

## RESISTIVE INDEX ON DOPPLER ULTRASOUND AFTER RENAL TRANSPLANTATION AS RENAL FUNCTION PREDICTOR

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### ABSTRACT

**Objective:** To determine the correlation between doppler resistive index and serum creatinine levels in renal transplant recipients.

**Study Design:** Cross sectional study.

**Place and Duration of Study:** Department of Radiology, Military Hospital Rawalpindi from Oct 2009 to Oct 2010.

**Patients and Method:** A total of 82 outdoor and admitted patients of both genders, within age group of 18-60 years, were included in the study. These patients were referred from Nephrology department Military Hospital, Rwp and Armed Forces Institute of Urology after renal transplant. Written informed consent was taken alongwith history of any co-morbid disease like diabetes or hypertension and for post transplant duration. Gray scale ultrasound was performed first, followed by doppler ultrasound of transplanted kidney and resistive index was calculated. The presence of any post transplant complications were also recorded. The values of resistive index were then correlated with the serum creatinine levels.

**Results:** Doppler ultrasound was performed on 82 patients included in the study and resistive index was calculated. A strong correlation between resistive index (RI) and serum creatinine level was found as calculated through Pearson's equation i-e 0.89. Thus making resistive index a strong predictor of transplanted kidney function and survival. Patients with RI>0.8 were older with mean age of 45.56, had raised serum creatinine level with mean value of 276.69 $\mu$ mol/l and had longer post transplant duration (mean 21.63 weeks). These patients also had other co-morbid diseases like diabetes mellitus and hypertension. The commonest post transplant complication was raised parenchymal echogenicity (30.5%), followed by perinephric collections (18.3%).

**Conclusion:** RI on doppler ultrasound in renal transplant patients shows a strong correlation with serum creatinine levels. Renal transplant patients with elevated serum creatinine levels had raised resistive indices.

**Keywords:** Doppler US, Renal transplant, Resistive Index.

### INTRODUCTION

Incidence of renal replacement therapy (RRT) varies markedly between Eastern and Western European countries, ranging from 12 to 455 per million population (pmp) in these countries<sup>1</sup>. Renal transplantation is recognized as being the optimal treatment modality for many patients with established renal failure<sup>2</sup>. Despite a resource poor environment, Rizvi reported 1 and 5 year survival rates of 92 and 85% respectively, among 2, 249 living related kidney transplants in Pakistan. Transplant rates of more than 30 pmp in 2010 were restricted to Western Europe, USA, and Australia, with a

slightly broader spread of countries achieving between 20 and 30 pmp<sup>3</sup>.

Gray-scale renal sonography combined with color doppler has become the main noninvasive imaging method for evaluating a kidney transplant, as it provides information about the kidney anatomy and its vascular flow<sup>4</sup>.

Duplex doppler ultrasonography is suggested as a noninvasive way of assessing the hemodynamics of renal blood flow in renal and intrarenal arteries in patients with various renal diseases and patients undergoing renal transplant. Renal doppler ultrasound is the imaging modality of choice for following up of renal transplant recipients. It can diagnose initial graft dysfunction as well as postoperative complications. Resistive index is an indirect indicator for degree of resistance of the

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intrarenal vessels. In other words, it shows the "vascular compliance" of the recipient<sup>5</sup>.

Interestingly, RI shows direct linear correlation with serum creatinine level ( $p=.03$ ,  $r=.13$ ). Because of significant correlation between doppler ultrasound indices and serum creatinine level, we can use doppler ultrasound as a tool to predict kidney function in association with serum creatinine<sup>6</sup>. The results of doppler ultrasound have been very positive, with substantial improvement in patient care and physician efficiency. These benefits, plus the fact that renal doppler ultrasound does not require expensive equipment indicates that ultrasound should become an integral procedure in the practice of nephrology<sup>7</sup>.

