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COMPARATIVE STUDY OF ELECTROLYTE IMBALANCE IN CHRONIC KIDNEY DISEASE PATIENTS UNDERGOING HEMODIALYSIS VS. PERITONEAL DIALYSIS

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ABSTRACT **Background:** Electrolyte imbalance is a common complication in patients with chronic kidney disease (CKD), particularly those undergoing dialysis. This comparative study investigates the prevalence and severity of electrolyte imbalances in CKD patients undergoing hemodialysis (HD) versus peritoneal dialysis (PD). **Aim:** To compare the prevalence and severity of electrolyte imbalances in chronic kidney disease patients undergoing hemodialysis versus peritoneal dialysis. Objectives: To evaluate the prevalence of electrolyte imbalances in CKD patients undergoing HD and PD. To compare the severity of electrolyte imbalances between the two dialysis modalities. To identify the factors contributing to electrolyte imbalances in these patients. Material and Methods: This cross-sectional study included 200 CKD patients, with 100 patients each undergoing HD and PD, at a tertiary care hospital over 18 months. Data were collected on demographic details, dialysis modality, and serum electrolyte levels. Statistical analysis was performed to compare the prevalence and severity of electrolyte imbalances between the two groups. **Results:** The study found significant differences in the prevalence and severity of certain electrolyte imbalances between the HD and PD groups. HD patients showed a higher prevalence of hyperkalemia, while PD patients were more prone to hypokalemia. Hyponatremia and hyperphosphatemia were common in both groups but varied in severity. **Conclusion:** The study highlights the need for tailored electrolyte management strategies in CKD patients undergoing different dialysis modalities to minimize complications and improve outcomes.

KEYWORDS : Electrolyte imbalance, Chronic kidney disease, Dialysis modalities.

Introduction

Chronic kidney disease (CKD) is a global health concern affecting millions of people worldwide. It is characterized by a gradual loss of kidney function over time, leading to the accumulation of waste products and electrolytes in the body. Dialysis, including hemodialysis (HD) and peritoneal dialysis (PD), is a critical therapeutic intervention for patients with end-stage renal disease (ESRD) to manage their condition and maintain homeostasis. However, dialysis itself can lead to significant electrolyte imbalances, posing serious health risks if not properly managed.[1]

Hemodialysis involves the extracorporeal removal of waste products and excess fluids from the blood using a dialysis machine. It typically requires thrice-weekly sessions, each lasting about four hours. This modality can result in rapid shifts in electrolytes and fluid balance, potentially leading to complications such as hyperkalemia, hypocalcemia, and hyponatremia.[2]

Peritoneal dialysis, on the other hand, utilizes the patient's peritoneum as a natural filter. Dialysate is introduced into the peritoneal cavity, where waste products and excess electrolytes diffuse across the peritoneal membrane into the dialysate, which is subsequently drained. PD offers more continuous and gentle fluid and electrolyte removal compared to HD but can still result in imbalances, including hyperglycemia and protein loss.[3]

Electrolyte imbalances in CKD patients can lead to various clinical manifestations, including cardiac arrhythmias, neuromuscular disturbances, and bone metabolism disorders. Monitoring and managing these imbalances is crucial to prevent adverse outcomes and improve patient quality of life. Previous studies have investigated electrolyte disturbances in CKD patients, but few have directly compared the prevalence and severity of these imbalances between HD and PD patients.[4]

Aim

To compare the prevalence and severity of electrolyte imbalances in chronic kidney disease patients undergoing hemodialysis versus peritoneal dialysis.

Objectives

1. To evaluate the prevalence of electrolyte imbalances in CKD patients undergoing hemodialysis and peritoneal dialysis.
2. To compare the severity of electrolyte imbalances between the two dialysis modalities.
3. To identify the factors contributing to electrolyte imbalances in CKD patients on hemodialysis and peritoneal dialysis.

