Correlation of Renal Ultrasonographic Parameters with Serum Creatinine in Staging of Chronic Kidney Disease - Our Experience

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Abstract: _Objective: Present study was designed to conduct with main objective to assess the correlation of renal ultrasonographic parameters with serum creatinine. Identifying the significance of renal echogenicity in grading the chronic kidney disease (CKD) ultrasonographically._ _Methodology: This is an institution based cross-sectional study of sixty patients diagnosed with CKD. Ultrasound of the kidneys and liver were performed. Serum creatinine were assayed. The data were then evaluated using appropriate statistical tools._ _Results: The results of present study revealed statistically significant positive correlation between serum creatinine and renal parenchymal echogenicity and its grading with serum creatinine (<0.001). In addition to this statistically significant positive correlation between renal echogenicity and mean longitudinal size, renal echogenicity, parenchymal thickness and cortical thickness were also observed. However, a negative correlation was observed between serum creatinine and mean longitudinal size, mean parenchymal thickness, mean cortical thickness._ _Conclusion: In conclusion, results of our study identified the renal echogenicity and its grading show a better correlation with serum creatine when compared to other ultrasonographic renal parameters (longitudinal size, parenchymal thickness and cortical thickness). Besides use of ultrasonography for early detection of renal function and morphologic abnormalityis found cost effective, non-invasive, easy and reproducible._

Keywords: CKD, USG, Echogenicity, Creatinine

1. Introduction

Chronic kidney disease (CKD) is defined by the Kidney Disease Improving Global Outcome (KDIGO) as
1) Kidney damage >3 months, as defined by structural or functional abnormalities of the kidney with or without decreasing GFR, manifest by either pathological abnormalities or markers of kidney damage including abnormalities in the composition of blood or urine or abnormalities in the imaging tests.
2) GFR <60 ml/min/1.73m^2 for > 3 months with or without kidney damage.

CKD is recognized as a risk factor for cardiovascular disease and is a major public health problem globally [1-3]. In western countries, diabetes and hypertension accounted for over 2/3rd of the cases of CKD [4]. In India too, diabetes and hypertension today accounted for 40–60% cases of CKD [5]. As per recent Indian Council of Medical Research data, prevalence of diabetes in Indian adult population has risen to 7.1%, (varying from 5.8% in Jharkhand to 13.5% in Chandigarh) and in urban population (over the age of 40 years) the prevalence is as high as 28% [6].Likewise, the reported prevalence of hypertension in the adult population today is 17% (14.8% from rural and 21.4% from urban belt). A similar prevalence of 17.4% has been reported by Panesar et al. (in the age group of 20–59 years) even from slum-resettlement colony of Delhi [7,8].KDIGO in 2013 revised CKD staging by including both 5 stages of GFR and 3 categories of albuminuria so as to define CKD severity (Table 1).

Table 1: Staging of CKD based on GFR [2,9]

CKD Stage	Definition
1	Kidney damage with GFR ≥ 90 mL/min/1.73 m^2
2	Kidney damage with GFR of 60-89 mL/min/1.73 m^2
3	GFR of 30-59 mL/min/1.73 m^2
4	GFR of 15-29 mL/min/1.73 m^2
5	GFR of < 15 mL/min/1.73 m^2, or kidney failure treated by

CKD can be diagnosed by its pathological abnormalities, changes in the levels of kidney function markers in the blood or urine, or by imaging investigations [10]. Ultrasonography is an ideal imaging modality in CKD because of its non-invasiveness and easy accessibility, besides it also provides a detailed renal morphology as well as insight in its function. In most cases, ultrasonography is the first and in the only imaging investigation required in the work-up of chronic renal failure. Observation of a small kidney with a thin, echogenic cortex or parenchyma indicates irreversible damage [11,12] The best screening modality to evaluate renal insufficiency in patients is sonography [13]. Ultrasonographic (USG) findings like renalechogenicity, longitudinal length, cortical and parenchymal thickness represent irreversible changes. Ultrasonography is a better imaging modality when it comes to ascertaining the progression of the disease [11,12]. The grade of kidney disease is determined by renal echogenicity with Grade 1 mild form, Grade 2 moderate form, Grade 3 severe form and Grade 4 as end-stage renal disease [14].

The serum creatinine level is an endogenous serum marker that is commonly used to estimate GFR, and accordingly,

the stage of CKD [15]. In context, present study was designed to assess the association of ultrasonographic parameters with serum creatinine in diagnosis of CKD among study population.

2. Materials and Methods

Institute ethical committee approval was sought obtained before the beginning of the study. This is an institution based cross-sectional study conducted for duration of one years from January 2018 to December 2019.

Data were collected from study subjects referred to Department of Radiodiagnosis, S. S. Institute of Medical Sciences & Research Centre (SSIMS & RC) Davangere, Karnataka, India.

