Original Article

A Cross-Sectional Study on Correlation Of Fibroblast Growth Factor 23 With Parathyroid Hormone and Vitamin D Among CKD Patients

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ABSTRACT

Introduction: CKD patients have a higher cardiovascular risk, exacerbated by altered phosphate metabolism, which independently increases cardiovascular events and mortality. Serum parathyroid hormone, fibroblast growth factor 23, and vitamin D imbalances significantly contribute to cardiovascular disease in patients with CKD. This study investigates the correlation among fibroblast growth factor 23, parathyroid hormone, and vitamin D in patients with CKD. **Materials & Methods:** This study at the National Institute of Kidney Diseases & Urology NIKDU), Dhaka, enrolled 103 adults with CKD stages III-V, excluding those with recent acute conditions to focus on CKD's chronic impact. Participants provided informed consent and underwent interviews, physical exams, and tests, including fibroblast growth factor 23, parathyroid hormone, and vitamin D, to assess CKD progression and biochemical associations. **Results:** The study population had a mean age of 56.0 ± 9.4 years for CKD Stage III, 52 ± 10.0 years for CKD Stage IV, and 53.0 ± 9.8 years for CKD Stage V. No significant age difference was found across stages III-V. Mean serum parathyroid hormone (PTH) significantly ($p < 0.05$) increased from 145.1 ± 107.4 pg/ml for patients with CKD stage III to 150.9 ± 88.2 pg/ml for CKD stage IV and 280.4 ± 220.2 pg/ml for CKD stage V. Mean serum vitamin D was 18.4 ± 6.8 ng/ml, 18.9 ± 7.1 ng/ml and 15.6 ± 5.5 ng/ml respectively for CKD stage III, IV and V, without any statistically significant difference among the CKD groups. Mean Fibroblast growth factor 23 (FGF-23) was significantly ($p < 0.05$) increased from 31.6 ± 22.9 pg/ml for patients with CKD stage III to 38.4 ± 27.8 pg/ml for CKD stage IV and 53.84 ± 46.5 pg/ml for CKD stage V. FGF-23 and iPTH levels both rose with advancing CKD stages, but correlations among FGF-23, iPTH and vitamin D were not significant. **Conclusion:** The present study suggests a positive correlation between serum FGF-23 and PTH, and a negative correlation with vitamin D in CKD patients, indicating FGF-23 as a potential therapeutic target. Further research is needed to confirm its role in CKD management and prevention.

Keywords: Fibroblast Growth Factor 23, Parathyroid Hormone, Vitamin D, Chronic Kidney Disease.

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Introduction:

Patients with chronic kidney disease (CKD) face a heightened risk of cardiovascular events compared to those with normal kidney function.[1] Beyond the usual cardiovascular risk factors such as high blood pressure and cholesterol, CKD patients also contend with disruptions in phosphate metabolism. These disturbances are considered a significant contributor to the increased cardiovascular mortality observed in CKD patients.[2,3] Elevated levels of serum phosphate can lead to secondary hyperparathyroidism, characterized by high parathyroid hormone (PTH) levels. Both elevated serum phosphate and secondary hyperparathyroidism are independently linked to an increased incidence of cardiovascular events and overall mortality in individuals with CKD.[4] This is due to the fact that high phosphate levels can cause vascular calcification, leading to stiffening of the blood vessels, while high PTH levels can contribute to cardiac remodeling and dysfunction. As such, managing phosphate levels and PTH is crucial in reducing cardiovascular risks for CKD patients.[5,6]

Chronic kidney disease-mineral and bone disorder (CKD-MBD), often characterized by deranged metabolism of parathyroid hormone (PTH), fibroblast growth factor 23 (FGF-23), and vitamin D, is a well-established complication of CKD.[7] CKD-MBD contributes to the large burden of cardiovascular disease, which is the leading cause of death in patients with CKD.[8] The complex pathophysiology involved with CKD-MBD usually commences early in the course of CKD prior to the onset of clinically detectable abnormalities in serum PTH and vitamin D levels.[9–12] Previous studies demonstrated that patients with CKD have decreased renal Klotho expression, and as CKD progresses, Klotho concentration continues to decline, causing FGF-23 resistance and therefore leading to marked increases in serum FGF-23 and PTH levels, as well as decreases in serum 25-hydroxyvitamin D (25(OH)D) levels.[13–15] However, hypocalcemia and hyperphosphatemia are usually observed in later stages of CKD. PTH primarily reflects the function of the parathyroid gland and also participates in phosphate, FGF-23, and vitamin D metabolism,[16], establishing it as a commonly used marker for assessing kidney impairment, where elevated PTH levels are mostly associated with CKD.[17] The present study aims to assess the correlation of fibroblast growth factor 23 with parathyroid hormone and vitamin D among CKD patients. By assessing FGF-23 levels and using them to guide appropriate therapeutic intervention, morbidity related to CKD-MBD can be reduced, thereby improving long-term outcomes.

