e-ISSN: 0975-9506, p-ISSN: 2961-6093

Available online on www.ijpqa.com doi: 10.25258/ijpqa.16.11.83

International Journal of Pharmaceutical Quality Assurance 2025; 16(11); 529-535

Original Research Article

Clinical Evaluation of Electrolyte Alterations in Chronic Kidney Disease Patients

Ghanshyam Jha

Associate Professor, Department of General Medicine, Himalaya Medical College and Hospital, Paliganj, Patna, Bihar, India

Received: 10-09-2025 / Revised: 21-10-2025 / Accepted: 20-11-2025

Corresponding Author: Dr. Ghanshyam Jha

Conflict of interest: Nil

Abstract:

Background: Electrolytes are vital for physiological homeostasis, and the kidneys play a central role in regulating their balance. Chronic Kidney Disease (CKD) impairs renal function, often leading to disturbances in sodium, potassium, and chloride levels, which can exacerbate morbidity and complications.

Aim: To clinically evaluate electrolyte alterations in CKD patients and assess their distribution with respect to gender and age.

Methodology: A hospital-based cross-sectional study was conducted at Himalaya Medical College and Hospital, Patna, including 80 participants (40 CKD patients and 40 healthy controls). Serum sodium, potassium, and chloride levels were measured using a semi-automatic analyzer. Data were analyzed with IBM SPSS Version 20, and independent t-tests assessed differences between groups.

Results: Electrolyte imbalances were observed among CKD patients, with decreased sodium, potassium, and chloride levels being common. No statistically significant differences were found between genders for sodium ($p=0.421$), potassium ($p=0.53$), or chloride ($p=0.216$). Most participants were middle-aged or older, reflecting a higher vulnerability to electrolyte disturbances in this population.

Conclusion: CKD is associated with notable electrolyte derangements irrespective of gender. Routine monitoring of serum electrolytes is essential for early detection, timely correction, and improved clinical management of CKD patients.

Keywords: Chronic Kidney Disease, Electrolytes, Sodium, Potassium, Chloride, Serum Analysis, Renal Function.

Introduction

Electrolytes are basic biochemical entities that can, upon dissolution in a polar solvent like water, dissociate into ions, hence gaining electricity-conducting properties. That is because the separation of the dissolved compound into oppositely charged ions-cations (positively charged) and anions (negatively charged)-frees them to distribute uniformly throughout the solvent, retaining overall electrical neutrality [1]. In electrolyte solutions, the conducting properties of electricity are caused by the movement of these ions-not electrons-toward oppositely charged electrodes upon applying an electric field. This means cations move toward the negatively charged electrode with plenty of electrons, while anions move toward the positively charged, electron-poor electrode. The bidirectional motion of the ions generates an electric current and forms the basis of the behavior of electrolytes in chemical and biological systems [2]".

Although most commonly associated with aqueous solutions, electrolytes are actually common under a variety of physical states. Some gases, like hydrogen chloride (HCl), are known to act as electrolytes under specific physical conditions, such as when low pressure or high temperature is used to increase ionization of the gas. Solid-state electrolytes and polyelectrolytes-including biological macromolecules like DNA and polypeptides, as well as synthetic polymers such as polystyrene sulfonate-possess charged functional groups that confer ionic conductivity [3]. Common among all electrolytes is the fact that their ability to conduct electricity is imparted to the solution of a molten product through dissociation into ions. This property is especially important in physiological contexts, where electrolytes dissolved in bodily fluids play a crucial role in homeostasis.

In this respect, the term "electrolyte" refers primarily in the medical and clinical context to biologically relevant ions dissolved in body fluids such as plasma, interstitial fluid, and intracellular compartments. The important electrolytes are sodium (Na^+), potassium (K^+), chloride (Cl^-), calcium (Ca^{2+}), magnesium (Mg^{2+}), and phosphate (PO_4^{3-}), each with its unique role in critical physiological functions, from the maintenance of osmotic gradients and fluid balance to nerve conduction, muscle contraction-including cardiac muscle activity-to the regulation of acid-base equilibrium. Due to their central physiological role, electrolyte disturbances can lead rapidly to life-threatening complications if not timely identified and appropriately managed [4].

