



Original Article

Estimation of Parathyroid Hormone, Calcium, Phosphorus and Alkaline Phosphatase in Various Stages of Chronic Kidney Disease: A Cross-Sectional Study

Dr. Umashanker Nama¹, Dr. Kusum Bala Jain², Dr. Shiv Prakash Rathore³, Dr. (Mrs.) Gulab Kanwar⁴

¹PG Resident, Department of Biochemistry, Government Medical College, Kota.

²Associate Professor, Department of Biochemistry, Government Medical College, Kota.

³Associate Professor, Department of Biochemistry, Government Medical College, Kota.

⁴Senior Professor and Head, Department of Biochemistry, Government Medical College, Kota.

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Corresponding Author:

Dr. Umashanker Nama

PG Resident, Department of
Biochemistry, Government Medical
College, Kota.

Received: 21-03-2026

Accepted: 03-04-2026

Available online: 28-04-2026

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Medical and Pharmaceutical Research

ABSTRACT

Background: Chronic Kidney Disease (CKD) is progressive worsening of renal function and disturbances in mineral metabolism. Alterations in serum calcium, phosphorus, parathyroid hormone (PTH) and alkaline phosphatase (ALP) contribute to CKD-mineral bone disorder. Cardiovascular disease (CVD), which is the main cause of death in patients with CKD, is more likely to affect them.

Aim: To evaluate the levels of serum parathyroid hormone, calcium, phosphorus and alkaline phosphatase in patients with different stages of CKD.

Material and Method: This cross-sectional study included 120 patients diagnosed with CKD. Patients were classified into stages based on eGFR. Serum calcium, phosphorus, alkaline phosphatase and PTH were measured and compared across stages of CKD.

Result: Serum calcium showed a down trend with advancing CKD stages, whereas serum phosphorus, alkaline phosphatase and PTH levels uptrends progressively.

Conclusion: Disturbances in mineral metabolism become more marked with aggravating CKD. Tracking these parameters may help in early detection and management of CKD-related mineral bone disorders.

Keywords: Chronic kidney disease, Parathyroid hormone, Calcium, Phosphorus, Alkaline phosphatase, CKD-MBD.

INTRODUCTION

Chronic kidney disease (CKD) is a major public health problem characterized by a gradual and irreversible decline in kidney function over time, ultimately leading to loss of nephron number and function and frequently progressing to end-stage renal disease (ESRD)¹. The most common causes of CKD include diabetes mellitus, hypertension, chronic glomerulonephritis, prolonged use of analgesic medications, autoimmune disorders, polycystic kidney disease, and unresolved acute kidney injury¹.

CKD typically develops over weeks, months, or years, in contrast to acute renal failure, which has a sudden onset and rapid progression. CKD represents a significant and growing health burden in India, with increasing prevalence. Patients with CKD are at a markedly higher risk of developing cardiovascular disease (CVD), which remains the leading cause of mortality in this population^{4,7}.

Due to the absence of a comprehensive national registry, the exact incidence of CKD in India remains uncertain. However, it is estimated that approximately 800 individuals per million population may be affected, with an overall prevalence ranging between 5–10%². This highlights CKD as a global public health concern.

The kidneys play a vital role in maintaining mineral homeostasis, including the regulation of calcium, phosphorus, and vitamin D metabolism¹. As kidney function declines, disturbances in mineral metabolism occur, resulting in

abnormalities in serum calcium, phosphorus, parathyroid hormone (PTH), and alkaline phosphatase (ALP) levels³. These abnormalities are collectively referred to as chronic kidney disease–mineral and bone disorder (CKD-MBD)¹.

ALP is an important biochemical marker of bone turnover and is widely used to assess metabolic bone disease associated with CKD³. Elevated ALP levels are indicative of increased bone turnover, and the degree of elevation correlates with the severity of high-turnover renal osteodystrophy². Increased PTH levels in CKD stimulate bone resorption, leading to bone demineralization and high-turnover bone disease. This process is characterized by enhanced osteoblastic activity and increased ALP production, resulting in elevated plasma ALP levels as glomerular filtration rate (GFR) declines^{2,3}.

CKD patients are at an increased risk of cardiovascular complications due to associated metabolic abnormalities. Hyperphosphatemia, hypocalcemia, elevated PTH, increased ALP levels, and declining renal function are strongly associated with increased cardiovascular morbidity and mortality^{5,6}. In particular, hyperphosphatemia and an elevated calcium–phosphate product serve as early independent predictors of vascular calcification and are important markers for assessing cardiovascular risk, especially in advanced stages of CKD⁵.

