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Outcome of living kidney donors left with multiple renal arteries

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Abstract

Individuals with kidneys having 2 arteries appear to have an increased incidence of hypertension. Whether kidney donors in whom the remaining kidney has 2 arteries are at increased risk of hypertension is unknown. Therefore, we studied 3685 kidney donors to determine whether donors left with a kidney having 2 arteries were at increased risk of hypertension, impaired renal function, or death. Cohorts were assigned based on our practice pattern and the anatomy of the donated kidney. Of the 3685 donors, 1211 were estimated to have a remaining kidney with 2 arteries. Mean follow-up time for the single-artery group was 14.1 (± 11.0) yr and 15.3 (± 11.2) yr for the 2 artery group. Six-month hospital readmission rate was 1.4% and 1.2%, hypertension was noted in 22.4% and 21.8% and proteinuria in 9.7% and 9.6%, and estimated glomerular filtration rate at last follow-up was 62 (± 28) and 62 (± 16) for single vs. 2 renal artery groups, respectively. Our data suggest no adverse clinical sequelae nor any decrease in long-term survival for donors left with a kidney having 2 renal arteries.

Keywords

estimated glomerular filtration rate; kidney transplant; living donor; modification of diet in renal disease; multiple renal arteries

A living kidney donor undergoes an operation without any significant personal medical benefit. Therefore, it is important to ensure that any short- or long-term donor risks are minimized. Long-term outcome has been shown to be similar to the age-matched non-donor population (1). However, similar to the general population, some subgroups may be at increased risk of short- and long-term mortality, as well as development of hypertension, diabetes, and chronic kidney disease (2, 3).

Numerous studies have shown an association between essential hypertension and the presence of multiple renal arteries (4–9). However, transplantation of a kidney with 2 renal

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Author contributions

MD Rizzari, TM Suszynski, and KJ Gillingham were involved in data analysis and writing of the manuscript. MD Rizzari, HN Ibrahim, and AJ Matas were involved in research design. HN Ibrahim and AJ Matas were involved in writing of the manuscript and mentorship.

arteries has not been found to be detrimental to recipient survival or graft outcome (10–12). Specific to living kidney donors, little information is available on their long-term outcome when they are left with a kidney that has 2 arteries (13). Therefore, we studied whether donors left with a kidney having 2 renal arteries were at increased risk of development of hypertension, proteinuria, impaired renal function, or death.

Patients and methods

Between June 6, 1963, and November 1, 2009, 3882 patients underwent living donor nephrectomy at the University of Minnesota. All donor and recipient information is maintained in an Institutional Review Board approved database. Over the past two decades, we have made intermittent attempts to contact former donors and collect follow-up information. In December 2003, we began an extensive effort to locate, contact, and gather additional information from former kidney donors. For those located, we have maintained contact a minimum of every three yr (1). Of the 3882 donors, follow-up information was available on 3685 (95% of total).

Our donor evaluation and acceptance criteria have been described previously (1). For donor nephrectomy, our practice has been to use the left kidney when there is a single artery. If there are 2 renal arteries on the left and a single artery on the right, the right kidney is removed. If there are multiple arteries bilaterally, the left kidney is removed. Occasionally, one kidney has a minor abnormality; in that instance we use the kidney with the abnormality (e.g., a simple cyst), leaving the donor with the normal kidney. The same algorithm has been applied to both open and laparoscopic nephrectomy (14).

Historical angiographic information was not available for all donors; therefore, cohorts were assigned based upon the anatomy of the donated kidney (information maintained in the recipient database) (Fig. 1). Group 1 included patients who donated a left kidney with a single renal artery ($n = 2474$). We assumed that the remaining kidney in the vast majority of these patients had a single renal artery. Group 2 patients donated either a right kidney with a single artery ($n = 919$) or a left kidney with 2 arteries ($n = 292$). Based on our practice, the remaining kidney in the vast majority of these patients had 2 arteries to their remaining kidney (total $n = 1211$). To verify this approach, we studied angiographic data collected in the last five yr ($n = 460$) and found multiple artery rates of 28% in the non-donated kidney when using the above algorithm, compared to 35% of donors left with a multiple artery kidney when using angiographic verification.

Vital status was ascertained for all donors utilizing the Social Security Death Master File. Hypertension was defined as taking an antihypertensive medication at any point during follow-up after living donation. Proteinuria was defined as any positive result on urinalysis throughout post-donation follow-up.

