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REVIEW

Bariatric surgery in prospective obese living kidney donors: scoping review and management decision algorithm

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ABSTRACT

INTRODUCTION: Global chronic kidney disease is now epidemic, with substantial health and economic consequences. While scientific support for living donor renal transplants (LDRT) is strong, donor shortages necessitate consideration of expanded criteria, including obese individuals. Bariatric surgery (BS) may mitigate obesity-related risks, but research on living donor candidates is scarce. Our scoping review aims to compile evidence, identify gaps, and formulate an algorithm to guide healthcare professionals in evaluating BS for obese living donors.

EVIDENCE ACQUISITION: We did a systematic search of studies on living kidney donors and obesity. We searched the MEDLINE Ovid, Embase Ovid, CENTRAL and Web of Science databases for studies from database inception to March 30, 2023. All English-language articles available in full text have been considered. Excluded are commentaries, editorials, letters, and abstracts.

EVIDENCE SYNTHESIS: Obesity in LDRT raises long-term ESRD risk. Current high BMI donor admission raises ethical and clinical concerns. Encouraging timely weight loss can make obese candidates suitable donors, reducing risks. Sleeve gastrectomy is the most reported and preferable approach, since it minimizes hyperoxaluria risk. Re-evaluation for donation is possible 6-12 months post-BS, with BMI<35 for three months. Cost-benefit analysis favors BS over nephrectomy in obese donors (cost-benefit ratio: 3.64) when graft survival is equal.

CONCLUSIONS: BS shows promise with short-term effectiveness and potential long-term outcomes. However, it should not be perceived as a means to expand the donor pool but rather as a personalized approach to address obesity and improve individuals' health.

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KEY WORDS: Living donors; Kidney transplantation; Bariatric surgery; Body Mass Index; Obesity.

Introduction

The global prevalence of chronic kidney disease (CKD) has reached epidemic proportions, driven by factors like population growth, aging, and an increased incidence of diabetes and hypertension. This condition affects nearly 300 million individuals worldwide and leads to approximately 1.2 million deaths annually.[1] The associated direct and indirect costs are substantial,

posing a significant threat to the sustainability of healthcare systems, especially those with universal coverage, such as Italy or UK. In this intricate context, the advantages of transplantation are firmly established, showcasing its superior clinical outcomes and cost-effectiveness compared to the alternative of dialysis.[2-6] A mounting body of scientific evidence strongly supports the promising role of living donor renal transplant (LDRT) as the optimal choice for all stakeholders involved, including donors, recipients, and healthcare systems.[7-9] Consequently, existing guidelines establish pre-emptive LDRT as the preferred treatment for addressing end-stage renal disease (ESRD), and transplant centers are encouraged to prioritize living donor programs.[10-12] Regrettably, there is a decrease in the count of living kidney donors.[13] To reverse this trend and tackle the shortage of organs, there is an increasing tendency to consider marginal donors, also called expanded criteria living donors, *i.e.* individuals deemed eligible despite having suboptimal clinical or surgical conditions.[14, 15] This circumstance often gives rise to clinical and ethical dilemmas that require attention from the scientific community.[16]

Donor obesity stands as a crucial component of such "expanded criteria," generating significant attention due to epidemiological, technical, and strategic considerations. High BMI often leads to donor exclusion, but if managed safely, it can strategically help widen the donor pool. At present, a universally defined BMI threshold for the acceptance of living donor candidates does not exist, and various guidelines and recommendations propose distinct cutoffs and strategies. For instance, KDIGO recommendations propose a personalized approach for approving donor candidates with obesity and a BMI>30.[10] In contrast, more recent guidelines from the British Transplant Society expand the acceptable eligibility range to individuals with a BMI up to 35.[17] Undoubtedly, the acceptance rate for obese living kidney donors is on the rise, albeit with significant variations among different centers. According to a recent survey conducted by Lafranca *et al.*, the findings indicate that 99.5% of participating centers are open to donors who fall into the overweight category (BMI 25-30), 69.5% accept obese donors (BMI 30-35), morbidly obese donors are considered in 16.2% of the centers, while only 5.1% are willing to accept donors with a BMI exceeding 40.[18] Based on the latest USA data from 2021, approximately 24% of living donors have a BMI>30, while the number of morbidly obese donors – those with a BMI>40 – is lower than 5% and remains consistent with previous years.[13] The intriguing aspect, though lacking concrete statistics, pertains to the rejection rates of living donor candidates due to their BMI. As per Montgomery *et al.*, relying on data from single-center studies, exclusion rates for obesity seem to range from 1.8% to 25%.[19] A report from a single Italian Center that retrospectively analyses the causes of exclusion among living kidney donor candidates reveals that approximately 14.5% of them are excluded due to obesity.[20] Given this context of high prevalence of CKD and obesity as well as of scarce of living donors, the transplant community can hardly afford such exclusion rates and associated uncertainty regarding the acceptance of obese living donors.

On the opposing side, it is essential to acknowledge the increasing risks of obesity in living donors, which have implications for both the donor and the recipient. Based on available literature, the study by Montgomery *et al.* indicates that: "*when compared to normal-weight donors, obese donors are more likely to experience short-term postoperative decline in eGFR and have a higher long-term risk of developing ESRD. They also have higher post-donation rates of newly diagnosed diabetes (up to 6.3%), cardiovascular disease (up to 8.3%), hypertension (up to 69%), abnormal high-density lipoprotein (up to 44%), microalbuminuria (up to 21%), and further weight gain (up to 35%). Recipients of kidney from obese LKDs also do worse: they experience a higher risk of graft loss, and recipients of kidneys from donors who later develop ESRD have a higher risk of mortality.*"[19]

Reported weight loss strategies aiming to reduce obesity and make obese donor candidates eligible for donation exist; however, the long-term outcomes remain uncertain.[21] The potential risk of weight regain post-surgery must be diligently evaluated, as it poses a significant concern for potential donors. Moreover, longer time needed to weight loss through conservative meth-

ods could result in prolonged dialysis exposure or the reception of a deceased donor organ offer. Additionally, this prolonged process might place unacceptable psychological pressure on donor candidates. Latest guidelines recommend bariatric surgery (BS) for individuals with a BMI>35, regardless of presence, absence, or severity of comorbidities. In addition, BS should be considered for individuals with metabolic disease and BMI of 30-34.9.[20] Long-term weight loss outcomes following BS consistently show over 60% excess weight loss maintained for years post-surgery, with slight variations based on the specific procedure performed.[22-24] BS has demonstrated its superiority to diet, exercise, and other lifestyle interventions in achieving sustained and significant weight loss.[21, 25, 26] Therefore, BS might benefit obese living kidney donors and recipients and potentially mitigate higher risks related to obesity as well as enhance the overall health profile of potential living donors. However, there is a significant lack of published literature regarding the use of BS for weight loss in potential living donor candidates.

