

Long-Term Outcomes of Left versus Right Laparoscopic Living Donor Nephrectomy with Multiple Renal Arteries

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Keywords

Kidney transplantation · Laparoscopic donor nephrectomy · Graft survival · Renal artery · Long-term outcomes

Abstract

Objectives: The objective of this study was to compare the long-term graft outcomes of left-versus-right donor nephrectomy with multiple renal arteries (MRAs), and therefore creating a reference for the expansion of the potential living kidney donor pool. **Methods:** Laparoscopic live donor nephrectomy cases between May 2010 and October 2020 were included in this retrospective cross-sectional study. The data relating to donor and recipient demographics, surgical and anatomical characteristics, recipient, and graft status were retrieved and compared using nonparametric statistical methods and multivariate regression. Analyses were fit for survival factors. **Results:** A total of 1,009 recipients were included in this retrospective cross-sectional study with their donors. 16.7% of the donors had been discovered to have more than one renal artery supplying the donated kidney. The acute rejection rate was 12.8%. Death-censored graft survival at postoperative year 5 for single renal artery (SRA) transplants was 89.6%, 89.5% for left-sided MRAs, and

88.2% for right-sided ones. **Conclusions:** Both right donor nephrectomy and left donor nephrectomy are safe procedures with no significant negatively impacted rates for neither survival nor complications of the recipients in the long-term, compared to SRA ones.

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Introduction

Donor nephrectomy with kidneys with multiple renal arteries (MRAs) and veins was first reported in the 1980s with minimal graft survival variance from conventional single artery donor nephrectomy [1]. Although back then rather unfavorable outcomes with high delayed graft function (DGF), acute tubular necrosis (ATN), and complication rates were reported, this was mostly due to non-routine immunosuppressant usage and nonoptimized surgical techniques with a long cold ischemia time (CIT) [2]. As the surgical techniques have improved, enhanced immunosuppressant regimens have been appropriated, and with the emergence of advanced imaging modalities, these short-term outcomes have become interchangeable with single artery donor nephrectomies [3–5].

Variations in the renal vasculature are prevalent at different rates depending on the country and the region it was investigated. For instance, a study from Australia had reported MRAs in 22% of the subjects while a previous cross-sectional research in our center had revealed 35.8% of the donors had MRAs including polar arteries and 19% of them had multiple renal veins [6, 7]. The presence of vascular anatomy variations was previously considered as anomalies and a relative contraindication for kidney transplantation. As the clinical and surgical relevance of these variations were discovered, they began to be regarded as multiple vasculatures in the literature. The left kidney is preferred for laparoscopic live donor nephrectomy (LLDN) as right-sided LLDN requires further technical attention due to shorter vascular length [8]. However, not all potential living donors have vascular anatomy favorable for left nephrectomy; this situation also leads to an inclination toward novel surgical techniques such as hand-assisted approaches [9]. Hence, it carries great importance to take all plausible kidneys into account regardless of the side, especially considering the scarcity of living donors. Nunes-Carneiro et al. [10] had reported no difference in graft survival rates between multiple-artery left kidney nephrectomy and right kidney nephrectomy. Several recent studies have also investigated the short-term outcomes of donor nephrectomy with multiple vasculatures; however, there was a distinct lack of long-term outcome research, especially with right versus left side comparison [11, 12]. Higher ureteral complication rates have been reported in laparoscopic living renal transplantation cases with arterial multiplicity [13].

The deceased organ donation rate in 2019 was 7.5 per million population (pmp) in Turkey, deeming consideration and, if possible, operation of every volunteering living kidney donor especially important [14]. The objective of this study is to compare left versus right donor nephrectomy with multiple arteries according to long-term graft outcome parameters such as death-censored graft survival (DCGS) and serum creatinine (SCr) levels measured in post-op 1st, 3rd, and 5th years.

Methods

Outcomes of right and left LLDN with multiple arteries were compared according to recipient survival, acute rejection, DGF, DCGS, discharge and 1st, 3rd, 5th year SCr levels (mg/dL), duration of warm and cold ischemia, donor operative time, donor intraoperative bleeding volume, length of postoperative hospital stay for the donor and recipient, and the post-op recipient and donor complications categorized according to the Clavien-Dindo classification. DCGS rate was determined by the exclusion of the pa-

tients' deaths with functioning grafts. Additionally, the transplanted renal graft was defined as having delayed function if the recipient had to undergo hemodialysis during the postoperative week 1. All patients received induction therapy with antithymocyte globulin. Baseline immunosuppression of all patients included a calcineurin inhibitor, an antimetabolite (mycophenolate mofetil), and steroids.