Sampling procedure
All eligible adult patients referred from all departments of the hospital for routine diagnostic sonographic scanning and are willing to be in compliances with the inclusion criteria were included to the study.

Inclusion criteria are as follows; he/she
1) Diagnosed CKD patients according to the guidelines of the National Kidney Foundation were selected [10]
2) Those patients who gave consent to participate in the study,
3) Willing to fast for at least six hours,

The exclusion criteria are he/she
1) Patients unwilling to give consent.
2) Should not be a pregnant woman.
3) Should not be on haemodialysis, peritoneal dialysis.
4) No recent surgery for any reasons or renal transplantation,

After the inclusion and exclusion criteria sixty patients above 20 years of age were selected.

Detailed information from patients regarding age, sex, duration of diabetes mellitus, hypertension (if a known case for the same), other causes of chronic renal failure, and treatment history were collected.

Blood sample was collected for from all the 60 study subjects who fulfilled the eligibility criterion and serum was separated for serum creatinine assay. Serum creatinine assay was carried using standardized kit-based assay.

USG Equipment and Procedure:
An ultrasound machine GE LOGIQS7 Expert with convex probe with a frequency of 2.5-4 MHz, sonography was used. Quality control maintenance check was routinely performed on the equipment by the medical physicist of the department prior to measurements. ultrasound of the kidneys and liver were performed by two radiologists with experience of 5 and 6 years respectively. Speckle reduction imaging and low tissue harmonic imaging were applied to visualize the liver and kidney echogenicity. The radiologists were unaware of patients' serum creatinine profile, and all patients were reviewed by both radiologists.

Low tissue harmonic imaging was applied to visualize the kidney echogenicity. Renal longitudinal size (both Right and Left), cortical echogenicity, corticomedullary differentiation and associated renal cortical cysts were evaluated. Renal cortical echogenicity was compared and graded with the echogenicity of the liver [Fig 1, 2, 3 and 4] where:

Grade 0	Normal echogenicity less than that of the liver, with maintained corticomedullary definition
Grade 1	Echogenicity the same as that of the liver, with maintained corticomedullary definition
Grade 2	Echogenicity greater than that of the liver, with maintained corticomedullary definition
Grade 3	Echogenicity greater than that of the liver, with poorly maintained corticomedullary definition
Grade 4	Echogenicity greater than that of the liver with a loss of corticomedullary definition

Fig 1 Ultrasonography of right kidney, parenchymal ecogenicity same as that of the liver with maintained corticomedullary definition-Grade 1

Fig 2 Ultrasonography of right kidney, ecogenicity greater than that of the liver with maintained corticomedullary definition-Grade 2
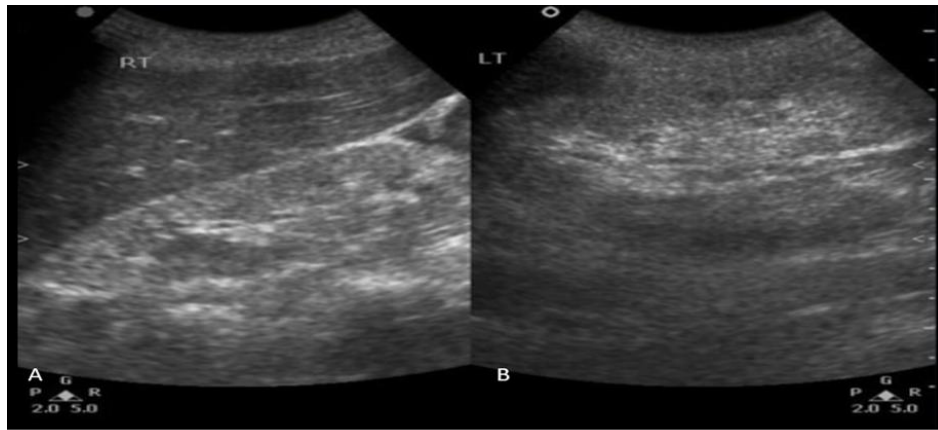
Fig 3 Ultrasonography of bilateral kidneys, [A] ecogenicity greater than that of the liver with poorly maintained corticomedullary definition-Grade 3. [B] ecogenicity greater than that of the liver with loss of corticomedullary definition-Grade 4
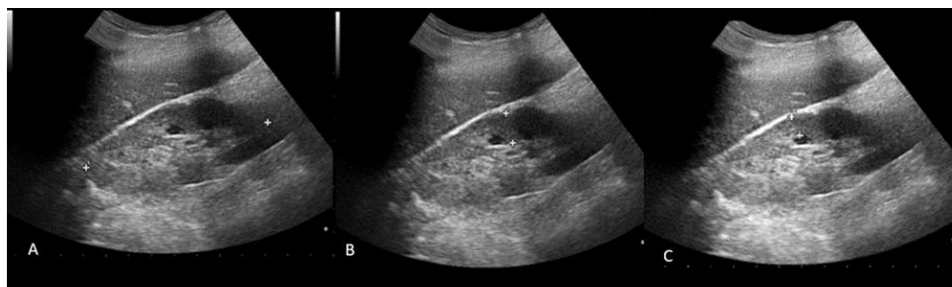