This scoping review aims to gather existing evidence, both quantitative and qualitative, to give a complete picture of the topic, including what is missing and what further research is needed. Ultimately, drawing from the accessible studies, our intention is to formulate an algorithm assisting healthcare professionals in the evaluation and recommendation of BS for selected obese living donor candidates.

Evidence acquisition

This scoping review aims to aggregate available evidence concerning BS in prospective living kidney donors. The decision to conduct a scoping review is based on the anticipated lack of studies, diverse sources and designs, and the need to comprehensively map existing literature instead of addressing a specific research question. All English-language articles available in full text have been considered. Excluded are commentaries, editorials, letters, and abstracts.

We searched four scientific databases – Medline Ovid, EMBASE Ovid, CENTRAL, and Web of Science – for studies available up to March 30, 2023. Detailed search terms for each database are outlined in the *Appendix*. All records retrieved were imported into EndNote ver.20, with duplicates automatically removed. For screening, the Rayyan platform was utilized.[27] Two reviewers (FP and IU) independently assessed titles and abstracts for eligibility, resolving discrepancies through reviewers' discussion or consulting a third party (MIB or JR). Articles meeting eligibility criteria underwent full-text review and data extraction. In cases of eligible articles lacking full text, corresponding authors were contacted *via* email. To ensure comprehensive coverage, reviewers (FP and IU) also checked reference lists of included studies.

No patients or public were involved in the study.

Evidence synthesis

Results of our search are summarized in the PRISMA flow diagram in Figure 1.[28]

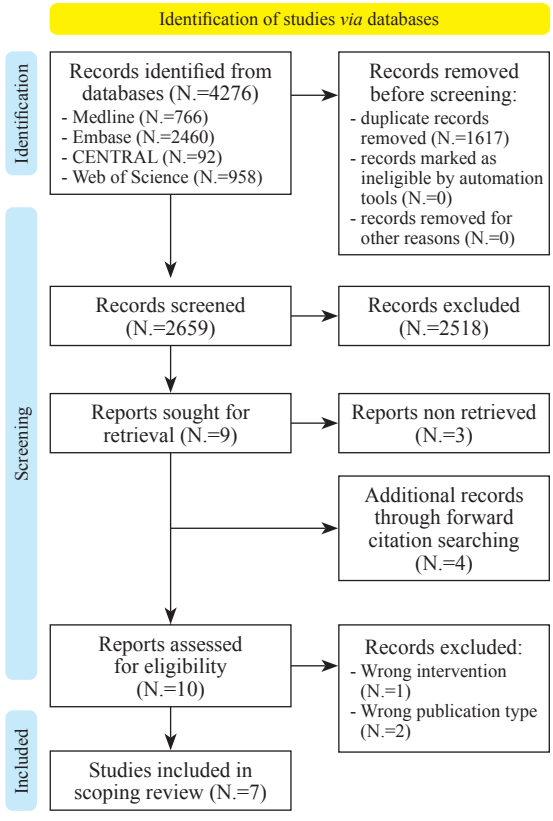

Figure 1.—PRISMA flow diagram of selection process.

Following the removal of duplicates, the database search generated 2659 citations. Screening titles and abstracts led to an initial categorization, with nine papers advancing to full-text assessment. Additionally, the full texts of three extra references identified through forward citation searching were examined. Among the 12 studies eligible for full-text review, four were not accessible, and two were excluded after comprehensive reading due to an incorrect intervention description and incorrect publication type. Efforts were made to contact corresponding authors for unretrievable articles, yielding no response. During the crafting of the manuscript, we came across an additional and very recent eligible article, published in September 2023. Considering the scant availability of pertinent literature, we decided to include it in our scoping review. Ultimately, seven studies were incorporated into the scoping review, summarized in Table I.[19, 29-33]

Among these studies, there are two case reports that describe three instances of BS performed to attain donation eligibility. Additionally, two retrospective case series involving living donor candidates who had previously undergone bariatric procedures in two prominent USA centers were identified. The remaining three studies function as background papers detailing the risks and benefits of bariatric and metabolic surgery in potential living donor candidates.

For a more comprehensive and reader-friendly structure, our scoping review's data synthesis is divided into three primary sections. Firstly, we provide a contextual overview of obesity as a modifiable risk factor in living donor candidates. Secondly, we present outcomes regarding the practical application of BS to improve donor eligibility or aid donor weight loss efforts. Lastly, we discuss the available data on the economic and social implications of BS in potential living donors. It is important to note that the content within this section is drawn from existing literature and may not necessarily align with the individual perspectives of the authors of the scoping review.

Obesity as a modifiable risk factor among living donor candidates

The connection between obesity and an increased risk of long-term end-stage renal disease (ESRD) has led to the prevailing perception that obese individuals might be less ideal as kidney donors, and in some cases, even deemed ineligible. However, recent research has provided a fresh perspective. Emerging studies indicate that the real risk associated with obese living donors is in fact lower compared to that of obese non-donors.[35] This contrast arises because these donors belong to a highly selective population characterized by a lower-than-average susceptibility to medical complications and undergo more stringent health assessments throughout their lives. However, simply having a "lower risk" does not automatically mean that donor nephrectomy is entirely safe for obese candidates. A study conducted by Locke *et al.* examined a massive cohort of 119,769 living kidney donors from across the USA.[29] Their findings showed

TABLE I.—*Summary table of included studies.*[19, 29-33]

Year	Authors	Title	Publication type
2007	Branco *et al.*[31]	Laparoscopic live donor nephrectomy in patients surgically treated for morbid obesity	Case report
2010	Koshy *et al.*[30]	Laparoscopic adjustable gastric band in an obese unrelated living donor prior to kidney transplantation: a case report	Case report
2017	Brooks *et al.*[34]	Bariatric surgery for obese live kidney donors: an analysis of risks and benefits	Background article
2017	Locke *et al.*[29]	Obesity increases the risk of end-stage renal disease among living kidney donors	Background article
2019	Montgomery *et al.*[19]	Bariatric surgery for prospective living kidney donors with obesity?	Background article
2019	Nguyen *et al.*[32]	Bariatric surgery prior to living donor nephrectomy: a solution to expand the living donor kidney pool - a retrospective study	Retrospective case series
2023	Bielopolski *et al.*[33]	Bariatric Surgery in Severely Obese Kidney Donors Before Kidney Transplantation: A Retrospective Study	Single-center retrospective study

that out of every 10,000 donors, around 40 non-obese and 94 obese individuals developed ESRD within 20 years after donation. In other words, compared to non-obese donors, those who were obese had a 1.9 times higher risk of experiencing post-donation ESRD and the risk of post-donation ESRD increased by 7% for each additional unit increase in pre-donation BMI beyond 27 kg/m^2. In addition, the authors found that, after controlling for multiple risk factors, such as age at donation, ethnicity, gender, baseline eGFR and blood pressure, the only potentially modifiable factor that remained independently associated with increased risk for development of ESRD post-donation was obesity.

