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Original Research Article

Study of Renal Doppler Ultrasonography in Cases of Chronic Kidney Disease at IGIMS, Patna with the Influence of Demographic Data

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Abstract:

Introduction: CKD (Chronic kidney disease) universally is considered as a major disease affecting public health and critically raises the burden on health care system. Timely diagnosis and management of CKD is very vital to holdup the advancement of disease. Doppler renal ultrasonography (US) possibly plays a significant role in defining CKD and its advancement to end stage renal disease (ESRD).

Material and Methods: This study was a hospital based cross-sectional observational study performed on 50 CKD patients hospitalized or attending IGIMS, Patna. After 8-12 hours fasting, blood, Doppler US reports and demographic profile were collected. The collected data from all the participants was analysed using "SPSS Statistics Base 22 software" and p value <0.05 was considered statistically significant.

Results: Our research observed significant difference in mean of pulsatility index (PI) and renal resistive index (RRI) from left interlobular arteries and both sides of main renal artery. PI from right interlobular arteries was also significantly different from control group although difference in mean RRI was statistically non-significant. The significant positive correlation of RRI with age and negative correlation with eGFR (glomerular filtration rate) was observed.

Conclusion: Our study concludes that a suspected or diagnosed CKD patient must be examined by Doppler US to confirm or assess the renal prognosis. The better clinical application and understanding of Doppler US data can be made by simultaneously assessing the comprehensive variables which can influence the data.

Keywords: CKD, Doppler US, eGFR, RRI, PI etc.

Introduction

CKD is a disease affecting kidneys resulting in slow and continuing loss of their function over a time period of months to years. [1,2] CKD universally is considered as a major disease affecting public health and critically raises the burden on health care system.[3] CKD contributed to 409,000 deaths in 1990 [4,5] and the number has been increased to 1.2 million in 2015. According to a survey 753 million people were suffering from CKD in 2015.[6,7]

In CKD, the definite structural or functional renal abnormalities are evident by markers of renal damage like reduced creatinine clearance, appearance of protein in urine and reduction in GFR. These markers not very sensitive for diagnosis of CKD as they can be affected by number of reasons like age, sex, diet etc. and can result in longer time intervals prior to accurate intervention. So for timely diagnosis of CKD, the imaging studies patients can rely on but the use of contrast dyes raises burden on their kidneys leading to chances of upraised morbidity and mortality and the MRI (magnetic resonance imaging) cannot be used as routine test due to its high cost. Renal US is typically the gateway amid renal imaging studies due to its safety, extensive availability and less charge and this test can spot CKD by assessing cortical brightness and longitudinal length of the kidneys. Inflammatory conditions are related to hyperechoic characteristic of renal parenchyma and the maximum cases having small & echogenic kidneys propose chronic kidney disease rather than acute kidney injury (AKI). Timely diagnosis and management of CKD is very vital to holdup the advancement of disease. Hence, it is crucial to get better early detection rate and correctness of US examination as a regular technique for renal disorders.[8]

Doppler renal US possibly plays a significant job in defining CKD and its advancement to ESRD. It is

vital for assessing kidneys and is more precise than conventional US as it gives functional and vascular data by noticing the renal and extra-renal patterns of vascularization. [9]

Doppler US has to be done appropriately to get helpful information regarding presence and course of blood stream in renal vessels in the form of doppler indices like "peak systolic velocity (PSV)" and "end-diastolic velocity (EDV)" grounded on the pattern of waves followed by blood flow in arteries of each region. Further PI and RRI are calculated. The vascular resistance level i.e. RRI can be calculated from PSV and EDV.[10,11] Till now, RRI has been considered as the most sensitive and dependable indicator of intrarenal hemodynamic disturbance.[12-14] Moreover, RRI also reflects progression of disease, as patients in late stage of CKD depicted significantly higher RRI when compared to patients in earlier CKD stage. Though, not many studies at the same time have calculated PSV, EDV, RRI and PI and then compared RRI and PI along with their clinical significance in CKD patients. [15] So we aimed to study renal Doppler US in CKD patients at IGIMS, Patna. Recently in the year 2017, Global Kidney Disease Health Survey documented that different areas of the globe illustrate noteworthy differences in the attention to and care of renal disorders, proving the variation in diagnostic and management levels of kidney disorders in different areas. Hence, the before time detection of kidney disorders and execution of secondary prevention are crucial to lessen the advancement of kidney disorders and failure. [16,17] So to appropriately interpret the renal doppler US results, we planned to study inclusive analysis along with the covariates like demographic variables including age and sex that can influence the accuracy of the observed ultrasonic data.

