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ORIGINAL ARTICLE

Outcomes of kidney transplant recipients who underwent pre-transplant bariatric surgery for severe obesity: a long-term follow-up study

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Abstract

Background Kidney transplantation (KT) is the preferred therapy for end-stage renal disease (ESRD). While a major cause for ESRD, obesity is also a key obstacle to candidacy for KT. Bariatric surgery, particularly sleeve gastrectomy (SG), is increasingly used to improve access to KT in patients with obesity, but the literature especially on outcomes post-KT remains lacking. We aimed to provide a long-term follow-up analysis of efficacy and outcomes of a previously described cohort of patients with obesity, who had SG as a means for access to KT.

Methods This is a single-center retrospective follow-up study of 32 patients with advanced chronic kidney disease or ESRD, who were referred and underwent SG between 2013 and 2018 as an access strategy to KT. The primary outcome was successful KT. Ninety-day outcomes, long-term graft function, and changes in weight and obesity-related comorbidities after KT were assessed. Descriptive statistics are presented as count (percentage) or median (interquartile range).

Results At baseline, 18 (56%) were male with a median age and BMI of 51 (11) years and 42.3 (5.2) kg/m^2, respectively. Median follow-up time post-SG was 53 (58) months. At last follow-up, 23 (72%) patients received KT. Median time to KT was 16 (20) months and BMI was 34.0 (5.1) kg/m^2 at time of transplant. At KT, 13 (57%) and 20 (87%) had diabetes and hypertension, respectively. Median follow-up post-KT was 16 (47) months. There was one graft loss requiring return to dialysis. At 5-year post-KT, median serum creatinine was 136 (66) µmol/l. At last follow-up post-KT, median BMI remained at 33.7 (7.6) kg/m^2. Among patients with diabetes and hypertension, 7/13 (54%) and 5/20 (25%) had either improvement or remission of their comorbidities, respectively.

Conclusion SG is an effective strategy to improve access to KT in patients with severe obesity. Transplant recipients also continue to benefit from sustained weight loss and improved related comorbidities that may positively impact their graft function after KT.

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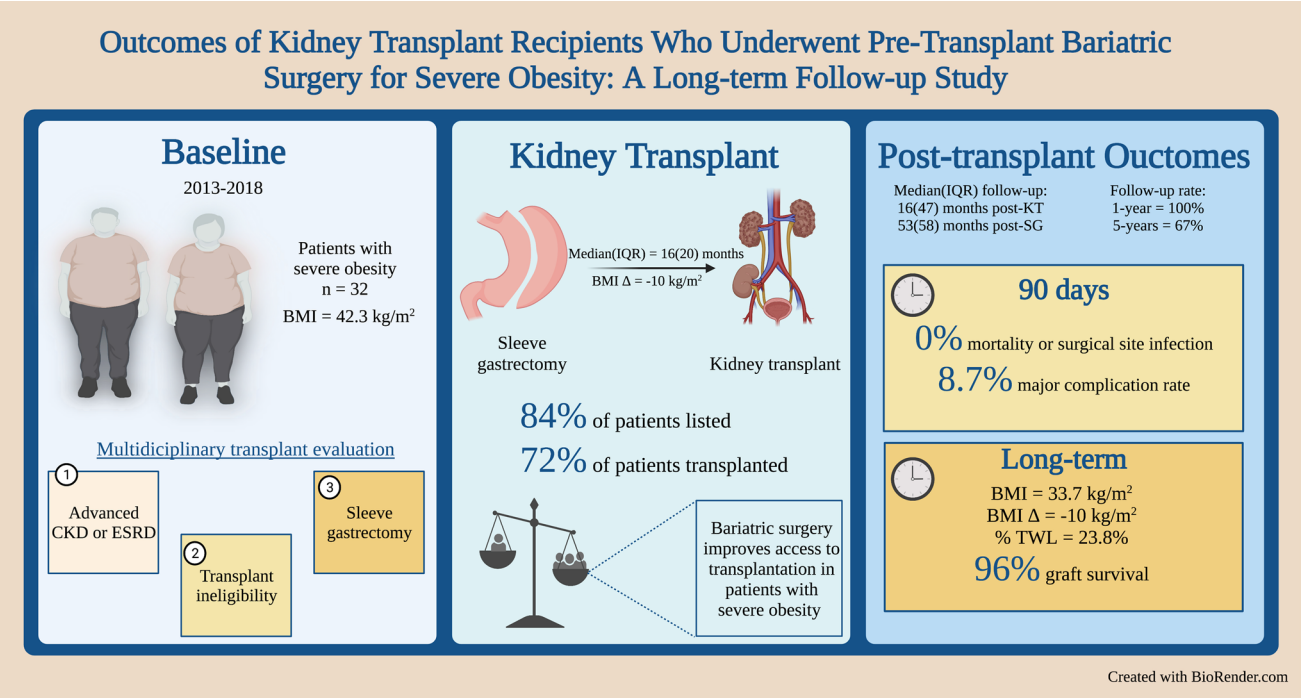
Graphical abstract



