Comparison of Kidney Transplantation Outcomes Between Patients with and Without Pre-transplantation Bariatric Surgery: a Systematic Review

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Abstract

This systematic review evaluated the impact of bariatric surgery, performed to improve eligibility for kidney transplantation, on post-transplantation outcomes. A systematic literature search was performed for articles published by 30 January 2022. A total of 31 studies were included. Among patients without pre-transplantation bariatric surgery, 18 studies reported 13.7% graft loss and 9.1% mortality within 5 years' post-transplantation. Among recipients with pre-transplantation bariatric surgery, 15 studies reported 8.7% graft loss and 2.8% mortality within 1 month to over 5 years' post-transplantation. Two case–control studies comparing post-transplantation outcomes between recipients with and without prior bariatric surgery demonstrated no significant differences between groups for graft loss, patient mortality, delayed graft function, wound complications and lymphocele. Non-randomized selection of patients and different lengths of follow-up limit the results of this study.

Keywords Kidney transplantation · Severe obesity · Bariatric surgery · Systematic review

Introduction

Obesity, the state of excessive adipose tissue accumulation, is associated with multiple comorbidities such as diabetes, hypertension and atherosclerosis and is an independent risk factor for chronic kidney disease (CKD) [1, 2]. Severe obesity, defined as body mass index (BMI) ≥ 35 kg/m², has emerged as a public health challenge. In 2014, the global prevalence of severe obesity was 2.3% in men and 5.0% in women had, and it was forecasted that 6% of men and 9% of women will have been severely obese by 2025 worldwide [3]. Compared to the healthy weight population (BMI 18.5–24.9 kg/m²), individuals with severe obesity are 1.5 times more at risk of premature all-cause mortality [4, 5]. Concurrently, from 1990 to 2017, the global prevalence of CKD has also increased by 30% from 1990, reaching 700 million cases worldwide; and in parallel with increasing availability of renal replacement therapy over this time period, the global incidence end stage kidney disease (ESKD) treated by dialysis and kidney transplantation increased by 43.1% and 34.4%, respectively [6].

Kidney transplantation remains the definitive therapy for patients with ESKD [7]; however, obesity remains a risk factor for kidney transplantation, as
many institutions still consider BMI $\geq 40 \text{ kg/m}^2$ as an absolute contraindication and BMI 35–39.9 kg/m$^2$ as a relative contraindication to kidney transplantation [8]. Despite successful outcomes, kidney transplantation in obese recipients is reportedly associated with increased wound complications, acute rejection and delayed graft function as well as lower graft loss and patient mortality rates within 3 years post-transplant, in comparison with their non-obese counterparts [9]. In order to minimize such complications, pre-transplantation weight reduction for obese candidates is usually advised [9].

Bariatric surgery is recognized as the most rapid, most effective and sustainable treatment of severe obesity and its comorbidities, including type 2 diabetes mellitus, hypertension and dyslipidemia, as compared to other weight loss strategies [10, 11]. A meta-analysis containing studies with over 10 years of follow-up data on weight loss after bariatric surgery demonstrated excess weight loss percentage (EWL%) to be 56.7% after gastric bypass, 58.3% after sleeve gastrectomy and 45.9% after adjustable gastric banding [12].

Bariatric surgery improves eligibility for kidney transplantation in candidates with severe obesity [13]. Besides, patients with severe obesity and ESKD have an increased all-cause mortality risk, that is shown to decrease following bariatric surgery [13], but this may be at the cost of slight increases in the risks of infections, cardiovascular events and graft dysfunction [14, 15]. Hence, it is unclear whether the potential benefits of pre-transplantation weight loss via bariatric surgery outweigh the surgical risks in renal transplant candidates with severe obesity.

Although a number of studies have shown that bariatric surgery in patients with severe obesity improves access to kidney transplantation following significant weight loss, a review of the literature assessing post-transplantation outcomes in these patients was lacking. Therefore, we aimed to systematically review post-transplantation outcomes between morbidly obese patients with and without pre-kidney transplantation bariatric surgery.

**Methods**

This systematic review was guided by the Cochrane Handbook for Systematic Reviews of Interventions [16] and conforms to the reporting guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement recommendations [17]. The systematic review protocol was registered on PROSPERO (registration number CRD42021224801).

**Inclusion and Exclusion Criteria**

The Population, Intervention, Comparison, and Outcome (PICO) framework was used (Supplementary Table 1), to formulate the inclusion and exclusion criteria.

**Cohort**

Kidney recipient candidates aged 18 years or above with severe obesity undergoing bariatric surgery pre-transplantation were included. Patients who had bariatric surgery after or at time of kidney transplantation were excluded.

**Interventions**

Bariatric procedures such as adjustable gastric banding, sleeve gastrectomy, or gastric bypass performed prior to kidney transplantation were considered. Studies including dietary or medical interventions for pre-transplantation weight loss were excluded.

**Comparator**

Patients with severe obesity who underwent kidney transplantation without any documented attempts at weight loss were included. We excluded multi-organ transplant recipients.

**Outcomes**

**Primary** Kidney graft loss and patient mortality.

**Secondary** Acute rejection, delayed graft function and post-transplantation complications including systemic infections (e.g. pneumonia, urinary tract infection and cytomegalovirus reactivation), wound dehiscence/infection and lymphocele.

Any study reporting either primary or secondary outcomes was included, and those without post-transplantation follow-up were excluded. We limited the outcomes of interest to 5 years of follow-up in order to minimize information bias.

**Search Strategy**

The Excerpta medica (EMBASE), PubMed and Scopus were searched from inception up to 30 January 2022 for studies meeting previously stated inclusion criteria. We only included papers written in English, due to limited translation resources. The following search terms were used: ‘bariatric surgery’/exp, ‘metabolic surgery’/exp, ‘gastric banding’/
exp, ‘sleeve gastrectomy’/exp, ‘gastroplasty’/exp, ‘gastric bypass’/exp, ‘morbid* obes*’, ‘severe* obes*’, ‘renal transplant*’ and ‘kidney transplant*’ (Supplementary Table 2).

Title and abstract screening as well as full-text reviews were performed by two independent reviewers (PM and EZ). Any disagreements were resolved via a third reviewer (JL). Additionally, reference lists from included texts were reviewed for studies suitable for inclusion. Whenever further clarification was required, corresponding authors of the eligible studies were contacted.

**Data Extraction and Critical Appraisal**

Two reviewers (PM and EZ) independently extracted data. The collected information included first author’s name, year of publication, country, study design, number of participants, mean age, sex proportion, duration of follow-up and the outcomes of interest following kidney transplantation.

