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Estimation of some Electrolytes in Kidney Disease Patients

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ABSTRACT: Present case-control study explored the associations between the role of urea and creatinine levels in kidney patients. Sixty patients with chronic Kidney disease participated in this study; their age ranged from 28-60 years during the period from March 2019 until August 2019 at the National Hematological Center/ Al-Mustansiryah University. They were compared with 30 subjects as control group. A sample of 60 Iraqi patients were divided into two groups, the first over 50 years old were 42 samples, while the second group for patients under the age of 50 years recorded 18 samples, and the samples of healthy people recorded only 30 samples.Current study was designed to estimate the status of renal function in the blood and electrolytes in the serum were measured for all patients.

KEYWORDS: CKD, creatinine, Electrolytes, Kidney disease, Urea.

INTRODUCTION

Kidney disease, also known as chronic kidney disease (CKD), is a prevalent and under-recognized public health crisis. It affects approximately 37 million people in the U.S., which accounts for 15% of the adult population, or more than 1 in 7 adults. What's even more alarming is that about 90% of those with kidney disease are unaware they have it, and even 2 out of 5 adults with severe kidney disease remain undiagnosed. This lack of awareness is concerning considering that kidney disease is a leading cause of death in the U.S.(Hsiao *et al*.2020)

The two primary causes of kidney disease are diabetes and high blood pressure. In fact, these two conditions account for about 76% of kidney failure cases. Diabetes is the leading cause, responsible for 47% of new cases, while hypertension is the second leading cause at 29%. Other factors that can contribute to kidney disease include glomerulonephritis (diseases that damage the kidney's filtering units), inherited diseases like polycystic kidney disease, obstructions such as kidney stones or an enlarged prostate, and repeated urinary tract infections.(Molla *et al*.2020)

Early detection and awareness are crucial in managing kidney disease. Unfortunately, many individuals with the condition do not experience symptoms until later stages when complications arise. Screening at-risk individuals is recommended to identify the problem early on. Treatment options include medications to control blood pressure, blood sugar, and cholesterol levels. Additionally, lifestyle changes like maintaining an active lifestyle and following a low-salt diet can be beneficial.(Ljungberg *et al*. 2022)

For those with advanced stages of chronic kidney disease (CKD), treatments such as hemodialysis or a kidney transplant may be necessary for survival. Regular monitoring

of serum electrolytes, calcium, and phosphorus levels is essential in managing patients undergoing hemodialysis.(Soumya and Pratibha,, 2021).

In conclusion, kidney disease is a widespread and often undiagnosed condition that poses significant health risks and complications. Early detection, awareness, and proper management are crucial in improving outcomes for individuals with kidney disease. Regular monitoring of electrolyte levels is important for those undergoing hemodialysis.

I. Importance of studying electrolytes in kidney disease patients

Studying electrolytes in kidney disease patients is of utmost importance in understanding and managing the condition effectively. Electrolytes play a crucial role in maintaining the body's fluid balance and regulating various physiological processes. In patients with chronic kidney disease (CKD), imbalances in electrolyte levels can have serious implications for their overall health and well-being.(Mutalib and Adirahardja, 2021)

CKD is a global public health problem, with a rising incidence and prevalence, leading to poor outcomes and high healthcare costs. It is associated with an increased risk of cardiovascular disease and end-stage kidney disease (ESKD), making it the 10th leading cause of death in the United States. Mortality rates among CKD patients are significantly higher compared to those without CKD, particularly in advanced stages of the disease.(Vaidya *et al*. 2022)

The early detection of kidney complications is crucial for effective management and prevention of further damage. Routine laboratory tests, including the analysis of electrolyte levels, can serve as valuable indicators of nephrotoxicity. A retrospective analysis found that abnormal electrolyte levels were present in a significant percentage of cancer patients treated with cisplatin, a chemotherapy drug associated with renal damage.(Alrfeai *et al*. 2023)

Fig. 1: Chronic kidney disease (Vaidya et al. 2022)

Furthermore, electrolyte abnormalities can aid in predicting renal toxicity as part of chemotherapy complications. Monitoring changes in electrolyte levels, such as hypomagnesemia, hypokalemia, and hypocalcemia, can help reduce the risk of dialysis or the need for kidney transplant. (Hafiz *et al.* 2022).