Statistical analysis

The characteristics of the two groups were compared using the Wilcoxon rank-sum test and the chi-squared test. Kaplan–Meier methods were used to estimate actuarial survival and the development of post-donation hypertension and proteinuria, and the log-rank test was used to compare groups. Post-donation hospital readmissions within six months were compared using the Fisher's exact test. Yearly mean creatinine level, mean difference between pre- and post-donation creatinine and estimated glomerular filtration rate (eGFR) were compared using the Wilcoxon rank-sum test. The modification of diet in renal disease study equation was used to calculate eGFR. p -Value <0.05 was considered significant for all statistical analyses.

Results

Age, proportion of men and race distribution were comparable between the two groups (Table 1). Approximately 3% of donors in each group had hypertension at the time of donation. Mean eGFR ($\pm$ SD) at the time of donation was 88 ($\pm$ 17) and 87 ($\pm$ 17) ($p = 0.1$). Mean ($\pm$ SD) BMI at donation was 26 ($\pm$ 5) and 26 ($\pm$ 4) ($p = 0.1$), and 52% and 56% ($p = 0.02$) of donors had a history of tobacco use at the time of donation for Group 1 and Group 2, respectively. Additional donor characteristics are shown in Table 1.

After a mean follow-up of 14.1 ($\pm$ 11.0) yr for Group 1 and 15.3 ($\pm$ 11.2) yr for Group 2 ($p = \text{NS}$), there were no significant differences in actuarial survival ($p = 0.7$) (Fig. 2). Total fraction of living patients (vital status) at the time of the study was 79% for Group 1 and 79% for Group 2 ($p = 0.1$). A minority of Group 1 (1.4%) required hospital readmission within the first six months post-donation vs. 1.2% in Group 2 ($p = \text{NS}$). Post-donation hypertension developed in 22.4% of donors in Group 1 and 21.8% in Group 2 ($p = \text{NS}$). Mean time ($\pm$ SD) to the development of hypertension was 15 ($\pm$ 9) yr for Group 1 and 16 ($\pm$ 10) for Group 2 ($p = 0.2$). Post-donation proteinuria occurred in 9.7% of donors in Group 1 and 9.6% in Group 2 ($p = \text{NS}$). Lastly, mean eGFR ($\pm$ SD) at latest follow-up was 62 ($\pm$ 28) for Group 1 and 62 ($\pm$ 16) for Group 2 ($p = 0.8$) (Table 2).

Discussion

Our study suggests that donors whose remaining kidney has 2 arteries have the same long-term outcome as donors whose remaining kidney has a single artery. Our findings support those of Fehrman- Ekholm et al. (13) who studied 154 living donors with angiographic definition of renal vascular anatomy. The authors found no statistically significant differences in eGFR or development of post-donation hypertension between donors whose remaining kidney had 1 vs. 2 arteries.

Based upon autopsy data, the frequency of multiple renal arteries in the general population has been estimated to occur at a rate of 18–30%, and more recent studies involving both cadaveric and living donors approximate the frequency of multiple arteries to be between 19% and 22% (15–18).

Early literature suggested that transplanting kidneys with vascular or urologic anomalies resulted in poor short-term outcomes in the recipient, including increased incidence of renal artery stenosis and vascular thrombosis (11, 18–21). However, with increased experience, outcomes have improved. In 1995, Benedetti et al. (11) published a large retrospective, single-center experience of nearly 1000 kidney transplants, suggesting that transplanted kidneys with multiple renal arteries were associated with equivalent outcome when compared to kidneys having a single artery. Others have made similar observations in both adult and pediatric recipient populations (10, 12, 16, 22–25).

