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ORIGINAL ARTICLE

Clinical Characteristics and Outcomes of CKD Patients Presenting with Fluid and Electrolyte Disorders: A Prospective Observational Study

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Rajat Shuvra Paul[1], Dilip Kumar Roy[2], Zahid Hasan[3], Habib Sadat Chowdhury[4]

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Correspondence to
Rajat Shuvra Paul

ABSTRACT

Introduction: *Chronic kidney disease (CKD) is a progressive and irreversible disorder characterized by persistent decline in renal function, leading to impaired regulation of fluid balance, electrolyte homeostasis, and acid–base equilibrium. Fluid retention and electrolyte disturbances become increasingly common with worsening renal function, particularly in advanced stages of CKD. Important complications include fluid overload, hyperkalemia, metabolic acidosis, and dysnatremias such as hyponatremia, all of which contribute significantly to morbidity and mortality in CKD patients. This study aimed to determine the clinical characteristics and short-term outcomes of hospitalized CKD patients presenting with fluid and electrolyte disorders.* ***Methods & Materials****-This prospective observational study was conducted at the Dialysis Center of International Medical College Hospital from January 2025 to December 2025. A total of 58 adult patients with CKD presenting with fluid and electrolyte imbalance were enrolled. Patient assessment included demographic and clinical evaluation, electrolyte and arterial blood gas analysis, stage of CKD, and treatment interventions during hospitalization. Data analysis was performed using SPSS version 25.0.* ***Results****-The study population consisted predominantly of middle-aged males, with a high burden of advanced CKD. Diabetic nephropathy was the most common underlying etiology. Fluid overload and electrolyte disorders were frequently observed, including hyperkalemia (53.4%), hyponatremia (50.0%), hyperphosphatemia (58.6%), hypocalcemia (44.8%), and metabolic acidosis (56.9%). The prevalence of electrolyte imbalance increased significantly with progression of CKD stage. Clinical improvement was achieved in 70.7% of patients following fluid restriction, diuretics, potassium-lowering strategies, bicarbonate therapy, and dialysis as required. Hemodialysis was required in 32.8% of cases.* ***Conclusion-*** *Fluid and electrolyte disorders were highly prevalent among hospitalized CKD patients, particularly in advanced stages. More than half of the patients had hyponatremia, hyperkalemia, and metabolic acidosis, and these abnormalities demonstrated significant association with stage progression. Appropriate intervention strategies including fluid restriction, diuretic therapy, potassium-lowering measures, sodium bicarbonate supplementation, and initiation of dialysis improved short-term outcomes in the majority of patients.*

Keywords: *Chronic Kidney Disease, Fluid overload, Electrolyte disorders, Hyperkalemia, Hyponatremia, Metabolic acidosis, Dialysis*

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1. *Associate Professor, Department of Nephrology, International Medical College, Gazipur, Bangladesh (ORCID: 0009-0003-0338-5989)*
2. *Professor, Department of Nephrology, National Institute of Kidney Diseases & Urology (NIKDU), Dhaka, Bangladesh*
3. *Assistant Professor, Department of Nephrology, International Medical College Hospital, Gazipur, Bangladesh*
4. *Professor and Head of the Department, Department of Biochemistry, International Medical College, Gazipur, Bangladesh*

INTRODUCTION

Chronic kidney disease (CKD) is a progressive and irreversible disorder characterized by sustained abnormalities in renal structure or function, with a gradual decline in glomerular filtration rate (GFR) over time. As kidney function deteriorates, the body's ability to maintain internal homeostasis becomes impaired, resulting in disturbances in fluid regulation, electrolyte balance, and acid–base equilibrium. CKD affects approximately 10–13% of the global population, contributing substantially to morbidity, mortality, and rising healthcare burden worldwide.[1] The prevalence of CKD continues to increase, particularly in low- and middle-income countries, primarily due to the growing incidence of diabetes mellitus and hypertension.[3]

The common etiological factors leading to CKD include diabetes mellitus, hypertensive nephropathy, and chronic glomerular diseases. With progressive nephron loss, renal adaptive mechanisms become insufficient, leading to a spectrum of systemic complications. One of the most clinically significant consequences of CKD is impaired sodium and water excretion, resulting in sodium and water retention. This is often manifested by peripheral edema, pulmonary congestion, ascites, and uncontrolled hypertension.[2] Fluid overload contributes to cardiovascular complications and is a major driver of hospitalization and mortality among CKD patients.

