codes. All patients with previous OSOT were included in this study. Patient records were reviewed for the following clinical characteristics: transplanted organ; history of organ rejection; immunosuppressive medication daily dosage and blood levels; time from OSOT to bariatric surgery; sex, age, and body mass index at the time of bariatric surgery; and obesity-related comorbidities, such as hypertension, type 2 diabetes mellitus, obstructive sleep apnea, and hyperlipidemia. Hypertension, type 2 diabetes mellitus, and hyperlipidemia were determined by need for daily medication, and obstructive sleep apnea by need for overnight continuous positive airway pressure therapy.

Patients were referred to the bariatric surgery clinic by the transplant team after failed clinical management of morbid obesity. All patients referred to our team were offered bariatric surgery after meeting eligibility criteria based on the National Institute of Health Guidelines on obesity [14], with no additional criteria assigned based on transplant status. Surgical procedure, either laparoscopic sleeve gastrectomy (LSG) or robotic Roux-en-Y gastric bypass (rRYGB), was chosen based on patient condition following the same criteria standards used for non-OSOT patients, except in the following situations: LSG was preferred for patients after liver transplant to maintain endoscopic access to the biliary tree, but was avoided for patients with lung transplant due the high reported rate of postoperative reflux [15, 16] and potential for aspiration. LSG and rRYGB were performed as previously described [17]. rRYGB is the routine approach in our institution when performing a primary gastric bypass.

Outcomes reviewed included perioperative adverse event rate, change in immunosuppressive dosage or blood levels, organ rejection, readmission, comorbidity management, weight loss 12 and 24 months after bariatric surgery, and mortality. Early readmission was defined as readmission occurring within the first 30 days after surgery. Comorbidity management and weight loss were assessed by medication usage and percentage of excess body weight loss, respectively. Continuous variables are expressed as mean (SD) or median (range), and categorical variables are reported as number (percentage). Potential factors associated with adverse events were assessed using univariate logistic regression models. Findings are presented as odds ratios (OR) and corresponding 95% confidence intervals (CI). Results were considered statistically significant when P value was found to be less than 0.05. SPSS software, version 25.0, Statistical Package for the Social Sciences (IBM Corp) was used for data analysis.

Results

During the study period, 38 patients met inclusion criteria, 28 underwent LSG, and 10 underwent rRYGB. Median (range) time from transplant to bariatric surgery was 54.3 (10.0–253.0) months. Demographic information, comorbidities, and organ transplant history are detailed in Table 1. Four patients had undergone previous bariatric surgery and were converted from adjustable gastric band to LSG (2) and from LSG to rRYGB (2).

Operative details are included in Table 2. Conversion to open procedure occurred in only 1 patient due to dense adhesions during rRYGB. Thirty-day postoperative adverse event rate was 23.7%, with a higher rate after rRYGB than after LSG; however, no events required radiologic or surgical intervention. Immediate postoperative adverse events included fever (1), hyperkalemia (1), and acute increase in creatinine requiring intravenous fluids (2) in the LSG group and

Table 1 Patients characteristics and transplant information by bariatric surgery performed

Characteristic	Bariatric surgery	
	LSG ($n = 28$)	rRYGB ($n = 10$)
Age, mean (SD) (year)	56.74 (10.61)	48.03 (11.97)
Sex, No. (%), female	9 (32.1)	8 (80.0)
BMI, mean (SD) (kg/m^2)	42.02 (6.16)	40.93 (7.63)
Comorbidities, No. (%)		
Hypertension	26 (92.9)	9 (90.0)
Diabetes	19 (67.9)	6 (60.0)
Hyperlipidemia	16 (57.1)	7 (70.0)
OSA	17 (60.7)	5 (50.0)
Transplant organ, No. (%)		
Kidney	3 (10.7)	5 (50.0)
Liver	19 (67.9)	0 (0.0)
Heart	3 (10.7)	3 (30.0)
Lung	0 (0.0)	2 (20.0)
Combined[a]	3 (10.7)	0 (0.0)
Chronic corticosteroid use, No. (%)	8 (28.6)	8 (80.0)
History of rejection, No. (%)	6 (21.4)	2 (20.0)
Previous transplant, No. (%)	2 (7.1)	0 (0.0)