Table 1: Study participants' demographic and clinical characteristics. (Hafiz *et al*. 2022).

Empty Cell	*N* = 612
Mean age (years)	48.6 ± 16.27
Gender (n, %)	
Male	352 (57.5)
Female	260 (42.5)
Age groups (years) (n, %)	
1–20	16 (3.6)
21–40	111 (25.6)
41–60	218 (50.3)
61–80	76 (17.5)
81–100	12 (2.7)
Diabetes	
Diabetics	266 (43.5)
Non-diabetics	346 (56.5)
Blood tests	
Urea (mg/dL)	180.5 ± 8.3
Creatinine (mg/dL)	7.6 ± 3.6
Glucose (mg/dL)	149.2 ± 8.8
Uric acid (mg/dL)	8.8 ± 3.4
Albumin (g/dL)	2.9 ± 0.75
Calcium (mg/dL)	7.9 ± 1.3
Phosphorus (mg/dL)	6.7 ± 2.8

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Magnesium (mg/dL)	2.6 ± 0.62
Sodium (mEq/L)	135.8 ± 7.2
Potassium (mEq/L)	5.1 ± 1.2
Chloride (mEq/L)	101.4 ± 8.4

METHODOLOGY OF THE STUDY

- **Participants and control group**

The document describes several studies conducted in different countries to investigate chronic kidney disease (CKD) in various patient populations.(Mwenda *et al*, 2018) In Nigeria, a study recruited CKD patients attending a hospital clinic over a fourteen-month period(Osunbor *et al*,2023). In South Korea, participants were CKD patients visiting a university hospital outpatient department. Colombia conducted an analytical study among two cohorts of CKD patients over a four-year follow-up period. (Choi and Lee, 2012) Ethiopia included adult patients with chronic disease who had regular follow-ups.(Sierra *et al*, 2022) .Greece invited people undergoing hemodialysis treatment to participate in a study(Endalkachew et al, 2022). Kenya conducted a cross-sectional study among medical inpatients at a tertiary health facility. (Thaweethamcharoern *et al*, 2014)The studies involved different numbers of participants and had varying inclusion and exclusion criteria.(Obiagwu et al,2023) The age range of participants also varied across the studies (Hsiao *et al*.2020).

Table 2: Descriptive statistics of the socio-demographic characteristics of study participants at Dessie Referral Hospital in Dessie town, Amhara region, May 2020 (N = 480) (Endalkachew *et al*, 2022).

Variables	Category	N %
Sex respondent	Male	179 (37.3)
	Female	301 (62.7)
Place of residence		
Urban		332 (69.2)
Rural		148 (30.8)
Marital status		
Currently married		374 (77.9)
Separated		45 (9.4)
Widowed		36 (7.5)
Divorced		25 (5.2)
Main occupation		
Government		54 (11.3)
Non-government		20 (4.2)
Self employed		290 (60.4)
Student		11 (2.3)
Homemaker		105 (21.9)