In addition to volume overload, declining kidney function affects urinary concentrating and diluting capacity,

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predisposing patients to dysnatremias. Both hyponatremia and hypernatremia can occur due to disrupted water handling, altered neurohormonal responses, and the influence of therapies such as diuretics.[4] Among these, hyponatremia is particularly common and has been associated with increased hospitalization, adverse renal outcomes, and higher mortality rates.[5]

Hyperkalemia is another important electrolyte abnormality in CKD, mainly due to reduced renal excretion of potassium and frequent prescription of renin–angiotensin–aldosterone system inhibitors. Hyperkalemia can lead to life-threatening arrhythmias even at modest elevations of serum potassium and is associated with increased risk of progression to end-stage kidney disease and overall mortality.[6,7]

Disturbances of calcium and phosphate metabolism are also highly prevalent in CKD, especially in advanced stages, leading to CKD-mineral and bone disorder (CKD-MBD). These imbalances contribute to vascular calcification, bone disease, and increased cardiovascular risk, ultimately worsening patient outcomes.[8] Metabolic acidosis is another major complication in CKD due to impaired acid excretion and decreased bicarbonate regeneration. Chronic metabolic acidosis has been linked to muscle wasting, bone demineralization, inflammation, and accelerated progression of CKD.[9-12]

Fluid overload and electrolyte abnormalities often occur simultaneously and may independently worsen prognosis. Observational evidence suggests that these conditions are strongly associated with adverse outcomes such as increased mortality, hospitalization, and accelerated progression to kidney failure.[1,6] However, much of the existing evidence has been derived from retrospective studies or registry-based analyses rather than prospective observational evaluation in hospitalized CKD patients presenting with acute fluid and electrolyte disorders.[2] Therefore, the present study aimed to assess clinical characteristics and short-term outcomes of CKD patients admitted with fluid and electrolyte imbalance in a tertiary care hospital setting.

METHODS & MATERIALS

This prospective observational study was conducted at the Dialysis Centre of International Medical College and Hospital from January 2025 to December 2025. A consecutive series of 58 adult patients diagnosed with chronic kidney disease (CKD) and presenting with fluid and electrolyte imbalance were included in the study. Patients with acute kidney injury, postoperative renal dysfunction, and other life-threatening illnesses unrelated to CKD were excluded to ensure diagnostic and clinical consistency.

All enrolled patients underwent detailed history taking and clinical examination. Baseline demographic characteristics including age and sex were recorded. Etiology and stage of CKD were documented based on clinical assessment and available medical records. Fluid-related symptoms and signs were systematically assessed, including pedal edema, facial puffiness, pulmonary edema, ascites, and abnormalities of blood pressure such as hypertension or hypotension.

Laboratory assessment included measurement of serum electrolytes (sodium, potassium, calcium, and phosphate) and arterial blood gas analysis to determine acid–base status. Electrolyte abnormalities were categorized as hyponatremia, hypernatremia, hyperkalemia, hypokalemia, hypocalcemia, and hyperphosphatemia. Metabolic acidosis was diagnosed based on arterial blood gas findings. The study specifically evaluated the distribution of electrolyte imbalance across different stages of CKD to determine the association between CKD progression and the burden of fluid/electrolyte complications.

Interventions during hospitalization were documented, including fluid restriction, diuretic therapy, potassium-lowering measures, sodium bicarbonate supplementation, and initiation of hemodialysis, as recommended in standard clinical practice guidelines. Short-term outcomes were recorded, including clinical response, dialysis dependence, ICU admission, and in-hospital mortality.

Data analysis was performed using SPSS version 25.0. Descriptive statistics were used to present categorical variables as frequencies and percentages. The association between electrolyte disturbances and CKD stage was evaluated using the chi-square test. A p-value <0.05 was considered statistically significant. Ethical clearance was obtained from International Medical College & Hospital, and patient confidentiality was ensured throughout the study.

RESULTS

The mean age distribution showed that most patients belonged to the 41–60-year age group (46.6%). The population was predominantly male (60.3%). The major etiologies of CKD were diabetic nephropathy (41.4%) and hypertensive nephropathy (31.0%). A large proportion of patients presented at advanced stages of CKD, with stage 4 and stage 5 comprising 72.4% of the study population (Table).