Electrolyte imbalances are common in pathological states and during physiological stress. Conditions like prolonged vomiting and diarrhea, and excessive sweating from aggressive physical exertion can cause significant loss of electrolytes. This is a real concern among vulnerable populations like young children, who easily become dehydrated. Therefore, commercial electrolyte solutions include oral rehydration therapy that promotes fluid and electrolyte replenishment in home and clinical settings. Furthermore, electrolyte balance is important to monitor in the treatment of eating disorders like anorexia and bulimia as chronic nutrient restriction and/or purging behavior result in extreme disturbances to serum electrolyte levels [5].

Clinically, the concentrations of electrolytes are commonly monitored by an electrolyte panel, also called a serum electrolyte test. This test measures the major electrolyte concentrations in blood, urine, or other bodily fluids and is frequently part of a comprehensive metabolic panel. Based on electrolyte levels, clinicians can identify imbalances that indicate broader disturbances in water balance, acid–base balance, renal function, and metabolism [6]. Since electrolyte levels are tightly maintained by renal, endocrine, and respiratory mechanisms, abnormal values are often an early sign of systemic illness.

They perform their function of maintaining electrolyte balance, regulating body fluids, and preserving acid-base equilibrium by mechanisms of filtration, reabsorption, secretion, and hormonal functions, which ensure that the body retains essential ions and excretes excess quantities. CKD is the progressive and irreversible deterioration of renal function and profoundly disrupts such regulatory mechanisms. With the decline in renal function, the maintenance of stable levels of electrolytes becomes impaired, leading to clinically significant alterations in sodium, potassium, calcium, phosphate, and bicarbonate levels. These abnormalities result in many of the severe complications of CKD, including metabolic acidosis, hyperkalemia, mineral and bone disorders, and cardiovascular instability [7].

Given the growing worldwide burden of CKD, electrolyte disorders in this population constitute an important clinical and public health issue. CKD affected approximately 753 million people globally in 2016, including 417 million females and 336 million males. Such statistics underscore the importance of understanding the biochemical and physiological consequences of declining renal function. Electrolyte changes are not only common in CKD but also among the important determinants of morbidity, hospitalization rates, and mortality. Thus, their timely detection and correction are crucial parts of CKD management [8].

Despite this well-accepted role of the kidneys, the electrolyte disturbances caused by CKD remain mostly underdiagnosed and poorly managed, especially in resource-constrained settings where routine laboratory assessment may not be readily available. Electrolyte assessment allows the clinical establishment of early diagnosis, accurate disease staging, and appropriate therapeutic interventions, along with prevention of adverse outcomes in CKD patients. Moreover, through analysis of the pattern of electrolyte variations in various stages of CKD, clinicians can elucidate more about the disease process of renal deterioration and can thus optimize treatment strategies such as dietary modification, drug adjustment, and planning for dialysis.

Thus, it is critical that appropriate clinical assessment of electrolyte disturbances in CKD patients be carried out for better prognosis and quality of care. This study will seek to determine the prevalence, degree, and clinical importance of electrolyte disturbances in CKD patients and explain the relationship between the different disturbances and disease progression and complications. Such findings would lead to better diagnostic accuracy, improved monitoring of the patients, and more efficient protocols for clinical management of CKD worldwide.

Materials and Methods

Study Design A hospital-based cross-sectional observational study was conducted to evaluate serum electrolyte alterations—specifically sodium, potassium, and chloride levels—among patients diagnosed with chronic kidney disease (CKD).

Study Area: The study was carried out in the Department of General Medicine, Himalaya Medical College and Hospital, Paliganj, Patna, Bihar, India.

Study Duration: The data were collected for the period of 12 months.

Sample Size: A total of 80 participants were included in the study.

Sample Population

The study population consisted of individuals attending the Department of General Medicine.

- **CKD Group:** 40 patients clinically diagnosed with Chronic Kidney Disease.
- **Control Group:** 40 age- and sex-matched healthy individuals without renal disease.

Inclusion Criteria

1. Patients aged ≥ **20 years**.
2. Individuals clinically diagnosed with CKD (for CKD group).
3. Healthy individuals with no known renal impairment (for control group).
4. Patients willing to provide written informed consent.

