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Original Research Article

ANATOMICAL CHANGES IN RENAL IMPAIRMENT AND ITS IMPLICATION: A SONOGRAPHIC STUDY

Panchali Datta [1], Rajarshi Roy *[2], Sumit Datta [3], Shankhadeep Sarkar [4].

[1] Demonstrator, Department of Anatomy, Diamond Harbour Medical College, Kolkata, West Bengal, India.

*[2] Demonstrator, Department of Anatomy, Medical College, Kolkata, West Bengal, India.

[3] Consultant Radiologist, AMRI Hospital, Kolkata, West Bengal, India.

[4] RMO, Department of Chest Medicine, Purulia Medical college, West Bengal, India.

ABSTRACT

Background: Renal failure (Azotemia) reflects inability of kidneys to maintain normal homeostatic function, simultaneously accompanied with rise in Blood Urea and Serum Creatinine levels. The manifestations may develop over days- Acute; or span over weeks to months – Chronic. Gray Scale Ultrasonography is employed, in our Study, to assess kidneys in Acute and Chronic Renal Failure.

This study aims to determine the size and location of the kidneys; cortical echogenicity; severity of cortical loss; detection and aetiology of renal obstruction; and finally in the follow-up during and after the management. 200 persons were taken as Control, whereas 100 patients – 50 each suffering from Acute and Chronic Renal Failure, were interrogated.

Results: Renal dimension, cortical echogenicity with cortico-medullary differentiation of Control (Normal) individuals were observed. The above mentioned renal parameters were assessed both in Acute and Chronic renal failure.

No significant correlation was found between renal length and Serum Creatinine or Blood Urea levels in Acute Renal Failure. Whereas, a statistically significant correlation between kidney length and Serum Creatinine/ Blood Urea levels in Chronic Renal Failure is established. A statistically significant relationship was also observed between renal cortical echogenicity and Serum Creatinine level; but not with Blood Urea level.

Conclusion: Non-involvement of ionising radiation, wide spread availability with low-cost imaging modality, makes Gray Scale Ultrasonography, the cornerstone of imaging in Renal Parenchymal Disease.

KEY WORDS: Ultrasonography, Serum creatinine, Acute and chronic renal failure.

Address for Correspondence: Dr. Rajarshi Roy, Demonstrator, Department of Anatomy Affiliated institutions: Medical College, Kolkata- 700073, West Bengal, India. Mobile number: 09433110980
E-Mail: rajarshi.bubai@gmail.com

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INTRODUCTION

Renal failure is defined as the deterioration of renal function associated with accumulation of nitrogenous wastes in the body (azotemia) that is not due to external factors. Renal failure is not a cascade of sharply defined stages but a continuum of progressive inability of the kidneys to maintain normal homeostatic functions; associated with a rise in Blood Urea and Serum Creatinine. Acute renal failure develops over days to weeks. Chronic renal failure develops over months to years. Acute renal failure may be pre-renal (renal hypo-perfusion secondary to a systemic cause), renal (due to renal medical disease) or post-renal (as a result of outflow obstruction). While acute tubular necrosis is the commonest cause of acute renal failure; glomerular, vascular and interstitial abnormalities are usually associated with chronic renal failure.

Hence, it is the necessity of a proper and accurate evaluation of the anatomy and morphology of the failing kidneys. Ultrasound is a valuable investigation in the evaluation of both acute and chronic renal failure.

The ease of visualisation of the kidneys coupled with safety as no ionising radiation is involved, simplicity, low cost and easy availability makes it the modality of choice in routine initial method of evaluation. It provides an edge over the traditional renal biopsy and intravenous urography being non-invasive and without the risk factors of intravenous contrast administration.

By assessing the presence, size, renal echogenicity and collecting system dilatation, it can be established whether renal function is impaired by chronic or acute renal changes or by obstructive changes.

In this study we have tried to assess the kidney size and echogenicity (in different grades) on Ultrasonography and to arrive at a proper diagnosis which will aid in the diagnosis and further management of these patients.

Ellenbogan P.H. et al in 1978 compared the reliability of ultrasound to that with excretory urography in detecting urinary tract obstruction [1]. The degree of hydronephrosis was graded in both IVU and sonography. The sonographic grading was from grade 0 to grade 3. Grade 0 has been described as central collecting system echoes are compact and homogenous. Grade 1 has been described as slight separation of collecting system echoes (Fig.5) with a central ovoid or fusiform sonolucency. Grade 2 depicted as further separation of collecting system echoes with a rounded sonolucency seen centrally. The grade 3 had been described as where major portion of the kidney are replaced by sonolucent sac.