Table – I: Baseline Demographic and Clinical Characteristics of the Study Population (*n* = 58)

Variable	Frequency (n)	Percentage (%)
Age group (years)		
≤40	14	24.1
41–60	27	46.6
>60	17	29.3
Sex		
Male	35	60.3
Female	23	39.7
Etiology of CKD		
Diabetic nephropathy	24	41.4
Hypertensive nephropathy	18	31.0
Chronic glomerulonephritis	9	15.5
Others/Unknown	7	12.1
CKD stage		
Stage 3	16	27.6
Stage 4	21	36.2
Stage 5	21	36.2

Clinical features of fluid overload were highly prevalent at admission. Pedal edema was observed in nearly two-thirds (65.5%) of patients. Hypertension was noted in 70.7%, consistent with volume expansion and impaired sodium handling in CKD. Pulmonary edema was present in 27.6% of patients (Table II).

Table – II: Clinical Presentation Related to Fluid Status at Admission (*n* = 58)

Clinical feature	Frequency (n)	Percentage (%)
Pedal edema	38	65.5
Facial puffiness	22	37.9
Pulmonary edema	16	27.6
Ascites	9	15.5
Hypertension	41	70.7
Hypotension	6	10.3

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Electrolyte disturbances were common among the enrolled CKD patients. Hyperkalemia (53.4%) and hyponatremia (50.0%) were among the most frequently observed abnormalities. Metabolic acidosis was present in 56.9% of patients. Disorders related to mineral metabolism, especially hyperphosphatemia (58.6%) and hypocalcemia (44.8%), were also widely prevalent (Table III).

Table – III: Distribution of Electrolyte Abnormalities Among CKD Patients (*n* = 58)

Electrolyte disorder	Frequency (n)	Percentage (%)
Hyponatremia	29	50.0
Hypernatremia	6	10.3
Hyperkalemia	31	53.4
Hypokalemia	5	8.6
Hypocalcemia	26	44.8
Hyperphosphatemia	34	58.6
Metabolic acidosis	33	56.9

A significant association was found between CKD stage and frequency of electrolyte abnormalities (**Table IV)**. Hyponatremia increased progressively with advancing CKD stage and was present in 71.4% of stage 5 patients (p = 0.013). Hyperkalemia also increased significantly with stage progression, with more than two-thirds of stage 5 patients affected (p = 0.019). Metabolic acidosis was similarly more common in advanced CKD, reaching 71.4% in stage 5 patients (p = 0.034).

Table – IV: Association of Electrolyte Disorders with CKD Stage (*n* = 58)

Electrolyte abnormality	Stage 3 (n=16)	Stage 4 (n=21)	Stage 5 (n=21)	p-value
Hyponatremia	4 (25.0%)	10 (47.6%)	15 (71.4%)	0.013
Hyperkalemia	5 (31.3%)	11 (52.4%)	15 (71.4%)	0.019
Metabolic acidosis	6 (37.5%)	12 (57.1%)	15 (71.4%)	0.034

Management strategies during hospitalization reflected the high burden of fluid overload and electrolyte disturbances. Fluid restriction was used in 72.4% of patients and diuretics were administered in 67.2%. Potassium-lowering measures were required in 53.4% of patients due to hyperkalemia. Sodium bicarbonate therapy was used in 48.3% of patients to treat metabolic acidosis. Hemodialysis was required in 32.8% of cases (Table V).

Table – V: Management Interventions During Hospital Stay (*n* = 58)

Intervention	Frequency (n)	Percentage (%)
Fluid restriction	42	72.4
Diuretics	39	67.2
Sodium bicarbonate therapy	28	48.3
Potassium-lowering measures	31	53.4
Hemodialysis	19	32.8

Short-term outcomes showed that 70.7% of patients experienced clinical improvement following management. Dialysis dependence during hospitalization occurred in 19.0%. ICU admission was required in 15.5% of patients, primarily due to pulmonary edema and severe hyperkalemia. In-hospital mortality was observed in 8.6% of cases, likely reflecting advanced CKD severity and associated complications (Table VI).

Table – VI: Short-Term Clinical Outcomes (*n* = 58)

Outcome	Frequency (n)	Percentage (%)
Clinical improvement	41	70.7
Progression to dialysis dependence	11	19.0
ICU admission	9	15.5
In-hospital mortality	5	8.6

DISCUSSION

In this prospective observational study, most patients presenting with fluid and electrolyte disorders were middle-aged, and males constituted 60.3% of the study population. Diabetic nephropathy and hypertensive nephropathy were the predominant underlying etiologies, reflecting the growing burden of metabolic and vascular causes of CKD in developing countries.[3] Additionally, nearly three-fourths of patients presented with advanced CKD (stages 4 and 5), indicating delayed diagnosis, limited access to nephrology care, or late hospital presentation.