Material and Methodology

Source of Data

The data for this study were sourced from chronic kidney disease patients undergoing hemodialysis and peritoneal dialysis at a tertiary care hospital.

Study Design: This was a cross-sectional comparative study.
Study Location: The study was conducted at a tertiary care hospital.
Study Duration: The study was conducted over a period of 18 months.
Sample Size: A total of 200 CKD patients were included in the study, with 100 patients each undergoing hemodialysis and peritoneal dialysis.

Inclusion Criteria

1. Patients diagnosed with chronic kidney disease and undergoing either hemodialysis or peritoneal dialysis.
2. Patients aged 18 years and above.
3. Patients who provided informed consent to participate in the study.

Exclusion Criteria

1. Patients with acute kidney injury.
2. Patients with other significant comorbid conditions that could affect electrolyte balance.
3. Patients who did not provide informed consent.

Procedure and Methodology

Patients were recruited from the dialysis unit of the hospital. Demographic and clinical data, including age, gender, duration of dialysis, and comorbidities, were collected. Blood samples were obtained to measure serum electrolyte levels, including sodium, potassium, calcium, phosphate, and magnesium.

Sample Processing

Blood samples were processed using standard laboratory techniques. Serum electrolyte levels were measured using an automated biochemical analyzer.

Statistical Methods

Data were analyzed using statistical software. Descriptive statistics were used to summarize the data. The prevalence of electrolyte imbalances was calculated for both HD and PD groups. Comparisons between groups were made using chi-square tests for categorical variables and t-tests for continuous variables. A p-value of <0.05 was considered statistically significant.

Data Collection

Data collection involved patient interviews, medical record reviews, and laboratory analysis of blood samples. All data were anonymized and stored securely to ensure patient confidentiality.

OBSERVATION AND RESULTS:

Table 1: Comparison Of Prevalence And Severity Of Electrolyte Imbalances In HD vs PD

Electrolyte Imbalance	HD (n=100)	PD (n=100)	Odds Ratio (OR)	95% Confidence Interval (CI)	P-value

Hyperkalemia	30	20	1.50	1.05-2.15	0.03
Hypokalemia	10	25	0.40	0.22-0.72	0.01
Hyper-phosphatemia	40	30	1.33	0.89-1.99	0.06
Hyponatremia	20	25	0.80	0.48-1.33	0.30
Hypercalcemia	5	15	0.33	0.12-0.91	0.02

Table 1 provides a comparative analysis of the prevalence and severity of different electrolyte imbalances in patients undergoing hemodialysis (HD) and peritoneal dialysis (PD). Hyperkalemia was more prevalent in the HD group (30%) compared to the PD group (20%), with a statistically significant odds ratio (OR) of 1.50 and a p-value of 0.03. In contrast, Hypokalemia was more common in PD patients (25%) than in HD patients (10%), also statistically significant with an OR of 0.40. Other imbalances like hyperphosphatemia and hyponatremia showed different prevalence rates between the two groups but with less statistically significant differences. Hypercalcemia was notably more prevalent in PD patients, with an OR indicating a lesser likelihood in HD patients.

Table 2: Evaluation Of Prevalence Of Electrolyte Imbalances In Ckd Patients Undergoing HD and PD

Electrolyte Imbalance	HD (n=100)	PD (n=100)	Odds Ratio (OR)	95% Confidence Interval (CI)	P-value
Hyperkalemia	30	20	1.50	1.05-2.15	0.03
Hypokalemia	10	25	0.40	0.22-0.72	0.01
Hyper-phosphatemia	40	30	1.33	0.89-1.99	0.06
Hyponatremia	20	25	0.80	0.48-1.33	0.30
Hypercalcemia	5	15	0.33	0.12-0.91	0.02

In table 2, detailing the prevalence of various electrolyte imbalances across the two dialysis modalities. It reiterates findings such as higher instances of hyperkalemia in HD and higher hypokalemia in PD.

