

Resistive Index of the Remaining Kidney in Allograft Kidney Donors

Sirous Nekouei,¹ Hassan Ahmadnia,² Mahboobeh Abedi,³ Mohammad Hossein Alamolhodae,⁴
Mohammad Sadegh Abedi⁵

Abstract

Objectives: Kidney transplant is the last resort in patients with end-stage renal disease. In living-kidney donors undergoing nephrectomy for transplant; however, morphologic and hemodynamic changes may occur in the remaining kidney with time. If there would be such a change, then it may alter the diagnostic utility of Doppler ultrasound in evaluating diseased conditions of the solitary kidney. Using Doppler ultrasound, this study sought to determine whether there are hemodynamic changes in the remaining kidney.

Materials and Methods: Forty-one patients (38 men, 3 women) for kidney donation were examined using a MyLab 50 color Doppler apparatus with a convey 3.5- to 5-MHz probe. Resistive index values of the main renal, interlobar, and interlobular arteries in the remaining kidney were assessed before, and at 7 and 90 days after nephrectomy. The size and parenchymal thickness of the remaining kidney also were measured before and after nephrectomy.

Results: At day 90, a statistically significant increase ($P < .001$) in resistive index was seen at all levels, compared with before and 7 days after nephrectomy. No significant changes, however, could be noticed on the day 7, when compared with before the

nephrectomy. Renal size and parenchymal thickness remained constant over the time studied.

Conclusions: Although a statistically significant increase in resistive index values of the remaining kidney was seen 90 days after the nephrectomy, these values have remained within the normal limits of renal resistive index. So, our findings indicate that resistive index measurement is useful in assessing the diseased condition of the remaining kidney after removing the contralateral kidney.

Key words: Doppler, Ultrasound, Contralateral, Nephrectomy, Hemodynamic

Introduction

End-stage renal disease is caused by an irreversible loss of nephrons, which, if left untreated, can be fatal.¹ Today, hemodialysis, peritoneal dialysis, and transplant are the treatment options in end-stage renal disease patients.² Although both living-donor and deceased-donor kidney transplants are possible, optimal results can best be achieved through living-donor kidney transplant.³ In a successful living-kidney transplant, the risk of acute tubular necrosis is low, renal function is rapidly normalized, and hospitalization is reduced.⁴ Donation, however, maybe associated with complications in kidney donors. The risk of immediate complications after nephrectomy (namely, pulmonary infection, wound infection, and postoperative bleeding) have been reported to be the same as other surgeries.^{5, 6} Long-term complications, in theory, could be glomerulosclerosis, renal dysfunction, proteinuria, and hypertension. As to long-term postsurgical repercussions, glomerulosclerosis, hyperinfiltration, and renal dysfunction have been observed in animal experimentation,⁷⁻⁹ whereas studies conducted on 3000 human donors have not

From the Department of ¹Radiology; the Department of ²Urology, Ghaem Hospital, Faculty of Medicine, Mashhad University of Medical Sciences, Mashhad; Department of ³Radiology, Imam Reza Hospital, Faculty of Medicine, Mashhad University of Medical Sciences, Mashhad; and Department of ⁴Radiology, Ghaem Hospital, Faculty of Medicine, Mashhad University of Medical Sciences, Mashhad; and the Department of ⁵Surgery, Imam Khomeini Hospital, Faculty of Medicine, Tehran University of Medical Sciences, Tehran, Iran.

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Corresponding author: Mahboobeh Abedi MD, Resident of Radiology, Department of Radiology, Imam Reza Hospital, Faculty of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran.

Phone: +98 51 1801 2313 Fax: +98 51 1841 6314 E-mail: AbediM871@mums.ac.ir

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demonstrated considerable evidence of renal failure during a 20-year follow-up.¹¹⁻¹²

Based on previous studies, patients undergoing nephrectomy for any reason experience increasing blood flow to the remaining kidney, associated with induction of rapid compensatory growth and parenchymal hypertrophy with an unpredictable rate.^{7, 13, 14} However, only limited data exist assessing hemodynamic changes of the remaining kidney, after removing a healthy kidney from a donor for transplant.¹⁵⁻¹⁷

Color Doppler ultrasound, by evaluating the resistive indices of arteries, is an efficient means of assessing hemodynamic changes in any organ. In this study, we investigated the effect of donor nephrectomy on hemodynamics of the remaining kidney in allograft donors.

Materials and Methods

This is a prospective study that was performed on 41 kidney donors. The study was approved by the Ethics Committee of Mashhad University of Medical Sciences. Written, informed consent was obtained from all patients. All protocols conformed with the ethical guidelines of the 1975 Helsinki Declaration. Patients who met the criteria for donation were included. The resistive index (RI) values of the remaining kidney were assessed before nephrectomy as well as at 7 and 90 days after surgery. The remaining kidney's size (coronal area = length × width) and parenchymal thickness also were measured before and after the operation.