Keywords Sleeve gastrectomy · Bariatric surgery · Kidney transplant · Dialysis · End-stage renal disease · Obesity

Obesity is a major risk factor for chronic kidney disease (CKD) and end-stage renal disease, ESRD [1]. The ideal therapy for ESRD is kidney transplantation (KT), which is preferred over chronic dialysis treatment [2]. However, patients with obesity are known to consistently remain on dialysis and face longer wait times for KT [3]. Although specific guidelines differ among transplant centers, most programs use either a body mass index (BMI) or waist circumference (WC) cut-off for transplantation eligibility [4, 5]. Furthermore, it is shown that a KT in a recipient with severe obesity (BMI ≥ 40 kg/m^2) fails to provide a clear benefit over remaining on hemodialysis [6]. Consequently, given the limited donor-recipient ratio, patients with severe obesity are often excluded from eligibility for transplant listing at most centers worldwide, in fact for some organs in particular the heart and lung transplants, the International Society for Heart Lung Transplantation uses a strict BMI cut-off of 35 kg/m^2 for listing [7–9].

In addition to obesity, some of the main related comorbidities including hypertension and diabetes are also among the leading causes for CKD and ESRD [10, 11]. Moreover, these obesity-related conditions have also been shown to compromise graft survival in the first year after KT [12]. After KT, obesity is also shown to increase the risk of surgical site infections, a major postoperative complication which is associated with premature graft loss and reduced recipient survival [13]. Since bariatric/metabolic surgery is the most definitive treatment for severe obesity and related conditions and in keeping with its use as a bridge strategy to other complex procedures in patients with severe obesity [14–17], it has also been shown to improve access to KT in patients with obesity and ESRD [18].

However, the literature on the outcomes of bariatric/metabolic surgery especially at long-term follow-up and its impact on and after KT remains scant. Hence, we aimed to provide a long-term follow-up analysis of efficacy and outcomes of a previously described cohort of 32 patients with obesity [18], who underwent sleeve gastrectomy (SG) as a means for access to KT.

Materials and methods

This is a single-center retrospective long-term follow-up study of an original cohort of 32 consecutive patients with advanced CKD (stages IV and V), who were referred and underwent SG between 01/01/2013 and 08/31/2018 as an access strategy to KT at the McGill University Health Center (MUHC) through a special access program and collaboration between the bariatric surgery and multi-organ transplant

programs. The institutional practice at MUHC including the multidisciplinary structure, the approach to those on peritoneal dialysis, and perioperative dialysis plan are already detailed in the original publication of the safety and efficacy outcomes of SG in this study cohort as a means to improve access to KT [18]. The respective transplantation and bariatric surgery databases were linked and surveyed for the selected patients. Medical chart review was performed for additional information if necessary. The study was approved by the Research Ethics Board of MUHC.