Material and Method

This study was a hospital based cross-sectional observational study done on fifty CKD patients hospitalized or attending IGIMS (Indira Gandhi Institute of Medical Sciences), Patna between the period of January 2023 to June 2023. The study was approved by ethical committee of the institute and informed consent was obtained from the participants. The CKD patients of age above 18 years who were willing to participate, were enrolled in study group after clinical examination of the patients considering the guidelines given by "National Kidney Foundation of the United States under the Kidney Disease Prognosis Quality Initiative (K/DPQI)". The participants having any other kidney disorder or lesion and the patients whose spectrum perhaps was not correctly detected were excluded from the study. Further the patients having >3m/sin a difference among the highest and lowest RRI values after multiple observations were also expelled from the study. In addition, 50 gender & age matched volunteers who were detected to be free from any kidney disorders after clinical and other examination were made part of the study as control group.

The Participants were asked to be on 8-12hours fasting then blood, demographic profile and renal Doppler US data were collected. The serum of the patient was analyzed to estimate creatinine level and CKD stage was observed using eGFR, which was calculated using "MDRD equation: $175 \times \text{s-Cr}^{-1.154} \times \text{Age}^{-0.203}$ ($\times 0.742$ for women)". [18] Demographic data like sex and age was observed. The renal doppler US data were broadly recorded by using $\leq$ 60 degree doppler angle and the participant were asked to hold breath. Renal doppler US data was depicted as indices PSV, EDV, PI and RRI measured in interlobar region, segmental region, hilum and trunk of the renal artery. [19] This ultrasonic examination was performed on both kidneys $\geq$ three times in every position and mean of values were taken for analysis. PI value was assessed by formula i.e. PSV-EDV/Mean renal arterial flow velocity. [18] The RRI was derived from the EDV & PSV values by considering the formula i.e. PSV-EDV/PSV. (12) The internationally accepted criterion was considered to detect the occurrence of renal arterial stenosis (RAS) i.e value of PSV greater than 180 cm/sec, RAR (renal artery aortic ratio) greater than 3.5:1(20,21) and RRI value >0.7. The collected data from all the participants was analyzed using "SPSS Statistics Base 22 software" and p value <0.05 considered to be statistically significant.

Result

The current research was comprised of 50 CKD patients and 50 healthy volunteers after considering exclusion and inclusion criteria. As seen in Table 1, the mean age of study and control group in our study was 61.2 ± 12.2 and 51.6 ± 14.4 years respectively and the difference between these two means was statistically significant. In terms of gender, statistically non-significant difference was observed among both the groups and the gender distribution was similar as both groups had more males than females. As visible from figure 1, the study group had 29(58%) males and 21(42%) females whereas the control group had 28(56%) males and 22(44%) females. It is clearly shown from Table 1 that the serum creatinine levels were more in study group i.e. 1.24 ±1.12 mg/dl than control group having 0.4 ± 0.11mg/dl level whereas the calculated eGFR levels were higher in control group i.e. 107 ± 11.66 ml/min/1.73m2 as compared to study group i.e. 63.4 ± 27.7 ml/min/1.73m2. Further on the basis of eGFR, the stages of CKD were categorized in CKD patients from stage 1 to stage 5 having 9, 20, 16, 3 and 2 patients consecutively.

Table 1: Demographic and biochemical profile of the participants

Parameters		Study group	Control group	p-value	Significance level
Sex	Males	29 (58%)	28 (56%)	0.8395	NS
	Females	21 (42%)	22 (44%)		
Age (years)		61.2 ± 12.2	51.6 ± 14.4	0.0005	S
S. Creatinine(mg/dl)		1.24 ±1.12	0.4 ± 0.11	<0.0001	S
eGFR (ml/min/1.73m^2)		63.4 ± 27.7	107 ± 11.66	<0.0001	S
CKD stage 1/2/3/4/5	9/20/16/3/2	0			

