

Resistive index as a predictor of early failure of kidney transplantation

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Background: Ultrasonography is a simple and noninvasive examination that can be easily performed after renal transplantation because of the lack of toxicity. The resistive index (RI) was measured using Doppler ultrasound at 7 days postoperatively in patients who underwent renal transplantation. The study aimed to determine the risk of graft loss and premature death within 1 year after transplantation.

Methods: This study was conducted from January 2011 to October 2017 and involved 97 patients who underwent renal transplantation at the Chosun University Hospital, Kwangju, Korea. Brain-dead donors were selected. Several parameters were assessed as recipient variables. In addition, postoperative delayed renal function and complications were examined. At 7 days after surgery, the RI was measured in all patients (the mean value of three measurements taken at different positions was used).

Results: Of the 97 patients, 40 had an RI of ≥ 0.8 or greater. Of these, four patients died, and a total of seven developed transplant failure. Logistic regression analysis was conducted to predict the risk of transplant failure and mortality based on complex influences of the relevant variables. The RI showed a relative risk value of 12.711 for transplant failure ($P=0.003$) and was significantly associated with mortality ($P=0.001$).

Conclusions: The RI was highly correlated with graft loss and recipient mortality after renal transplantation. Measurement of the RI after renal transplantation may lead to a more aggressive management of high-risk patients, and consequently improve the post-transplantation outcome.

Keywords: Duplex ultrasonography; Kidney transplantation; Transplant failure; Resistive index

INTRODUCTION

Renal transplantation is an established therapeutic option for patients with end-stage renal disease (ESRD). It aims to improve patients' quality of life and reduce mortality rates [1]. This approach has significantly improved short-term outcomes of kidney transplantation over the past few decades. However, graft loss and premature mortality in transplant recipients are concerns that need to be

addressed.

Ultrasonography is a simple and noninvasive imaging modality that does not involve exposure to ionizing radiation and can be safely and easily used in patients undergoing renal transplantation [2]. Currently, several transplantation centers use the intrarenal resistive index (RI), which is calculated using Doppler ultrasonography, to evaluate renal allografts [3]. In this study, the RI was calculated using Doppler ultrasonography on postoperative day 7 in patients undergoing renal transplantation. This study investigated the risk of graft loss and premature mortality within 1 year after transplantation.

METHODS

This study included 145 patients who underwent renal

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HIGHLIGHTS

- All patients who underwent kidney transplantation were examined for a study of graft failure or mortality.
- The characteristics of each patient, surgical parameters and postoperative complications were investigated.
- Among these, the resistive index measured 7 days after surgery showed significant results in graft failure and mortality.
- Surgical bleeding or postoperative renal function delay did not yield significant results and further research is needed.

transplantation at the Chosun University Hospital, Kwangju, Korea between January 2011 and September 2017. Deceased-donor and living-donor renal transplantations were performed in 120 and 25 patients, respectively. Only recipients of deceased-donor transplants were selected, and of these, 23 patients were excluded owing to insufficient data. Eventually, 97 patients were selected, and their postoperative outcomes were retrospectively investigated.

In this study, deceased donors were selected, and the variables analyzed included age and serum creatinine levels. Recipient-associated variables that were analyzed included age, sex, body mass index (BMI), and duration of dialysis. Variables analyzed postoperatively included transfusion within 24 hours after surgery, cold ischemia time, delayed renal function, and complications.

Delayed renal function was defined as the institution of dialysis within 1 week postoperatively. RI was calculated using the following formula: (peak systolic velocity-end diastolic velocity)/peak systolic velocity. The RI was calculated in all patients on postoperative day 7 (the mean value of three measurements obtained in different positions was used).

All statistical analysis was performed using the PASW ver. 18.0 (SPSS Inc., Chicago, IL, USA). Univariate analysis was performed for each recipient-associated variable, and the chi-square test was used to determine the association between these variables and graft loss. Variables showing $P \leq 0.05$ were subjected to multivariate logistic regression analysis. Variables showing P -value ≤ 0.05 were consid-

ered statistically significant. This study was approved by the Institutional Review Board of Chosun University Hospital (IRB No. 2019-02-002-001).