The RI was calculated with the peak systolic velocity (PSV or VPSV) and the end-diastolic velocity (EDV or VEDV), using the following formula:

$$RI = \frac{V_{PSV} - V_{EDV}}{V_{PSV}}$$

Patients were all admitted for Doppler examination after 6 hours of fasting as well as smoking abstinence. After complete bladder emptying, with the patient laid in a lateral decubitus position, the examination was performed using a MyLab 50 color Doppler apparatus (Prakar Medic Inc, Tenggara, Indonesia) with a convey 3.5- to 5-MHz probe.

Indices were measured for main renal, interlobar, and interlobular arteries, and a mean RI value was calculated and registered after 5 consecutive measurements. Interlobar and interlobular arteries were selected at the midpole of the kidney, where vessels are perpendicular to the transducer with a blood flow toward it. Statistical analyses were performed with SPSS software (SPSS: An IBM Company, version 11.5, IBM Corporation, Armonk, New York, USA). All values are reported as means ± SD. Data were analyzed with the paired *t* test and independent *t* test where appropriate.

Results

Participants included 41 kidney donors (38 male, 3 female; mean age, 30 ± 3 y; mean body weight, 67 ± 9.5 kg). The size of the coronal area and parenchymal thickness of the remaining kidney, and RI values of the main renal, interlobar, and interlobular arteries were measured before nephrectomy and 7 and 90 days after (Table 1). These results indicate a statistically significant increase in RI indices of the remaining kidney 90 days after the nephrectomy, compared with before and at day 7 after nephrectomy (Figures 1A, B, and C show a patient profile).

At the end, we compared the RI of right remaining kidney in patients who underwent a left nephrectomy with that of the left remaining kidney in patients with a right nephrectomy. This comparison was performed at 3 levels of the main renal, interlobar, and interlobular arteries at 7 and

Table 1. Clinical, Ultrasonographic, and DU Findings in Kidney Allograft Donors Before and After Nephrectomy

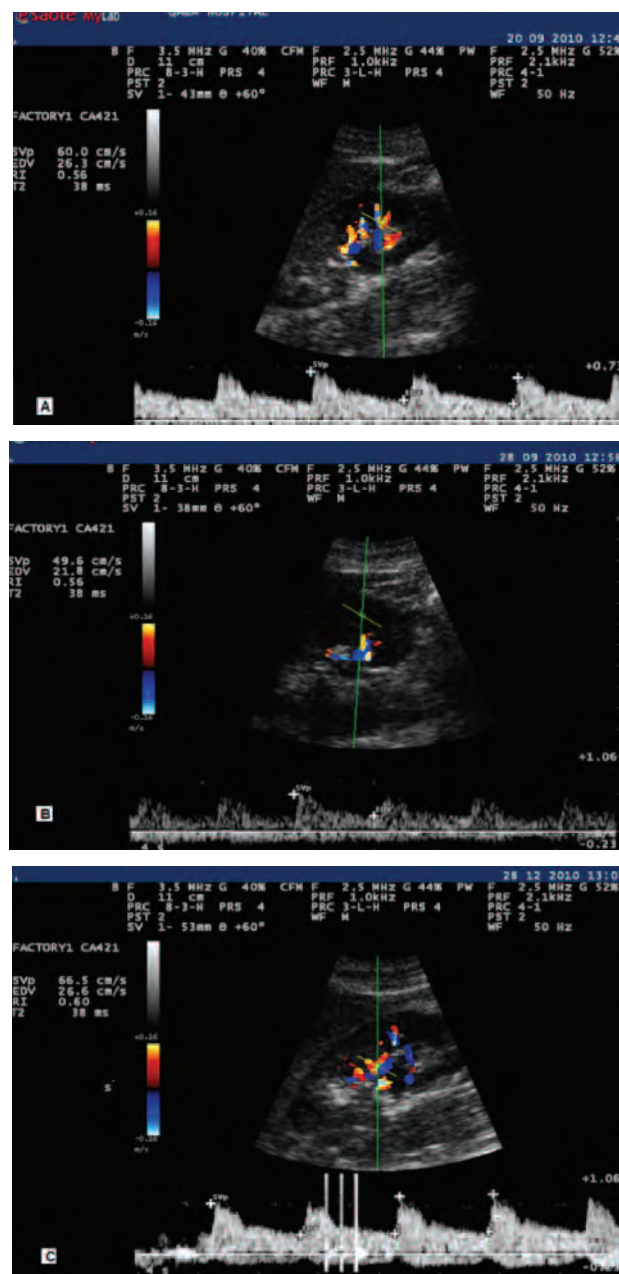
	Coronal Area [†]	Cortical Thickness [‡]	RI of Renal Arteries		
			Main Renal	Interlobar	Interlobular
Before nephrectomy	4490 ± 783	17.2 ± 2.7	0.57 ± 0.04	0.55 ± 0.04	0.54 ± 0.04
7 Days after nephrectomy	4624 ± 809	17.5 ± 2.7	0.57 ± 0.04	0.55 ± 0.04	0.54 ± 0.04
90 Days after nephrectomy	4615 ± 809	17.5 ± 2.5	0.59 ± 0.04	0.565 ± 0.044	0.55 ± 0.04
Before vs 7th day (<i>P</i> value)	.450	.618	.788	.823	.966
Before vs 90th day (<i>P</i> value)	.481	.605	< .001	.013	.030
7th Day vs 90th day (<i>P</i> value)	.951	01.01	< .001	< .001	.002

Abbreviations: DU, Doppler ultrasound; RI, resistive index

[†]mm²; [‡]mm

90 days after the nephrectomy. There was no significant difference between these values (Tables 2 and 3).

