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Recommendations

Kidney transplantation in adult candidates with obesity: Guidelines by the Association Française d'Urologie and Société Francophone de Transplantation

Transplantation rénale chez le candidat adulte en situation d'obésité : recommandations de l'Association Française d'Urologie et de la Société Francophone de Transplantation

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ABSTRACT

Introduction: Patients with obesity have a reduced access to kidney transplantation due to the higher risk of surgical and medical complications. Our aim was to provide clinical guidelines in this population focused on: (i) the main anthropometric parameter that contraindicates open kidney transplantation; (ii) other clinical factors to consider before transplantation; (iii) contraindications to robot-assisted transplantation; (iv) efficient and safe weight loss methods for kidney transplantation candidates with obesity.
Methods: After a systematic review of studies published between January 2010 and June 2025 performed following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses criteria, these guidelines were developed by a multidisciplinary task force and reviewed by independent experts.
Results: In total, 153/962 publications met the inclusion criteria. The decision to allow kidney transplantation should not be based solely on Body Mass Index (BMI), but also on skin-to-vessel distance and pelvis angle. Robot-assisted kidney transplantation may be considered in highly selected patients with obesity and limited vascular disease, even those with grade 3 obesity. Patients with frailty should receive appropriate care before weight loss therapies. After appropriate nutritional preparation, bariatric surgery should be considered fairly quickly in patients with kidney failure and grade ≥ 2 obesity (grade B), or grade 1 obesity and poorly controlled type 2 diabetes. While Roux-en-Y gastric bypass achieves superior long-term weight loss than sleeve gastrectomy, it is associated with an increased mortality and morbidity. Pharmacological treatment (mainly GLP-1 agonists) is currently evaluated for weight loss in this population.
Conclusions: These guidelines allow personalizing the management in kidney transplantation candidates with obesity.

Mots-clés:
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Chirurgie bariatrique
Maladie rénale chronique
Obésité
Transplantation rénale

RÉSUMÉ

Introduction : Les patients en situation d'obésité ont un accès réduit à la transplantation rénale en raison d'un taux plus élevé de complications médicales et chirurgicales. Notre objectif était d'établir des recommandations cliniques dans cette population, portant sur : (i) le principal paramètre anthropométrique contre-indiquant la transplantation rénale par voie ouverte ; (ii) les autres facteurs cliniques à prendre en compte avant transplantation ; (iii) les contre-indications à la transplantation assistée par robot ; (iv) les méthodes de perte de poids efficaces et sûres dans cette situation.
Méthodes : Après revue systématique des études publiées entre janvier 2010 et juin 2025 selon les critères PRISMA, ces recommandations ont été élaborées par un groupe de travail multidisciplinaire et évaluées par des experts indépendants.
Résultats : Au total, 153 publications sur 962 ont satisfait aux critères d'inclusion. La décision d'autoriser une transplantation rénale ne doit pas reposer uniquement sur l'indice de masse corporelle (IMC), mais également sur la distance cutanéo-vasculaire et l'angle pelvien. La transplantation rénale assistée par robot peut être envisagée chez des patients soigneusement sélectionnés présentant une obésité avec une maladie vasculaire limitée, y compris en cas d'obésité de grade 3. Les patients présentant une fragilité doivent bénéficier d'une prise en charge adaptée avant l'instauration de tout traitement amaigrissant. Après une préparation nutritionnelle appropriée, la chirurgie bariatrique doit être rapidement envisagée chez les patients en insuffisance rénale présentant une obésité de grade ≥ 2 (grade B), ou une obésité de grade 1 associée à un diabète de type 2 mal équilibré. Le bypass gastrique « Roux-enY » permet une perte de poids supérieure sur le long terme à la sleeve gastrectomie, au prix d'une mortalité et d'une morbidité accrues. Le traitement pharmacologique (principalement les agonistes du GLP-1) est actuellement évalué pour la perte de poids dans cette population.
Conclusions : Ces recommandations permettent de personnaliser la prise en charge des candidats à la transplantation rénale en situation d'obésité.

1. Introduction

In the past few decades, the number of individuals with overweight or obesity has increased in many industrialized countries [1,2]. Globally, the highest age-standardized prevalence of overweight and obesity is observed in Oceania, North Africa and the Middle East where a prevalence > 80% in adults has been reported in many countries [3]. The 2024 OFEO (French Observatory of Obesity Epidemiology) study found that 48% of the French adult population lives with overweight or obesity, and 18% of French adults are classified as having obesity [4]. Compared with people without obesity, patients with obesity are at greater risk of developing chronic kidney disease and kidney failure [5–7]. The prevalence of obesity in patients with kidney failure is also steadily increasing [8]. Transplantation represents the treatment of choice for end-stage renal disease (ESRD). However, patients with obesity have reduced access to this option due to the increased risk of surgical and medical complications, such as parietal complications (infection, hematoma, evisceration, or eventration) and cardiovascular events (deep vein thrombosis, pulmonary embolism, and myocardial infarction) [9–11], wound healing problems, delayed graft function, or hospital readmissions for complications [12,13]. Obesity can be detrimental to recipient survival due to its association with these early postoperative complications and with various renal, metabolic [14] and cardiovascular conditions, such as high blood pressure [15], coronary insufficiency [16], type 2 diabetes [17,18], respiratory disorders [19] and stroke [20]. Many other studies evaluated the kidney transplantation outcomes in recipients with obesity, often with controversial results [21], particularly concerning patient and transplant survival [22–25]. The additional surgical difficulties and poorer clinical outcomes in this population lead some transplant centers to discriminate against patients with obesity by reducing their access to transplantation beyond a certain BMI threshold [26,27]. Furthermore, kidney transplantation presents several challenges in patients with obesity, particularly related to the depth of the iliac vessels [28,29]. However, compared to remaining on the transplant

waiting list, kidney transplantation in recipients with obesity appears to improve long-term survival [30] and quality of life [31], although grade 2 or grade 3 obesity is strongly associated with reduced long-term patient and transplant survival [32,33]. Therefore, systematically removing patients with obesity from transplant waiting lists or keeping them lifelong on the waiting list (in the absence of successful weight loss) is unethical.

To reduce inequalities and the risk of loss of opportunity and given the new recently published findings, it was deemed necessary to standardize practices in guidelines developed using a rigorous and well-defined method. In this context, the Transplantation and Chronic Kidney Disease Committee of the French Association of Urology (CTAFU) and the Francophone Transplantation Society (SFT) decided to conduct a systematic review of the literature in order to propose updated recommendations. The aims of these guidelines were to define: (i) the main anthropometric criterion (BMI, abdominal perimeter, depth, fat distribution, fat density) contraindicating open kidney transplantation in patients with obesity; (ii) the other clinical factors that increase the risk of complications and that should be considered for the indication of transplantation (e.g. arterial calcifications, arteriopathy, peripheral arterial disease, sarcopenia, iterative transplantation, ethnicity); (iii) the criteria that contraindicate robot-assisted kidney transplantation in patients with obesity; and (iv) the safest and most efficient weight loss methods that should be used in patients with obesity on the transplant waiting list.