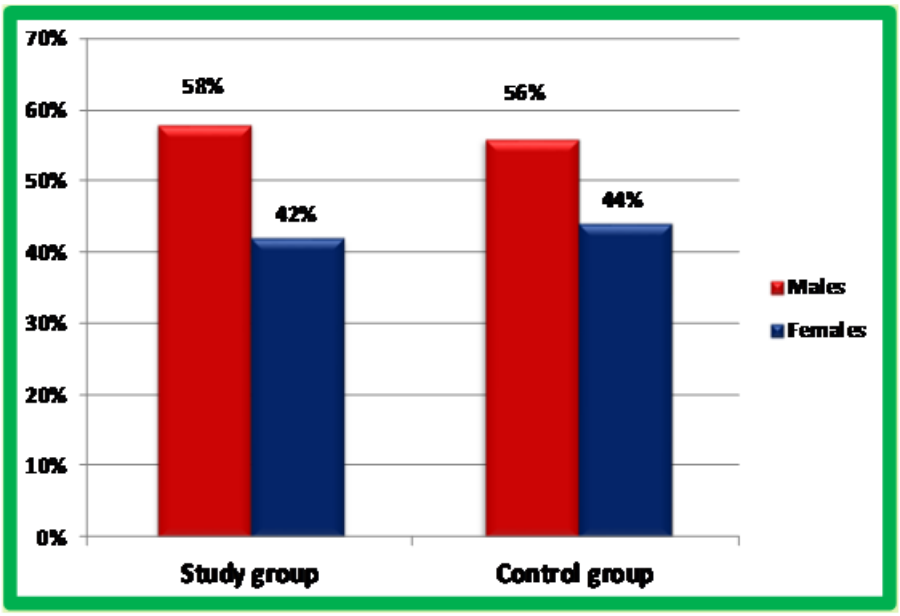

Figure 1: Gender distribution of the participants

Table 2 shows the RRI and PI values from left & right main renal artery and interlobular arteries. RRI value from right and left main renal artery in study group was 0.73 ± 0.08 and 0.74 ± 0.078 whereas in control it was found to be 0.63 ± 0.04 and 0.64 ± 0.05 respectively. Difference in RRI from right and left main renal artery among both the groups was calculated to be significant.

As far as PI value from right and left main renal artery is considered it was observed to be 1.47 ± 0.37 and 1.62 ± 0.43 in study group while in control it was assessed to be 1.05 ± 0.24 and 0.98 ± 0.15. Difference in PI from right & left main renal artery was also statistically significant among both the groups. As seen from table 2, in study group the RRI from right & left interlobular arteries was seen to be 0.68 ± 0.074 and 0.70 ± 0.07, at the same time in control group it was 0.66 ± 0.036 and 0.63 ± 0.04 respectively.

The difference of RRI value from right interlobular arteries among both the groups was non-significant although it was significant when taken from left interlobular arteries. Similarly the PI values from right and left interlobular arteries was also calculated & found to be 1.27 ± 0.32 and 1.29 ± 0.26 in study group though it was 1.01 ± 0.17 and 1.05 ± 0.11 in control group. As observed in the case of main renal artery, PI from right and left interlobular arteries were also calculated to be significant among both the groups.

Table 2: Comparison of RRI and PI values of the participants

Parameters		Study group	Control group	p-value	Significance level
Right main renal artery	RRI	0.73 ± 0.08	0.63 ± 0.04	<0.0001	S
	PI	1.47 ± 0.37	1.05 ± 0.24	<0.0001	S
Left main renal artery	RRI	0.74 ± 0.078	0.64 ± 0.05	<0.0001	S
	PI	1.62 ± 0.43	0.98 ± 0.15	<0.0001	S
Right interlobular arteries	RRI	0.68 ± 0.074	0.66 ± 0.036	0.0889	NS
	PI	1.27 ± 0.32	1.01 ± 0.17	<0.0001	S
Left interlobular arteries	RRI	0.70 ± 0.07	0.63 ± 0.04	<0.0001	S
	PI	1.29 ± 0.26	1.05 ± 0.11	<0.0001	S

Table 3 clearly depicts that RRI value in all 4 regions (trunk, hilum, segmental and interlobar) had significant correlations with age and eGFR. RRI value from all 4 regions depicted statistically significant and positive correlation with age having pearson's correlation coefficient (r value) as 0.462, 0.480, 0.589 and 0.596 respectively for all the four regions. As far as correlation of RRI value from these regions with eGFR is concerned, it was also observed to be significant, and the negative correlation with eGFR having values to be -0.406, -0.300, -0.371 and -0.328 consecutively in the above regions. Observation of statistically significant differences seen among the stages of chronic kidney disease of study group in terms of every considered parameter was another prominent outcome.