The data were retrieved from the hospital's electronic medical records system. This retrospective cross-sectional study was conducted at Acibadem International Hospital Kidney Transplantation Center, Istanbul, Turkey.

Selection and Description of Participants

A total of 1,009 donors and recipients who had LLDN in our Kidney Transplantation Center between May 2010 and October 2020 were included in this retrospective cross-sectional study. Re-transplantations, cases with deceased donors, and nephrectomy techniques other than LLDN were excluded. Age, sex, and body mass index (BMI) of both donors and recipients, etiology of renal transplantation, number of renal arteries recorded on the preoperative computed tomography (CT) and at surgery, donor surgical technique, types of vascular anastomosis, duration of recipient follow-up, duration of graft and recipient survival, the relation of donor with the recipient, side of the donor's kidney were noted for a specific depiction of the study population. The demographics of the patients with the contrast of kidney sides are presented in Table 1.

Technical Information

Preoperative Evaluation

Abdominal CT angiography with a Siemens® SOMATOM Definition AS CT scanner (Siemens Trademark GmbH & Co. KG, Berlin, Germany) was performed for each kidney donor during the preoperative examinations. A volume of 70–90 mL of nonionic contrast medium was injected with a rate of 3.5–4 mL/s through the antecubital veins with an automatic pressure injector. The axial, coronal, sagittal, and 3D reconstruction images were assessed by a single radiologist and the number, as well as the morphology, of renal vasculature were reported.

In this study, the renal arterial system was defined by the number of arteries arising from the abdominal aorta and entering the renal hilum or directly into the renal parenchyma. The presence of more than a single renal artery (SRA) was reported as an MRA case. Renal arteries that were branching early from the aorta that were dissected into two by the surgeon during the LLDN procedure and the presence of polar arteries were not considered as MRA but they were separately recorded. 3D computed tomography angiography images of the SRA (Fig. 1a) and MRA with 2 (Fig. 1b), 3 (Fig. 1c), and 4 (Fig. 1d) arteries were shown in Figure 1.

Surgical Techniques

Laparoscopic Live Donor Nephrectomy
Pneumoperitoneum was achieved via a 12-mm trocar placed from the right or the left lower quadrant and the abdominal cavity was dilated with CO₂ on 12-mm Hg pressure in the lateral decubitus position. Five-millimeter trocars were placed 3 cm below the intersection point of the anterior axillary line and arcus costarum, to the lateral umbilicus, and 3-cm superior-medially to crista iliaca anterior superior. After the trocar placement, the colon and mesocolon were mobilized and deviated medially, then the ureter was

