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Correlation between estimated glomerular filtration rate and serum electrolytes in chronic kidney disease patients

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ABSTRACT

Background: The occurrence of chronic kidney disease (CKD) a highly prevalent condition has been escalating in recent years. Electrolytes are the key to homeostasis and furthermore, their regulation is dependent upon renal function. CKD is associated with aberrations in the metabolism of electrolytes such as calcium, magnesium, sodium, and potassium. **Aims and Objectives:** The aim of this study is to study the correlation between estimated glomerular filtration rate (eGFR) and serum electrolytes in CKD patients. **Materials and Methods:** The present study was a cross-sectional study. One hundred patients with CKD aged 18 years or above were enrolled with inclusion and exclusion criteria. Complete blood investigations, urine analysis and ultrasonographic findings for detection of CKD were done and a semi-structured pro forma was used to record clinical profile in a cross-sectional study and patients were grouped into their respective CKD stages based on their eGFR. **Results:** The mean value of eGFR was 40.92 ± 21.35 mL/min/1.73 m^2. The mean value of serum sodium, calcium, magnesium, and potassium was 137.1 ± 2.16 meq/L, 9.15 ± 0.61 mg/dL, 3.16 ± 0.93 mg/dL, and 4.65 ± 0.96 meq/L, respectively. In the present study, we found that the mean serum magnesium levels in Stages 1, 2, 3, 4, and 5 of CKD were 2.10 ± 0.20, 2.10 ± 0.28, 2.74 ± 0.50, 3.95 ± 0.54, and 4.66 ± 0.43 mg/dL, respectively. Mean serum magnesium levels were the mean serum potassium levels in Stages 1, 2, 3, 4, and 5 of CKD were 4.13 ± 0.57, 4.15 ± 0.68, 3.86 ± 0.41, 5.55 ± 0.39, and 6.25 ± 0.08 meq/L, respectively. The mean serum calcium levels in Stages 1, 2, 3, 4, and 5 of CKD were 9.83 ± 0.05, 9.79 ± 0.20, 9.43 ± 0.27, 8.72 ± 0.38, and 7.8 ± 0.10 mg/dL, respectively. The mean serum sodium levels in Stages 1, 2, 3, 4, and 5 of CKD were 137.33 ± 0.57, 136.43 ± 2.87, 136.92 ± 2.15, 137.51 ± 1.90, and 137.5 ± 2.07 meq/L, respectively. **Conclusion:** There was significant rise in serum potassium and magnesium levels with decrease in eGFR in CKD patients. There was significant fall in serum calcium levels with decrease in eGFR in CKD patients. There was no significant correlation between serum sodium levels and eGFR in CKD patients.

Key words: Chronic kidney disease; Serum magnesium; Serum potassium; Serum calcium; Serum sodium; Estimated glomerular filtration rate

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INTRODUCTION

Over the past decade, CKD has been recognized as a major global public health problem.[1] A variety of electrolyte and acid–base derangements predictably occur with progressive loss of kidney function.[2] In developed countries, chronic kidney disease is generally associated with old age, diabetes, hypertension, obesity, and cardiovascular disease, with diabetic glomerulosclerosis and hypertensive nephrosclerosis as the presumed pathological entities; however, exact diagnosis is often difficult.[3] End-stage renal disease is defined as a GFR of <15 mL/min/1·73 m^2, or the need for treatment with dialysis or transplantation. Other outcomes include complications of reduced GFR, such as increased

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risk of cardiovascular disease, acute kidney injury, infection, cognitive impairment, and impaired physical function.[4-8]

Due to the central role of GFR in the pathophysiology of complications, the disease is classified into five stages on the basis of GFR: More than 90 mL/min/1·73 m^2 (Stage 1), 60–89 mL/min/1·73 m^2 (Stage 2), 30–59 mL/min/1·73 m^2 (Stage 3), 15–29 mL/min/1·73 m^2 (Stage 4), and <15 mL/min/1·73 m^2 (Stage 5). Findings from experimental and clinical studies have suggested an important role for proteinuria in the pathogenesis of disease progression.[9]

Criteria for CKD (either of the following present for >3 months).[10]

Markers of kidney damage (one or more)	Albuminuria (AER≥30 mg/24 h; ACR ≥30 mg/g Urine sediment abnormalities Electrolyte and other abnormalities due to tubular disorders Abnormalities detected by histology Structural abnormalities detected by imaging History of kidney transplantation
Decreased GFR	GFR <60 mL/min/1.73 m^2 (GFR categories G3a-G5)

