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Assessment of Renal Functions and Electrolytes in Patients of Chronic Kidney Disease with Hypertension

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ABSTRACT

Background: Chronic kidney disease (CKD) is defined as "persistent structural or functional renal abnormalities for over three months, indicated by reduced GFR (<60 mL/min/1.73 m²) and albuminuria". Serum creatinine and eGFR are key diagnostic measures because creatinine alone may be insufficient. The objectives are to evaluate serum creatinine, urea, uric acid, glomerular filtration rate and electrolytes in chronic kidney disease patients with hypertension; and to determine the association between hypertension and the severity of renal dysfunction.

Methods: This study employed a hospital-based cross-sectional analytical design over three months, including 55 adult CKD patients with hypertension selected through consecutive sampling. Biochemical parameters such as urea, creatinine, uric acid and electrolytes (Na^+, K^+, Cl^-) were analysed, with eGFR estimated using the Cockcroft–Gault equation. Data were processed using SPSS version 27, with results expressed as mean ± SD. Pearson correlation assessed associations, and $p < 0.05$ was considered to be statistically significant.

Results: The findings indicate advanced renal dysfunction with elevated mean values of urea (98.65 mg/dL), creatinine (7.82 mg/dL) and BUN (46.11 mg/dL) alongside markedly reduced GFR (9.02 mL/min/1.73 m²). Serum electrolytes like sodium showed a significant negative correlation with urea and BUN ($r = –0.268$, $p = 0.048$), while potassium and chloride demonstrated no significant association with renal parameters ($p > 0.05$).

Conclusion: In the relationship between renal functions and serum electrolytes it was found that there is a significant negative correlation of sodium with urea and BUN ($r = –0.268$, $p = 0.048$).

Key-words: Chronic kidney disease, Hypertension, Renal function, Serum electrolytes, Glomerular filtration rate

INTRODUCTION

Chronic kidney disease (CKD) is referred to as structural or functional abnormalities in kidney function for 3 months and is characterised by damage in the kidney, which is mostly identified as persistent albuminuria or proteinuria. The glomerular filtration rate (GFR) is reduced to (< 60 ml/min/1.73 m^2) [1]. GFR estimates the amount of blood that passes through the glomeruli. It is regarded as the best index of overall kidney function [2].

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The most crucial and significant marker of GFR is Serum creatinine (SCr), which is used clinically. The level of SCr is affected by various other factors apart from GFR, which is sensitive for the identification of CKD on its own and has the ability to remain in the normal range of values [3].

The National Kidney Disease Education Program (NKDEP) was conducted, which recommended serum creatinine (SCr) and estimated GFR (eGFR), apart from SCr, for more evaluation to evaluate the function of kidneys among adults aged>18 years [4]. Electrolytes perform several body functions in the human body. While electrolyte disorders can cause multiple problems, cardiac issues are crucial disorders, as the function of the heart is dependent on normal levels of electrolytes. Specifically, in heart failure patients, the electrolytic disorder

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develops complications. There are several factors, such as hormonal and physiological stress, which interact among themselves in the formation of changes [5]. However, the high prevalence of CKD and the imbalance of electrolytes make patients more prone to CVD morbidity and mortality [6]. Many researchers recommend a screening procedure for evidence of kidney disease among all CVD patients using eGFR and albuminuria. Also, many physicians depend on SCr as the measurement of renal function and the normal levels of SCr are interpreted to analyse normal function [7].

Kidneys have major roles and responsibilities in controlling blood pressure due to the production of renin, maintaining fluid and electrolyte balance, removing waste products as well as acids, and producing erythropoietin [8]. The initial stages of kidney disease are reported to include a reduction in GFR and albuminuria, while the advanced stage can lead to ESRD. This requires transplantation or dialysis, imposing a major challenge or burden on patients. The prevalence of CKD among Africans is estimated to be 10.1%, and 24.7% is observed among patients with diabetes mellitus [9]. Enhanced patient awareness and altered lifestyle are significant in preventing kidney disease and hypertension. Early detection can reduce the associated complications of hypertension, like cardiovascular disease and can effectively improve patient outcomes [10]. The study objective was to evaluate the renal function and electrolyte levels among CKD patients with hypertension. Also, the biochemical parameters were evaluated to determine the association between hypertension and renal dysfunction for improved clinical regulation, management, and to prevent the progression of CKD.