Hence, even though there is a growing acceptance of obese individuals as potential donors, it is crucial to bear in mind that obesity is linked to an increased risk of ESRD among living donors.[36] Importantly, this risk is modifiable. Consequently, it is highly advisable to encourage and support patients in adopting feasible strategies to reduce weight. Such efforts will significantly enhance both the patients' well-being and their overall quality of life, irrespective of their decision to proceed with donation. In this light, their eligibility for living kidney donation could be viewed as an opportunity for them to embark on a journey of comprehensive self-care: undoubtedly, this represents an extra clinical and societal benefit offered by living donor programs.

BS in living donors: strategies and reported performances

The number of published case reports on BS in living kidney donors is extremely limited. Our thorough literature review has revealed just three articles detailing a total of 25 cases where living kidney donors underwent BS prior to their donation. These cases have been succinctly summarized in Table II.[30-32] However, it is important to highlight that among these three articles, only two describe three cases of living donor candidates choosing BS as a preparatory step before

TABLE II.—*Case series of bariatric interventions in living kidney donors: synthesis of available case reports.*[30-32]

N.	Bariatric surgery					Living donor nephrectomy					Follow-up		Authors
	Age (yrs)	Sex	BMI Pre-BS	BMI Post-BS	Type of BS	BS to LD (YRS)	Surgical approach	WIT (sec)	EBL (cc)	OT (min)	Cr(s)	BMI	
1	23	M	40.9	28.1	RYGB	NA	ha-LDN	108	100	75	1.1	25.7	Branco *et al.*[31]
2	54	F	48.7	32.4	RYGB	NA	LDN	132	80	90	1.1	32	Branco *et al.*[31]
3	53	F	41.5	32.6	LAGB	1	ha-LDN	NA	NA	NA	NA	33.5	Koshy *et al.*[30]
4	60	F	40.8	33.7	LAPBAND	0.7	LDN	273	50	213	NA	NA	Nguyen *et al.*[32]
5	35	F	46.9	34.8	LAPBAND	3	LDN	187	50	230	NA	NA	Nguyen *et al.*[32]
6	28	M	50.1	34.2	LAPBAND	4	LDN	198	100	250	NA	NA	Nguyen *et al.*[32]
7	31	F	40.4	28.8	LAPBAND	2	LDN	248	100	281	NA	NA	Nguyen *et al.*[32]
8	29	F	44.6	31.8	LAPBAND	5	ha-LDN	142	50	177	NA	NA	Nguyen *et al.*[32]
9	50	F	38.6	33.3	LAPBAND	NA	ha-LDN	73	50	177	NA	NA	Nguyen *et al.*[32]
10	64	F	*n.a.*	27.4	RYGB	8	ha-LDN	NA	0	320	NA	NA	Nguyen *et al.*[32]
11	51	F	46.4	31.9	RYGB	22	LDN	248	75	185	NA	NA	Nguyen *et al.*[32]
12	50	F	50.5	30.2	RYGB	3	LDN	203	700	223	NA	NA	Nguyen *et al.*[32]
13	58	F	45	20.2	RYGB	5	LDN	NA	50	225	NA	NA	Nguyen *et al.*[32]
14	41	F	52.7	33.5	RYGB	6	LDN	243	50	246	NA	NA	Nguyen *et al.*[32]
15	31	M	51.8	33.6	RYGB	9	LDN	224	75	285	NA	NA	Nguyen *et al.*[32]
16	36	F	44	32.9	RYGB	21	LDN	NA	500	313	NA	NA	Nguyen *et al.*[32]
17	62	F	43.6	32	RYGB	13	ha-LDN	NA	200	192	NA	NA	Nguyen *et al.*[32]
18	33	F	34	26.5	SLEEVE	2	LDN	136	100	165	NA	NA	Nguyen *et al.*[32]
19	49	F	36.5	25.6	SLEEVE	1	LDN	155	50	174	NA	NA	Nguyen *et al.*[32]
20	57	F	51.7	26.1	SLEEVE	2	LDN	270	75	209	NA	NA	Nguyen *et al.*[32]
21	50	F	44	29.2	SLEEVE	4	LDN	NA	50	213	NA	NA	Nguyen *et al.*[32]
22	40	F	42.9	25.4	SLEEVE	3	LDN	NA	50	250	NA	NA	Nguyen *et al.*[32]
23	43	F	48.1	32.4	SLEEVE	0.8	ha-LDN	NA	0	251	NA	NA	Nguyen *et al.*[32]
24	34	F	60.7	37.2	SLEEVE	4	ha-LDN	NA	0	253	NA	NA	Nguyen *et al.*[32]
25	63	F	54.9	33.5	BPD	14	ha-LDN	NA	150	296	NA	NA	Nguyen *et al.*[32]

BMI: Body Mass Index; BS: bariatric surgery; LD: living donation; WIT: warm ischemia time; EBL: estimated blood loss, OT: operation time; Cr(s): serum creatinine;, RYGB: Roux-en-Y gastric bypass; LAPBAND: laparoscopic gastric banding; SLEEVE: sleeve gastrectomy; BPD: bilio-pancreatic diversion; LDN: laparoscopic donor nephrectomy; ha-LDN: hand-assisted laparoscopic donor nephrectomy.

kidney donation.[30, 31] In contrast, the third article presents a series of 22 patients who underwent BS before their living kidney donations, but their decision to donate was independent of the earlier weight loss procedures.[32] A recent similar retrospective study was also published by Bielopolski *et al.*, however, individual patient data are not available and therefore those cases have not been included in Table II.[33]

Branco *et al.* outline the cases of two individuals grappling with class III obesity (BMI>40) who underwent laparoscopic Roux-en-Y gastric bypass (RYGB) surgery with the primary objective of expediting kidney donation.[31] Both patients managed to shed weight successfully, rendering them eligible for donation within a span of 4 to 7 months. After weight loss, both patients underwent uneventful laparoscopic nephrectomies and were discharged on the first postoperative day. Follow-up data, extending only to a few months, document normal creatinine levels and the sustenance of weight loss after donation.

