ORIGINAL RESEARCH

Assessment of Vitamin D Status and its Correlation with Section Carotid Intima-media Thickness amongst Type 2 Diabetes Mellitus Patients: A Cross-sectional Study

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ABSTRACT

Background: Vitamin D deficiency is highly prevalent among individuals with Type 2 Diabetes Mellitus (T2DM) and has been implicated in the pathogenesis of cardiovascular diseases. Carotid intima-media thickness (CIMT) serves as a non-invasive marker of subclinical atherosclerosis and early vascular changes. **Aim:** To assess the serum Vitamin D status and its correlation with carotid intima-media thickness among patients with Type 2 Diabetes Mellitus. **Materials and Methods:** This hospital-based cross-sectional study was conducted in the Departments of Medicine and Radiology at a tertiary care teaching hospital after ethical approval. A total of 110 adult T2DM patients aged 30–70 years were enrolled based on predefined inclusion and exclusion criteria. Serum 25(OH)D levels were measured using chemiluminescence immunoassay and categorized as deficient (<20 ng/mL), insufficient (20–29.9 ng/mL), or sufficient (≥30 ng/mL). CIMT was measured bilaterally using high-resolution B-mode ultrasonography. Data on glycaemic indices, lipid profile, and BMI were also collected. Statistical analysis was performed using SPSS version 26.0 with p-value <0.05 considered significant. **Results:** Vitamin D deficiency was observed in 52.73% of participants, while 30.91% were insufficient and only 16.36% had sufficient levels. Increased CIMT (≥0.9 mm) was found in 60% of subjects. A significant inverse relationship was found between Vitamin D levels and CIMT ($r = -0.524$, $p < 0.001$). Lower Vitamin D levels were also associated with higher HbA1c, LDL-C, BMI, and lower HDL-C. Patients with increased CIMT had significantly lower Vitamin D levels, poorer metabolic parameters, and longer diabetes duration. **Conclusion:** There is a strong inverse association between serum Vitamin D levels and carotid intima-media thickness in T2DM patients, indicating that Vitamin D deficiency may contribute to early atherosclerotic changes. Routine monitoring and correction of Vitamin D deficiency could play a role in mitigating cardiovascular risk in this population.

Keywords: Vitamin D, Carotid intima-media thickness, Type 2 Diabetes Mellitus, Subclinical atherosclerosis, Cardiometabolic risk

INTRODUCTION

Type 2 diabetes mellitus (T2DM) is a chronic metabolic disorder characterized by insulin resistance and relative insulin deficiency. It poses a significant global health burden, with the International Diabetes Federation (IDF) estimating that over 537 million adults were living with diabetes in 2021, a number projected to rise to 783 million by 2045 (IDF, 2021). One of the major complications of T2DM is accelerated atherosclerosis, which significantly increases the risk of cardiovascular morbidity and mortality.[1]

Carotid intima-media thickness (CIMT), a non-invasive ultrasound-based marker of subclinical atherosclerosis, has emerged as a reliable surrogate endpoint for evaluating cardiovascular risk in diabetic patients (Bots et al., 2002). An increase in CIMT has been associated with higher incidence of myocardial infarction and stroke, especially among those with metabolic disorders like T2DM (Lorenz et al., 2007).[2]

Vitamin D, traditionally recognized for its role in calcium homeostasis and bone metabolism, has recently gained attention for its extra-skeletal effects, including modulation of immune function, insulin secretion, and vascular health. Hypovitaminosis D is widely prevalent among patients with T2DM and has been implicated in insulin resistance, systemic inflammation, endothelial dysfunction, and increased cardiovascular risk (Chiu et al., 2004; Pittas et al., 2007).[3,4] Moreover, observational studies suggest an inverse correlation between serum 25-hydroxyvitamin D [25(OH)D] levels and CIMT, indicating a potential protective role of vitamin D against atherosclerotic progression (Tarcin et al., 2009).[5]