According to KDOQI guidelines, abnormalities in mineral metabolism begin to appear when the GFR falls below 60 mL/min/1.73 m²⁻¹. PTH is considered the earliest and most sensitive marker of disturbed bone mineral metabolism. Serum calcium levels may be normal or decreased, whereas serum phosphorus levels tend to increase with declining kidney function. Additionally, bone histological abnormalities are present in the majority of patients with advanced kidney disease¹. Therefore, regular monitoring of biochemical markers of mineral metabolism is essential for early detection and effective management of CKD-related complications.

MATERIAL AND METHODS

The present study was carried out in Department of Biochemistry, Government Medical College, Super Specialty Hospital, Central Laboratory SSH Kota.

STUDY DESIGN

The study design is observational cross-sectional study.

MATERIAL

Questionnaire, Serum Urea, Serum Creatinine, Serum PTH, Serum Calcium, Serum Phosphorus, Serum Alkaline Phosphatase.

STUDY GROUP

The study comprises of 120 cases of chronic kidney disease attending nephrology OPD and ward of GMC Kota.

INCLUSION CRITERIA

1. Patients with diagnosed chronic renal failure.
2. All patients aged 18 to 60 years.
3. Patients who are willing to participate in the study and have given written consent.

EXCLUSION CRITERIA

1. Post parathyroidectomy status patients.
2. Pregnancy.
3. Critically ill patients admitted in intensive care unit.
4. Acute on CKD.

METHODOLGY

Venous blood sample were collected from all the participants under aseptic precaution from antecubital vein by venipuncture in plain vials. Serum was separated by centrifugation at 3000 rpm for 10 minutes and subjected to following assays:

- 1) PTH – Chemiluminescence immunoassay (CLIA)
- 2) Serum calcium - Photometric test using arsenazo III
- 3) Phosphorus - Photometric UV test with endpoint determination
- 4) Blood urea - GLDH method : Fully Enzymatic method
- 5) Serum creatinine - Modified Jaffe's Method
- 6) Alkaline Phosphatase - Kinetic photometric test

OBSERVATION

Table 1: - Distribution of cases in various stages of CKD

Stage of disease	No. of patients	%
Stage 1	14	11.66
Stage 2	32	26.66
Stage 3	16	13.33
Stage 4	20	16.66
Stage 5	38	31.66
Total	120	100

Table 2: Biochemical parameters across different stages of CKD:

Variables	Stage of CKD				
	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
Calcium (mg/dl)	9.07±0.35	8.95±0.33	8.21±0.41	8.09±0.52	7.81±0.87
Phosphorus (mg/dl)	3.95±0.85	3.92±1.45	4.65±1.56	5.18±1.36	6.35±2.07
Alkaline Phosphatase (IU/L)	59.57±8.71	74.90±16.91	79.81±16.38	93.6±28.39	115.05±42.51
PTH (pg/ml)	52.71±14.04	76.09±17.06	116.87±28.65	172.4±56.18	253.73±65.12

Table 2 demonstrates progressive derangement in mineral metabolism with advancing stages of CKD. Serum calcium levels showed a down trend while serum phosphorus, alkaline phosphatase and PTH levels increased progressively. These findings support the conception that disturbances in mineral metabolism worsen with declining renal function and contribute to CKD-MBD.

Table 3: Statistical analysis using one-way ANOVA.

Variable	F value	p value	Significance
Calcium	8.42	<0.001	Significant
Phosphorus	11.63	<0.001	Significant
Alkaline Phosphatase	9.78	<0.001	Significant
PTH	15.24	<0.001	Significant

One-way ANOVA was performed to compare the biochemical parameters among the study groups. The analysis showed statistically significant differences in serum calcium (F = 8.42, p < 0.001), phosphorus (F = 11.63, p < 0.001), alkaline phosphatase (F = 9.78, p < 0.001), and parathyroid hormone (PTH) levels (F = 15.24, p < 0.001).