2. Methods

2.1. Evidence acquisition

These guidelines were based on a systematic review performed following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) criteria [34]. The protocol was registered in the International Prospective Register of Systematic Reviews (PROSPERO) database (CRD 20251057832).

2.2. Literature search

A systematic literature search was performed in PubMed/Medline® to identify reports (in French or English) on kidney transplantation in adult patients with obesity, published between January 2010 and January 2025 (see full report on https://www.urofrance.org/themereco/transplantation/). The full search strategy is displayed in Supplementary Table 1. Selection was based on the PICOS criteria: (i) population (P): adults with obesity and ESRD who are candidates for kidney transplantation, regardless of the severity and duration of the kidney disease and comorbidities; (ii) intervention (I): kidney transplantation; dialysis; robotic assisted surgery; bariatric surgery; glucagon-like peptide-1 (GLP-1) receptor agonists; (iii) compared intervention (C): waiting list control; dialysis; diet education; physical exercise; sleeve gastrectomy; robotic assisted surgery; GLP-1 receptor agonists, one-anastomosis gastric bypass, Roux-en-Y gastric bypass; (iv) outcome (O): graft failure; renal function; all-cause mortality; cardiovascular mortality; (v) study design (S): meta-analysis, randomized controlled trial, prospective non-randomized study, or retrospective study. The literature data were completed by literature monitoring (up to June 2025), consultation of the websites of international organizations (e.g. European Association of Urology, American Urological Association, American Spinal Injury Association), search of systematic reviews in the Cochrane Library database, and suggestions from the working group members, particularly on studies not indexed in Medline® at the time of the bibliographic search.

2.3. Study selection

The inclusion and exclusion criteria were defined before the study. Solely studies on adults with obesity and ESRD who are candidates for transplantation were included. Publications deemed ineligible were: (i) studies on children or patients with cancer; (ii) studies on immunosuppression, transplantation technique, nephrectomy technique for living donors, different dialysis types, retransplantation, anesthesia modalities, transplantation from living donor with obesity, post-transplant bariatric surgery, or double transplantation (pancreas-kidney); (iii) health economic studies since they depend largely on the country's healthcare system; (iv) experimental studies in animals or in vitro; (v) studies on clinical practices; (vi) case reports, general reviews, editorials, letters, or comments. Studies were selected by the methodologist (DK) using these criteria, after reading the abstract. The selection was independently validated by the steering committee (MOT, JAW, TB, TPO, LA, LB, TB, PM, FP, ESM, TPR, SD) and then by the whole working group. The full text of the selected publications was read. After an initial round of data extraction by the steering committee, article selection was confirmed by two other authors (MOT and DK) and disagreements were resolved through discussion within the working group.

2.4. Project methodology

This project was carried out by the AFU transplantation and ESRD committee with a multidisciplinary task force that included urologists, nephrologists, immunologists, and other healthcare professionals involved in the management of patients with kidney graft failure (e.g. immunology biologists, pediatric surgeons, vascular surgeons). The recommendations were defined following the Clinical Practice Guideline methodology based on the systematic review and the experts' judgment. The methodological quality of the selected studies was analyzed using dedicated grids. The level of evidence (LOE) of each study and its conclusions was assessed by taking into account the result consistency. These conclusions and the working group members' arguments were used to define the recommendations as follows: (i) the recommendation is the clinical practice unanimously acknowledged as the reference by the experts: (ii) if a clinical practice was considered acceptable on the basis of literature data and expert opinion, but was not unanimously acknowledged as the reference, it is indicated that it can be discussed/proposed; (iii) in the absence of expert consensus, no recommendation was proposed. The classification of conclusions by LOE (LOE1 is the highest; LOE4 the lowest) and the recommendation grading [grade A is the highest; grade C the lowest; Expert Agreement (EA) in the absence of data] are based on the grid proposed by the French Higher Health Authority (Haute Autorité de Santé, HAS) [35]. In October 2025, the document was reviewed using the Appraisal of Guidelines for Research and Evaluation II tool [36] by 52 independent experts from all medical and surgical specialties involved in the management of adults with obesity and ESRD who are candidates for transplantation (23 urologists, 8 nephrologists, 5 nutritionists/endocrinologists, 4 vascular surgeons, 2 digestive surgeons, 2 immunologists, 2 cardiologists, and 6 patient representatives). Their comments were incorporated into the final version of the guideline in November 2025. The complete document, including the project rationale, methodology, detailed study analysis, conclusions, recommendations, and review process, can be consulted on Urofrance (https://www.urofrance.org/themereco/transplantation/).

3. Results and guidelines

The study selection is outlined in the PRISMA flow diagram (Fig. 1). In total, 962 publications were screened for eligibility and