Exclusion Criteria

1. Patients below 20 years of age.
2. Patients with acute kidney injury (AKI).
3. Individuals with conditions known to alter electrolyte levels such as chronic diarrhea, vomiting, endocrine disorders, or those on diuretics.
4. Patients with severe comorbidities such as heart failure, liver cirrhosis, or malignancy.
5. Pregnant women.

Data Collection: Data collection was carried out using a structured format designed to obtain demographic, clinical, and biochemical information from all study participants. After obtaining written informed consent, relevant patient details such as age, sex, clinical history, and CKD status were recorded. Blood samples were collected from each participant under aseptic conditions using standard venipuncture of the median cubital vein. The collected blood was allowed to clot, and serum was subsequently separated for biochemical analysis. Serum electrolyte levels, including sodium, potassium, and chloride, were measured using the ELYTE 5i semi-auto analyzer. All samples were processed promptly to ensure reliability and were analyzed following standard laboratory protocols.

Procedure: Following registration and verification of inclusion criteria, participants were guided to the sample collection area. A trained phlebotomist performed venipuncture, and approximately 3–5 mL of blood was drawn into plain vacutainer tubes. The blood samples were transported immediately to the biochemistry laboratory, where they were centrifuged to obtain serum. The serum samples were then analyzed for electrolyte concentrations using a semi-automatic analyzer calibrated prior to each batch run. The primary electrolytes assessed in this study were sodium, potassium, and chloride, as alterations in these parameters are commonly associated with chronic kidney disease. All instruments were maintained and operated according to manufacturer guidelines to ensure accuracy and consistency in results.

Statistical Analysis: Statistical analysis was performed using IBM SPSS Version 20. The collected data were initially checked for completeness and accuracy before being entered into the software. Continuous variables such as electrolyte levels were expressed as mean ± standard deviation. The comparison between CKD patients and healthy controls was conducted using the independent samples t-test to determine whether significant differences existed between the two groups. A p-value of less than 0.05 was considered statistically significant. In the present study, the p-values for sodium ($p = 0.42$), potassium ($p = 0.53$), and chloride ($p = 0.216$) indicated that the differences observed between CKD patients and control subjects were not statistically significant."

Result

Table 1 shows the gender distribution of the study population, with a slightly higher proportion of males (42 participants, 52.5%) compared to females (38 participants, 47.5%). This indicates a relatively balanced gender representation in the sample.

Table 1: Gender Distribution

Gender	Count	Percentage
Male	42	52.50%
Female	38	47.50%

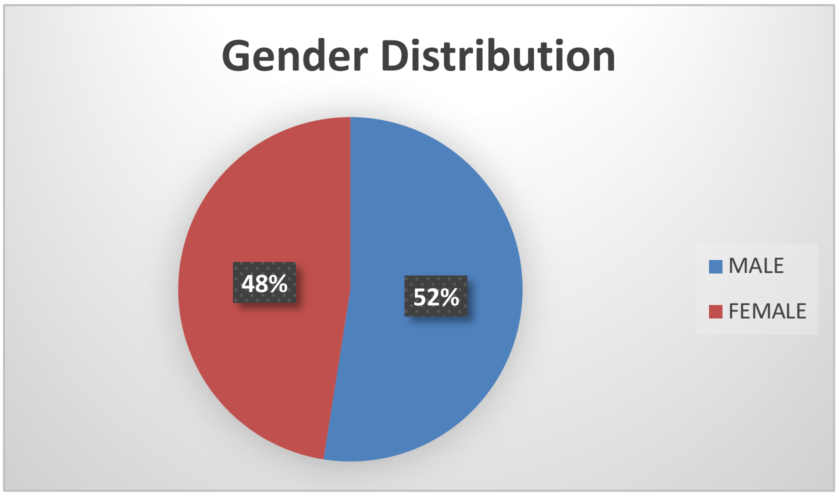

Figure 1: Gender Distribution

Table 2 presents the age distribution of the study population. The largest group was aged 41–60 years, comprising 30 participants (37.5%), followed by those aged 61–80 years (26 participants, 32.5%). Participants younger than 40 years accounted for 18 individuals (22.5%), while the smallest group was over 80 years, with 6 participants (7.5%). Overall, the majority of the population falls within the middle-aged to older adult range.

