ORIGINAL ARTICLE

Laparoscopic sleeve gastrectomy for morbid obesity in renal transplantation candidates: a matched case–control study

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ABSTRACT

Obesity has become an important issue in patients with end-stage renal disease (ESRD). Since it is considered a relative contraindication for renal transplantation, bariatric surgery has been advocated to treat morbid obesity in transplant candidates, and laparoscopic sleeve gastrectomy (LSG) is the most reported procedure. However, comparative data regarding outcomes of LSG in patients with or without ESRD are scarce. Consecutive patients with ESRD ($n = 29$) undergoing LSG were compared with matched patients with normal renal function undergoing LSG in a 1:3 ratio using propensity score adjustment. Data were collected from a prospective database. Eligibility for transplantation was also studied. A lower weight loss (20 kg (16–30)) was observed in patients with ESRD within the first year as compared to matched patients (28 kg (21–34)) ($P < 0.05$). After a median follow-up of 30 (19–50) months in the ESRD group, contraindication due to morbid obesity was lifted in 20 patients. Twelve patients underwent transplantation. In patients with ESRD potentially eligible for transplantation, LSG allows similar weight loss in comparison with matched patients with normal renal function, enabling lifting contraindication for transplantation due to morbid obesity in the majority of patients within the first postoperative year.

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Key words
bariatric surgery, chronic kidney disease, dialysis, end-stage renal disease, morbid obesity, sleeve gastrectomy

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Introduction

The prevalence of obesity is increasing in patients with end-stage renal disease (ESRD) as observed in the general population across the world [1]. Moreover, obesity has shown to be a strong risk factor for ESRD [2] and the proportion of patients with morbid obesity presenting for renal transplant evaluation demonstrated an exponential rise [3,4]. Because obesity has shown to increase morbidity in transplant recipients [5] and to decrease renal graft survival [6], weight reduction is recommended in patients with a body mass index (BMI) > 30 kg/m^2 before transplantation [7]. In patients with ESRD and morbid obesity, a decrease in

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BMI after the initiation of dialysis is associated with a subsequent improvement in the likelihood of access to renal transplantation [8]. As in general population, medical management leads to insufficient weight loss [9]. Therefore, bariatric surgery has become a popular method to reduce BMI and increase eligibility for transplantation in patients with ESRD and morbid obesity [10].

Laparoscopic sleeve gastrectomy (LSG) has become one of the most performed bariatric procedures worldwide. Compared with gastric bypass surgery, LSG is technically less challenging, faster, has lower postoperative morbidity [11] and shows comparable results regarding excess weight loss [12]. LSG does not affect intestinal drug absorption, which will be significant in the context of renal transplantation requiring immunosuppressive therapy with a narrow window for the therapeutic activity. Besides, Roux-en-Y gastric bypass promotes hyperoxaluria that could potentially lead to chronic kidney disease [13]. Indeed, LSG is the most frequently reported surgical technique to overcome the barrier of obesity in patients with ESRD eligible for renal transplantation [14–21].

Although safety of LSG has been evaluated in patients with ESRD [14–21], only limited comparative data specifically focusing on weight loss and co-mordities evolution are available [22]. The aim of this case–control study was to compare the outcomes of LSG in patients with dialysis-dependent ESRD potentially eligible for renal transplantation versus patients with normal renal function with regard to morbidity, weight loss, and co-morbidity resolution. Patients' final access to renal transplantation and transplantation outcomes were also studied.

Patients and methods

Between March 2013 and July 2018, data from all consecutive patients with ESRD on dialysis potentially eligible to renal transplantation who underwent LSG were prospectively collected and retrospectively analyzed after institutional review board approval. All patients were informed about perioperative and intraoperative management, and informed consent was obtained before surgery. Patients were operated on at University Hospital Antoine Béclère, Clamart (France), which is a first level bariatric center and part of the specialized center for obesity Paris-Sud. All patients were followed by a nephrologist at a transplantation center in Bicêtre Hospital, Le Kremlin-Bicêtre (France), and were registered on transplantation waiting list but were temporarily contraindicated for transplantation due to morbid obesity (BMI $\geq$ 35 kg/m^2).