In brief, all patients who suffer from advanced CKD (stages IV or V) are evaluated by the MUHC transplant clinic for candidacy for KT. If the patients have a BMI $\geq$ 35 kg/m^2 or a WC $\geq$ 110 cm in the presence of metabolic comorbidities, they are precluded from transplant listing and are referred to the MUHC Bariatric Center. Patients who require multi-organ transplantation such as pancreas or liver are excluded from this study. Eligible patients subsequently undergo a SG (as a first step and in the absence of contraindications), which is performed in a standard fashion without any routine use of staple line reinforcement. After a satisfactory recovery and sufficient weight loss during parallel follow-ups by both bariatric and transplant teams at standard intervals, the patients are reassessed for listing at the discretion of the transplant nephrologists and surgeons. Once listed, patients undergo KT according to organ availability. The peri-transplant management is like non-bariatric patients except for some vitamin supplementation and occasional use of liquid formula for immunosuppression in cases of gastrointestinal symptoms in the early postoperative period after bariatric surgery.

Demographic characteristics including age, sex, weight, and comorbidities were assessed at baseline (initial evaluation in transplant clinic), at the time of KT and at the last available follow-up. Donor characteristics including age, sex, weight, donation after circulatory death (DCD), standard criteria donors (SCD), and extended criteria donors (ECD) were also assessed at time of transplant. The primary outcome was successful KT defined as a functioning graft by 90 days after transplant. The secondary endpoints measured were 90-day outcomes after KT, including major morbidity, unplanned readmission, reintervention, and reoperation. Graft function in the immediate postoperative period, which included delayed graft function (DGF), slow graft function (SGF), and immediate graft function (IGF), along with serum creatinine and estimated glomerular filtration rate (eGFR) at 90 days and various time points after KT were also evaluated. DGF was clinically defined as the need for dialysis within the first postoperative week and SGF was clinically defined as a slow recovery in kidney function not necessitating dialysis, as done by others [19]. Biopsy-proven acute and chronic graft rejections were also documented. Complete graft failure was defined as need for prolonged return to dialysis. Changes in weight and obesity-related comorbidities among the transplant recipients were also assessed. Initial weight was recorded prior to SG and used as reference to calculate various weight loss metrics. Ideal body weight was set for BMI 25 kg/m^2. For bariatric patients who were not transplanted during the follow-up period, their current transplant evaluation status was assessed.

Statistical analysis

Descriptive statistics are presented as count (percentage) and median (interquartile range). Mann–Whitney *U* test was used to compare the medians for the continuous variables. Data analyses were performed using SPSS version 28.0.0. Inference was based on a two-sided 5% level.

Results

In this study, we performed the long-term follow-up assessment of the original 32 consecutive patients, who after evaluation by the transplant team, underwent SG at MUHC during 2013 and 2018. Since the implementation of the multidisciplinary corridor of service at MUHC using bariatric/metabolic surgery as a strategy to improve access to KT in patients with advanced CKD and severe obesity and as of September 2018, another 29 patients have undergone SG and 2 others have had their SG converted to Roux-en-Y gastric bypass (RYGB) for further weight loss and are being evaluated by the transplant team for listing. However, in this study we only focused on the long-term outcomes of the original 32 patients specifically the sub-cohort of patients who received KT during the follow-up period. The baseline characteristics of the original study cohort are described in Table 1. At baseline, 18 (56%) were male with a median age of 51 (11) years and a median BMI of 42.3 (5.2) kg/m^2. Diabetes and hypertension were present in 15 (47%) and 25 (78%), respectively.

In the original study, out of 32 patients, 20 (63%) patients were listed for transplantation and 14 (44%) had successfully underwent KT at a median time of 8 months [18]. In this follow-up study and as of March 2022, these statistics were both improved with 27 (84%) of the original cohort having been listed for transplantation and 23 (72%) patients who were successfully transplanted. The median follow-up time after SG was 53 (58) months for the entire study cohort and the median time to KT was 16 (20) months.