CKD: Chronic kidney disease; GFR: Glomerular filtration rate

A community-based study around Delhi using estimated glomerular filtration rate (eGFR) by MDRD and Cockroft–Gault equations found that 4.2% of the population had low eGFR (<60 mL/min/1.73 m^2).[11]

The major homeostasis of magnesium is maintained between the amount absorbed by the gut and the amount excreted by the kidney. The signs and symptoms of hypomagnesemia and hypermagnesemia are very subtle and not easily detected, unless specifically looked for.[12]

In CKD patients, hyperkalemia is of great concern due to its possible implications for patient safety related to the potential for associated adverse cardiac outcomes.[13-15]

CKDmineral bone disease is a systemic disorder that is characterized by abnormal calcium, phosphorous, parathyroid hormone, and vitamin D metabolism, which, in addition to affecting the skeletal system, is related to the appearance of cardiovascular and soft tissue calcifications that in turn are associated with cardiovascular pathologies in patients with CKD.[16-19]

Aims and objectives

To study the correlation between eGFR and serum electrolytes in CKD patients

MATERIALS AND METHODS

The present study was carried out at Shyam Shah Medical College and Sanjay Gandhi Memorial Hospital, Rewa from April 2021 to March 2022 for a time period of 12 months. This cross-sectional study was approved by the Institutional Ethics Committee. Voluntary informed consent was taken from all the subjects of the study.

Inclusion criteria

The following criteria were included in the study:

- CKD patients of all types.

Exclusion criteria

The following criteria were excluded from the study:
Patients with:

1) Presenting complains of diarrhea, pancreatitis, vomiting.
2) Patients on diuretics.
3) Patients on steroids.
4) Patients with shock.
5) Patients with urological causes.
6) Age <18 years.

Methodology

After informed consent from the enrolled patients, patient's vital parameters were recorded. Patients were subjected to laboratory investigations such as complete blood counts, urine routine and microscopy, renal function tests, serum magnesium, serum potassium, serum sodium, serum calcium levels, and ultrasonographic finding of kidney.

After the investigations, patients were diagnosed as CKD and MDRD formula was used for eGFR calculation and patients were classified into their respective CKD stages.

RESULTS

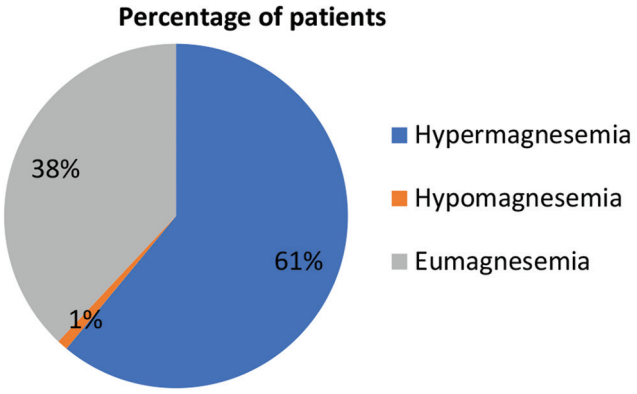
Table 1 showed that the mean serum magnesium levels were 2.10±0.20 mg/dL, 2.10±0.28 mg/dL, 2.74±0.50 mg/dL, 3.95±0.54 mg/dL, and 4.66±0.43 mg/dL in patients with Stages 1, 2, 3, 4, and 5 of CKD, respectively.

Table 1: Correlation between CKD stages and mean serum magnesium levels

CKD stage	Mean serum magnesium levels (mg/dL)	P-value
1	2.10±0.20	t=9.55, P<0.0001
2	2.10±0.28	t=17.1, P<0.0001
3	2.74±0.50	t=13.3, P<0.0001
4	3.95±0.54	t=12.0, P<0.0001
5	4.66±0.43	t=23.3, P<0.0041

CKD: Chronic kidney disease

There was significant correlation between CKD Stages 1, 2, 3, and 4 with mean serum magnesium levels (P<0.0001). The correlation between CKD Stage 5 and mean serum magnesium levels was statistically significant (P<0.004).



In our study, we found that 61% of the patients (n=61) had hypermagnesemia, 38% of the patients (n=38) had eumagnesemia, and 1% of the patients (n=1) had hypomagnesemia.

Table 2 showed the mean serum potassium levels were 4.13±0.57 meq/L, 4.15±0.68 meq/L, 3.86±0.41 meq/L, 5.55±0.39 meq/L, and 6.25±0.08 meq/L in patients with Stages 1, 2, 3, 4, and 5 of CKD, respectively.

There was significant correlation between CKD Stages 1, 4, and 5 and mean serum potassium levels (P<0.0001). There was insignificant correlation between CKD Stages 2 and 3 with mean serum potassium levels (P<0.9626 and P<0.0550, respectively).