RESULTS

The mean ages of kidney donors and recipients were 48.5 and 47.7 years, respectively. Recipients included 63 men and 34 women. The mean BMI was 23.6 kg/m², which was analyzed based on 25 kg/m². Etiopathological contributors to ESRD included diabetes mellitus (37 patients), hyper-

Table 1. Patient' demographics, origin of ESRD, duration of dialysis, and outcomes

Characteristics	Value
Donor's age (yr)	48.5±6.36
Sex (male:female)	63:34
Patient's age (yr)	47.7±7.07
BMI (kg/m ²)	23.6±0.85
Origin of ESRD	
Hypertension	21
DM	37
CGN	15
Rheumatoid disease	6
PCKD	1
Ureter stone	2
Pre-eclampsia	1
Hepatorenal syndrome	1
Unknown	13
Duration of dialysis (yr)	
≤1	10
>1 & ≤3	24
>3 & ≤5	19
>5 & <10	25
≥10	15
Re-KT	4
Complication	
Bleeding	4
Ureter injury	1
Lymphocele	11
Wound dehiscence	2
Delayed function	13
Graft loss	7 (7.2)
Death	4 (4.1)
Transplant failure	9 (9.3)

Values are presented as mean±standard deviation or number (%). ESRD, end-stage renal disease; BMI, body mass index; DM, diabetes mellitus; CGN, chronic glomerular nephritis; PCKD, polycystic kidney disease; re-KT, underwent retransplantation.

tension (21), chronic glomerulonephritis (15), rheumatic disease (6), urinary stones (2), polycystic kidney disease, pre-eclampsia, and hepatorenal syndrome (1 each). Four patients had previously undergone transplantation. The duration of dialysis prior to transplantation was classified and analyzed, as shown in Table 1.

The RI was ≥ 0.8 in 26 patients. Of these 26, nine patients showed delayed renal function. Of the 71 patients in whom the RI was < 0.8 , four patients showed delayed renal function. Postoperative complications observed in this study included bleeding (4 patients), ureteral injury (1), lymphocele (11), and wound-related issues (2). Graft loss occurred in seven patients. Four patients died within 1 year postoperatively, with a mortality rate of 4.1%. Pneumonia-induced sepsis and intestinal infarction-induced panperitonitis occurred in two patients each. Transplantation failure was defined as graft loss or death within 1 year after transplantation (nine cases, 9.3%).

Of the 97 patients enrolled in the study, four died and seven developed transplant failure. Transfusion within 24 hours postoperatively was required in 51 patients. Of these, four died, and eight developed transplant failure. Delayed renal function was defined as initiation of dialysis within 7 days postoperatively and this occurred in 13

Table 3. Factors related to transplant failure and mortality based on the logistic regression analysis

Variable	Transplant failure		Mortality	
	OR (95% CI)	P-value	OR (95% CI)	P-value
Transfusion		0.104		0.187
RI	12.711 (2.437-66.281)	0.003		0.001
Delayed function		0.192		0.482

OR, odds ratio; CI, confidence interval; RI, resistive index.

Table 2. Factors related to transplant failure and mortality based on chi-square analysis

Factor	Transplant failure			Mortality		
	No. (%)	OR (95% CI)	P-value	No. (%)	OR (95% CI)	P-value
Sex		1.547 (0.387-6.189)	0.535		0.606 (0.061-6.061)	0.667
Male	5 (7.9)			3 (4.8)		
Female	4 (11.8)			1 (2.9)		
Age (yr)		0.917 (0.231-3.645)	0.902		3.643 (0.365-36.324)	0.241
< 50	5 (9.6)			1 (1.9)		
≥ 50	4 (8.9)			3 (6.7)		
BMI (kg/m ²)		1.628 (0.406-6.521)	0.488		0.635 (0.063-6.358)	0.697
< 25	5 (7.8)			3 (4.7)		
≥ 25	4 (12.1)			1 (3.0)		
Origin of ESRD			0.080			0.631
HTN	0			0		
DM	7 (18.9)			3 (8.1)		
CGN	1 (6.2)			0		
Others	1 (4.2)			1 (4.2)		
Duration of dialysis			0.623			0.911
Cold ischemia time			0.902			0.657
Donor age (yr)			0.389			0.118
Transfusion	8 (15.7)	8.372 (1.004-69.781)	0.022	4 (7.8)		0.052
RI		12.711 (2.437-66.281)	0.001			0.001
< 0.8	2 (2.8)			0		
≥ 0.8	7 (26.9)			4 (15.4)		
Delayed function	4 (30.8)	7.022 (1.591-30.991)	0.004	2 (15.4)	7.455 (0.952-58.402)	0.028

OR, odds ratio; CI, confidence interval; BMI, body mass index; ESRD, end-stage renal disease; HTN, hypertension; DM, diabetes mellitus; CGN, chronic glomerular; RI, resistive index.

patients. Of these, two died and four developed transplant failure.