Hricack. H. Cruz C, Romanski R et al in a landmark article in 1982 advocated a study conducted on patients who underwent renal biopsy, to correlate the sonographic appearance of the kidney with histologic changes, clinical and laboratory findings in various parenchymal diseases [2]. Cortical echogenicity was classified into four groups, grade 0 to III. Grade 0 where the renal echogenicity was less than that of liver. In grade I the echogenicity is equal to that of liver where as in grade II its greater than liver but less than that of renal sinus. In grade III it's depicted as similar to renal sinus.

Amis, Jr E.S. et al in 1984 has evaluated the causes of ultrasonic inaccuracies in diagnosing renal obstruction [3]. Several conditions resulting in false negative and false positive scans where false negative accounting for less than 1% cases.

Jagdeesh K. Siddappa et al in an article in 2013 titled “Correlation of Ultrasonographic Parameters with Serum Creatinine in Chronic Kidney Disease”, noted that renal echogenicity and its grading correlates better with serum creatinine in CKD than other sonographic parameters such as longitudinal size, parenchymal thickness, and cortical thickness [4].

Wu- xing zhang et al also depicted in a study done in 2014, titled “Sonographic measurement of renal size in patients undergoing chronic hemodialysis: Correlation with residual renal function” that renal size assessment by ultrasonography could be useful for residual renal function evaluation in patients undergoing chronic hemodialysis [5].

Samia Rafael Yamashita et al in an article titled “Value of renal cortical thickness as a predictor of renal function impairment in chronic renal disease patients” in 2015 obtained good interobserver reproducibility for renal measurements in renal failure patient. Also a correlation was observed between estimated GFR and cortical thickness [6].

Aims:

i) To study the sonographic changes in the kidney in cases of renal insufficiency.

ii) To study the role of ultrasound in detecting-

a) The type of renal insufficiency (acute or chronic)

b) The aetiology of renal insufficiency (obstructive or non-obstructive)

iii) To study the efficiency of sonography as a screening procedure in renal insufficiency.

iv) Evaluation of renal size in acute and chronic renal failure and its correlation with serum creatinine and blood urea levels.

Grading of renal parenchymal changes in acute and chronic renal failure and its correlation with Serum Creatinine and Blood Urea levels.

MATERIALS AND METHODS

This study was performed on 100 patients from both in-patient and out-patient departments of Vision Care Hospital (AMRI, Mukundapur), Kolkata and in MGM medical college and LSK Hospital, Kishanganj, Bihar.

Duration of the study: June 2016 to may 2017.

Sample size: 100 adult patients of both sexes of 20-80 yrs of age were considered for the study.

Selection criteria: all the patients found to be suffering from impaired renal function- diagnosed clinically as well as raised blood urea and serum creatinine levels, were taken up for sonographic evaluation of renal insufficiency.

Detailed clinical history including symptomology and signs were taken. Laboratory investigations of blood urea; serum creatinine; serum electrolytes- sodium, potassium, chloride, calcium and bicarbonate were done on the day of examination. Informed consents of the patients were taken prior to the examination. The data was collected as per the detailed proforma prepared for the study and required follow up was done. Out of those 100, fifty patients were diagnosed as acute renal failure and the rest were suffering from chronic renal failure.

Control group: 200 adult individuals in the age group of 20-80 years of both sexes were scanned to determine the variations of normal renal dimension correlated with age, sex and height. The concerned individuals had normal blood urea and serum creatinine levels and any history of diabetes, hypertension or any previous surgical intervention were excluded from the study. Heights of every individual were recorded.

Equipments used: State of art Ultrasound Machine employed- PHILIPS 11 HD XE and Voluson Expert E8.

Mode of ultrasound used: Gray scale Ultrasound was the cornerstone of this Imaging study. Colour and Power Doppler was employed, as and when required.

The kidney was scanned in both longitudinal and transverse planes, with the patient supine and lateral decubitus position. The right kidney was scanned using liver as an acoustic window; while the left kidney was scanned using the spleen or fluid filled stomach as an acoustic window. Prone position was used when other views impeded by intervening bowel gas.

In longitudinal plane (ranging from sagittal to coronal), the kidney has a characteristic oval shape with a hypoechoic rim of cortex and medulla surrounding the echogenic sinus fat. The examination is performed at frequencies varying from 3.5 to 5 MHz and measurements were obtained in suspended respiration. The transducer is positioned so that the upper pole is placed on the left hand side of the image.

On transverse scanning, the kidney will appear circular at each pole and C-shaped through the centre because of the break in the parenchyma where the ureter and vessels enter. Transverse scans therefore provide the best views of the renal pelvis.

