

Postnephrectomy Changes in Doppler Indexes of Remnant Kidney in Unrelated Kidney Donors

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Introduction: We aimed to evaluate the intralobar renal arteries indexes using the Doppler ultrasonography indexes, which have become the established method of kidney monitoring, in living unrelated kidney donors during the postnephrectomy period.

Materials and Methods: In this prospective study, we evaluated and followed up 34 living unrelated kidney donors. The Doppler ultrasonography indexes, including resistive index, pulsatility index, and peak systolic velocity, along with the grey-scale ultrasonographic indexes of cortical thickness, length, and anteroposterior diameter of the kidney were determined before nephrectomy, and then, 1 week and 3 months after nephrectomy. In addition, glomerular filtration rate were assessed simultaneously.

Results: The resistive index and pulsatility index did not change 1 week and 3 months after nephrectomy ($P = .66$ and $P = .38$, respectively). The peak systolic velocity at 1 week was significantly higher than its pre-nephrectomy value ($P = .02$). Also, the peak systolic velocity at 3 months was significantly higher than that prior to nephrectomy ($P < .001$). Indexes of the kidney size all increased during the follow-up period. The estimated glomerular filtration rate increased decreased 1 week after nephrectomy, but it reach to a level comparable with its preoperative values after 3 months.

Conclusion: Results of the present study showed an increased peak systolic velocity in association with unaltered resistive index and pulsatility index in the remnant kidney of donors, during the short-term follow-up. This finding indicates the increased blood flow and kidney size in the remnant kidney of donors, following nephrectomy.

Keywords: kidney transplantation, nephrectomy, kidney physiology, Doppler ultrasonography

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INTRODUCTION

The need for kidney transplantation continues to increase as a result of rising numbers of patients with end-stage renal disease.^(1,2) Living donor kidney transplantation is one of the solutions with proven efficacy and safety for its recipients. However, the postoperative outcome of the donors has been subjected to little investigation.⁽³⁾

Although medical literature

indicates that kidney donation is currently a safe procedure with low morbidity and mortality,^(4,5) several studies have claimed that living kidney donation has calculable long-term risks and complications that may not be apparent in the short-term.⁽⁶⁻⁸⁾ However, the potential risks of living kidney donation are still controversial,⁽⁷⁾ and there are few published reports examining the extended outcome after donor nephrectomy, especially

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in unrelated kidney donors.⁽²⁾

Living donor kidney transplantation has become more common in the past few years in Iran. Thus, we need more investigations on postnephrectomy outcome of donors and regular follow-ups to identify at-risk populations. Ultrasonography examination of the kidneys is relatively inexpensive and provides a way to assess location, contour, and size of the kidneys.⁽⁹⁻¹¹⁾ In addition, color Doppler ultrasonography (CDU) has been validated as a noninvasive method to evaluate hemodynamic features of renal blood flow in patients with various renal diseases,⁽¹⁰⁾ and currently, CDU velocimetry of interlobar renal arteries has become an established method of screening of kidney allograft donors and monitoring of recipients.⁽¹²⁻¹⁴⁾ We designed the present study to evaluate the health condition of donors' remnant kidney using the CDU indexes of interlobar renal arteries before, 1 week, and 3 months after nephrectomy.

MATERIALS AND METHODS

In this prospective study, we evaluated and followed up 34 living unrelated kidney donors who underwent nephrectomy between July 2006 and August 2008 at Imam Reza Hospital in Tabriz, Iran. All of the participants provided informed consent. Furthermore, the whole work was supervised and approved by the ethic committee at Tabriz University of Medical Sciences, and compliance with the Helsinki Declaration was considered.

Permission for donation was done by the nephrologists and the urologists responsible for transplant program. Receiving any medication that might affect renal blood flow and kidney function, surgical complications, and loss of follow-up were the exclusion criteria. Of 105 donors, 47 accepted to participate in the study and signed consent form, but only 34 donors remained in the study. Two donors were excluded because of surgical complications and 11, because of lost to follow-up.