The demographic profile of the present study is comparable to the findings from the Chronic Renal Insufficiency Cohort (CRIC) study, which reported a median age near 58 years and male predominance, with diabetes being a leading cause of CKD.[1] The high proportion of advanced stage CKD in the current study likely explains the substantial prevalence of fluid overload and severe electrolyte disturbances observed at hospital admission.

Clinical evidence of fluid overload was prominent, with pedal edema present in 65.5% and hypertension in 70.7% of patients. Pulmonary edema was documented in more than one-fourth of patients, highlighting the burden of volume expansion in this hospitalized cohort. Electrolyte and acid–base disorders in CKD are well recognized, particularly as renal function declines and compensatory mechanisms fail.[2] The findings also suggest late-stage presentation and high volume overload burden compared to previous reports where edema and pulmonary edema prevalence were lower.[2]

Hyponatremia was present in 50% of patients, which is higher than rates reported in many outpatient CKD studies. Hyponatremia is often influenced by fluid overload, impaired urinary dilution, and diuretic use, and is known to be associated with adverse renal outcomes.[5] Similarly, the observed hyperkalemia rate of 53.4% reflects the high prevalence of impaired potassium excretion in advanced CKD, often further worsened by medications such as RAAS inhibitors.[6] Hyperkalemia carries significant clinical risk due to cardiac conduction abnormalities and increased mortality association.[7]

Metabolic acidosis occurred in 56.9% of patients, indicating marked acid-base derangement in this advanced CKD cohort. Metabolic acidosis is a common complication in CKD and is linked to muscle wasting, inflammation, bone disease, and faster progression of renal failure.[9,12] Mineral metabolism disorders were also common, with hyperphosphatemia in 58.6% and hypocalcemia in 44.8%, supporting the strong prevalence of CKD-MBD in advanced CKD, which has major implications for cardiovascular risk and survival.[8]

The study further demonstrated a statistically significant relationship between CKD stage and the prevalence of

hyponatremia, hyperkalemia, and metabolic acidosis, with the highest prevalence observed in stage 5 CKD. This is consistent with evidence showing that dysnatremias and hyperkalemia increase progressively as eGFR declines.[13] The stage-wise increase supports the concept that progressive nephron loss directly worsens the ability of kidneys to regulate electrolytes and acid-base balance.

Management strategies in this study included fluid restriction, diuretics, potassium-lowering therapy, sodium bicarbonate supplementation, and hemodialysis when required. These interventions align with clinical recommendations emphasizing proper fluid management and correction of hyperkalemia and metabolic acidosis to reduce complications and improve outcomes.[8] In the present cohort, clinical improvement was achieved in 70.7% of patients, while dialysis dependence developed in 19%. The observed in-hospital mortality rate (8.6%) was comparable to reports indicating increased mortality among CKD patients with severe electrolyte disturbances and advanced disease stage.[13]

Overall, the study highlights that fluid and electrolyte disorders remain highly prevalent among hospitalized CKD patients, particularly in advanced stages. Prompt recognition and targeted interventions are essential to reduce short-term complications and improve patient survival.

LIMITATIONS OF THE STUDY

This study was conducted in a single tertiary care hospital with a relatively small sample size. Therefore, the results may not represent the wider CKD population and may limit generalization across different healthcare settings.

CONCLUSION

Fluid overload and electrolyte disorders are highly prevalent among hospitalized CKD patients, especially those presenting in advanced stages. More than half of patients had hyponatremia, hyperkalemia, and metabolic acidosis, and these abnormalities were significantly associated with worsening CKD stage. Timely interventions such as fluid restriction, diuretics, potassium-lowering measures, sodium bicarbonate therapy, and initiation of hemodialysis played an important role in improving short-term clinical outcomes.

RECOMMENDATION

Early detection and careful monitoring of fluid status, electrolyte disturbances, and acid–base imbalance should be emphasized in CKD patients, particularly in advanced stages. Improved outpatient follow-up, patient education, and timely hospital intervention may reduce the burden of complications, optimize short-term outcomes, and decrease morbidity and mortality. Appropriate management through fluid restriction, electrolyte correction, bicarbonate therapy, and early initiation of dialysis when indicated should be ensured for better clinical outcomes.

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