BMI body mass index, *LSG* laparoscopic sleeve gastrectomy, *OSA* obstructive sleep apnea, *rRYGB* robotic Roux-en-Y gastric bypass

[a] Combined organ included 2 patients with kidney and liver transplant and 1 with kidney and pancreas transplant

Table 2 Perioperative details by bariatric surgery performed

Characteristic	Bariatric surgery	
	LSG ($n = 28$)	rRYGB ($n = 10$)
Revisional bariatric procedure, No. (%)	2 (7.1)	2 (20.0)
Conversion to open procedure, No. (%)	0 (0.0)	1 (10.0)
Estimated blood loss, median (range) (mL)	10 (0–50)	10 (0–100)
Operative time, mean (SD) (min)	104.54 (60.04)	140.40 (45.45)
Drain placed, No. (%)	2 (7.1)	1 (10.0)
Length of stay, median (range) (day)	2 (2–5)	2 (2–10)
30-day adverse events, No. (%)[a]	6 (21.4)	3 (30.0)
Early readmission (< 1 month), No. (%)	2 (7.1)	1 (10.0)

LSG laparoscopic sleeve gastrectomy, *rRYGB* robotic Roux-en-Y gastric bypass

[a] Adverse events included fever, hyperkalemia, and acute increase in creatinine requiring intravenous fluids (2) for the LSG group and prolonged postoperative ileus and mild diabetic ketoacidosis with increase in creatinine for the rRYGB group

prolonged postoperative ileus (1) and mild diabetic ketoacidosis with increase in creatinine (1) in the rRYGB group. Early readmission rate was 7.9%. After LSG, 1 liver recipient was readmitted due to abdominal pain related to a gastric ulcer, and 1 combined liver and kidney recipient was readmitted due to nausea, vomiting, and acute kidney injury. After rRYGB, 1 heart recipient required early readmission due to abdominal pain and shortness of breath, but workup was unremarkable. No leaks were documented in either group.

Follow-up data were available for 30 (78.9%) patients after 12 months and for 19 (50.0%) after 24 months. Later than 30-day readmissions occurred after LSG in 3 liver recipients due to dehydration, gastric sleeve stenosis, and incarcerated incisional hernia from previous band port 4, 6, and 7 months after surgery, respectively. Gastric sleeve stenosis was refractory to endoscopic dilation and was subsequently managed and resolved with laparoscopic seromyotomy. The incarcerated incisional hernia was repaired laparoscopically. Later than 30-day readmissions after rRYGB were due to tricuspid valve regurgitation requiring replacement in 1 heart recipient 9 months after surgery and acute rejection noted as an increase in serum creatinine in 2 kidney recipients 3 and 7 months after surgery. One of the patients with rejection was nonadherent with postoperative instructions and immunosuppressive medications.

Outcomes of weight loss and comorbidity management are summarized in Table 3. Excess body weight loss 12 months after surgery was higher than 50% for both procedures and higher than 90% in the rRYGB group after 24 months. Most patients had better comorbidity control after bariatric surgery. One heart recipient died 20 months after rRYGB due to adverse effects of the tricuspid valve replacement previously mentioned.

Univariate logistic regression analysis did not find that the type of surgical procedure affected adverse events rate (rRYGB vs LSG; OR: 0.64, CI 0.12–2.55; $P = 0.58$). Patient characteristics (age, gender, preoperative BMI, obesity-related comorbidities) and transplant history (transplanted organ, history of organ rejection, time from OSOT to bariatric surgery, chronic corticosteroid use) were not associated with increased adverse events rate in the entire cohort (Table 4).