The purpose of my study is to determine the correlation of resistive index and serum creatinine levels in transplanted kidneys. Doppler ultrasound is a non-invasive, radiation free and easily available imaging modality that provides help in quick assessment of transplanted kidney. This study will help to authenticate the role of resistive index in evaluation of transplanted kidney function.

## PATIENTS AND METHODS

This cross-sectional study (validation study) was carried out from Oct. 23, 2009 to Oct 2010 in Department of Radiology, Military Hospital (MH) Rawalpindi. Patients referred from Nephrology department, Military Hospital Rwp and Armed Forces Institute of Urology (AFIU) Rwp, of both genders with age group 18-60 years and post transplant duration of more than 1 month were included in the study. Patients who had acute febrile illness or who had transplant failure and were started on dialysis again were excluded from the study.

Eighty two patients were included in the study through non probability convenience sampling. An informed consent was taken from all subjects included in the study after explaining the objective of study. History for presence of co-morbid diseases like diabetes mellitus (DM) or hypertension (HTN) and post transplant duration was taken and recorded on patient's performa. Ultrasonography was performed in the Department of Radiology, MH

Rawalpindi. Ultrasonography was done on Aloka Diagnostic Ultrasound Machine (SSD-5500) equipped with colour and pulsed wave. Doppler 3 to 5 MHz probe was used with a liberal amount of jelly with the patient lying in supine position and in suspended normal respiration. Gray scale imaging was performed first. Presence of any post transplant complication like fluid collection or raised parenchymal echogenicity were recorded. Probe was placed in right lumbar region and doppler gate was set in main branches of renal artery near the hilum of kidney. Measurements were made at three sites in the kidney i.e. in the upper, middle and lower poles. A 2-5 mm sample volume was used and angle correction was not applied. Waveforms were optimized for measurement using the lowest pulse repetition frequency without aliasing (to maximize waveform size), the highest gain without background noise, and the lowest wall filter. Three to five waveforms were recorded at each site and the average RI was calculated. RI greater than 0.79 was considered significant.

Serum creatinine analysis on blood sample of patients was carried out in Armed Forces Institute of Pathology (AFIP) and report was available in 2 days.

Data for each patient was recorded on patient's proforma and analyzed via SPSS 17 version. Mean and standard deviation were calculated for quantitative variables while frequency and percentages were calculated for qualitative variables. The correlation between the RI and serum creatinine was determined by using Pearson's correlation. Comparison was done between patients with  $RI < 0.8$  and  $> 0.8$ . Independent sample t test was used for comparison of normally distributed continuous variables like age and serum creatinine. For comparison of non normally distributed continuous variable (duration after transplant), Mann-Whitney U test was used. A  $p$ -value  $< 0.05$  was considered as significant.

## RESULTS

In this study a total of 82 patients were included. The minimum age of the patients in the study was 22 years and maximum age was 58 years with a mean age of  $42.34 \pm 8.906$  years.

The distribution of patients with respect to age intervals shows that majority 33 (40.24%) of the patients belonged to the age group of 41-50 years followed by 24 (29.26%) patients with age group of 31-40 and 10 (12.19%) patients in the age interval of 21-30 years (fig-1).

In this sample of 82 patients 63 (76.83%)

and obstructed transplanted kidney (8, 9.8%). Seven (8.5%) patients of diminished arterial vascularity and 4 (4.9%) patients of renal vein thrombosis were noted.

The patients included in the study were classified further into two groups depending on the value of RI keeping a cut off value of 0.8. It

**Table-1: Comparison of age and serum creatinine among resistive index groups (n=82).**

Variable	Resistive index category	Mean	SD	p value
Age	<0.8	36.14	6.61	0.0001*
	>0.8	45.56	8.25	
Serum Creatinine	<0.8	91.39	9.5	0.0001*
	>0.8	276.69	94.34	

**Table-2: Comparison of duration after transplant among resistive index groups (n=82).**

Duration after transplant	Mean	SD	Mean Rank	p value
<0.8	15.21	6.89	27.96	0.0001*
>0.8	21.63	7.05	48.52	

\*test of significance =Mann Whitney U test.

were males and 19 (23.17%) were females. The descriptive analysis for resistive index shows minimum value of 0.58 and maximum value of 3.80 with mean value of  $1.49 \pm 0.933$ . The descriptive analysis for serum creatinine levels shows that minimum level was 69 and maximum level was 630 with mean value of  $213.4 \pm 116.91$ . Minimum duration after renal transplant of the patients included in the study was 4 months and maximum was 36 months with mean value of  $19.4 \pm 7.601$ . A total of 65.1% of patients with raised RI values had other co-morbid diseases like DM and HTN.