Materials and Methods

This cross-sectional study was conducted in the Department of Nephrology, National Institute of Kidney Diseases and Urology (NIKDU), Dhaka, Bangladesh, between July 2018 and June 2019. According to the selection criteria, 103 adult patients (age ≥ 18 years) with diagnosed CKD were enrolled in the study. These patients were carefully selected using a purposive sampling technique, which is a non-random method of gathering participants with specific characteristics—in this case, those with stage III (eGFR 30-59ml/min/1.73m2),IV(eGFR 15-29ml/min/1.73m2), or V (eGFR <15ml/min/1.73m2)CKD, representing moderate to advanced stages of the disease(not on dialysis but receiving Vitamin D analogue and Phosphate binders). By excluding patients who had experienced an acute myocardial infarction (MI) or acute renal failure within the last three months, it was ensured that the study's focus remained on the chronic aspects of kidney disease. This exclusion criterion was set to avoid confounding factors that acute conditions could introduce, thereby allowing a clearer understanding of CKD's chronic progression and its association with a select biochemical profile. After patient selection, the aims, objectives, and procedures of the study were explained to the patients in understandable language. Risks and benefits were also made clear to the respondents. The respondents were encouraged to participate voluntarily, and they were allowed to withdraw from the study. Then, written informed consent was obtained from each respondent. Data were collected through face-to-face interviews using a semi-structured questionnaire and data collection tools. The study population underwent detailed history taking, physical examination, and relevant investigations. Serum parathyroid hormone (PTH) and vitamin D were assessed for each respondent. Sample size was determined using the equation of.

$$n = \frac{2\sigma^2}{\Delta^2}\left(Z_\alpha + Z_\beta\right)^2$$

Statistical analysis was performed using a Windows-based software program, Statistical Package for the Social Sciences 25 (SPSS-25) (Chicago, IL,

USA). After collection, all the data were checked and cleaned. Quantitative data were expressed as percentages, means, and standard deviations, and qualitative data were expressed as frequency distributions and percentages. To determine statistical significance, one-way ANOVA and the Pearson correlation test were used as appropriate. A p-value of < 0.05 was considered statistically significant. Serum iFGF-23 had been measured using the Thermo Fisher Scientific Invitrogen Human FGF-23 ELISA kit. Detection range was 3.12 pg/mL – 200 pg/mL.

Results

The study population had a mean age of 56.0 ± 9.4 years for CKD Stage III, 52 ± 10.0 years for CKD Stage IV, and 53.0 ± 9.8 years for CKD Stage V (Figure 1). There was no statistically significant difference in mean age among the CKD groups.

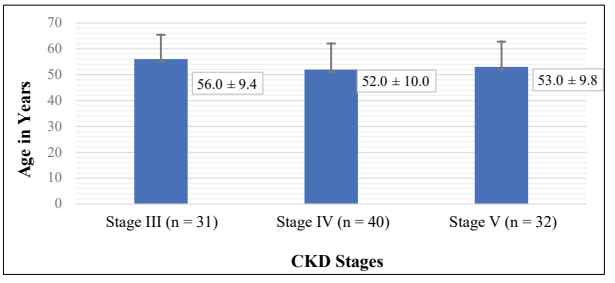

Figure 1: Age of study population according to CKD Stages. (n = 103)

Mean serum parathyroid hormone (PTH) level was 145.1 ± 107.4 pg/ml for patients with CKD stage III, 150.9 ± 88.2 pg/ml for CKD stage IV, and 280.4 ± 220.2 pg/ml for CKD stage V. There was a statistically significant ($p < 0.05$) difference in serum PTH levels among different CKD stages. Mean serum vitamin D was 18.4 ± 6.8 ng/ml, 18.9 ± 7.1ng/ml and 15.6 ± 5.5ng/ml respectively, for CKD stage III, IV, and V, without any statistically significant difference among the CKD groups. Mean Fibroblast growth factor-23 (FGF-23) was 31.6 ± 22.9 pg/ml for patients with CKD stage III, 38.4 ± 27.8 pg/ml for CKD stage IV, and 53.84± 46.5 pg/ml for CKD stage V. There was a statistically significant ($p < 0.05$) difference in FGF-23 levels among different CKD stages.