Table 2: Age Distribution

Age	Count	Percentage
<40	18	22.50%
41–60	30	37.50%
61–80	26	32.50%
>80	6	7.50%

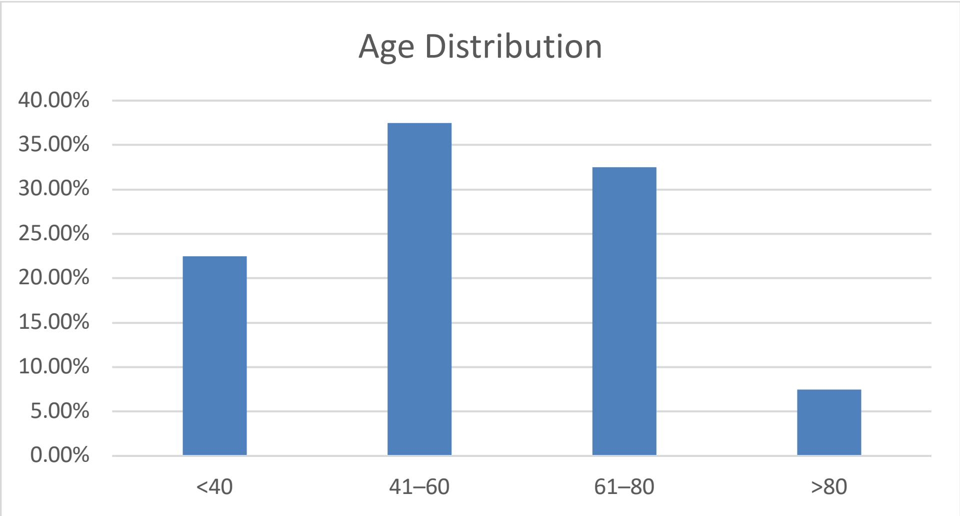

Figure 2: Age distribution

Table 3 shows that sodium levels do not differ significantly between males and females (p = 0.421). Among males, 20 had normal sodium levels, 5 had increased levels, and 17 had decreased levels, while females showed a similar distribution with 18 normal, 3 increased, and 17 decreased sodium values. The closely aligned patterns across genders indicate that sodium abnormalities occur at comparable rates in both groups, with no meaningful gender-based variation.

Table 3: Sodium Compared with Gender

Gender	Normal	Increased	Decreased	P Value
Male	20	5	17	0.421 NS
Female	18	3	17	

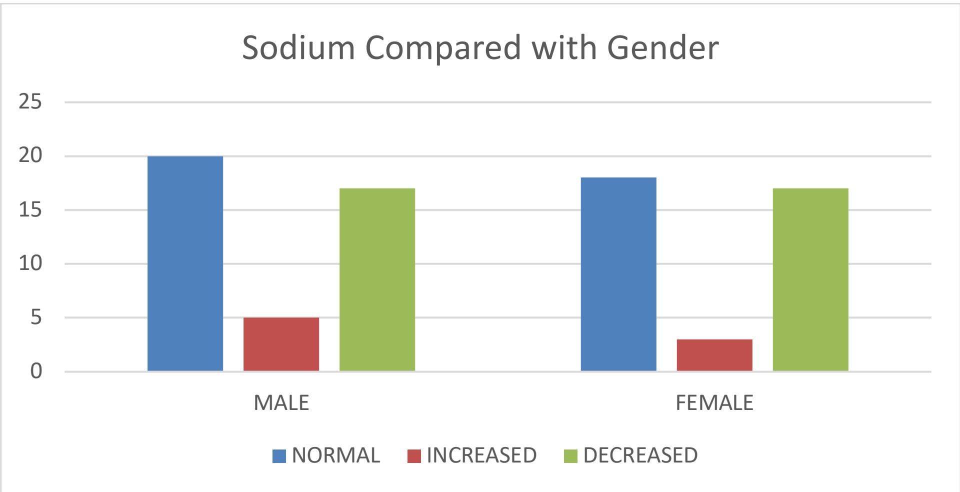

Figure 3: Sodium compared with gender

Table 4 compares potassium levels by gender and shows no statistically significant difference between males and females (p = 0.53). Among males, 19 had normal potassium levels, 10 showed increased levels, and 13 had decreased levels, while in females, 17 were within the normal range, 7 had increased potassium, and 14 had decreased levels. The overall distribution is similar across genders, indicating that potassium abnormalities do not differ meaningfully between males and females in this study.

