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Original Research Article

Impact of Vitamin D Deficiency on Lipid Profile in Patients with End-Stage Renal Disease: A Biochemical Evaluation

Ratna Priya[1], Manish Kumar Sinha[2], Chandan Kishore[3], Madhu Sinha[4]

[1]Associate Professor, Department of Biochemistry, Patna Medical College and Hospital, Patna, Bihar, India

[2]Associate Professor, Department of Biochemistry, Patna Medical College and Hospital, Patna, Bihar, India

[3]Professor, Department of Radiology, Narayan Medical College and Hospital Jamuhar, Sasaram, Bihar, India

[4]Professor and HOD, Department of Biochemistry, Patna Medical College and Hospital, Patna, Bihar, India

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Corresponding Author: Manish Kumar Sinha

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Abstract:

Background: One of the main causes of the elevated cardiovascular morbidity and mortality linked to end-stage renal disease (ESRD) is dyslipidemia. Vitamin D insufficiency is prevalent among ESRD patients and is becoming more widely acknowledged for its possible effects on cardiovascular risk and lipid metabolism. However, limited data are available from the Indian subcontinent regarding this association.

Aim: To use a retrospective analysis to assess how vitamin D insufficiency affects lipid profiles in ESRD patients.

Methods: Between October 2024 and June 2025, a retrospective study was carried out at Patna Medical College and Hospital in Patna. 200 ESRD individuals' data were examined. Vitamin D deficiency (<20 ng/mL, n = 136) and vitamin D sufficiency (≥20 ng/mL, n = 64) were the two groups into which the participants were split. Values from the lipid profile (total cholesterol, triglycerides, LDL-C, and HDL-C) and serum vitamin D were extracted from hospital records. For the statistical analysis, SPSS version 23.0 was employed, along with the t-test, chi-square, and Pearson correlation.

Results: Sixty-eight percent of subjects had vitamin D insufficiency. The triglycerides (176.5 ± 41.8 vs. 149.3 ± 38.4 mg/dL, $p<0.001$), total cholesterol (218.4 ± 36.2 vs. 192.7 ± 32.5 mg/dL, $p<0.001$), and LDL-C (132.6 ± 28.7 vs. 111.2 ± 24.3 mg/dL, $p<0.001$) were significantly higher in the deficient patients, while HDL-C was lower (36.4 ± 7.8 vs. 42.8 ± 8.2 mg/dL, $p<0.001$) were lower. Vitamin D levels were positively connected with HDL-C ($r=+0.311$, $p<0.001$) and negatively correlated with LDL-C ($r=-0.367$, $p<0.001$), triglycerides ($r=-0.298$, $p<0.001$), and total cholesterol ($r=-0.342$, $p<0.001$).

Conclusion: Vitamin D insufficiency is quite prevalent in ESRD patients and is closely linked to an atherogenic lipid profile, which may increase the risk of cardiovascular disease.

Recommendations: Routine monitoring of vitamin D levels and correction of deficiency should be considered as part of ESRD management to mitigate dyslipidemia and reduce cardiovascular complications. To determine causal links and assess the therapeutic role of vitamin D supplementation, further prospective interventional studies are necessary.

Keywords: End-stage renal disease; Vitamin D deficiency; Lipid profile; Cardiovascular risk; Retrospective study.

Introduction

End-stage renal disease (ESRD), the final phase of chronic kidney disease (CKD), is characterized by a gradual and irreversible decline in kidney function, making dialysis or kidney transplantation essential for survival. The rising rates of diabetes mellitus, hypertension, and an aging global population have significantly contributed to the growing burden of ESRD worldwide [1]. Among affected patients, cardiovascular disease (CVD) remains the leading cause of death, placing this group at exceptionally high risk of both illness and mortality [2]. Dyslipidemia—a key modifiable risk factor for CVD—occurs far more frequently in individuals with ESRD compared to the general population [3].

The traditional function of vitamin D, a fat-soluble secosteroid hormone, in the metabolism of calcium and phosphate is well recognized. However, in

recent years, attention has expanded toward its extra-skeletal functions, including modulation of immune responses, insulin sensitivity, and lipid metabolism [4]. Vitamin D deficiency is highly predominant among ESRD patients, attributed to reduced renal 1-α hydroxylase activity, limited sun exposure, poor nutritional intake, and dialysis-related loss of vitamin D metabolites [5]. Numerous studies have shown that vitamin D deficiency is linked not only to bone and mineral disorders but also to metabolic issues, including dyslipidemia, endothelial dysfunction, and atherosclerosis [6].

Given the increased risk of cardiovascular events, the connection between vitamin D insufficiency and changes in lipid profiles in ESRD is especially significant. Hypovitaminosis D has been shown to adversely influence lipid metabolism by upregulating parathyroid hormone (PTH), enhancing systemic inflammation, and impairing insulin sensitivity, thereby leading to elevated triglycerides, LDL-C, and reduced HDL-C [7]. While outcomes differ across communities, recent evidence suggests that vitamin D supplementation may improve lipid abnormalities in patients with CKD and those undergoing dialysis [8].

