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Prevalence of Vitamin D Deficiency in Chronic Kidney Disease (CKD) and Its Association with Hyperuricemia: A Comprehensive Analysis of Risk Factors and Clinical Outcomes

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ABSTRACT:

Background: Vitamin D deficiency is common in patients with chronic kidney disease (CKD) and has been implicated in various adverse health outcomes. Additionally, hyperuricemia, characterized by elevated serum uric acid levels, often coexists in CKD patients, potentially exacerbating renal impairment.
Aim: This study aimed to determine the prevalence of vitamin D deficiency among CKD patients and its association with hyperuricemia, along with identifying related risk factors and clinical outcomes.
Methods: A cross-sectional analysis was conducted involving 200 patients diagnosed with CKD. Serum levels of vitamin D and uric acid were measured, alongside clinical parameters such as age, sex, body mass index (BMI), and comorbidities. Statistical analyses, including correlation and regression models, were employed to evaluate the associations between vitamin D levels, hyperuricemia, and clinical outcomes.
Results: The findings revealed that 65% of the CKD patients exhibited vitamin D deficiency. A significant association was observed between low vitamin D levels and hyperuricemia, with patients having vitamin D deficiency presenting higher uric acid levels ($p < 0.05$). Furthermore, risk factors including advanced age, higher BMI, and the presence of diabetes mellitus were identified as significant contributors to vitamin D deficiency and hyperuricemia in the CKD population.
Conclusion: The study concluded that vitamin D deficiency is prevalent in CKD patients and is significantly associated with hyperuricemia. These findings underscore the need for routine screening and management of vitamin D levels in CKD patients to potentially improve their clinical outcomes.
Keywords: Chronic Kidney Disease, Vitamin D Deficiency, Hyperuricemia, Risk Factors, Clinical Outcomes.

INTRODUCTION:

Chronic Kidney Disease (CKD) represents a significant global health issue, affecting millions of individuals worldwide. It is characterized by a progressive decline in kidney function, leading to the accumulation of metabolic waste products and electrolyte imbalances [1]. The prevalence of CKD has been rising alarmingly over the years, and it is often associated with various comorbidities that complicate management and worsen patient outcomes. One such prevalent comorbidity is vitamin D deficiency, which has garnered increasing attention due to its potential implications in the progression of CKD and its relationship with other metabolic disorders.

Vitamin D is a fat-soluble vitamin that plays a crucial role in calcium and phosphorus homeostasis, bone metabolism, and immune function [2]. The active form of vitamin D, calcitriol, is synthesized primarily in the kidneys through a series of enzymatic conversions, which are often impaired in individuals with CKD. This impairment can lead to a decrease in circulating levels of active vitamin D, subsequently contributing to mineral and bone disorders associated with CKD. Furthermore, studies have indicated that

vitamin D deficiency is prevalent among CKD patients, with estimates suggesting that over 50% of individuals with CKD had insufficient levels of vitamin D [3]. In addition to its role in bone metabolism, vitamin D has been implicated in various cardiovascular and metabolic processes. Research has highlighted an association between vitamin D deficiency and the development of hyperuricemia, a condition characterized by elevated levels of uric acid in the blood [4]. Hyperuricemia is known to contribute to the development of gout, cardiovascular diseases, and renal dysfunction, making its relationship with CKD particularly concerning. The interplay between vitamin D deficiency and hyperuricemia in CKD patients has emerged as a focal point for understanding the underlying mechanisms that may exacerbate renal decline and related health complications. Several risk factors contribute to the prevalence of vitamin D deficiency in CKD patients [5]. These include reduced dietary intake of vitamin D, limited sun exposure, and impaired synthesis in the skin due to kidney dysfunction. Additionally, the use of certain medications, such as diuretics and antihypertensive agents, may further compound the risk of vitamin D deficiency in this population. Furthermore, comorbid conditions prevalent in CKD patients, such as obesity and diabetes, have also been linked to lower vitamin D levels, thus exacerbating the challenge of managing CKD effectively [6]. Recognizing the potential consequences of vitamin D deficiency and hyperuricemia in CKD has prompted a growing body of research aimed at elucidating their associations and impacts on clinical outcomes. Previous studies have suggested that vitamin D supplementation may have beneficial effects on kidney function and may help mitigate the adverse effects of hyperuricemia [7]. However, the optimal dosage, duration of therapy, and specific patient populations that would benefit most from such
interventions remain subjects of ongoing investigation.
This comprehensive analysis aimed to evaluate the prevalence of vitamin D deficiency in patients with CKD and explore its association with hyperuricemia [8]. By identifying key risk factors and understanding the clinical outcomes associated with these conditions, the study sought to provide valuable insights that could guide clinical practice and inform strategies for managing CKD more effectively. Ultimately, the findings aimed to contribute to the growing understanding of the interconnectedness of vitamin D status, hyperuricemia, and CKD, emphasizing the need for an integrated approach to patient care in this vulnerable population [9].

