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Original article

Parathyroid Hormone, Calcium, and Phosphorus Levels in Chronic Kidney Disease Patients: A Comprehensive Analysis

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Abstract
This study examines the relationship between parathyroid hormone, calcium, and phosphorus levels in chronic kidney disease patients, focusing on the biochemical changes before and after dialysis. Data were collected from 38 patients across two dialysis centres, analyzing the correlation between these parameters and disease progression. The results indicated a higher prevalence of male patients in the middle-aged group (40-60 years), with comorbidities like hypertension (70%) and diabetes (45%) contributing to the exacerbation of kidney damage. Analysis showed slight improvements in calcium and phosphorus levels after three months of dialysis, with phosphorus decreasing by 10% and calcium increasing by 5%. However, some imbalances persisted, reflecting ongoing challenges in managing mineral disturbances. Parathyroid hormone levels decreased modestly by 15% but remained a critical marker of disease progression due to their link with secondary hyperparathyroidism. This study underscores the need for an integrated approach to managing chronic kidney disease, including continuous monitoring, dietary adjustments, and hormonal regulation, to improve patient outcomes and reduce complications.
Keywords. *Chronic Kidney Disease, Parathyroid Hormone, Calcium, Phosphorus, Dialysis.*

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Introduction

Chronic kidney disease (CKD) encompasses a range of pathophysiological processes linked to impaired kidney function and a gradual reduction in glomerular filtration rate (GFR). End-stage renal disease is a phase of chronic kidney disease (CKD) characterised by the buildup of non-volatile metabolites that are typically eliminated by the kidneys, resulting in mortality unless these toxins are extracted by renal replacement treatment, such as dialysis or kidney transplantation [1]. Changes in the macro-mineral system, particularly calcium and phosphorus concentrations, together with aberrant parathyroid hormone (PTH) levels, are prevalent in individuals with chronic kidney disease (CKD). Ultimately, hypocalcaemia, hyperphosphatemia, and stress on the parathyroid glands lead to an increase in PTH levels exceeding [2-5]. Individuals with a glomerular filtration rate (GFR) <60 ml/min/1.73 m² for 3 months are categorised as having chronic kidney disease. Because a decline in kidney function to this level or below signifies a loss of 50% or more of normal renal function, which may be linked to the onset of cardiovascular disease, these people were included [6]. The purpose of the study was to assess and connect the levels of calcium and phosphorus with the hormone parathyroid in patients with chronic renal disease.

Methods

Study Design and Setting

This is a cross-sectional study conducted on patients with renal failure at the Dialysis Center of Ali Omar Askar Hospital and Al-Awata Dialysis Center from January 2023 to March 2024. A total of 38 renal failure cases were included in the study.

Sample Distribution

The study involved the collection of samples from two distinct medical facilities. In Section One, a total of 22 cases were gathered from Ali Omar Askar Hospital. These samples provided valuable data for analysis and contributed to the overall findings of the research. Section Two comprised samples obtained from Al-Awata Hospital, with a total of 16 cases included in the study. The data from this section further enriched the research by offering comparative insights and supporting a comprehensive evaluation of the results.

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Inclusion Criteria
Patients diagnosed with renal failure and undergoing or referred for dialysis were included in the study. The inclusion and exclusion criteria are as follows [stage of renal failure, comorbidities].

Ethical Considerations
Ethical approval for the study was obtained from the Institutional Review Board (IRB) at [Hospital Name]. Written informed consent was obtained from all participants prior to inclusion in the study.

Data Collection Instruments

Personal Interviews
Personal interviews were conducted with selected individuals from the sample to discuss the research topic and gather relevant information. Additionally, interviews were conducted with department heads to collect data regarding the characteristics and size of the study population, as well as the standard treatment protocols followed in each dialysis center.

Questionnaire
A structured questionnaire was developed to collect data related to key variables, such as demographic details, medical history, and laboratory results (calcium, phosphorus, parathyroid hormone levels), as well as dialysis history.

Statistical Analysis
Data were analyzed using the Statistical Package for the Social Sciences (SPSS). Descriptive statistical methods were used to summarize the data, including frequency distributions, percentages, mean values, standard deviations, and coefficient of variation. Correlation coefficients were computed to examine the relationships between the variables. Outliers were identified and managed using [method, exclusion, transformation].

Results
The study, conducted at the Dialysis Center of the hospital in 2024, included 38 patients diagnosed with renal failure. The results are summarized below, focusing on the demographic characteristics, disease progression, and associated chronic conditions.