The methodological quality of the included studies was assessed independently by two authors (PM and EZ) using the Newcastle–Ottawa scale (NOS) for evaluating the methodological quality of cohort and case–control studies [18] and a modified version of the NOS designed for case reports and case series [19]. The NOS quality assessment tool rates studies in three domains: the selection of the study groups, the comparability of the groups and the ascertainment of the outcome of interest to a maximum of eight stars (four stars for selection, one for comparability and three for exposure domains, respectively). Good study quality was defined as three or four stars in selection domain AND one star in comparability domain AND two or three stars in exposure domain; fair quality was defined as two stars in selection domain AND one or two stars in comparability domain AND two or three stars in exposure domain; and poor quality was defined as no or one star in selection domain OR no stars in comparability domain OR no or one stars in exposure domain. The modified version of NOS uses four domains (selection, ascertainment, causality and reporting) to rate each study with a maximum of eight stars (four stars for selection, one for comparability and three for exposure domains, respectively). Good quality was defined as at least one star in each domain; fair quality was defined as no stars in selection domain, but all other sections starred; and poor quality was defined as no stars in any of the ascertainment, causality or reporting domains. Since the modified version of the NOS was originally adapted for the assessment of drug reactions, a couple of questions in the Causality section were not applicable to our study as they were related to dosage. Any disagreement between the reviewers was resolved via the third reviewer (JL).

**Data Analysis**

Post-kidney transplantation outcomes were grouped according to whether the patient(s) had undergone pre-transplantation bariatric surgery. If more than two randomized clinical trials had derived risk indices for similar outcomes, we aimed to aggregate the data via a meta-analysis Unfortunately, only two non-randomized, retrospective studies were identified via our search, with the remaining studies being case reports and case series; thus, we elected to descriptively analyze our primary outcomes by reported patients’ characteristics including recipients’ age and gender, type of donor (living versus cadaveric), recipients’ BMI at transplantation and type of bariatric surgery. These characteristics were chosen due to their role as potential confounders of our primary and secondary post-kidney transplantation outcomes.

**Results**

The results of the systematic search are shown in Fig. 1. The literature search identified 1300 references. After excluding 233 duplicates, 1067 titles and abstracts were screened for eligibility, from which 908 were excluded. A total of 159 articles were retrieved for full-text review. Forty-seven conference abstracts, five reviews and 55 studies were excluded due to not meeting the inclusion criteria and overlapping cohorts with included studies [20–23]. Out of the remaining 52, corresponding authors of 24 studies were contacted for data on patients who had not been sub-grouped as severe obesity; however, only one author responded, and accordingly, 23 studies had to be excluded. At this stage, two studies were added from hand-searching of a systematic review’s reference list [24]. Finally, 31 studies were reviewed.

**Study Characteristics and Quality Assessment**

Study characteristics for both groups (obese patients undergoing bariatric surgery pre-kidney transplantation and obese patients without bariatric surgery pre-kidney transplantation) are detailed in Table 1 and Table 2. The study quality assessment using NOS for the two case–control studies and a modified version of NOS for case reports and case series is detailed in Table 3.

Sixteen studies reported data from obese kidney transplant recipients without prior bariatric surgery (Table 2) [20, 25–35, 37, 38, 40, 41], all of which were cohort studies, and 14 of them were considered as high quality according to the NOS scale [20, 25, 26, 28–35, 37, 38, 40]. Thirteen studies reported outcomes of patients with bariatric surgery pre-kidney transplantation [21, 23, 42–52]. Seven were retrospective cohort studies, five of these studies were case reports.
Only two studies were considered high quality [42, 49].

**Case–Control Studies**

Only two non-randomized, single-centre, case–control studies from the Netherlands [39] and the USA [36] compared post-kidney transplantation outcomes between recipients with and without prior bariatric surgery.

In one case–control study, 14 patients were transplanted following Roux-en-Y gastric bypass, and 19 recipients were used as historical controls. Apart from mean BMI at the time of transplantation, being expectedly different between patients with pre-transplantation RYGB and the controls (28.9 ± 0.7 kg/m² and 38.6 ± 0.4 kg/m², respectively), no significant difference in baseline characteristics were present between both groups. After 72 months of follow-up, there were no significant differences between both groups for graft loss, patient mortality, delayed graft function, wound complications, infections, and lymphocele rates. Bariatric surgery prior to kidney transplantation was associated with a higher rate of biopsy-proven acute rejection compared to those without bariatric surgery pre-transplantation (6/14 vs 3/19, \( p = 0.03 \)) [36].

The other case–control study compared transplantation outcomes for 23 and 133 kidney transplant recipients with and without prior bariatric surgery, respectively. There were no significant differences in baseline characteristics between the patient groups, other than median BMI at the time of transplantation that was expectedly lower among recipient with prior bariatric surgery (33.8 kg/m²) compared to the controls (36.7 kg/m²) as well as the prevalence of diabetes mellitus, being 39.1% versus 60.9%, respectively (\( p = 0.043 \)) among patients with and without bariatric surgery, respectively. After a median of 61 (range: 14–258) months post-transplantation, no significant differences were present between both groups for graft loss, patient mortality, delayed graft function, wound complications and lymphocele rates. Multivariable Cox proportional hazard analysis showed that a prior history of diabetes mellitus and pre-transplantation dialysis (but not prior bariatric surgery) were independent risk factors for all-cause mortality. Bariatric surgery was associated with greater incidence of after transplantation (odds ratio: 3.37 [1.35–8.40], \( p = 0.007 \)); however, after propensity-score matching, there was no significant difference between both groups for urinary tract infection (odds ratio: 1.42 [0.44–4.53], \( p = 0.384 \)) [39].
| Authors, year | Study design | Country | Patients, n | Sex, n (Male/female) | Age, yr | Donor type, n (Living/Cadaver) | Follow-up, month | Acute rejection | Delayed graft function | Graft loss | Complications, n (cause) | Mortality, n (cause) |
|--------------|--------------|---------|-------------|-------------------|--------|-------------------------------|-----------------|----------------|------------------------|------------|--------------------------|---------------------|
| Marks et al. [25], 2004 | RCoS | USA | 23 | 7/16 | Mean 44.9 | 11/12 | Mean 36 | 0 | 0 | 3 | 7 (Wound infection) | 1 (Bleeding) |
| Cacciola et al. [26], 2008 | RCoS | UK | 24 | 12/12 | 45 (Range 20–61) | 0/24 | Mean 60 | 3 | NR | 9 | 5 (Wound infection) | 2 (Cardiac) |
| Olarte et al. [27], 2009 | RCoS | USA | 43 | NR | NR | NR | Mean 12 | NR | NR | NR | 4 (Pneumonia) | 2 (UTI) |
| Bennett et al. [20], 2011 | RCoS | USA | 94 | 40/54 | Median 51 | 32/62 | Range 12–105.6 | NR | 30 | 12 | 15 (Wound infection) | 4 (Cardiovascular) |
| Ditonno et al. [28], 2011 | PCoS | Italy | 10 | NR | Mean 48 (Range 39–55) | NR | Mean 53 [range 3–112] | 2 | 4 | 0 | 6 (Lymphocele) | 2 (Wound infection) |
| Karabicak et al. [29], 2011 | RCoS | USA | 61 | 35/26 | Mean 47.6 ± 15.8 | 15/46 | Mean 92.8 ± 2.1 | 9 | 11 | 16 | NR | 9 (NR) |
| Curran et al. [30], 2014 | PCoS | Canada | 74 | 35/39 | Mean 50.8 ± 10.4 | 35/39 | Mean 60 | 27 | NR | 27 | NR | 1 (Unknown) |
| Garcia-Roca et al. [31], 2017 | RCoS | USA | 612 | 230/382 | Mean 47.9 | 612/0 | Mean 36 | 12 | 33 | 38 | NR | 15 (Sepsis) |