All patients underwent preoperative evaluation by a multidisciplinary team with standard investigations by endoscopy, imaging, polysomnography, endocrinologic, psychiatric, and nutritional evaluations. Patients were eligible for surgery according to French guidelines [23] (BMI $\geq$ 40 kg/m^2 or BMI between 35 and 40 kg/m^2 with significant co-morbidities after failed medical management program), and the indication was validated during a multidisciplinary staff meeting 1 month before surgery.

The procedure was performed on a day after dialysis. In the early postoperative period, patients were systematically transferred to the intensive care unit (ICU) for monitoring and a dialysis session the day after surgery. This first postoperative dialysis in ICU was performed without systemic anticoagulation using a heparin-grafted membrane. For this reason, postoperative ICU hospitalization was not considered as an adverse event. Following dialysis sessions were performed with systemic anticoagulation in patients' regular dialysis centers. Surgical technique of LSG was performed as previously described [24]. Transection of the stomach was done using a 60-mm endoscopic stapler after placement of a 36-Fr orogastric calibration tube. Reinforcement of the staple line with buttressing material, suture, or glue was not performed routinely, nether was intraoperative methylene blue dye test nor abdominal drainage. Thromboprophylaxis was performed by external pneumatic compression during surgery and administration of heparin sodium for a period of 2 weeks in the postoperative period. Patients were allowed free liquid intake the day after surgery allowing oral drug administration and placed on a semi-liquid diet 2 days after surgery. Proton-pump inhibitor was prescribed for at least 1 month. Patients were monitored with a standard 5-year follow-up program consisting of four visits to the outpatient clinic during the first postoperative year and biannual consultation for the next 4 years. Follow-up was supervised by a multidisciplinary team in connection with personal physicians and patient associations. Follow-up program was similar to the non-dialysis-dependent patients. All patients continued follow-up with their nephrologist postoperatively and were reevaluated for transplant candidacy on a case-by-case basis by the transplantation team.

Demographic data were obtained from a prospective electronic database with additional retrospective medical records reviewed when necessary. Data recorded concerning bariatric surgery included patients'

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characteristics, perioperative course, and follow-up details. Complication severity was stratified according to the modified Clavien classification. If a patient had two or more complications, the most severe was taken in account. Complications and operative mortality considered were those that occurred within 90 days of surgery, or at any time during the postoperative hospital stay. Staple-line leakage was regarded as a complication when an intra-abdominal abscess, requiring drainage or antibiotic treatment, was found on computed tomography (CT) scan or during relaparoscopy. Weight loss and remission of co-morbidities were evaluated. In the ESRD group, dry weight was considered for weight loss evaluation. Discontinuation of all medication for the treatment of a co-morbidity or of continuous positive airway pressure (CPAP) in patients with obstructive sleep apnea syndrome (OSAS) was regarded as remission. Percentage total weight loss (TWL) was calculated using the following formula: %TWL = [weight loss (kg)/total weight (kg)] × 100. Percentage excess weight loss (EWL) was calculated using the following formula: %EWL = [weight loss (kg)/ excess weight (kg)] X 100. Excess weight was based on the patient's ideal weight, with a BMI of 25 kg/m^2. Data recorded concerning renal transplantation included etiology of renal failure, perioperative outcomes, and long-term outcomes.

The ESRD group comprised patients temporarily contraindicated for transplantation due to morbid obesity who underwent LSG. The control group comprised matched patients with normal renal function (defined as estimated glomerular filtration rate ≥ 90 ml/min/1.73 m^2) who underwent LSG during the same period. Matching was done using a propensity score adjustment performed using binary logistic regression on the main factors known to potentially influence postoperative outcomes. The latter included baseline characteristics (sex, age, American Society of Anesthesiologists (ASA) grade, BMI), co-morbidities (diabetes, OSAS, hypertension, dyslipidemia, cardiovascular disease), history of previous abdominal surgery, and use of antiplatelet and/or anticoagulant therapy. Nearest neighbor matching was performed in a 1:3 ratio, and a caliper width of 0.01 SD was specified. Quantitative variables are expressed as mean ± standard deviation (SD) or median and interquartile range (IQR). Qualitative variables were compared using the chi-square test or Fisher exact test, as appropriate. Quantitative variables were compared using the Student t-test or the Mann–Whitney test, as appropriate. Values of $P < 0.05$ were considered statistically significant. Kaplan–Meier analysis was used to assess transplantation rates after LSG and was reported with 95% confidence interval (CI). Statistical analysis was carried out with SPSS software (IBM Company, New York, NY, USA).