Regarding immunosuppressive medication, none of the patients required substantial adjustments to tacrolimus dosage (Fig. 1). There was also no notable change in tacrolimus blood through levels (Fig. 2), despite 2 kidney recipients presenting with signs of organ rejection, as previously mentioned.

Discussion

Our study shows that bariatric surgery can be safely performed in patients after OSOT. Time from transplant to bariatric surgery in our cohort was approximately 4 years, with the earliest being only 10 months after transplant. However, we agree with current recommendations of waiting at least 1 year after OSOT because adverse effects associated with immunosuppression are highest during the first year [18].

In the current study, 30-day adverse event rate was 23.7%, which is higher than usual. Rate of adverse event has a wide range of variation, from 0.6 to 10.3%, depending on multiple factors, including bariatric center operative volume [19]. The early readmission rate of 7.9% is also higher than the 5% reported in a cohort of 187,000 patients undergoing primary bariatric surgery [20]. The mortality rate of 2.6% reported in this study is similar to previous reports of bariatric surgery in patients with previous OSOT [9, 21]; however, mortality in our study was due to an adverse event in the transplanted organ not directly related to bariatric surgery.

Recent studies assessing the Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program

Table 3 Bariatric surgery outcomes for patients with previous OSOT

Outcome	Bariatric surgery	
	LSG ($n = 28$)	rRYGB ($n = 10$)
Readmission, No. (%)	5 (17.9)	4 (40.0)
Transplant rejection, No. (%)	0 (0.0)	2 (20.0)
%EBWL (12 mo), mean (SD) (kg/m^2)[a]	58.54 (21.91)	68.74 (23.13)
%EBWL (24 mo), mean (SD) (kg/m^2)[b]	63.48 (27.21)	95.65 (30.14)
Reduction in hypertension medication, No. (%)[c]	12 (46.2)	6 (66.7)
Resolution of hypertension, No. (%)[c]	5 (19.2)	2 (22.2)
Reduction in diabetes medication, No. (%)[d]	12 (63.2)	6 (100.0)
Resolution of diabetes, No. (%)[d]	6 (31.6)	3 (50.0)
Deceased, No. (%)	0 (0.0)	1 (10.0)

%EBWL percentage excess body weight loss, *LSG* laparoscopic sleeve gastrectomy, *OSOT* orthotropic solid organ transplant, *rRYGB* robotic Roux-en-Y gastric bypass

[a] Twelve months after bariatric surgery, the total number of patients decreased to 23 and 7 in the LSG and rRYGB groups, respectively

[b] Twenty-four months after bariatric surgery, the total number of patients decreased to 16 and 3 in the LSG and rRYGB groups, respectively

[c] Hypertension was a comorbidity for 26 and 9 in the LSG and rRYGB groups, respectively

[d] Diabetes was a comorbidity for 19 and 6 in the LSG and rRYGB groups, respectively

database reported perioperative risks of bariatric surgery in patients with and without history of OSOT and demonstrated a higher incidence of readmissions and adverse events, such as leaks and surgical site infections; however, no information about transplant organ and graft rejection or failure was documented [22, 23].

It is debatable whether patients after OSOT would need higher doses of immunosuppressive agents, and postsurgery time interval may have an effect [9, 13]. While there was no notable change in tacrolimus daily dosage or blood levels over time in our study, 2 patients had organ rejection after rRYGB. Previous reports, including a total of 19 patients undergoing LSG after liver transplant, had no episodes of rejection [24, 25]. There is marked concern regarding the malabsorptive effect of bariatric surgery in these patients, especially with rRYGB.