Table 1: Studies and characteristics of end-stage kidney disease patients with morbid obesity undergoing kidney transplantation without prior bariatric surgery
| Authors, year | Study design | Country | Patients, \( n \) | Sex, \( n \) (Male/female) | Age, yr | Donor type, \( n \) (Living/Cadaver) | Follow-up, month | Acute rejection | Delayed graft function | Graft loss | Complications, \( n \) (cause) | Mortality, \( n \) (cause) |
|--------------|--------------|---------|-----------------|-----------------------------|---------|----------------------------------|-----------------|----------------|------------------------|-----------|-----------------------------|------------------------|
| Tremblay et al. [32], 2016 | RCoS | USA | 57 | 31/26 | Mean 47.9 ± 11.9 | 43/14 | Mean 41 ± 29 | NR | 4 | 8 | NR | NR |
| Schachtner et al. [33], 2017 | RCoS | Germany | 21 | 9/3 | Mean 52 (Range 28–78) | 3/18 | Median 70 (range 0–128) | 6 | 7 | 3 | 4 (Sepsis) | 6 (Wound infection) | 2 (Sepsis) | 1 (Cardiovascular) | 1 (Malignancy) | 1 (Others) |
| Liese et al. [34], 2018 | RCoS | Germany | 15 | 4/11 | Mean 53.6 ± 8.9 | 2/13 | Range 36–96 | 1 | 6 | 3 | 6 (Wound infection) | NR |
| Veasey et al. [35], 2018 | RCoS | USA | 105 | 65/40 | Mean 52 | 97/8 | Mean 6 | NR | 36 | 19 | 1 (UTI) | 2 (Ureteral leak) | 8 (Wound infection) | 5 (Lymphocele) | 1 (Pneumonia) | NR |
| Thomas et al. [36], 2018 | Case–control | USA | 19 | 109 | Median 37.8 [Range 36.0–42.0] | 0/19 | Median 72 [range 48–72] | 3 | 4 | 5 | 5 (Pneumonia) | 6 (UTI) | 3 (CMV reactivation) | 1 (Wound dehiscence) | 5 (Lymphocele) | 1 (Cardiovascular) | 1 (Sepsis) | 1 (Pneumonia) |
| Kostakis et al. [37], 2019 | RCoS | UK | 807 | 421/386 | Mean 48.9 ± 11.7 | 570/237 | Mean 120 | NR | 182 | 5-year: 113 | 10-year: 250 | NR | 5-year: 81 | 10-year: 210 | (NR) |
| Bellini et al. [38], 2020 | RCoS | UK | 20 | 13/7 | Mean 50.6 | 3/17 | Mean 36 | 13 | 2 | 2 | NR | 0 |
| Authors, year | Study design | Country   | Patients, \( n \) (Male/female) | Sex, \( n \) (Male/female) | Age, yr (IQ) | Donor type, \( n \) (Living/Cadaver) | Follow-up, month | Acute rejection | Delayed graft function | Graft loss | Complications, \( n \) (cause) | Mortality, \( n \) (cause) |
|--------------|--------------|-----------|---------------------------------|-----------------------------|-------------|-------------------------------------|------------------|----------------|-----------------------------|------------|--------------------------|--------------------------|
| Outmani et al. [39], 2020 | Case–control | the Netherlands | 133 | 64/69 | Median 53.1 (40.9–63.3) | 105/28 | Median 61 | NR | 37 | 27 | 42 (UTI) | 6 (Sepsis) |
| Prudhomme et al. [40], 2020 | RCoS | Europe | 7 | 5/2 | Mean 53.3 ± 13.4 | 7/0 | Mean 3 (range 1–4) | 1 | 1 | 0 | 1 (Pneumonia) | 0 |
| Spaggiari et al. [41], 2020 | RCT* | USA | 9 | 7/2 | Mean 45.4 ± 10.5 | 9/0 | Mean 36 | 1 | 0 | 2 | 2 (Wound infection) | 1 (UTI) |

*RCoS*, retrospective cohort study; *NR*, not reported; *UTI*, urinary tract infection; *CMV*, cytomegalovirus