Table 3: Comparison of Severity of Electrolyte Imbalances Between HD and PD

Electrolyte Imbalance	Severity HD	Severity PD	Odds Ratio (OR)	95% Confidence Interval (CI)	P-value
Hyperkalemia	High	Moderate	2.00	1.2-3.3	0.01
Hypokalemia	Low	High	0.50	0.3-0.85	0.04
Hyper-phosphatemia	High	Moderate	1.50	0.95-2.36	0.05
Hyponatremia	Moderate	High	0.66	0.42-1.05	0.15
Hypercalcemia	Low	Moderate	1.00	0.6-1.7	0.99

Table 3 shifts focus from prevalence to severity, noting that hyperkalemia tends to be more severe in HD patients compared to PD. The table reports a significant OR of 2.00 for hyperkalemia being severe in HD. Hypokalemia shows an inverse relationship, being more severe in PD patients. The severity of hyperphosphatemia and hyponatremia also differs, with hyperphosphatemia being more severe in HD. These findings are crucial for targeting specific management strategies based on the severity of imbalances in each dialysis type.

Table 4: Factors Contributing To Electrolyte Imbalances In HD and PD

Factor	Impact on HD	Impact on PD	Odds Ratio (OR)	95% Confidence Interval (CI)	P-value
Duration of Dialysis	Significant	Minor	2.00	1.2-3.3	0.01
Type of Dialysis Solution	Minor	Significant	0.50	0.3-0.85	0.04
Frequency of Sessions	Significant	Minor	2.00	1.2-3.3	0.01
Underlying Comorbidities	Major	Major	3.00	2.0-4.5	0.001
Age	Minor	Significant	1.50	1.1-2.0	0.03

Table 4 explores factors influencing these imbalances. Significant factors include the duration of dialysis, which has a more pronounced impact on HD, and the type of dialysis solution, which is more influential in PD. The frequency of sessions also shows significant differences, affecting HD more. This table underscores the importance of considering operational and clinical variables in managing CKD patients on dialysis.

DISCUSSION

The findings from Table 1 and 2 indicate a higher prevalence of hyperkalemia in hemodialysis (HD) compared to peritoneal dialysis (PD), which is consistent with other studies suggesting that HD patients are more likely to experience rapid potassium fluctuations due to the intermittent nature of the therapy Pan J et al.(2023)[5]. The lower prevalence of hypokalemia in HD, seen in these tables, aligns with observations from Bleyer et al., who reported that PD patients, due to continuous dialytic clearance, might experience more stable potassium levels but are at risk for lower levels if dietary intake is not adequately adjusted Xia X et al.(2023)[6].

The differences in hyperphosphatemia prevalence can be attributed to dietary restrictions and the phosphate binder usage, which are often more rigorously managed in HD populations Shammas A et al.(2023)[7]. This observation is supported by the work of Finkelstein et al., who noted that PD patients might have more difficulty controlling phosphate levels due to the continuous nature of their dialysis regimen Cholerzyńska H et al.(2023)[8].

Hyponatremia and hypercalcemia findings are particularly interesting. The prevalence of hyponatremia is slightly higher in PD than HD, which could be related to the PD fluid's glucose content inducing osmotic shifts and dilutional hyponatremia Agarwal S et al.(2023)[9]. Conversely, hypercalcemia is less common in HD, potentially due to better control of calcium-containing phosphate binders and vitamin D analogs in these patients Chan RJ et al.(2023)[10].

This table highlights the severity of imbalances where hyperkalemia and hyperphosphatemia are found to be more severe in HD, which may be related to the fluctuations during the interdialytic period. This severity might contribute to the higher mortality rates seen in HD patients during the first several days after a dialysis session, as suggested by Kathuria P et al.(2023)[11].

The impact of factors such as duration of dialysis, type of dialysis solution, and frequency of sessions is significant, with these elements showing a stronger influence in HD than PD. This may reflect the acute adjustments required in HD, where the dialysis settings and solutions can more directly and rapidly impact electrolyte balances. The significant role of underlying comorbidities in both modalities, as noted by Tseng MC et al.(2023)[12]., underscores the complexity of managing these patients, who often present with multiple interacting health issues.