The characteristics of the sub-group of transplant recipients ($N = 23$) at the time of KT are detailed in Table 2. In this sub-group at time of KT, 15 (65%) were male. Thirteen (57%) and 20 (87%) had diabetes and hypertension, respectively. The median BMI at transplantation had decreased to 34.0 (5.1) kg/m^2, corresponding to a median BMI change

Table 1 Baseline characteristics of the original study cohort prior to SG [17]

Study cohort	32
Age (year): median (IQR)	51 (11)
Sex (male): count (%)	18 (56%)
Weight (kg): median (IQR)	120.4 (36.8)
BMI (kg/m^2): median (IQR)	42.3 (5.2)
Comorbidities: count (%)	
Diabetes	15 (47%)
Hb_{A1C} (%): median (IQR)	7.2 (1.5)
Hypertension	25 (78%)
Dyslipidemia	21 (66%)
Obstructive sleep apnea	16 (50%)
ESRD	
Dialysis[a]: count (%)	29 (91%)
Time on dialysis (month): median (IQR)	28 (31)
Peritoneal: count (%)	5 (17%)
Hemodialysis: count (%)	27 (93%)
Primary etiology of ESRD: count (%)	
Type 2 diabetes	10 (34%)
Polycystic kidney disease	5 (17%)
Focal segmental glomerulosclerosis	2 (7%)
IgA nephropathy	2 (7%)
Type 1 diabetes	2 (7%)
Pyelonephritis	1 (3%)
Hypertensive renal vascular disease	2 (7%)
Other/uncertain	5 (17%)

SG sleeve gastrectomy, *IQR* interquartile range, *BMI* body mass index, Hb_{A1C} glycated hemoglobin A1C, *ESRD* end-stage renal disease

[a]Some patients had previous use of both types of dialysis prior to SG accounting for total percentage being higher than 100%

Table 2 Characteristics of the sub-cohort of transplant recipients at the time of KT

Sub-cohort: count (%)	23 (72%)
Age at KT (year): median (IQR)	51 (13)
Sex (male): count (%)	15 (65%)
Comorbidities: count (%)	
Diabetes	13 (57%)
Hypertension	20 (87%)
Dyslipidemia	13 (57%)
Obstructive sleep apnea	11 (48%)
Weight at KT (kg): median (IQR)	102 (24.7)
BMI at KT (kg/m^2): median (IQR)	34.0 (5.1)
Weight loss at KT (kg): median (IQR)	27 (17.4)
BMI change at KT (kg/m^2): median (IQR)	− 10 (6)
%TWL: median (IQR)	21 (13.3)
Time to KT (month): median (IQR)	16 (20)
Donor type: count (%)	
DND (SCD)	10 (44%)
DND (ECD)	4 (17%)
DCD	8 (35%)
LD	1 (4%)
Donor sex (male): count (%)	15 (65%)
Donor age (year): median (IQR)	53 (22)
Donor weight (kg): median (IQR)	75.8 (21.3)

KT kidney transplantation, *IQR* interquartile range, *BMI* body mass index, *%TWL* percent total weight loss, *DND* donation after neurologic death, *SCD* standard criteria donor, *ECD* extended criteria donor, *DCD* donation after circulatory death, *LD* living donor

of − 10 (6) kg/m^2 and a percent total weight loss (%TWL) of 21% (13.3) since SG. In terms of donor characteristics, 8 (35%) grafts were DCD and 4 (17%) were ECD (Table 2).

Following the transplant, median length of stay (LOS) was 8 (3) days. As for renal graft function, 4 (17%) patients experienced IGF, while 12 (52%) had DGF (Table 3). The 90-day postoperative complications after KT are detailed in Table 3. There were no mortality or surgical site infections requiring treatment. However, there were three unplanned reinterventions in two patients which were all upper endoscopies and carried out for persistent nausea/vomiting and dysphagia. The patient who required two scopes was found to have herpetic esophagitis. Another 2 patients required reoperation in the first 90 days after KT. One patient required reoperation on the same day as transplant for control of bleeding from the arterial anastomosis. The second patient underwent an exploratory laparotomy on day 1 for a suspected renal vein thrombosis which was ruled out by an intraoperative ultrasound. In addition, there were a total of four unplanned readmissions for different patients, none of which were related to the transplant (Table 3). Long-term graft-related adverse events are also detailed in Table 3. There were two biopsy-proven acute rejections that occurred nearly 8 months after KT, one of which progressed to a biopsy-proven chronic rejection. In addition, there were two other biopsy-proven chronic rejections that occurred in the context of sub-therapeutic immunosuppression. One was at 6 months after KT due to reduced immunosuppression for a cytomegalovirus infection that only resulted in a mild reduction in kidney function. The other occurred 4-year post-transplant due to poor patient compliance with immunosuppressants, which eventually resulted in the loss of graft function and return to intermittent hemodialysis. During the follow-up period, there was one death 3.5 years after KT in a patient who suffered a stroke, albeit with a functioning renal graft.

