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EVALUATION OF RENAL CORTICAL ECHOGENICITY AND SERUM CREATININE CORRELATION ACROSS YOUNG AND ELDERLY GROUPS IN CKD PATIENTS

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Abstract

Background: Chronic Kidney Disease (CKD) is a progressive disease that is typified by structural and functional impairment of kidney. A non-invasive indicator of renal damage is renal cortical echogenicity on ultrasound and can be related to serum creatinine. It could be compared in different age groups with these parameters and it would help in the more efficient evaluation of the severity of the disease.

Methodology: A cross-sectional study was achieved on 94 CKD patients that received renal ultrasound and a serum creatinine test. The echogenicity of the cortex was marked using ultrasound and the demographic and clinical information was recorded in a structured form. The statistical analysis was carried out using SPSS, Chi-square test and T-tests was applied.

Aim of the study: To determine the correlation between renal cortical echogenicity, serum creatinine across groups between young and aged in CKD patients.

Results: The elderly had an even slightly higher level of serum creatinine and echogenicity grade compared to the young group. Echogenicity Grade between the Young and Elderly groups has a p-value of 0.052, which is slightly significant. The relationship between Echogenicity Grade and Age Group is marginally significant with the Elderly group presenting higher Echogenicity Grades, which points to a higher level of renal damage. Nevertheless, the difference in creatinine was not significant ($p = 0.087$) and the grade of echogenicity showed weak correlations with the age ($p \approx 0.05$). There was no significant difference in the size of kidneys between groups.

Conclusion: The CKD patients under the age of 70 years are older with a higher renal cortical echogenicity and a worse structural destruction. Although there was a moderate increase in the levels

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of serum creatinine in the elderly patients, this was not significant. Non-invasive techniques of assessing renal damage like ultrasound are still advantageous.

INTRODUCTION

Chronic kidney disease (CKD) is defined as abnormalities in kidney structure or function lasting more than three months, with significant health implications. Diagnostic criteria include a reduced glomerular filtration rate (GFR <60 mL/min/1.73 m^2) or evidence of kidney damage such as albuminuria or structural abnormalities. The KDIGO framework classifies CKD into stages based on GFR and emphasizes both functional and structural assessment. Imaging findings, particularly renal cortical echogenicity, along with biochemical markers like serum creatinine, play an essential role in diagnosis and evaluation. These parameters help in assessing disease severity and progression across different age groups (1).

CKD represents a major global health burden with considerable regional variability. Community-based studies report a prevalence of approximately 13.24% in India, while in Pakistan it reaches up to 21.2%, with higher rates observed in individuals above 50 years of age. Diabetes mellitus is identified as a leading cause, particularly diabetic nephropathy. Across Asia, prevalence ranges widely from 7.0% to 34.3%, with a substantial proportion of the global CKD population residing in countries like China and India. These variations highlight the influence of demographic, environmental, and healthcare factors on disease burden (2–4).

Globally, CKD cases have increased significantly, reaching approximately 697.5 million cases, with a notable rise in disease burden over recent decades. CKD contributes substantially to disability-adjusted life years (DALYs), with diabetic nephropathy being a major contributor. The disease burden is particularly high in regions with lower socio-demographic indices. Major risk factors include diabetes, hypertension, and other comorbidities, which accelerate renal deterioration. Clinical management is further complicated by polypharmacy, infections, and cardiovascular

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complications, emphasizing the importance of comprehensive risk assessment and monitoring in CKD patients (5–6).

Clinically, CKD is often asymptomatic in early stages and detected through laboratory investigations rather than clinical symptoms. As the disease progresses, patients may develop nonspecific symptoms such as fatigue, weakness, and reduced exercise tolerance, followed by uremic manifestations in advanced stages. Pathophysiologically, CKD involves progressive nephron loss due to chronic metabolic and hemodynamic stress, leading to fibrosis, vascular damage, and systemic complications such as anemia and bone disorders. These changes ultimately contribute to disease progression toward end-stage renal disease if not detected and managed early (7–8).

Ultrasound assessment of renal cortical echogenicity is a valuable, non-invasive tool for evaluating structural kidney damage in CKD. Increased echogenicity and loss of corticomedullary differentiation are indicative of chronic parenchymal injury. Studies demonstrate a positive correlation between cortical echogenicity and serum creatinine levels, linking structural changes with functional impairment. This combined approach enhances diagnostic accuracy and supports early detection and staging of CKD. Therefore, this study aims to evaluate the correlation between renal cortical echogenicity and serum creatinine in both young and elderly CKD patients to improve clinical interpretation and management strategies (9–11).