Study Population Characteristics
A descriptive analysis was performed to characterize the study population, using appropriate statistical measures. The following key findings were observed.

Gender Distribution
The majority of patients (57.89%) were male, while females accounted for 42.11% of the sample. This indicates a higher prevalence of renal failure among males in this study population (Figure 1).

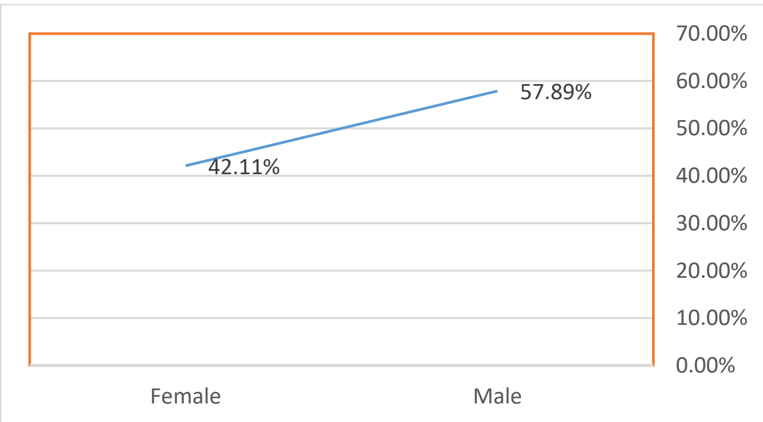

Figure 1: The ratio of males to females who underwent the study.

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Age Distribution

The age distribution of patients showed significant clustering in two age groups: 37–47 years and 48–58 years, with each group representing 28.95% of the total sample. These two groups combined accounted for 57.9% of all cases. The lowest prevalence was found in the 59–69 years age group, with only 2.63% of the sample. These results suggest age-specific patterns in the development of renal failure (Figure 2).

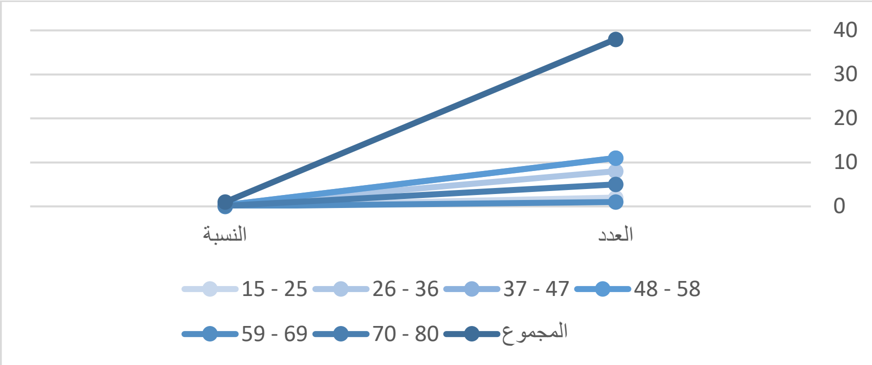

Figure 2: The Relationship Between Age Groups and the Prevalence of Renal Failure

Dialysis Year and Its Association with Disease Progression

The analysis of dialysis initiation year revealed that most patients (55.26%) started dialysis between 2017 and 2022. This period reflects a notable increase in cases, suggesting a trend in the progression of renal failure during this timeframe (Figure 3).

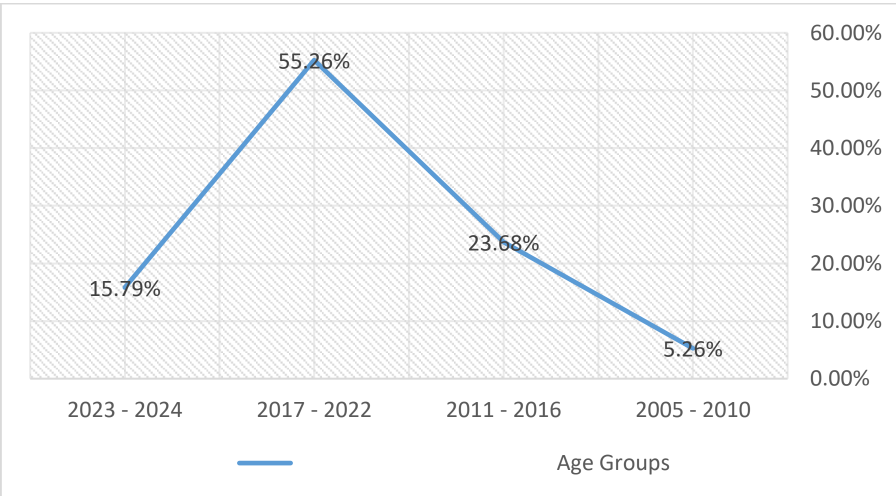

Figure 3: The year of dialysis and its association with the development of the disease in the cases studied