Correlation between RI and serum creatinine was found to be 0.89 ( $p=0.0001$ ) which depicts a strong and significant correlation between the two variables.

Many post-transplant complications were noted. The most common was increased parenchymal echogenicity and diminished corticomedullary demarcation (25, 30.5%), followed by perinephric collections (15, 18.3%)

was found that patients with  $RI < 0.8$  were younger with mean age of  $36.14 \pm 6.615$  years while those with  $RI > 0.8$  were older with mean age of  $45.56 \pm 8.252$  years ( $p=.0001$ ) as shown in table-1. Serum creatinine strongly correlated with RI values with mean value of  $91.39 \pm 9.5$   $\mu\text{mol/l}$  in patients with  $RI < 0.8$  and mean value of  $276.69 \pm 94.36$   $\mu\text{mol/l}$  in patients with  $RI > 0.8$  ( $p=.0001$ ). Patients with  $RI < 0.8$  had a shorter post transplant duration (mean  $15.21 \pm 6.89$  months) and those with  $RI > 0.8$  had a longer duration with mean value of  $21.63 \pm 7.05$  months ( $p=.0001$ ) as shown in table-2. So the patients with  $RI < 0.8$  were relatively younger, had serum creatinine levels within normal range and had shorter post transplant duration.

## DISCUSSION

Kidney transplantation is acknowledged as a major advancement of modern medicine which provides high-quality life years to patients with irreversible kidney failure (end-stage renal disease, ESRD) worldwide. What

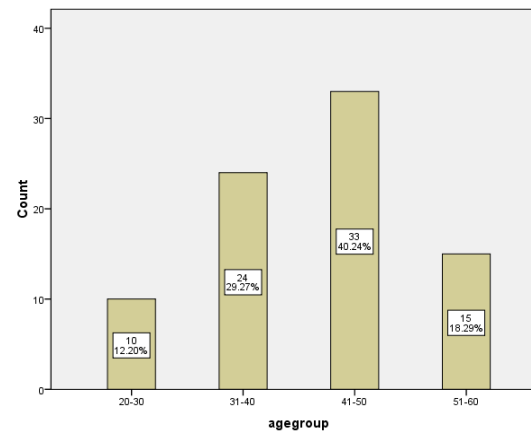
was an experimental, risky and very limited treatment option fifty years ago, is now routine clinical practice in more than 80 countries. Transplantation of the kidney, when properly applied, is thus the treatment of choice for patients with ESRD because of lower costs and better outcomes<sup>3</sup>.

Ultrasonography, both in B-mode and with doppler ultrasound, is an important diagnostic tool in case of clinical conditions which might impair kidney function<sup>8</sup>. Serum creatinine screening and sonography are commonly used to assess the function and condition of renal transplants. RI has been used as an indicator for evaluating the hemodynamics of transplanted and native kidneys<sup>9</sup>. The renal arterial resistance index (RI) is reported to be a significant predictive parameter for renal allograft failure or death<sup>10</sup>.