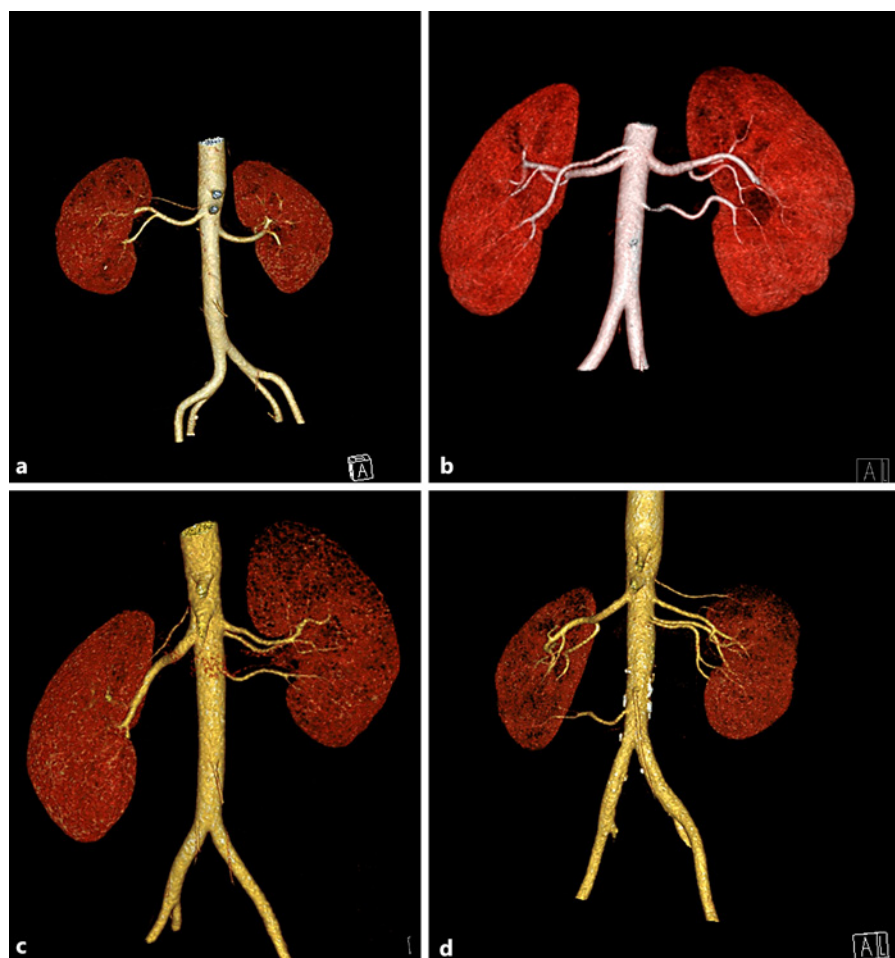


Fig. 1 **a** 3D CTA image of donor kidney with single artery. **b** 3D CTA image of donor kidney with 2 renal arteries. **c** 3D CTA image of donor kidney with 3 renal arteries. **d** 3D CTA image of donor kidney with 4 renal arteries.

suspended. The renal artery and vein were dissected, and then the surrounding tissues of the kidney were mobilized via LigaSure™. After the complete mobilization of the kidney, a 6-cm lateral Pfannenstiel incision was opened for kidney extraction. The ureter was clipped and cut, followed by the obliteration and cutting of the renal artery then the renal vein via the laparoscopic vascular stapler. Laparoscopic stapler cuts were individually performed in cases with multiple arteries and/or veins. Donor nephrectomy was done with the extraction of the kidney from the preprepared region in the inguinal area. Ensuring hemostasis, a soft drain was placed inside the inguinal incision, which was sealed appropriately. Finally, the skin was sutured with 4/0 rapid Vicryl.

Recipient Procedure

An inguinal hockey-stick incision was opened in the supine position. External iliac artery and external iliac vein were prepared for anastomosis via dissection.

Multiple Vasculature Management

In cases with MRA, double-barrel anastomosis (conjoining of two arteries in order to form a common ostium) was performed with 6/0 prolene if the aberrant renal arteries were close to each other and then this double-barrel was joined to the target vessel (as seen in Fig. 2). If unsuitable, each artery was separately anasto-

mosed with end-to-side anastomosis. Hence, arterial anastomoses in MRA kidney recipients were evaluated under 2 categories: separate anastomoses and double-barrel. In LLDN where 3 or 4 MRA were present, they were anastomosed either with a combination of both techniques or each artery individually. The extracted kidney was promptly perfused with 1 L of cold ringer lactate solution at the back table. In the presence of polar arteries, several options prevailed; if the polar artery was distributing blood to the superior pole of the kidney, the anastomosis choice was dependent on the surface area of the perfused space. If the area was making up less than 10% of the kidney, the polar artery was ligated. In cases when it was more than 10%, the polar artery was anastomosed to the recipient's vessel. Further, on the occasion that the polar artery was supplying blood for the inferior pole, it was indubitably anastomosed. Most commonly, the transplanted renal vein was conjoined to the external iliac vein and the renal artery was anastomosed to the external iliac artery. Ensuring the perfusion of the kidney, color change, and urine excretion was observed. Then, ureteroneocystostomy was performed with the Lich-Gregoir technique with 6/0 polydioxanone suture. A 4.8 F (12 cm) ureteric magnetic stent was utilized. A Jackson-Pratt drain was placed, and the operation was finalized with anatomically concordant closure of the layers. All of the LLDN and renal transplantation surgeries were performed by the same surgical team.