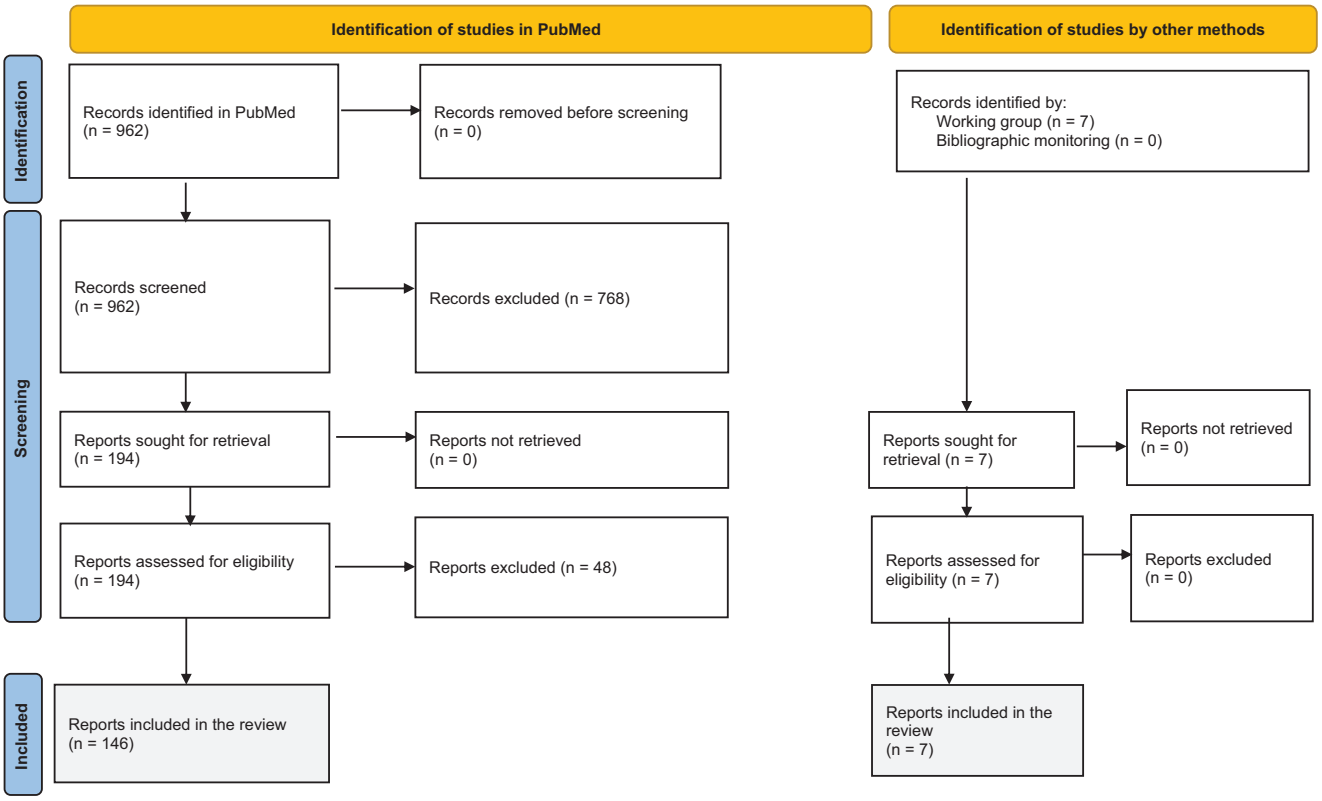

Fig. 1. Flow diagram (PRISMA 2020).

194 were retrieved. After full-text reading, literature monitoring and working group suggestions, 153 studies were retained for analysis. The systematic review corresponding to their detailed analysis will be available in a future report.

3.1. What is the main anthropometric criterion against open kidney transplantation in patients with obesity?

For this clinical question, the following studies were included: two recommendations [37,38], ten systematic reviews/meta-analyses [22,24,25,39–45], one prospective study [46], two comparative studies [47,48], fifty-two observational studies [9,13,21,28,49–96], and nine retrospective studies [30,97–104].

3.1.1. Conclusions based on the data analysis

3.1.1.1. Definitions of obesity. The World Health Organization defines obesity as 'abnormal or excessive fat accumulation that presents a risk to health'. Body mass index (BMI) is the most commonly used metric to diagnose obesity because it correlates well with total adiposity. BMI is practical for epidemiological studies, but has several limitations: (i) it does not always accurately reflect the person's adiposity: two individuals with the same BMI may have different body compositions; (ii) it does not reflect fat distribution (android/gynoid or amount of ectopic depot); (iii) it is not correlated with histological alterations within the adipose tissue (e.g. inflammation, fibrosis) linked to obesity comorbidities or the risk of resistance to weight loss.

The latest Lancet 2025 commission provides a new definition of obesity [105]: screening is based on the waist circumference ($>$ 102 cm in men and $>$ 88 cm in women), the waist-to-hip ratio ($>$ 0.9 in men or $>$ 0.85 in women) or waist-to-height ratio ($>$ 0.5 for both sexes); however, in people with BMI $>$ 40 kg/m^2, obesity can be assumed. Body composition measurement may be offered if available. Once screening has been carried out, individuals can be classified into two categories: preclinical obesity (obesity without medical or functional repercussions) and clinical obesity (if at least one comorbidity or functional repercussion is present).

These elements are consistent with the latest French HAS recommendations on obesity management. Preclinical obesity corresponds to stage 1a of the HAS classification [106] and clinical obesity to stages 1b, 2, 3a, or 3b in function of its severity. Obesity severity is determined by the presence of at least one of the following seven parameters: BMI, medical consequences, functional impact, presence of a psychological disorder (cause or consequence of obesity), obesity etiology, presence of an eating disorder, and obesity trajectory.

3.1.1.2. The role of the different anthropometric parameters in predicting kidney transplant outcomes. Despite its limitations, studies on obesity and kidney transplantation have mainly used BMI to define obesity. Few studies evaluated other phenotypic parameters, besides BMI, to better characterize the localization of adiposity: skin-to-vessel distance (SVD), visceral adipose tissue area, subcutaneous adipose tissue area, and waist circumference.

To date, SVD is the most reliable morphometric parameter for predicting a temporary contraindication to kidney transplantation [88] (LOE4). Increasing age and SVD are predictive factors of complications in transplant recipients [88] (LOE4). Furthermore, increasing age and SVD and low psoas muscle area are associated with urological complications in the first year post-transplantation. Complications are increased in patients with SVD $>$ 14.9 cm (from the lower edge of the iliac artery bifurcation to the skin via the semilunar line) and in patients with psoas muscle area $<$ 22.3 cm^2 (indicative of sarcopenia) [28] (LOE4). The visceral adipose tissue/subcutaneous adipose tissue ratio (used as a continuous variable) predicts poorer transplant function.

Other morphometric criteria, namely SVD and pelvic opening angle, may allow selecting patients with a BMI $\leq$ 44 kg/m^2 who can

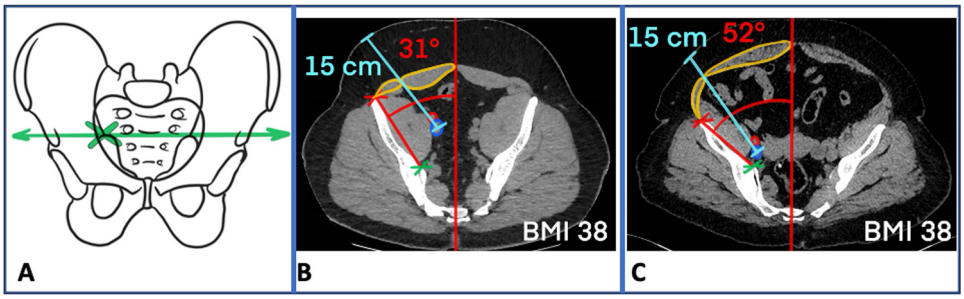

Fig. 2. Morphometric parameters. A. Locating the incision at the lowest level of the sacroiliac joint. B. Example of a "closed angle" pelvis. C. Example of a pelvis with an "open angle" (patients in B and C have the same skin-to-vessel distance and BMI).

undergo transplantation with outcomes similar to those of patients with a BMI = 28 kg/m^2. There was no significant difference for any of the criteria studied: delayed graft function, hospital length of stay, reoperation, readmission, parietal complications, renal function at 1 year, BMI at 1 year, and cardiac events [52] (LOE4). However, this study involved highly selected patients, and fewer patients with BMI > 40 kg/m^2 had a previous kidney transplant (6% vs 17%).