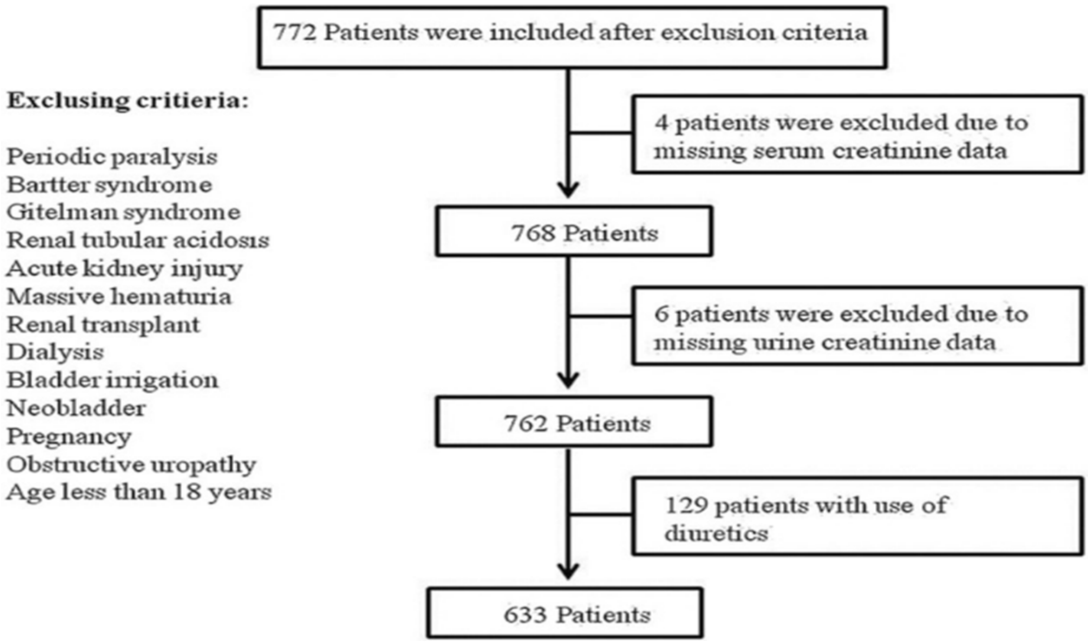

Fig. 2: Cross-sectional study design.

- **Sampling procedure**

In order to assess the estimation of electrolytes in kidney disease patients, various sampling procedures were employed in different studies. In a study conducted at Kenyatta National Hospital in Kenya, the sample size was determined using the Cochrane formula. The assumptions made included a Z statistic of 1.96 for a 95% confidence level, an expected prevalence of chronic kidney disease (CKD) of 27% based on previous studies, and a precision of 0.05. From this calculation, a minimum sample size of 300 was determined (Mwenda *et al*, 2018).

To select participants for sampling from each ward in the Kenyatta National Hospital study, a pre-visit was conducted to determine the patients on admission at the time of the study. Since all wards had the same capacity, an equal allocation of participants was made by dividing the total sample size (300) by the number of medical inpatient wards (Thaweethamcharoern *et al*, 2014), resulting in 38 patients to be sampled from each ward (Osunbor *et al*,2023). Systematic random sampling with replacement was then used to select these 38 patients from each ward using the ward inpatient register as the sampling frame.(Choi and Lee, 2012).

Similarly, in a study conducted at Dessie Referral Hospital in Ethiopia, adult patients with chronic diseases who had regular follow-ups at the outpatient clinic were included. Only those who gave informed consent and agreed to provide samples of urine and blood were enrolled (Sierra *et al*, 2022).

In another study carried out at a university hospital in Seoul, South Korea, participants were selected based on certain inclusion criteria. These criteria included being diagnosed with CKD as an outpatient and not having started renal replacement therapy. The participants also had to be aged 20 years or older and able to understand and communicate during the study (Endalkachew *et al*, 2022).

The methodology employed in these studies had both strengths and limitations. One limitation was potential recall bias among participants regarding their family history or other factors due to not living with their family for a long time. Another limitation was that estimated glomerular filtration rate (eGFR) was calculated using formulae rather than direct measurements. Additionally, the findings of these studies may not be representative due to the lack of a representative sample. However, the quality of data collection and entry was strictly controlled in order to mitigate these limitations
(Hsiao *et al*.2020).

Overall, the sampling procedures used in these studies were effective in selecting participants who met the inclusion criteria for assessing electrolytes in kidney disease patients. The sample sizes were calculated based on various assumptions and calculations, ensuring that an adequate number of participants were included. While there were limitations to consider, these studies provide valuable insights into the estimation of electrolytes in kidney disease patients (Molla *et al*.2020).