MATERIALS AND METHODS

Research design- The study was a hospital-based cross-sectional analytical study to evaluate the renal functions and the electrolytes among CKD patients who suffered from hypertension. The study was conducted for a period of 3 months at the Department of Biochemistry and at Departments of Medicine and Nephrology at teaching hospital of Karwar Institute of Medical Sciences, Karwar. Data source includes the adult patients who attended the hospital from the outpatient and inpatient departments and were diagnosed with CKD conditions, along with hypertension. The population of the study was categorised on the basis of the status of hypertension to provide a comparative study. Specific clinical and biochemical parameters were performed, including the renal function tests and serum electrolyte levels, to assess the relationship with CKD.

Inclusion criteria

- Adults aged 18 years and above.
- Patients with a confirmed diagnosis of chronic kidney disease.
- Patients with chronic kidney disease with documented hypertension.
- Patients attending outpatient or inpatient services of the study centre.
- Clinically stable patients at the time of evaluation.

Exclusion criteria

- Patients with acute kidney injury or acute-on-chronic kidney disease.
- Patients with chronic kidney disease due to active systemic infections.
- Patients with malignancy or autoimmune disorders affecting renal function.
- Pregnant women.
- Patients who have undergone renal transplantation.
- Patients on long-term renal replacement therapy.
- Patients receiving recent nephrotoxic drug therapy or high-dose steroids.
- Patients unwilling or unable to provide informed consent.

Procedure- The ethical approval was taken from the Institutional Ethics Committee, and the included patients were selected on the basis of the pre-defined criteria following the patients' consent. 55 patients diagnosed with CKD along with hypertension were included in the study by consecutive sampling method. 5 ml of venous blood was collected aseptically from each of the participants. The collected blood samples were centrifuged for serum isolation for further biochemical analysis. The samples of serum were used for measuring urea, uric acid, creatinine and electrolytes such as sodium (Na^+), potassium (K^+) and chloride (Cl^-). GFR was measured by the use of the Cockcroft–Gault equation. Data collection includes the clinical investigation along with laboratory evaluations. The status of hypertension was defined on the basis of standard criteria of blood pressure or the use of antihypertensive medications.

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Outcome assessment- The primary outcome of the study was to evaluate the renal function and the electrolyte status among CKD patients with hypertension. The renal function was evaluated by serum urea, uric acid and creatinine levels, while the eGFR was estimated by Cockcroft–Gault equation. Electrolyte balance was evaluated by the serum sodium (Na^+), potassium (K^+), and chloride (Cl^-) levels. Comparative analysis was done to identify the relationship between the hypertension and alterations in renal function parameters. The outcomes help in understanding the extension of the renal impairment and the metabolic conditions of the CKD patients with hypertension.

Statistical Analysis- Data analysis was done by SPSS software version 27. Descriptive statistics was used for summarization of the baseline parameters of the population under study. Continuous variables were expressed as the mean ± standard deviation or median, on the basis of the distributed data. Multivariate analysis (Pearson Correlation) was conducted to analyze the association between the renal function parameters and serum electrolytes. A p-value of <0.05 was considered to be statistically significant.

RESULTS

Fig. 1 shows that the age distribution of patients is predominantly skewed towards middle and older age groups. The highest proportion of individuals falls within the 50 to 59 years category (30.9%), followed by 60 to 69 years (23.6%), indicating that more than half of the study population lies between 50 to 69 years of age. Younger age groups such as 19 to 29 years (3.6%) and 30 to 39 years (7.3%) are minimally represented. The cumulative percentage rises sharply after 50 years, reaching 81.8% by 69 years, suggesting a concentration of cases in later adulthood. The distribution clearly reflects an age-related clustering, likely indicating higher disease burden in older populations.