In conclusion, the other morphometric parameters that are better suited than BMI, are standardized on the level of CT Scan cut passing through the lowest point of the sacroiliac joint (green cross). This point is at the S2-S3 junction and corresponds reproducibly to the end of the iliac bifurcation (Fig. 2); these parameters include:

- SVD: distance from the center of the external iliac vein (blue circle) to the skin, passing through the semilunar line (junction between the oblique and rectus abdominis muscles, in yellow); a SVD < 15 cm is an argument to consider withdrawal of a temporary contraindication to kidney transplantation;
- pelvic opening angle: angle formed by the line passing through the iliac crest (red cross) and the sacroiliac joint (green cross) with the median sagittal line (a wider angle indicates easier surgical procedure).

3.1.1.3. Indications/contraindications for inclusion in the kidney transplant waiting list. Compared with dialysis, patients with obesity benefit from kidney transplantation in terms of survival, including patients with grade 2 obesity (BMI 35–40 kg/m^2) and to a lesser extent, patients with grade 3 obesity (BMI > 40 kg/m^2) [45] (LOE not applicable) [101] (LOE4) [30] (LOE4). This benefit seems more pronounced when the graft originates from a living donor [30] (LOE4). On the other hand, transplantation in recipients with obesity (BMI ≥ 30 kg/m^2) increases the risk of complications, such as delayed graft function [45] (LOE not applicable, systematic review) and graft loss [45] (LOE not applicable). As all studies were retrospective, this might introduce a risk of bias when comparing these populations.

In recipients, increased waist circumference is correlated with all-cause mortality [40] (LOE4). However, in patients on pre-dialysis or hemodialysis, obesity (based on BMI, waist-to-hip ratio, or waist circumference) may reduce their overall mortality [40] (LOE4). This association was not observed in patients on peritoneal dialysis [40] (LOE4).

Compared with being placed on a waiting list (and remaining on dialysis), kidney transplantation offers an overall survival benefit regardless of the BMI, but lower in men and patients with type 2 diabetes. However, this relationship is unlikely to be linear, and the mortality risk is highest in patients with the lowest and highest BMI values [73] (LOE3).

3.1.1.4. Comparison of transplantation vs. remaining on dialysis and in the waiting list. Studies on post-transplant outcomes analyzed patient survival, transplant survival, delayed graft function recovery, renal function, post-surgical complications (e.g. surgical site complications, urological complications), number of hospitalizations, number of emergency room visits, and number of consultations. Most studies were retrospective, with highly variable median follow-up periods and without taking relevant confounding factors into account, which could explain the inconsistent results. Older age and smoking increase mortality, while serum albumin concentration > 35 g/L is a protective factor. Dialysis duration > 3 years and expanded criteria donors or transplant from a donor in cardiac arrest are risk factors of transplant dysfunction [95] (LOE2). Survival differences can be explained by advances in immunosuppressive therapy and in general medical practice, as illustrated by the improved control of comorbidities, such as lipid disorders, hypertension, diabetes, heart disease, but also the acquisition of experience in kidney transplantation [22] (LOE4).

In terms of patients' survival after kidney transplantation, some studies suggest that subgroups of patients with obesity (younger, without diabetes, non-smoking, graft from a living donor, good functional status) have equivalent or even better outcomes than normal-weight patients at higher risk [81] (LOE3) [102] (LOE4). The absence of malnutrition, assessed by an indirect marker (e.g. serum albumin concentration > 35 g/L, is a protective factor for patient survival. Dialysis duration > 3 years and expanded criteria/donors or transplant from a donor in cardiac arrest are risk factors for transplant dysfunction [95] (LOE2).

However, other studies show a detrimental effect of transplantation on patient's survival [21] (LOE2) [9,25,43,54,55,82] (LOE4), particularly in patients with grade 2 obesity (BMI > 35 kg/m^2) [39,40] (LOE4) (studies published before 2003), [22] (LOE4) [104] (LOE2) and on graft survival [13,21,95,104] (LOE2) [9,24,25,39,41,50,69,77,98,99] (LOE4), particularly studies published before 2003 [22] (LOE4), or after 10 years of follow-up [62,65] (LOE4).

Other studies suggest that obesity does not influence patient survival [95] (LOE2) [13,22,24,40,41,48,50,53,61,62,64,71,74,76,77,80,84,92,94,98–103] (LOE4) or graft survival [48,53,61,64,70,71,74,76,80,84,89,92,94,100,102,103] (LOE4).

Excess mortality linked to obesity is not directly related to transplant failure [82] (LOE4).

For recipients with obesity, compared to recipients without obesity, most studies agree that:

- cardiovascular mortality is increased [22] (LOE4) [40] (LOE4);
- the risk of delayed graft function is increased [24] (LOE4) [25] (LOE4) [41] (LOE4) [22] (LOE4) [39] (LOE4) [103] (LOE4) [92] (LOE4) [59] (LOE4) [54] (LOE4) [62] (LOE4) [77] (LOE4) [55] (LOE4) [80] (LOE4) [83] (LOE2) [60] (LOE4) [56] (LOE4) [107] (LOE4) [13] (LOE4), although other studies show no impact of obesity [61] (LOE4) [98] (LOE4) [97] (LOE4);
- the risk of acute rejection is increased [25] (LOE4) [41] (LOE4) [100] (LOE4) [77] (LOE4) [107] (LOE4) [97] (LOE4); however, two