In our study, we found that 25% of the patients had hyperkalemia and 75% of the patients had eukalemia.

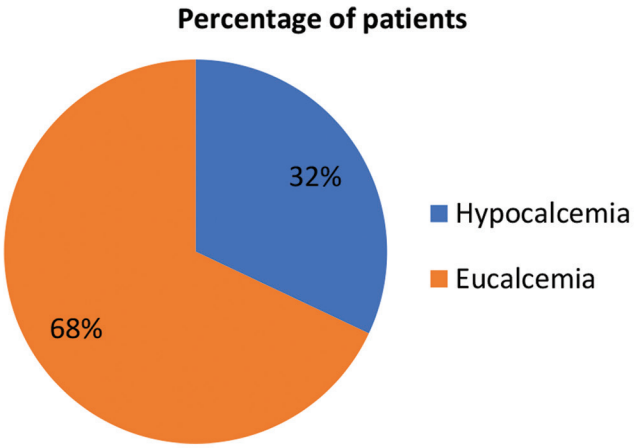
Table 3 showed that the mean serum calcium levels were 9.83±0.05 mg/dL, 9.79±0.20 mg/dL, 9.43±0.27 mg/dL, 8.72±0.38 mg/dL, and 7.8±0.10 mg/dL in patients with Stages 1, 2, 3, 4, and 5 of CKD, respectively.

There was significant correlation between CKD Stages 1, 3, 4, and 5 with mean serum magnesium levels (P<0.0001).

Table 2: Correlation between CKD stages and mean serum potassium levels

CKD stage	Mean serum potassium levels (meq/L)	P-value
1	4.13±0.57	t=9.60, P<0.0001
2	4.15±0.68	t=0.48, P<0.9626
3	3.86±0.41	t=1.96, P<0.0550
4	5.55±0.39	t=18.21, P<0.0001
5	6.25±0.08	t=4.33, P<0.0001

However, a statistically insignificant correlation was found between CKD Stage 2 and mean serum magnesium levels (P<0.7402).



In our study, we found that 32% of the patients (n=32) had hypocalcemia, whereas 68% of the patients (n=68) had eucalcemia.

Table 4 showed that the mean serum sodium levels were 137.33±0.57 meq/L, 136.43±2.87 meq/L, 136.92±2.15 meq/L, 137.51±1.90 meq/L, and 137.5±2.07 meq/L in patients with Stages 1, 2, 3, 4, and 5 of CKD, respectively.

Table 3: Correlation between CKD stages and mean serum calcium levels

CKD stage	Mean serum calcium levels (mg/dL)	P-value
1	9.83±0.05	t=32.38, P<0.0001
2	9.79±0.20	t=0.337, P<0.7402
3	9.43±0.27	t=4.82, P<0.0001
4	8.72±0.38	t=9.41, P<0.0001
5	7.8±0.10	t=5.83, P<0.0001

CKD: Chronic kidney disease

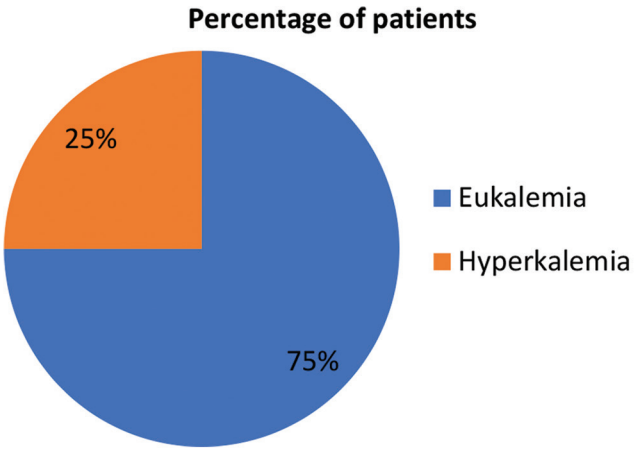
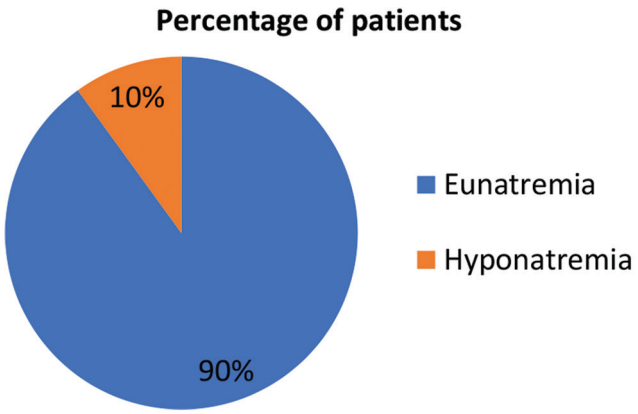


