ORIGINAL ARTICLE

Correlation of Ultrasonographic Findings in Renal Parenchymal Disease with Creatinine Levels at a Tertiary Care Setting in Rawalpindi

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ABSTRACT

Objective: The study aims to determine the correlation of ultrasonic measurements in assessing renal parenchymal disease (RPD) with the results of creatinine levels in serum to support or oppose the findings.

Study Design: Cross-sectional and descriptive study.

Place and Duration of Study: This study was conducted at the Department of Radiology, Armed Forces Institute of Radiology and Imaging (AFIRI) Rawalpindi, Pakistan, from September 2022 to February 2023.

Methods: Two diagnostic tools were used, i.e., ultrasound and serum creatinine levels. All the patients reporting at a tertiary care hospital for Abdomen and Kidney Ureter Bladder (KUB) ultrasound were included. All the results were finalized under the supervision of a Classified Radiologist. Those patients who hadn't had their serum creatinine levels checked beforehand were asked to get it done and provide the results later on. The data was analyzed using the Statistical Package for Social Sciences (SPSS) version 26. Pearson's correlation was done to find the relationship of serum creatinine with different ultrasound parameters.

Results: A positive correlation that was statistically significant was found to exist between serum creatinine and echogenicity grades (r = 0.418, $P < 0.0001$), renal length (r = 0.220, $P < 0.0001$), corticomedullary differentiation (r = 0.354, $P < 0.0001$) and parenchymal echogenicity (r = 0.261, $P < 0.001$) in right kidney. Similarly, in the left kidney, a significant positive relationship that was confirmed through statistical analysis was found between serum creatinine and echogenicity grades (r = 0.435, $P < 0.0001$), renal length (r = 0.169, $P = 0.003$), corticomedullary differentiation (r = 0.338, $P < 0.0001$) and parenchymal echogenicity (r = 0.294, $P < 0.001$).

Conclusion: The results produced a significant correlation through statistical analysis between sonographic findings and serum creatinine levels paving the way for the use of ultrasonography as an early diagnostic tool for the timely diagnosis of renal parenchymal disease.

Keywords: *Acute Kidney Injury, Creatinine, Chronic Kidney Disease, Glomerular Filtration Rate, Ultrasonography.*

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Introduction

Renal Parenchymal Disease refers to a group of diseases affecting glomeruli, interstitial, tubules and small blood vessels of the kidneys.[1] These diseases can be generally categorized into two forms: Acute Renal Failure (ARF) and Chronic Renal Disease (CRD). ARF, also known as AKI (Acute Kidney Injury), refers to an instant decline in kidney function that results in the rapid loss of the capacity to remove waste and extra fluid from the blood.[2] Chronic renal disease, commonly termed as CKD (Chronic Kidney Disease), refers to the progressive irreversible

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deterioration of the function and structure of kidneys over months or even years, which may or may not be accompanied with decreased Glomerular Filtration Rate (GFR).[3] GFR is the calculative measure for blood filtration by kidneys recorded in units of volume per time. A normal GFR is considered to be above 100 milliliters per minute per 1.73 square meters.[4] Currently, 30% of patients who experience AKI while in the Intensive Care Unit (ICU) are found to have CKD.[5] Similarly, AKI can also lead to the development of CKD.[6]

Diabetic nephropathy is the most frequent underlying cause of CRD.[7] Other causes of renal parenchymal disease include; congenital or hereditary conditions, viral and bacterial infections, kidney stones, high BP, autoimmune disorders and certain medications.[8] Clinical depression and chronic pain are the two widespread symptoms of kidney disease.[9] Additional prevalent indicators of kidney tissue damage include swelling, elevated blood pressure, a decrease in red blood cells, alterations in bones, the presence of blood in urine, and abdominal bloating.[10] Globally, CKD ranks 12th as a cause of mortality and 17th as a cause of impaired functioning.[7] In Pakistan, the overall prevalence of CKD in adults is found to be 21.2% ranging between 12.5% to 29.9%.[8]

Various diagnostic methods or techniques are available for RPD. These include; detection of pathological anomalies, alterations in markers of kidney function through blood or urine tests, or through imaging studies.[3] The conventional method to evaluate CKD has involved measuring serum creatinine levels.[7] For the evaluation of CRD, ultrasonography is considered the ideal imaging modality due to its non-invasive nature, ease of access, and ability to visualize the kidneys.[3] Sonography offers details regarding the length, shape, as well as the relative echogenicity and pattern of the cortex and medulla. Increased echogenicity of the renal parenchyma, as seen on an ultrasound, is often used as an indicator of declining kidney function.[11] Over time, the size of the kidneys, their echogenicity, and the distinction between the cortex and medulla (corticomedullary differentiation) are acclaimed to be associated with severity of CKD.[12]