Results

Characteristics of patients

During the study period, 1436 patients underwent LSG including 29 patients (2.0%) registered on renal transplantation waiting list but temporarily contraindicated for transplantation due to morbid obesity (median BMI = 39.3 (37.2–43.1) kg/m^2). Those 29 patients were successfully matched to 87 patients with normal renal function who underwent LSG during the same period. Three patients from the ESRD group were initially treated with an intragastric balloon and were referred to our center for insufficient weight loss. All patients in this study underwent LSG as a primary surgical bariatric procedure. The etiology of renal failure was mainly diabetes (n = 10) or hypertension (n = 9), and all patients in the ESRD group were treated with hemodialysis three times per week. The mean dialysis duration before LSG was 45 ± 32 months. Baseline characteristics of matched cohort including co-morbidities are depicted in Table 1.

Operative and postoperative outcomes

Operative time was similar in both groups, and LSG were performed successfully without conversion to laparotomy and without significant (>100 ml) intraoperative bleeding. An additional trocar was needed in one patient of the ESRD group due to difficulty in exposure. One patient in each group required an abdominal drain at the end of the procedure. Postoperative morbidity was statistically similar in both groups despite a minor increase in the ESRD group (4/29 vs. 10/87, P = 0.742). Severe complication (Dindo-Clavien Grade ≥ IIIa) rates were similar in both groups including two patients from the ESRD group: one suspicion of staple-line leak (unfirmed by surgical and endoscopic explorations) and one dysphagia successfully treated with endoscopic naso-jejunal feeding tube placement and exclusive enteral nutrition during 5 days. All patients in the ESRD group were transferred to the ICU (internal procedure) for monitoring and a dialysis session the day after surgery while 7 patients (8.0%) of the control group required postoperative ICU hospitalization. Global length of stay in the ESRD group was two days longer than in the control group. Operative and

Table 1. Baseline characteristics of matched cohorts

Characteristic	ESRD (n = 29)	Control (n = 87)	P
Gender (female/male)	15/14	56/31	0.226
Age at LSG, year, mean ± SD	52 ± 12	50 ± 11	0.316
ASA grade ≥ III, *n* (%)	29 (100)	80 (91.9)	0.115
Weight at LSG, kg, median (IQR)	117 (100–132)	113 (103–130)	0.872
BMI at LSG, kg/m^2, median (IQR)	39.3 (37.2–43.1)	39.6 (37.2–46)	0.865
Previous history of intragastric balloon, *n* (%)	3 (10.3)	0	–
Previous abdominal surgery			
Overall, *n* (%)	12 (41.3)	48 (55.1)	0.198
Upper abdominal surgery, *n* (%)	4 (13.7)	16 (18.4)	0.570
Etiology of kidney failure			
Diabetes, *n* (%)	10 (34.5)	–	–
Hypertension, *n* (%)	9 (31)	–	–
Urologic disorders, *n* (%)	4 (13.8)	–	–
FSGS, *n* (%)	3 (10.3)	–	–
Pre-eclampsia, *n* (%)	1 (3.4)	–	–
Idiopathic nephrotic syndrome, *n* (%)	1 (3.4)	–	–
Unknown, *n* (%)	1 (3.4)	–	–
Dialysis, *n* (%)	29 (100)	–	–
Dialysis duration before LSG, month, mean ± SD	45 ± 32	–	–
Co-morbidities			
Diabetes, *n* (%)	16 (55.1)	37 (43.7)	0.513
Hypertension, *n* (%)	28 (96.5)	83 (95.4)	0.791
Dyslipidemia, *n* (%)	16 (55.1)	45 (51.7)	0.747
OSAS, *n* (%)	20 (68.9)	56 (64.3)	0.651
Cardiovascular disease, *n* (%)	14 (48.3)	38 (43.7)	0.666
Fatty liver disease, *n* (%)	5 (17.2)	25 (28.7)	0.220
Antiplatelet and/or anticoagulant therapy, *n* (%)	11 (37.9)	22 (25.3)	0.191
Tobacco use, *n* (%)	2 (6.9)	5 (5.7)	0.821

ESRD, end-stage renal disease; LSG, sleeve gastrectomy; SD, standard deviation; ASA, American Society of Anesthesiologists; IQR, interquartile range; BMI, body mass index; FSGS, focal segmental glomerulosclerosis; OSAS, obstructive sleep apnea syndrome.

postoperative outcomes of matched cohort are depicted in Table 2.