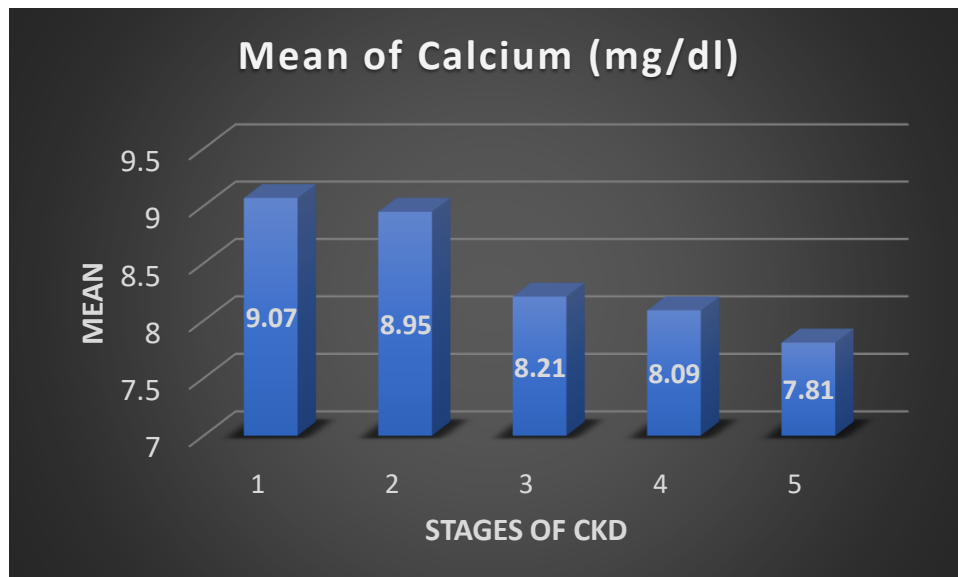


Figure 1: Mean serum calcium levels across stages of chronic kidney disease.