Fig 4 Ultrasonography of right kidney, [A] Normal longitudinal length, [B] Normal parenchymal thickness, and [C] Normal cortical thickness

Data Analysis
Data were edited manually, entered in MS-Excel (Office 365 Version). Descriptive statistics (mean, standard deviation) and one-way ANOVA was done using SPSS version 22. The p-value <0.05 was considered as statistically significant.

3. Results

Table 2: Age and gender wise distribution of sample

S. No.	Characteristics	No. of Cases	Percentage
1.	Age (in years)		
	20-30	2	3.33
	31-40	3	5.00
	41-50	9	15.00
	51-60	30	50.00
	Above 60	16	26.67
2.	Gender		
	Male	26	43.30
	Female	34	56.70

Out of total 60 patients who underwent USG, 30 patients (50.00%)were found to be in age group 51-60 years followed by 16 patients (26.6%) were above 60 years and 9patients (15.0%) were found to be in age group of 41-50 years. (Table 1) Among 60 patients the male and female percentage was found to be 43.30% (26 patients) and 56.70% (34 patients) respectively. [Table 2]

Table 3: Comparison of serum creatinine with renal cortical echogenicity

Renal Cortical Echogenicity (Based on USG features)	No. of Patients	Frequency (%)	Serum Creatinine (mg/dL)		
			Mean ± S.D	F-value	p-value
Grade 1	31	51.67	2.70 ± 1.50	4.565	<0.001
Grade 2	19	31.67	3.50 ± 2.15		
Grade 3	8	13.33	3.76 ± 1.83		
Grade 4	2	3.33	8.10 ± 2.30		

The renal cortical echogenicity grading based on ultrasound revealed that 31 patients had Grade 1 CKD (51.67%), followed by 19 patients had Grade2(31.67%), 8 patients had Grade 3 (13.33%) and only 2 patients had Grade 4 (3.33%). The mean serum creatinine was 2.70±1.50, 3.50±2.15, 3.76±1.83, and 8.10±2.30 for Grade 1, 2, 3, and 4 respectively. The ANOVA analysis depicted that mean serum creatinine was significant (<0.001) among renal cortical echogenicity grades. [Table 3]

Table 4: Comparison of renal echogenicity with mean longitudinal size

Renal Cortical Echogenicity (Based on USG features)	No. of Patients	Mean Longitudinal Size (cm)		
		Mean ± S.D	F-value	p-value
Grade 1	31	11.19 ± 1.23	24.585	<0.001
Grade 2	19	9.50 ± 0.71		
Grade 3	8	7.96 ± 0.73		
Grade 4	2	7.01 ± 0.61		

The mean longitudinal size for Grade 1, Grade 2, Grade 3, and Grade 4 was 11.19 ± 1.23,9.50 ± 0.71, 7.96 ± 0.73, and

7.01 ± 0.61 respectively. The mean longitudinal size was found to be statistically significant indicator (<0.001) in renal cortical echogenicity grades. [Table 4]

Table 5: Comparison of mean parenchymal thickness with renal cortical echogenicity

Renal Cortical Echogenicity (Based on USG features)	No. of Patients	Mean Parenchymal Thickness (cm)		
		Mean ± S.D	F-value	p-value
Grade 1	31	5.18 ± 0.88		
Grade 2	19	4.50 ± 0.61	4.782	<0.001
Grade 3	8	4.01 ± 0.63		
Grade 4	2	3.58 ± 0.51		

The results of mean parenchymal thickness (Cm) was presented in Table 5. The mean parenchymal thickness was 5.18 ± 0.88, 4.50 ± 0.61, 4.01 ± 0.63, and 3.58 ± 0.51 for Grade 1, Grade 2, Grade 3, and Grade 4 respectively. The mean longitudinal size was found to be statistically significant (<0.001) with renal cortical echogenicity grades.