"Research examining the relationship between vitamin D and lipid metabolism in ESRD patients from the Indian subcontinent remains limited, even though growing evidence supports this link. This is particularly important considering the widespread occurrence of (CKD) and vitamin D deficiency in the general population. India offers a special setting for these kinds of studies [9]. Understanding this association is crucial for developing targeted strategies to reduce cardiovascular risk in ESRD patients. In order to better understand vitamin D insufficiency's possible role in cardiovascular risk stratification and therapy, this study aims to evaluate how vitamin D deficiency influences the lipid profile in patients with ESRD.

Methodology

Study Design: This was a retrospective observational study.

Study Setting: The research was conducted in the Department of Biochemistry, Patna Medical College and Hospital, Patna, in relation with the Department of Nephrology, which routinely monitored patients with ESRD.

Study Duration: The study covered a period of eight months, from October 2024 to June 2025, during which relevant patient records and laboratory results were retrieved and analyzed.

Participants: This group consisted of 200 patients with ESRD who were being treated at Patna Medical College and Hospital. The study made use of information from their medical records, including clinical specifics and biochemical results.

Inclusion Criteria: Participants were individuals aged 18 years or older who had a confirmed diagnosis of end-stage renal disease and for whom lipid profile and vitamin D data were available during the study period.

Exclusion Criteria: Patients with incomplete laboratory records, those receiving lipid-lowering therapy or vitamin D supplementation during the study period, individuals with liver disease, thyroid disorders, or acute infections, and patients below 18 years of age were excluded to minimize confounding factors.

Bias: All eligible ESRD patients meeting the inclusion criteria during the study period were consecutively enrolled to reduce selection bias. Standardized laboratory reports from the hospital's central biochemistry laboratory were used to reduce information bias.

Data Collection: Serum vitamin D levels, clinical history, demographic information, and lipid profile data (total cholesterol, triglycerides, LDL, and HDL) were all taken from hospital medical records. Records were reviewed systematically, and only complete datasets were included.

Procedure: The laboratory measurements had been performed as part of routine patient management using standardized automated analyzers. Serum vitamin D levels were assessed using chemiluminescent immunoassay, and lipid profile was analyzed using enzymatic colorimetric methods. Data were extracted into a structured proforma for uniformity and accuracy.

Statistical Analysis: For statistical analysis, the dataset was processed using IBM SPSS Statistics software, version 23.0 (Armonk, NY, USA). Categorical variables were summarized as frequencies and percentages, while continuous variables were expressed as mean ± standard deviation (SD). Group comparisons (vitamin D sufficient vs. deficient) were conducted using either the independent t-test or the chi-square test, depending on the type of data. The association between vitamin D levels and lipid profile parameters was assessed using Pearson’s correlation coefficient. A p-value below 0.05 was considered statistically significant.

Results

The study included 200 patients diagnosed with (ESRD). Their ages ranged from 21 to 78 years, with an average of 52.6 ± 12.4 years. Among the participants, 72 (36%) were female and 128 (64%) were male. Vitamin D deficiency (<20 ng/mL) was observed in 68% (n=136), whereas 32% (n=64) had adequate levels (≥20 ng/mL).

Table 1: Baseline Demographic and Clinical Characteristics of Participants

Characteristics	Vitamin D Deficient (n=136)	Vitamin D Sufficient (n=64)	p-value
Age (years, mean ± SD)	53.1 ± 12.7	51.4 ± 11.8	0.428
Male, n (%)	88 (64.7%)	40 (62.5%)	0.764
Female, n (%)	48 (35.3%)	24 (37.5%)	
BMI (kg/m², mean ± SD)	23.8 ± 3.2	24.1 ± 3.1	0.543
Duration of ESRD (years)	4.2 ± 2.5	3.9 ± 2.2	0.312

"No significant differences were observed between the vitamin D deficient and sufficient groups with respect to age, gender distribution, BMI, or duration of ESRD, indicating that the groups were comparable at baseline."

Lipid Profile Comparison: Lipid levels were analyzed and compared between groups with vitamin D deficiency and those with sufficient vitamin D. LDL-C, triglycerides, and total cholesterol were all greater in patients with vitamin D insufficiency, while HDL-C was noticeably lower.

Table 2: Lipid Profile in Relation to Vitamin D Status

Lipid Parameter (mg/dL)	Vitamin D Deficient (n=136)	Vitamin D Sufficient (n=64)	p-value
Total Cholesterol	218.4 ± 36.2	192.7 ± 32.5	<0.001 **
Triglycerides	176.5 ± 41.8	149.3 ± 38.4	<0.001 **
LDL-C	132.6 ± 28.7	111.2 ± 24.3	<0.001 **
HDL-C	36.4 ± 7.8	42.8 ± 8.2	<0.001 **

All lipid levels demonstrated a statistically significant difference between the two groups. Patients with inadequate vitamin D had a higher atherogenic lipid profile than those with enough vitamin D.

Correlation Analysis: A correlation between blood vitamin D concentrations and lipid profiles was assessed using Pearson correlation.