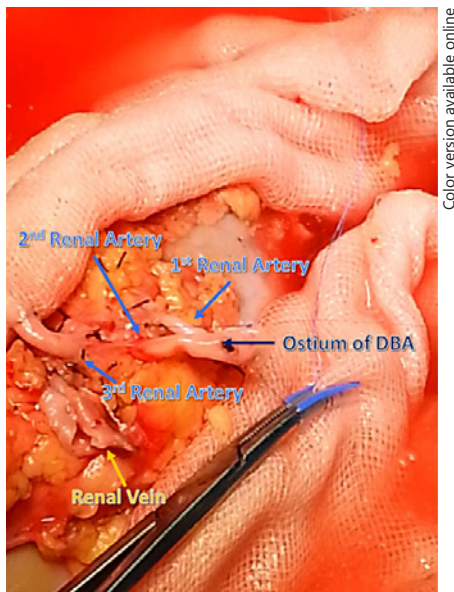


Fig. 2. Intraoperative image of a DBA in a donor kidney with 3 renal arteries.

Statistics

The normality of the data was calculated with the Shapiro-Wilk test. Nonparametric statistical methods were used for values with skewed (nonnormally distributed, Shapiro-Wilk $p > 0.05$) distribution. As the data retrieved in this study were mostly made up of non-normal distribution, the variables were presented with the median (and minimum-maximum) values.

Multiple linear regression or multivariate regression was utilized for defining the relationship between dependent variables and multiple independent variables. The one-way analysis of variance test was performed while comparing three or more unmatched normally distributed groups and as for non-Gaussian populations, the Kruskal-Wallis test was done. Multiple regression analysis was performed in the presence of more than one predictor variable. The χ^2 test (Fisher's exact test) was used for categorical variables and expressed as observation counts (and percentages). Statistical significance was accepted when a two-sided p value was lower than 0.05. Kaplan-Meier analysis was used to compare DCGS with regard to the presence of MRA and renal arterial anastomosis techniques. Log-rank testing was used. Additionally, Cox Proportional Hazards regression analysis for DCGS was performed using 16 parameters in order to determine cumulative effects on graft survival: age, sex, and BMI of donors and recipients, recipient SCr levels at discharge, post-op recipient hospital stay, DGF, side of the donated kidney, warm ischemia time, CIT, number of arteries, type of arterial anastomosis, donor operation time, and donor bleeding volume. Statistical analysis was performed using the IBM® SPSS® Statistics Version 26.0 for Windows (IBM Corporation, Armonk, NY, USA: released 2019).

Results

Demographics

The donor population was made up of 52.9% females and 47.1% males while these ratios were 33.9% and 66.1% for the recipients, respectively. The median age of the SRA donor population at the time of transplantation surgery was 49.0 (22.0–88.0) and it was 48.0 (24.0–81.0) for the MRA donors. Correspondingly, the median age of the SRA recipients was 42.0 (2.0–73.0) and 42.0 (2.0–76.0) for the MRA recipients. The median BMI of the SRA and MRA donors were 27.9 (15.9–42.7) and 28.2 (18.6–39.6), respectively. These values were determined as 24.7 (11.0–43.0) and 25.5 (14.0–42.0), for the recipients. None of the demographic data was found to be significant for the presence of SRA nor MRA, whether left or right sided. The comparison of the demographic data according to the number of renal arteries and the side of the donated kidney is presented in Table 1. Donor relation to the recipient was found to be most commonly spouses with 25.0%, followed by mothers (15.5%), and fathers (12.5%).

The most common etiology for end-stage renal disease in the study population was hypertension with 20.0%, followed by 18.1% diabetes mellitus patients, 15.3% idiopathic, 6.9% had glomerulonephritis, 5.7% of the patients had polycystic kidney disease, and 4.5% had kidney stones as a precursor for kidney transplantation. About 6.4% of patients additionally had a secondary etiology for end-stage renal disease. On the preoperative evaluation 3D Renal CT angiogram, 16.7% of the donors had been discovered to have more than one renal artery on the kidney side planned for LLDN: 15.2% with two, 1.3% with three, and 0.2% with four renal arteries out of the total population. Additionally, 21.2% of the donors had polar arteries and 16.1% had multiple renal veins, discovered incidentally.