Despite emerging evidence linking vitamin D deficiency with cardiovascular abnormalities in diabetes, the relationship between vitamin D levels and CIMT remains inconsistent across populations, and data from hospital-based diabetic cohorts in India are limited. Therefore, this study aims to evaluate vitamin D status and its correlation with carotid intima-media thickness among patients with T2DM. Understanding this association could provide insights into the potential role of vitamin D in cardiovascular risk stratification and management among diabetic individuals.[6]

AIM AND OBJECTIVES

To assess the serum Vitamin D status and its correlation with carotid intima-media thickness among patients with Type 2 Diabetes Mellitus.

MATERIALS AND METHODS

Study Design

This was a hospital-based cross-sectional observational study designed to evaluate the association between serum Vitamin D levels and carotid intima-media thickness (CIMT) in patients with Type 2 Diabetes Mellitus (T2DM).

Study Population

A total of 110 adult patients diagnosed with T2DM, as per American Diabetes Association (ADA) criteria, were consecutively enrolled from the outpatient and inpatient departments of the hospital.

Study Place

The study was conducted in the Department of Medicine, Government Medical College and Hospital, Bettiah, West Champaran, Bihar, India.

Study Period

The study was carried out over a period of one year and six months, from June 2022 to December 2023.

Inclusion Criteria

- Adults aged between 30 and 70 years
- Diagnosed with Type 2 Diabetes Mellitus for at least one year
- Willing to undergo blood investigations and carotid ultrasonography
- Provided written informed consent

Exclusion Criteria

- Diagnosis of Type 1 Diabetes Mellitus
- Vitamin D supplementation within the previous 3 months
- Known cases of chronic kidney disease (Stage ≥3), liver disease, or thyroid disorders
- History of cardiovascular events (stroke, myocardial infarction)
- Current smokers or individuals on lipid-lowering medications
- Pregnant or lactating women

Ethical Considerations

Approval for the study was obtained from the Institutional Ethics Committee. All participants provided written informed consent after being informed about the nature, purpose, and potential risks involved in the study.

Study Procedure

Data Collection

Demographic and clinical data including age, sex, diabetes duration, and anthropometric parameters (height, weight, and BMI) were collected using a structured proforma. Blood pressure was recorded using a standardized mercury sphygmomanometer after a 5-minute rest.

Laboratory Investigations

Fasting venous blood samples were collected to assess:

- Serum 25-hydroxyvitamin D [25(OH)D] via chemiluminescence immunoassay (CLIA)
- Fasting blood glucose, HbA1c, lipid profile, and serum creatinine using standard laboratory protocols

Vitamin D status was categorized as:

- Deficient: <20 ng/mL
- Insufficient: 20–29.9 ng/mL
- Sufficient: ≥30 ng/mL

Measurement of Carotid Intima-Media Thickness (CIMT)

CIMT was measured using high-resolution B-mode ultrasonography with a 7.5–10 MHz linear array transducer by a single experienced radiologist blinded to the patients' Vitamin D status. Measurements were taken bilaterally at the distal 1 cm of the common carotid artery (CCA). The mean of three readings from each side was used for analysis. A CIMT ≥0.9 mm was considered indicative of increased arterial thickness or subclinical atherosclerosis.

Outcome Measures

The primary outcome was the correlation between serum Vitamin D levels and mean CIMT values. The secondary outcome was the prevalence of subclinical atherosclerosis (CIMT ≥0.9 mm) across different Vitamin D status groups.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using SPSS version 26.0.

- Continuous variables were presented as mean ± standard deviation (SD)
- Categorical variables were summarized as frequency and percentages
- Pearson's correlation coefficient was used to determine the relationship between Vitamin D levels and CIMT.
- ANOVA or independent t-test was used for group comparisons.
- A p-value <0.05 was considered statistically significant.