Table 3: Correlation between Serum Vitamin D Levels and Lipid Parameters

Lipid Parameter	r-value	p-value
Total Cholesterol	-0.342	<0.001 **
Triglycerides	-0.298	<0.001 **
LDL-C	-0.367	<0.001 **
HDL-C	+0.311	<0.001 **

Vitamin D levels were inversely associated with total cholesterol, triglycerides, and LDL-C, while showing a direct correlation with HDL-C. These correlations were statistically significant, suggesting that lower vitamin D levels are correlated with adverse lipid profile changes in ESRD patients.

Summary of Findings

- 68% of ESRD patients had vitamin D deficiency.
- Patients with the deficiency exhibited notably elevated levels of total cholesterol, triglycerides, and LDL-C, along with reduced HDL-C.
- Vitamin D levels were significantly correlated with lipid parameters, highlighting its potential role in lipid metabolism among ESRD patients.

Discussion

Nearly two-thirds (68%) of the 200 patients with ESRD in this retrospective research had vitamin D insufficiency, which was found to be highly prevalent. Age, gender distribution, BMI, and length of ESRD were among the baseline demographic and clinical features that were similar between participants lacking vitamin D and those with adequate levels, preventing these factors from confusing the observed variations in biochemical measures.

There were notable variations between the two groups, according to the lipid profile study. Patients with vitamin D deficiency showed notably lower average HDL-C levels and higher average levels of total cholesterol, triglycerides, and LDL-C compared to those with sufficient vitamin D. This reflects a shift toward a more atherogenic lipid profile in ESRD patients is associated with vitamin D insufficiency, thereby raising the risk of cardiovascular problems.

The findings were reinforced by correlation analysis, which revealed a significant positive association between serum vitamin D levels and HDL-C, along with an inverse relationship with total cholesterol, triglycerides, and LDL-C. This pattern points to a dose–response effect, where decreasing vitamin D concentrations are increasingly linked to unfavorable lipid alterations. Overall, the study

highlights that vitamin D deficiency is not only prevalent among individuals with ESRD but may also contribute to cardiovascular risk and disturbances in lipid metabolism. The influence of vitamin D on lipid regulation—potentially mediated by parathyroid hormone activity, insulin resistance, and inflammatory mechanisms—could explain the observed atherogenic lipid profile in vitamin D–deficient patients.

These results highlight the clinical importance of identifying and managing vitamin D deficiency as part of holistic patient care, given that dyslipidemia is a well-established risk factor for cardiovascular disease—the leading cause of mortality in individuals with end-stage renal disease. Furthermore, while prospective interventional studies are needed to confirm causality, the significant associations observed between vitamin D levels and lipid profiles suggest that improving vitamin D status could beneficially influence lipid metabolism.

All of these investigations show that vitamin D insufficiency in ESRD is consistently linked with dyslipidemia, specifically aberrant LDL/HDL balance and increased triglycerides. Although results vary from patient to patient, supplementing with active vitamin D analogs shows promise in reversing these lipid abnormalities.

Vitamin D deficiency is highly prevalent in patients with (ESRD) receiving dialysis, and numerous studies have emphasized its association with lipid metabolism and cardiovascular health. According to Cernaro et al., low vitamin D levels in individuals with (CKD)—especially those with ESRD—are strongly linked to dyslipidemia, particularly elevated triglycerides, which play a major role in increasing cardiovascular morbidity and mortality [10].

Clinical studies have shown that supplementation with active vitamin D analogs can modulate lipid abnormalities. Li et al. demonstrated that treatment with paricalcitol in dialysis patients improved lipid parameters, specifically lowering triglycerides and improving the HDL/LDL ratio, suggesting a potential protective cardiovascular role [11]. Similarly, Jean et al. observed that correction of CKD-mineral and bone disorder (CKD-MBD) with vitamin D analogs improved biochemical parameters, with secondary favorable effects on lipid metabolism [12].

Vitamin D deficiency is also linked with worsening cardiovascular and metabolic outcomes in ESRD patients. Bouillon et al. emphasized that low vitamin D status contributes to dyslipidemia and atherogenesis, exacerbating cardiovascular risk in this population [13]. Zoccali et al. further confirmed that disordered mineral metabolism in CKD, including vitamin D deficiency, worsens cardiovascular profiles partly via lipid abnormalities [14].

Observational data reinforce these findings. Pereira et al. found that patients with ESRD and vitamin D deficiency exhibited more atherogenic lipid profiles, with significantly higher LDL, VLDL, and triglycerides compared to vitamin D-sufficient counterparts, "highlighting the need to sustain sufficient vitamin D levels to reduce cardiovascular strain [15].

Conclusion

In patients with ESRD, vitamin D deficiency was highly prevalent and showed a strong link to an atherogenic lipid profile, characterized by reduced HDL-C and elevated levels of total cholesterol, triglycerides, and LDL-C. These findings emphasize the importance of regular monitoring and intervention, suggesting that vitamin D status plays a key role in lipid metabolism and cardiovascular risk in ESRD.

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