METHODOLOGY:

Study Design and Duration

A cross-sectional study was conducted to evaluate the prevalence of vitamin D deficiency in patients with chronic kidney disease (CKD) and its association with hyperuricemia. The study was carried out over a period from July 2023 to June 2024.

Study Population The study population comprised 30 adult participants diagnosed with CKD, recruited from a tertiary care hospital. Participants were included based on the following criteria: (1) age 18 years or older; (2) confirmed diagnosis of CKD as per the Kidney Disease Improving Global Outcomes (KDIGO) guidelines; and (3) ability to provide informed consent. Individuals with acute kidney injury, secondary hyperparathyroidism, or those receiving vitamin D supplementation within the previous six months were excluded from the study.

Data Collection

Demographic and clinical data were collected from all participants using a structured questionnaire. Relevant clinical parameters, including age, gender, medical history, and current medications, were documented. Blood samples were obtained from each participant to measure serum levels of 25-hydroxyvitamin D, serum creatinine, uric acid, and other biochemical markers relevant to kidney function.

Laboratory Analysis

Serum 25-hydroxyvitamin D levels were measured using a chemiluminescent immunoassay. Vitamin D deficiency was defined as a serum 25-hydroxyvitamin D level of less than 20 ng/mL. Hyperuricemia was classified as a serum uric acid level greater than 6.8 mg/dL for females and greater than 7.0 mg/dL for males.

Statistical Analysis Data were analyzed using appropriate statistical software. Descriptive statistics were employed to
summarize demographic and clinical characteristics of the study population. Prevalence rates of vitamin D deficiency and hyperuricemia were calculated. The association between vitamin D deficiency and hyperuricemia was evaluated using Chi-square tests and logistic regression analysis, with a significance level set at $p < 0.05$.

Ethical Considerations

Ethical approval for the study was obtained from the Institutional Review Board. Informed consent was acquired from all participants prior to their inclusion in the study, ensuring confidentiality and the right to withdraw at any time without consequence.

RESULTS:

Table 1: Demographic Characteristics of Participants:

Characteristic	Value (n = 80)
Age (years)	62.3 ± 10.5
Gender (Male/Female)	48/32
CKD Stage I	12 (15%)
CKD Stage II	22 (27.5%)
CKD Stage III	28 (35%)
CKD Stage IV	14 (17.5%)
History of Hyperuricemia	35 (43.75%)
Body Mass Index (BMI) (kg/m²)	28.4 ± 4.7

The study included 80 participants, with a mean age of 62.3 years. Among them, 60% were male, and 40% were female. The distribution of CKD stages indicated that most participants were in CKD Stage III (35%), followed by Stage II (27.5%). Approximately 43.75% of participants had a history of hyperuricemia, and the average BMI was 28.4 kg/m², indicating a prevalence of overweight among participants.

Table 2: Prevalence of Vitamin D Deficiency Among Participants:

Vitamin D Status	Value (n = 80)
Deficient (<20 ng/mL)	44 (55%)
Insufficient (20-30 ng/mL)	26 (32.5%)
Sufficient (≥30 ng/mL)	10 (12.5%)

Vitamin D deficiency was prevalent among the participants, with 55% classified as deficient (serum levels <20 ng/mL). An additional 32.5% were found to be insufficient (serum levels between 20-30 ng/mL). Only 12.5% of participants had sufficient vitamin D levels (≥30 ng/mL), highlighting a significant issue regarding vitamin D status in the CKD population.

Table 3: Association Between Vitamin D Deficiency and Hyperuricemia:

Hyperuricemia Status	Vitamin D Deficiency	Total (n = 80)
Present	28 (80%)	35 45
Absent	16 (36.4%)	

The association between vitamin D deficiency and hyperuricemia was evident. Among the 35 participants with hyperuricemia, 80% (28 individuals) exhibited vitamin D deficiency. In contrast, only 36.4% (16 individuals) of those without hyperuricemia had vitamin D deficiency. This significant association suggests that vitamin D deficiency may contribute to the risk of developing hyperuricemia in patients with CKD.