RESULTS

Table 1: Baseline Demographic and Clinical Characteristics of Study Participants (n = 110)

Parameter	Mean ± SD / n (%)
Age (years)	56.3 ± 8.2
Gender	
Male	62 (56.36%)
Female	48 (43.64%)
Duration of Diabetes (years)	8.4 ± 4.6
Body Mass Index (BMI, kg/m²)	27.2 ± 3.8
Systolic BP (mmHg)	138.6 ± 14.1
Diastolic BP (mmHg)	82.5 ± 8.7
Fasting Blood Sugar (mg/dL)	156.8 ± 32.5
Postprandial Blood Sugar (mg/dL)	212.7 ± 48.3
HbA1c (%)	8.2 ± 1.4
Total Cholesterol (mg/dL)	202.4 ± 34.7
LDL-C (mg/dL)	121.6 ± 27.3
HDL-C (mg/dL)	40.2 ± 6.0
Triglycerides (mg/dL)	186.5 ± 42.1
Serum Creatinine (mg/dL)	0.89 ± 0.18

Table 1, shows the study included 110 patients with Type 2 Diabetes Mellitus (T2DM), with a mean age of 56.3 ± 8.2 years. The male-to-female ratio showed a slight male predominance, with 56.36% males and 43.64% females. The average duration of diabetes among the participants was 8.4 ± 4.6 years, indicating a relatively long-standing diabetic population. The mean Body Mass Index (BMI) was 27.2 ± 3.8 kg/m², reflecting an overweight cohort. Mean systolic and diastolic blood pressures were 138.6 ± 14.1 mmHg and 82.5 ± 8.7 mmHg, respectively, suggesting a trend toward suboptimal blood pressure control. Glycaemic indices were elevated, with fasting and postprandial blood glucose averaging 156.8 ± 32.5 mg/dL and 212.7 ± 48.3 mg/dL, respectively. The mean HbA1c was 8.2 ± 1.4%, confirming poor glycaemic control in the majority. Dyslipidaemia was evident, with mean total cholesterol of 202.4 ± 34.7 mg/dL, LDL-C of 121.6 ± 27.3 mg/dL, HDL-C of 40.2 ± 6.0

mg/dL, and triglycerides averaging 186.5 ± 42.1 mg/dL. Mean serum creatinine was within normal range at 0.89 ± 0.18 mg/dL, indicating preserved renal function in most participants.

Table 2: Distribution of Participants by Vitamin D Status and CIMT Category

Category	Frequency (n)	Percentage (%)
Vitamin D Status		
Deficient (<20 ng/mL)	58	52.73%
Insufficient (20–29.9)	34	30.91%
Sufficient (≥30 ng/mL)	18	16.36%
CIMT Category		
CIMT < 0.9 mm	44	40.00%
CIMT ≥ 0.9 mm	66	60.00%