The median follow-up time after KT was 16 (47) months. Among the 23 transplant recipients, all were eligible for 1-year follow-up, 19/23 for 3 years, and 12/23 eligible for 5-year follow-up. Among those eligible at each time point, our follow-up rates were 100%, 68%, and 67% at 1-year, 3-year, and 5-year intervals, respectively (Table 4). The

Table 3 Postoperative morbidity after KT in the sub-cohort of transplant recipients

LOS (day): median (IQR)	8 (3)
90-day major complication: count (%)	
Mortality	0
Surgical site infection	0
90-day unplanned readmission[a]	4 (17%)
90-day unplanned reintervention	3 (13%)
90-day reoperation	2 (9%)
90-day graft function: count (%)	
IGF	4 (17%)
SGF	7 (30%)
DGF	12 (52%)
Long-term graft-related complication: count (%)	
Acute graft rejection	2 (8.7%)
Chronic graft rejection	3 (13%)
Return to dialysis	1 (4.3%)

KT kidney transplantation, *LOS* length of stay, *IQR* interquartile range, *IGF* immediate graft function, *SGF* slow graft function, *DGF* delayed graft function

[a]The four unplanned readmissions were unrelated to KT and in different patients; 1 patient was readmitted once for poor glycemic control (POD 16) and another time for a testicular abscess (POD 41); 1 patient was readmitted for incision and drainage of an abscess at a former dialysis catheter site (POD 40); another was admitted for cystitis (POD 80)

renal graft, weight, and obesity-related comorbidity outcomes after KT are provided for the sub-cohort of transplant recipients in Table 4. Renal function after KT was assessed at 90 days and compared with various time intervals. The median serum creatinine level was 126 (66) µmol/l at 90 days and 122 (40) µmol/l at 1 year after KT ($P=0.59$). For those eligible for 5-year follow-up, the median serum creatinine had increased to 136 (66) µmol/l but was still similar to 90 days after KT ($P=0.15$). The 90-day median eGFR was 61 (31) ml/min/1.73 m^2, which remained similar at 1-year after surgery at 57 (19) ml/min/1.73 m^2 ($P=0.70$). However, among the eligible at 3-year and 5-year follow-up, median eGFRs had significantly decreased compared to 90-day after transplant and were 45 (23) µmol/l ($P=0.03$) and 44 (25) µmol/l ($P=0.02$), respectively. At last follow-up after KT, the median BMI remained at 33.7 (7.6) kg/m^2 corresponding to an enduring BMI change of − 10.0 (4.9) kg/m^2 and a %TWL of 23.8% (13.3) since SG. As for changes to the obesity-related comorbidities, at last follow-up, the same 13 (57%) patients remained diabetic and but only 17 (74%) patients were treated for hypertension (Table 4).

For the remaining 5/32 patients that as of March 2022 were not listed for transplant, one patient has a complex large ventral hernia along with an ileal conduit that would undoubtedly complicate the transplant surgery despite an adequate weight loss after SG. While an abdominal wall reconstruction has been recommended, the patient is not interested and is lost to follow-up. Another patient was not a candidate for listing due to insufficient weight loss after SG (BMI of 50 kg/m^2 down from 65 kg/m^2 prior to SG). After a multidisciplinary discussion, in December 2021, the patient underwent a conversion to RYGB 3.5 years after the original SG and has had progressive weight loss and will soon be re-evaluated for listing (BMI = 42 kg/m^2 as of March 2022).