- **Measurement of renal function and electrolytes**
- **Blood tests used to estimate renal function**

Blood tests are commonly used to estimate renal function and electrolyte levels in patients with kidney disease. These tests play a crucial role in diagnosing and monitoring the progression of chronic kidney disease (CKD). The measurement of serum electrolytes, such as potassium (K), and urine electrolytes and creatinine, provide valuable information about the functioning of the kidneys (Mutalib and Adirahardja, 2021).

In a study conducted at Dr. Kariadi Semarang, CKD patients were recruited as samples to analyze the relationship between serum electrolyte levels of potassium and urine electrolytes and creatinine. The study followed an observational approach and collected data on K electrolyte levels in serum and urine, as well as creatinine levels. These samples were then analyzed at the Iodine Deficiency Disorders (GAKI) laboratory (Vaidya *et al*. 2022).

The inclusion criteria for the study were patients aged 19-67 years with normal body temperature, normal blood pressure, and who had not smoked for at least 1 year. Exclusion criteria included patients taking anticoagulant drugs, corticosteroids, or diuretics, those who had consumed alcohol in the past month, those with a history of malignancy or renal failure/hemodialysis (Endalkachew *et al*, 2022).

Another study evaluated the relationship between cisplatin-induced nephrotoxicity and electrolyte abnormalities. Cisplatin is a chemotherapy drug used to treat various types of malignancies but has been associated with renal damage. The study reviewed laboratory tests from cancer patients treated with cisplatin between April 2015 and July 2019. It found that abnormal electrolyte levels, such as low magnesium, potassium, sodium, and calcium, were present in a significant number of patients. Electrolyte abnormalities serve as early indicators of renal damage during chemotherapy (Alrfeai *et al*. 2023).

Furthermore, a retrospective review of laboratory records at Aminu Kano Teaching Hospital in Nigeria provided insights into renal function assessment in children. Serum chemistry testing results were analyzed for various electrolytes, including sodium, potassium, chloride, bicarbonate, urea, and creatinine. The study classified patients into different age groups and sources (inpatient or outpatient). Repeat samples and missing data were excluded from the analysis. The study emphasized the challenges of assessing kidney function in infants due to their developmental changes and susceptibility to conditions like malaria and sepsis (Obiagwu *et al*,2023).

- **Importance of measuring urea and creatinine levels**

The measurement of urea and creatinine levels is of utmost importance in the assessment of renal function and electrolytes in patients with kidney disease. These laboratory tests provide valuable information about the functioning of the kidneys and help in the diagnosis, management, and monitoring of renal disorders (Mutalib and Adirahardja, 2021).

One significant aspect that these tests evaluate is the level of electrolytes, particularly potassium (K). Electrolytes play a vital role in maintaining fluid balance in the body and ensuring that serum levels match the body's needs. In patients with chronic kidney disease (CKD), imbalances in electrolytes can occur due to impaired renal function. Therefore, measuring the levels of potassium in both serum and urine can provide valuable insights into the patient's condition (Vaidya *et al*. 2022).

In a study conducted on CKD patients, it was found that abnormalities in electrolyte levels were prevalent. Specifically, low magnesium, potassium, sodium, and calcium were observed. These imbalances can have significant implications for patient health and may lead to complications such as renal toxicity (Alrfeai *et al*. 2023).

The study also highlighted that an average of 15% of patients with electrolyte abnormalities developed renal toxicity and reduced kidney function. This emphasizes the importance of early detection through routine laboratory tests (Obiagwu *et al*,2023).

Furthermore, assessing urea and creatinine levels is crucial for evaluating renal function. Urea is a waste product produced by protein metabolism, while creatinine is a byproduct of muscle metabolism. Elevated levels of these substances indicate impaired kidney function since healthy kidneys are responsible for filtering them out from the blood (Hsiao *et al*.2020).

