Original Research Article

Sonographic grading of renal cortical echogenicity and raised serum creatinine in patients with chronic kidney disease

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Abstract

Introduction: Chronic Kidney Disease (CKD) is a worldwide public health problem, both for the number of patients and cost of treatment involved. Globally, CKD is the 12th cause of death and the 17thcause of disability, respectively. This is an underestimate as patients with CKD are more likely to die of cardiovascular disease than to reach End-Stage Renal Disease (ESRD).**Materials and Methods:** Two Hundred patients, clinically diagnosed with chronic kidney disease (GFR <60/mL/min calculated by using Cockcroft-Gault equation, for three months or more) above the age of 18 years, referred to the Department of Medicine, Radiodiagnosis, Prathima Institute of Medical Sciences, Karimnagar from January 2020 to December 2020. **Results:** The grade of renal disease was determined by cortical echogenicity with Grade 1 mild form, Grade 2 moderate and Grade 3 severe form and Grade 4 as end-stage renal disease. The mean serum creatinine was 2.87 mg/dL for Grade 1, 3.27 mg/dL for Grade 2, 4.3 mg/dL for Grade 3 and 5.8 mg/dL for Grade 4. No correlation was observed between renal length, parenchymal thickness and cortical thickness with serum creatinine levels. The grading of renal echogenicity on sonography correlated well with serum creatinine in CKD than any other sonographic parameters with a statistically significant positive correlation (P<0.001).**Conclusion:** The renal cortical echogenicity has its advantages of being irreversible compared to serum creatinine levels, which improve with renal replacement therapies like haemodialysis and peritoneal dialysis. Also, quantification of echogenicity of the renal cortex relative to that of the liver has been shown to be reproducible with only little variability between different scanners and probes in previous studies.

Key Words: Chronic Kidney Disease, haemodialysis, peritoneal dialysis.

Introduction

Chronic Kidney Disease(CKD) is a worldwide public health problem,both for the number of patients and cost of treatment involved. Globally, CKD is the 12th cause of death and the 17th cause of disability, respectively. This is an underestimate as patients with CKD are more likely to die of cardiovascular disease than to reach End-Stage Renal Disease (ESRD)[1]. the approximate prevalence of CKD in India is 800 per million population (pmp) and the incidence of ESRD is 150-200 per million population. The commonest cause of CKD is diabetic nephropathy[2].CKD is defined 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/1.73 m^2 for >3 months with or without kidney damage[3].

Renal ultrasound is simple, inexpensive and can be done at the bedside to provide the clinician with important anatomical details of the kidneys with a low inter-observer variability[4].The safety of the diagnostic procedure using ultrasound is well established[5].The measurement of serum creatinine has been the traditional approach to assessing CKD. eGFR derived from formulas such as the Modification of Diet in Renal Disease (MDRD) equation is superior to serum creatinine alone in the diagnosis of CKD. However, busy clinicians are unlikely to routinely calculate eGFR from serum creatinine for all of their older patients[6,7].

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Materials and methods

Two Hundred patients, clinically diagnosed with chronic kidney disease (GFR <60/mL/min calculated by using Cockcroft-Gault equation, for three months or more) above the age of 18 years, referred to the Department of Medicine, Radiodiagnosis, Prathima Institute of Medical Sciences, Karimnagar from January 2020 to December 2020. The patient was made to lie supine on the examination table. The ultrasound coupling gel was applied to the abdomen so as to remove air between the abdominal skin and the transducer. Patients were subjected to sonographic examination on Philips Envisor C ultrasound machine/Toshiba ultrasound machine model–SSA.510A/Esaote ultrasound machines using curvilinear probe of 3.5 MHz-5 MHz or linear high frequency probe 7-12 MHz. Longitudinal, transverse and oblique views were taken. The exclusion criteria were the patients on haemodialysis, peritoneal dialysis, renal transplant patients, patients with hepatic diseases diagnosed on ultrasonography and renal tumours (Both Primary and Secondaries).The detailed history from patients regarding age, duration of diabetes mellitus if diabetic, duration of hypertension if hypertensive, other causes of chronic renal failure and treatment history. The most recent serum creatinine values were noted. After taking the informed consent of the patient for investigation, each patient was subjected to ultrasound of the abdomen for kidneys and liver. Low tissue harmonic imaging was applied to visualize the liver