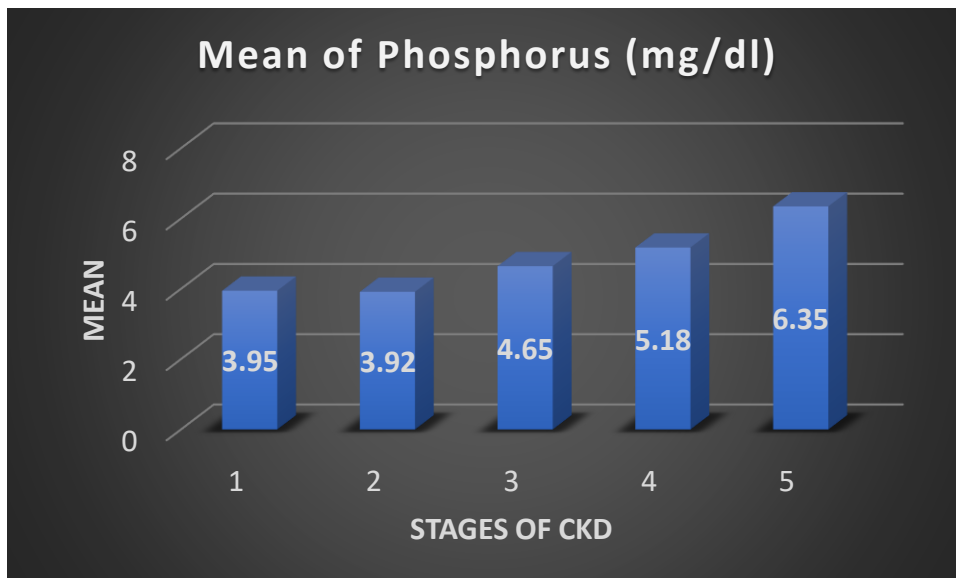


Figure 2: Mean serum phosphorus levels across stages of chronic kidney disease

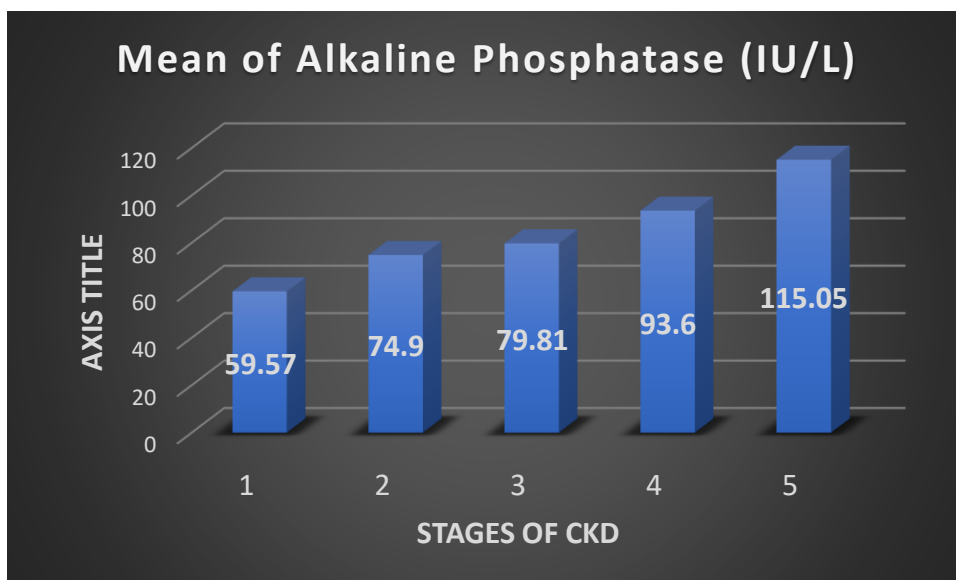


Figure 3: Mean serum alkaline phosphatase levels across stages of chronic kidney disease.

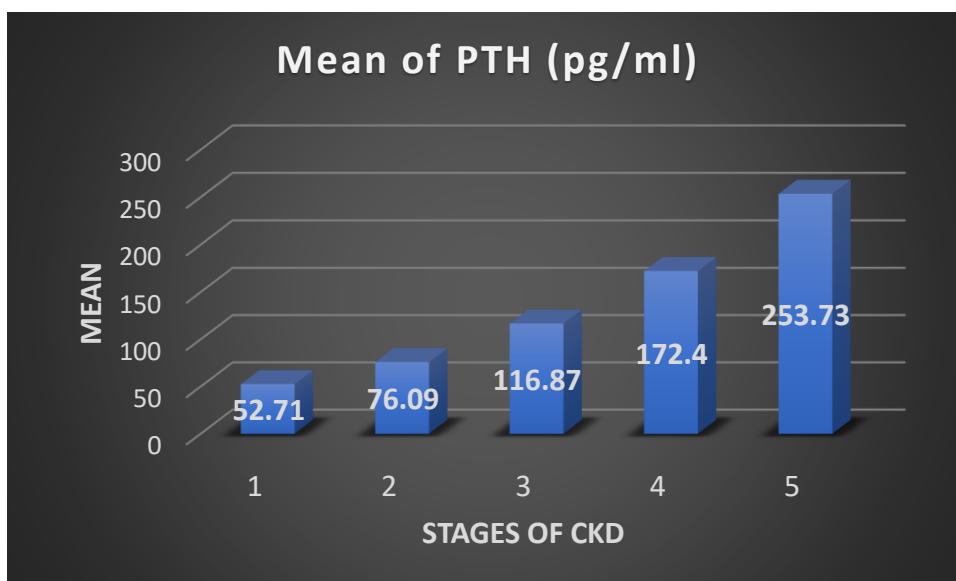


Figure 4: Mean serum parathyroid hormone levels across stages of chronic kidney disease.

RESULT

It was an Observational Cross-sectional, Hospital based study of 120 patients of CKD between age group 18-60 years. It was found that in CKD patients as renal function deteriorates serum calcium level falls and levels of phosphorus, alkaline phosphatase and PTH elevates.

DISCUSSION

The present study demonstrates progressive derangement in mineral metabolism with advancing stages of CKD. Serum calcium levels showed a down trend while serum phosphorus, alkaline phosphatase and PTH levels increased progressively. These findings support the concept that disturbances in mineral metabolism worsen with declining renal function and contribute to CKD-MBD.

The findings are similar to Block et al study, a significant increase in PTH levels was observed in CKD. They also linked high PTH levels as a significant correlate of all-cause mortality. They concluded that elevations in serum PTH might be associated with increased risk of death from cardiac causes⁵. Among mineral abnormalities; hyperphosphatemia is most prevalent among patients with ESRD. Shanthi K et al studies have set up that a significant increase in serum phosphorus levels in patients in CKD⁸, which is similar to that of our study. Significant increase in alkaline phosphatase levels in cases as compared to control. Sigrist et al conducted a longitudinal study and found elevated levels of alkaline phosphatase in stage IV and V of CKD⁹, which is similar to our study. Kim et al. have described decrease in levels of 25(OH)D/1,25 (OH)2D with progression of CKD¹⁰.

CONCLUSION

Disturbances in calcium-phosphorus metabolism and elevated PTH and ALP levels increase with progression of CKD. Regular monitoring of these biochemical parameters is essential for early detection and management of CKD-related mineral and bone disorders.

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