Surgical Data

Right-sided kidneys made up 32.3% and left-sided ones represented 67.7% of the donated kidneys. In addition to the 16.7% MRA discovered during preoperative evaluation, 5.6% of the donors had prehilum branching which required dissection of the renal artery into two by the operating surgeon during LLDN. The median CIT was 57.0 (19.0–173.0) min, 55.0 (19.0–173.0) for SRA, 68.5 (24.0–169.0) for left MRAs (LMRAs), and 70.0 (24.0–170.0) for right MRAs (RMRA) cases. CIT was significantly longer in RMRA recipients compared to SRA and LMRA patients ($p < 0.0001$). About 12.6% of the recipients ($n = 127$) had an anastomosis time longer than 40

Table 1. Comparison of the demographic data according to the number and side of renal arteries

Demographics	Total (n = 1,009)		SRA (n = 853)		MRA (n = 156)		p value
	L	R	L	R	L	R	
Sex, n (%)							
Donor	683 (67.7)	326 (32.3)	578 (67.8)	275 (32.2)	105 (67.3)	51 (32.7)	
Female (n = 534)	344 (34.1)	190 (65.9)	290 (33.9)	158 (66.1)	54 (34.6)	32 (65.4)	0.018
Male (n = 475)	339 (33.6)	136 (66.4)	288 (33.8)	117 (66.2)	51 (32.7)	19 (67.3)	
Recipient	683 (67.7)	326 (32.3)	578 (67.8)	275 (32.2)	105 (67.3)	51 (32.7)	
Female (n = 342)	237 (23.5)	105 (76.5)	202 (23.7)	87 (76.3)	35 (22.4)	18 (77.6)	0.434
Male (n = 667)	446 (44.2)	221 (55.8)	376 (44.1)	188 (55.9)	70 (44.9)	33 (55.1)	
Age (median + min-max), years							
Donor	49.0 (22.0–88.0)	46.0 (22.0–81.0)	51.0 (24.0–88.0)	47.0 (22.0–80.0)	50.0 (25.0–79.0)	41.0 (26.0–81.0)	0.318
Recipient	42.0 (2.0–76.0)	43.0 (2.0–71.0)	41.0 (2.0–72.0)	42.5 (2.0–71.0)	42.0 (12.0–76.0)	43.0 (17.0–66.0)	0.266
BMI (median + min-max)							
Donor	26.5 (17.4–40.0)	27.9 (15.9–42.7)	27.7 (17.4–40.0)	27.8 (15.9–42.7)	28.5 (18.6–39.6)	28.0 (19.2–39.1)	0.623
Recipient	24.3 (11.1–41.0)	25.1 (12.9–42.3)	24.3 (11.1–41.0)	25.1 (12.9–42.3)	25.7 (12.9–38.1)	24.6 (16.2–40.5)	0.898

Multiple logistic regression. SRA, single renal artery; MRA, multiple renal arteries; L, left; R, right; BMI, body mass index.

Table 2. Summary and comparison of perisurgical data with regard to the number and side of renal arteries

Surgical data	Total, n (%)	SRA (n = 853), n (%)	LMRA (n = 105), n (%)	RMRA (n = 51), n (%)	p value
Cold ischemia, min	57.0 (19.0–173.0)	55.0 (19.0–173.0)	68.5 (24.0–169.0)	70.0 (24.0–170.0)	<0.0001
Warm ischemia, s	164.0 (60.0–414.0)	162.0 (60.0–414.0)	178.0 (100.0–317.0)	168.0 (110.0–301.0)	<0.0001
Post-op stay, days					
Donor	2.0 (1.0–10.0)	2.0 (1.0–10.0)	2.0 (1.0–8.0)	2.0 (2.0–8.0)	0.166
Recipient	7.0 (4.0–168.0)	7.0 (4.0–168.0)	7.0 (4.0–64.0)	7.0 (5.0–27.0)	0.966
Donor bleeding volume, mL	50.0 (0.0–900.0)	50.0 (0.0–900.0)	50.0 (0.0–300.0)	50.0 (10.0–500.0)	0.509
Donor operative time, min	150.0 (65.0–300.0)	145.0 (75.0–300.0)	150.0 (65.0–270.0)	150.0 (105.0–240.0)	<0.0001

Multivariate linear analysis. SRA, single renal artery; LMRA, left multiple renal arteries; RMRA, right multiple renal arteries.

min. CIT was approximately double-fold of the anastomosis time, yielding statistical results; accordingly, with anastomosis time being significantly longer in RMRA recipients when compared to SRA and LMRA groups ($p < 0.0001$). Warm ischemia time median was 164.0 (60.0–414.0) seconds, 162.0 (60.0–414.0) for SRA, 178.0 (100.0–317.0) for LMRA, and 168.0 (110.0–301.0) for RMRA cases. Warm ischemia time was significantly longer in LMRA recipients compared to SRA and RMRA patients ($p < 0.0001$). Postoperative donor and recipient hospital stay was at a median of 2.0 (1.0–10.0) and 7.0 (4.0–168.0) days, respectively. Donor bleeding volume was found to be 50.0 mL (0.0–900.0), with no significant change in SRA, LMRA, or RMRA patients. Donor operative time was at a median of 150.0 (65.0–300.0) min, significantly longer for RMRA donors ($p < 0.0001$). Summary and compari-

son of perisurgical data with regard to the number of renal arteries and kidney side are displayed in Table 2.