The patients described by Koshy *et al.* underwent laparoscopic adjustable gastric banding (LAGB), leading to a weight loss of 21.5% achieved over seven months.[30] This patient eventually underwent laparoscopic hand-assisted donor nephrectomy. Importantly, eight months following the donor nephrectomy procedure, the donor's kidney function remained stable, and the LAGB was still securely in place. Additionally, the donor's latest BMI corresponded with previous measurements, underscoring the enduring influence of the bariatric intervention.

The study by Nguyen *et al.* study stands as the most extensive case series involving individuals with class II and III obesity who underwent BS prior to living kidney donation, albeit not explicitly aimed at donation.[32] In all documented cases, these patients had previously been deemed ineligible for donation due to high BMI. However, their eligibility was restored following the bariatric procedure. Collectively, an average weight loss of 32.6% was accomplished post-BS, accompanied by an average decline in BMI from 46.2 to 30.6. The procedures discussed comprise six sleeve gastrectomy (SG), eight RYGB, six LAGB, and one biliopancreatic diversion (BPD). While the authors did not highlight distinct performance disparities linked to various procedures, a broad overview of the data implies that SG could potentially be linked to the shortest operation time and the shortest interval between BS and donation. However, available data are inadequate to conclude that SG results in the quickest weight loss and eligibility for donation. The duration between the BS and the subsequent donation exhibited significant variation, ranging from less than a year to over two decades. As pointed out by the authors, this aspect has both its limitations and its benefits. While it does not provide a clear guideline for the ideal time span between BS and donor nephrectomy, it does offer valuable information about postdonation weight changes. Many donors had a substantial time gap between BS and the following laparoscopic donor nephrectomy. During this period, they managed to sustain meaningful weight loss. This suggests that significant weight gain in the long term after donation is unlikely. In Nguyen's study, an initial comparison between donors who underwent BS prior to laparoscopic living donor nephrectomy and obese donors with a BMI between 35 and 40 was also conducted.[32] Notable differences emerged between the two groups: obese donors experienced longer warm ischemia time, extended operative time, and increased hospital stays in contrast to the BS donor group. Additionally, the obese donor group accounted for the only two instances of postoperative complications necessitating exploratory laparotomy due to peritonitis. It is important to clarify that these findings are purely observational and do not establish any causal relationships. However, considering the absence of existing evidence on the subject, this "artificial control" approach presents valuable insights for guiding future research endeavors.

Bielopolski *et al.*[33] conducted a retrospective analysis comparing 23 LDs who underwent BS before kidney donation with two control groups: patients who had BS but did not proceed with kidney donation and patients who underwent donor nephrectomy without prior BS. The value of this study is twofold: it allows to assess the combined impact of weight loss and nephron loss and it provides data over an extended follow-up period of up to 7-8 years postintervention. Sleeve

gastrostomies accounted for more than 60% of bariatric procedures, and all LD nephrectomies were performed laparoscopically. The study group exhibited an average BMI of 41 before undergoing BS, with all patients successfully reducing their BMI to 28 within one year following the bariatric intervention. It is noteworthy that both the study and control groups experienced a slight weight regain few years after BS. The mean time between BS and nephrectomy was 5±5 years in the study group. This wide range can be attributed to the fact that not all patients in this group underwent BS with the explicit intention of donating a kidney. Regarding the results of this retrospective analysis, it emerges that sequential BS and donor nephrectomy led to a notable decline in lipid profiles for patients, specifically elevated LDL and cholesterol levels. Importantly, this difference did not affect their 10-year cardiovascular risk, as assessed by the Framingham calculator. While the authors advocate for considering BS before LD nephrectomy in obese donor candidates, it is essential to emphasize the need for vigilant monitoring of lipid abnormalities. Furthermore, evaluating the potential benefits of early statin therapy may help mitigate the combined impact of BS and nephrectomy on lipid profiles. Regarding kidney function, both before and one year after nephrectomy, the study group's values for serum creatinine, eGFR, and absolute GFR were similar to those of matched nonobese kidney donors. However, at the end of the follow-up period, the study group displayed a significantly higher absolute eGFR compared to the control group of nonobese donors. Notably, the authors highlighted that the commonly used eGFR formula standardized to a body surface area (BSA) of 1.73 m^2 could be misleading when comparing GFR levels before and after BS in the same patients. To avoid overestimation, it is crucial to calculate eGFR while adjusting for individual BSA. As pointed out by the authors, patients undergoing sequential BS and nephrectomy experience two significant changes: the reversal of hyperfiltration due to the reduction in body mass and the loss of 50% of nephron mass due to nephrectomy. According to the study's analysis, only nephrectomy affects eGFR when using individual BSA-adjusted formulas. In the article's conclusion, the authors emphasize the importance of long-term follow-up. They stress that obese patients who eventually undergo nephrectomy subject their remaining kidney to hyperfiltration twice: initially as an adaptive response to cope with increased body mass and subsequently as an adaptive response to compensate for the reduced nephron mass. The long-term consequences of this double impact on the kidney, as well as the extent to which BS reduces the risks of developing CKD, remain areas that warrant further investigation.

Economic evaluation

BS offers not only clinical advantages but also substantial financial benefits and societal value for obese potential living kidney donors and their recipients. An insightful study by Brooks *et al.* delves into the economic assessment of incorporating BS prior to living donor nephrectomy.[34] While the study's foundation rests upon theoretical scenarios, empirical data is drawn from preceding studies, and a series of sensitivity analyses are rigorously performed to enhance the study's robustness. The study's findings are particularly noteworthy: the benefit-cost ratio associated with the sequence of BS followed by living donor nephrectomy is reported as 3.79. In contrast, the ratio attributed to transplantation using organs from deceased donors stands at 0.97. In essence, the economic advantage of transforming an initially obese and potentially disqualified living donor into a viable contributor through BS is nearly fourfold compared to the alternative scenario wherein a recipient accepts an organ from a deceased donor.