Weight loss, co-morbidities evolution, and nutritional assessment

All patients completed one-year follow-up, and at the time of analysis, median follow-up was 6 months longer in the ESRD group (30 (19–50) vs. 24 (12–29) months). A higher weight loss at 3, 6, and 12 months after surgery was initially observed in the control group. Similarly, a higher percentage of total weight loss (%TWL) at 3 months after surgery was initially observed in the control group but this difference disappeared at 6 months. On the contrary, %EWL and BMI reduction remained globally similar in both groups during the follow-up. Co-morbidities resolution 12 months following the procedure was higher in the control group concerning diabetes (1/29 vs. 21/87, $P < 0.001$), hypertension (7/29 vs. 40/87, $P = 0.031$), and dyslipidemia (1/29 vs. 33/87, $P < 0.001$). On the contrary, OSAS resolution was similar in both groups ($P = 0.166$). An improvement of median glycated hemoglobin was observed one year after surgery in the ESRD group (7.2 (5.8–8.7) % vs. 6.3 (5.5–6.7) %, $P = 0.023$). However, no difference was observed in glycated hemoglobin evolution between both groups ($P = 0.492$) one year after surgery. Weight loss and co-morbidities evolution of matched cohort are depicted in Table 3. Nutritional assessment was available one year after LSG in 25 patients in the ESRD group. A lower level of vitamin B9 was observed in the ESRD group (13.7 (7.8–49.7) vs. 24.9 (8.2–36.1) nmol/l, $P = 0.047$). Other nutritional parameters are presented in Table 4.

During the follow-up, twenty patients on the waiting list became eligible for kidney transplantation because

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Table 2. Operative and postoperative outcomes of matched cohorts

Outcome	ESRD (*n* = 29)	Control (*n* = 87)	*P*
Operative time, min, median (IQR)	85 (71–106)	84 (70–112)	0.943
No additional extraport, *n* (%)	28 (96.5)	87 (100)	0.081
Conversion to laparotomy, *n* (%)	0	0	–
Additional procedure, *n* (%)	0	0	–
Significant intraoperative bleeding (>100 ml), *n* (%)	0	0	–
Abdominal drainage, *n* (%)	1 (3.4)	1 (1.1)	0.410
90-day postoperative complications, *n* (%)	4 (13.8)	10 (11.5)	0.742
Bleeding (intra-abdominal or intraluminal), *n* (%)	1 (3.4)	3 (3.4)	1.000
Staple-line leak, *n* (%)	0	2 (2.3)	0.410
Pyelonephritis, *n* (%)	1 (3.4)	0	0.082
Dysphagia, *n* (%)	1 (3.4)	1 (1.1)	0.410
Fever of unknown origin, *n* (%)	1 (3.4)	0	0.082
Pleural effusion, *n* (%)	0	1 (1.1)	0.562
Dyspnea, *n* (%)	0	1 (1.1)	0.562
Chest pain, *n* (%)	0	1 (1.1)	0.562
Incisional abscess, *n* (%)	0	1 (1.1)	0.562
Dindo–Clavien Grade ≥ IIIa, *n* (%)	2 (6.9)	6 (6.9)	1.000
Mortality, *n* (%)	0	0	–
Readmission (30-day)	0	1 (1.1)	0.562
Incisional hernia, *n* (%)	1 (3.4)	4 (4.6)	0.791
ICU hospitalization, *n* (%)	29 (100)	7 (8.0)	–
ICU length of stay, day, median (IQR)	4 (3–5)	0 (0–0)	–
Length of stay, day, median (IQR)	6 (5–8)	4 (4–4)	–

ESRD, end-stage renal disease; IQR, interquartile range; ICU: intensive care unit.

of sufficient weight loss. Twelve patients have been transplanted. One-year and two-year transplantation rates after LSG were 11.5 (0.1–49.8) and 30.4 (7.9–57.2), respectively (Fig. 1a). In these patients, median BMI at renal transplantation was 30.1 (26.9–33.3) kg/m^2 whereas their median BMI before LSG was 39.8 (37.4–42.5). The median follow-up after transplantation was 17 (9–33) months, and BMI at last follow-up visit after transplantation remained stable (median BMI = 29.5 (22–50.3) kg/m^2).