All of the participants underwent CDU before nephrectomy, and then, 1 week and 3 months after nephrectomy, and the results were compared with each other. The ultrasonographies were all

performed by a Hitachi model EUB 525 (Hitachi Medical Corp, Tokyo, Japan) using convex probes (3.5 MHz and 7.5 MHz) by one radiologist (MKT). The CDU Indexes including resistive index (RI), pulsatility index (PI), and peak systolic velocity (PSV), and the grey-scale ultrasonographic indexes including cortical thickness, length, and anteroposterior diameter of the kidney were recorded for both kidneys' prior to nephrectomy and the remnant kidney after the operation. After visualization of the interlobar arteries of the upper, middle, and lower pole by CDU, the indexes were determined in the interlobar arteries of each pole by pulsed Doppler ultrasonography, and then, the mean of the values were reported. In the interlobar renal arteries, the RI and PI were calculated from the Doppler spectra using the following equations:

$$RI = \frac{\text{peak systolic velocity} - \text{end-diastolic velocity}}{\text{peak systolic velocity}}$$

$$PI = \frac{\text{peak systolic velocity} - \text{end-diastolic velocity}}{\text{mean velocity}}$$

In addition to the CDU indexes, systolic and diastolic blood pressure, glomerular filtration rate (GFR), serum creatinine, and blood urea levels were determined, simultaneously. The estimated GFR was calculated according to the Cockcroft-Gault formula. Serum creatinine and blood urea levels were determined by the Jaffe method (mg/dL) and a commercial kit (mg/dL), respectively. Blood pressure was measured using a manual sphygmomanometer.

Statistical analyses were performed by the SPSS software (Statistical Package for the Social Sciences, version 13.0, SPSS Inc, Chicago, Illinois, USA). The results were presented as mean values \pm standard deviation for continuous variables. Statistical significance between the times of evaluation was estimated using the 1-way repeated measures analysis of variance, the Friedman, and the Bonferroni tests. Also, correlation of variables was studied by the Pearson correlation coefficient test. A *P* value less than .05 was considered significant.

RESULTS

The mean age of the donors was 25.56 ± 2.31 years and 8 of them (23.5%) were women. Nephrectomies were right-sided and left-sided in 11 and 23 cases,

Clinical and Laboratory Findings in Kidney Allograft Donors Before and After Nephrectomy*

Parameters	Measurements Before and After Nephrectomy			P			Overall†
	Before	1 w After	3 m After	Before vs 1 w	1 w vs 3 mo	Before vs 3 mo	
Systolic BP, mm Hg	96.78 ± 6.38	100.35 ± 3.07	98.21 ± 6.38	.14	.34	.45	.34
Diastolic BP, mm Hg	64.64 ± 4.58	67.01 ± 2.15	62.14 ± 2.56	.15	.27	.35	.31
Serum creatinine, mg/dL	0.85 ± 0.19	1.06 ± 0.22	0.90 ± 0.14	.03	.01	.10	.02
Blood urea, mg/dL	17.53 ± 3.88	20.50 ± 5.14	19.50 ± 1.01	.07	.42	.67	.12
GFR, mL/min	123.68 ± 17.99	101.20 ± 14.75	118.43 ± 13.03	.003	.004	.09	.003
Kidney length, mm	108.93 ± 6.93	112.25 ± 4.37	115.53 ± 6.53	.01	.005	< .001	< .001
Kidney AP diameter, mm	41.46 ± 3.21	45.14 ± 4.09	48.54 ± 4.41	.18	.005	.04	< .001
Cortical thickness, mm	8.59 ± 1.77	12.20 ± 5.97	14.18 ± 4.44	.02	< .001	.003	.001
Resistive Index	0.61 ± 0.04	0.60 ± 0.03	0.61 ± 0.04	.31	.43	.65	.66
Pulsatility Index	1.10 ± 0.17	1.06 ± 0.14	1.10 ± 0.21	.06	.40	.37	.38
Peak systolic velocity	21.10 ± 2.43	23.38 ± 2.37	29.22 ± 3.66	.02	.009	< .001	< .001

*BP indicates blood pressure; GFR, glomerular filtration rate; and AP, anteroposterior.