Renal parenchymal disease usually remains asymptomatic until stage 4, therefore mostly the diagnosis occurs as a result of routine blood/urine tests or ultrasound. Chronic renal disease with an irreversible damage is marked by small shrunken kidneys with thin echogenic cortex or parenchyma on ultrasound. Serum creatinine level is a serum marker that is produced by the body as a result of breakdown of body muscle protein. Alternative noninvasive methods of creatinine measurement are through saliva and urine. A rise of at least 0.3 mg/dl in serum creatinine concentration signifies the presence of acute kidney injury. In clinical setting, this is the most common method used to determine kidney function. Nonetheless, serum creatinine levels can be affected by multiple factors, including age, gender, ethnicity, muscle mass, and dietary intake, making it an insufficient tool for diagnosing renal parenchymal disease on its own. Serum creatinine level can lead to misdiagnosis of CRD because it can provide an estimate of changes in the glomerular filtration rate (GFR), but it cannot determine the absolute GFR. Among different sonographic parameters, the grading of renal echogenicity has a stronger correlation with serum creatinine levels compared to other diagnostic methods. CRD is generally linked with an increase in echogenicity. For the presence of RPD, an increase in renal echogenicity has been shown to have a 96% specificity and a 67% positive predictive value (PPV).[13]

The objective of this study is to investigate the correlation between echogenicity of kidney and levels of creatinine in serum, as well as to assess the relevance of renal echogenicity in the diagnosis of chronic renal disease (CRD) and the effectiveness of sonographic imaging in detecting renal parenchymal disease (RPD). The results will predict diagnostic efficacy of ultrasound for evaluation and grading of renal parenchymal disease (RPD). Therefore, if ultrasound is found to provide accurate results,

it can more often be used as a diagnostic modality for RPD and timely diagnosis can be made as it is a non-invasive and efficient modality as compared to histopathology.

Methods

This study was conducted at the Department of Radiology, Armed Forces Institute of Radiology and Imaging (AFIRI) Rawalpindi, Pakistan from September 2022 to February 2023. The World Health Organization Sample Size Analyzer was used to determine the sample size. The minimum limit of sample size calculated was 257. However, the study included 260 patients to account for drop out.

Samples were collected by Consecutive, Non-probability technique. All male and female patients referred for Abdomen and KUB ultrasound in the Radiology OPD for the evaluation of kidney disease and patients depicting incidental renal parenchymal disease findings on ultrasound were included in the study. Patients whose creatinine levels hadn't been checked beforehand were advised to get it done. Known patients of kidney disease, patients on renal replacement therapy like kidney transplant, dialysis, patients with major physical handicap and patients with solitary kidney were not included in the investigation.

The Ethical Review Committee (ERC) of the institute has granted ethical approval against ID Number 001. Before taking part in the study, all individuals provided verbal informed permission.

Ultrasound abdomen and KUB were performed on patients with the aid of ultrasound machine Toshiba Xario 200. The results obtained were compared to serum creatinine levels. All the results were finalized under supervision of a Classified Radiologist.

The Statistical Package for the Social Sciences (version 26) was used to analyze statistical data. For all of the study's variables, descriptive statistics, such as frequencies and mean/ standard variation, were performed. Additionally, the association between serum creatinine and ultrasonography parameters was determined using Pearson's association.

Results

260 patients visited the department of which 62.7% underwent ultrasound abdomen and KUB was performed in 37.3% in Radiology OPD.

Among 260 participants, 5 (1.9%) patients were under 20 years of age, 30 (11.5%) between age group 20-40 years, 153 (58.8%) were between the ages of 41-70 and 72 (27.7%) were above 70 years of age. Therefore, the highest frequency observed was between age group 41-70 years and the lowest frequency was of the patients below the age of 20.

Out of 260, 209 patients were male having a percentage of 80.4%, whereas 51 were female with a percentage of 19.6%.