Table 4: Potassium Compared with Gender

Gender	Normal	Increased	Decreased	P Value
Male	19	10	13	0.53 NS
Female	17	7	14	

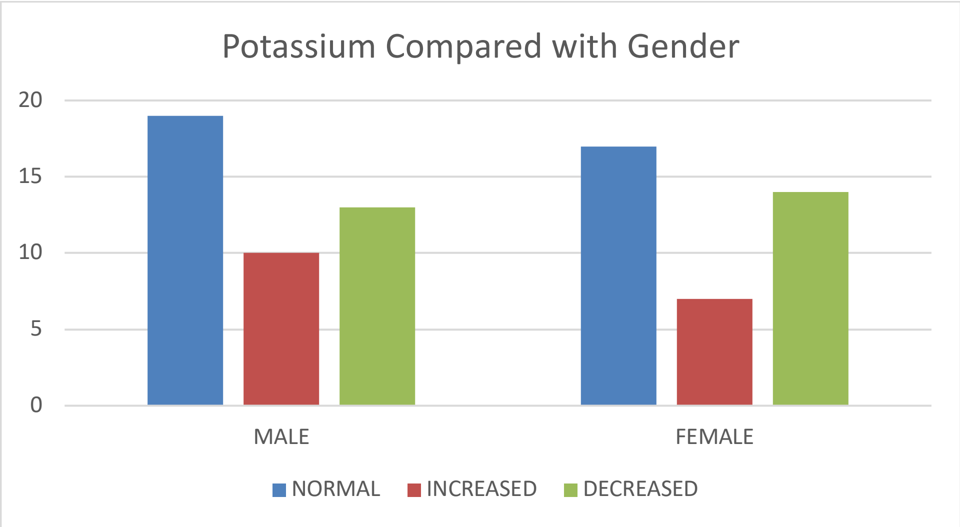

Figure 4: Potassium compared with gender

Table 5 compares chloride levels between genders and shows no statistically significant association (p = 0.216). Among males, 21 had normal chloride levels, 3 had increased levels, and 18 showed decreased levels. In females, 19 had normal chloride, 5 had increased levels, and 14 had decreased levels. Although both genders displayed a similar distribution pattern—with most participants falling into the normal or decreased chloride categories, the differences were not significant, indicating that chloride abnormalities did not vary meaningfully by gender in this sample.