The reasons for such a remarkable cost-effective advantage are manifold. Firstly, as previously mentioned, obese donor candidates derive a pronounced survival benefit and an improved quality of life following BS. This effect is highlighted in the work of Peeters *et al.*, who suggest that individuals undergoing BS experience an extension of life expectancy by up to seven years when compared to those employing conventional weight loss strategies.[37] Similar outcomes are noted in the work of Carlsson *et al.*, where it is suggested that BS is linked to a comparable decrease in overall and cardiovascular mortality,

along with an increased life expectancy.[38] Notably, this change also implies a substantial reduction in the societal burden of expenses associated with morbid obesity. It is estimated that these costs exceed those of individuals with a normal BMI by more than $ 3,000 per year, with the discrepancy growing exponentially with greater BMI.[37] Furthermore, extending the opportunity for ineligible obese living kidney donor candidates to participate in donation holds the potential to bring about a dual cascade of positive effects. On one hand, this practice effectively removes a recipient from the waiting list for deceased donor organs, thus enhancing the prospects of organ allocation for other individuals who may lack viable donor options. On the other hand, facilitating living kidney donation generally translates to reduced periods of dialysis exposure, leading to considerable cost savings for healthcare providers. Brooks *et al.*'s estimation serves as a case in point: for instance, the inclusion of formerly obese live-donor kidneys could potentially lead to Medicare savings ranging from $6.05 million to $24.2 million for every 50 recipients taken off the waitlist, contingent upon the extent of dialysis obviation for each individual. Analogous scenarios manifest in various contexts, underscoring the wider relevance of this concept.[39-41] In the same study conducted by Brooks *et al.*, a comparison is drawn between the benefit-cost ratios of an obese living kidney donor who undergoes BS before donation and one who donates as an obese individual. According to their analysis, the cost-benefit ratios for these scenarios are approximately equivalent, rendering both alternatives equally favorable. Nevertheless, it's important to reiterate that the process of donor nephrectomy in obese patients carries elevated pre-, peri-, and post-surgical risks, which can be substantially mitigated through weight loss achieved by means of BS.

Discussion

Clinical and social concerns surrounding obesity are distinctly unrelated to the context of living kidney donation; rather, they stem from the amplified morbidity and mortality hazards that obese individuals face due to a wide array of deleterious clinical conditions. Indeed, the repercussions of obesity are far-reaching, impacting one's overall quality of life and heightening the susceptibility to conditions such as type 2 diabetes, cardiovascular diseases, various prevalent cancers, osteoarthritis, and numerous other health complications.[42] Projections of overall obesity-related mortality suggest a 42.7% increase from 2020 to 2030, with a greater percentage change seen in females.[43]

In the context of LDKT, obesity constitutes a notable concern as it exhibits an association with an increased long-term susceptibility to the development of ESRD.[29] Hence, the straightforward present trajectory of admitting potential donors with elevated BMI raises noteworthy clinical and ethical considerations. Despite advancements in surgical techniques that enable safer interventions for obese donors, these do not translate to mitigated long-term ESRD risks, particularly for those with BMI>35. It is therefore advisable to recommend timely weight reduction approaches, which could render obese candidates suitable for donation while concurrently diminishing their prospective long-term vulnerabilities.

BS presents a chance for individuals in this group, showing excellent effectiveness in the short term and highly promising outcomes in sustaining lost weight. However, it's crucial to grasp that this procedure should not be seen as a means to increase the donors' pool. Instead, it aims to provide patients with the most valuable and suitable approach to tackle obesity according to their individual traits. As outlined in one of our review papers by Montgomery *et al.*, proposing BS to potential living donors constitutes a highly pivotal stage. This action may catch certain patients unaware, evoke feelings of resentment in some, and could even be perceived as coercive by others, as if transplant surgeons are suggesting BS solely to facilitate nephrectomy.[19] Hence, the authors propose that obese patients, for whom BS might be considered prior to kidney donation, should be directed to a separate center for an impartial evaluation of the most appropriate obesity treatment. This step is crucial in emphasizing that the choice to donate is based solely on the individual's well-being, and their decision to donate should be distinct and not a primary concern. Indeed, existing literature con-

sistently underscores that a favorable outcome from BS does not inherently correlate with suitability for donation.

Concerning the most suitable bariatric intervention, none of the examined studies propose a singular optimal strategy, and there is insufficient evidence to assert the superiority of a restrictive method over a malabsorptive one, or to determine the ideal patient profile for each. In fact, the compiled cases encompass a diverse array of surgical techniques, ranging from RYGB to LAGB to BPD to SG, and a direct comparison between them is understandably lacking.[44] The RYGB stands as the benchmark weight loss procedure due to its established track record of achieving lasting weight reduction and resolving obesity-linked comorbidities.[45] Nevertheless, owing to its malabsorption mechanism, the RYGB is connected with the potential for enduring nutritional and metabolic disturbances. In the specific context of kidney donation, these metabolic shifts could influence the urinary environment, resulting in an approximate twofold rise in the risk of calcium oxalate nephrolithiasis and the rare chance of developing oxalate nephropathy.[46] Nguyen *et al.* have observed that the SG, due to its ability to deliver enduring weight loss, with fewer complications and a less complex surgical procedure, has risen to prominence as the most commonly chosen bariatric procedure.[32]

As observed by Montgomery *et al.*, a pending issue pertains to the influence of age on eligibility for organ donation subsequent to BS. Limited information exists concerning the maintenance of weight loss over periods exceeding 5 years post-BS. It is plausible that in contrast to older individuals, younger patients face a heightened possibility of weight regain and/or the resurgence of comorbidities over their extended lifetimes. Presently, there is not enough evidence to endorse a specific "minimum age" for donation subsequent to BS. Nonetheless, transplant surgeons should remain mindful of this potential long-term risk when advising younger prospective living kidney donors about the option of donation.

Another unresolved matter pertains to the timing of kidney donation following successful weight loss through BS. Notably, there exists a lack of conclusive evidence to support any specific timing or threshold for such a scenario. Nevertheless, available data does indicate that the most substantial weight reduction, ranging from 20% to 40% depending on the type of BS, is typically attained within six months to one year.[47] It is not uncommon for supplementary conservative interventions, like dietary measures, to be necessary for further weight reduction or to prevent weight regain. Conversely, it is reasonable to assume that potential kidney donors who are enthusiastic about the donation process would prefer to avoid prolonged waiting periods once they have achieved their desired or suitable weight.

