Original Article

Integration of Biochemical Markers and Radiological Imaging for the Evaluation of Pulmonary Fibrosis in Mirpur, AJK

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ABSTRACT

Objective: To Integrate Biochemical Markers and Radiological Imaging for the Evaluation of Pulmonary Fibrosis in Mirpur, AJK.

Study Design: Cross-sectional study

Place and Duration of Study: This study was conducted at the Department of Radiology and Biochemistry & Mohi-ud-Din Islamic Medical College, Mirpur AJK, from 10th April 2023 to 10th March, 2024.

Methods: This cross-sectional study was conducted collaboratively by the Department of Biochemistry and the Department of Radiology, Mirpur AJK. A total of 200 patients with confirmed Chronic Kidney Disease (CKD. Blood samples were collected carefully after overnight fasting. Serum creatinine was measured reliably using the Jaffe kinetic method, while serum sodium, potassium, calcium, and phosphate were analyzed accurately with an automated electrolyte analyzer. Radiological evaluation was performed routinely in the Department of Radiology using ultrasonography with a 3.5–5 MHz convex transducer. Data were analyzed statistically using SPSS 21.

Results: Radiological assessment demonstrated abnormalities occurring predominantly. Reduced renal size was observed commonly in 153 patients (77.3%), while increased cortical echogenicity appeared most frequently, affecting 166 patients (82.6%). Additionally, loss of corticomedullary junction developed notably in 132 patients (66.6%), whereas renal cysts emerged occasionally in 48 patients (24.7%) and hydronephrosis occurred rarely in 22 patients (10.6%). Correlation analysis revealed that serum creatinine correlated inversely and significantly with renal size ($r = –0.63$, $p < 0.001$). Conversely, creatinine correlated positively and strongly with cortical echogenicity ($r = +0.72$, $p < 0.001$) and loss of corticomedullary junction ($r = +0.67$, $p < 0.001$). A moderate positive correlation appeared with renal cysts ($r = +0.31$, $p = 0.012$), whereas hydronephrosis correlated weakly and insignificantly ($r = +0.27$, $p = 0.08$)

Conclusion: When jointly and integratively interpreted, biochemical parameters and radiological features comprehensively and accurately explain CKD progression. This approach not only diagnostically enhances accuracy but also clinically and timely supports decision-making and individually guides patient care

Key Words: Biochemical, Radiological, Pulmonary Fibrosis

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INTRODUCTION

Chronic Kidney Disease (CKD) is globally increasingly recognized as a major public health problem that progressivelly impacts morbidity and mortality.[1]

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It is clinically characteristically manifested by a decline in renal function, which is diagnostically monitored through serum creatinine levels and electrolytic profiles.[2] Serum creatinine serves diagnostically as one of the most widely utilized markers for renal dysfunction, as its concentration indicatively rises with decreasing glomerular filtration rate (GFR).[3] Simultaneously, electrolyte imbalances, including hyperkalemia, hyponatremia, hypocalcemia, and hyperphosphatemia, are frequently observably present in CKD patients, contributing detrimentally to cardiovascular and systemic complications.[4]

Radiological imaging, including ultrasonography, CT, and MRI, is evaluatively employed to provide morphologic insight into renal size, cortical thickness, and structural abnormalities, which correlatively complement biochemical findings.[6]Integration of

biochemical markers with radiological features permits early diagnostical recognition of CKD progression, thereby allowing preventive and therapeutic interventions to be strategically implemented.[5]

In regions like Mirpur, AJK, where access to advanced healthcare facilities is comparatively limited, simple and reliable biochemical parameters such as serum creatinine, along with basic radiological modalities like ultrasound, can be effectively utilized to monitor CKD progression.[6] Previous studies have consistently demonstrated that higher serum creatinine levels correlatively associate with ultrasonographic findings of reduced renal size, cortical thinning, and altered echogenicity.[7] Additionally, electrolyte disturbances have been systemically shown to directly impact radiological changes, highlighting the interplay between metabolic derangements and structural kidney pathology.[8]

Therefore, exploring the correlation of serum creatinine and electrolyte imbalance with radiological changes in CKD patients can provide a cost-effective and regionally relevant approach for diagnostic evaluation, risk stratification, and management planning.[9]

METHODS

This cross-sectional study was conducted collaboratively by the Department of Biochemistry and the Department of Radiology, Mirpur AJK. A total of 200 patients with confirmed Chronic Kidney Disease (CKD), classified systematically into stages 1–5 based on estimated glomerular filtration rate (eGFR), were enrolled. Patients younger than 18 years, those with acute kidney injury, obstructive nephropathy, or concurrent severe systemic disorders, were excluded strictly.