Table 6: Comparison of mean cortical thickness with renal cortical echogenicity

Renal Cortical Echogenicity (Based on USG features)	No. of Patients	Mean Cortical Thickness (cm)		
		Mean ± S.D	F-value	p-value
Grade 1	31	1.21 ± 0.05		
Grade 2	19	0.88 ± 0.15	184.512	<0.001
Grade 3	8	0.49 ± 0.11		
Grade 4	2	-		

The mean cortical thickness for Grade 1, Grade 2, and Grade 3 was 1.21 ± 0.05, 0.88 ± 0.15, and 0.49 ± 0.11 respectively. The mean cortical thickness for Grade 4 was not measured due to loss of corticomedullary distinction. The mean cortical thickness was found to be statistically significant (<0.001) with renal cortical echogenicity grades. [Table 6]

Table 7: Statistical correlations between serum creatinine and mean longitudinal length, mean parenchymal thickness and mean cortical thickness

Renal Parameters	Serum Creatinine (mg/dL)		
	Pearson's Correlation Coefficient	p-value	N
Mean longitudinal length (cm)	-0.296	0.34	60
Mean parenchymal thickness (cm)	-0.257	0.56	60
Mean cortical thickness (mm)	-0.054	0.78	58

Analysis of statistical correlations by Pearson's correlation coefficient test depicted that serum creatinine did not show any positive correlation with mean longitudinal length (r= -0.296; p=0.34), mean parenchymal thickness (r= -0.257; p=0.56), and mean cortical thickness (r= -0.054; p=0.78). [Table 7]

4. Discussion

In CKD there is increased blood urea and serum creatinine due to decreased glomerular filtration rate. CKD is defined as progressive kidney damage >3 months defined by structural or functional abnormalities of the kidney, manifest by either pathological abnormalities or markers of kidney damage including abnormalities in the composition of blood or urine or abnormalities in the imaging tests. As the renal damage progresses, the functional impairment manifest as a worsening in the renal function test and imaging parameters [10]. Hence present study was designed to assess the association of ultrasonographic parameters with serum creatinine in grading of CKD patients.

In our study, a significant positive correlation was indicated between serum creatinine and renal cortical echogenicity and its grading. There was also a positive correlation between mean longitudinal size and cortical echogenicity; positive correlation between mean parenchymal thickness and renal echogenicity and positive correlation between mean cortical thickness and renal echogenicity. However, a negative correlation was indicated between mean longitudinal size and cortical echogenicity; negative correlation was indicated between mean parenchymal thickness and renal echogenicity and negative correlation was indicated between mean cortical thickness and renal echogenicity.

Renal morphology can be represented by length of the kidney, volume and renal cortical thickness. Renal function and progression can be accessed through renal cortical echogenicity, cortical thickness and length [16].Chronic kidney disease can alter the Ultrasonographic findings like longitudinal length, parenchymal and cortical thickness [17].

In glomerulosclerosis and interstitial fibrosis due to presence of collagen increases the cortical echogenicity [18].It was also found that there is a significant correlation between cortical echogenicity with glomerular sclerosis [19].

In Our study statistically significant positive correlation between serum creatinine and renal cortical echogenicity and its grading (<0.001) from Grade 1 to Grade 4 CKD was identified. These findings were in accordance with previous studies reported in literature by Moghazi et al., wherein the renal echogenicity has the strongest correlation with histologic parameters (glomerular sclerosis, tubular atrophy, interstitial fibrosis, and interstitial inflammation) [20]. In another research study conducted by Päivänsalo et al., revealed that a highly echogenic cortex was the most common abnormality; this was slightly more frequent in tubule interstitial disease (75%) than in glomerular disease (61%) [21].

Furthermore, there was statistically significant positive (p<0.001) correlation was indicated between renal echogenicity grading and mean longitudinal size in our study. As per American College of Radiology practice guidelines, renal length has traditionally been considered a surrogate marker of renal function because renal length decreases with decreasing renal function [22]. We identified a statistically significant (p<0.001) positive correlation between renal echogenicity grading and mean thickness of parenchyma and cortex. The echogenicity was indirectly proportional to thickness of renal parenchyma and cortex. Study done by Beland et al., showed that cortical thickness measured on ultrasound appears to be more closely related to GFR than renal length [23].However, a negative correlation was indicated between mean longitudinal size and cortical echogenicity; negative correlation was indicated between mean parenchymal thickness and renal echogenicity

and negative correlation was indicated between mean cortical thickness and renal echogenicity. Similar negative correlation was reported in a study conducted by Siddappa et al., [24]. This negative correlation indicates, that the renal cortical echogenicity has a better correlation with serum creatinine in the grading of CKD ultrasonographically.

In summary, Renal cortical echogenicity and its grading correlated better with serum creatinine in diagnosis of CKD. Although, serum creatinine is an indicator of kidney function, renal cortical echogenicity is a better parameter to estimate renal function with the added advantage of irreversibility. Serum creatinine improves with hemodialysis, peritoneal dialysis, and renal transplantation in chronic kidney disease [25].

5. Conclusions

In conclusion, the results of the present study reveal that renal cortical echogenicity and its grading correlated better with serum creatinine in grading of CKD ultrasonographically when compared to longitudinal size, parenchymal thickness and cortical thickness. Furthermore, use of ultrasonography for early detection of renal function and morphologic abnormality was found cost effective, non-invasive, easy and reproducible.

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