Additionally, measuring urea and creatinine levels helps differentiate between acute and chronic kidney dysfunction. Acute kidney injury (AKI) is characterized by a rapid decline in kidney function over a short period. On the other hand, chronic kidney disease (CKD) involves a progressive loss of kidney function over an extended period (Hsiao *et al*.2020).

Moreover, assessing urea and creatinine levels provides insights into an individual's risk for cardiovascular disease as CKD is

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associated with an increased risk of cardiovascular complications. Therefore, monitoring these levels is crucial for identifying individuals at higher risk and implementing preventive measures.

In conclusion, the measurement of urea and creatinine levels is essential for assessing renal function and electrolyte balance in patients with kidney disease. These tests provide valuable information about the functioning of the kidneys, help in diagnosing and managing renal disorders, and can serve as early indicators of complications such as renal toxicity (Hsiao *et al*.2020).By monitoring these levels, healthcare professionals can intervene timely to prevent further deterioration of kidney function and mitigate the risk of cardiovascular disease.

THE RESULTS

In this study, the researchers aimed to compare kidney disease patients with a control group, as well as compare the findings in patients over 50 years old and under 50 years old. Additionally, they wanted to compare the results of the study with those of healthy individuals.

The study was conducted at the University of Benin Teaching Hospital (UBTH) in Benin City, Edo State, Nigeria. It took place over a fourteen-month period from October 2016 to November 2017. The participants were dialysis naive CKD patients attending the nephrology consultant out-patient clinic in UBTH who met the inclusion criteria.

The sample size for the study was determined using Fleiss formula, with a minimum sample size of 80 for CKD patients and 40 for the control group. The inclusion criteria for CKD patients were being aged 18 years and above, having stage 3-5 CKD, and giving informed consent. Patients on maintenance haemodialysis, steroids, and kidney transplant recipients were excluded from the study. As for the control group, apparently healthy individuals without CKD or other chronic medical conditions were recruited from the workforce of the hospital.

Socio-demographic information such as age, sex, marital status, occupation, educational status, and medical history were obtained from all study participants through an investigator-administered structured questionnaire. Physical examinations including weight and height measurements were also conducted. Body mass index (BMI) was calculated based on weight and height values.

Aetiology of CKD was determined by the nephrologist's opinion using clinical history, physical examination results, and investigation findings. Laboratory investigations were conducted on fasting venous blood samples collected from each participant. These investigations included fasting blood glucose, full blood count, erythrocyte sedimentation rate (ESR), serum total cholesterol levels, urea levels, creatinine levels, electrolyte levels (such as sodium, potassium, and chloride), and albumin levels.

The study found that mortality rates associated with CKD were significantly higher than those without CKD. After adjusting for various factors, it was revealed that mortality in patients with CKD in 2009 was 56% greater compared to those without CKD. For patients with stages 4-5 CKD, the adjusted mortality rate was even higher at 76%.

Furthermore, the study found that mortality rates were consistently higher for men compared to women and for black individuals compared to white individuals and patients of other races. Among Medicare CKD patients aged 66 years and older, deaths per 1000 patient-years were higher for black patients compared to white patients.

Interestingly, the highest mortality rate was observed within the first six months of initiating dialysis. However, there was a slight improvement in mortality rates over the next six months before gradually increasing over the next four years. The 5-year survival rate for a patient undergoing long-term dialysis in the United States was approximately 35%, and around 25% for patients with diabetes.

Another study mentioned in the data showed that the risk of mortality was elevated in patients with end-stage renal disease (ESRD) and congestive heart failure who received peritoneal dialysis compared to those who received hemodialysis. The median survival time was shorter for patients receiving peritoneal dialysis compared to those receiving hemodialysis.

In terms of life expectancy, it was observed that individuals with ESRD on dialysis had significantly increased mortality at every age compared to non dialysis patients and individuals without kidney disease. For example, a healthy person aged 60 years could expect to live for more than 20 years, whereas a patient aged 60 years starting hemodialysis had a life expectancy closer to just four years. Among ESRD patients aged 65 years or older, mortality rates were six times higher than in the general population.