Outcomes of renal transplantation

At the time of analysis, corresponding to a median follow-up of 30 (19–50) months in the ESRD group, the contraindication for renal transplantation due to morbid obesity was lifted in 20 patients with a median delay between LSG and waiting list registration of 9 (6–11) months. One-year and two-year lift of contraindication rates after LSG were 61.5 (44.6–74.6) and 65.4 (49.7–77.2), respectively (Fig. 1b). In the remaining 9 patients, contraindication for renal transplantation was not lifted because of insufficient weight loss in 4 cases, vascular disorders in 1 case, ongoing screening in a hyperimmunized patient in 1 case, and time interval <6 months after LSG in three patients.

Twelve patients underwent renal transplantation including one renal and pancreas transplantation and one living donor transplantation. One patient in whom weight-related contraindication was not lifted at the time of renal transplantation was transplanted in emergency 8 months after LSG with a BMI of 48.5 kg/m^2 due to complications of arteriovenous hemodialysis access. Median time interval between LSG and kidney transplantation was 24 (15–31) months. One patient underwent graft loss during the immediate post-transplantation period and one patient during the first year of follow-up because of vascular thrombosis. One of them was retransplanted successfully one year after. The median serum creatinine in kidney transplant recipients at last follow-up visit was 179 (116–299) µmol/l.

Other post-transplantation complications included two postoperative infections: a 67-year-old male patient who had an unexplained postoperative septic shock followed by neurologic complications and finally died one year after transplantation with a functioning kidney, and a 38-year-old female patient who presented an obstructive pyelonephritis after a renal and pancreas

Table 3. Weight loss and co-mordities evolution of matched cohorts

Outcome	ESRD (n = 29)	Control (n = 87)	P
Follow-up after LSG, month, median (IQR)	30 (19–50)	24 (12–29)	–
Weight loss, kg, median (IQR)			
3 months postsurgery	13 (10–19)	19 (14–22)	0.007
6 months postsurgery	19 (15–25)	22 (19–30)	0.031
12 months postsurgery	20 (16–30)	28 (21–34)	0.049
BMI reduction, kg/m^2, median (IQR)			
3 months postsurgery	8.4 (5.6–11.7)	6.8 (5.6–8.1)	0.071
6 months postsurgery	10.2 (6.9–14)	8.5 (6.7–11)	0.192
12 months postsurgery	11.8 (7.1–15.7)	9.9 (7.6–12.1)	0.251
%TWL, median (IQR)			
3 months postsurgery	12 (10–16.2)	15.9 (11.6–19.4)	0.017
6 months postsurgery	17.7 (13–21.5)	20 (17–23.2)	0.085
12 months postsurgery	20.5 (14–27.1)	23 (19–29)	0.109
%EWL, median (IQR)			
3 months postsurgery	33.8 (22.8–46.6)	42.5 (28.2–55.7)	0.216
6 months postsurgery	54.6 (31.7–63.6)	53.5 (38.5–70.2)	0.526
12 months postsurgery	57.9 (38.7–81.1)	61 (43–81)	0.542
Co-morbidities resolution 12 months postsurgery			
Diabetes resolution, n (%)	1 (6.2)	21 (56.7)	<0.001
Hypertension resolution, n (%)	7 (25)	40 (48.2)	0.031
Dyslipidemia resolution, n (%)	1 (6.2)	33 (73.3)	<0.001
OSAS resolution, n (%)	9 (45)	24 (42.8)	0.166

ESRD, end-stage renal disease; LSG, sleeve gastrectomy; IQR, interquartile range; BMI, body mass index; TWL, total weight loss; EWL, excess weight loss; OSAS, obstructive sleep apnea syndrome.