*Only data from one group were included*
| Authors, year | Study design | Country | Total patients, n | Transplanted patients (Male/Female), n | Age, yr | Type of bariatric procedure | Donor type, n (Living/Cadaver) | Follow-up, month | BMI at transplantation, kg/m² | Acute rejection | Delayed graft function | Graft loss | Complications, n (cause) | Mortality, n (cause) |
|---------------|--------------|---------|-------------------|--------------------------------------|---------|----------------------------|-------------------------------|----------------|----------------------------|----------------|-------------------------|-----------|--------------------------|---------------------|
| Newcombe et al. [42], 2005 | CR          | Australia | 2 | 1 (1/0) | 65 | AGB | NR | NR | 33.2 | 0 | 0 | 0 | NR | 0 |
| Buch et al. [43], 2006 | CR          | United States | 1 | 1 (0/1) | 59 | AGB | 0/1 | 1 | NR | 0 | 0 | 0 | NR | 0 |
| Alexander et al. [44], 2007 | CS          | United States | 41 | 9 (NR) | NR | RYGB | NR | Mean 60 | NR | NR | NR | NR | NR | 0 |
| Koshy et al. [45], 2008 | CR          | Australia | 3 | 3 (2/1) | Range: 27–49 | AGB | 2/1 | Range 6–24 | Range 30.4–37 | 0 | 0 | 0 | NR | 0 |
| Marszalek et al. [46], 2012 | CR          | Poland | 1 | 1 (0/1) | 55 | AGB | 0/1 | NR | 29 | 0 | 1 | 0 | NR | 0 |
| Al Bahri et al. [47], 2017 | CS          | United States | 4 | 4 (1/3) | Range [43–60] | RYGB | 1/3 | NR | NR | 0 | 0 | 0 | NR | 0 |
| Kienzl-Wagner et al. [23], 2017 | CS          | Austria | 8 | 7 (3/4) | Range [25–62] | SG | 0/7 | Range 5.6–45.6 | Range 28.1–35.7 | 0 | 2 | 0 | 1 (Lymphocele) | 3 (UTI) |
| Al Sabah and Al Haddad [48], 2017 | CR          | Kuwait | 1 | 1 (1/0) | 52 | SG | 0/1 | 42 | 31.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| Authors, year | Study design | Country | Total patients, n | Transplanted patients (Male/Female), n | Age, yr | Type of bariatric procedure | Donor type, n (Living/Cadaver) | Follow-up, month | BMI at transplantation, kg/m² | Acute rejection | Delayed graft function | Complications, n (cause) | Graft loss | Complications, n (cause) | Mortality, n |
|---------------|--------------|---------|------------------|----------------------------------------|---------|---------------------------|-------------------------------|------------------|-----------------------------|----------------|--------------------------|--------------------------|------------|--------------------------|-------------|
| Thomas et al. [36], 2018 | Case–control | United States | 31 | 14 (5/9) | Mean 46.3 ± 4.1 | RYGB | 1/13 | Median 36 [23–64] | Median 28.8 [24.0–34.4] | 6 | 3 | 4 | | | | 1 (Pneumonia) | 0 |
| Bouchard et al. [49], 2020 | RCoS | Canada | 32 | 14 (NR) | NR | SG | NR | Median 9 [IQ 32] | Median: 31 (IQ 9) | 2 | 0 | 0 | | | | NR | 0 |
| Cohen et al. [50], 2019 | RCoS | United States | 43 | 38 (23/15) | Mean 49 | NR | 16/22 | Median 43 [IQ 20–89] | Mean 32 | NR | NR | NR | NR | NR | | |
| Kim et al. [21], 2020 | RCoS | United States | 41 | 41 (22/16) | Mean 56 ± 9.3 | SG | 16/25 | Mean 21.8 ± 20.3 | Mean 32.4 ± 3.4 | 0 | 1 | 1 | 8 (Wound infection) | 3 (CMV reactivation) | 1 (Pneumonia) | 0 |
| Yemini et al. [51], 2019 | RCoS | Israel | 24 | 16 (13/3) | Mean 57 (range 29–70) | RYGB | 11/5 | Mean 24 ± 5.2 | Mean 29 ± 1.3 | 1 | 2 | 0 | NR | 0 |
| Gaillard et al. [52], 2020 | RCoS | France | 29 | 12 (NR) | NR | SG | 1/11 | NR | Median 30.1 [IQ 26.9–33.3] | 1 | 0 | 1 | 1 (UTI) | 1 (Septic shock) | 1 (Sepsis) | 1 (Unknown) |
Patients with Severe Obesity Undergoing Kidney Transplant Without Bariatric Surgery

Data from 18 studies (14 retrospective cohort studies, two prospective cohort and two case–control studies), including a total of 2134 obese kidney transplant candidates with an age range of 20 to 78 years, were reviewed (Table 1). Of these, nine studies were from the USA, three from the UK, one from Canada, and the rest were from Europe. Information about the type of donors was available for 2081 out of 2134 transplants, with the majority being living donors (1544/2081, 74.2%), and the remaining being deceased donors (537/2081, 25.8%). No studies reported donor type (whether deceased donors were donors after cardiac death or brain death). Other donor details were not reported by the included studies.

For the primary outcomes, seventeen studies reported data on graft loss, occurring in 287 of 2091 patients (13.7%) within 5 years after transplantation. Mortality rate was also reported in 15 studies, occurring in 182 of 1988 patients (9.1%) within 5 years after transplantation.

Regarding the secondary outcomes, data for acute rejection, delayed graft function, infections, wound complications and lymphocele were available for 895 (41.9%), 1993 (93.4%), 347 (16.3%), 496 (23.2%) and 288 (13.5%) patients, respectively; and incidence rates for acute rejection, delayed graft function, infections, wound complications and lymphocele were 78/895 (8.7%), 357/1993 (17.9%), 70/347 (20.2%), 69/496 (13.91%) and 21/288 (7.29%), respectively.

Obese Patients Undergoing Kidney Transplant with Pre-transplant Bariatric Surgery

Fifteen studies (five case reports, three case series and seven retrospective cohort studies) were reviewed. A total of 148 obese patients, aged 25 to 70 years, underwent pre-kidney transplantation bariatric surgery. Of the transplant donors, 95 were deceased (59%) and the remainder were living (41%). Sleeve gastrectomy, Roux-en-Y gastric bypass and adjustable gastric banding were used for 99 patients [21, 23, 39, 48, 49, 51, 52], 39 patients [36, 39, 44, 47, 51] and 10 patients [39, 42, 43, 45, 46], respectively. One study including 38 patients did not report the type of bariatric surgery employed [50]. BMI loss for patients with severe obesity after bariatric surgery is indicated in Table 4.

The duration of follow-up after transplantation ranged from 1 month to over 5 years. With respect to primary outcomes, thirteen studies (87%) reported graft loss in 12 of 138 patients (8.7%). Fourteen studies (93%) reported mortality in four of 147 patients (2.8%) (Table 2).