Vascular complications are common and serious events affecting patient and graft survivals. A perfect surgical technique and rigorous radiological monitoring may result in decreased incidence and severity of these complications<sup>11</sup>. Early vascular complications include renal artery or vein thrombosis, lesions to the iliac vessels and cortical necrosis. Delayed complications mainly include renal artery stenosis, arteriovenous fistula, and rarely false aneurysm. Doppler sonography, sometimes with the use of intravenous contrast, is the imaging modality of choice in the acute setting or routine follow-up<sup>12</sup>. Renal allograft thrombosis may be responsible for 2–7% of early allograft losses in adults and up to 35% in children. The North American Pediatric Renal Transplant Cooperative Study (NAPRTCS) reported that graft thrombosis represented the main cause of graft failure in the first year. Thrombosis may initially involve the renal artery or more frequently the renal vein, but in some cases it is difficult to ascertain where the thrombosis originated. Late allograft thrombosis has been defined as occurring later than 14 days postoperatively, but rarely renal artery thrombosis may develop a few months post-transplantation<sup>13</sup>.

The specificity of doppler ultrasound is very important in case of stenosis of the

transplanted renal artery, pseudoaneurysms, arteriovenous fistulas, and thrombosis with complete or partial artery or vein occlusion. Doppler and color determinations present high diagnostic accuracy, which is higher in case of successive measurements performed during the follow-up of the graft<sup>8</sup>.



**Figure-1: Distribution of renal transplant patients with respect to different age groups(n=82).**

RI is significantly correlated to Cr, and may serve as an indicator for predicting renal graft function after transplantation<sup>14</sup>. My study is based on the correlation of resistive index and serum creatinine levels in the assessment of the transplanted kidney function.

This study was conducted on the sample of 82 patients which showed that maximum frequency of patients had age in the interval 41-50 years followed by interval of 31-40 years and mean age of 42.34 years, which is slightly less than international studies (mean age of 47 years). It can be explained by the fact that most of the influx of the patients in MH constitutes serving soldiers<sup>15</sup>.

In this sample of 82 patients, 64 (78.04%) were males and 18 (21.95%) were females. This is very much in accordance with international studies, which favour slight male predilection for the renal transplant recipients<sup>16</sup>.

A renal arterial RI of 0.8 or higher predicts a poor outcome of treatment and also predicts worsening renal function or death in patients with renal diseases<sup>17</sup>. Values of RI strongly

correlated with serum creatinine levels showing a correlation  $r=0.89$ . This was in accordance with the study conducted by Huang et al which showed that the RI and creatinine levels in patients with  $RI \geq 0.75$  demonstrated a significant positive correlation ( $p < 0.05$ )<sup>14</sup>.

In this study, it was found that patients with  $RI < 0.8$  were younger with mean age of 36.14 and had a shorter post transplant duration (mean 15.21wks). While those with  $RI > 0.8$  were older with mean age of 45.56, had a longer post transplant duration (mean 21.63 weeks) and had raised serum creatinine levels with mean value of  $276.69 \pm 94.36 \mu\text{mol/l}$ . So patients with at values of 0.8 or higher were significantly older, had had their transplants for a longer time and had raised serum creatinine levels<sup>17,18</sup>.

A study by Radermacher et al showed that a resistance index of 0.8 or higher in an allograft was a strong predictor of both allograft failure and death with a functioning graft<sup>17</sup>. The aim of our study was to stress the importance of duplex doppler ultrasound in assessment of transplanted kidney function, so that invasive diagnostic techniques like renal biopsy can be avoided. Doppler ultrasonography is widely available and this simple doppler index can be easily measured by ultrasonographic machines equipped with automatic tracing and calculation, and can be measured simultaneously during routine ultrasonographic screening. Very few local studies are done to emphasize the importance of role of RI in transplanted kidney patients. Our study suggests a quick and non-invasive protocol to assess the function of transplanted kidney. It is a non invasive, radiation free and cost effective technique. There is minimum burden on the patient in terms of cost effectiveness and minimum hospital stay. Further studies will substantiate its role in the renal transplant recipients by avoiding a long list of cumbersome investigations.

## CONCLUSION

The results showed that resistive index values in transplanted kidney correlated strongly with serum creatinine levels. Thus a specific measurement RI in transplanted kidney was highly accurate in identifying the function, survival and complications of renal allograft.

## CONFLICT OF INTEREST

This study has no conflict of interest to declare by any author.

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