Table 4 Univariate logistic regression analysis between patient characteristics and adverse events in the entire cohort

Characteristics	OR (95% CI)	*P* value
Male gender	0.56 (0.12–2.55)	.46
BMI	0.98 (0.87–1.10)	.74
Hypertension	0.59 (0.05–7.41)	.68
Diabetes	1.05 (0.21–5.13)	.95
Hyperlipidemia	0.76 (0.17–3.47)	.73
OSA	1.62 (0.34–7.79)	.54
Kidney transplant	2.51 (0.52–12.03)	.25
Liver transplant	0.56 (0.12–2.55)	.46
Heart transplant	1.78 (0.27–11.85)	.55
Chronic corticosteroid use	2.04 (0.45–9.30)	.35
History of rejection	2.40 (0.44–12.98)	.31
Time from transplant to bariatric surgery	1.00 (0.98–1.01)	.94
Bariatric procedure (rRYGB vs LSG)	0.63 (0.12–3.23)	.58

BMI body mass index, *LSG* laparoscopic sleeve gastrectomy, *rRYGB* robotic Roux-en-Y gastric bypass

Despite the higher risk of adverse events and graft rejection, our patients experienced considerable weight loss and improvement of comorbidities. In our study, 12 months after bariatric surgery, patients in both procedure groups achieved a loss of more than 50% excess body weight, and weight loss was even higher at 24-month follow-up, especially in the rRYGB group. Improvement in comorbidity control with a reduction in prescribed medications was also noted in a majority of patients. We recommend that patients with previous OSOT undergo bariatric surgery only in places with active transplant programs, as close collaboration with the transplant team is necessary to achieve better outcomes.

Our study did not reach a level of significance to determine predictors of adverse events probably due to the small patient population. Other limitation is that this was a retrospective analysis lacking a control group. Comparison could be made with a morbidly obese OSOT group without bariatric surgery to clarify whether there is measurable benefit. Also, a longer follow-up is advisable to assess for long-term outcomes, such as malnutrition and effect on graft function and survival.

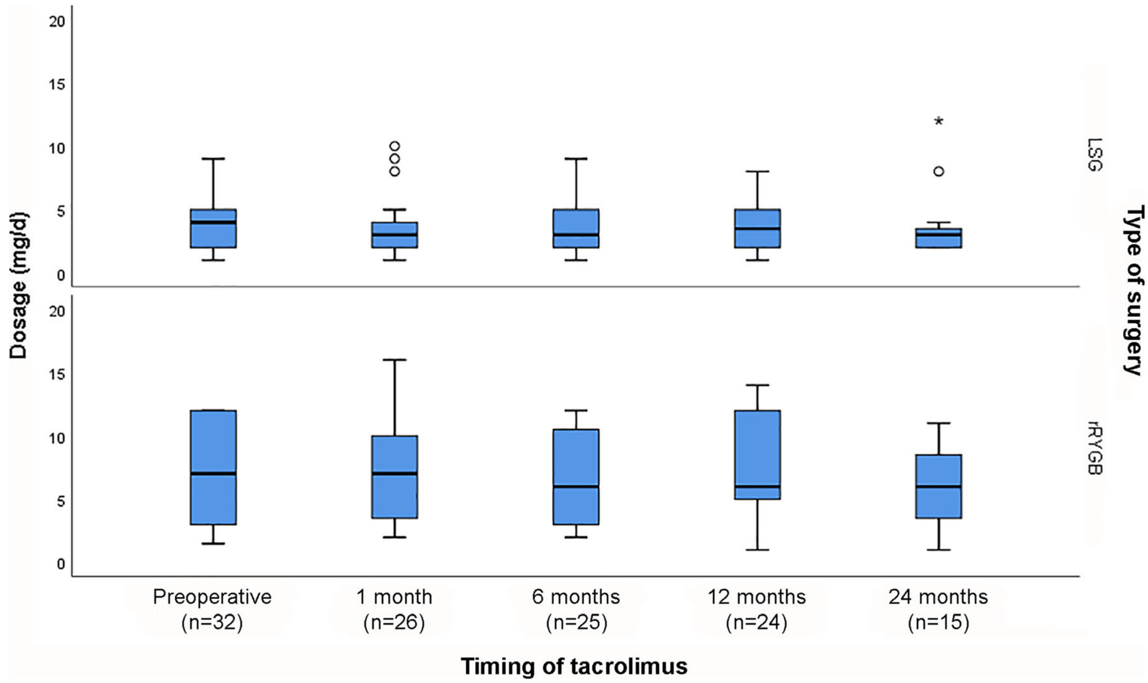

Fig. 1 Tacrolimus dosage before and after LSG and rRYGB. The number of patients with data available for both groups is demonstrated in parenthesis. LSG laparoscopic sleeve gastrectomy, rRYGB robotic Roux-en-Y gastric bypass

Consequently, further studies with more patients and longer follow-up are needed to evaluate the effectiveness of bariatric surgery after OSOT.