Table 5: Chloride Compared with Gender

Gender	Normal	Increased	Decreased	P Value
Male	21	3	18	0.216 NS
Female	19	5	14	

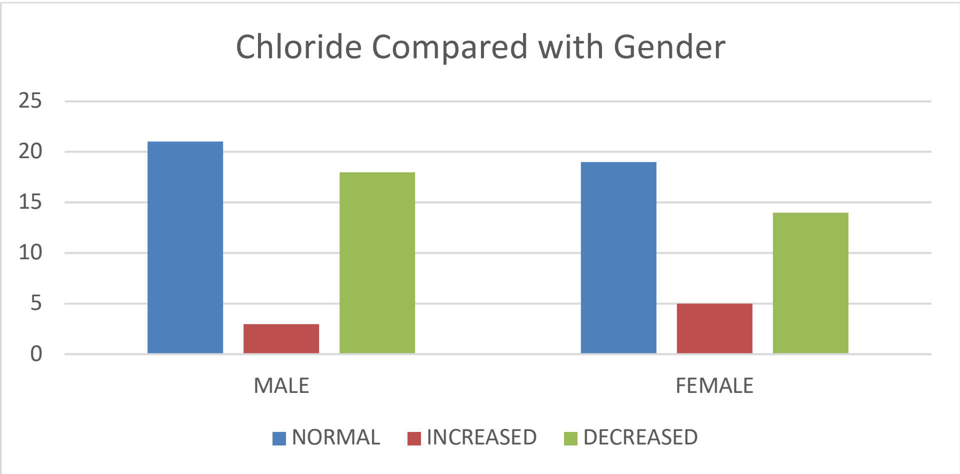

Figure 5: Chloride compared with gender

Discussion

In the current study, the gender distribution of patients with CKD is almost equal, with males making up 52.5% and females 47.5%, thus making valid comparisons on electrolyte changes among both genders possible. Indeed, various previous studies on CKD also reported similar gender distributions, indicating that renal dysfunction has comparable effects in both sexes (Owiredu et al., 2012; Satirapoj et al., 2016) [3,8]. Our age distribution showed that the majority of the subjects had middle-age to older adult age brackets of 37.5% from 41–60 years and 32.5% between 61–80 years. These are the populations most at risk due to their advanced age which already includes decline in renal function and comorbid diseases that affect normal physical function (Obrador & Pereira, 2015; Hsieh & Power, 2015) [9,10]. This constitutes a similar representation of the global epidemiology of CKD in the general population, which normally increases with advancing age across countries (Chen et al., 2019) [7]."

Serum sodium abnormalities were common in both sexes; 17 males and 17 females had reduced sodium levels, while a few had hypernatremia. The lack of statistical significance in gender differences ($p = 0.421$) agrees with other studies that show similar sodium derangements irrespective of sex among CKD patients (Makhlough et al., 2016; Zhang et al., 2016) [1,11]. This is of particular importance since hyponatremia has been found to be associated with increased morbidity and mortality among CKD patients and is often multifactorial, influenced by impaired renal water handling, the use of diuretics, and comorbid heart failure (Dhondup & Qian, 2017; Widmer et al., 1979) [5,12]. In contrast, some studies have shown mild sex-related differences in sodium disturbances among specific populations of CKD patients, especially among those on dialysis, though these are often explained as due to differences in body composition and hormonal regulation rather than intrinsic renal function (Abdulla et al., 2020) [2].

There were no significant gender differences regarding serum potassium levels, $p = 0.53$, with 10 males and 7 females having hyperkalemia and 13 males and 14 females presenting with hypokalemia. These results align with literature stressing that potassium imbalance is one of the common metabolic disturbances in CKD, mainly due to impaired renal excretion as well as the use of potassium-sparing medication (Lin et al., 2017; Satirapoj et al., 2016) [4,8]. Hyperkalemia is a particular cause for concern because it predisposes the patient to serious cardiac arrhythmias, so our findings illustrate that male and female patients are at equal risk, which is consistent with previous reports also (Luo & Zoccali, 2016) [13]. However, some studies have suggested that men may have slightly higher prevalence rates for hyperkalemia, partly due to dietary factors or differences in muscle mass, but this was not reflected in our study population (Dhondup & Qian, 2017) [5].

Disturbances in chloride mirrored the patterns observed with sodium and potassium. In our study, low chloride levels were seen in 18 males and 14 females. As seen in other studies, hyperchloremia was minimal. No significant difference was elicited between genders, $p=0.216$, which also led to similar analyses that noted hypochloremia is common in CKD and largely reflects concurrent sodium loss or metabolic acidosis rather than sex variations (Elisaf et al., 1996; Dhondup & Qian, 2017) [14,5]. Hypochloremia has been repeatedly described in relation to deteriorating renal function and a rise in hospitalizations amongst CKD patients (Makhlough et al., 2016; Zhang et al., 2016) [1,11]. Although some literature suggests disturbances in chloride may be modified by different dialysis modalities or fluid therapy, similarities in distribution for both males and females from this present study indicate that baseline impairment of renal function is the major determinant for these disturbances rather than sex-related factors (Satirapoj et al., 2016; Widmer et al., 1979) [8,12].

In summary, our findings point toward electrolyte disturbances as a common presentation among CKD patients irrespective of gender. This corresponds well with the pathophysiological mechanism because CKD impairs renal homeostasis, which affects the control of sodium, potassium, and chloride by the kidneys (Lin et al., 2017; Dhondup & Qian, 2017) [4,5]. The presence of a higher proportion of aged individuals in our cohort likely contributed to the higher frequency of electrolyte disturbances because aging nephrons express reduced glomerular filtration and tubular capacity, thereby predisposing this age group to metabolic disorders (Obrador & Pereira, 2015; Hsieh & Power, 2015) [9,10]. Comparisons with previous studies suggest that while the absolute prevalence of abnormalities may vary across different regions and stages of CKD, the overall patterns of electrolyte alterations and their non-significant gender differences remain essentially identical (Makhlough et al., 2016; Satirapoj et al., 2016; Zhang et al., 2016) [1,11].