Based on various ultrasound parameters, the grading of renal parenchymal disease for right kidney was; 8.8% (n = 23) for grade 0, 62.3% (n = 162) for grade 1, 18.5% (n = 48) for grade 2, 6.9% (n = 18) for grade 3 and 3.5% (n = 9) for grade 4. Similarly, on left side, 8.5% (n = 22) subjects had grade 0 renal parenchymal disease, 57.7% (n = 150) had grade 1, 24.2% (n = 63) had grade two,

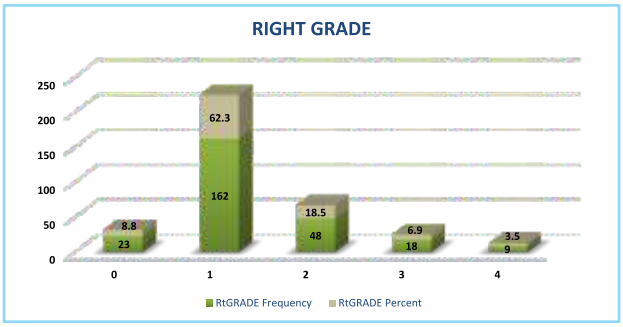

Fig.1: Frequency distribution of Renal Parenchymal Disease grades in right kidney

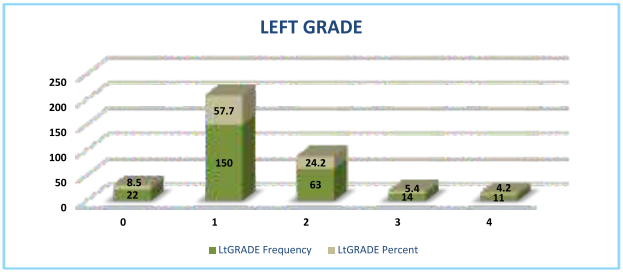

Fig.2: Frequency distribution of Renal Parenchymal Disease grades in left kidney

5.4% (n = 14) had grade three and 4.2% (n = 11) had fourth grade RPD. These trends are depicted by Figure.1 and 2. In right kidney, the grades of RPD and serum creatinine were found to be statistically significantly positively associated (r

= 0.340, *P* < 0.01). There was also a positive, strong association of serum creatinine with renal length (r = 0.198, *P* < 0.01) and corticomedullary differentiation (r = 0.317, *P* < 0.01). A positive connection was found between parenchymal echogenicity and creatinine values ® = 0.100, *P* = 0.106). (Table-1). Similarly, in left kidney, grades of RPD and serum creatinine were found to be statistically significantly positively linked (r = 0.359, *P* <0.01). A positive, strong association of serum creatinine with renal length (r = 0.143, *P* < 0.05), corticomedullary differentiation (r = 0.296, *P* < 0.01), parenchymal echogenicity (r = 0.145, *P* <0.05) was also estimated. (Table-2).

Table-1: Correlation investigation among ultrasound parameters of right kidney and serum creatinine

	Serum Creatinine		
USG Renal - Parameters (Right)	**No. of Patients**	**Pearson's Coefficient (r)**	***P*-value**
Length	260	0.198**	<0.01
Corticomedullary Differentiation	260	0.317**	<0.01
Echogenicity	260	0.100	0.106
Grade	260	0.340**	<0.01

*The significance level for correlation is 0.01 (2-tailed)***
*The significance level for correlation is 0.05 (2-tailed)**

Table-2: Correlation investigation among ultrasound parameters of left kidney and serum creatinine

	Serum Creatinine		
USG Renal -Parameters (Left)	**No. of Patients**	**Pearson's Coefficient (r)**	***P*-value**
Length	260	0.143*	0.05
Corticomedullary Differentiation	260	0.296**	<0.01
Echogenicity	260	0.145*	<0.05
Grade	260	0.359**	<0.01

*The significance level for correlation is 0.01 (2-tailed)***
*The significance level for correlation is 0.05 (2-tailed)**

Discussion

In the current investigation, sonological first-degree CKD was present in 62.3% of the participants in the right side of the kidney, Grade 2 in 18.5%, Grade 3 was found in 6.9%, and Grade 4 in 3.5% of patients. On the left side, there were 57.7% with a first-grade RPD, 24.2% with Grade 2, 5.4% with the third grade and 4.2% with Grade 4 RPD. 65 individuals were reported as having Grade one, 63 grade two, 40 Grade 3, and 32 fourth-grade CKD in a research by Khadka et al.[14] 35% of patients in a research by Singh A and collaborators had first-degree echogenicity, 42% had the second grade, 16% had a grade of 3, and 7% experienced Grade 4 echogenicity.[7] This conclusion is in line with what they discovered. Sonological grade one CKD was detected in 48.3%, grade two CKD in 35.5%, grade three CKD in 11.7%, and fourth-grade CKD in 5% of individuals in another study by Siddapa et al.[3] Because these patients are more likely to die from cardiovascular disease than from end-stage renal disease (ESRD), there aren't many patients in Grades three and four. Additionally, because the facility serves as a tertiary referral center, the majority of patients were treated with replacement renal function therapy and weren't included in the study.