Table 4. Nutritional parameters one year after LSG of Matched Cohorts

Outcome	ESRD (n = 25*)	Control (n = 87)	P
Hemoglobin, g/dL, median (IQR)	13.2 (12.4–14.8)	13.4 (12.2–14.7)	0.231
Serum albumin, g/l, median (IQR)	42.6 (38.2–45.2)	41.3 (37.6–43.6)	0.452
Serum prealbumin, g/l, median (IQR)	0.4 (0.32–0.5)	0.3 (0.27–0.55)	0.524
Serum ferritin, µg/l, median (IQR)	174 (92–338)	184 (87–360)	0.095
Serum calcium, mmol/l, median (IQR)	2.36 (2.20–2.46)	2.27 (2.12–2.42)	0.123
Vitamin B9, nmol/l, median (IQR)	13.7 (7.8–49.7)	24.9 (8.2–36.1)	0.047
Vitamin B12, pmol/l, median (IQR)	332 (307–379)	317 (298–393)	0.256
Vitamin D, ng/ml, median (IQR)	33 (21–39)	25.1 (15.8–34.4)	0.172

LSG, laparoscopic sleeve gastrectomy; ESRD, end-stage renal disease.

*Available data

transplantation which was treated with antibiotics and endoscopic management. A 70-year-old female patient died 18 months after transplantation with a functioning kidney of unknown cause. Outcomes concerning renal transplantation are depicted in Table 5.

Discussion

Bariatric surgery in patients requiring organ transplantation is likely to have an important future due to the combined influence of the increasing prevalence of obesity across the developed and developing countries [25] and the global increase of the number of patients requiring organ transplantation [26]. The efficiency of the LSG in terms of weight loss and resolution of co-morbidities, but also its relative simplicity have participated in establishing LSG as the primary procedure for many bariatric teams [24,27]. Our analysis demonstrates that LSG in patients with ESRD potentially eligible for renal transplantation is a safe and efficient approach

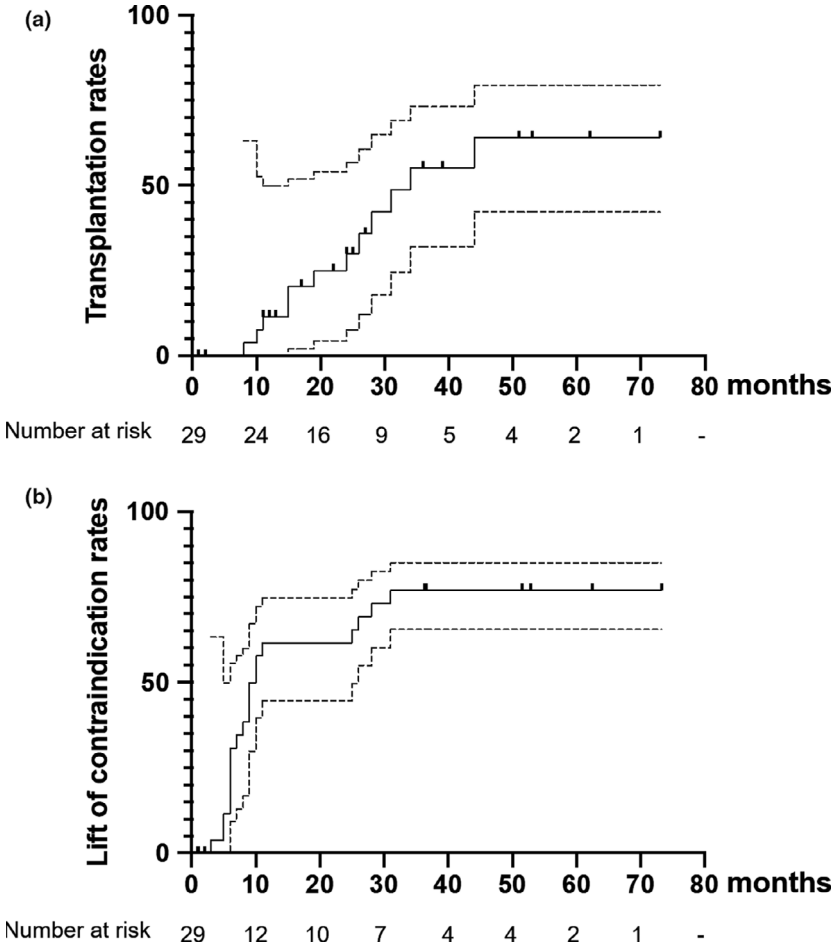

Figure 1 Kaplan–Meier plot with 95% confidence interval of time to renal transplantation (a) and lift of contraindication to transplantation (b) in the ESRD group.

allowing similar weight loss in comparison with comparable patients with normal renal function. Moreover, LSG enables to lift the contraindication for renal transplantation due to morbid obesity in the majority of patients within less than one year of postoperative follow-up.