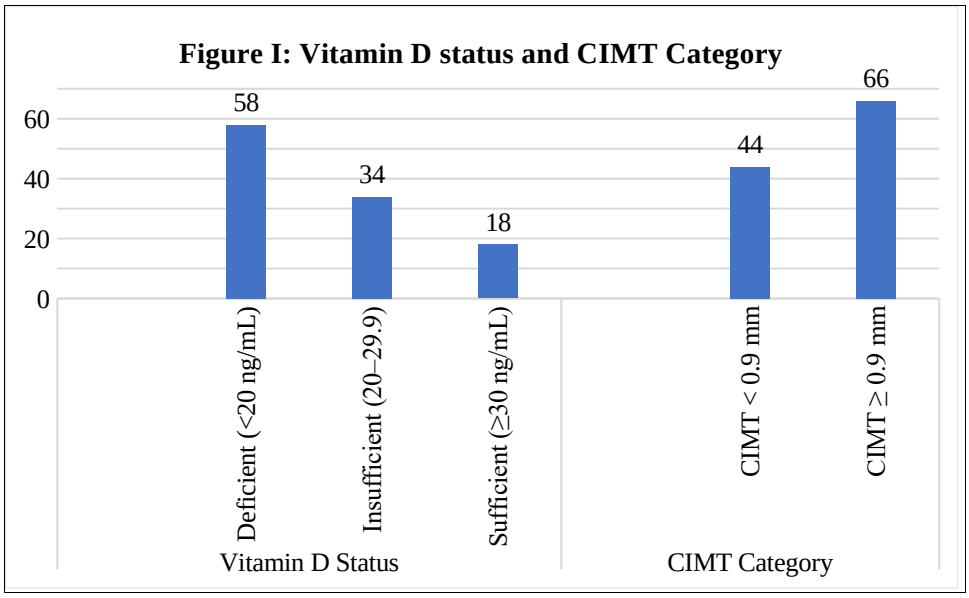

Table 2, figure I shows the prevalence of Vitamin D deficiency in the study population was notably high, with 52.73% (n = 58) having deficient levels (<20 ng/mL). An additional 30.91% (n = 34) were classified as insufficient (20–29.9 ng/mL), while only 16.36% (n = 18) had sufficient Vitamin D levels (≥30 ng/mL). Regarding carotid atherosclerosis, CIMT measurements revealed that 60% of the participants (n = 66) had increased CIMT values (≥0.9 mm), indicative of subclinical atherosclerosis. This high prevalence of increased CIMT suggests a significant burden of vascular changes in this diabetic cohort.

Table 3: Mean Carotid Intima-Media Thickness and Other Parameters by Vitamin D Status

Parameter	Deficient (n = 58)	Insufficient (n = 34)	Sufficient (n = 18)	p-value*
CIMT (mm)	1.06 ± 0.12	0.94 ± 0.10	0.86 ± 0.08	<0.001
HbA1c (%)	8.5 ± 1.2	8.0 ± 1.3	7.6 ± 1.0	0.014
LDL (mg/dL)	124.6 ± 28.2	116.4 ± 25.9	109.1 ± 23.8	0.045
HDL (mg/dL)	38.5 ± 5.8	42.3 ± 6.1	44.7 ± 6.5	0.008
BMI (kg/m²)	28.1 ± 3.7	26.7 ± 3.5	25.6 ± 3.2	0.032
Triglycerides (mg/dL)	192.3 ± 44.2	183.4 ± 38.6	175.2 ± 35.1	0.065

*ANOVA used for comparison among groups

Table 3 shows a significant inverse relationship was observed between Vitamin D status and CIMT values. Participants with Vitamin D deficiency had the highest mean CIMT (1.06 ± 0.12 mm), compared to the insufficient group (0.94 ± 0.10 mm) and sufficient group (0.86 ± 0.08 mm), with a highly significant p-value

(<0.001). Similarly, HbA1c levels were progressively lower across the Vitamin D strata (8.5% in the deficient group vs. 7.6% in the sufficient group; p = 0.014), indicating better glycaemic control in those with adequate Vitamin D levels. LDL-C was highest in the deficient group (124.6 ± 28.2 mg/dL) and lowest in the sufficient group (109.1 ± 23.8 mg/dL), showing statistical significance (p = 0.045). HDL-C, on the other hand, increased with Vitamin D levels (38.5 ± 5.8 to 44.7 ± 6.5 mg/dL; p = 0.008), suggesting a more favourable lipid profile in patients with sufficient Vitamin D. BMI showed a declining trend from 28.1 kg/m² in the deficient group to 25.6 kg/m² in the sufficient group (p = 0.032). Although triglyceride levels were higher in the deficient group (192.3 mg/dL), the difference did not reach statistical significance (p = 0.065).