†Compared with repeated measures analysis of variance.

respectively. Clinical parameters and CDU indexes are outlined in the Table. Blood pressure and blood urea hovered around the normal ranges with no significant alterations. A slight increase in serum creatinine, and subsequently a decrease in GFR, was seen 1 week postoperatively, which was corrected after 3 months. Constant increases in the kidney’s length, anteroposterior diameter, and cortical thickness were recorded at the 1st week and the 3rd months after nephrectomy. Concerning the function of the remnant kidney compared to its function before nephrectomy of the contralateral kidney, the estimated GFR increased up to 63% and 91% after 1 week and 3 months after nephrectomy, respectively.

The RI did not change significantly after nephrectomy (Figure 1; $P = .66$). There was no significant alterations in the PI, either (Figure 2;

$P = .38$). However, the PSV increased 3 months after nephrectomy to a significant level (Figure 3; $P < .001$).

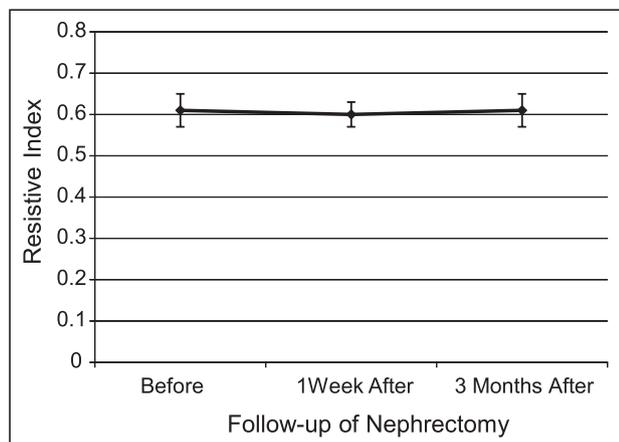


Figure 1. Changes in the resistive index of the interlobar renal arteries.

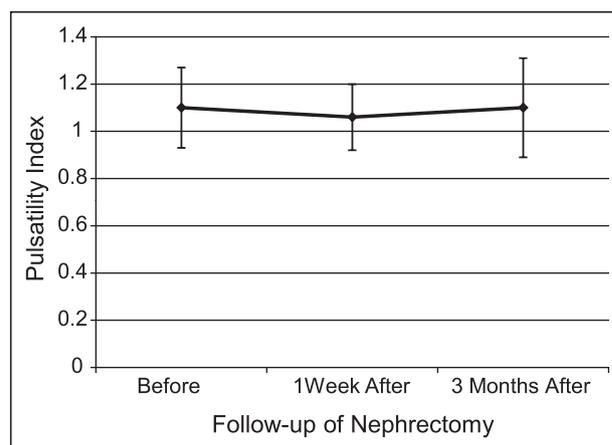


Figure 2. Changes in the pulsatility index of the interlobar renal arteries.

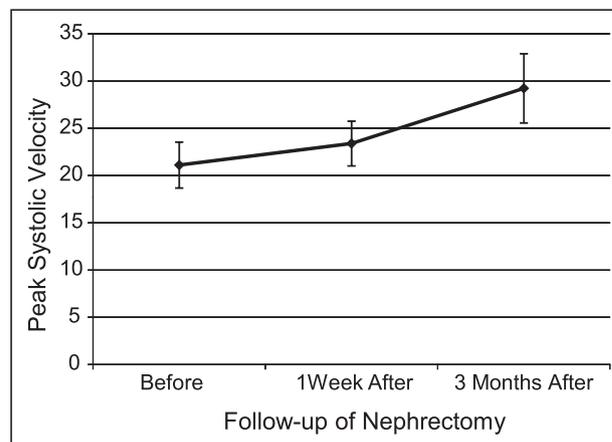


Figure 3. Changes in the peak systolic velocity of the interlobar renal arteries.