Table 4: Correlation between CKD stages and mean serum sodium levels

CKD stage	Mean serum sodium levels (meq/L)	P-value
1	137.33±0.57	t=0.135, P<0.8961
2	136.43±2.87	t=0.529, P<0.6035
3	136.92±2.15	t=0.698, P<0.4880
4	137.51±1.90	t=1.251, P<0.2149
5	137.5±2.07	t=0.012, P<0.9907

CKD: Chronic kidney disease

There was no significant correlation between CKD Stages 1, 2, 3, 4, and 5 and mean serum sodium levels (P<0.8961, P<0.6035, P<0.4880, P<0.2149, and P<0.9907, respectively).



In our study, 90% of the patients (n=90) had eunatremia, whereas 10% of the patients (n=10) had hyponatremia.

DISCUSSION

The present study showed that mean serum magnesium levels increased with the stage of CKD. The mean serum magnesium levels were highest in Stage 5 CKD. We found that 61% of the patients had hypermagnesemia, 38% of the patients had eumagnesemia, and 1% of the patients had hypomagnesemia.

A study done by Harith et al., found that nearly 79% (35 out of 44) CKD patients had hypermagnesemia in the first predialysis sample with over 34% having significant hypermagnesemia.[20]

Spiegel et al., suggested that Stage 5 CKD patients on dialysis are generally felt to have elevated serum magnesium concentration and to be at risk for acute and chronic magnesium overload.[21]

Navarro-González et al., suggested that as CKD progresses (GFR < 30 mL/min), urinary Mg excretion may be insufficient to balance intestinal Mg absorption, at which point dietary Mg intake then becomes a major determinant of serum and total body Mg levels.[22]

In this study, mean serum potassium levels increased with the stage of CKD. The mean serum potassium levels were highest in Stage 5 CKD. We found that 75% of the patients had eukalemia, whereas 25% of the patients had hyperkalemia.

Akhter et al., found that hyperkalemia, that is, S.K+ >5.5 mmol/L was observed in 25 patients (25%, n=100). Twenty-one patients belonged to Stage-V CKD and four patients belonged to Stage-IV CKD.[23]

Einhorn et al., showed that individuals with CKD had a higher risk of increased potassium compared with patients with no renal injury.[24]

In the present study, we found that mean serum calcium levels decreased with the stage of CKD. The lowest mean serum calcium levels were in Stage 5 CKD. We found that 68% of the patients had eucalcemia, whereas 32% of the patients had hypocalcemia.

A study done by Vikrant et al., showed that hypocalcemia was present in 23.8% of the CKD patients and was quite common in Indian CKD subjects.[25]

Mehmood et al., suggested that in CKD, the majority of the patients with disturbed calcium had hypocalcemia 98.9% and hypercalcemia 1.05%.[26]

Hannan and Thakker suggested that hypocalcemia, which can be severe in CKD, is a consequence of diminished renal production of 1, 25-dihydroxyvitamin D and hyperphosphatemia.[27]

In the present study, the mean serum sodium levels did not change significantly with the stage of CKD. The mean serum sodium levels in Stage 5 CKD patients were 137.5±2.07 meq/L. About 90% (n=90) of the patients had normal serum sodium levels, whereas 10% (n=10) of the patients had hyponatremia.

A study done by Chaudhari et al., showed that in CKD patients, 66% had eunatremia where as 28% of the patients had hyponatremia.[28]

Arzhan et al., concluded that dysnatremias occur frequently in patients with CKD and are associated with adverse outcomes.[29]

Mitch et al., suggested that sodium imbalance could be secondary to diuretic usage, particularly in patients with CKD, because the ability of kidneys to regulate dilution

and concentration becomes impaired as renal disease progressing.[30]

Limitations of the study

1) Lack of control groups is the major limitation in our study.
2) Our study had small sample size.

CONCLUSION

There was significant rise in serum potassium and magnesium levels with decrease in eGFR in CKD patients. There was significant fall in serum calcium levels with decrease in eGFR in CKD patients. There was no significant correlation between serum sodium levels and eGFR in CKD patients.

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RKN- Concept and design of the study, prepared first draft of manuscript; **DKM-** Interpreted the results, reviewed the literature, and manuscript preparation; **MI-** Concept, coordination, statistical analysis, interpretation, preparation of manuscript and revision of the manuscript.

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