Journal of Population Therapeutics & Clinical Pharmacology

RESEARCH ARTICLE
DOI: 10.53555/nx517e66

CORRELATION OF CAROTID INTIMA MEDIA THICKNESS WITH GLYCAEMIC CONTROL AND ANTHROPOMETRIC PARAMETERS IN PATIENTS WITH TYPE 2 DIABETES MELLITUS: A CROSS-SECTIONAL STUDY

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Abstract:
Background: Type 2 Diabetes Mellitus (T2DM) is a chronic condition associated with increased cardiovascular risk due to subclinical atherosclerosis. Carotid Intima Media Thickness (CIMT) is a non-invasive marker for early atherosclerotic changes.
Objectives: To assess CIMT in patients with T2DM and determine its correlation with glycaemic control and anthropometric risk factors.
Methods: This cross-sectional observational study was conducted at a tertiary care hospital in Solan over 18 months. A total of 80 T2DM patients aged 25–60 years were recruited. CIMT was measured using B-mode ultrasonography at three points on each side of the common carotid artery. Glycaemic control was assessed using fasting blood glucose and HbA1c levels. Anthropometric data including BMI, waist circumference, and waist-to-hip ratio were recorded. Statistical analysis was performed using Stata 17.0, with significance set at $p<0.05$.
Results: The mean age of participants was 48.1 years. The mean CIMT was 0.77 mm on the right and 0.773 mm on the left. High-risk CIMT values were observed in 26.3% of participants. CIMT showed a statistically significant positive correlation with BMI ($r=0.313$, $p=0.005$), waist-to-hip ratio ($r=0.672$, $p<0.0001$), HbA1c ($r=0.664$, $p<0.001$), and total cholesterol ($r=0.413$, $p=0.003$). Most participants (77.5%) had no detectable carotid plaque.
Conclusion: CIMT is significantly associated with poor glycaemic control and adverse anthropometric indices in T2DM patients. Routine CIMT assessment may help in early detection of cardiovascular risk and guide preventive strategies in this population.

Keywords: Type 2 Diabetes Mellitus, Carotid Intima Media Thickness, Glycaemic Control, Anthropometry, Cardiovascular Risk, Subclinical Atherosclerosis

Introduction

Type 2 Diabetes Mellitus (T2DM) is a chronic metabolic disorder characterized by insulin resistance and relative insulin deficiency, leading to elevated blood glucose levels.[1] It is the most common form of diabetes, accounting for approximately 90-95% of all diabetes cases worldwide.[1] As a progressive condition, T2DM contributes to the development of various long-term complications, particularly affecting the cardiovascular system, eyes, kidneys, and nerves.[2] According to the World Health Organization (WHO), an estimated 422 million adults worldwide are living with diabetes, with T2DM being the predominant form.[3] In India, the situation is particularly alarming, as it ranks second in the world with over 77 million people diagnosed with diabetes. Projections suggest that this number will reach 134 million by 2045, making India the "diabetes capital" of the world.[3,4]

Carotid Intima Media Thickness (CIMT) is a non-invasive marker of subclinical atherosclerosis and has emerged as a valuable tool for assessing cardiovascular risk in T2DM patients.[5] CIMT refers to the thickness of the intima and media layers of the carotid artery walls, which can be measured using B-mode ultrasonography.[6] Increased CIMT is considered an early indicator of atherosclerosis and has been shown to correlate with the presence of cardiovascular disease, even before clinical symptoms manifest.[7] Atherosclerosis is a progressive condition characterized by the accumulation of lipid deposits, inflammation, and fibrous tissue within the arterial walls, leading to narrowing and hardening of the arteries.[8] Over time, these plaques can rupture, resulting in acute cardiovascular events such as myocardial infarction or stroke.[5] CIMT reflects the early stages of atherosclerosis by measuring the thickening of the intima and media layers of the carotid arteries.[9] The measurement of CIMT not only reflects the burden of atherosclerotic plaque but also serves as a predictor of future cardiovascular events such as myocardial infarction and stroke.[10] Given its predictive value, CIMT measurement is increasingly used in clinical practice to identify high-risk individuals who may benefit from aggressive preventive measures, including lifestyle modification, glycaemic control, and lipid-lowering therapy.[10,11]

This study aims to fill the gap by examining the correlation between CIMT, glycaemic control, and anthropometric parameters in T2DM patients from India. The findings could provide insights into the early detection of cardiovascular risks and inform clinical practice, ultimately improving the management of T2DM patients and reducing the burden of cardiovascular complications.

AIM:

To evaluate the carotid intima media thickness (CIMT) in patients with Type 2 Diabetes Mellitus (T2DM) and to assess its correlation with glycaemic control and anthropometric parameters.