Table 4 Long-term outcomes after KT in the sub-cohort of transplant recipients

Follow-up time after KT (month): median (IQR)	16 (47)
Follow-up rate after KT: count (%)	
Eligible for 1-year follow-up (23/23)	23 (100%)
Eligible for 3-year follow-up (19/23)	13 (68%)
Eligible for 5-year follow-up (12/23)	8 (67%)
Weight loss outcome: median (IQR)	
BMI after KT (kg/m^2) for entire sub-cohort	33.7 (7.6)
At 1 year for those eligible	32.5 (9.2)
At 3 years for those eligible	31 (5.4)
At 5 years for those eligible	33.3 (7.5)
BMI change KT (kg/m^2) for entire sub-cohort	− 10 (4.9)
At 1 year for those eligible	− 10.5 (7.7)
At 3 years for those eligible	− 10 (4.8)
At 5 years for those eligible	− 10.5 (4.2)
%TWL after KT for entire sub-cohort	23.8 (13.3)
At 1 year for those eligible	24.4 (15)
At 3 years for those eligible	24.2 (12.9)
At 5 years for those eligible	25.8 (11.8)
Obesity-related comorbidity outcome: count (%)	
Diabetes	13 (57%)
Hb_{A1C} (%): median (IQR)	
At SG	7.2 (1.3)
At KT	6.5 (1.0)
At 1 year for those eligible (%): median (IQR)	7.3 (2.1)
At 3 years for those eligible (%): median (IQR)	8.1 (2.6)
Hypertension	17 (74%)
Graft-related outcomes: median (IQR)	
Serum creatinine (µmol/l)	
At 90 days for those eligible	126 (66)
At 1 year for those eligible	122 (40)
At 3 years for those eligible	129 (74)
At 5 years for those eligible	136 (66)
eGFR (ml/min/1.73 m^2)	
At 90 days for those eligible	61 (31)
At 1 year for those eligible	57 (19)
At 3 years for those eligible	45 (23)
At 5 years for those eligible	44 (25)

KT kidney transplantation, IQR interquartile range, *BMI* body mass index, *%TWL* percent total weight loss, Hb_{A1C} glycated hemoglobin A1C, *SG* sleeve gastrectomy, *eGFR* estimated glomerular filtration rate

One patient has died prior to being listed. The remaining 2 patients are under evaluation for listing at the time of this study.

Discussion

In this follow-up study of the original cohort of 32 patients with advanced CKD and obesity, who underwent SG during 2013–2018 as an access strategy to transplant listing, we observed that 84% of patients were successfully listed for transplant. Moreover, 72% (85% of those listed) went on to receive KT at a median of 16 months after SG. The efficacy of our study cohort in achieving candidacy/listing status and a subsequent transplantation is also comparable to the results from a recent systematic review evaluating the role of bariatric surgery on KT (83% and 69% at a mean time to KT of 24 months, respectively) [20]. In light of the perpetual shortage of the donor-recipient ratio, most transplant centers especially in Canada utilize BMI 35 kg/m^2 as a stringent cut-off for listing for KT [5]. Therefore, our findings have profound implications as none of these patients would have otherwise been considered for transplantation at most if not all centers.

Since the establishment of the multidisciplinary special access program at MUHC in 2016 and after demonstrating its safety [18], despite the negative impact of COVID-19 pandemic since March 2020, we have been able to safely increase the numbers at our center so that in the last 3.5 years, we have managed to perform the same number of bariatric procedures for patients with severe obesity and advanced CKD (29 primary SG and 2 conversions to RYGB), than we had performed in the first 5.5 years of this study dating back to January 2013. These statistics highlight the importance of multidisciplinary collaborations at high-volume tertiary care centers to improve care for this marginalized patient population and allow access to KT as the definitive care. Our findings also emphasize the need for a multidisciplinary guideline that can be jointly issued by the respective specialty experts and societies to set a blueprint for various institutions that could follow such algorithm for similar patients.