Three renal measurements were obtained- length, antero-posterior dimension and parenchymal thickness. The longitudinal measurement was obtained from the sagittal scan; while the maximum antero-posterior dimension was measured from the same sagittal image measured perpendicular to the long axis. The parenchymal thickness was obtained by measuring the maximum distance between the renal capsule and the margin of the sinus echoes.

The renal cortical echogenicity was assessed by comparing it with that of the adjacent liver or spleen. Cortical echogenicity was graded as normal (Grade 0) when the renal cortical echogenicity was less than that of liver (Fig.1), as grade I when the echogenicity of the cortex was equal to that of liver (Fig.2), grade II when it was greater than liver but less than that of renal sinus (Fig.3) and grade III when the echogenicity of the cortex was equal to that of renal sinus (Fig.4).

Fig. 1: Gray scale ultrasonography reveals renal cortical echogenicity less than that of hepatic parenchymal echogenicity.

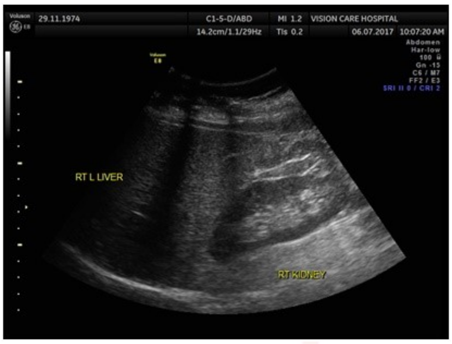


Fig. 2: Right Kidney longitudinal section exhibits cortical echogenicity equal to echogenicity of hepatic parenchyma.

Fig. 3: Renal cortical echogenicity is more than liver parenchymal echogenicity, but less than renal sinus. Mild hydronephrosis appreciated.

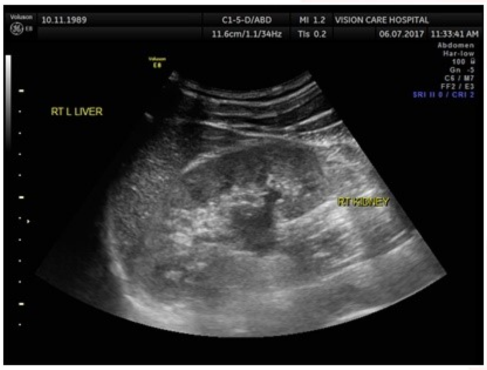


Fig. 4: Decreased renal dimension, with cortical echogenicity equal to that of renal sinus. A simple cortical cyst was seen.

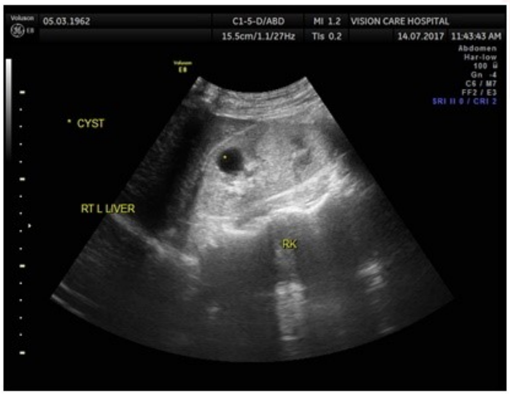
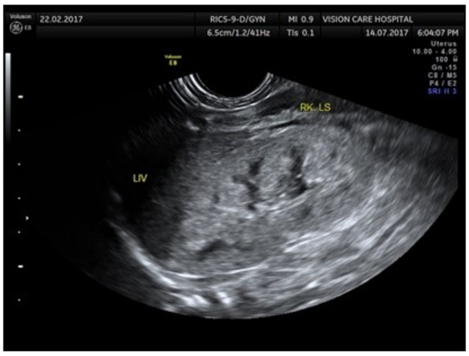


Fig. 5: Right Kidney longitudinal section depicts slight separation of collecting system echoes.



RESULTS

Total 200 control persons with 400 kidneys and 100 study group cases with 200 kidneys were examined under various headings like renal length, cortical echogenicity, corticomedullary differentiation etc. out of the 100 cases in study group 50 persons were suffering from acute renal failure and 50 from chronic renal failure. Their Serum Creatinine and Urea levels were measured and compared.