These findings further stress that there is a need for regular monitoring of electrolytes in CKD patients to guide therapeutic interventions and prevent complications, hence slowing the progression of the disease. Early detection of disturbances, particularly sodium, potassium, and chloride, allows the clinician to appropriately individualize dietary advice, medication regimen, and dialysis strategy, thus optimizing outcome. The present study thus adds to the rapidly mounting literature on the universal nature of electrolyte imbalances in CKD and the need for vigilant clinical evaluation across all patient demographics.

Conclusion

This study shows that chronic kidney disease is often associated with significant disturbances in major electrolytes; sodium, potassium, and chloride imbalances were observed across all patients irrespective of gender or age. Although no significant differences based on gender were found, the trends of both high and low levels of electrolytes indicate the persistent impairment of renal regulatory function due to CKD. The pattern of distribution indicates that abnormalities in electrolytes emanate from the progressive loss in glomerular filtration, altered tubular handling, and accompanying metabolic adaptation to chronic impairment. Overall, the findings emphasize that CKD patients require routine and comprehensive electrolyte surveillance to make timely corrections, avoid complications, and allow more effective long-term management.

References

1. Makhlough A, Ilali E, Mohseni R, Shahmohammadi S. Effect of intradialytic aerobic exercise on serum electrolytes levels in hemodialysis patients.
2. Abdulla JE, Shakor JK, Shallal AF, Kheder R. Effect of dialysis on some Hematological and Electrolyte parameters in chronic kidney patients. Annals of Tropical Medicine and Public Health. 2020;23(11):9-13.
3. Owiredu WK, Ephraim RK, Eghan Jnr BA, Amidu N, Laing EF. Relationship between parathyroid hormone and electrolytes in chronic kidney disease.
4. Lin J, Cheng Z, Ding X, Qian Q. Acid-base and electrolyte managements in chronic kidney disease and end-stage renal disease: case-based discussion. Blood purification. 2018 Apr 20;45(1-3):179-86.
5. Dhondup T, Qian Q. Electrolyte and acid-base disorders in chronic kidney disease and end-stage kidney failure. Blood purification. 2017 Jan 24;43(1-3):179-88.
6. Dhondup T, Qian Q. Acid-base and electrolyte disorders in patients with and without chronic kidney disease: an update. Kidney Diseases. 2017 Oct 5;3(4):136-48.
7. Chen TK, Knicely DH, Grams ME. Chronic kidney disease diagnosis and management: a review. Jama. 2019 Oct 1;322(13):1294-304.
8. Satirapoj B, Prapakorn J, Punpanich D, Pongsuparbchon C, Supasyndh O. The effect of ONCE Renal on minerals and electrolytes in predialysis patients with chronic kidney disease. International Journal of Nephrology and Renovascular Disease. 2016 Apr 5:81-6.
9. Obrador GT, Pereira BJ. Systemic complications of chronic kidney disease: Pinpointing clinical manifestations and best management. Postgraduate medicine. 2002 Feb 1;111(2):115-22.
10. Hsieh M, Power DA. Abnormal renal function and electrolyte disturbances in older people. Journal of Pharmacy Practice and Research. 2009 Sep;39(3):230-4.
11. Zhang R, Wang S, Zhang M, Cui L. Hyponatremia in patients with chronic kidney disease. Hemodialysis International. 2017 Jan;21(1):3-10.
12. Widmer B, Gerhardt RE, Harrington JT, Cohen JJ. Serum electrolyte and acid base composition: the influence of graded degrees of chronic renal failure. Archives of internal medicine. 1979 Oct 1;139(10):1099-102.
13. Luo J, Brunelli SM, Jensen DE, Yang A. Association between serum potassium and outcomes in patients with reduced kidney function. Clinical Journal of the American Society of Nephrology. 2016 Jan 1;11(1):90-100.
14. Elisaf MS, Tsatsoulis AA, Katopodis KP, Siamopoulos KC. Acid-base and electrolyte disturbances in patients with diabetic ketoacidosis. Diabetes research and clinical practice. 1996 Sep 1;34(1):23-7.