Table 3: Correlation of RRI with age and eGFR in CKD patients

RRI	Trunk		Hilum		Segmental		Interlobar	
	r value	p value	r value	p value	r value	p value	r value	p value
Age	0.462	<0.0001	0.480	<0.0001	0.589	<0.0001	0.596	<0.0001
eGFR	-0.406	<0.0001	-0.300	0.00027	-0.371	<0.0001	-0.328	<0.0001

Discussion

This research was a hospital based cross-sectional and observational study done on CKD patients visited or hospitalized at IGIMS, Patna. CKD generally progress toward ESRD or CVD (cardiovascular diseases) so for prevention from these diseases early detection and suitable management is essential. At present, renal arterial doppler US is done mostly to detect renal arterial diseases [19,22] and for better interpretation of data and to increase the clinical efficacy of renal doppler ultrasonography data, complete analyses with extensive range of clinical variables are needed. So in our research we have assessed the renal doppler US data along with other demographic variables and blood test result and a strong correlation was observed. Mean age of study and control group in our study was 61.2 ± 12.2 & 51.6 ± 14.4 years and the difference was statistically significant which is nearly similar to the mean age found in research by B.Gulek et al. [23] although they did not observe statistically significant difference. The mean s.creatinine and the calculated eGFR in current study was 1.24 ±1.12mg/dl and 63.4 ± 27.7ml/min/1.73m2 which is in harmony with findings by Abe M et al. [24]

The distribution of CKD patients according to CKD stages and gender in our study is nearly similar to the distribution observed by Abe M et al. [24] and B.Gulek et al.[23] respectively. Doppler US plays an important role in diagnosis of chronic kidney disease and its advancement to end stage renal disease. In current study PSV and EDV values were assessed by doppler US and further RRI and PI values were calculated. Evaluation of RRI can give useful medical information in a range of kidney disorders.[9] RRI is reported to be linked with inflammatory lesions more than any other morphologic parameters.[25] Research by Platt et al.[26], documented renal biopsy results to be correlated with RI results . In general, normal values of RRI is <0.65 and high normal RRI value is 0.65 ≤ RRI < 0.7. [27] Patients having high-normal RRI show satisfactory response to steroid treatment than patients with RRI > 0.7.[25]

The present study observed significant difference in mean of PI and RRI of CKD patients from left interlobular arteries and both sides of main renal artery when compared with control group. As far as right interlobular arteries are concerned mean PI values were also significantly different from control group although difference in mean RRI was statistically non-significant. This finding is strongly supported by B. gulek et al. [23] our study observed correlation of age and eGFR with RRI value from 4 regions (trunk, hilum, segmental and interlobar) and found age to have significantly positive correlation with RRI. This outcome is in harmony with a study by Ikee R et al. [28], Toshihiro Sugiura et al. [29] and Abe M et al. [24] as they also documented RRI to increase with age. As far as eGFR is concerned, it showed significantly negative correlation with RRI which is in agreement with findings by Abe M et al.(24) Recent studies [30] have revealed RRI to be indicator of advancement of kidney disease instead being used as a marker of specific kidney disorder. The present study also found that RRI value can predict the progression of CKD as higher RRI values were related to decreased eGFR and advanced stages of CKD.

This outcome of our research is in strongly supported by Toshihiro Sugiura et al. [29] and Splendiani G et al. [31] as they reported correlation between RRI and renal disease outcome. Further our findings are also in harmony with Meola M et al. [32] and Yanli Huang et al. [33] as they documented that moderate and severe injury to microcirculation brings statistically significant difference in RRI values and minor injury shows no significant difference.

Conclusion

The present study was done to study renal doppler US data in CKD patients with influence of demographic data. The current study observed RRI

to be related to CKD stage and further documented RRI to be affected by age and eGFR. RRI is yet thought to be the best ultrasonic index to assess functioning of kidney. So our study concludes that a suspected or diagnosed CKD patient must be examined by Doppler US to confirm or assess the renal prognosis. The Doppler arterial waveform is the result of the interrelation of a number of factors, so for better clinical application and understanding of doppler US data, these factors which can influence the data should also be assessed and taken care of.

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