The safety of the bariatric procedure is of particular importance in an especially vulnerable population of patients. Several reports have already demonstrated the feasibility and safety of LSG in patients with ESRD [14–21]. In a large national study, Andalib et al. [28] reported a higher prevalence of global and major morbidity in patients on chronic dialysis undergoing bariatric surgery. However, in their analysis dependence on dialysis did not independently increase the risk of adverse outcomes but it was attributed in this group of patients to older age, male sex, higher BMI, cardiac comorbidities, and hypertension. Our case-matched study confirms that operative and postoperative results are globally similar when comparing two groups of comparable patients. A minor nonstatistically significant increase of morbidity was though observed in the ESRD group (4/29 vs. 10/87, $P = 0.742$) and an intrinsic fragility in patients with ESRD must be anticipated. The higher prevalence of sarcopenic obesity in this group of patients [29] might explain this intrinsic fragility. Indeed, sarcopenia and sarcopenic obesity have been associated with inferior surgical outcome after abdominal surgery [30]. More specifically, sarcopenic obesity was demonstrated to be directly associated with an increased risk of postoperative morbidity after LSG [31]. Chronic kidney disease accelerates muscle wasting through nutritional deficiency, metabolic acidosis, vitamin D deficiency, mineral bone disorders, insulin resistance, proteinuria, and chronic inflammation [32]. Sarcopenic obesity could be anticipated in patients with ESRD using preoperatively radiological examination as it was reported [31] and the interest of dietary preparation with or without exercise training programs before bariatric surgery should be discussed.

Table 5. Outcomes of renal transplant patients

Outcome	ESRD (n = 29)
Follow-up after LSG, month	30 (19–50)
Active on transplant waiting list, *n* (%)	20 (68.9)
Delay between LSG and active waiting list, month, median (IQR)	9 (6–11)
Renal transplantation, *n* (%)	12 (41.4)
Delay between LSG and transplantation, month, median (IQR)	24 (15–31)
Weight at transplantation, kg, median (IQR)	91 (80–96)
BMI at transplantation, kg/m^2, median (IQR)	30.1 (26.9–33.3)
Deceased donor, *n* (%)	11 (91.7)
Living donor, *n* (%)	1 (8.3)
Renal and pancreas transplantation, *n* (%)	1 (8.3)
Perioperative complications	
Postoperative infection, *n* (%)	2 (16.7)
Graft loss, *n* (%)	1 (8.3)
Long-term outcomes	
Graft loss, *n* (%)	1 (8.3)
Retransplantation, *n* (%)	1 (8.3)
Mortality, *n* (%)	1 (8.3)

ESRD, end-stage renal disease; LSG, sleeve gastrectomy; IQR, interquartile range; BMI: body mass index.

To our knowledge, this is the largest case-matched study to evaluate the efficacy of bariatric surgery in terms of weight loss in patients with ESRD who are dependent on dialysis. Hansel et al. [22] recently reported a retrospective comparative study assessing weight loss at 6 and 12 months according to estimated glomerular filtration rate categories. They observed that patients with severe chronic renal failure or ESRD including patients on dialysis had impaired weight loss compared with others categories of patients including patients with normal renal function. Those results are not consistent with the results observed in our analysis. Although, in our study patients with normal renal function presented a higher weight loss within the first year of postoperative follow-up, this difference was no longer present at the last follow-up visit postsurgery. Besides, %EWL and BMI reduction remained similar in both groups during the follow-up, even in the 12 patients that underwent renal transplantation. In the study of Hansel et al. [22], four surgical centers participated to the recruitment of 101 patients and only 12 patients on dialysis. This limited number of patients with ESRD per center could clearly have biased the results observed as specific management can clearly affect this vulnerable population of patients. The good results in our analysis might be the results of a close and careful follow-up, which is almost as important as the quality of surgery to achieve effective weight loss. Indeed, all patients in our department are followed in a dedicated day-care unit, which enable patient adherence. A close contact with the nephrology department is also crucial as patients with ESRD are mainly followed after surgery by their nephrologist. Besides, a particular attention is paid to stimulate patients, one month after surgery to regularly practice sport (45 min at least two times per week), which is not simple for patients that are dialyzed three times per week. For that purpose, all patients are involved in a pre- and postbariatric surgery coaching program of physical activity. Indeed, energy expenditure is reduced in patients with chronic kidney disease as resting expenditure is lower due to reduced lean body mass and ESRD is associated with a decrease in daily activity due to patients frailty and sedentary lifestyle [33].