DISCUSSION

The aim of the present study was to evaluate and compare the CDU findings of the remnant kidney in living unrelated kidney donors at 1 week and 3 months after nephrectomy. To the best of our knowledge, this is the first report on the CDU indexes of the remnant kidney in living unrelated kidney donors. Results of this study revealed that PSV values of the donors significantly increased 3 months after nephrectomy, while the RI and PI did not change significantly. We also found that the size and function of the remnant kidney consistently increased during the follow-up period, despite a slight decrease in GFR 1 week after nephrectomy.

Several studies have reported that surgical ablation of the kidney tissue such as unilateral nephrectomy leads to an increase in the GFR from half the preoperative level to an average of about 75% of the 2-kidney performance within 2 to 4 weeks after nephrectomy, and around 85% after 2 to 6 years.^(15,16) The functional compensation is obviously seen in the increase of the remaining functional volume of donors' kidneys after nephrectomy.⁽¹⁷⁾ In the present study, although the pre-nephrectomy GFR was higher than its value at 1 week or 3 months after the operation, the estimated GFR was the result of only one functioning kidney. Hence, despite a decline in GFR after 1 postnephrectomy week, considering the pre-nephrectomy GFR as a result of both kidneys' function and half of its value as a marker of the remnant kidney's function, the calculated GFR for the remnant kidney is supposed to have an increase of about 63% after 1 week and 91% after 3 months (Table). In fact, the loss of one kidney due to either a disease or surgical removal results in compensatory changes in the remaining kidney.⁽¹⁸⁾ Primary studies have reported similar results and shown that the creatinine clearance increases by 72% to 78%, compared to the preoperative creatinine clearance, within several weeks postoperatively, and then, stabilizes or increases very slightly for more than 10 years after nephrectomy.^(19,20) Examination of donors by technetium Tc 99m mercaptoacetyl triglycine renal showed a functional increase of the remaining kidney of 20% in the mean tubular

excretion rate levels compared to the values of healthy carriers of two kidneys.⁽²¹⁾

Circulatory changes reflected in Doppler waveforms of the intralobar renal arteries predict possible adverse outcomes.^(22,23) The RI, PI, and PSV has proved as Doppler waveforms in screening and mentoring of various renal pathophysiologic conditions.⁽²⁴⁻²⁶⁾ The increasing volume of PSV during the follow-up period of our study showed the increase in the remnant kidney's blood flow. This finding, as well as the increased kidney size, demonstrates the compensatory phase of the remnant kidney, which confirms "the demand and supply law" of basic medical physiology.⁽²⁷⁾ Moreover, the unaltered systolic and diastolic blood pressure during the postnephrectomy period indicates that increased PSV is a result of unilateral nephrectomy, and subsequently, shifting the removed kidney's blood flow to the remnant kidney.

The unchanged RI and PI in our study demonstrated unchanged resistance in the interlobar renal arteries. On the other hand, presence of constant RI and PI in association with increased PSV and kidney size, all described net compensatory increase in kidney volume and function which continued up to the 3rd month postnephrectomy. Consistent with the present study results, Khosroshahi and colleagues⁽¹¹⁾ did not show any changes in the RI and PI of the interlobar renal arteries of the remnant kidney, 6 to 12 months after donation. In case of serum creatinine level, although its levels increased 1 week and 3 months after nephrectomy, such rising volumes all were in normal limits. Previous studies also have reported that the serum creatinine level usually increases up to 20% above the baseline, while remaining within the normal range.⁽²⁸⁾

CONCLUSION

Our study showed an increase in PSV in association with unaltered RI and PI in the remnant kidney of donors in short-term. This finding indicates the increased blood flow of the remnant kidney. Although the GFR decreased and serum creatinine increased within

normal range values 1 week after nephrectomy, considering the fact that there is only one kidney left functioning in the body of donors, we can assume that function of the remnant kidney even has increased up to 63% to 90% at 1 week and 3 months after nephrectomy.

CONFLICT OF INTEREST

None declared.

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