Moving on to the findings specific to the study conducted at the University of Benin Teaching Hospital, a total of 250 pre-dialysis CKD patients and 125 age and sex-matched apparently healthy controls without CKD were recruited. The mean age of the participants was 50 years, with a range of 25-85 years. The majority of respondents were urban dwellers (69.2%) and women

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(62.7%). Most participants were currently married (77.9%) and self-employed (60.4%). With regard to educational status, 34.4% had no formal schooling, while 15.4% had attained a college level education or higher.

Table 5: Demographic characteristics of cisplatin patients treated between 19 April 2015 and 17 July 2019. (N.A. : not applicable). (7)

No.	Characteristics		Patients No. (%)
1	Gender	Male	124 (48.81%)
		Female	130 (51.4%)
2	Nationality and	Saudi	253 (100%)
	Marital status	Single	75 (29.6%)
		Married	150 (59.3%)
		Divorced	2 (0.8%)
		N.A.	26 (10.3%)
3	Age (2–84 years)	Pediatric patients	34 (13.4%)
	Median 46 years	Adults	220 (86.6%)
4	BMI	Overweight	110 (43.3%)
		Normal weight	144 (56.7%)
5	Cisplatin	Alone	50 (19.7%)
		In combination	204 (80.3%)

THE DISCUSSION

The significance of the results discussed in this essay is crucial for understanding the implications of electrolyte imbalances in kidney disease patients. The data retrieved from various studies provides valuable insights into the mortality rates and prognosis associated with chronic kidney disease (CKD). It is evident that mortality rates in patients with CKD are significantly higher compared to those without CKD. The adjusted mortality rate for patients with stages 4-5 CKD is even greater, highlighting the severity of the disease (Mwenda *et al*, 2018).

Furthermore, the highest mortality rate occurs within the first 6 months of initiating dialysis, emphasizing the need for early intervention and close monitoring during this critical period. The 5-year survival rate for patients undergoing long-term dialysis is alarmingly low, especially for those with diabetes. This information underscores the importance of effective management strategies to improve patient outcomes (Vaidya *et al*. 2022).

Additionally, the relationship between electrolyte derangements and kidney function tests is explored in several studies. Electrolyte disorders are commonly seen in CKD patients and can indicate kidney tubular damage, particularly when CKD progresses to end-stage renal failure (ESRF). However, it is worth noting that none of the study participants in a particular investigation were under serious kidney disease, suggesting that electrolyte derangements may be less likely associated with reduced glomerular filtration rate (Hsiao *et al*.2020)

Factors associated with stage II kidney disease include older age, high BMI, and previous history of cardiovascular diseases. These findings align with similar studies conducted in different regions but contrast with a study from South Africa where high prevalence was found in younger age groups. These variations may be attributed to differences in risk factors prevalent within specific populations (Molla *et al*.2020).

Moreover, fractional excretion (FE) of electrolytes plays a significant role in clinical practice and can serve as a potential predictor of CKD progression. The FE tends to increase as renal function declines, regardless of diabetes mellitus (DM) status. Diabetic patients often exhibit higher FE of magnesium at certain stages of CKD, indicating a potential association between magnesium derangement and disease progression (Wang *et al*. 2021).

The discussion also highlights the importance of electrolyte balance, particularly potassium, in determining the prognosis of stroke. Hypokalemia is associated with poor functional outcomes and increased risk of death in patients with acute ischemic stroke (AIS) or transient ischemic attack (TIA). On the other hand, hyperkalemia is identified as a potential risk factor for poor outcomes in patients with chronic kidney disease and acute myocardial infarction (Hafiz *et al*. 2022).

In conclusion, the significance of the results discussed in this essay lies in their contribution to our understanding of electrolyte imbalances and their impact on kidney disease patients (Hafiz *et al*. 2022).These findings can inform clinical decision-making, treatment strategies, and monitoring protocols to improve patient outcomes and prevent disease progression. Further research is needed to explore the underlying mechanisms and develop targeted interventions for managing electrolyte imbalances in this patient population (Hafiz *et al*. 2022).