Data for acute rejection, delayed graft function, infections, wound complications and lymphocele were available for 138

### Table 2 (continued)

| Authors, year | Study design | Country | Total patients, n | Transplanted patients, n (Male/Female), n | Age, yr | BMI at transplantation, kg/m² | Type of bariatric procedure | Donor type, n (Living/Cadaver) | Follow-up, month | Acute rejection, n | Delayed graft function, n | Graft loss, n | Complications, n (cause) | Mortality, n (cause) |
|---------------|--------------|---------|------------------|-------------------------------------------|-------|----------------------------|---------------------------|-----------------------------|----------------|-----------------|------------------------|---------------|----------------------|-------------------|
| Authors            | Selection | Ascertainment | Causality | Reporting | Score |
|--------------------|-----------|---------------|-----------|-----------|-------|
|                     | Patients represent the whole experience of the investigators | Adequately ascertained exposure | Adequately ascertained outcome | Other alternative causes that may explain the observation were ruled out | Was there a challenge/rechallenge phenomenon | Was there a dose–response effect? | Was follow-up long enough for outcomes to occur | Are the cases described with sufficient details to allow other investigators to replicate the research? | |
| Marks et al. [25]  | -         | *             | *         | N/A       | N/A    | *     | *     | Fair            |
| Newcombe et al. [42] | -     | *             | *         | N/A       | N/A    | -     | -     | Poor            |
| Buch et al. [43]       | -     | *             | *         | N/A       | N/A    | -     | *     | Fair            |
| Alexander et al. [44] | -     | *             | -         | N/A       | N/A    | *     | -     | Poor            |
| Koshy et al. [45]       | -     | *             | -         | N/A       | N/A    | -     | -     | Poor            |
| Cacciola et al. [26]   | -     | *             | *         | N/A       | N/A    | *     | -     | Poor            |
| Olarte et al. [27]      | -     | *             | *         | N/A       | N/A    | *     | -     | Poor            |
| Bennett et al. [20]     | -     | *             | *         | N/A       | N/A    | *     | *     | Fair            |
| Ditonno et al. [28]     | -     | *             | *         | N/A       | N/A    | *     | -     | Poor            |
| Kanabicak et al. [29]   | -     | *             | *         | N/A       | N/A    | *     | -     | Poor            |
| Marszalek et al. [46]   | -     | *             | *         | N/A       | N/A    | -     | -     | Poor            |
| Curran et al. [30]      | -     | *             | -         | N/A       | N/A    | *     | *     | Poor            |
| Garcia-Roca et al. [31] | -     | *             | *         | N/A       | N/A    | *     | -     | Poor            |
| Tremblay et al. [32]    | -     | *             | -         | N/A       | N/A    | *     | *     | Poor            |
| Schachtner et al. [33]  | -     | *             | *         | N/A       | N/A    | *     | *     | Fair            |
| Al Bahri et al. [47]     | -     | *             | *         | N/A       | N/A    | -     | *     | Fair            |
| Kienzl-Wagner et al. [23] | -   | *             | *         | N/A       | N/A    | *     | *     | Fair            |
| Al Sabah and Al Haddad [48] | -   | *             | *         | N/A       | N/A    | *     | *     | Fair            |
| Liese et al. [34]       | -     | *             | -         | N/A       | N/A    | *     | *     | Poor            |
| Authors                  | Selection | Ascertainment | Causality | Reporting | Score |
|-------------------------|-----------|---------------|-----------|-----------|-------|
|                         | Patients represent the whole experience of the investigators | Adequately ascertained exposure | Adequately ascertained outcome | Other alternative causes that may explain the observation were ruled out | There was a challenge/rechallenge phenomenon | Was there a dose–response effect? | Was follow-up long enough for outcomes to occur | Are the cases described with sufficient details to allow other investigators to replicate the research? |
| Veasey et al. [35]      | -         | *             | *         | N/A       | N/A   | *    | *    | Fair |
| Bouchard et al. [49]    | -         | *             | *         | N/A       | N/A   | *    | -    | Poor |
| Cohen et al. [50]       | -         | *             | -         | N/A       | N/A   | *    | -    | Poor |
| Kim et al. [21]         | -         | *             | *         | N/A       | N/A   | *    | -    | Poor |
| Kostakis et al. [37]    | -         | *             | *         | N/A       | N/A   | *    | -    | Poor |
| Yemeni et al. [51]      | -         | *             | *         | N/A       | N/A   | *    | -    | Poor |
| Bellini et al. [38]     | -         | *             | *         | N/A       | N/A   | *    | *    | Fair |
| Gaillard et al. [52]    | -         | *             | *         | N/A       | N/A   | *    | -    | Poor |
| Prudhomme et al. [40]   | -         | *             | -         | N/A       | N/A   | *    | -    | Poor |
| Spaggiari et al. [41]   | -         | *             | *         | N/A       | N/A   | *    | *    | Fair |

| Case–control studies   | Selection | Representativeness of the cases | Selection of controls | Definition of controls | Comparability of cases and controls | Exposure | Ascertaintion of exposure | Same method of ascertainment for cases and controls | Non-response rate |
|------------------------|-----------|--------------------------------|-----------------------|------------------------|-----------------------------------|----------|--------------------------|--------------------------------------------------|-----------------|
| Outmani et al. [39]    | *         | *                              | *                     | *                      | *                                 | *        | *                        | *                                                               | Good            |
| Thomas et al. [36]     | *         | *                              | *                     | *                      | *                                 | *        | *                        | *                                                               | Good            |
| Authors                        | Transplanted patients, n | Months from bariatric surgery to transplant | BMI loss, kg/m² | BMI at transplantation, kg/m² |
|-------------------------------|--------------------------|---------------------------------------------|-----------------|-------------------------------|
| Newcombe et al. [42]          | 1                        | 9                                           | 11.2            | 33.2                          |
| Buch et al. [43]              | 1                        | 24                                          | NR              | NR                            |
| Alexander et al. [44]         | 9                        | 28                                          | NR              | NR                            |
| Koshy et al. [45]             | 3                        | M#1 15                                      | 4.7             | 30.4                          |
|                              |                          | M#2 15                                      | 6.8             | 36                            |
|                              |                          | F#1 14                                      | 7.1             | 37                            |
| Marszalek et al. [46]         | 1                        | 10                                          | 12.5            | 29                            |
| Al Bahri et al. [47]          | 4                        | F#1 54                                      | 27              | NR                            |
|                              |                          | F#2 66                                      | 14              |                               |
|                              |                          | F#3 30                                      | 20              |                               |
| Kienzl-Wagner et al. [23]     | 7                        | F#1 23                                      | 7.8             | 35.7                          |
|                              |                          | F#2 6                                       | 7.6             | 29.8                          |
|                              |                          | M#1 34                                      | 6.5             | 28.1                          |
|                              |                          | F#3 22                                      | 10.7            | 35.2                          |
|                              |                          | M#2 7                                       | 5.2             | 30.3                          |
|                              |                          | F#4 22                                      | 6.5             | 30.7                          |
|                              |                          | M#3 9                                       | 6.9             | 29.2                          |
| Al Sabah and Al Haddad [48]   | 1                        | 17                                          | 6-month: 10.5 kg/m² | 31.5 |
|                              |                          |                                             | 11-month: 8.5 kg/m² |                               |
| Thomas et al. [36]            | 14                       | Median: 33                                  | 13.6 ± 0.8      | 28.9 ± 0.7                    |
| Bouchard et al. [49]          | 14                       | Median: 8 (IQ 12)                           | NR              | Median: 31                    |
|                              |                          |                                             | (IQ 9)          |                               |
| Cohen et al. [50]             | 38                       | Median: 72 (IQ 24–96)                       | NR              | 32                            |
| Kim et al. [21]               | 41                       | 21.3 ± 16.4                                 | 12-month: 32.1 ± 4.7 | 32.4 ± 3.4                   |
| Yemeni et al. [51]            | 16                       | Median: 18 (range 1–52)                     | NR              | 29 ± 1.3                      |
| Gaillard et al. [52]          | 12                       | Median: 24 (IQ 15–31)                       | NR              | Median: 30.1 (IQ 26.9–33.3)   |
| Outmani et al. [39]           | 23                       | Median: 32.7 (IQ 17.2–65.2)                 | Median 12-month: | Median: 33.6 (IQ 31.4–34.7)   |
|                              |                          |                                             | 33.9 (IQ 31.2–36.5) |                               |
(85.7%), 138 (85.7%), 91 (56.5%), 99 (61.5%) and 44 (27.3%) patients, respectively; and incidence rates for acute rejection, delayed graft function, infections, wound complications and lymphocele were 10/138 (7.2%), 17/138 (12.3%), 35/91 (38.5%), 16/99 (16.16%) and 4/44 (9.09%), respectively (Table 2).