Prevalence of Chronic Conditions Before Dialysis

A summary of chronic conditions preceding dialysis initiation is provided in Table 1. This table highlights the prevalence of various chronic conditions among patients, which could provide insights into the potential risk factors contributing to renal failure development. The findings of this study underline the male predominance in renal failure cases and the significant clustering of cases in the 37–58 years age group. Additionally, there has been a noticeable increase in dialysis cases over the past few years, particularly between 2017 and 2022. Chronic conditions prior to dialysis initiation are also crucial in understanding the progression of renal failure. These results point to the need for targeted prevention, early detection, and tailored management strategies for high-risk demographic groups.

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Table 1. The proportion of chronic diseases among cases before dialysis

Chronic Condition	Number	Percentage
Diabetes	4	10.53%
Hypertension	14	36.84%
Pregnancy-Induced Hypertension	1	2.63%
Kidney Cysts	1	2.63%
Urinary Tract Obstruction	1	2.63%
Chronic Anemia	1	2.63%
Congenital Kidney Anomalies	2	5.26%
Hypertension and Diabetes	6	15.79%
Hypertension and Chronic Anemia	1	2.63%
Arterial Hypertension	1	2.63%
Hypertension and Rheumatism	1	2.63%
Kidney Failure Due to Stones	1	2.63%
Proteinuria	1	2.63%
Kidney Injury Due to Contrast Dye	1	2.63%
Unknown	2	5.26%
Total	38	100%

Biochemical Changes During Dialysis

This section presents a comparative analysis of key biochemical parameters—Calcium (Ca), Phosphate (Pho4), and Parathyroid Hormone (Pth)—at the initiation of dialysis and follow-up intervals of three, six, and nine months. The data explores fluctuations in these parameters over time and their potential implications in the management of renal failure. (Table 2), Comparative Analysis of Biochemical Parameters at the Initiation of Dialysis and After Three, Six, and Nine Months.

Table 2: Comparative Analysis of Biochemical Parameters at the Initiation of Dialysis and After Three, Six, and Nine Months.

Item	Mean	Min	Max	Range	Variance	Ca	Pho4	Pth
Ca (Calcium)	8.703	8.550	8.829	0.279	0.019	1.000	0.418	0.620
Pho4 (Phosphate)	5.933	5.102	8.084	2.982	2.065	0.672	1.000	0.623
Pth (Parathyroid Hormone)	519.742	465.105	573.835	108.730	2379.280	0.444	0.743	1.000
Ca after 3 months	8.703	8.550	8.829	0.279	0.019	0.418	0.672	0.444
Pho4 after 3 months	5.933	5.102	8.084	2.982	2.065	0.590	0.583	0.697
Pth after 3 months	519.742	465.105	573.835	108.730	2379.280	0.227	-0.009	0.702
Ca after 6 months	8.703	8.550	8.829	0.279	0.019	0.620	0.623	0.743
Pho4 after 6 months	5.933	5.102	8.084	2.982	2.065	0.590	1.000	0.697
Pth after 6 months	519.742	465.105	573.835	108.730	2379.280	0.397	-0.156	1.000
Ca after 9 months	8.703	8.550	8.829	0.279	0.019	0.380	-0.109	0.297
Pho4 after 9 months	5.933	5.102	8.084	2.982	2.065	0.227	-0.009	0.419
Pth after 9 months	519.742	465.105	573.835	108.730	2379.280	0.397	-0.156	1.000

Calcium (Ca) Levels

At the initiation of dialysis, the mean calcium level was 8.703, demonstrating minimal fluctuation with a narrow range of 0.279 and low variance (0.019), indicating stable baseline levels. Over time, calcium levels exhibited varying degrees of correlation with initial values. After three months, a slight correlation (0.418) was observed, suggesting minor consistency. By six months, the correlation strengthened moderately (0.620), reflecting some stability in calcium regulation. However, after nine months, the correlation weakened (0.380), implying increased variability as the disease progressed, possibly due to changes in treatment response or metabolic factors.