Serum FGF-23 levels showed a negative correlation with serum PTH levels in patients with CKD stage III ($r = -0.274$, $p = 0.129$), CKD stage IV ($r = 0.247$, $p = 0.125$), and CKD stage V ($r = 0.208$, $p = 0.262$), respectively (Table II).

Serum FGF-23 levels showed a negative correlation with vitamin D levels in CKD stages III, IV, and V; $r = -0.093$, $p = 0.625$; $r = -0.173$, $p = 0.307$; and $r = -0.313$, $p = 0.087$, respectively. None of the correlations were statistically significant (Figure 2).

Table I: Distribution of study population according to clinical parameters. (n = 103)

Clinical Parameters	Clinical Parameters	CKD Stage III	CKD Stage IV	CKD Stage V	P Value
	iPTH (pg/ml)	145.1 ± 107.4	150.9 ± 88.2	280.4 ± 220.2	< 0.05a
	Vitamin D (ng/ml)	18.4 ± 6.8	18.9 ± 7.1	15.6 ± 5.5	0.095a
	FGF-23 (pg/ml)	31.6 ± 22.9	38.4 ± 27.8	53.84± 46.5	< 0.05a

Data presented as mean ± SD. a = one-way ANOVA was used. A p-value < 0.05 was considered statistically significant.

Table II: Correlation of FGF-23 with PTH and vitamin D according to CKD Stages.

Correlation of FGF-23	Correlation of FGF-23	Stage III	Stage III	Stage IV	Stage IV	Stage V	Stage V
Correlation of FGF-23	Correlation of FGF-23	r value	p value	r value	p value	r value	p value
	iPTH	-0.274	0.129b	0.247	0.125b	0.208	0.262b
	Vitamin D	-0.093	0.625b	-0.173	0.307b	-0.313	0.087b

b = Pearson correlation test was used to measure the level of significance. A p-value < 0.05 was considered statistically significant.

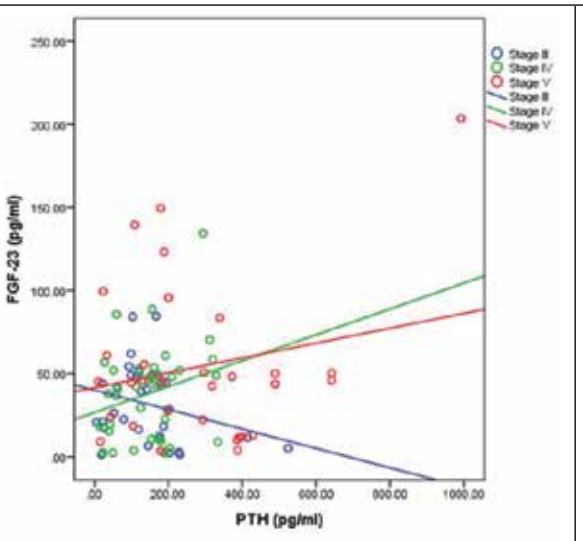

Fig 2(a): Correlation of FGF-23 with serum PTH levels according to CKD Stage III, IV and V.

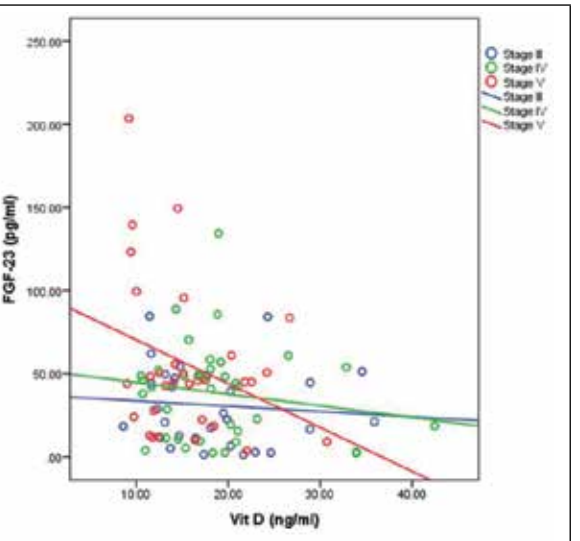

Fig 2(b): Correlation of FGF-23 with serum vitamin D levels according to CKD Stage III, IV and V.