The average creatinine level in the serum across the board in this study was 3.35 mg/dL. The mean levels of creatinine in the serum were

found to be 2.79 mg/dL for patients with grade 1 kidney disease (RPD) (with a range 0.24-14.51 mg/dL, deviation from the mean SD: 2.63), 4.11 mg/dL for patients with grade 2 RPD (with a range 0.62-18.37 mg/dL, SD: 4.10), 5.44 mg per deciliter for patients with grade 3 CKD (ranging from 0.79-12.84 mg/dL, SD: 3.98), and 7. Our findings demonstrated a statistically significant relationship (*P* value less than 0.01) among the classification of RPD with creatinine levels in serum. The average serum creatinine levels in the left kidney appeared 1.78 mg/dL for grade zero (with a range 0.64-5.2 mg/dL, SD: 1.08), 2.9 mg/dL for the first grade (range: 0.24-14.51 mg/dL, SD: 2.77), 3.72 mg/dL for grade 2, 0.59-18.37 mg/dL, SD: 3.92, 5.03 mg/dL for grade 3, 1.41-10.8 mg/dL, SD: 3.11, and 8. The grade of the disease in the left kidney, as well as creatinine levels in the serum, were statistically correlated, with a *P* value of 0.001 indicating statistical significance. The average serum creatinine levels increased as the grade of CKD increased, according to additional investigations by Singh A and colleagues and Siddapa JK et al.and collaborators, which contrasted and revealed comparable findings.[7,3]

According to the study's findings, there is a direct link between rising serum creatinine levels and a higher RPD grade. This was in line with the findings of Singh A et al., his colleagues, Siddapa JK, and his fellow researchers, which showed that the serum creatinine levels increased along with the grading of RPD.[7,3] These studies concluded that there was a strong association between elevated sonographic grading and elevated serum creatinine levels.

The current study found that as renal parenchymal disease (RPD) progresses, the renal parenchymal echogenicity, or the level of reflectiveness of ultrasound waves, increases. A decrease in renal function is linked to this rise in echogenicity. With time, the echogenicity of the renal sinus and the entire kidney parenchyma may combine, resulting in the echogenic appearance of the kidney as a whole.[15,16] The positive link between cortical echogenicity and the severity of renal failure can be explained by the findings of Rosenfield and Siegel, who discovered that the echogenicity of the kidneys is substantially connected with the degree of interstitial disease as seen in biopsy samples. They found that, in contrast to more extensive scarring, focal interstitial changes typically only produce a modest increase in cortical echogenicity.[17]

In conclusion, the study showed that the increase in RPD grading is positively associated with the extent of renal failure. The results suggest that increased renal cortical echogenicity is indicative of worsening renal function and the existence of interstitial fibrosis, glomerular sclerosis, the disappearance of either individual tubular epithelial cells or entire tubules, interstitial inflammation, and hyaline casts.[14] However, the results go against those of Platt JF et al. discovered that having liver and kidney echogenicity equal is not a reliable sign of illness.[18]

A Pearson's association score of 0.198 (*P* less than 0.01) in this investigation revealed a favorable association between serum creatinine and mean renal length. This finding contradicts the results of Siddappa et al. found a negative association between renal length and creatinine levels.[3] On the other hand, the results are in accordance with those of Lucisano et al. also reported a favorable relation between renal length and eGFR in adult patients with kidney disease.[19] A positive correlation means that as GFR decreases (indicating decreased renal function), renal length also decreases.[20]

Conclusion

In conclusion, the study suggests that ultrasonography based grading may be a reliable indicator of kidney function in patients with renal parenchymal disease. Furthermore, the advantage of using kidney echogenicity as an indicator is that it remains irreversible even with replacement kidney treatments such as hemodialysis and peritoneal dialysis, unlike serum creatinine levels that may improve with these treatments.

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Authors Contribution

LZ: Idea conception, study designing, data collection, data analysis, results and interpretation, manuscript writing and proofreading

MZA: Idea conception, data analysis, results and interpretation, manuscript writing and proofreading

SAK: Study designing, manuscript writing and proofreading

NA: Study designing, manuscript writing and proofreading

AA: Data analysis, results and interpretation

FI: Data collection