In the control group mean kidney length was found to be 9.93cm and 10.29cm in right and left kidyes respectively (Table1). In the acute renal failure cases in terms of cortical echogenicity, 3(6%) patients had hypoechoic, 17(34%) patients had grade 0, and 15(30%) patients hade grade I and 15(30%) patients had grade II cortical echogenicity. Where as in acute renal failure cases mean length of right kidney in hypoechoic, grade 0, grade I, grade II changes were 10.9cm, 10.0cm, 10.4cm and 10.1 cm respectively with standard deviation (SD) of 0.4, 1.0, 1.0, 1.3 respectively. The mean left kidney lengths were 11.5cm, 11.0 cm, 10.8cm and 10.8cm respectively with SD of 0.6, 1.0, 0.9 and 1.3 respectively. (Table2)

No significant correlation was found between kidney length and serum creatinine and blood urea levels in acute renal failure. Cortico-medullary differentiation becomes poor as the cortical echogenicity increases with almost 93% cases in the grade II echogenicity pattern showing poor cortico-medullary differentiation where as 67% in hypoechoic grade showing poor differentiation (Table3). However no significant correlation was found in between cortical echogenicity and serum creatinine and blood urea levels. Out of the 100 cases (200 kidneys) our study reflected 8 cases as hydronephrosis out of which 6 proved to be as obstructed uropathy in final diagnosis having a sensitivity of 98% and a specificity of 98.9% as a screening modality.

In the chronic renal failure cases in terms of cortical echogenicity, 9(18%) patients had grade I, 20(40%) patients had grade II, and 21(42%) patients hade grade II cortical echogenicity (Table4). The mean serum creatinine level in chronic renal failure with grade I, II and III changes were 5.6mg/dl, 5.7mg/dl, 8.9mg/dl respectively. The mean serum urea level in chronic renal failure with grade I, II and III changes were 110.4mg/dl, 136mg/dl, 172.9mg/dl respectively with SD of 53.4, 43.5 and 115.9 respectively. The mean right kidney length withgrade I, II and II were 8.1cm, 8.0cm and 7.0cm respectively with SD of 0.9, 1.8 and 1.2 respectively (Table 5). A statistically significant correlation between the kidney length and serum creatinine and blood urea levels in chronic renal urea failure is noted (Table 6). Cortico-medullary differentiation becomes poor as the cortical echogenicity increases with almost 78% cases in the grade I echogenicity pattern showing poor cortico-medullary differentiation where as 65% in grade II showing poor differentiation (Table 7). Using one-way analysis of variants (ANOVA) technique a statistically significant relationship was obtained between cortical echogenicity i.e. renal parenchymal changes and serum creatinine level. However no significant relation was found with blood urea levels (Tab.8).

Table 1: Normal Kidney Length.

Kidney	Renal length (cm)		
	Range (cm)	Mean (cm)	SD
Right Kidney	8.6-11.6	9.93	0.67
Left Kidney	8.9-12.0	10.29	0.76

Table 2: Mean renal length in acute renal failure.

State Or Grading Of Cortical Echogenicity	No of Cases	Percentage	Renal length (in cm)					
			Right Kidney			Left Kidney		
			Range (cm)	Mean (cm)	SD	Range (cm)	Mean (cm)	SD
Hypoechoic	3	6	10.4-11.1	10.9	0.4	10.8-12	11.5	0.6
Grade 0	17	34	8-11.7	10	1	8.9-12.9	11	1
Grade I	15	30	8.6-12.3	10.4	1	8.7-12.2	10.8	0.9
Grade II	15	30	8-11.5	10.1	1.3	8.6-12.4	10.8	1.3

Table 3: Corticomedullary differentiation in acute renal failure.

State Or Grading Of Cortical Echogenicity	No of Cases	Corticomedullary differentiation [no of cases(%)]			
		Absent	Poor	Normal	enhanced
Hypoechoic	3	1(33)	2(67)	-	-
Grade 0	17	-	5(29)	12(71)	-
Grade I	15	-	4(27)	9(60)	2(13)
Grade II	15	1(7)	14(93)	-	-

Table 4: Mean renal length in chronic renal failure.

State Or Grading Of Cortical Echogenicity	No of Cases	Percentage	Renal length (in cm)					
			Right Kidney			Left Kidney		
			Range (cm)	Mean (cm)	SD	Range (cm)	Mean (cm)	SD
Grade I	9	18	7-9.3	8.1	0.8	7.7-10.6	8.7	0.9
Grade II	20	40	4.5-13.3	8	1.9	3.9-13.2	8.5	1.8
Grade III	21	42	3.6-9.0	7	1.2	4.6-9.1	7.4	1.2

Table 5: Serum creatinine and blood urea levels in chronic renal failure.