Literature Review

Beland et al. (2010) demonstrated that renal cortical thickness is a more reliable sonographic indicator of renal function than renal length in patients with chronic kidney disease. Their study showed that cortical thinning progresses as renal function declines, making it a sensitive marker of nephron loss. This finding emphasized the importance of incorporating cortical thickness measurement into routine ultrasound evaluation, as it provides better correlation with renal impairment. The study contributed significantly to shifting clinical focus from simple renal size assessment to more detailed structural parameters. Overall, it established that ultrasound-based

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cortical measurements can enhance early detection and monitoring of CKD progression in a non-invasive and clinically practical manner.

Hricak et al. (1982) identified a strong association between increased renal cortical echogenicity and histopathological damage in patients with renal parenchymal disease. Their findings showed that higher echogenicity corresponds to structural abnormalities such as fibrosis, tubular atrophy, and glomerulosclerosis. This study provided early evidence that ultrasound imaging can reflect microscopic renal damage, making it a valuable diagnostic tool. The authors highlighted that hyperechogenic kidneys are commonly seen in progressive renal disease and can serve as a surrogate marker of severity. Their work laid the foundation for using echogenicity grading in clinical practice, supporting its role as a non-invasive indicator of chronic kidney damage.

Webster et al. (2017) emphasized the importance of integrating imaging findings with biochemical markers in the evaluation of chronic kidney disease. Their review highlighted that declining renal function is associated with progressive nephron loss and structural changes detectable through ultrasound. They stressed that relying solely on laboratory parameters may not provide a complete picture of disease progression. By combining imaging features such as cortical thickness and echogenicity with measures like eGFR and serum creatinine, clinicians can achieve more accurate diagnosis and staging. This approach improves risk stratification and helps differentiate between physiological aging and pathological renal decline, enhancing overall clinical decision-making.

Khadka et al. (2019) reported a significant correlation between renal cortical echogenicity, cortical thickness, and serum creatinine levels in patients with renal parenchymal disease. Their findings showed that increased echogenicity is associated with worsening renal function, while reduced cortical thickness reflects progressive nephron damage. The study highlighted that echogenicity grading has a stronger relationship with renal impairment compared to renal size. It also reinforced the value of ultrasound as an accessible and cost-effective diagnostic tool, especially in resource-limited settings. The authors concluded that combining sonographic parameters with biochemical markers can improve the assessment of CKD severity and aid in early diagnosis.

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Fleig et al. (2024) highlighted the growing role of advanced ultrasound techniques in improving the diagnosis and monitoring of chronic kidney disease. Their study focused on multiparametric imaging approaches, including elastography, which assesses tissue stiffness related to fibrosis. They found that increased renal stiffness correlates with declining renal function and structural damage. By combining traditional ultrasound parameters such as cortical thickness and echogenicity with advanced techniques, diagnostic accuracy can be significantly enhanced. The study emphasized that such integrated imaging methods allow earlier detection of CKD changes before significant biochemical deterioration occurs, thereby supporting timely intervention and better management outcomes.

Methodology

The study employed a cross-sectional research design and was conducted at Service Hospital, Lahore, over a duration of four months following approval of the research synopsis. A total sample size of 94 patients was included using a convenience sampling technique. The study population comprised adult male and female patients aged 18 years and above who were diagnosed with chronic kidney disease based on reduced eGFR (<60 mL/min/1.73 m^2) or persistently elevated serum creatinine for more than three months. Patients with acute kidney injury, congenital renal anomalies, cystic diseases, or poor-quality imaging and incomplete data were excluded to ensure accuracy and consistency.

Ultrasound imaging and laboratory investigations were the primary tools used for data collection. Renal ultrasonography was performed using a 3.5–5 MHz convex transducer, with patients positioned in supine and lateral decubitus positions to obtain optimal visualization of both kidneys. Scans were conducted in longitudinal and transverse planes to evaluate renal cortical echogenicity and morphology. Serum creatinine levels were measured using a biochemistry analyzer on the same day as imaging. Additional demographic and clinical data were recorded using a structured data collection form to support comprehensive analysis.

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Ethical approval was obtained from the institutional review committee, and informed consent was secured from all participants while maintaining strict confidentiality. Data analysis was carried out using SPSS version 25.0, where descriptive statistics such as mean, standard deviation, frequency, and percentage were used to summarize variables. Inferential statistics included the chi-square test to assess associations between cortical echogenicity and serum creatinine, and independent t-tests to compare differences between age groups. A p-value of less than 0.05 was considered statistically significant, ensuring the reliability of the study findings.