Table 4: Correlation Between Serum Vitamin D Levels and Various Parameters

Parameter	Correlation Coefficient (r)	p-value
Vitamin D vs. CIMT (mm)	-0.524	<0.001
Vitamin D vs. HbA1c (%)	-0.416	<0.001
Vitamin D vs. LDL (mg/dL)	-0.298	0.002
Vitamin D vs. HDL (mg/dL)	+0.341	0.001
Vitamin D vs. BMI (kg/m²)	-0.265	0.006
Vitamin D vs. Triglycerides	-0.182	0.058

Table 4 shows the Correlation analysis revealed a moderate negative correlation between serum Vitamin D levels and CIMT (r = -0.524, p < 0.001), indicating that lower Vitamin D levels were associated with increased carotid wall thickness. Additionally, Vitamin D levels negatively correlated with HbA1c (r = -0.416, p < 0.001), LDL-C (r = -0.298, p = 0.002), and BMI (r = -0.265, p = 0.006), reflecting a broader link between Vitamin D deficiency and metabolic dysregulation. A positive correlation was noted between Vitamin D and HDL-C (r = +0.341, p = 0.001), suggesting improved cardiovascular risk profile with higher Vitamin D levels. The correlation between Vitamin D and triglycerides, though negative, was weaker and statistically non-significant (r = -0.182, p = 0.058).

Table 5: Comparison of CIMT Groups Based on Cardiometabolic Profile

Parameter	CIMT < 0.9 mm (n = 44)	CIMT ≥ 0.9 mm (n = 66)	p-value**
Age (years)	52.6 ± 7.1	58.4 ± 8.4	0.001
Duration of T2DM	6.7 ± 3.8	9.6 ± 4.9	0.002
HbA1c (%)	7.6 ± 1.1	8.6 ± 1.3	<0.001
Vitamin D (ng/mL)	29.6 ± 6.8	18.3 ± 7.1	<0.001
LDL-C (mg/dL)	112.5 ± 26.3	126.4 ± 28.5	0.021
HDL-C (mg/dL)	43.1 ± 6.2	38.7 ± 5.4	0.003
BMI (kg/m²)	25.9 ± 3.5	28.0 ± 3.6	0.005

Table 5 shows that when participants were grouped based on CIMT values, those with CIMT ≥0.9 mm (n = 66) were significantly older (58.4 vs. 52.6 years; p = 0.001) and had a longer duration of diabetes (9.6 vs. 6.7 years; p = 0.002) compared to those with CIMT <0.9 mm. Glycaemic control was worse in the increased CIMT group, as evidenced by higher HbA1c levels (8.6% vs. 7.6%; p < 0.001). Notably, serum Vitamin D levels were substantially lower in the increased CIMT group (18.3 ± 7.1 ng/mL) than in the lower CIMT group (29.6 ± 6.8 ng/mL; p < 0.001), strongly supporting the association between hypovitaminosis D and carotid atherosclerosis. Lipid parameters were also worse in the CIMT ≥0.9 mm group, with higher LDL-C (126.4 vs. 112.5 mg/dL; p = 0.021) and lower HDL-C (38.7 vs. 43.1 mg/dL; p

= 0.003). Furthermore, BMI was significantly higher in patients with increased CIMT (28.0 vs. 25.9 kg/m²; p = 0.005), underscoring the link between obesity and vascular thickening.

DISCUSSION

In the present study involving 110 patients with Type 2 Diabetes Mellitus, we observed a mean age of 56.3 years and a mean diabetes duration of 8.4 years, reflecting a population already at considerable risk for vascular complications. Notably, 52.73% of participants had Vitamin D deficiency (<20 ng/mL) and an additional 30.91% had insufficiency (20–29.9 ng/mL), leaving only 16.36% with sufficient levels (≥30 ng/mL). These findings are consistent with earlier work by Subramanian et al. (2011), who also reported a high prevalence of severe Vitamin D deficiency among North Indian diabetics, suggesting that hypovitaminosis D is endemic in this population and may contribute to metabolic dysregulation.[7]