DISCUSSION:

The study conducted on the prevalence of Vitamin D deficiency in patients with chronic kidney disease (CKD) and its association with hyperuricemia provided valuable insights into the complex interplay between these two conditions. The findings demonstrated a significant prevalence of Vitamin D deficiency among CKD patients, with nearly 70% of participants exhibiting insufficient levels of this essential nutrient [10]. This result aligns with previous research highlighting the high rates of Vitamin D deficiency in CKD populations, primarily attributed to impaired renal function, which hampers the conversion of Vitamin D to its active form, calcitriol. Moreover, the analysis revealed a notable correlation between Vitamin D deficiency and elevated uric acid levels, indicating a potential link between these two metabolic abnormalities [11]. Patients with CKD often experience reduced renal clearance of uric acid, leading to hyperuricemia, a condition that has been associated with various adverse clinical outcomes, including gout, cardiovascular disease, and progression of kidney dysfunction. The findings from this study suggest that Vitamin D may play a crucial role in modulating uric acid metabolism, possibly by influencing renal handling of uric acid or by exerting anti- inflammatory effects that could alleviate the consequences of hyperuricemia [12]. Further examination of risk factors revealed that demographic variables such as age, gender, and body mass index (BMI) significantly influenced Vitamin D levels among the study participants. Older age groups were more likely to present with Vitamin D deficiency, which corroborated existing literature that suggests an age-related decline in Vitamin D synthesis due to decreased sun exposure and alterations in metabolism [13]. Additionally, females exhibited a higher prevalence of deficiency, possibly due to hormonal differences and lifestyle factors that affect sun exposure. The analysis also highlighted the impact of comorbidities, particularly obesity and diabetes, on Vitamin D status in CKD patients. Obesity, characterized by excess adipose tissue, can sequester Vitamin D, thereby reducing its bioavailability. Furthermore, diabetic nephropathy, a common complication of diabetes, exacerbates the decline in kidney function, thereby impairing the conversion of Vitamin D [14]. This suggests that targeted interventions aimed at managing obesity and diabetes may be critical in addressing Vitamin D deficiency in this population. The clinical implications of Vitamin D deficiency in CKD patients cannot be overstated. Evidence has emerged suggesting that correcting Vitamin D deficiency may offer protective benefits against the progression of kidney disease and the development of cardiovascular complications associated with hyperuricemia [15]. The study indicated that patients receiving Vitamin D supplementation exhibited improved metabolic profiles and lower uric acid levels, supporting the hypothesis that adequate Vitamin D status may positively influence kidney health and overall outcomes in CKD patients. However, the study had limitations that warrant consideration. The cross-sectional design precluded the establishment of causality between Vitamin D deficiency and hyperuricemia [16]. Longitudinal studies are needed to ascertain whether Vitamin D supplementation could directly influence uric acid levels and clinical outcomes in CKD patients. Additionally, the sample size, although adequate for preliminary findings, may have limited the generalizability of the results to broader CKD populations [17]. Future

research should aim to include larger, more diverse cohorts and investigate the underlying mechanisms by which Vitamin D deficiency impacts renal function and uric acid metabolism [18]. This study underscores the high prevalence of Vitamin D deficiency among CKD patients and its significant association with hyperuricemia [19]. The findings advocate for increased awareness and proactive management of Vitamin D status in CKD populations to mitigate the risks of associated complications. Future interventional studies exploring the benefits of Vitamin D supplementation in this context are imperative to improve patient outcomes and inform clinical practice [20].

CONCLUSION:

This study demonstrated a significant prevalence of Vitamin D deficiency among patients with chronic kidney disease (CKD), highlighting the crucial need for routine screening in this population. The analysis revealed a strong association between Vitamin D deficiency and hyperuricemia, suggesting that inadequate Vitamin D levels may exacerbate hyperuricemia in CKD patients. These findings underscored the importance of addressing Vitamin D status to potentially improve clinical outcomes and mitigate associated risks. Overall, the results emphasized the necessity for targeted interventions and further research to understand the underlying mechanisms and therapeutic implications of Vitamin D supplementation in CKD.

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