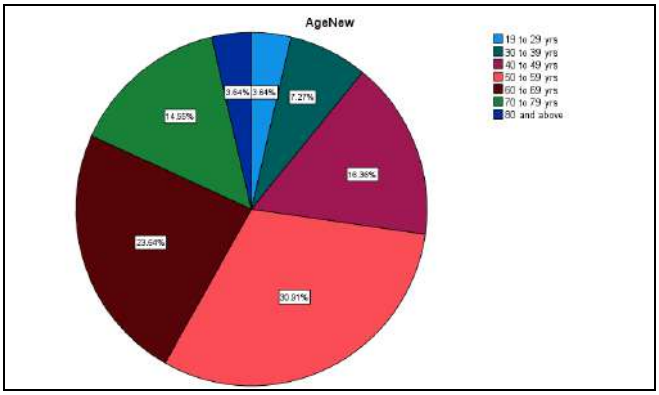

Fig. 1: Distribution of patients in different age range

Fig. 2 shows that the study population is predominantly male, with males constituting 80% (n = 44) of the total sample, whereas females account for only 20.0% (n = 11). This marked gender disparity indicates a strong male predominance in the study cohort. The cumulative percentage reaches 100% after inclusion of male participants, reflecting the complete sample distribution. In comparison, female representation is substantially lower, suggesting a higher prevalence of the condition among males. The observed difference in proportions may have implications for gender-specific risk assessment and clinical interpretation.

Table 1 shows that the study population demonstrates elevated systolic blood pressure with a mean of 150.71 mm Hg, indicating a predominantly hypertensive cohort, whereas diastolic pressure remains comparatively lower (mean 83.04 mm Hg), suggesting isolated systolic predominance in several individuals. The wide range of systolic values (120–210 mm Hg) and notable standard deviation (18.99) indicate substantial variability in blood pressure control. In contrast, weight distribution appears relatively moderate (mean 57.84 kg), though the broad range (30.9–89.3 kg) reflects heterogeneity in nutritional or metabolic status. The dispersion of values suggests clinically significant variation, particularly in systolic blood pressure, which may have implications for cardiovascular and renal risk stratification within the cohort.

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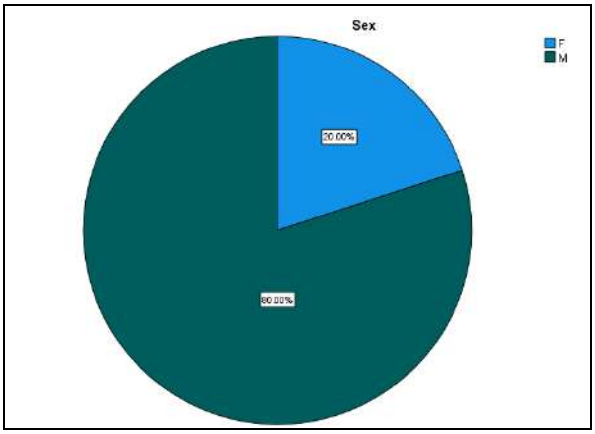

Fig. 2: Distribution of male and female patients

Table 1: Blood Pressure and Weight

Parameter	Mean	Std. Deviation	Minimum	Maximum
Systole (mm Hg)	150.7091	18.98798	120	210
Diastole (mm Hg)	83.0364	10.50038	54	110
Weight (kg)	57.84	12.04042	30.9	89.3

Table 2 shows that, renal function test parameters indicate markedly impaired kidney function with considerable inter-individual variability. Urea demonstrates the highest mean value (98.65 mg/dL) with a wide dispersion (SD= 28.05), followed by BUN (46.11 ± 13.09 mg/dL), both reflecting significant Azotaemia. Creatinine is substantially elevated (7.82 ± 2.64 mg/dL), corresponding with a severely reduced GFR (9.02 ± 3.23 mL/min/1.73 m²), indicating advanced renal dysfunction. Uric acid levels (7.98 ± 1.91 mg/dL) are moderately elevated. Comparatively, GFR shows the lowest mean, inversely reflecting renal impairment relative to other parameters.

Table 2: Findings related to Renal Function Tests of the patients

Parameter	Mean	Std. Deviation (SD)	Minimum	Maximum
Urea (mg/dL)	98.656	28.048	53.1	177.7
Uric Acid(mg/dl)	7.982	1.9125	2.1	14.6
Creatinine(mg/dl)	7.818	2.639	3.62	14.87
GFR (ml/min/1.73 m^2)	9.018	3.228	4.03	16.93
BUN (mg/dl)	46.114	13.092	24.81	83.03

Table 3 demonstrates correlations between blood pressure parameters and renal function indices. Systolic blood pressure shows weak positive correlations with urea (r = 0.218, p = 0.11), uric acid (r = 0.121, p = 0.38), creatinine (r = 0.109, p = 0.428), and BUN (r = 0.218, p = 0.111), along with a weak negative correlation with GFR (r = −0.129, p = 0.348); however, none of these associations reach statistical significance. In contrast, diastolic blood pressure demonstrates stronger associations, particularly with creatinine (r = 0.327, p = 0.015) and GFR (r = −0.314, p = 0.02), both of which are statistically significant, indicating that higher diastolic pressure is associated with increased creatinine and reduced GFR. The correlations with urea (r = 0.071, p = 0.605), uric acid (r = 0.21, p = 0.124), and BUN (r = 0.072, p = 0.604) remain weak and statistically non-significant. Overall, diastolic blood pressure exhibits a more meaningful association with renal dysfunction markers compared to systolic blood pressure, particularly in relation to creatinine and GFR.