meta-analyses [41] (LOE4) [39] (LOE4) and three studies [53] (LOE4) [98] (LOE4) [80] (LOE4) show no impact of obesity;
- the risk of primary non-function is increased [41] (LOE4) [39] (LOE4) [62] (LOE4) [79] (LOE4) [65] (LOE4);
- the risk of impaired kidney function at 1 year is increased [62] (LOE4) [61] (LOE4) [60] (LOE4) [63] (LOE3) [65] (LOE4) [75] (LOE4); however, four studies show no impact of obesity [53] (LOE4) [55] (LOE4) [79] (LOE4) [80] (LOE4). Recipient age and donor age are independent predictors of impaired kidney function (creatinine concentration > 100 μmol) [75] (LOE4);
- the risk of postoperative medical and surgical complications is increased [39] (LOE4) [100] (LO4) [92] (LOE4) [56] (LOE4) [76] (LOE4), particularly cardiovascular and urological complications [98] (LOE4) [99] (LOE4) [60] (LOE4) [67] (LOE4), such as the risk of ureteral stenosis [63] (LOE3) and skin complications [93] (LOE4). Other studies show no impact of obesity [48] (LOE4) [80] (LOE4), particularly on urinary or vascular complications [21] (LOE2). Other studies report an increased risk of parietal complications (seromas, dehiscence, infection) [89] (LOE4) [74] (LOE4) [56] (LOE4) [47] (LOE4), surgical site infection [54] (LOE4) [55] (LOE4) [72] (LOE4), urinary tract infections [49] (LOE4), wall abscesses [97] (LOE4) [65] (LOE4), lymphocele [64] (LOE4) [74] (LOE4) [56] (LOE4) [97] (LOE4), delayed healing [103] (LOE4) [99] (LO4) [97] (LOE4), eventration [55] (LOE4), myocardial infarction [55] (LOE4), prolonged warm ischemia time [98] (LOE4), and longer surgery duration [98] (LOE4) [89] (LOE4). Wall complications are associated with increased abdominal circumference (taken midway between the lowest point of the costal margin and the upper iliac crest), BMI and weight [68] (LOE3). These risks decrease when using minimally invasive para-rectal surgery [66] (LOE4);
- length of stay and number of readmissions are increased [54] (LOE4) [92] (LOE4) [84] (LOE4) [74] (LOE4) [60] (LOE4) [56] (LOE4), although four studies show no impact of obesity on these outcomes [53] (LOE4) [99] (LOE4) [87] (LOE4) [91] (LOE4) and also on emergency room visits and number of consultations after transplantation [87] (LOE4). Delayed graft function and previous kidney transplantation appear to be associated with multiple emergency room visits [87] (LOE4);
- the risk of developing new-onset diabetes after transplantation (NODAT) is increased in patients with obesity, according to six studies [42] (LOE4) [41] (LOE4) [39] (LOE4) [103] (LOE4) [99] (LOE4) [107] (LOE4), while one study reports no impact of obesity [25] (LOE4).

In Asian populations, data are conflicting. One study suggests that obesity, according to Asian standards (BMI ≥ 25 kg/m^2), is an independent risk factor of transplant loss [85] (LOE3), while another found that obesity has no impact on recipient or transplant survival [51] (LOE4). However, there was a significant risk of rejection, NODAT, and post-transplant cardiovascular events [51] (LOE4).

In recipients older than 70 years, obesity (BMI > 35 kg/m^2) is associated with decreased patient and graft survival [86] (LOE4). As BMI increases, the likelihood of preemptive transplantation decreases and the duration of dialysis increases [86] (LOE4). Dialysis duration and patient's functional capacity (one of the components of frailty, defined by ≥ 3 of the following four criteria: weakness, fatigue, slow walking speed, and low physical activity level) are independent risk factors of mortality and graft loss [86] (LOE4).

3.1.2. Recommendations

The recommendations related to this question (Q1) are grouped with those for Q2 (see:3 Recommendations (Q1 + Q2).

3.2. What other clinical factors (predictive of complications) should be considered for the indication of kidney transplantation?

For this clinical question, the following studies were included: one systematic review/meta-analysis [108], one prospective study [109], ten observational studies [110–119], and ten retrospective studies [107,120–128].

3.2.1. Conclusions based on the data analysis

BMI impact on all-cause graft loss is variable and depends on several clinical parameters (recipient age, nephropathy etiology, sex, and ethnicity) that should be considered to personalize risk interpretation [122] (LOE2).

3.2.1.1. Ethnicity. The recipient's ethnicity appears to influence the long-term outcomes after kidney transplantation in patients with obesity (BMI > 30 kg/m^2), but this parameter remains unused in France. The risk of all-cause graft loss is higher in Caucasian than African-American recipients. Among Caucasians, the risk of transplant loss censored for death is higher when both donor and recipient have obesity. The risk of long-term complications is higher in Caucasian than African-American recipients, whereas the short-term risk is similar [120] (LOE2).

3.2.1.2. Medications/Modifiable factors. In patients with ESRD, the use of more than one drug associated with weight gain, particularly antidepressants, anticonvulsants, corticosteroids and antipsychotics, reduces the chance of being placed on the transplant waiting list, particularly in the case of grade 2 obesity [111] (LOE3).

3.2.1.3. Sarcopenia/frailty. Visceral obesity (i.e. increased waist circumference) and sarcopenia are common in patients with kidney failure, regardless of the kidney disease stage or treatment [113] (LOE3).

Sarcopenic obesity has a detrimental effect on mortality, delayed graft function, infections and post-transplant readmission, but does not appear to affect quality of life (SF-36 questionnaire) [110] (LOE4).

Myosteatosis, defined as muscle density below the normal values adapted to age and sex associated with the presence of fat (the density of which is negative in Hounsfield units on CT images), is independently associated with the occurrence of postoperative complications (Clavien–Dindo grade ≥ 2) within 90 days post-transplantation [119] (LOE4).

BMI > 35 kg/m^2 and frailty (Karnofsky Performance Status Scale score < 70: able to care for oneself, but unable to work) are risk factors of transplant surgery complications, especially parietal complications, and delayed graft function, but have no impact on transplant or patient survival [117] (LOE4).

Weight loss, if too rapid (> 5% at 1 month or > 10% at 6 months), is a sign of malnutrition that may be associated with sarcopenia, and a risk of parietal complications [116] (LOE4).

3.2.1.4. Immunosuppression. In the modern era of immunosuppression (after 2000 vs. before 2000), BMI is no longer considered an independent risk factor of graft loss and patient death [112] (LOE2).

3.2.1.5. Age, smoking. Like in patients without obesity, in patients with obesity, older age and smoking increase mortality, whereas serum albumin concentration > 35 g/L is a protective factor. Dialysis duration > 3 years and expanded criteria donors (defined below) and/or a transplant from a donor in cardiac arrest are risk factors of transplant dysfunction [95] (LOE2). Expanded criteria donors include donors older than 60 years of age or between 50 and 59 years of age with at least two comorbidities among creatinine concentration ≥ 1.5 mg/dL, history of high blood pressure, or death from stroke.

Longer cold ischemia time increases the risk of surgical site complications and consequently, of graft failure [115] (LOE4).

3.2.1.6. Donor type (living vs. deceased). The impact of comorbidities on graft and patient survival depends on the donor type (living vs. deceased). In recipients of deceased donor kidneys, peripheral vascular disease and obesity increase the risk of graft loss, while heart failure, cerebrovascular disease and chronic liver disease increase the mortality risk. In recipients of living donor kidneys, heart failure and diabetes are associated with reduced transplant survival [118] (LOE2).

