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CORRELATIVE ASSESSMENT OF THE LEVEL OF CREATININE IN SERUM WITH SONOLOGICAL GRADING OF CHRONIC RENAL FAILURE

Radio-Diagnosis

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ABSTRACT

Background: Chronic renal failure or chronic kidney disease (CKD) is a major contributor to renal failure and is characterized by a progressive decline in kidney function. Diagnosis can be established through histological changes, biochemical markers in blood or urine, or imaging studies. Ultrasound is the preferred imaging modality for CKD because it is non-invasive, widely available, and effective in visualizing renal structures. Sonographic features such as renal echogenicity, longitudinal length, parenchymal thickness, and cortical thickness reflect irreversible structural alterations that accompany disease progression. Serum creatinine, an endogenous marker, remains the standard biochemical measure for estimating glomerular filtration rate (GFR) and staging CKD. **Aims:** The purpose of this study is to correlate renal echogenicity with serum creatinine levels, assess its role in identifying progression of CKD, and explore the utility of sonographic imaging in grading the disease. **Conclusion:** In CKD, renal echogenicity and its grading show a stronger correlation with serum creatinine levels than other sonographic parameters. While serum creatinine is a key biochemical marker of renal function, echogenicity provides a more consistent sonographic indicator of irreversible renal damage. Thus, echogenicity serves as a preferred imaging parameter for estimating renal function. Ultrasonography, by combining echogenicity with other morphologic measurements, plays a pivotal role in CKD evaluation—facilitating accurate classification, monitoring disease progression, screening, and guiding individualized medical or surgical management.

KEYWORDS

Chronic kidney disease (CKD), renal echogenicity, ultrasonography, Serum creatinine level

INTRODUCTION:

Chronic kidney disease (CKD) is a frequent cause of renal failure and is marked by a gradual decline in kidney structure and function over several months, with or without a reduction in glomerular filtration rate (GFR). Diagnosis can be established through pathological changes, alterations in blood or urine markers of kidney function, or imaging studies. Ultrasound is the preferred imaging technique in CKD because it is non-invasive, widely accessible, and provides clear visualization of the kidneys. In fact, ultrasonography is often the first and, in many cases, the only imaging test required in evaluating chronic renal failure. A reduced sized kidney with a thin, raised echogenic cortex or parenchyma on ultrasound suggests irreversible damage. Since sonographic features such as echogenicity, kidney length, parenchymal thickness, and cortical thickness reflect permanent changes, ultrasound is particularly useful in monitoring disease progression. Serum creatinine, an endogenous marker, is commonly used to estimate GFR and staging of CKD. The purpose of this study is to correlate renal echogenicity with serum creatinine levels, assess its role in identifying progression of CKD, and explore the utility of sonographic imaging in grading the disease.

AIMS & OBJECTIVES:

- To analyze the relationship between renal echogenicity and serum creatinine concentrations.
- To determine the importance of renal echogenicity in tracking the progression of chronic kidney disease (CKD).
- To assess how ultrasonographic evaluation contributes to grading CKD severity.

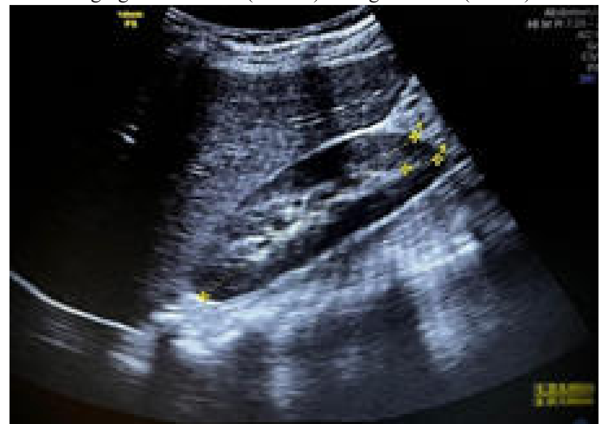
MATERIALS & METHODS:

This prospective study over a period of one year after getting ethical approval from our institution's committee was conducted at Rajarajeswari Medical College & Hospital . We enrolled 30 patients over 30 years diagnosed with CKD according to National Kidney Foundation guidelines, while excluding those receiving kidney replacement therapies or having liver conditions identified via ultrasound. Demographic information was thoroughly collected from participants, encompassing details such as age, sex, duration of diabetes (if applicable), duration of hypertension (if pertinent), additional factors contributing to chronic renal failure, and previous treatment history.