All variables were analyzed using the chi-square test to predict the risk of graft loss and death. The RI was significantly associated with transplant failure and mortality ($P=0.001$ for both), as was delayed renal function ($P=0.004$ and $P=0.028$, respectively) (Table 2).

Multivariate logistic regression analysis was performed to evaluate the combined effects of variables showing significant associations in the univariate analysis. Multivariate analysis revealed that the relative risk of the RI was 12.711 for transplant failure ($P=0.003$) and that RI was significantly associated with mortality ($P=0.001$) (Table 3). However, no statistically significant association was observed with transfusion or delayed renal function.

DISCUSSION

Renal allograft dysfunction remains a major concern in patients undergoing transplantation, and early diagnosis is critical to ensure optimal therapeutic outcomes. It is estimated that the early acute rejection rate is as high as 20% of all cases of renal transplantation [4,5].

Ultrasonography combined with spectral and color Doppler imaging has contributed to significant advances in the evaluation of kidney disease over the last few decades. Additionally, ultrasonography may be used as a guide for the rejection of a transplant, kidney biopsy, and percutaneous aspiration of masses in close proximity to the kidneys [6]. Ultrasonography is useful to monitor kidney allograft function and related vascular complications following transplantation [7] and enables the rapid diagnosis of complications that endanger graft survival.

The RI, which is obtained using ultrasonography is a hemodynamic index commonly used to measure blood flow resistance in organs to assess vascular disease. Several studies have reported that an increased RI is diagnostic of acute transplant dysfunction.

However, the usefulness of the RI after kidney transplantation remains controversial. In 1990, Perrella et al. [8] reported that the sensitivity and specificity of the RI in diagnosing transplant rejection were 43% and 67%, respectively. Other studies have also reported the useful-

ness of the RI; however, the specificity of RI reported by these authors was low [9].

Recent studies have reported that a high RI observed after transplantation can indicate kidney dysfunction [10] and adverse cardiovascular events [11-13]. A previous cross-sectional study reported an association between an increased intrarenal RI after kidney transplantation and a high risk of graft loss or recipient mortality [14]. In the present study, the high RI observed after renal transplantation was associated with delayed graft function and a higher risk of graft loss and recipient mortality.

Currently, several centers use the RI for evaluation of graft dysfunction after kidney transplantation [3]. Several studies have suggested that a high RI is associated with an increased risk of kidney graft dysfunction and early graft loss after transplantation [14-16].

Naesens et al. [17] compared the RI with histopathological findings of renal biopsies and reported that the RI was associated with the recipient's central hemodynamic factors than with intrarenal disease of the kidney transplant. They concluded that a high RI was strongly associated with graft outcomes (loss or dysfunction) and recipient mortality rates. Kolonko et al. [15] reported that a high RI measured during the early posttransplantation period predicts poor kidney graft function and is associated with an increased risk of all-cause graft loss. They highlighted that the predictive value of the RI is not completely independent of the adverse effects of delayed graft function on premature graft loss.

Several recent studies have established the usefulness of RI. Our study also demonstrates the validity of the RI as a useful tool to predict outcomes after renal transplantation. The baseline RI value useful for this purpose remains controversial. Based on a RI of 0.9 determined in their study, Perrella et al. [8] concluded that the usefulness of the RI was low. Parolini et al. [12] reported significantly worse outcomes in patients with a $RI \geq 0.7$. Our study showed significant results based on a RI of 0.8.

The effects of a high RI on a transplanted kidney remain unclear. The pathomechanisms associated with specific outcomes after kidney transplantation also remain unknown. Further research is warranted to determine the optimal cut-off value of the RI and its effects on transplanted

kidneys. The RI is significantly associated with graft loss and recipient mortality after renal transplantation and its measurement after transplantation may enable more aggressive management of high-risk patients and consequently improve post-transplantation outcomes.

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Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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