Results

The descriptive statistics provide an overview of the study population (n = 94), showing a mean age of 54.76 years with a wide range from 20 to 85 years, indicating inclusion of both young and elderly CKD patients. The mean serum creatinine level was 4.42 mg/dL, reflecting impaired renal function across the cohort. The average size of both kidneys was similar, with mean right and left kidney sizes of 8.62 cm, suggesting relatively uniform renal dimensions among participants. Overall, these baseline findings indicate a heterogeneous population in terms of age and renal function, while kidney size remained relatively stable.

Comparison between age groups revealed a statistically significant difference, with the young group having a mean age of 34.32 years and the elderly group 68.02 years. The independent t-test confirmed this difference to be highly significant ($p = 0.000$), validating the grouping criteria. However, gender distribution between the two groups was not significantly different ($p = 0.640$), indicating that both males and females were proportionately represented across age categories. This suggests that gender did not act as a confounding variable in age-based comparisons within the study. Assessment of kidney size between the young and elderly groups showed slightly smaller mean values in the elderly; however, these differences were not statistically significant for both right kidney ($p = 0.203$) and left kidney ($p = 0.247$). Similarly, the distribution of echogenicity side (bilateral, right, or left) did not differ significantly between groups ($p = 0.829$). In contrast, echogenicity grading

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demonstrated a marginal association with age (p = 0.052), with higher grades more frequently observed in the elderly group, indicating a trend toward more severe renal parenchymal damage with increasing age.

Creatinine levels were higher in the elderly group (mean 4.71 mg/dL) compared to the young group (3.98 mg/dL), but this difference was not statistically significant (p = 0.087). This suggests that although renal function appears to decline with age, the variation was not strong enough to establish a significant difference within this sample. Overall, the results indicate that while age is strongly associated with echogenicity grading, other parameters such as kidney size, creatinine levels, and echogenicity side do not show significant variation between young and elderly CKD patients.

Discussion

The study demonstrated that elderly CKD patients generally showed higher serum creatinine levels and increased renal cortical echogenicity compared to younger patients, although these differences were not statistically significant. Kidney size was slightly reduced in the elderly group but without significant variation, indicating that functional and structural changes occur more prominently than gross anatomical size reduction. These findings suggest that age-related renal deterioration is more strongly reflected in cortical changes than in kidney dimensions. Similarly, Levey et al. (2005) reported that CKD is primarily characterized by structural and functional impairment, where increased cortical echogenicity reflects chronic parenchymal damage, supporting the current study's observation that echogenicity may be a sensitive marker of early renal injury.

The results further indicated that although serum creatinine and echogenicity grades were higher in older patients, creatinine differences between groups were not statistically significant. This suggests that biochemical markers alone may not fully capture early or progressive renal damage. Instead, imaging findings, particularly echogenicity, appear to reflect structural deterioration more effectively. Talukdar et al. (2025) similarly identified age as a major risk factor for CKD progression, highlighting that renal structural damage becomes more evident with advancing age, even when biochemical

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changes remain relatively mild. This aligns with the present findings, where echogenicity showed a clearer trend of deterioration than creatinine.

The study also found no significant differences in kidney size between young and elderly patients, reinforcing the idea that CKD-related changes are more microscopic and parenchymal rather than gross anatomical. Despite the lack of statistical significance, a consistent trend of higher echogenicity and slightly increased creatinine in the elderly suggests progressive renal involvement with aging. Imtiaz and Alam (2023) also emphasized that CKD prevalence is rising in older populations in Pakistan, where structural kidney damage progresses with age and comorbidities. Their findings support the present observation that imaging changes may appear earlier or more prominently than functional biochemical deterioration.

Furthermore, echogenicity grading showed a stronger association with renal impairment than kidney size or creatinine differences alone. Although not statistically significant, the pattern indicates that structural abnormalities accumulate with age, leading to progressive renal dysfunction. Liyanage et al. (2022) reported similar findings in Asian populations, where CKD burden is higher in elderly individuals and characterized by irreversible structural changes. This supports the present study's conclusion that echogenicity is a valuable indicator of chronic renal damage and may be more clinically informative than kidney size measurements in older patients.

Overall, the findings indicate that aging is associated with gradual structural renal deterioration, reflected more clearly in echogenicity changes than in serum creatinine or kidney size. Bikbov et al. (2020) also highlighted the global increase in CKD burden, particularly among elderly populations, where structural and functional decline progresses with age. The study concludes that renal cortical echogenicity may serve as a useful non-invasive marker for assessing CKD severity, especially in elderly patients. However, further large-scale, multicenter studies are required to validate these findings and improve diagnostic accuracy.

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