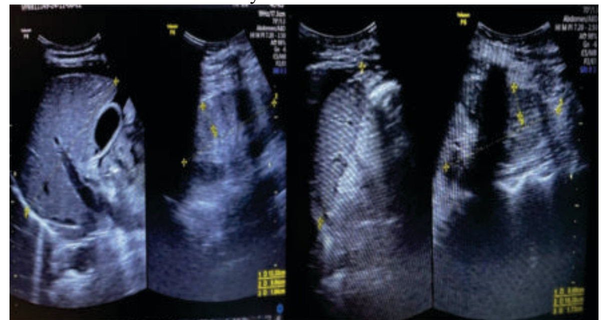
Using standard B-mode grayscale ultrasound (Voluson GE P8 and E8), we examined kidneys and livers utilizing curved array transducers operating at frequencies between 2.5–4 MHz while manually adjusting gain together with time gain compensation (TGC). Measurements included:

- Length of kidney: Measured pole-to-pole.
- Thickness of renal parenchyma: Measured from the hilum to the maximum convex border at the lateral margin.
- Thickness of renal: Assessed sagittally across medullary pyramids perpendicular to capsule.

For each case analyzed, average values were recorded for right and left kidneys' longitudinal dimensions along with parenchymal thicknesses and cortical thicknesses evaluated against liver tissue while establishing criteria for corticomedullary differentiation across graded scales ranging from Grade 0 (normal) through Grade 4 (severe).



Grade 0: Normal Echogenicity Is Less Than That Of The Liver, With Maintained Corticomedullary Differentiation



Grade 1: Echogenicity Is The Same As That Of The Liver, With Maintained Corticomedullary Differentiation

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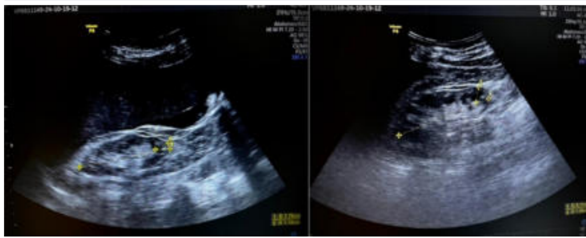
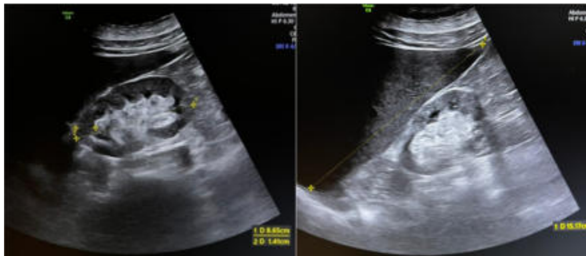
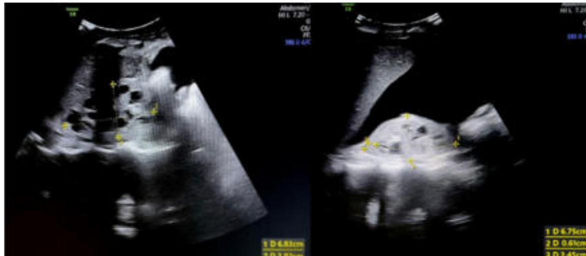


Grade 2: Echogenicity Is Greater Than That Of The Liver, With Maintained Corticomedullary Differentiation



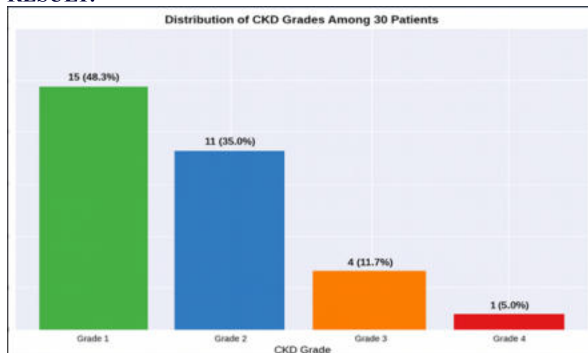
Grade 3: Echogenicity Is Greater Than That Of The Liver, With Poorly Maintained Corticomedullary Differentiation.