and kidney echogenicities. A manual method of adjusting the gain and Time Gain Compensation(TGC) was used.Renal lengths were measured as the greatest pole to pole distance in the sagittal plane . Renal parenchymal thickness was measured from the renal hilum to the maximum convex border of the lateral renal margin. Renal cortical thickness was measured over a medullary pyramid, perpendicular to the capsule as the shortest distance from the base of the medullary pyramid to renal capsule. In every case, the mean values of the right and left renal longitudinal size, parenchymal thickness and cortical thickness were calculated. Renal cortical echogenicity and cortico-medullary differentiation was evaluated. Renal cortical echogenicity was compared and graded with the echogenicity of the liver and renal medulla with Grade 0: Normal echogenicity less than that of the liver with maintained cortico-medullary differentiation. Grade 1: Echogenicity the same as that of the liver with maintained cortico-medullary differentiation . Grade 2: Echogenicity greater than that of the liver with maintained cortico-medullary differentiation. Grade 3: Echogenicity greater than that of the liver with poorly maintained cortico-medullary differentiation. Grade 4: Echogenicity greater than that of the liver with a loss of cortico-medullary differentiation The data were entered and stored in a spreadsheet (Excel, Microsoft). Statistical analysis was performed between the ultrasonographic renal parameters and serum creatinine levels with the aid of SPSS statistical software (version 17.0). Analysis was done using one way ANOVA and Pearson's correlation coefficient.

Results

The age range of the patients was 19-85 yrs. with mean age of the patients was 54.32 years (Table 1). There were 58% male cases and 46% were females with male:female ratio of 1.38:1 (Table II). The most common known cause of CKD in these patients was diabetes mellitus seen in 64 cases (32%) followed by hypertension in 36 cases (18%), diabetes and hypertension together in 5% of the cases. In 2% of cases, the cause was HIV associated nephropathy. No provisional cause was made in 86 cases (43%) at the time of scanning (Table 3).

The kidneys were small in size in 35% of the cases, the difference in size between right and left kidneys was more than 2 cm in 4% of the cases and the kidneys were enlarged in 3% of the cases. In 62% of cases, the kidneys were of normal size. The average kidney length measured in the present study was 8.69 cm (Range, 6.6-15.45 cm; SD=1.35 cm).The average parenchymal thickness of 1.7 cm was seen in 75% of the cases, reduced in 18% of the cases and in 7% of the cases the cortico-medullary differentiation was lost. Cortical thickness could not be assessed in 16 patients, as the renal pyramids could not be identified on USG (Table 4).The mean parenchymal thickness obtained in the present study was 1.77 cm (Range 1-2.35 cms; SD=0.3 cm).The mean cortical thickness in our study was found to be 8.5 mm(Range 5.2 mm-12.8 mm; SD = 1.63 mm) (Table 4). The increased renal cortical echogenicity was reported in all the patients with CKD. Grade 1 increased echogenicity in 70 (35%) cases, Grade 2 in 84 (42%) cases, Grade 3 in 32 (16%) cases and Grade 4 in 14 (7%) cases.Corticomedullary differentiation was maintained in 77% of the cases, poorly maintained in 16% of the cases and it was lost in 7% of the cases (Table 5).The mean serum creatinine values were 2.87 mg/dL for Grade 1 echogenicity (Range 1.8-5.6 mg/dL;SD=0.81),3.26 mg/dL for Grade 2 echogenicity (Range 1.6-6.1 mg/dL; SD=1.09),4.3 mg/dL for Grade 3 echogenicity (Range 2.7-7.5 mg/dL; SD=1.58) and 5.81 mg/dLfor Grade 4 echogenicity (Range 3.6-9.5mg/dL; SD=5.81) (Table 6).

Table 1: Age Distribution

S.No	Age Range (In Years)	No of cases	Percentage
1	18-30	06	03%
2	31-40	16	08%
3	41-50	62	31%
4	51-60	66	33%
5	61-70	32	16%
6	71-80	18	9%
7	81-90	02	01%
8	Total	200	100%

Table 2: Gender Distribution

S.No	Gender	No of cases	Percentage
1	Male	116	58%
2	Female	84	42%

Table 3: Provisional Clinical Causes of Chronic Kidney Disease

S.No	Cause of CKD	No of cases	Percentage
1	Underlying cause of CKD not established	86	43%
2	Diabetes	64	32%
3	Hypertension	36	18%
4	Diabetes and Hypertension Combined	10	05%
5	HIV	04	02%

Table 4: SG Findings of Renal Size Parameters with Chronic Kidney Disease

Sonography Renal Findings			
Renal Parameters		**No of cases**	**Percentage**
Renal Size Difference(Right vs. Left)	Not Significant(<2cm) Significant(>2cm)	192 08	96% 04%
Average Renal Length(8.69cm)	Enlarged(>12 cm) Normal(8-12cm) Small (<8 cm)	06 124 70	03% 62% 35%
Average Parenchymal Thickness(1.77 cm)	Normal(>15 mm) Reduced(<15 mm) Could not be assessed	75 18 07	75% 18% 07%
Average Cortical Thickness(8.5 mm)	Reduced Could not be assessed	168 32	84% 16%

Table 5: USG Findings Related to Echogenicity and Cortico-Medullary Differentiation in Cases with Chronic Kidney Disease (N=200)

Renal changes		No of cases	Percentage
Bilateral Echogenicity	Similar	192	96%
	Different	08	04%
Grade of Echogenicity	Grade 1	70	35%
	Grade 2	84	42%
	Grade 3	32	16%
	Grade 4	14	07%
Corticomedullary Differentiation	Maintained		
	Poorly Maintained	154	77%
	Lost	32	16%