In line with the insights from our reviewed sources, a general guideline emerges that suggests performing laparoscopic donor nephrectomy between six months and one year after BS.[30, 31, 45] This timeframe aims to ensure a smooth post-BS recovery and capitalize on the advantages of substantial and optimal weight loss. Furthermore, Montgomery *et al.* assert that the act of donation should be discouraged until prospective living kidney donors meet specific eligibility criteria set by the transplant center and exhibit stable adherence to these criteria for a minimum of three months.[19]

Despite being based on restricted and lower-quality evidence, we have consolidated all the accessible data into a single algorithm for managing obese living donor candidates who qualify for BS (Figure 2). It is important to clarify that this algorithm is not intended to furnish comprehensive and evidence-based guidelines, nor are we in a position to make definitive recommendations on the subject. Instead, it serves as a condensed presentation of insights gathered from various sources examined in our study. Its purpose is to potentially provide clinicians, surgeons, and patients with convenient access to this information, an overarching perspective on the matter, and potential directions for further research.

Limitations of the study

Several limitations need to be acknowledged. Firstly, the scoping review's emphasis on broad literature coverage comes at the cost of the in-

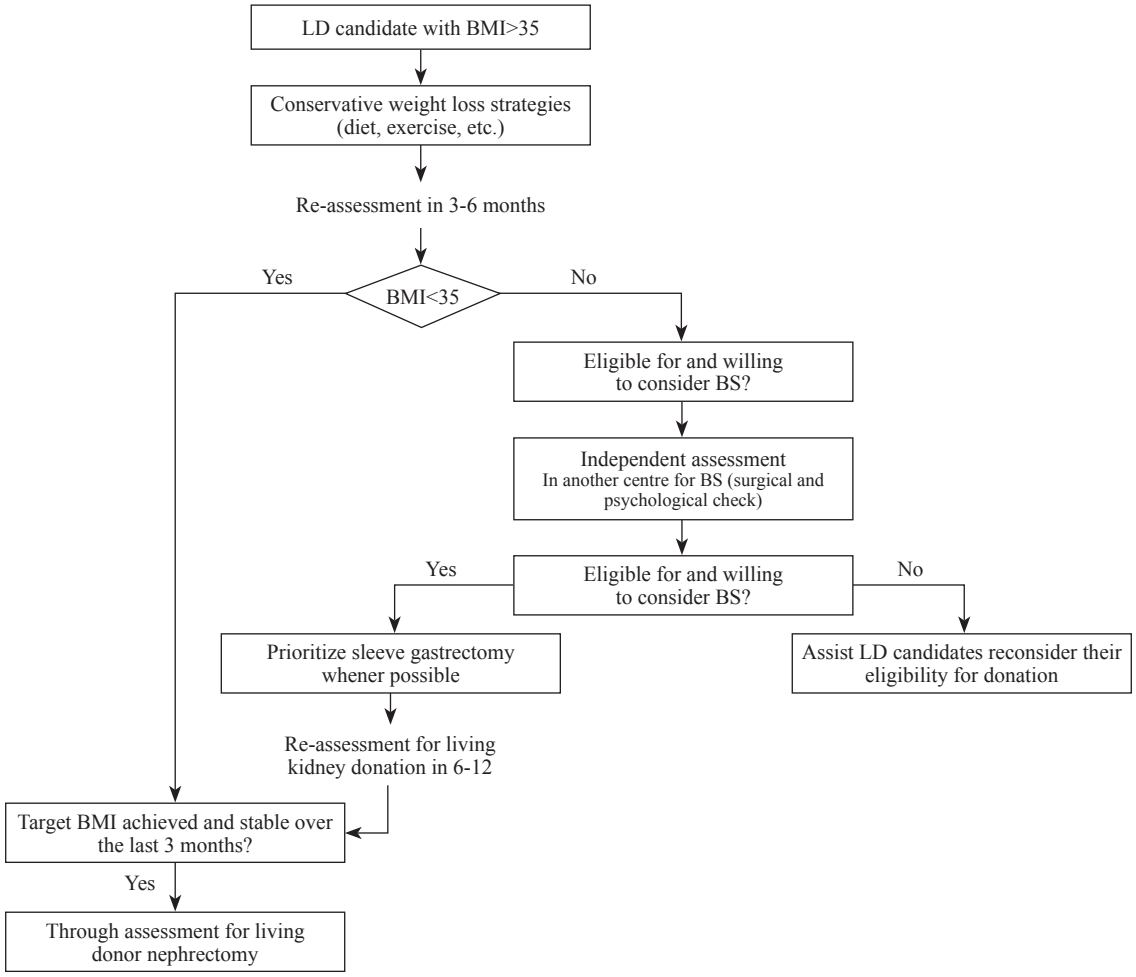

Figure 2.—Decision algorithm for assessing bariatric surgery in living kidney donor candidates.

depth analysis and synthesis typically found in more focused systematic reviews. However, this approach was necessitated by the qualitative and quantitative limitations of available studies in this area, constituting the second major limitation. Notably, no experimental or quasi-experimental trials exist, with the entirety of available evidence relying solely on case reports. Unfortunately, these case reports often encompass only a few cases, most of which do not entirely align with the specific study population and intervention in question. The remaining evidence incorporated in the study comprises background articles and broader reviews, from which we sought valuable insights regarding BS for prospective living donors. While we did not conduct a formal quality assessment of the included studies, it is probable that the overall quality is low. Consequently, this scoping review cannot serve as the basis for drawing conclusive claims or recommendations on the subject. Thirdly, the quantity of included studies ultimately proved to be minimal, and despite efforts to secure full texts, three potentially relevant records remained inaccessible even after contacting corresponding authors. This further reduced the pool of reviewed articles, subsequently impacting the robustness of our findings. Despite these acknowledged limitations, this scoping review stands as our most comprehensive attempt to compile

all available literature on this intricate subject. It could potentially serve as an initial reference point for gaining insights into the management of obese donor candidates and as a catalyst for future research endeavors in this field.