Grade 4: Echogenicity Is Greater Than That Of The Liver, With A Loss Of Corticomedullary Differentiation

For serum creatinine measurement, Samples of blood were collected from participating patients using the modified kinetic Jaffe method. Statistical analysis was carried out using one-way ANOVA(analysis of variance) followed by Scheffe's post hoc test. Correlation coefficient analysis was employed to explore relationships between serum creatinine levels and sonographic parameters with statistical significance set at $P < 0.05$.

RESULT:



A graphical representation indicates distributions among subjects: Sonological grade one CKD: 14 patients accounting for 48.3%; Grade two comprising 11 patients at 35%; Grade three indicating 04 patients representing 11.7%; Grade four consisting of 01 individuals making up 5%.

Among 30 selected subjects-21 males and 9 females-14 patients (48.3%) displayed sonological Grade one CKD; 11 patients (35%) exhibited Grade two; 04 patients (11.7%) had Grade three; 01 patient (5%) represented Grade four CKD (Figure 1). The mean serum creatinine for Grade one was 2.8 mg/dl (range: 0.9-9.2 mg/dl), for Grade two was 3.70 mg/dl (range: 1.2-10.3 mg/dl), for Grade three was 3.86 mg/dl (range: 1.1-6.5 mg/dl), and for Grade four was 7.9 mg/dl (range: 3.1-11.4 mg/dl) [Table 1]. The mean longitudinal size for Grade one was 101.38 mm (range: 76-124 mm), for Grade two was 91.43 mm (range: 63-115 mm), for Grade three was 89.43 mm (range: 60-111 mm), and for Grade four was 78 mm (range: 67-91 mm) (Table 2). The mean parenchymal thickness for Grade one was 47.38 mm (range: 37-61 mm), for Grade two was 41.14 mm (range: 30-61 mm), for Grade three was 40 mm (range: 21-50 mm), and for Grade four was 37.33 mm (range: 31-44 mm) (Table 3). The mean cortical thickness for Grade one 15.59 mm (range: 10-24 mm), for Grade two was 12.86 mm (range: 7-21 mm), and for Grade three was 11.33 mm (range: 9-14 mm). The cortical thickness cannot be measured in Grade 4 CKD due to loss of corticomedullary differentiation (Table 4).

The bar graph illustrates that most individuals within the general CKD population fall under early-stage categories, where Grades One and Two are predominant. Advanced stages corresponding with Grades Three and Four are less frequent but carry higher clinical significance, requiring follow-up scans for ongoing monitoring and intervention needs. The visual representation underscores recognizing early-stage burdens associated with CKD, along with emphasizing critical importance of early detection.

The Mean Serum Creatinine Levels Relationship With Grading Of CKD (Table 1):

CKD Grade (renal cortical echogenicity grading)	No. of Patients	Percentage	Mean Serum Creatinine (mg/dl)	Range (mg/dl)
Grade 1	14	48.3%	2.8	0.9 – 9.2
Grade 2	11	35%	3.70	1.2 – 10.3
Grade 3	4	11.7%	3.86	1.1 – 6.5
Grade 4	1	5%	7.9	3.1 – 11.4
Total	**30**	**100%**	—	

The Mean Longitudinal Size Varied Across Grades (Table 2):

CKD Grade (renal cortical echogenicity grading)	Mean (mm)	Range (mm)
Grade 1	101.38	76–124
Grade 2	91.43	63–115
Grade 3	89.43	60–111
Grade 4	78.00	67–91

The Mean Parenchymal Thickness Findings Were (Table 3):

CKD Grade (renal cortical echogenicity grading)	Mean (mm)	Range (mm)
Grade 1	47.38	37–61
Grade 2	41.14	30–61
Grade 3	40.00	21–50
Grade 4	37.33	31–44