Table 3: Multinomial regression analysis to assess the risk factors associated with hyperuricemia (Hafiz *et al*. 2022).

Variables	AOR (95% CI)	*P*-value
Age	1.010 (0.997–1.02)	0.134
Gender	0.859 (0.583–1.264)	0.440
Diabetes	1.000 (0.998–1.002)	0.996
Malnutrition	1.459 (1.081–1.970)	0.014*
Calcium	0.855 (0.719–1.017)	0.077
Phosphorus	0.950 (0.863–1.046)	0.296
Magnesium	1.606 (1.137–2.270)	0.007*
Sodium	0.993 (0.949–1.038)	0.754
Potassium	0.862 (0.725–1.024)	0.091
Chloride	0.984 (0.948–1.022)	0.409

- **Implications for the understanding and management of kidney disease**

The estimation of electrolytes in kidney disease patients is important for understanding and managing the condition (Hsiao *et al*.2020). Previous studies have shown that lower levels of potassium, sodium, and chloride are associated with a higher risk of poor outcomes and death in patients with acute ischemic stroke or transient ischemic attack. Hypokalemia, a common electrolyte disorder, is correlated with an increased risk of ischemic stroke and worse prognosis following stroke (Wang *et al*. 2021).

Hyperkalemia, often seen in chronic kidney disease patients, is a potential risk factor for poor outcomes in acute myocardial infarction and kidney disease. However, more research is needed to fully understand the role of hyperkalemia in stroke (Hafiz *et al*. 2022). Various studies have looked at the association between serum electrolytes and chronic kidney disease, with phosphorus showing the most consistent association. Additionally, monitoring serum urea, uric acid, creatinine, and magnesium levels can help assess renal function and prevent progression to renal failure. Overall, understanding electrolytes in kidney disease patients improves management and prognosis (Mehmood *et al*. 2022).

Table 4: (Mehmood *et al*. 2022)

Variables	AOR (95% CI)	*P*-value
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CONCLUSION

A study was conducted to estimate electrolyte levels in kidney disease patients, with a focus on detecting and preventing Cisplatin-induced kidney complications. The study included 254 Saudi patients and found that gender and body mass index (BMI) were not significant factors in relation to developing nephrotoxicity (Alrfeai *et al*. 2023).

The median BMI score was 23, and the median age of participants was 46 years old. Marital status varied among the patients (Hsiao *et al*.2020). Cisplatin treatment was often combined with other chemotherapies, and pediatric patients represented a significant portion of the cohort (Mehmood *et al*. 2022). Another study explored the association between chronic kidney disease (CKD) and risk factors such as age and gender. (Hansen *et al.* 2021) It found a significant association between CKD and gender, with younger patients having a higher prevalence of CKD due to factors like hypertension.(Hansen *et al*. 2021) The study also highlighted the coexistence of diabetes with CKD and its role as a leading cause of diabetic nephropathy. Magnesium was identified as a vital ion in CKD patients, with a high incidence of hypomagnesemia reported. Phosphorus showed a statistically significant association with CKD.(Hansen *et al*. 2021) Creatinine and urea levels were elevated in all CKD patients, and hyperuricemia was present in many cases. Serum uric acid was found to be an independent risk factor for CKD progression. A cross-sectional study examined electrolyte excretion and renal function biomarkers at different stages of CKD (Ljungberg *et al*. 2022).Kidney disease is a global public health crisis, affecting millions of people worldwide. Women are more prone to kidney disease, while men face a higher risk of kidney failure. Diabetes and high blood pressure are common comorbidities associated with kidney disease. Overall, these studies provide valuable insights into electrolyte estimation in kidney disease patients, prevalence and risk factors of CKD, and potential avenues for prevention and treatment strategies. Further research is needed for better management and prevention of kidney disease (Ljungberg *et al*. 2022).

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