3.2.1.7. Abdominoplasty before kidney transplantation. Abdominal dermolipectomy for removing excess skin, when indicated by the transplant surgeon before kidney transplantation in a selected population of non-smoking patients, appears to be effective and without major complications; it may reduce the waiting time before transplantation [129] (LOE4).

3.2.1.8. Other risk factors (e.g. carotid stenosis, abdominal diameter, metabolic syndrome, arterial stiffness). Obesity is associated with more atherosclerosis risk factors (hypertension, dyslipidemia) and morphological alterations (carotid stenosis and increased left ventricular mass) [126] (LOE4).

Abdominal diameter and several parameters of the "metabolic syndrome" as well as inflammation and arterial stiffness are negatively associated with graft survival after transplantation [127] (LOE4).

Malnutrition, inflammation, atherosclerosis are predictive of coronary complications after kidney transplantation [109] (LOE4).

Modifiable risk factors and non-modifiable risk factors (e.g. long vs. short ureter, defatted ureter, reflux, or other abnormalities on retrograde urethrography in the recipient) and second transplantation vs. first transplantation are associated with post-transplantation urinary complications (stenosis, fistulas, lithiasis, symptomatic reflux) [124] (LOE4).

Comorbidities associated with obesity (e.g. type 2 diabetes, diabetic nephropathy) have a negative impact on post-transplant outcomes [123] (LOE4) [117] (LOE4).

BMI, dialysis duration and transplant function (assessed using the eGFR), but not metabolic syndrome, increase the occurrence of major post-transplant events (death, cardiovascular events, and graft loss) [125] (LOE3).

3.2.2. Working group discussion

Most of the identified meta-analyses/systematic reviews did not assess post-surgical complications in transplant recipients with obesity. Importantly, obesity was defined solely based on the BMI value despite its known limitations: no study considered waist circumference, waist-to-hip ratio, or fat distribution. Not all confounding factors affecting transplant outcomes were taken into account, particularly the recipients' immunological profile, medication compliance, donor characteristics and comorbidities. All studies showing the survival benefit of transplantation in recipients with obesity were based on rigorous patient selection and control of their comorbidities. Obesity significantly increases the perioperative risk and surgical complications, particularly when combined with other risk factors, such as peripheral arterial disease.

3.2.3. Recommendations (Q1 + Q2)

Recommendations must comply with the regulatory framework in force.

R1. We recommend that patients with chronic kidney disease should be informed about the possibility of joining the transplant waiting list and about their specific risks (mortality, graft loss, complications) based on their characteristics (e.g. anthropometric and demographic parameters, comorbidities) (Grade EA).

R2. BMI alone (30–50 kg/m^2) is not a sufficient anthropometric criterion to block access to the pre-transplant evaluation (Grade EA). We recommend to use other criteria, such as the SVD (target value < 15 cm) to allow kidney transplantation (Grade C). In case of SVD > 15 cm, a greater pelvis angle should enable to consider transplant surgery (Grade C).

R3. Patients with BMI = 30–50 kg/m^2 should be referred to a specialized obesity center and concomitantly registered in the transplant waiting list (Grade EA). When referring patients to a specialized obesity center, the transplant team must specify the target weight and/or waist circumference as well as the average waiting time on the list (in relation to the group and immunological parameters) (Grade EA). Until the target weight is reached, the patient should be registered in the transplant waiting list, but left on temporary contraindication (Grade EA). The transplantation and nutrition teams should plan a multiprofessional discussion (Grade EA).

R4. Patients with BMI > 50 kg/m^2 who are candidates for kidney transplantation should be referred to a specialized obesity center; registration on the transplant waiting list will be considered once the target anthropometric criteria determined with the transplant team have been reached (Grade EA). The decision should be shared with the patient after multiprofessional discussion between the transplantation and nutrition teams (Grade EA).

R5. The temporary contraindication should be removed only after a thorough clinical assessment that includes non-modifiable factors (age and male sex) and also modifiable factors [smoking, drugs associated with weight gain, visceral obesity (i.e. increased waist circumference), sarcopenia, frailty, myosteatosis, rapid weight loss, donor type, and comorbidities (cerebral vascular disease, heart failure, chronic liver disease, type 2 diabetes) associated with reduced transplant survival] (Grade C).

R6. In recipients older than 70 years, the strategy must be adapted to their frailty status (sarcopenia, functional capacity, weakness, fatigue) and the weight loss risk-benefit balance, evaluated in a multiprofessional discussion with the nutritionist and geriatrician (Grade EA).

Noteworthy, in Asian populations, obesity is defined by a lower BMI than in other ethnic groups (> 25 kg/m^2 vs > 30 kg/m^2).

3.3. What criteria contraindicate robot-assisted transplantation in patients with obesity?

For this clinical question, the following studies were included: one recommendation [130], two prospective studies [131,132], one comparative study [133], four observational studies [134–137], and three retrospective studies [138–140].

3.3.1. Conclusions based on the data analysis

3.3.1.1. Feasibility of robot-assisted kidney transplantation in patients with obesity. Robot-assisted transplantation has acceptable outcomes if performed in selected patients by an experienced team [141], including in patients with grade 3 obesity [135] (LOE4), although the risk of delayed graft function increases with the BMI [135] (LOE4) [131] (LOE3). The number of transplant arteries is the only independent predictor of impaired kidney function [131] (LOE3).

3.3.1.2. Comparison with open surgery. In selected recipients with grade 3 obesity, the results of robot-assisted kidney transplantation are similar to those of open surgery, particularly in terms of graft survival, patient survival, delayed graft function, kidney function and readmission rates, with fewer technical complications [133] (LOE3). In patients with grade 3 obesity, robot-assisted kidney transplantation

is associated with reduced parietal complications [137] (LOE3) [136] (LOE3) [139] (LOE3). Graft function and survival are similar to those of open surgery [137] (LOE3) [136] (LOE3).

The working group emphasizes that robot-assisted surgery must take into account organizational aspects. Furthermore, it can almost exclusively be considered on a scheduled basis, thus solely with a living donor.

3.3.2. Working group discussion

Most of the data originates from studies in patients with obesity for whom conventional (open) transplant surgery was not suitable, or who received a kidney from a living donor. In these studies, the techniques were not standardized, thus limiting the result generalizability. Robot-assisted transplantation raises a number of specific issues, such as vascular control, transplant mobility and positioning. Placing the transplanted kidney in the peritoneum may increase the risk of poor kidney positioning, thus limiting the possibility of graft biopsy. However, a technique for fixing the kidney in an extraperitoneal pocket has been developed to avoid vascular torsion and allow biopsy [142]. Furthermore, there is a substantial learning curve for surgeons wishing to perform robot-assisted kidney transplantation [142]. In the European study on robot-assisted kidney transplantation, early arterial thrombosis was reported only in 3/120 recipients (118 from living donors, average BMI: 25 kg/m^2) [141].