Table 6: Statistical Correlation of Serum Creatinine with Renal Cortical Echogenicity with Chronic Kidney Disease (Grading Determined by Ultrasound Features)

SERUM CREATININE							
Renal cortical echogenicity	N	Mean	SD	Min	Max	F Value	P Value
Grade 1	70	2.8771	0.8106	1.80	5.60	14.927	<0.001
Grade 2	84	3.2690	1.099	1.60	6.10		
Grade 3	32	4.300	1.5811	2.70	7.50		
Grade 4	14	5.8143	2.1106	3.60	9.50		
Total	200	3.4750	1.4198	1.60	9.50		

Table 7: Associated Findings on Ultrasound with Chronic Kidney Disease (N=200)

S.No	Associated USG Findings	No of cases	Percentage
1	Renal Cysts	18	09%
2	Pleural Effusion	16	08%
3	Renal calculi with or without hydronephrosis	14	07%
4	Ascites	10	05%
5	Prominent intrahepatic veins	2	01%
6	Hepatic Cysts	2	01%
7	GB wall oedema	2	01%

That renal cysts were the most common associated finding seen in 09% of the cases followed by pleural effusion (08%), renal calculi with or without hydronephrosis (07%), ascites (05%), prominent intrahepatic veins (01%), hepatic cysts (01%), and GB wall oedema (01%).

Discussion

The burden of CRF has increased exponentially and is consuming the resources of both developed and developing economies and efforts to reduce the cost of managing this dreadful disease are always welcomed. This study was geared towards looking for a simpler method of determining the functional capacity of the kidneys in CKD and eliminating (If possible) the need for double determination of GFR using serum biochemistry, particularly in resource-poor settings.The ultrasound machine is quite cheaply and widely available and provides real-time information on the renal measurements and echogenicity particularly in resource poor settings [8]. Renal length is measured as the longest diameter obtained on a posterior oblique image with a lower limit of normality generally indicated as 9 cm. According to Fiorini and Barozzi, renal length under 8 cm is definitely reduced and should be attributed to chronic renal failure, whereas a length between 8 and 9 cm should always be correlated to the patient's phenotype, particularly the height[9]. Hence, a lower limit of 8 cm was selected for the present study. According to O'Neill, the useful upper limit of the normal range for kidney length is said to be 12 cm. Also, a threshold of 2 cm is considered reasonable for diagnosing pathological size discrepancy between the two kidneys[10]. Kidneys measuring more than 12 cm in length were considered enlarged in the present study.Kidney length was affected in 38% of the patients –the kidneys were small in size in 35% of the cases and the kidneys were enlarged in 3% of the cases. In the remaining 62% of cases, the kidneys were of normal size. The pathological discrepancy in size (>2cm) was seen in 4% of the cases in the present study. Of the 3 cases having enlarged kidney sizes, 2 cases were diabetic and 1 case had Adult Polycystic Kidney Disease (APKD), thus explaining the enlarged kidney sizes in CKD, as nephromegaly is common in both DM and APKD[11,12].Of the 4 cases having size discrepancies 1 case had unilateral hydronephrosis, 1 case was hypertensive with unilateral small kidney with the clinical suspicion of renal artery stenosis, 1 case had clinical suspicion and sonographic features of pyelonephritis in a diabetic and the remaining case had adult polycystic kidney disease having irregular enlargement of the two kidneys due to numerous cysts, thus explaining the difference in the sizes. In the study conducted by Moccia et al, the kidney size was affected in 57% of the cases having chronic renal disease, of which 7 cases had size discrepancy[13].The mean renal length measured in the present study was 8.69 cm (Range 6.6-15.45 cm; SD=1.35 cm). This correlated well with the findings of Yamashita et al,in which the average renal length was 9.5 cm in CKD patients (Range 6.99–13 cm; SD = 1.25 cm)[6]. Normal parenchymal thickness ranges from 1.5-2 cm[9].The mean parenchymal thickness obtained in the present study was 1.77 cm (Range 1-2.35 cms; SD=0.3 cm). The average parenchymal thickness was normal in 75% of the cases. In 18% of the cases it was reduced and in 7% of the cases it could not be assessed as the cortico-medullary differentiation was lost. These findings correlated well with those of Moghazi et al who found the mean parenchymal thickness to be 1.71 cm (Range, 0.7-3.3 cm)[14,15].

Conclusion

Despite its limitations, the present study has shown a good correlation of renal cortical echogenicity with serum creatinine levels. The renal cortical echogenicity has its advantages of being irreversible compared to serum creatinine levels, which improve with

renal replacement therapies like haemodialysis and peritoneal dialysis. Also, quantification of echogenicity of the renal cortex relative to that of the liver has been shown to be reproducible with only little variability between different scanners and probes in previous studies.

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