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Table 3: Association of blood pressure (systolic and diastolic) with that of renal function test parameters

Renal Parameter		Systole	Diastole
Urea (mg/dl)	Pearson Correlation	0.218	0.071
	p-value	0.11	0.605
Uric Acid (mg/dl)	Pearson Correlation	0.121	0.21
	p-value	0.38	0.124
Creatinine (mg/dl)	Pearson Correlation	0.109	0.327*
	p-value	0.428	0.015
GFR (ml/min/1.73 m^2)	Pearson Correlation	-0.129	-0.314*
	p-value	0.348	0.02
BUN (mg/dl)	Pearson Correlation	0.218	0.072
	p-value	0.111	0.604

Table 4 shows that serum electrolyte levels are relatively maintained within or near physiological ranges, though deviations are evident. Sodium exhibits a mean of 140.56 mmol/L with low variability (SD= 4.82), remaining within normal limits compared to potassium (5.07 ± 0.77 mmol/L), which is at the higher end, suggesting towards hyperkalemia. Chloride levels (105.6 ± 4.26 mmol/L) are also within normal range but show moderate dispersion. Compared to sodium; potassium demonstrates greater clinical deviation, while chloride remains stable.

Table 4: Findings related to Serum Electrolytes of the patients

Parameter	Mean	Std. Deviation	Minimum	Maximum
Na^+ (mmol/L)	140.563	4.821	129	150
K^+ (mmol/L)	5.074	0.768	3.1	6.7
Cl^- (mmol/L)	105.6	4.258	95	116

Table 5 shows that correlation analysis between renal function parameters and serum electrolytes. Urea demonstrates a significant negative correlation with sodium ($r = –0.268$, $p = 0.048$), indicating that higher urea levels are associated with lower sodium concentrations. A similar pattern is observed with BUN ($r = –0.268$, $p = 0.048$), reinforcing this relationship. Other correlations, including those involving uric acid, creatinine, and GFR with electrolytes, are weak and statistically non-significant ($p > 0.05$), suggesting minimal linear association. Potassium and chloride show no correlations with renal parameters. Overall, sodium appears to exhibit a significant relationship with markers of nitrogenous waste accumulation.

Table 5: Analysis of Renal Function Test Parameters and Serum Electrolytes in CKD patients

Parameter		Na^+ (mmol/L)	K^+ (mmol/L)	Cl^- (mmol/L)
Urea (mg/dl)	Pearson Correlation	-.268*	0.012	0.121
	p-value	0.048	0.932	0.379
Uric Acid (mg/dl)	Pearson Correlation	-0.096	-0.094	0.086
	p-value	0.485	0.496	0.534
Creatinine (mg/dl)	Pearson Correlation	-0.145	0.061	0.168
	p-value	0.29	0.66	0.219
GFR (ml/min/1.73 m^2)	Pearson Correlation	0.092	-0.032	-0.012
	p-value	0.503	0.816	0.932
BUN (mg/dl)	Pearson Correlation	-0.268*	0.013	0.122
	p-value	0.048	0.923	0.374

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DISCUSSION

The patients who underwent CKD were classified into 7 stages according to eGFR. The Fractional excretion (FE) of electrolytes increased with the reduction in renal function from CKD1 to CKD5. This indicated a reduction in the renal tubular reabsorption capacity. Significant variations have been noticed regarding the blood and urine biochemical parameters. The mean value of FENa, FEK, FECl, FECa, FEP and FEMg increased with the advancement of CKD. While similar trends were noted after patients' exclusion by the use of diuretics. The comparison between the diabetic and non-diabetic groups revealed no difference between the electrolytes, although the diabetic patients had a significantly high rate of excretion of magnesium (FEMg) in CKD2 and CKD5 stages [11]. The development of hypertension is related to body mass index, dietary salt intake and volume overload and is treated with antihypertensives.