3.3.3. Recommendations

Recommendations must comply with the regulatory framework in force.

R7. Robot-assisted transplantation may be considered in selected patients with obesity, even with grade 3 obesity (i.e. patients with limited vascular disease, no history of major abdominal or pelvic surgery) (Grade C).

3.4. What weight loss methods should be used in transplant candidates with obesity?

For this clinical question, the following studies were included: one recommendation [143], five systematic reviews/meta-analyses [144–148], three prospective studies [149–151], two comparative studies [152,153], twenty-nine observational studies [154–181], and four retrospective studies [182–185].

3.4.1. Conclusions based on the data analysis

3.4.1.1. Weight loss. In patients with BMI between 30 and 35 kg/m^2, weight loss could increase post-transplant complications [95] (LOE2), without any effects on the patient or graft survival [96] (LOE4). Noteworthy, weight loss is mandatory to access the transplant waiting list and be eligible for kidney transplant. Furthermore, unaccompanied weight loss is associated with loss of muscle function and mass (sarcopenia) and nutritional deficiency, increasing the risk of post-transplant complications and weight regain [178] (LOE3). In patients with frailty ($\geq$ 3 of the following four criteria: weakness, fatigue, slow walking speed, and low level of physical activity), including those with sarcopenia, unintentional weight loss increases mortality while on the waiting list [185] (LOE2). Despite the vital motivation (access to transplantation), weight loss remains modest (1.7 kg/m^2 on average) in the absence of personalized medical and surgical support [183] (LOE3).

3.4.1.2. Health, dietary and lifestyle guidelines. In patients with ESRD, obesity and type 2 diabetes, health and dietary guidelines have limited success and lead to a potential risk of "dropout" (withdrawal) from the transplant list [160] (LOE4). Bariatric surgery is more effective in promoting access to transplantation than lifestyle and dietary guidelines alone [149] (LOE3). The implementation of dietary and lifestyle modifications appears complex due to poor patient compliance, whereas weight loss using at least one GLP-1 receptor agonist is significant, yet more studies are still needed in that field [180] (LOE4).

3.4.1.3. Bariatric surgery. Bariatric surgery reduces body weight, BMI and waist circumference [144] (LOE2). It is considered safe and effective in patients with ESDR before transplantation [145] (LOE4) [146] (LOE4); however, the risk of complications and death is higher than in candidates for bariatric surgery without kidney failure [146] (LOE4). The sequence "bariatric surgery before kidney transplantation" is a protective factor against delayed graft function, all-cause transplant failure and mortality, but is associated with an increased risk of acute rejection in the year following transplantation [169] (LOE4). However, results differ among studies. The sequence "bariatric surgery before transplantation" appears to be more protective than the sequence "transplantation before bariatric surgery" in terms of graft survival [169] (LOE4).

All the studies discussed below included a population with a bariatric surgery indication, thus with BMI $>$ 35 kg/m^2 and an obesity-related disease.

Sleeve gastrectomy (SG), whether laparoscopic or robotic, appears to be safe and effective and reduces mortality [174] (LOE3) [152] (LOE4), improves obesity-related comorbidities (e.g. type 2 diabetes, hypertension) [168] (LOE4) [153] (LOE4) [Hajjar et al., 2021] (LOE4) [152] (LOE4), reduces post-transplant complications [173] (LOE4) [156] (LOE4) and improves kidney function [152] (LOE4). Weight loss after SG is similar in patients with obesity with or without ESRD. In patients with kidney failure, SG improves or even induces the remission of some comorbidities (e.g. type 2 diabetes, hypertension) [167] (LOE3).

No study on endoscopic techniques (endo-sleeve) was included because this technique has not yet been included in the basket of care recommended by the French HAS in 2025.

Roux-en-Y gastric bypass (RYGB) reduces BMI [170] (LOE4) [171] (LOE4) [175] (LOE4), leads to metabolic improvement and improves obesity-related comorbidities (e.g. type 2 diabetes, hypertension) [170] (LOE4) [181] (LOE4). RYGB is associated with adverse effects, such as nausea, vomiting, chronic abdominal pain, but does not influence the post-transplant outcomes [170] (LOE4). However, patients who underwent RYGB require higher doses of tacrolimus to achieve the same blood concentrations as patients with obesity who have undergone transplantation without bariatric surgery [170] (LOE4).

A comparison of the different bariatric surgery types in patients with ESRD showed that RYGB is the most effective procedure in terms of early postoperative weight loss, followed by SG and ajustable gastric banding. However, RYGB was associated with an increased morbidty and mortality rate compared with SG. Comorbidities improvement is consistent with all techniques [182] (LOE not applicable).

Two studies support a new combination strategy (robot-assisted kidney transplantation and robotic SG performed simultaneously) in patients with obesity. They show significant weight loss, without negative impact on graft function in this high-risk population [140] (LOE not applicable) [132] (LOE2).

3.4.1.4. Pharmacological treatments. The use of GLP-1 receptor agonists is not currently approved for patients with obesity and ESRD. However, they are not contraindicated, and several studies evaluated their effects. Most studies on daily GLP-1 receptor agonists included patients with type 2 diabetes and kidney impairment. Daily GLP-1 receptor agonists induce a moderate but significant BMI reduction, which varies depending on the study (different molecules and doses). Weight loss is slightly higher with dulaglutide than

liraglutide (approximately half of the patients received 4.5 mg of dulaglutide and 1.2 mg of liraglutide) [147,186–195] (LOE4) (studies cited in the narrative review [148]). The plasma concentrations of liraglutide (1.8 mg/day max for 12 weeks) increase during treatment in patients with type 2 diabetes and ESRD, and gastrointestinal side effects are more pronounced and frequent [151] (LOE2) (this type of study only exists for liraglutide and not longer term GLP1 receptor agonists). In prospective studies that included patients with ESRD and in retrospective cohort studies on type 2 diabetes and kidney transplantation [150] (LOE4), and in studies in patients without diabetes on dialysis [176] (LOE3), semaglutide [max 1 mg/week (injectable) or 14 mg/day orally (not yet available in France), median treatment duration of 17 months, or max 1 mg/week for 12 weeks] leads to moderate weight loss (5 kg on average) [150] (LOE4) [176] (LOE3). Noteworthy, in the general population without ESRD, patients with type 2 diabetes usualy lose less weight than patients without type 2 diabetes upon GLP1 receptor agonist. No data are available for the 2.4 mg/week dose (used for obesity management) in this population. Semaglutide is well tolerated and gastrointestinal side effects are similar to those observed in patients without renal function impairment. In patients with type 2 diabetes, the risk of hypoglycemia is increased, particularly in individuals treated with insulin or those who are too well controlled (studies cited in the narrative review [147]) [150] (LOE4) [176] (LOE3).