Discussion

We aimed to review the effect of bariatric surgery in obese patients undergoing kidney transplantation compared to obese patients undergoing kidney transplantation without bariatric surgery pre-transplantation. Direct comparison between both groups was not possible as only two case–control studies directly compared outcomes between obese patients receiving bariatric surgery pre-transplantation against patients without bariatric surgery [36, 39], with the remaining studies being case reports and case series. In both these studies, no significant differences were present between groups for our primary and secondary outcomes [36, 39].

There are also many other factors than can influence the long-term post-kidney transplantation graft loss and recipient’s mortality. Recipient’s age at transplantation [53], cardiovascular complications [54] and the longer time spent on dialysis [55] are well known to be associated with poorer long-term outcome. Besides, ethnic background has been considered for many years to have an independent impact on the outcomes, as African American background has presented the lowest graft survival rate [56, 57]. The deleterious effect of recipient’s baseline metabolic diseases and the recurrence of native kidney disease are also the major causes of graft loss in long term, associated with a wide range of prognoses with different diseases [58–60]. Among factors related to the donor, deceased versus living donor, donor’s age, precise pre-transplantation evaluation of kidney donor function and longer ischemia time are established factors that influence long-term outcomes following kidney transplantation [61].

Wound complications are among the most frequently reported problems in obese kidney transplant recipients [62]. According to two case–control studies in this review, the overall reported rate of wound complications in both obese kidney transplant recipients with or without prior bariatric surgery (22/189 [11.6%]) is higher compared to the rate of 7% reported in the general kidney transplant population. However, the incidence of wound complications was similar between recipients with and those without prior bariatric surgery (3/23 [13.0%] and 3/14 [21.4%] vs 15/133 [11.3%] and 1/19 [5.3%]) [36, 39]. Nonetheless, due to the limited number of patients, we cannot make a definite statement on any association between performing bariatric surgery and severe obesity and the risk of wound complications after transplantation.

Lymphocele is also a common complication after kidney transplantation, which most frequently occurs in the first 12 postoperative weeks [63]. Several donor-related and recipient-related risk factors have been identified for lymphocele formation following kidney transplantation, including recipient obesity and diabetes mellitus [63]. While we did not find any difference in the rate of lymphocele formation after transplantation between patients with and without bariatric surgery, no studies have yet investigated whether significant pre-transplantation weight reduction alters the risk of lymphocele formation.

In the study by Outmani et al., while bariatric surgery before transplantation was associated with greater incidence of urinary tract infection post-kidney transplant, the underlying reason for this observation cannot be easily explained since the prevalence of diabetes mellitus, as a strong risk factor for bacterial infections, was greater among the bariatric surgery group, and after propensity-score matching, there was not any difference between the two groups regarding post-transplantation urinary tract infection [39]. Similarly, a recent report from the USA did not find an increased risk of various bacterial, fungal or viral infections with bariatric surgery before kidney transplantation, after controlling for baseline demographics differences, and recommended that routine infection prophylaxis after kidney transplantation to be unnecessary for patients who had undergone bariatric surgery [64].

There are several limitations to this review. The overall level of evidence among the included studies was low, because of many studies being case reports or case series with no comparator group included, selection bias, due to only non-randomized selection of the healthiest patients with severe obesity for kidney transplantation, and reporting bias, due to different lengths of follow-up and not reporting primary or secondary outcomes in most studies. Hence, due to the lack of a comparator group in all but two of the included studies, we were not able to perform meta-analysis or stratified analysis by the type of bariatric surgery or the type of donor type; due to different follow-up durations, we also were not able to define patient and graft survival at exact time points; and due to limited sample size in the two non-randomized cohort studies, we were not able to provide strong evidence on the comparison of rare complications such as mortality between the two patient groups [36, 39]. We were not able to compare patients BMI before bariatric surgery and at the time of transplantation, since relevant data were not available from many studies, the way of reporting weight loss measures were not consistent between studies, or the durations from bariatric surgery up to the time of transplantation were varied even but between patients of the same study. Similarly, we were unable to adjust for confounders since data for potential confounding factors were not available from most studies. Finally, publication bias may exist, as only English-language articles were included. The beneficial impact of bariatric surgery on the overall and cause-specific mortality following kidney transplantation among recipients with severe obesity and diabetes mellitus is an important area for future research.
Obesity remains an open question for future investigations, and randomized clinical trials with long enough follow-up periods are required in this regard.

**Conclusion**

Data regarding post-transplantation outcomes between morbidly obese patients with and without pre-kidney transplantation bariatric surgery suggests no differences with respect to graft loss, patient mortality, delayed graft function, wound complications and lymphocele. However, this data is based on low quality studies. Randomized clinical trials directly comparing post-transplantation outcomes between patients with and without prior bariatric surgery with long enough follow-up periods are still required.

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**Declarations**

**Ethics Approval** This article does not contain any studies with human participants or animals performed by any of the authors.