Figure 1. DU Findings in 1 Patient



(A) RI value before nephrectomy. (B) RI value 7 days after nephrectomy. (C) RI value 90 days after nephrectomy.

Abbreviations: DU, Doppler ultrasound, RI, resistive index

Table 2. RI Values in Rt Remnant Kidney as Compared With Lt Remnant Kidney 7 Days After Nephrectomy

RI of Renal arteries	Rt Remnant Kidney	Lt Remnant Kidney	P Value
Main renal	0.56 ± 0.05	0.58 ± 0.01	.227
Interlobar	0.55 ± 0.04	0.55 ± 0.03	.774
Interlobular	0.54 ± 0.04	0.54 ± 0.04	.850

Abbreviations: Lt, left; RI, resistive index; Rt, right

Table 3. RI Values in Rt Remnant Kidney as Compared With Lt Remnant Kidney 90 Days After Nephrectomy

RI of Renal Arteries	Rt Remnant Kidney	Lt Remnant Kidney	P Value
Main renal	0.59 ± 0.05	0.59 ± 0.01	.453
Interlobar	0.56 ± 0.04	0.56 ± 0.02	.768
Interlobular	0.55 ± 0.04	0.54 ± 0.03	.719

Abbreviations: Lt, left; RI, resistive index; Rt, right

Discussion

This study sought to assess the hemodynamic status of the remaining kidney in kidney allograft donors by means of renal arterial RI measurement. Arterial RI, which indicates the hemodynamic status of the kidney, could be affected by several physiologic factors such as age, heart rate, blood pressure, and the patient's hydration status. Also pathologic conditions such as obstruction of the urinary system, renal parenchymal disease, renal vein thrombosis, and renal artery stenosis may alter the RI values of the diseased kidney,^{18, 19} and this is the reason for using Doppler ultrasound examination as the first imaging modality in detecting such disorders.

One of the conditions that is expected to induce changes in renal RI values is turning into a single kidney status in kidney donors. Currently, most investigators consider 0.7 as the upper limit of the normal RI in adults.¹⁹ Because the use of contrast-enhanced imaging modalities in a solitary kidney is contraindicated, color Doppler imaging could play a significant role in detecting obstructions and other disorders. But as a previous study stated, "the current threshold of 0.7 as the upper limit of normal may not be useful for the diagnosis of pathological conditions, such as obstruction, in single-kidney adults, because contralateral nephrectomy, by itself, induces some changes in RI value of the remaining kidney."¹⁵

According to our findings, the arterial RI at 3 levels of main renal, interlobar, and interlobular arteries has a statistically significant increase at day 90 after nephrectomy, in comparison with those of before and day 7 after surgery. In spite of this increase, the RI value has remained within normal limits of renal RI. Shokeir and associates¹⁵ reported an increase in renal RI values on the second day after nephrectomy that was constant at weeks 6 and 12 after nephrectomy, and they concluded that because of such a change in RI value after contralateral nephrectomy, this index could not be used for detecting diseased conditions in the single kidney. Our study does not

confirm their conclusion, and it seems that in our population, $RI > 0.7$ as an indicator of the presence of a pathologic process is still valuable. However, we believe that such an inherent increase in RI value of the remaining kidney must be taken into account when interpreting Doppler ultrasound findings of a solitary kidney. Also, our results are not in agreement with Bohlouli and associates' and Khosroshahi and associates' studies that found no change in the RI and pulsatility index of the remaining kidney after donor nephrectomy.^{16, 17}

After uninephrectomy compensatory changes in volume and function of the remaining kidney and an increase in blood flow to the remaining kidney occurs, which is related to a shifting of the donated kidney's blood flow to the remaining kidney.¹⁶ Such an increase in blood flow may result in glomerulosclerosis and the glomerulosclerosis may be associated with elevated RI values in the remaining kidney.²⁰

Another notable result in our study was the absence of any significant difference between RI values of right remnant kidney in cases of left nephrectomy and those of left remaining kidney in cases of right nephrectomy. To our knowledge, there is no reported study dealing with such a comparison. Although some previous studies have estimated an asymmetric renal blood flow between right and left kidneys in normal healthy individuals,²¹ and some others have postulated that there may be possible functional asymmetry between the 2 kidneys,²² we found no difference between the RI values of the right remnant kidney and the left remnant kidney.

Conclusions

Unilateral donor nephrectomy could increase the RI values of the remaining kidney. But, despite such an increase, the RI value in our patients remained within the normal range. Thus, our findings indicate that the current normal range of renal RI value could still be used in evaluating diseased conditions in such patients.

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