Blood samples were collected carefully after overnight fasting. Serum creatinine was measured reliably using the Jaffe kinetic method, while serum sodium, potassium, calcium, and phosphate were analyzed accurately with an automated electrolyte analyzer.

Radiological evaluation was performed routinely in the Department of Radiology using ultrasonography with a 3.5–5 MHz convex transducer. The parameters were assessed consistently, including renal size, cortical echogenicity, cortico medullary differentiation, cyst formation, and hydronephrosis. Radiological grading of echogenicity and corticomedullary junction visibility was followed meticulously according to standard diagnostic guidelines.

Data were analyzed statistically using SPSS 21. Descriptive statistics were applied appropriately for demographic and biochemical variables. Pearson's correlation coefficient was used analytically to determine the relationship between serum creatinine, electrolyte levels, and radiological findings, with a p-value <0.05 considered statistically significant.

RESULTS

In this study, 200 patients with chronic kidney disease (CKD) were systematically evaluated. The average age was 52.6 ± 13.4 years, with males representing 129 (63%) and females 73 (37%). Hypertension occurred consistently in 127 patients (63.2%), while diabetes mellitus appeared regularly in 83 patients (42.0%). The mean duration of CKD extended steadily to 5.21 ± 2.11 years (Table 1).

Biochemical assessment across CKD stages showed that serum creatinine increased progressively, ranging from 1.21 ± 0.3 mg/dL in stage 1 to 7.21 ± 2.3 mg/dL in stage 5. Electrolyte abnormalities developed gradually with disease advancement. In stage 5, hyponatremia emerged frequently (40.3%), hyperkalemia appeared increasingly (33.4%), hypocalcemia occurred predominantly (47.3%), and hyperphosphatemia presented maximally (52.5%) compared to earlier stages (Table 2).

Table No. 1: Demographic and Clinical Characteristics of CKD Patients (n = 200)

Variable	Value	Percentage (%)
Mean Age (years)	52.6 ± 13.4	–
Gender (Male/Female)	129 / 73	63 / 37
Hypertension	127	63.2
Diabetes Mellitus	83	42.0
Mean Duration of CKD (years)	5.21 ± 2.11	

Radiological assessment demonstrated abnormalities occurring predominantly. Reduced renal size was observed commonly in 153 patients (77.3%), while increased cortical echogenicity appeared most frequently, affecting 166 patients (82.6%).

Table No. 2: Biochemical Profile Across CKD Stages (n = 200)

CKD Stage	Serum Creatinine (mg/dL)	Hyponatremia (%)	Hyperkalemia (%)	Hypocalcemia (%)	Hyper-phosphatemia (%)
Stage 1	1.21 ± 0.3	5.0	3.0	7.1	6.1
Stage 2	2.12 ± 0.5	10.6	7.6	12.1	15.1
Stage 3	3.41 ± 0.9	18.1	15.6	22.1	28.1
Stage 4	5.12 ± 1.4	28.1	25.1	38.1	44.1
Stage 5	7.21 ± 2.3	40.3	33.4	47.3	52.5

Table No. 3: Radiological Findings in CKD Patients (n = 200)

Radiological Feature	Frequency (n)	Percentage (%)
Reduced Renal Size	153	77.3
Increased Cortical Echogenicity	166	82.6
Loss of Corticomedullary Junction	132	66.6
Renal Cysts	48	24.7
Hydronephrosis	22	10.6

Table No. 4: Correlation of Serum Creatinine with Radiological Findings

Radiological Parameter	Correlation Coefficient (r)	p-value
Renal Size	–0.63	<0.001
Cortical Echogenicity	+0.72	<0.001
Loss of Corticomedullary Junction	+0.67	<0.001
Renal Cysts	+0.31	0.012
Hydronephrosis	+0.27	0.08

Table No. 5: Association of Electrolyte Imbalance with Radiological Severity

Electrolyte Abnormality	Radiological Feature Associated	Strength of Association	p-value
Hyponatremia	Severe Cortical Echogenicity	Strong	<0.001
Hyperkalemia	Loss of Cortico-medullary Junction	Strong	<0.001
Hypocalcemia	Parenchymal Atrophy	Moderate	0.003
Hyperphos-phatemia	Loss of Cortico-medullary Junction & Atrophy	Strong	<0.001

Additionally, loss of corticomedullary junction developed notably in 132 patients (66.6%), whereas renal cysts emerged occasionally in 48 patients (24.7%) and hydronephrosis occurred rarely in 22 patients (10.6%) (Table 3).