Figure 2: Correlation of FGF-23 with serum PTH and vitamin D levels according to CKD Stages.

Discussion

In this cross-sectional study of 103 CKD patients with stages III, IV, and V, we measured serum FGF-23, PTH, and vitamin D levels and assessed the correlations among FGF-23, PTH, and vitamin D. The mean age of the study population was 50–60 years across all 3 CKD groups. This is consistent with the PK, JO, and BA (2021) study, which reported a mean age of 52.11 ± 6.04 years for CKD patients.[18] Yeh et al. (2022) reported a mean age of 65 ± 13 years for CKD patients, which is higher than the findings of the present study.[19]

Mean serum parathyroid hormone (PTH) significantly ($p < 0.05$) increased from 145.1 ± 107.4 pg/ml for patients with CKD stage III to 150.9 ± 88.2 pg/ml for CKD stage IV and 280.4 ± 220.2 pg/ml for CKD stage V. This is consistent with prior studies showing a similar trend of increasing serum parathyroid hormone level with increasing renal impairment.[16,20,21] These findings are also within the parameters set by The Kidney Disease Outcomes Quality Initiative (K/DOQI) for bone metabolism and disease in chronic kidney disease (CKD) guidelines, which recommend that serum PTH concentration of patients with CKD should be measured regularly and maintained within target ranges that are defined according to the stage of CKD (i.e., 150–300 pg/ml in patients with CKD stage V).[22]

Mean serum vitamin D was 18.4 ± 6.8 ng/ml, 18.9 ± 7.1 ng/ml, and 15.6 ± 5.5 ng/ml, respectively, for CKD stage III, IV, and V, without any statistically significant difference among the CKD groups. Rozita et al. (2013) reported a mean serum vitamin D level of 16.1 ± 6.2 ng/mL, which is consistent with the present study's findings.[23] Ko et al., 2016 reported mean vitamin D levels of 13.6 ± 7.8 ng/mL among CKD stage V patients, which are lower than the present study's findings.[24]

Mean Fibroblast growth factor 23 (FGF-23) was significantly ($p < 0.05$) increased from 31.6 ± 22.9 pg/ml for patients with CKD stage III to 38.4 ± 27.8 pg/ml for CKD stage IV and 53.84 ± 46.5 pg/ml for CKD stage V in the present study. This is consistent with Gutiérrez et al. (2008), who showed that higher FGF-23 levels are strongly associated with increased mortality risk, with the highest FGF-23 quartile having a nearly 6-fold higher risk than the lowest.[25] Prior studies have shown FGF-23 levels to be a significant independent predictor of CKD progression, which is consistent with the present study findings.[26,27]

In the present study, serum FGF-23 levels showed a negative correlation with vitamin D levels for CKD stages III, IV, and V, but this was not statistically significant. This is consistent with Jonsson KB et al (2003) study showing negative correlation of FGF-

23 with vitamin D level.[28]Isakova T et al(2011) found that prevalence of abnormally high FGF23 versus PTH levels across the spectrum of eGFR, they calculated the proportions of participants with normal or high FGF23 and PTH levels within each eGFR category and the most common pattern in the strata of more preserved eGFR was normal FGF23/ normal PTH, whereas high FGF23/high PTH was predominant in the lower eGFR.In our study, S. PTH levels were 145.1 ± 107.4, 150.9 ± 88.2, and 280.4 ± 220.2 in stages 3, 4, and 5, respectively. S.PTH increased progressively with declining eGFR.FGF23 level was positively correlated with S.PTH level in stages 4 and 5, but the correlation was not significant.[29] Limitations of the study included a small sample size, a short time frame, and a single center, which may not reflect the full picture of the country.

Conclusions

The present study found that serum FGF-23 levels correlated negatively with parathyroid hormone and vitamin D. FGF-23 levels increased with advancing CKD stages and showed trends toward correlation with PTH and Vitamin D. Larger prospective studies are needed.

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