Results concerning co-morbidities evolution are more difficult to analyze. Indeed, very limited resolution of diabetes, hypertension, and dyslipidemia was observed one year after surgery in the group of patients with ESRD. Actually, in our analysis, only discontinuation of all medication for the treatment of a co-morbidity was regarded as remission and most patients on dialysis have continuous treatment for diabetes, hypertension, and dyslipidemia whatever their weight. Besides, in the ESRD group, 10 over 16 patients with diabetes presented type 1 diabetes, which might have underestimated the impact of bariatric surgery on diabetes resolution. Yet, a similar improvement of glycated hemoglobin was observed in both groups one year after surgery and OSAS resolution which is directly linked to weight loss was similar in both groups.

Morbid obesity is a barrier to renal transplantation. Indeed, access to the surgical site may be compromised by the abdominal wall and intra-abdominal fat. In addition to these potential technical difficulties, these high-risk patients have poor short- and long-term outcomes after transplantation, simplifying the decision to allocate limited organs to lower BMI patients. At our institution, we have adopted a BMI of 35 kg/m^2 as a relative contraindication to renal transplantation, although all patients are reviewed on a case-by-case basis in a multidisciplinary setting to determine candidacy for transplantation. In this high-risk population, the present study validates LSG as an approach allowing lifting the contraindication to renal transplantation in the majority of the patients within less than one year of postoperative follow-up. In the 12 patients that underwent renal transplantation, two graft losses were observed during

the follow-up because of vascular thrombosis. One of these two patients had an initial BMI of 58 kg/m^2 and was transplanted in emergency 8 months after LSG with a BMI of 48.5 kg/m^2 due to complications of arteriovenous hemodialysis access. Although LSG allowed planning renal transplantation in the majority of patients, most patients still presented obesity (BMI $\geq$ 30 kg/m^2) at transplantation, which clearly affects post-transplantation outcomes. Kim et al. [18] compared the outcomes of patients with morbid obesity that underwent LSG before renal transplantation to patients who did not undergo bariatric surgery before transplantation. Patients were matched, among others factors, for BMI at transplantation. Perioperative complications, allograft survival, and patient survival were similar between groups. Compared with non-LSG patients, post-LSG recipients had essentially lower rates of delayed graft function and renal dysfunction-related readmission.

This study has several limits that should be underlined. First, despite the use of prospective electronic database, our analysis is exposed to inherent classical bias due to its retrospective nature. Besides, although this is the largest case-matched study to evaluate the efficacy of bariatric surgery in terms of weight loss in patients with ESRD who are dependent on dialysis, the number of patients is still limited and these results have to be confirmed by a larger cohort. Particularly, only 12 patients finally underwent renal transplantation during the follow-up and thus post-transplantation results might be biased. Data concerning the evolution of several biological indicators of interest (as glycemia or serum albumin) is lacking. Finally, a longer follow-up would allow assessing more precisely the impact of LSG on global weight loss in patients with ESRD, and on renal transplant candidacy as well as weight evolution after transplantation.

In conclusion, the present comparative series validates LSG in patients with ESRD potentially eligible for renal transplantation as a safe and efficient procedure. This approach allows lifting the contraindication for renal transplantation due to morbid obesity in the majority of patients within less than one year of postoperative follow-up.

Authorship

GM: participated in data collection and writing the manuscript. TH: participated in data analysis and research design and in writing the manuscript. BS: contributed to the experimental design and interpretation of results. LA: contributed to the experimental design and interpretation of results. VC: Sebastian participated in data collection. LP: assisted in data analysis and correcting the paper. CR: participated in interpretation of the results and data collection. PG: participated in study conception and supervision of the research. PB: participated in data collection. HY: participated in research design and interpretation of the results. DA: participated in supervision of the research and correcting the paper and is co-senior author. DI: participated in supervision of the research and correcting the paper and is co-senior author.

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Conflict of interest

The authors declare no conflicts of interest.

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