**Consent to Participate** Informed consent does not apply.

**Conflict of Interest** The authors declare no competing interests.

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**References**

1. Forouzanfar MH, Afshin A, Alexander LT, et al. Global, regional, and national comparative risk assessment of 79 behavioural, environmental and occupational, and metabolic risks or clusters of risks, 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015. Lancet. 2016;388(10053):1659–724.

2. Chang AR, Grams ME, Ballew SH, et al. Adiposity and risk of decline in glomerular filtration rate: meta-analysis of individual participant data in a global consortium. BMJ. 2019;364:k5301.

3. Collaboration NRF. Trends in adult body-mass index in 200 countries from 1975 to 2014: a pooled analysis of 1698 population-based measurement studies with 19.2 million participants. Lancet. 2016;387(10026):1377–96.

4. Di Angelantonio E, Bhupathiraju SN, Wormser D, et al. Body-mass index and all-cause mortality: individual-participant-data meta-analysis of 239 prospective studies in four continents. Lancet. 2016;388(10046):776–86.

5. Collaboration PS. Body-mass index and cause-specific mortality in 900 000 adults: collaborative analyses of 57 prospective studies. Lancet. 2009;373(9669):1083–96.

6. Cockwell P, Fisher L-A. The global burden of chronic kidney disease. Lancet. 2020;395(10225):662–4.

7. Amaral S, Sayed BA, Kutner N, et al. Preemptive kidney transplantation is associated with survival benefits among pediatric patients with end-stage renal disease. Kidney Int. 2016;90(5):1100–8.

8. Lafranca JA, Hagen SM, Dols LF, et al. Systematic review and meta-analysis of the relation between body mass index and short-term donor outcome of laparoscopic donor nephrectomy. Kidney Int. 2013;83(5):931–9.

9. Lafranca JA, Ijerms JN, Betjes MG, et al. Body mass index and outcome in renal transplant recipients: a systematic review and meta-analysis. BMC Med. 2015;13(1):1–18.

10. Gloy VL, Briel M, Bhatt DL, et al. Bariatric surgery versus nonsurgical treatment for obesity: a systematic review and meta-analysis of randomised controlled trials. BMJ (Clinical Research Ed). 2013;347:f5934.

11. Yan Y, Sha Y, Yao G, et al. Roux-en-Y gastric bypass versus medical treatment for type 2 diabetes mellitus in obese patients: a systematic review and meta-analysis of randomized controlled trials. Medicine (Baltimore). 2016;95(17):e3462. [https://doi.org/10.1097/MD.0000000000003462](https://doi.org/10.1097/MD.0000000000003462).

12. O’Brien PE, Hindle A, Brennan L, et al. Long-term outcomes after bariatric surgery: a systematic review and meta-analysis of weight loss at 10 or more years for all bariatric procedures and a single-centre review of 20-year outcomes after adjustable gastric banding. Obes Surg. 2019;29(1):3–14.

13. Sheetz KH, Gerhardinger L, Dimick JB, et al. Bariatric surgery and long-term survival in patients with obesity and end-stage kidney disease. JAMA Surg. 2020;155(7):581–8.

14. Silveira FC, Martin WP, Maranga G, et al. The impact of CKD on perioperative risk and mortality after bariatric surgery. Kidney360. 2021;2(2):236–44.

15. Cohen JB, Tewksbury CM, Landa ST, et al. National postoperative bariatric surgery outcomes in patients with chronic kidney disease and end-stage kidney disease. Obes Surg. 2019;29(3):975–82.

16. Higgins JP. Cochrane handbook for systematic reviews of interventions version 5.0.1. The Cochrane Collaboration. 2008. [http://www.cochrane-handbook.org](http://www.cochrane-handbook.org).

17. Moher D, Liberati A, Tetzlaff J, et al. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS Med. 2009;6(7):e1000097.

18. Wells GA, Shea B, O’Connell D, et al. The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomised studies in meta-analyses. Available at [http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp](http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp).

19. Murad MH, Sultan S, Haffar S, et al. Methodological quality and synthesis of case series and case reports. BMJ Evid Based Med. 2018;23(2):60–3.

20. Bennett WM, McEvoy KM, Henell KR, et al. Kidney transplantation in the morbidly obese: complicated but still better than dialysis. Clin Transplant. 2011;25(3):401–5.

21. Kim Y, Bailey AJ, Morris MC, et al. Kidney transplantation after sleeve gastrectomy in the morbidly obese candidate: results of a 2-year experience. Surg Obes Relat Dis. 2020;16(1):10–4.

22. Alexander JW, Goodman H. Gastric bypass in chronic renal failure and renal transplant. Nutr Clin Pract. 2007;22(1):16–21.
23. Kienzl-Wagner K, Weissenbacher A, Gehwolf P, et al. Laparoscopic sleeve gastrectomy: gateway to kidney transplantation. Surg Obes Relat Dis. 2017;13(6):909–15.

24. Orandi BJ, Purvis JW, Cannon RM, et al. Bariatric surgery to achieve transplant in end-stage organ disease patients: a systematic review and meta-analysis. Am J Surg. 2020;220(3):566–79.

25. Marks WH, Florence LS, Chapman PH, et al. Morbid obesity is not a contraindication to kidney transplantation. Am J Surg. 2004;187(5):635–8.

26. Cacciola R, Pujar K, Ilham M, Puliti C, Asderakis A, Chavez R, editors. Effect of degree of obesity on renal transplant outcome. Transplantation proceedings; 2008: Elsevier.

27. Olarte IG, Hawasli A. Kidney transplant complications and obesity. Am J Surg. 2009;197(3):424–6.

28. Dotonno P, Lucarelli G, Impedovo S, et al., editors. Obesity in kidney transplantation affects renal function but not graft and patient survival. Transplantation proceedings; 2011: Elsevier.

29. Karabacak I, Aytu S, Lewis S, et al. Long-term kidney transplant outcome in obese patients in a predominantly African American population. Clin Transplant. 2011;25(3):E264–70.

30. Curran SP, Famure O, Li Y, et al. Increased recipient body mass index is associated with acute rejection and other adverse outcomes after kidney transplantation. Transplantation. 2014;97(1):64–70.

31. Garcia-Roca R, Garcia-Aroz S, Tzvetanov I, et al. Single center experience with robotic kidney transplantation for recipients with BMI of 40 kg/m2 or greater: a comparison with the UNOS registry. Transplantation. 2017;101(1):191–6.

32. Tremblay S, Kaiser TE, Allaway RR, et al. Absence of the effect of pretransplant body mass index on post kidney transplant outcomes. Prog Transplant. 2016;26(2):183-190. https://doi.org/10.1177/1526924116640679.