Finally, in light of the limited availability of concrete evidence, the extended timeline required for the development of robust new data, and the pressing nature of the issue under consideration, it is worth exploring the feasibility of utilizing intermediate forms of scientific evidence that can yield valuable insights through the amalgamation of shared field experiences and the consensus among experts. This methodology has already been embraced in various facets of kidney transplantation to address voids in publicly available evidence and is also endorsed by organ transplant societies.[48-50]

Conclusions

Obesity undoubtedly presents challenges for individuals considering kidney donation, and its quantitative and qualitative impact on organ supply is expected to increase in the coming years due to the widespread prevalence of metabolic disorders in the Western world. Conservative and surgical approaches are currently availabel to address obesity, aiming to benefit potential donors and enhance their capacity for a safer donation while ensuring the safety of the donated organ. This paper is the most up-to-date synthesis exploring the potential and limitations of bariatric surgery as a viable solution to tackle the obstacles faced by obese donor candidates.

References

1. Xie Y, Bowe B, Mokdad AH, Xian H, Yan Y, Li T, *et al.* Analysis of the Global Burden of Disease study highlights the global, regional, and national trends of chronic kidney disease epidemiology from 1990 to 2016. Kidney Int 2018;94:567–81.

2. Wolfe RA, Ashby VB, Milford EL, Ojo AO, Ettenger RE, Agodoa LY, *et al.* Comparison of mortality in all patients on dialysis, patients on dialysis awaiting transplantation, and recipients of a first cadaveric transplant. N Engl J Med 1999;341:1725–30.

3. Rao PS, Merion RM, Ashby VB, Port FK, Wolfe RA, Kayler LK. Renal transplantation in elderly patients older than 70 years of age: results from the Scientific Registry of Transplant Recipients. Transplantation 2007;83:1069–74.

4. Murtagh FE, Marsh JE, Donohoe P, Ekbal NJ, Sheerin NS, Harris FE. Dialysis or not? A comparative survival study of patients over 75 years with chronic kidney disease stage 5. Nephrol Dial Transplant 2007;22:1955–62.

5. Tonelli M, Wiebe N, Knoll G, Bello A, Browne S, Jadhav D, *et al.* Systematic review: kidney transplantation compared with dialysis in clinically relevant outcomes. Am J Transplant 2011;11:2093–109.

6. Heldal K, Midtvedt K, Lønning K, Iversen T, Hernæs KH, Tsarpali V, *et al.* Kidney transplantation: an attractive and cost-effective alternative for older patients? A cost-utility study. Clin Kidney J 2019;12:888–94.

7. Tushla L, Rudow DL, Milton J, Rodrigue JR, Schold JD, Hays R; American Society of Transplantation. Living-Donor Kidney Transplantation: Reducing Financial Barriers to Live Kidney Donation—Recommendations from a Consensus Conference. Clin J Am Soc Nephrol 2015;10:1696–702.

8. Bellini MI, Courtney AE, McCaughan JA. Living Donor Kidney Transplantation Improves Graft and Recipient Survival in Patients with Multiple Kidney Transplants. J Clin Med 2020;9:2118.

9. Bellini MI, Cantisani V, Lauro A, D'Andrea V. Living Kidney Donation: Practical Considerations on Setting Up a Program. Transplantology 2021;2:75–86.

10. Lentine KL, *et al.* KDIGO Clinical Practice Guideline on the Evaluation and Care of Living Kidney Donors. Transplantation 2017;101:1–109.

11. Bellini MI, Charalampidis S, Stratigos I, Dor FJ, Papalois V. The Effect of Donors' Demographic Characteristics in Renal Function Post-Living Kidney Donation. Analysis of a UK Single Centre Cohort. J Clin Med 2019;8:883.

12. Bellini MI, Nozdrin M, Pengel L, Knight S, Papalois V. How good is a living donor? Systematic review and meta-analysis of the effect of donor demographics on post kidney transplant outcomes. J Nephrol 2022;35:807–20.

13. Lentine KL, Smith JM, Miller JM, Bradbrook K, Larkin L, Weiss S, *et al.* OPTN/SRTR 2021 Annual Data Report: kidney. Am J Transplant 2023;23(Suppl 1):S21–120.

14. Matas AJ. Transplantation using marginal living donors. Am J Kidney Dis 2006;47:353–5.

15. Cantarelli C, Cravedi P. Criteria for Living Donation from Marginal Donors: One, No One, and One Hundred Thousand. Nephron 2019;142:227–32.

16. Tattoli L, Santovito D, Raciti IM, Scarmozzino A, Di Vella G. Risk Assessment and Management for Potential Living Kidney Donors: The Role of "Third-Party" Commission. Front Public Health 2022;10:824048.

17. British Transplantation Society. United Kingdom Guidelines for Living Donor Kidney Transplantation. Fourth Edition. March 2018 [Internet]. Available from: https://bts.org.uk/wp-content/uploads/2018/07/FINAL_LDKT-guidelines_June-2018.pdf https://bts.org.uk/wp-content/uploads/2018/01/BTS_LDKT_UK_Guidelines_2018.pdf [cited 2023, Oct 19].

18. Lafranca JA, Spoon EQ, van de Wetering J, IJzermans JN, Dor FJ. Attitudes among transplant professionals regarding shifting paradigms in eligibility criteria for live kidney donation. PLoS One 2017;12:e0181846.

19. Montgomery JR, Telem DA, Waits SA. Bariatric surgery for prospective living kidney donors with obesity? Am J Transplant 2019;19:2415–20.

20. Romagnoli J, Salerno MP, Calia R, Bianchi V, Pedroso JA, Spagnoletti G, *et al.* Expanding the living donor pool, "Ist Act": analysis of the causes of exclusion of potential kidney donors. Transplant Proc 2013;45:2632–4.

21. Sachdeva M, Sunday S, Israel E, Varghese J, Rosen L, Bhaskaran M, *et al.* Obesity as a barrier to living kidney donation: a center-based analysis. Clin Transplant 2013;27:882–7.

22. Buchwald H, Avidor Y, Braunwald E, Jensen MD, Pories W, Fahrbach K, *et al.* Bariatric surgery: a systematic review and meta-analysis. JAMA 2004;292:1724–37.

23. Maciejewski ML, Arterburn DE, Van Scoyoc L, Smith VA, Yancy WS Jr, Weidenbacher HJ, *et al.* Bariatric Surgery and Long-term Durability of Weight Loss. JAMA Surg 2016;151:1046–55.

24. Arterburn D, Wellman R, Emiliano A, Smith SR, Odegaard AO, Murali S, *et al.*; PCORnet Bariatric Study Collaborative. Comparative Effectiveness and Safety of Bariatric Procedures for Weight Loss: A PCORnet Cohort Study. Ann Intern Med 2018;169:741–50.