State Or Grading Of Cortical Echogenicity	No of Cases	Creatinine levels (in mg/dl)			Urea levels (in mg/dl)		
		Range	Mean	SD	Range	Mean	SD
Grade I	9	2.2-10.8	5.6	2.7	58-213.5	110.4	53.4
Grade II	20	2.7-11.5	5.7	2.5	75-207.1	136	43.5
Grade III	21	2.2-25	8.9	6.4	66-520	172.9	115.9

Table 6: Correlation between serum creatinine and renal length and blood urea and renal length in chronic renal failure.

Correlation between Serum creatinine and renal length		Correlation between blood urea levels and renal length	
Right Kidney	<.01(r=-0.36; t=2.67)	Right Kidney	<.01(r=-0.39; t=2.76)
Left Kidney	<.01(r=-0.42; t=3.21)	Left Kidney	<.01(r=-0.43; t=3.29)

Table 7: Corticomedullary differentiation in chronic renal failure.

State Or Grading Of Cortical Echogenicity	No of Cases	Corticomedullary differentiation [no of cases(%)]			
		Absent	Poor	Normal	enhanced
Grade I	9	1(11)	7(78)	1(11)	-
Grade II	20	7(35)	13(65)	-	-
Grade III	21	14(67)	7(33)	-	-

Table 8: Statistical significance between cortical echogenicity and serum urea and creatinine.

Cortical Echogenicity Vs	P value (Using ANOVA test)
Serum creatinine	<0.05 (F=3.23)
blood urea	0.014 (F=2.05)

DISCUSSION

Sonography is the first diagnostic imaging study performed in the workup of renal failure and has largely supplanted intravenous pyelography [7]. Renal failure may be prerenal (resulting from insufficient renal perfusion); renal (secondary to intrinsic renal disease) or post renal (due to obstructive uropathy) [8]. The primary role of sonography in renal failure is to differentiate obstructive aetiology from parenchymal causes so that the obstruction can be relieved by an appropriate invasive procedure [9].

In the sonographic evaluation of renal failure, in our study an attempt is made for:

· Identification of number, location and size of the kidneys;

· Assessment of their echogenicity;

· Detection of renal obstruction and estimation of severity of cortical loss;

· Localization of site and determination of cause of obstruction;

· Lastly deriving the follow up information during and after therapy.

In the control group the mean length of right kidney was found to be 9.93cm with standard deviation of 0.67 and of left kidney was 10.29 cm with standard deviation of 0.76.

The results of our study was similar to that of Emamian et al who in a study on kidney dimensions using sonography depicted median renal lengths were 11.2cm on the left side and 10.9 cm on the right side [10]. Normal renal dimension correlated well with age, height and in both sexes. Renal length correlated best with body height. The mean kidney lengths were less compared to the said study because of decreased average height of Indian population. The control group with 200 individuals having normal serum creatinine and blood urea levels without any known co-morbidities showed renal echogenicity was less than that of liver parenchyma similar to the study of Hricack. H et al [2].

In our study in the group with acute renal failure comprising 50 cases we found 28 right kidneys and 37 left kidneys were more than 10cm with smooth surface except two had lobulated margin while 13right kidneys and 9 left kidneys were in the range of 9-10 cms; and 9 right kidneys and 4 left kidneys were in between 8-9 cm in size with lobulated margin in one case.

No significant correlation was found between kidney length and serum creatinine and blood urea levels in acute renal failure. The results were comparable to the study of Hricack. H et al [2]. In both acute and chronic renal failure cases we found that corticomedullary differentiation becomes poor with increased cortical echogenicity. In our study, acute and chronic renal failure patients were evaluated separately. In acute renal failure, no significant correlation existed between cortical echogenicity and serum creatinine and blood urea levels. In chronic renal failure no significant correlation was found between cortical echogenicity and blood urea levels. However, a statistically significant relationship was obtained between cortical echogenicity i.e. renal parenchymal changes and serum creatinine level. Thus, we can say, in chronic renal failure cases, as serum creatinine level increases, cortical echogenicity increases. The observations were similar to that of the study by Sidappa et al [4]. As a screening modality in cases of obstructive uropathy, ultrasound showed sensitivity of 98% and specificity of 98.9%, hence, highly accurate in differentiating obstructive and non obstructive cases of renal failure.

Sonography is a critical component in the evaluation of both acute and chronic renal failure. The acoustic properties, ease of visualization of the kidneys, coupled with the safety, simplicity and widespread availability and low cost of Sonography, makes it the modality of choice for renal insufficiency. In our country, Sonography should be the first diagnostic imaging study performed in the work-up of renal failure and in most cases is the only imaging required.

Conflicts of Interests: None

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