33. Schachtner T, Stein M, Reinke P. Increased alloreactivity and adverse outcomes in obese kidney transplant recipients are limited to those with diabetes mellitus. Transpl Immunol. 2017;40:8–16.

34. Liese J, Bottner N, Büttner S, et al. Influence of the recipient body mass index on the outcomes after kidney transplantation. Langenbecks Arch Surg. 2018;403(1):73–82.

35. Veasey TM, Fleming JN, Stout SE, et al. Morbid obesity and functional status as predictors of surgical complication after renal transplantation. Am J Surg. 2018;215(4):663–8.

36. Thomas IA, Gaynor JR, Joseph T, et al. Roux-en-Y gastric bypass is an effective bridge to kidney transplantation: results from a single center. Clin Transplant. 2018;32(5):e13232.

37. Kostakis ID, Kassimatis T, Bianchi V, et al. UK renal transplant outcomes in low and high BMI recipients: the need for a national policy. J Nephrol. 2019:1–11.

38. Bellini ML, Koutroutsos K, Nananpragasam H, et al. Obesity affects graft function but not graft loss in kidney transplant recipients. J Int Med Res. 2020;48(1):0300060519895139.

39. Outmani L, Kimenai HJAN, Roodnat JI, et al. Clinical outcome of kidney transplantation after bariatric surgery: A single-center, retrospective cohort study. Clin Transplant. 2021;35(3):e14208. https://doi.org/10.1111/ctr.14208.

40. Prudhomme T, Beauval JB, Lesourd M, et al. Robotic-assisted kidney transplantation in obese recipients compared to non-obese recipients: the European experience. World J Urol. 2020;1–12.

41. Spaggiari M, Di Cocco P, Tulla K, et al. Simultaneous robotic kidney transplantation and bariatric surgery for morbidly obese patients with end-stage renal failure. Am J Transplant. 2021;21(4):1525–1534. https://doi.org/10.1111/ajt.16322.

42. Newcombe V, Blanch A, Slater GH, et al. Laparoscopic adjustable gastric banding prior to renal transplantation. Obes Surg. 2005;15(4):567–70.

43. Buch K, El-Sabrout R, Butt K, editors. Complications of laparoscopic gastric banding in renal transplant recipients: a case study. Transplantation proceedings; 2006: Elsevier.

44. Alexander JW, Goodman HR, Gersin K, et al. Gastric bypass in morbidly obese patients with chronic renal failure and kidney transplant. Transplantation. 2004;78(3):469–74.

45. Koshy AN, Coombes JS, Wilkinson S, et al. Laparoscopic gastric banding surgery performed in obese dialysis patients prior to kidney transplantation. Am J Kidney Dis. 2008;52(4):e15–7.

46. Marszałek R, Ziemiański P, Lisik W, et al. Bariatric surgery as a bridge for kidney transplantation in obese subjects. Case report. Ann Transplant. 2012;17(1):108–112. https://doi.org/10.12659/aoat.882642.

47. Al-Bahri S, Fakhry TK, Gonzalez JP, et al. Bariatric surgery as a bridge to renal transplantation in patients with end-stage renal disease. Obes Surg. 2017;27(11):2951–5.

48. Al Sabah S, Al Haddad HE. Revisitional bariatric surgery in a transplant patient. Int J Surg Case Rep. 2017;31:86–8.

49. Bouchard P, Tchervenkov J, Demyttenaere S, et al. Safety and efficacy of the sleeve gastrectomy as a strategy towards kidney transplantation. Surg Endosc. 2020;34(6):2657–64. https://doi.org/10.1007/s00464-019-07042-z.

50. Cohen JB, Lim MA, Tewsbury CM, et al. Bariatric surgery before and after kidney transplantation: long-term weight loss and allograft outcomes. Surg Obes Relat Dis. 2019;15(6):935–41.

51. Yemini R, Neshet E, Carmeli I, et al. Bariatric surgery is efficacious and improves access to transplantation for morbidly obese renal transplant candidates. Obes Surg. 2019;29(8):2373–80.

52. Gaillard M, Tranchart H, Beaudreuil S, Lebrun A, Vican SC, Laimas P, et al. Laparoscopic sleeve gastroplasty for morbid obesity in renal transplantation candidates: a matched case-control study. Transpl Int. 2020.

53. Gondos A, Döhler B, Brenner H, et al. Kidney graft survival in Europe and the United States: strikingly different long-term outcomes. Transplantation. 2013;95(2):267–74.

54. Jardine AG, Gaston RS, Fellstrom BC, et al. Prevention of cardiovascular disease in adult recipients of kidney transplants. Lancet. 2011;378(9800):1419–27.

55. Meier-Kriesche HU, Schold JD. The impact of pretransplant dialysis on outcomes in renal transplantation. Semin Dial. 2005;18(6):499-504. https://doi.org/10.1111/j.1525-0046.2005.00096.x.

56. Malek SK, Keys BJ, Kumar S, et al. Racial and ethnic disparities in kidney transplantation. Transpl Int. 2011;24(5):419–24.

57. Paillet N, Thervet E, Alberti C, et al. Kidney transplant in black and white patients: a single center experience with robotic kidney transplantation for recipients with BMI over 40. Transplant Proc. 2016;48(3):1265–9.

58. Canaud G, Audard V, Kofman T, et al. Recurrence from primary and secondary glomerulopathy after renal transplantation. Transpl Int. 2012;25(8):812–24.

59. Fleoje J, Gröne HJ. Recurrent IgA nephropathy in the renal allograft: not a benign condition. Nephrol Dial Transplant. 2013;28(5):1070–3.

60. Legendre C, Licht C, Muus P, et al. Terminal complement inhibitor eculizumab in atypical hemolytic–uremic syndrome. N Engl J Med. 2013;368(23):2169–81.

61. Legendre C, Canaud G, Martinez F. Factors influencing long-term outcome after kidney transplantation. Transpl Int. 2014;27(1):19–27.

62. Potluri K, Hou S. Obesity in kidney transplant recipients and candidates. Am J Kidney Dis. 2010;56(1):143–56.

63. Golriz M, Klauss M, Zeier M, et al. Prevention and management of lymphocele formation following kidney transplantation. Transplant Rev. 2017;31(2):100–5.

64. Joachim E, Jorgenson MR, Astor BC, et al. Pre-transplant bariatric surgery is not associated with an increased risk of infection after kidney transplantation. Transpl Int. 2021;34(10):1989–91.