Arterial anastomosis during MRA present renal transplantation was classified into 2 types, separate (95.0%) and double barrel (5.0%), whereas 0.7% of the transplantations had a combination of both types. Graft to artery anastomosis was most commonly performed to the external iliac artery with 75.9%, followed by the common iliac artery with 16.5%, and the aorta with 7.6%. Comparative graft and recipient outcomes with correspondence to arterial anastomosis types and kidney side are shown in Table 3.

Outcomes

The median follow-up was found to be 51.0 (0.0–125.0) months. Surgical complications occurred in 4.2%

Table 3. Comparative graft and recipient outcomes with correspondence to arterial anastomosis types

Outcomes	DGF, n (%)	Acute rejection, n (%)	Recipient survival			DCGS			SCr levels (median + min–max)			
			years			years			years			
			1	3	5	1	3	5	D	1	3	5
Separate anastomoses (n = 961)	27 (2.8)	125 (13.0)	97.3	95.0	93.3	96.7	92.6	89.6	1.2 (0.5–3.5)	1.3 (0.6–4.2)	1.3 (0.5–5.4)	1.3 (0.7–6.5)
Double-barrel (n = 48)	1 (2.1)	4 (8.3)	97.9	95.8	93.8	93.8	87.5	87.5	1.1 (0.5–7.5)	1.3 (0.7–3.3)	1.2 (0.6–5.1)	1.3 (0.6–3.3)
<i>p</i> value	>1.000*	0.505*	0.400			0.369			0.288			

DGF, delayed graft function; DCGS, death censored graft survival; SCr, serum creatinine; D, discharge. Fisher's exact test*, Kruskal-Wallis test.

Table 4. Comparison of postoperative short-term complications via the Clavien-Dindo classification with regard to the number and side of renal arteries

Clavien-Dindo classification	Total (n = 1,009)	SRA (n = 853)	LMRA (n = 105)	RMRA (n = 51)	<i>p</i> value
Uncomplicated, n (%)	742 (73.5)	624 (73.2)	79 (75.2)	39 (76.5)	0.140
1, n (%)	44 (4.4)	39 (4.6)	4 (3.8)	1 (2.0)	
2, n (%)	157 (15.5)	139 (16.3)	14 (13.3)	4 (7.8)	
3, n (%)	27 (2.7)	22 (2.6)	3 (2.9)	2 (3.9)	
4, n (%)	37 (3.7)	27 (3.2)	5 (4.8)	5 (9.8)	
5, n (%)	2 (0.2)	2 (0.2)	0 (0.0)	0 (0.0)	

Kruskal-Wallis test.

of the recipient population, the most common of them being hemorrhage (0.9%). 1.8% of the surgical complications had required reoperation; the most common cause being vesicoureteral reflux, seen in 4 patients. ATN was observed in 0.8% of the patients, DGF was seen in 1.8% of the patients and 12.8% had an acute rejection episode. 75.6% of these acute rejection cases were diagnosed through pathological evaluation of the kidney biopsy specimen and the rest were diagnosed clinically. Nineteen recipients (1.9%) had experienced early graft loss in the postoperative first month, with no significant difference between SRA, LMRA, and RMRA recipients. Comparison of the urological complications between the groups showed no statistically significant difference between the groups in terms of distal ureter stenosis (0.7%, 0.9%, and 0%), ureteral leak (2.1%, 1.9%, and 1.9%), and lymphocele (9.7%, 8.5%, and 7.8%) for SRA, LMRA, and RMRA, respectively. Clavien-Dindo classification of the postoperative complications of the recipients was visualized in Table 4. About 267 (26.5%) of this population had a deviation from the normal postoperative course, the vast majority of them (251 [24.9%] out of the total) being Class 2 with an infection requiring antibiotic or antiviral treatment (pneumonia, urinary tract, and viral infections with

BK virus or cytomegalovirus). Statistical analysis of the effect of anastomoses time has revealed no significance for the postoperative outcomes including complications requiring surgical intervention ($p = 0.738$), DGF ($p = 0.214$), early graft rejection ($p = 0.398$), and acute rejection ($p = 0.828$).

