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ORIGINAL ARTICLE

Impact of remaining kidney volume to body weight ratio on renal function in living kidney donors

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Abstract To investigate whether the ratio of remnant kidney volume to body weight (V/W ratio) can impact renal function in donors, 45 living kidney donors were enrolled. Kidney volume was analyzed by magnetic resonance imaging. Renal function was compared between donors with a V/W ratio of < 2.0 mL/kg ($n = 23$) or ≥ 2.0 mL/kg ($n = 22$). Donors in both V/W groups showed similar serum creatinine levels and estimated glomerular filtration rates (eGFRs) at 7 days and 1 year, whereas donors with a V/W ratio of < 2.0 mL/kg had significantly higher 24-hour urine protein levels at 1 year (0.54 ± 0.23 g/d vs. 0.33 ± 0.19 g/d, $p = 0.028$). Multivariate analysis revealed no correlation between the V/W ratio and eGFR at 7 days or 1 year, and a V/W ratio of < 2 mL/kg was not associated with an increased incidence of eGFR < 60 mL/min/1.73 m^2 at 1 year (risk ratio 1.73, 95% confidence interval 0.10–29.47). The V/W ratio correlated inversely with 24-hour urine protein ($r = -0.377$, $p = 0.021$) at 1 year, and donors with a V/W ratio of < 2.0 mL/kg were more likely to show 24-hour urine protein >300 mg (risk ratio 1.70, 95% confidence interval 1.08–2.67) at 1 year. Donors with lower V/W ratios have higher 24-hour urinary protein levels at 1 year after transplantation. These findings suggest that the V/W ratio may be useful for kidney selection.

Conflicts of interest: All authors declare no conflicts of interest.

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Introduction

Kidney transplantation has long been considered the preferred treatment for patients with end-stage renal disease, providing substantially longer survival and better quality of life than dialysis [1,2]. Rising numbers of patients reaching end-stage renal disease intensify the demand for expansion of donor pool, and living kidney transplantation is one of the solutions. Although living kidney transplantation results in better patient and graft survival and avoids the long wait on dialysis [3], controversies over safety of donors remain. While a large cohort study has reported living donor nephrectomy to be safe [4], this is still a major procedure that carries potential risks for the donor. Additionally, there is uncertainty on the risk of increased cardiovascular mortality and progression to end-stage renal disease in the long term [4,5]. This highlights the need to optimize how living kidney donors are selected in order to ensure the best post-transplantation outcomes for them as well as for recipients.

Several studies suggest that the ratio of allograft weight to recipient body weight predicts renal function in kidney transplantation recipients. One study reported that the mismatch of allograft weight to recipients' body weight was associated with an increased risk of graft failure [6], and another study found that lower ratios of kidney weight to recipient body weight were associated with inferior kidney function at 12 months [7]. Moreover, Nicholson et al. [8] found that lower ratios of ultrasound-based allograft size to recipient weight predicted poor long-term renal allograft function. These observations led us to ask whether the analogous ratio of remnant kidney volume to body weight (V/W ratio) may predict kidney function in donors after transplantation. We are unaware of studies addressing this question.

Therefore, we carried out a prospective study to investigate a possible association of the V/W ratio with renal function in living donors. We estimated kidney volume using magnetic resonance imaging (MRI)-based disc summation, which has been proved to be a reliable and reproducible method [9].

Methods

Patients

Between July 2011 and January 2012, we prospectively enrolled a consecutive sample of living kidney donors at our clinic. Participants had to be at least 18 years old, not pregnant, and without any contraindications to MRI. In addition, all potential participants underwent a thorough preoperative evaluation to ensure that they were medically fit for donation and that their kidney was suitable for transplantation. All patients provided informed consent before undergoing MRI. This study was approved by our hospital's Ethics Committee (West China Hospital, Sichuan University).

Assessment of kidney function

Renal scintigraphy with 99mTc-mercaptoacetyltriglycine was performed in all donors, and effective renal plasma flow was calculated using a camera-based technique. If renal function differed by $>$ 15% between the right and left kidneys, usually the less functional kidney was removed. Serum creatinine levels were determined preoperatively and on Postoperative Day 7 in all 45 patients, and at 1 year postoperatively in 36 patients. The estimated glomerular filtration rate (eGFR) was estimated using the Cockoroft—Gault formula [10]. Preoperative single-kidney eGFR was calculated by multiplying the preoperative total eGFR by the differential ratio of single-kidney effective renal plasma flow. In order to rule out differences in body surface area (BSA) among the donors, pre- and postoperative eGFRs were adjusted to the standard BSA (1.73 m^2). BSA was calculated as described previously [11].

Estimation of kidney volume

All donors were analyzed by MRI within 5 days prior to surgery. MRI was performed using a 3.0-Tesla scanner (Magnetom Trio Tim; Siemens, Munich, Germany). An eight-channel, phased-array coil was used for signal reception. A plain scan covering the entire kidney length in the craniocaudal direction was acquired using a T1-weighted gradient echo sequence. The specific acquisition parameters were as follows: TR (repetition time), 110 milliseconds; TE (echo time), 2.5 seconds; FOV (field of view), 380 $\times$ 380; flip angle, 70°; slice number, 7; slice thickness, 6 mm; gap, 1.2 mm; and breath-hold duration, 15 seconds. A fat saturation pulse was used to suppress the signal from surrounding perirenal adipose tissue and to improve delineation of the renal border.

Kidney volume was calculated from three dimensional volume images using the voxel-count method applied to coronal MR images, as described previously [9]. Boundaries of the renal parenchyma of each kidney slice were manually mapped, and kidney volume was calculated as follows:

$$\text{Kidney volume (mL)} = n\Sigma_{(i)}(\text{parenchymal area} \times \text{slice thickness})_i \quad (1)$$

Both donated and remnant kidney volumes were recorded in milliliters, and preoperative body weight of each donor was recorded in kilograms. The V/W ratio was calculated for each donor as an index of nephron dose.

Statistical analysis

All continuous data were reported as mean $\pm$ standard deviation and compared using the Student t test; categorical data were compared using the Chi-square test. Spearman's correlation coefficients were calculated to evaluate the relationship between kidney function and donor characteristics. Logistical regression was used to assess the relationship between the V/W ratio and kidney function, and results were expressed as risk ratios (RRs) with 95%