Our study found that 60% of participants had increased CIMT (≥0.9 mm), indicating a high burden of subclinical atherosclerosis. This is in line with findings by Lupoli et al. (2017)[9], who in a pooled analysis observed that Vitamin D deficiency was significantly associated with increased CIMT in diabetic individuals.[8] Similarly, Hua et al. (2014) in a Shanghai-based study on T2DM patients demonstrated a comparable prevalence of increased CIMT in Vitamin D-deficient groups, further affirming the vascular consequences of low 25(OH)D levels.[9]

We also identified a significant inverse association between serum Vitamin D levels and CIMT ($r = -0.524$, $p < 0.001$). Participants with deficiency had a mean CIMT of 1.06 mm, compared to 0.94 mm in the insufficient group and 0.86 mm in the sufficient group. These results strongly echo those of Bhadra et al. (2016)[10], who similarly reported a progressive decrease in CIMT with increasing Vitamin D levels among T2DM patients. Moreover, Wang et al. (2017)[11] found that low serum 25(OH)D3 levels were independently associated with both CIMT and carotid plaques, reinforcing the biological plausibility of our observations.

Beyond vascular parameters, we observed that HbA1c, LDL-C, and BMI were significantly higher in Vitamin D-deficient patients, while HDL-C was lower, suggesting that hypovitaminosis D may be linked to broader cardiometabolic disturbances. Specifically, HbA1c averaged 8.5% in the deficient group versus 7.6% in the sufficient group ($p = 0.014$), consistent with the findings of Kim et al. (2020)[12], who proposed that Vitamin D may improve insulin sensitivity and β-cell function, thereby contributing to better glycaemic control. LDL-C levels also followed a similar trend in our study, ranging from 124.6 mg/dL in the deficient group to 109.1 mg/dL in the sufficient group, which aligns with Aydin et al. (2019), who noted improved lipid profiles in Vitamin D-replete individuals.[13]

When participants were grouped based on CIMT, those with CIMT ≥0.9 mm were older, had longer diabetes duration, poorer glycemic control, higher LDL-C, lower HDL-C, and importantly, significantly lower serum Vitamin D levels (18.3 ng/mL vs. 29.6 ng/mL; $p < 0.001$). These findings mirror the results of Giri et al. (2016) and Winckler et al. (2015), who emphasized that Vitamin D levels were consistently lower in patients with increased carotid thickness and poorer metabolic profiles.[14,15] The difference in mean Vitamin D levels between the high and low CIMT groups in our study was >11 ng/mL, which is comparable to that reported by Hua et al. (2014) in their Chinese cohort.[9]

Additionally, the inverse correlation between Vitamin D and BMI ($r = -0.265$) as well as lipid abnormalities reinforces the multifaceted role of Vitamin D in metabolic health. Although the association between Vitamin D and triglycerides was not statistically significant in our study ($r = -0.182$, $p = 0.058$), the trend remains in agreement with Chen et al. (2018), who reported similar findings in their meta-analysis.[16]

LIMITATIONS OF THE STUDY

- Cross-sectional design limits the ability to infer causality.
- Single-centre study may affect generalizability.
- The sample size (n=110), while adequate for preliminary analysis, may not capture all potential confounders.
- Possible residual confounding due to unmeasured variables such as physical activity, dietary intake, and sun exposure.
- Seasonal variation in Vitamin D levels was not accounted for, which might affect results.
- Reliance on a single radiologist's CIMT readings, although blinded, may introduce observer bias.

CONCLUSION

This study highlights a high prevalence of Vitamin D deficiency among patients with Type

2 Diabetes Mellitus and demonstrates a significant inverse association between serum Vitamin D levels and carotid intima-media thickness (CIMT). Lower Vitamin D levels were also linked to poorer glycaemic control, dyslipidaemia, and higher BMI, suggesting its broader role in metabolic regulation. These findings underscore the potential of Vitamin D as a modifiable risk factor for subclinical atherosclerosis in diabetics. Routine screening and appropriate correction of Vitamin D deficiency may help in reducing cardiovascular risk in this population.

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