In the general population, patients with essential hypertension are more likely to have kidneys with multiple renal arteries (4–9). The mechanism of this increased incidence of hypertension is thought to be related to an increase in renin secretion, triggered by lower renal blood pressure in regions supplied by what are presumed to be more narrow accessory renal arteries (7). Studies of long-term living kidney donor outcome have shown that survival rates and the prevalence of hypertension and proteinuria are similar to age-, gender-, and ethnicity-matched controls within the general population (2, 3). However, similar to their increased risk in the general population, certain subgroups are also at increased risk after donation. Lentine et al. (3) reported that African American donors are at increased risk of the development of hypertension, diabetes, and chronic kidney disease when compared to Caucasian donors, at rates similar to those of the general African

American population. Additionally, Lentine et al. noted that Hispanic donors are also at risk of the development of diabetes and chronic kidney disease at rates similar to those of the general Hispanic population. Segev et al. (2) noted that African American donors are at increased risk of postoperative and long-term mortality when compared to Caucasian donors, although this did not exceed rates of matched controls in the general population. Given the findings of Lentine et al. and Segev et al. on subgroups at increased risk, it is also important to determine whether donors whose remaining kidney has 2 renal arteries are at any increased risk. Such information may impact donor selection (when there are multiple potential donors) and informed consent.

Our study is limited by the absence of complete angiographic studies for all donors. However, our multiple renal artery group (Group 2, n = 1211) is likely to be composed almost entirely of donors whose remaining kidney had 2 renal arteries. Outcome in this group is similar to our single-artery group and to other reports of long-term donor outcome (1, 13, 26). When verifying our algorithm with a recent donor set complete with angiography, we found a close concordance of our algorithm estimates with the verified angiographic data. However, based on our methods, Group 1 likely contained donors with >1 renal artery on the right side; therefore, it is likely that there is a slight overestimation of the incidence of single arteries in this group. One demographic to note is that the multiple artery group had a statistically significant, albeit small, difference in pre-donation history of tobacco use. The significance of this is unclear, as one might expect that this would negatively impact the rate of development of hypertension in this subset. Additional study limitations include short follow-up time for some donors and a racial composition of mostly Caucasian donors with a relatively low percentage of African Americans. Further studies with longer follow-up time and more extensive studies involving African Americans should be performed to determine whether differences exist in this subset of living donors.

In summary, our data suggest that there are no adverse clinical sequelae, nor any decrease in long-term survival for donors left with a kidney having 2 renal arteries.

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DONOR ALLOCATION SCHEME **Fig. 1.**

Flowchart outlines the allocation scheme used to place donors into either the single renal artery or multiple renal artery study groups.

Fig. 2. Kaplan-Meier analysis illustrating no significant differences in long-term actuarial survival for donors left with a kidney having either a single renal artery or multiple renal arteries.

Table 1Donor demographics, n (%) or mean ($\pm$ SD)

	Group 1 (SRA)	Group 2 (MRA)
Total, n	2474 (67.1%)	1211 (32.9%)
Age, yr	38.8 ($\pm$ 11.5)	39.2 ($\pm$ 11.8)
Male	42.6	44.3
Race (%)		
Caucasian	94.8	94.4
African American	2.6	2.3
Other	2.6	3.3
Donor relationship (%)		
LRD	82.5	82.7
LURD	17.5	17.3
Pre-donation history		
Pre-donation HTN (%)	3.0	3.2
eGFR at donation	88.0 ($\pm$ 17.5)	87.3 ($\pm$ 17.1)
BMI at donation	25.9 ($\pm$ 4.5)	25.7 ($\pm$ 4.4)
History of tobacco use (%) [*]	52.3	56.3

All demographic metrics between the SRA and MRA groups were found to be statistically insignificant, except for total numbers of donors in each group and history of tobacco use at the time of donation.

HTN, hypertension; LRD, living-related donor; LURD, living unrelated donor; MRA, multiple renal arteries; SD, standard deviation; SRA, single renal artery; eGFR, estimated glomerular filtration rate.

^{*} p < 0.05.

Table 2Post-donation course and complications, n (% of total) or mean ($\pm$ SD)

	Group 1 (SRA)	Group 2 (MRA)
Vital status (living)	1952 (78.9%)	953 (78.7%)
Hospital readmissions ^a	34 (1.4%)	15 (1.2%)
Post-donation HTN	556 (22.4%)	264 (21.8%)
Mean time to HTN (yr)	15.3 ($\pm$ 9.7)	16.3 ($\pm$ 10.0)
Post-donation proteinuria	241 (9.7%)	116 (9.6%)
eGFR at latest follow-up	62.4 ($\pm$ 28.2)	61.8 ($\pm$ 16.1)

All post-donation metrics between the SRA and MRA groups were found to be statistically insignificant.

eGFR, estimated glomerular filtration rate; HTN, hypertension; MRA, multiple renal arteries; SRA, single renal artery.

^aWithin six months post-donation.