The median of the discharge SCr levels was 1.1 (0.2–4.1); SCr levels at follow-up years 1, 3, and 5 were 1.2 (0.2–4.1), 1.3 (0.3–5.8), and 1.3 (0.5–6.5), respectively. Recipient survival was deduced as 93.3% at the end of follow-up year 5 and the DCGS rate was 89.1%. Comparison of clinical outcomes according to multiple artery presence and kidney side are visualized in Table 5. DCGS rate with regard to the anastomoses type in the post-op 1st, 3rd, and 5th years were not found to be significantly affected in the Kaplan-Meier Survival Analysis. Cox Proportional Hazards Regression Analysis censored at postoperative 10-years of the total population of 1,009 patients showed significance for the recipient age ($p = 0.004$) and donor age ($p = 0.001$), SCr levels at discharge ($p = 0.002$), post-op recipient hospital stay ($p < 0.0001$), CIT (< 0.0001), number of arteries ($p = 0.029$), and donor bleeding volume ($p = 0.008$) with the application of 16 parameters for DCGS.

Table 5. Comparison of clinical outcomes according to kidney side and presence of multiple arteries

Outcomes	DGF, <i>n</i> (%)	EGR, <i>n</i> (%)	Acute rejection, <i>n</i> (%)	Recipient survival, %			DCGS, %			SCr levels (median + min–max)			
				years			years			years			
				1	3	5	1	3	5	D	1	3	5
SRA (<i>n</i> = 853)	23 (2.7)	12 (1.4)	112 (13.1)	97.2	95.0	93.3	96.8	92.6	89.6	1.2 (0.2–3.7)	1.2 (0.3–4.8)	1.3 (0.4–5.5)	1.3 (0.5–6.2)
LMRA (<i>n</i> = 105)	3 (2.9)	4 (3.8)	10 (9.5)	97.1	96.2	94.3	95.2	92.4	89.5	1.1 (0.4–4.1)	1.3 (0.6–4.7)	1.3 (0.5–5.6)	1.4 (0.6–6.5)
RMRA (<i>n</i> = 51)	2 (3.9)	3 (5.9)	7 (13.7)	100	94.1	92.2	94.1	88.2	88.2	1.3 (0.7–3.1)	1.3 (0.8–5.1)	1.3 (0.9–5.8)	1.4 (0.9–2.9)
<i>p</i> value	0.531	0.426	0.066	0.799			0.078			0.082			

Multivariate linear analysis, ANOVA. DGF, delayed graft function; ANOVA, analysis of variance; DCGS, death censored graft survival; EGR, early graft rejection; SCr, serum creatinine; SRA, single renal artery; LMRA, left multiple renal arteries; RMRA, right multiple renal arteries.

Discussion

Historically, LDN with multiple arteries or veins has been considered a contraindication as it was believed to cause higher incidences of ATN, rejection, and complications due to the obligation for intricate surgical techniques with longer warm ischemia time and CIT [1, 2, 15]. Newer studies, however, indicate otherwise as advanced surgical techniques, optimized postoperative immunosuppressant regimens, and better management methods for complications have yielded the mentioned causes null [16]. Preoperative selection of the donor's kidney is a multifactorial process, depending on organ function, anatomy, and size as well as the morphology and number of renal arteries and veins. Appropriate reconstruction of renal arteries does not increase the risk of renal artery thrombosis [17]. Variations in the renal vasculature are dependent on ethnicity, race; correspondingly the country and the region it was investigated [7, 18, 19]. In the study by Pollak et al. [20], 23% of the allografts were found to have two arteries, 4% had three arteries, while 1% of allografts had four arteries. In our study, the incidence of more than two renal arteries supplying the donated kidney was 16.7%. Of these, there were two arteries in 15.2%, three arteries in 1.3%, and four arteries in 0.2% of allografts.