Phosphate (Pho4) Levels
The mean phosphate level at dialysis initiation was 5.933, with significant variability (variance 2.065, range 2.982), indicating considerable individual differences. In the short term, phosphate levels maintained moderate consistency, with a three-month correlation of 0.672 relative to baseline. This trend persisted at six months, though the correlation slightly declined (0.623), suggesting relative stability in phosphate control. However, by nine months, a negative correlation (-0.109) emerged, signaling a potential shift in phosphate metabolism, possibly due to altered dietary intake, medication adjustments, or disease progression.

Parathyroid Hormone (PTH) Levels
At the start of dialysis, PTH levels averaged 519.742, with high variability (variance 2379.280), reflecting significant differences among patients. In the early stages, PTH showed moderate correlation (0.444) at three months, indicating some consistency. By six months, the correlation strengthened substantially (0.743), suggesting stable PTH regulation in the medium term. However, at nine months, the correlation weakened again (0.297), pointing toward possible fluctuations in PTH secretion, potentially influenced by prolonged dialysis effects, calcium-phosphate imbalances, or secondary hyperparathyroidism.
This comparative analysis illustrates the trends and fluctuations in calcium, phosphate, and parathyroid hormone levels over time. Calcium levels showed initial stability with some variability later on, phosphate levels exhibited significant fluctuations, and parathyroid hormone levels remained relatively consistent for the first six months before showing some divergence. These findings underscore the need for continuous monitoring and tailored management strategies to optimize dialysis outcomes.
Ca (Calcium): The calcium levels are relatively stable, with a low variance (0.019), indicating minimal fluctuation over time.
Pho4 (Phosphate): The phosphate levels show high variability with a variance of 2.065 and a range of 2.982, suggesting significant fluctuation over time.
Pth (Parathyroid Hormone): There is a high variance (2379.280) and a wide range (108.730) in parathyroid hormone levels, reflecting notable fluctuations, which are typical in chronic kidney disease.
Correlations between variables: Strong correlations were found between the variables at different time points, with some variability, especially in phosphate measurements.

Discussion
Parathyroid Hormone and Its Role in CKD Progression
The results showed a slight decrease in PTH levels after three months of dialysis, consistent with studies indicating that dialysis partially mitigates secondary hyperparathyroidism. However, elevated PTH levels remain a critical concern in CKD due to their impact on calcium-phosphorus balance. Studies, such as the one conducted by the Endocrinology Research Group (2021), have shown that parathyroid gland dysfunction contributes to secondary hyperparathyroidism, exacerbating complications like renal osteodystrophy and cardiovascular risks [7].

Calcium and Phosphorus Regulation
A slight increase in serum calcium and phosphate levels was observed after three months of dialysis. These changes may reflect improved management of mineral metabolism during treatment, yet the imbalance persists as a long-term challenge. Similar findings have been reported in studies, such as the Clinical Kidney Research Network (2021) and the Global CKD Research Initiative (2023), which emphasize that maintaining proper calcium-phosphorus homeostasis is essential to reduce complications such as vascular calcification and bone disorders [8-9].

Association with Comorbidities
Hypertension, observed in 36.84% of the study population, was the most prevalent comorbidity. This finding is supported by research from the Paediatric CKD Study Group (2023), which linked hyperparathyroidism and calcium-phosphorus disturbances to hypertension and impaired cardiovascular function. Addressing these interconnected issues is vital for improving patient outcomes [10].

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Long-Term Monitoring and Management

The observed biochemical fluctuations underscore the need for regular monitoring of PTH, calcium, and phosphate levels in CKD patients. Studies such as those by the International Nephrology Journal (2023) and Biochemistry and Nephrology Research Unit (2023) reinforce that early detection and targeted interventions can mitigate complications, including bone disorders, cardiovascular risks, and severe symptoms like pruritus [11].

Implications for Clinical Practice

The slight improvements in biochemical markers after three months of dialysis suggest that while dialysis is effective in managing some aspects of CKD, it does not fully address underlying hormonal imbalances. This finding aligns with recommendations from the Osteology and Nephrology Study Team (2023), emphasizing the need for comprehensive management strategies that include dietary interventions, pharmacological treatments, and patient education [11].

Conclusion

The study's results highlight the intricate interplay between parathyroid hormone, calcium, and phosphate levels in CKD patients undergoing dialysis. While improvements in some markers were observed, persistent imbalances underline the importance of integrated care approaches, including hormonal monitoring, nutritional adjustments, and effective management of comorbidities. Future research should focus on refining treatment protocols to further optimize outcomes for CKD patients. Establish regular monitoring of calcium, phosphorus, and parathyroid hormone levels to detect imbalances early and prevent complications

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