The Mean Cortical Thickness Metrics Were (Table 4):

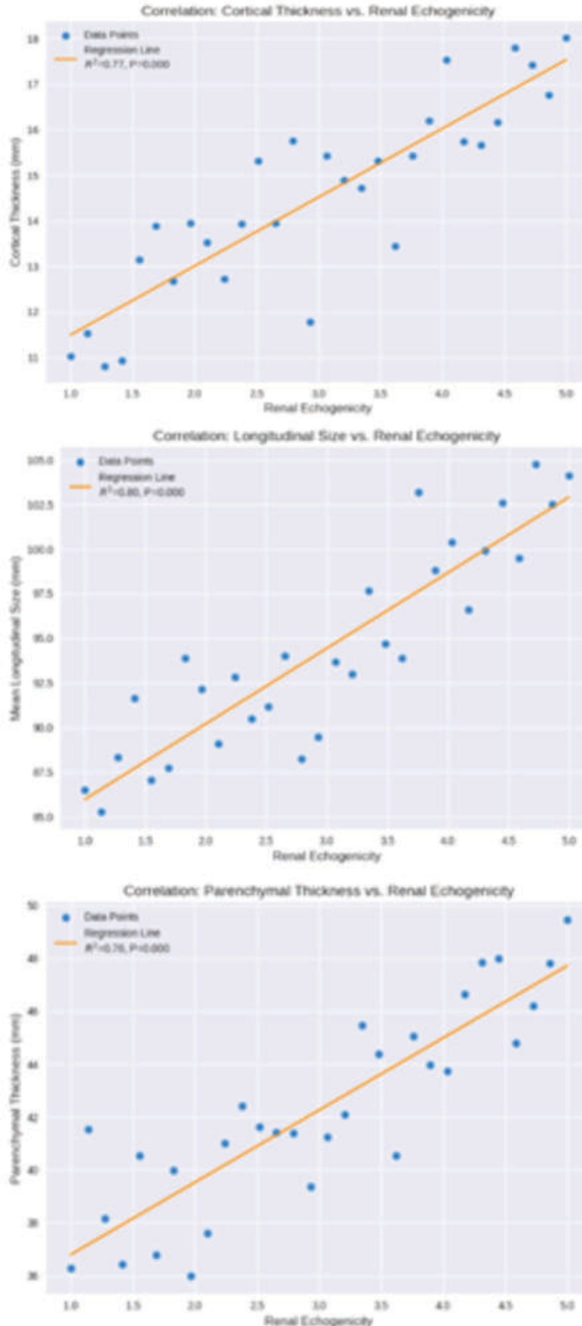
CKD Grade (renal cortical echogenicity grading)	Mean (mm)	Range (mm)
Grade 1	15.59	10–24
Grade 2	12.86	7–21
Grade 3	11.33	9–14
Grade 4	—	—

DISCUSSION:

Our findings indicate substantial positive correlations between mean longitudinal size along with various measures related to renal echogenicity including parenchymal thickness demonstrating that increased echogenicity correlates inversely with average values assessed for parenchymal evaluation. A conclusion that aligns with current literature emphasizes the consistent relationships identified between histopathological features observed in ultrasonographic assessments, such as tubular atrophy and interstitial fibrosis, as previously cited by researchers like Moghazi et al., who asserted "renal echogenicity has the strongest correlation with histologic parameters." Prior research conducted by Päivänsalo indicated that "the most frequent abnormality was a highly echogenic cortex." In contrast, our findings differ somewhat from those of Platt et al., who noted that "renal echogenicity comparable to that seen in the liver is not an effective indicator." Rosenfield & Siegel described "normal renal echogenicity being lower than hepatic echogenicity amongst typical populations, revealing better differences encountered when comparing echoes between hepatic tissues versus those found within renal tissues themselves".

A significant positive correlation emerged linking serum creatinine concentrations against cortical echogenic grades assigned (P=0.004).