Most of the study populations in the current literature consisted of deceased donors whereas our center's patient population is mostly made up of living donors, representing the country's organ donation culture and policies. For example, Makiyama et al. [15] had discovered multiple arteries in 24.4% of the study population in Japan, Ashraf et al. [21] had found 31.4% in Pakistan, and Cenal et al. [7] had revealed this ratio to be 35.8% in Turkey. These aforementioned studies have all been performed in coun-

tries where living renal donations surpass the deceased ones. It is especially important to utilize each viable organ, given the ever-increasing need for kidney transplantation. Living donor nephrectomies lead to better CIT and WIT with the disadvantage of removing an organ from a healthy person, even though the DGF incidences are lower for the recipient compared to deceased donor transplantations [22].

The requirement to perform transplantation with a right kidney or a kidney with multiple vasculatures should not render an obstacle for a potential living donor with today's advanced surgical revascularization techniques and feasible short- and long-term outcomes. The dimensions of each artery and vein decrease with each additional vessel, causing size discrepancies during the anastomosis process. Multiple arteries and veins cases basically lead to the creation of hand-crafted vasculature, only at the hands of experienced surgeons, leading to less vascular complications when compared to atherosclerotic or diseased singular vasculature.

Discouraging the significance of findings in this study, CIT was significantly longer in RMRA recipients compared to SRA and LMRA patients. Similarly, warm ischemia time was significantly longer in LMRA recipients compared to SRA and RMRA patients. Additionally, donor operative time was significantly longer for RMRA donors. The increase in the operation time, CIT, and WIT are explicable as surgical complexity and technicality are enhanced in MRA cases, during both the nephrectomy and the transplantation procedures. However, CIT being significantly different for RMRA and WIT being for LMRA could not be tied to a singular reason. Although a cohort study by Heylen et al. [23] had shown that an anastomosis time of <45 min is crucial to reduce the risk of graft loss, in our study, CIT, WIT, and anastomosis time

being statistically significant had no clinical correlation as there was no difference of significance between neither the short nor the long-term outcomes of the recipients in all compared groups. Postoperative donor and recipient hospital stay, donor bleeding volume, and complication rates were found to be of no significance in the comparison of SRA, LMRA, or RMRA patients. The early graft rejection rate in this study had stayed at 1.9%, a comparatively lower percentage than previously seen in literature [24, 25]. However, this finding could be directly associated with the sole inclusion of living donors, which is an established risk factor for posttransplant complications and graft loss. None of the parameters investigated for short-term outcomes, including Clavien-Dindo Classification findings, surgical, and urological complications had shown relation to the arterial multiplicity nor later-alization.

There was no significant difference between the left and right MRA group comparisons, neither observable nor statistical in survival, complication, and rejection rates. SCr levels and DCGS rates did not differ significantly in addition, yielding the long-term outcomes of LMRA and RMRA LLDN as safe and plausible as SRA LLDN. Cox Proportional Hazards Regression Analysis of the total population of 1,009 patients showed significance for the recipient and donor age, SCr levels at discharge, post-op recipient hospital stay, CIT, number of renal arteries, and donor bleeding volume with the application of 16 parameters for DCGS, in a like manner to nonparametric and linear statistical results. The number of renal arteries seems to be of essence on the topic of graft survival, together with donor age, BMI, and donor intraoperative bleeding volume; the importance of donor parameters is evident for the wellbeing of the recipient.

The limitations of this study include a retrospective study design. Although the patient population is befitting, multicentric, or even nationwide research could be held in order to conceptualize these findings to the general population.

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Both right- and left-sided laparoscopic donor nephrectomies with MRAs are safe procedures with no significant negatively impacted rates for neither survival nor complications for the recipients in the long term, compared to SRA ones. In the hands of trained surgeons, it should be of no concern to include donors with MRAs in the kidney transplant pool.

Statement of Ethics

The study protocol was reviewed and approved by our Institutional Ethics Committee (Acibadem Mehmet Ali Aydinlar University's Institutional Review Board), approval number: 2021-03/28. Written informed consent was obtained from the participants (or their parent/legal guardian/next of kin) to participate in the study.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

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Author Contributions

All authors have contributed to the acquisition, analysis, interpretation, and documentation of the findings. A.H.K., E.O., and I.B. have acquired and prepared the dataset. A.H.K. and S.B. descriptively and statistically analyzed the data. G.Y. and U.C. interpreted and documented the analyzed findings. All authors had a part in drafting and critically revising the study and approved the final version of the manuscript.

Data Availability Statement

All datasets used in the study are available upon request from the corresponding author.

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