As evidenced by three recent systematic reviews on the topic, despite the undeniable link between the efficacy of major weight loss and successful listing and organ transplantation, there is paucity of good quality literature as most information is still derived from case reports or small case series [20–22]. Even in larger case series the follow-up rate after either bariatric surgery or KT is poor, not reported and the data gathered are often incomplete rendering the data heterogeneous and not amenable for pooling of the estimates [20–22]. The median follow-up time after SG for our study cohort was nearly 4.5 years and up to 9 years and the long-term (≥ 5 years) follow-up rate after SG was 60%. Moreover, in the sub-cohort of transplant recipients, the median follow-up time after KT was almost 1.5 years and the long-term follow-up ≥ 5 years for those eligible was 67%. Our study also describes the weight loss and obesity-related comorbidity outcomes in addition to graft-related outcomes after KT. To our knowledge, our study is the largest case series to provide long-term follow-up (≥ 5 years and ≥ 60%) after both SG and subsequent KT in patients with obesity and severe CKD.

In terms of changes to obesity-related comorbidities after KT, we found that while there were improvements among those with hypertension, there were no further improvements in patients with diabetes after transplant. Nevertheless, overall 54% of the patients with diabetes in our study cohort had either an improvement or resolution of their diabetes after SG (results not shown), which is consistent with the pooled estimates from the recent systematic review by Lee et al. demonstrating an overall 56% improvement or remission of diabetes after bariatric surgery and prior to KT [19]. However, there were no reporting of changes in diabetes status subsequent to KT due to lack of data in the available studies [20]. We found that among those patients with diabetes while the median glycated hemoglobin (Hb_{A1C}) decreased from 7.2 to 6.5% after SG and at the time of KT, subsequently it increased to 7.3% at 1 year and further climbed to 8.1%, 3 years after KT. This observation could be in part due to the patient's severity of diabetes and/or long-standing duration of insulin dependence with minimal or non-existent ß-cell reserves. This finding may also not be surprising as post-transplant diabetes is a well-recognized entity that is likely due to or exacerbated by immunosuppression medications including systemic steroids and calcineurin inhibitors mainly tacrolimus [23, 24]. Nevertheless, the cardiometabolic risk profile of these high-risk patients were either likely improved or the rate of progression of their metabolic syndrome slowed after their metabolic/bariatric surgery which is clearly shown to provide protection against major adverse cardiovascular events including mortality among patients with obesity and metabolic syndrome [25, 26]. Hence, no such patient with obesity and advanced CKD should be denied at least a SG as the metabolic/bariatric surgery and in the absence of any contraindications.

As for long-term weight outcomes among recipients of KT, we found that the prior SG resulted in a 10-point drop in the median BMI by the time of transplant. The same median weight loss was sustained throughout the entire follow-up time after KT and translated into a 26%TWL at 5 years after KT among eligible patients. While there is no consensus on the optimal timing (either before or after KT) and the ideal type of metabolic/bariatric surgery in patients with obesity and advanced CKD, it has repeatedly been shown that the improvement in obesity-related conditions and

the significant weight loss after bariatric surgery not only increases access to transplant but also likely decreases the postoperative adverse events after KT and hence should ideally be offered prior to KT [20, 27]. The importance of such sequence in approach is evident for patients with extreme obesity (BMI ≥ 60 kg/m^2) and so is the significance of a multidisciplinary approach. At MUHC, since the launch of our special access program, 2 patients with extreme obesity at baseline have undergone subsequent conversions of their SG to RYGB and are successfully losing more weight and are on target to be listed soon. Moreover, we should not ignore other effective, promising, and non-surgical multidisciplinary adjuncts to lessen the burden of obesity and related conditions in such patients specifically some effective pharmacological agents like glucagon-like peptide-1 (GLP-1), such as Semaglutide, or combined glucose-dependent insulinotropic polypeptide (GIP) and GLP-1, like Tirzepatide, that have shown promising results for weight loss especially in patients with diabetes [28, 29]. The use of these agents either primarily or as a combination therapy can certainly make an impact in patients with lower BMIs (< 35 kg/m^2) but a large WC and metabolic syndrome and those with extreme obesity (BMI ≥ 60 kg/m^2) or inadequate weight loss after SG.