A remarkable statistically significant positive association was noted between grading levels assigned based upon echogenicity of kidneys compared against average longitudinal size (P=0.006) metrics, leading us towards concluding measurement associated with lengths should be prioritized over volume measurements when evaluating overall function levels because the value of renal length decreases with decreasing renal function. A detailed analysis conducted by Miletić et al, revealed that "relative size of kidney (measured using kidney length to body height ratio) preferably represents kidney size more than absolute renal length (measurements of longitudinal renal diameter) because it eliminates sex and height variances."



There was also a statistically remarkable positive association noted between renal echogenicity grading and parenchymal thickness (P = 0.009). As the echogenicity enhances, the mean parenchymal thickness declines. Research conducted by Moghazi et al, noted that "instead of cortical thickness, parenchymal thickness correlated with tubular atrophy [8]".

There was a statistically significant positive association between the grading of echogenicity of kidneys and the thickness of renal cortex (P = 0.008). As the echogenicity enhanced, there was a decline in mean cortical thickness.

A statistically significant inverse relationship was identified between the average longitudinal size and serum creatinine levels (P = 0.085). Similarly, a remarkable negative correlation was noted between mean parenchymal thickness and serum creatinine (P = 0.046), while the association between mean cortical thickness and serum creatinine was also statistically significant but less pronounced (P = 0.656).

Furthermore, the P value correlation with renal echogenicity (P = 0.004) was noted statistically more significant than those for average longitudinal size (P = 0.006), mean parenchymal thickness (P = 0.009), and mean cortical thickness (P = 0.008). (Table 5).

Since changes in echogenicity of the kidneys are irreversible, an ultrasonographic grading of CKD can be carried out, allowing the severity of chronic kidney disease to be followed up.

Our research demonstrated significant positive correlations between serum creatinine levels and the grading of renal echogenicity (P = 0.004) [Table 1], spanning from Grade 1 to Grade 4 chronic kidney disease (CKD). In a study conducted by Moghazi et al., it was noted that "renal echogenicity exhibits the most robust correlation with histological indicators, including glomerular sclerosis, tubular atrophy, interstitial fibrosis, and interstitial inflammation. A rise in serum creatinine is associated with heightened echogenicity in the renal cortex."

(Table 5): Statistical Correlation Between Serum Creatinine, Renal Echogenicity And Mean Longitudinal Size, Mean Parenchymal Thickness, And Mean Cortical Thickness

Parameter	Correlation with Creatinine	P Value (Correlation)	P Value (Comparative Significance)	Interpretation
Mean longitudinal size	Negative association	0.085 (NS)	0.006 (Significant)	Weak correlation, but significant in group comparison
Mean Parenchymal thickness	Negative	0.046 (Significant)	0.009 (Significant)	Stronger correlation and significant difference
Mean Cortical thickness	Negative (weak)	0.656 (NS)	0.008 (Significant)	No correlation, but group difference noted
Mean Renal echogenicity	Positive association	-	0.004 (Highly significant)	Strongest predictor among imaging parameters

CONCLUSION:

In chronic kidney disease, renal echogenicity and its grading demonstrate a stronger correlation with serum creatinine levels compared to other sonographic parameters. While longitudinal size (P = 0.085), parenchymal thickness (P = 0.046), and cortical thickness (P = 0.656) show weaker or less consistent associations, echogenicity emerges as the most reliable imaging marker. Since serum creatinine serves as a key indicator of renal function, echogenicity provides a more robust sonographic reflection of kidney impairment.

Renal echogenicity and its classification are associated with ultrasound metrics such as the length of the kidney, thickness of the parenchyma, and cortical thickness. The echogenicity of the kidneys is regarded as a more reliable indicator for assessing renal function, particularly because it remains unchanged compared to serum creatinine levels, which can improve with treatments like hemodialysis, peritoneal dialysis, and kidney transplantation in cases of chronic kidney disease.[17]

Ultrasonography is essential for assessing the kidneys in chronic renal failure cases. It allows for accurate classification, monitoring disease progression, screening for the condition, and supporting customized medical or surgical interventions. The implementation of Sonographic Grading of Renal Cortical Echogenicity enhances diagnostic precision and treatment results. It is important for radiologists to be knowledgeable about this classification system and the associated kidney anatomy to ensure optimal patient care.

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