25. Gloy VL, Briel M, Bhatt DL, Kashyap SR, Schauer PR, Mingrone G, *et al.* Bariatric surgery versus non-surgical treatment for obesity: a systematic review and meta-analysis of randomised controlled trials. BMJ 2013;347:f5934.

26. Schauer PR, Bhatt DL, Kirwan JP, Wolski K, Aminian A, Brethauer SA, *et al.*; STAMPEDE Investigators. Bariatric Surgery versus Intensive Medical Therapy for Diabetes - 5-Year Outcomes. N Engl J Med 2017;376:641–51.

27. Ouzzani M, Hammady H, Fedorowicz Z, Elmagarmid A. Rayyan-a web and mobile app for systematic reviews. Syst Rev 2016;5:210.

28. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, *et al.* The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71.

29. Locke JE, Reed RD, Massie A, MacLennan PA, Sawinski D, Kumar V, *et al.* Obesity increases the risk of end-stage renal disease among living kidney donors. Kidney Int 2017;91:699–703.

30. Koshy AN, Wilkinson S, Coombes JS, Fassett RG. Laparoscopic adjustable gastric band in an obese unrelated living donor prior to kidney transplantation: a case report. J Med Case Rep 2010;4:107.

31. Branco AW, Branco Filho AJ, Kondo W. Laparoscopic live donor nephrectomy in patients surgically treated for morbid obesity. Int Braz J Urol 2007;33:377–9, discussion 379.

32. Nguyen MJ, Carpenter D, Tadros J, Mathur A, Sandoval PR, Woodle ES, *et al.* Bariatric surgery prior to living donor nephrectomy: a solution to expand the living donor kidney pool - a retrospective study. Transpl Int 2019;32:702–9.

33. Bielopolski D, Yemini R, Gravetz A, Yoskovitch O, Keidar A, Carmeli I, *et al.* Bariatric Surgery in Severely Obese Kidney Donors Before Kidney Transplantation: A Retrospective Study. Transplantation 2023;107:2018–27.

34. Brooks J, Mitro G, DeLeonibus A, McGreevey W, Cash A, *et al.* Bariatric surgery for obese live kidney donors: an analysis of risks and benefits. Integr Obes Diabetes 2017;3.

35. Grams ME, Sang Y, Levey AS, Matsushita K, Ballew S, Chang AR, *et al.*; Chronic Kidney Disease Prognosis Consortium. Kidney-Failure Risk Projection for the Living Kidney-Donor Candidate. N Engl J Med 2016;374:411–21.

36. Bellini MI, Nozdrin M, Pengel L, Knight S, Papalois V. Risks for donors associated with living kidney donation: meta-analysis. Br J Surg 2022;109:671–8.

37. Peeters A, Barendregt JJ, Willekens F, Mackenbach JP, Al Mamun A, Bonneux L; NEDCOM, the Netherlands Epidemiology and Demography Compression of Morbidity Research Group. Obesity in adulthood and its consequences for life expectancy: a life-table analysis. Ann Intern Med 2003;138:24–32.

38. Carlsson LM, Carlsson B, Jacobson P, Karlsson C, Andersson-Assarsson JC, Kristensson FM, *et al.* Life expectancy after bariatric surgery or usual care in patients with or without baseline type 2 diabetes in Swedish Obese Subjects. Int J Obes 2023;47:931–8.

39. Paoletti F, Giorgio V, Jaser A, Zanoni NR, Ricciardi W, Citterio F, *et al.* Process control: simply a matter of efficiency or of survival and costs? A single-centre quality improvement project in living donor renal transplant. BMC Health Serv Res 2023;23:192.

40. Meier-Kriesche HU, Kaplan B. Waiting time on dialysis as the strongest modifiable risk factor for renal transplant outcomes: a paired donor kidney analysis. Transplantation 2002;74:1377–81.

41. Habbous S, McArthur E, Sarma S, Begen MA, Lam NN, Manns B, *et al.*; Donor Nephrectomy Outcomes Research (DONOR) Network. Potential implications of a more timely living kidney donor evaluation. Am J Transplant 2018;18:2719–29.

42. Finer N. Medical consequences of obesity. Medicine (Baltimore) 2015;43:88–93.

43. Chong B, Jayabaskaran J, Kong G, Chan YH, Chin YH, Goh R, *et al.* Trends and predictions of malnutrition and obesity in 204 countries and territories: an analysis of the Global Burden of Disease Study 2019. EClinicalMedicine 2023;57:101850.

44. Bellini MI, Paoletti F, Herbert PE. Obesity and bariatric intervention in patients with chronic renal disease. J Int Med Res 2019;47:2326–41.

45. Nguyen NT, Varela JE. Bariatric surgery for obesity and metabolic disorders: state of the art. Nat Rev Gastroenterol Hepatol 2017;14:160–9.

46. Espino-Grosso PM, Canales BK. Kidney Stones After Bariatric Surgery: Risk Assessment and Mitigation. Bariatr Surg Pract Patient Care 2017;12:3–9.

47. Sjöström L, Lindroos AK, Peltonen M, Torgerson J, Bouchard C, Carlsson B, *et al.*; Swedish Obese Subjects Study Scientific Group. Lifestyle, diabetes, and cardiovascular risk factors 10 years after bariatric surgery. N Engl J Med 2004;351:2683–93.

48. Romagnoli J, Tagliaferri L, Acampora A, Bianchi V, D'Ambrosio V, D'Aviero A, *et al.*; Consensus Conference Expert Panel. Management of the kidney transplant patient with Cancer: Report from a Multidisciplinary Consensus Conference. Transplant Rev (Orlando) 2021;35:100636.

49. Cillo U, Weissenbacher A, Pengel L, Jochmans I, Roppolo D, Amarelli C, *et al.* ESOT Consensus Platform for Organ Transplantation: Setting the Stage for a Rigorous, Regularly Updated Development Process. Transpl Int 2022;35:10915.

50. Kobashigawa J, Dadhania DM, Farr M, Tang WH, Bhimaraj A, Czer L, *et al.*; Consensus Conference Participants. Consensus conference on heart-kidney transplantation. Am J Transplant 2021;21:2459–67.

Conflicts of interest

The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

Authors' contributions
Filippo Paoletti and Maria I. Bellini have given substantial contributions to the conception or the design of the manuscript; Filippo Paoletti and Irene Urciuoli contribute to acquisition, analysis and interpretation of the data. All authors have participated to drafting the manuscript, Filippo Paoletti, Maria I. Bellini and Jacopo Romagnoli revised it critically. All authors read and approved the final version of the manuscript.

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