In CKD patients, managing hypertension can provide significant effects that can reduce the progression of CKD or minimise the complications associated with low glomerular filtration rate. The prevalence of hyperkalemia and hypokalemia among CKD patients was similar at 15-20% and 15-18%, respectively. Hyperkalemia is prevalent in CKD due to impaired potassium excretion. Serum potassium level is affected by renin-angiotensin-aldosterone system inhibitors and diuretics and dietary potassium intake, and can be managed by potassium restriction, optimised renin-angiotensin-aldosterone system inhibitor, sodium polystyrene sulfonate, patiromer and haemodialysis [12]. Hypertensive patients were observed with high body mass index, systolic and diastolic blood pressure and increased level of creatinine, urea, uric acid, magnesium and sodium ($P<0.05$).

In contrast, the vitamin D, calcium, potassium and phosphate levels are lower in hypertensive individuals than in the control group. No differences were observed with age and sex. The results indicated that hypertension is related with the electrolyte imbalance, renal dysfunction and deficiency of vitamin D. These findings highlighted the significance of regulating the biochemical parameters among hypertensive patients [13]. Acid-base and electrolyte alterations are commonly observed among CKD patients and patients with End-stage Renal Disease (ESRD). Complexity enhanced as CKD advances to ESRD leads to morbidity and mortality. Three cases are presented illustrating some key prototypic features in CKD and ESRD. Each is accompanied by a discussion of pathophysiology, diagnosis and treatment options.

Although assessment of various dialysis prescriptions is not present, a multi-pronged management plan to reduce the CKD/ESRD and dialysis-related electrolyte and acid-base disruptions is appropriate. There is a significant need for prospective interventional trials in the future.[14]

The acid-base status had been evaluated, and the electrolytic balance among CKD patients was assessed. Metabolic acidosis was noted among 76.7% of patients, which was predominant in stage G5 (48.2%). 37.5% of patients were observed with hyperkalemia, while 5.3% of cases were noted with hypokalemia. Hypermagnesemia was observed among 25% of cases, and hypomagnesemia was observed among 5.3% of patients. The major risk factors were hypertension and diabetes. The electrolyte disturbances and acid–base imbalance was enhanced with the advancement of CKD stages, specifically in the G5 stage patients [15].

The cross-sectional comparative study evaluated the electrolytic profiles among 100 patients with CKD. Males were 66% and were under the pre-elderly age group (45 to 59 years). Both of the groups showed high levels of urea, creatinine and glucose levels with low levels of glomerular filtration rate, which confirmed the advanced stage of CKD with diabetes mellitus. A significant difference was noted in the level of serum sodium (natrium), with a reduced level in stage 5 rather than stage 4. No significant differences were observed in the levels of potassium and chloride. The results indicated high sodium dysregulation with advanced CKD [16].

CONCLUSIONS

The study concluded that the patients showed advanced renal dysfunction with significant Azotaemia and markedly reduced GFR, alongside relatively stable but subtly altered electrolyte profiles. The principal finding was a statistically significant negative association between sodium and nitrogenous waste markers, specifically urea ($r = –0.268$, $p = 0.048$) and BUN ($r = –0.268$, $p = 0.048$), indicating that worsening renal impairment is linked with declining sodium levels. In contrast, potassium and chloride showed no significant correlations with renal parameters ($p > 0.05$). Additionally, diastolic blood pressure demonstrated significant associations with creatinine ($p = 0.015$) and

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GFR (p = 0.02), highlighting its clinical relevance in renal deterioration. The study concludes that CKD with hypertension is predominantly observed in older adults (50 to 69 years; 54.5%) and males (80%), with elevated systolic blood pressure (150.71 mmHg) indicating suboptimal control.

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CONTRIBUTION OF AUTHORS

Research concept – Soumyadeep Dutta, B.N. Malawadi
Research design – Soumyadeep Dutta, B.N. Malawadi
Supervision – B.N. Malawadi
Materials – Soumyadeep Dutta, B.N. Malawadi
Data collection – Soumyadeep Dutta, B.N. Malawadi
Data analysis and interpretation – Soumyadeep Dutta, B.N. Malawadi
Literature search – Soumyadeep Dutta
Writing article – Soumyadeep Dutta
Critical review – B.N. Malawadi
Article editing – Soumyadeep Dutta, B.N. Malawadi
Final approval – Soumyadeep Dutta, B.N. Malawadi

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