Conclusion

Bariatric surgery is safe in patients after transplant and achieves considerable weight loss and improvement of

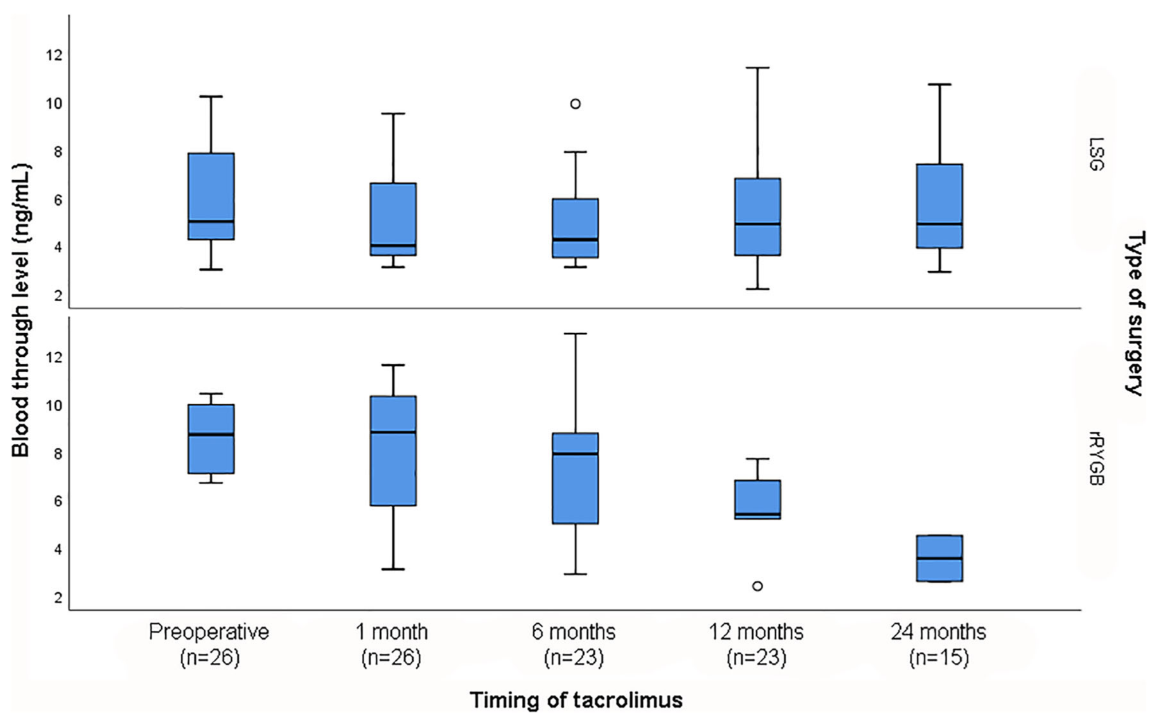

Fig. 2 Tacrolimus blood through levels before and after LSG and rRYGB. Tacrolimus blood through levels therapeutic range varied based on transplant organ. The number of patients with data available for both groups is demonstrated in parenthesis. LSG laparoscopic sleeve gastrectomy, rRYGB robotic Roux-en-Y gastric bypass

obesity-related comorbidities. However, it presents with higher adverse event and readmission rates. No change in immunosuppressive dosage is required without signs of organ rejection.

Compliance with Ethical Standards

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

Human or Animal Subjects All procedures performed in the studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent For this type of study, formal consent is not required.

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