In terms of impact of prior SG on 90-day postoperative complications after KT, we observed no surgical site infection, and only two major complications (8.7%) requiring reoperation for anastomotic bleeding and another to rule out venous thrombus neither of which were related to the patient's weight. Our observed 90-day major complication rate (Clavien–Dindo class ≥ III) after KT is comparable to other studies including those with KT in non-obese patients [21, 30]. Moreover, our observed early complication rate after KT is less than what has been described after renal transplant in obese recipients which can include wound infection (15–44%), wound dehiscence (3–14%), and lymphocele (3–18%) among other adverse events [31]. Hence, our results provide further support for the proposed strategy in performing metabolic/bariatric surgery prior to transplant, which in addition to weight loss and improvement in obesity-related comorbidities, can help mitigate major postoperative adverse events after KT.

Finally, early graft function in the immediate postoperative period was predominantly delayed, with 52% and 30% of the patients experiencing DGF and SGF, respectively. This observation may be partly explained by the donor type rather than the previous SG since the second major donor type in our cohort was DCD (35%), which is shown to have a 42–51% risk of DGF [32]. Indeed, 63% of our patients who received a DCD graft experienced DGF (results not shown). However, the improvement in serum creatinine after KT persisted throughout follow-up time and did not significantly decline compared to 90-day values. Moreover, our graft survival was 96% at the last follow-up. Only 1 patient out of 23 transplant recipients experienced a loss of graft function and returned to dialysis 4 years after KT which was due to poor patient compliance with immunosuppressants. Our observed graft survival rate was comparable to other studies and likely superior to reported rates after deceased organ donation [20, 33].

Our study has several limitations that should be considered. In addition to being a retrospective study, its relatively small sample size and single-center nature further limit the generalizability of our findings. Moreover, the small sample size especially for patients with diabetes or metabolic syndrome combined with the missing data limit the possibility of detailed statistical analyses to interpret various independent predictors of outcome both post-SG and after transplant. While the medium to long-term follow-up at 3- and 5-year intervals among eligible patients were all ≥ 60%, which is considered satisfactory and arguably superior for a retrospective study in this patient population, it can still introduce a selection bias. This bias, however, is likely toward the null given the high graft survival, low mortality, and other beneficial outcomes of KT after bariatric surgery in this patient population coupled with minimal inter-provincial migration in Canada. Finally, the absence of a matched comparative obese group that did not have metabolic/bariatric surgery but underwent KT hinders our ability to evaluate the impact of such approach prior to transplant and the outcomes of the transplant surgery in the early postoperative period and long-term graft function. Further research looking at this comparison along with objective assessment of graft outcomes as well as pharmacokinetics of immunosuppressant medications after a planned metabolic/bariatric surgery prior to KT are needed. Also, as the use of bariatric surgery as a means for access to transplantation becomes increasingly established, future studies should investigate what the optimal timing of the bariatric surgery is with respect to subsequent transplantation, taking into consideration pre-transplant evaluation and work-up.

Conclusion

The present study demonstrates that SG can be an effective strategy to improve access to KT in patients with advanced CKD and severe obesity. This approach not only does not delay the time to transplantation but efficiently increases transplant candidacy in a marginalized high-risk population that would not otherwise get listed for a transplant at most transplant centers. Transplant recipients also continue to benefit from sustained weight loss and improved related comorbidities that may positively impact their graft function after KT. To further support this, future studies should focus on comparing groups of obese patients with or without prior metabolic/bariatric surgery to elucidate the impact on

immediate KT outcomes as well as long-term graft function. Finally, since timely access to bariatric surgery is not always possible at each transplant center and likely worsened in the aftermath of COVID-19 pandemic, when feasible, special access programs to enhance communication between different specialties and to fast track these patients are crucial.

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