3.4.2. Working group discussion

The French Consultative and Coordination Group for Specialized Obesity Centers (GCC-CSO) recently produced a position statement for best practice on the support required when prescribing pharmacological treatments for obesity [196]. In patients with obesity without kidney failure, liraglutide (3 mg/day) and semaglutide (2.4 mg/day) decrease body weight by 8% and 15%, respectively. Noteworthy, weight loss is lower at lower treatment doses and the weight loss response displays high inter-individual variability. Moreover, despite comparable doses, weight loss is significantly lower in patients with obesity and type 2 diabetes than in patients with obesity but without type 2 diabetes.

Preserving muscle mass is an essential part of obesity management in these patients.

The working group emphasizes the importance of adjusting the insulin doses when introducing GLP-1 receptor agonists in patients with type 2 diabetes to prevent the risk of hypoglycemia.

Noteworthy, the available studies on GLP-1 receptor agonist-induced weight loss before kidney transplantation did not evaluate all-cause mortality, cardiovascular events, kidney transplant success, and nutritional status.

3.4.3. Recommendations

R8. Weight loss benefits/risks before kidney transplantation should be systematically balanced, taking into account BMI, obesity severity, obesity-related comorbidities, and the risk of sarcopenia (Grade EA).

R9. Patients with frailty (≥ 3 criteria among the following four criteria: weakness, fatigue, slow walking speed, and low level of physical activity), including those with sarcopenia, should receive appropriate nutritional care, in which optimized protein and calorie intake are combined with an appropriate physical activity program that includes muscle strengthening, before proposing any weight loss strategy (Grade B).

R10. Multidisciplinary support or weight loss methods should be considered by taking into account the expected waiting time before transplantation (based on immunological and blood group criteria) and target anthropometric parameters (Grade EA).

R11. The first-line of weight loss strategy should be based on nutritional management and appropriate physical activity and should be supported by a multidisciplinary team (nutritionist, surgeon, dietitian, adapted physical activity instructor, psychologist) (Grade EA).

R12. Unintentional and/or unsupervised weight loss before kidney transplantation (i.e. weight loss due to an intercurrent illness or following an overly restrictive and unsupervised diet) should raise awareness of a potential increased risk of post-transplantation mortality and requires a thorough evaluation (Grade B).

R13. The weight loss strategy should be considered in accordance with the HAS recommendations [143]:

- first-line treatment: nutritional management;
- second-line treatment: bariatric surgery.

However, in patients with kidney failure and to increase their chances of being placed on the transplant waiting list, the working group emphasizes that bariatric surgery should be considered fairly quickly after optimal nutritional preparation.

In patients with kidney failure, the pharmacological treatment of obesity is currently evaluated and may be considered with caution, especially if the required weight loss is modest.

3.4.3.1. Medical approaches and lifestyle changes. **R14**. It is recommended to offer appropriate and personalized therapeutic lifestyle changes, with close follow-up to improve compliance and optimization (Grade EA).

3.4.3.2. Bariatric surgery. **R15**. Bariatric surgery may be offered before transplantation in patients with grade ≥ 2 obesity and kidney failure (Grade B), or grade 1 obesity in the presence of poorly controlled type 2 diabetes (Grade EA).

R16. Bariatric surgery in patients with kidney failure must be performed in a center approved for bariatric surgery and with dialysis facilities, in accordance with the HAS guidelines [143].

R17. The type of bariatric surgery should be discussed by taking into account the amount of expected weight loss (RYGB is superior to SG, particularly in the long term), comorbidities, current pharmacological treatments, expected transplant waiting list time, and the surgical procedure morbidity (higher with RYGB than with SG), as part of a shared decision with the patient (Grade C).

R18. SG may be preferred in patients at high surgical risk, due to its lower morbidity and satisfactory weight loss results (Grade C). Regardless of the type of procedure chosen, adjustment of post-transplant immunosuppressant doses should be considered (Grade EA).

R19. Adjustable gastric banding may be discussed for patients with a formal contraindication to any other bariatric surgery type during a multidisciplinary discussion that includes nutritionist, bariatric surgeons and nephrologists (Grade EA).

R20. We do not recommend to perform bariatric surgery simultaneously with kidney transplantation except in the framework of research protocols (Grade EA).

3.4.3.3. Pharmacological treatments of obesity. **R21**. Pharmacological treatments of obesity (mainly GLP-1 receptor agonists) may be offered to patients with obesity and ESRD. Nevertheless, they should be closely monitored, including verification of digestive tolerance and dietary intake to cover their daily requirements. Doses should be adapted according to the weight loss results and digestive tolerance (Grade EA); see the GCC-CSO Force position statement [196].

R22. Pharmacological treatments of obesity (i.e. GLP-1 receptor agonists) should be used with caution because specific data in the pre-transplant population remain limited. Furthermore, drug treatments for obesity are indicated for long-term use, and discontinuation is accompanied by weight regain (Grade A); see the GCC-CSO Force position statement [196]. In patients with obesity and type 2 diabetes,

GLP-1 receptor agonists provide additional health benefits (particularly, cardiovascular benefits and improved glycemic control) in addition to weight loss, and may be continued after transplantation.

R23. Due to the increased risk of adverse digestive effects, it is recommended to start with low doses and slow titration (literature data for this population are available only for liraglutide). In patients with obesity and type 2 diabetes treated with insulin, the introduction of a GLP-1 receptor agonist must be accompanied by an adjustment of the insulin doses to prevent the risk of hypoglycemia (Grade EA).

3.4.3.4. Monitoring during weight loss regardless of the method used.
R24. Weight loss should be monitored regularly in accordance with the recommendations by HAS (surgery, available at https://www.has-sante.fr/) and the GCC-CSO Force (drug treatments for obesity, available at https://www.obesitefrance.fr/) (Grade B).

R25. It is recommended to actively monitor muscle strength (chair rise test and/or hand grip) and mass (e.g. bioimpedance, imaging) during weight loss programs to limit sarcopenia. Muscle prehabilitation programs to preserve lean mass may be suggested (Grade EA).

R26. It is recommended to reassess the kidney transplantation eligibility at each stage of weight loss in order to adjust the strategy and avoid missed opportunities (Grade EA).

Disclosure of interest

The authors declare that they have no competing interest.

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Appendix A. Supplementary data

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