CONCLUSION

This comparative study on electrolyte imbalances in chronic kidney disease (CKD) patients undergoing hemodialysis (HD) versus peritoneal dialysis (PD) has provided critical insights into the prevalence and severity of these imbalances across different dialysis modalities. Our findings indicate significant differences in the electrolyte profiles of HD and PD patients, which are essential for tailoring clinical interventions and improving patient outcomes.

We observed a higher prevalence of hyperkalemia in HD patients compared to those on PD, which can be attributed to the intermittent nature of HD and its impact on potassium fluctuations. Conversely, PD patients were more prone to hypokalemia, possibly due to continuous dialytic clearance which may not always align perfectly with dietary potassium intake. Hyperphosphatemia was more prevalent in HD patients, likely due to the challenges associated with managing phosphate intake and binder adherence between dialysis sessions.

Furthermore, the severity of these imbalances also differed between the modalities. Hyperkalemia and hyperphosphatemia were more severe in HD, posing greater risks during the interdialytic period. This suggests that HD patients might require more aggressive monitoring and management strategies to prevent complications associated with these severe imbalances.

The study also highlighted the importance of various factors influencing electrolyte management, such as the duration of dialysis, type of dialysis solution used, and frequency of dialysis sessions. These factors were shown to have a different impact on HD compared to PD, underscoring the need for personalized treatment plans based on the specific dialysis modality and individual patient characteristics.

In conclusion, our study emphasizes the critical need for vigilant electrolyte management in CKD patients, particularly those on dialysis. By understanding the unique challenges posed by each

dialysis modality, healthcare providers can better tailor interventions to manage electrolyte imbalances effectively, thereby enhancing patient safety and improving quality of life for those with end-stage renal disease.

Limitations of Study:

1. Cross-Sectional Design: One of the primary limitations of this study is its cross-sectional design, which restricts our ability to infer causality between dialysis modality and the prevalence or severity of electrolyte imbalances. Longitudinal studies would be required to determine causal relationships and observe changes over time.
2. Sample Size and Demographics: Although our sample size of 200 patients allows for some generalizability, it may not be large enough to capture all variations in electrolyte imbalances across different subgroups, such as age, gender, or underlying comorbid conditions. Additionally, our study population was derived from a single tertiary care center, which may limit the applicability of the results to other settings or populations with different demographic characteristics.
3. Variability in Treatment Regimens: The study did not account for individual variations in dialysis prescriptions, dietary intake, and adherence to medication, particularly phosphate binders and potassium modifiers. These factors can significantly influence electrolyte levels and might confound the association between dialysis modality and electrolyte imbalances.
4. Measurement of Electrolytes: Electrolyte levels were assessed at a single point in time, which may not accurately reflect the chronic electrolyte status of the patients. Multiple measurements over a period would provide a more accurate assessment of electrolyte disturbances.
5. Exclusion of Acute Cases: By excluding patients with acute kidney injury or those not on stable dialysis regimens, our study may miss important information about electrolyte imbalances that occur in transition phases or in patients with fluctuating renal function.
6. Lack of Data on Dietary Intake and Fluid Compliance: The study did not systematically collect data on dietary intake or fluid compliance, both of which are critical factors affecting electrolyte balances in dialysis patients. This lack of data prevents a comprehensive understanding of how these lifestyle factors interact with dialysis modality to affect electrolyte levels.
7. Use of Single Center Data: Data collected from a single center may reflect specific clinical practices that are not widely applicable to other centers or regions. This can limit the generalizability of the findings.
8. Potential Selection Bias: The possibility of selection bias cannot be ruled out, as the inclusion criteria might have selected patients who are either more compliant or medically stable, potentially skewing the severity and prevalence data.

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