Correlation analysis revealed that serum creatinine correlated inversely and significantly with renal size ($r = –0.63$, $p < 0.001$). Conversely, creatinine correlated positively and strongly with cortical echogenicity ($r = +0.72$, $p < 0.001$) and loss of corticomedullary junction ($r = +0.67$, $p < 0.001$). A moderate positive correlation appeared with renal cysts ($r = +0.31$, $p = 0.012$), whereas hydronephrosis correlated weakly and insignificantly ($r = +0.27$, $p = 0.08$) (Table 4).

Electrolyte imbalances associated significantly with radiological severity. Hyponatremia associated strongly with severe cortical echogenicity ($p < 0.001$), while hyperkalemia linked strongly with loss of corticomedullary junction ($p < 0.001$). Hypocalcemia correlated moderately with parenchymal atrophy ($p = 0.003$), whereas hyperphosphatemia associated strongly with both corticomedullary loss and parenchymal atrophy ($p < 0.001$) (Table 5).

DISCUSSION

The findings of this research emphatically support the strong correlation between biochemical derangements and radiological abnormalities in CKD. Serum creatinine, as a widely available biochemical marker, has been demonstratively shown to rise progressively with declining renal function, thereby correlatively aligning with radiological evidence of renal atrophy, cortical thinning, and increased echogenicity.[10] This correlation is consistently observable across multiple studies, suggesting that biochemical and radiological assessments should be complementarily employed for reliable evaluation of CKD progression.[11]

Electrolyte imbalance also plays a significantly contributory role in CKD-related morbidity and mortality. Hyperkalemia is clinically dangerously associated with arrhythmias, hyponatremia adversely influences neurological status, while disturbances in calcium and phosphate homeostasis structurally contribute to vascular calcification and renal osteodystrophy.[12] These biochemical abnormalities not only worsen patient outcomes but are also radiologically reflectable in terms of changes in renal parenchymal structure and calcification patterns.[13]

Studies have evidentially shown that ultrasound findings of reduced kidney size, loss of corticomedullary differentiation, and increased echogenicity correlatively match with elevated serum creatinine and electrolyte disturbances.[14]

Importantly, integrating biochemical markers with radiological imaging can significantly strengthen the diagnostic accuracy for CKD. For example, patients with moderate elevations of serum creatinine but with marked ultrasonographic changes may be diagnostically prioritized for earlier intervention.[15] Conversely, electrolyte imbalances in the absence of major radiological abnormalities can be clinically interpreted as early reversible stages of CKD, thereby preventively allowing for lifestyle or pharmacological corrections.

Thus, the combination of serum creatinine, electrolyte profiling, and radiological evaluation represent a synergistically powerful approach for the comprehensive assessment of CKD. This approach is particularly valuable in regions with limited resources, where reliance on readily available tests and imaging can substantially improve diagnostic and therapeutic outcomes.[16]

CONCLUSION

The present study conclusively highlights that serum creatinine and electrolyte disturbances are closely correlatively associated with radiological alterations observed in patients with Chronic Kidney Disease (CKD). Serum creatinine consistently and progressively reflects the decline in renal function, while electrolyte imbalances adversely and significantly contribute to systemic complications that detrimentally aggravate disease outcomes. Radiological imaging, particularly ultrasonography, effectively and complementarily aligns with biochemical findings by structurally and diagnostically evidencing renal parenchymal damage and disease progression.

When jointly and integratively interpreted, biochemical parameters and radiological features comprehensively and accurately explain CKD progression. This approach not only diagnostically enhances accuracy but also clinically and timely supports decision-making and individually guides patient care. For regions such as Mirpur, AJK, where healthcare resources are commonly limited, the combined application of serum creatinine, electrolyte profiling, and radiological evaluation practically, cost-effectively, and reliably demonstrates a diagnostic model. Such integration beneficially strengthens early detection, optimally guides treatment strategies, and ultimately improves patient outcomes.

Author's Contribution:

Concept & Design or acquisition of analysis or interpretation of data:	Memona Nazir, Saqib Ismail, Tahira Sanaullah
Drafting or Revising Critically:	Zahid Saeed, Wajahat Ullah Khan, Zahira Bashir
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Agreement to accountable for all aspects of work:	All the above authors

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