Material and Methods

- **Study Design:** A single centre, hospital-outpatient-based, cross-sectional, observational study.
- **Study Settings**: The study was conducted in the Department of General Medicine at Maharishi Markandeshwar Medical College and Hospital, Kumarhatti, Solan, involving patients attending the inpatient and outpatient facilities.
- **Ethical Clearance:** The study protocol, data collection forms, and informed consent documents were thoroughly reviewed and scrutinized by the Institute’s Ethical Committee.
- **Study Duration:** The total duration of the present study was 18 months: from March 2023 to September 2024 divided into the following three phases:
- **Primary Outcomes**: Carotid Intima Media Thickness (CIMT) was measured using B-mode ultrasonography at three sites on both sides of the carotid artery.
- **Secondary Outcomes:** Glycaemic control was assessed using fasting blood glucose and glycated hemoglobin (HbA1c). Anthropometric parameters, including Body Mass Index (BMI), waist circumference, and waist-to-hip ratio, were measured.

- **Study Participants:** The participants for this study included adults diagnosed with T2DM who met the eligibility criteria.
- **Inclusion Criteria:**

i. Male and female patients aged 25–60 years.
ii. Diagnosed cases of T2DM attending the study centre during the recruitment period.
iii. Participants who provided written informed consent to participate.

- **Exclusion Criteria:**

i. Patients aged below 25 years or above 60 years.
ii. Patients with a history of cardiovascular diseases, peripheral vascular diseases, cerebrovascular events, or hypertension.
iii. Patients with a history of smoking or renal disease.
iv. Patients on medications that could modify CIMT, such as statins, aspirin, ACE inhibitors, or Angiotensin Receptor Blockers.

- **Sample Size**: During the recruitment period, all eligible participants who provided written informed consent were enrolled. Following this approach, a total of 80 participants were included in the present study.
- **Sampling Methodology:** The study employed non-probability convenience sampling. Participants were recruited based on their availability and willingness to participate during their routine visits to the study centre.
- **Participant Recruitment:** Participants were recruited by the principal investigator through systematic screening during outpatient visits. Each participant underwent an initial assessment to confirm eligibility based on the inclusion and exclusion criteria.
- **Data Sources**

i. Dependent Variables: Data on CIMT was collected through B-mode ultrasonography.
ii. Independent Variables: Glycaemic control data (fasting blood glucose, HbA1c) was obtained from laboratory tests, while anthropometric data (BMI, waist circumference, waist-to-hip ratio) was measured during participant examinations.
iii. Confounding Variables: Information on age, gender, lipid profile, and socioeconomic status was obtained from medical records and interviews.

- **Data Collection Process:** The data collection process for this study involved the following steps:

i. Obtaining Informed Consent: Participants were approached during their visits to the outpatient departments. The Principal Investigator explained the study objectives, procedures, potential risks, and benefits in detail, using a consent form. Participants were given sufficient time to review the information, ask questions, and provide written informed consent voluntarily.

ii. Demographic and Socioeconomic Data Collection: Demographic information such as age, gender, and address was collected during interviews. Socioeconomic status was assessed using a modified Kuppuswamy scale, which considered educational background, occupation, and monthly family income.

iii. Height and Weight: Height was measured to the nearest 0.1 cm using a wall-mounted stadiometer, with participants standing straight and barefoot. Weight was measured to the nearest 0.1 kg using a standardized weighing scale. BMI Calculation: BMI was calculated as weight (kg) divided by the square of height (m^2).

iv. Waist and Hip Circumference: Waist circumference was measured at the narrowest part of the torso or the umbilicus (if no natural waistline was present), and hip circumference was measured at the widest part of the hips. Measurements were taken to the nearest 0.1 cm using a plastic-coated measuring tape.

v. Blood Pressure: Systolic and diastolic blood pressure were measured using a manual sphygmomanometer in the right arm while the participant was seated. Measurements were taken to the nearest 2 mmHg.

vi. Laboratory Tests: Fasting blood samples were collected to measure blood glucose, glycated hemoglobin (HbA1c), and lipid profiles, using standard laboratory protocols.

vii. Carotid Intima Media Thickness (CIMT) Assessment: CIMT assessment was conducted meticulously using B-mode ultrasonography, which is a non-invasive, high-resolution imaging technique for visualizing arterial walls. A senior radiological consultant performed all ultrasonographic examinations to ensure consistency and reliability of the measurements. Participants were instructed to lie down in a supine position on an examination table. To ensure optimal imaging of the carotid arteries, the participant's neck was slightly extended and turned away from the side being examined. This positioning provided unobstructed access to the carotid artery and minimized interference during the ultrasound procedure.

viii. The assessment was conducted using a Doppler USG Philips ultrasound machine with a 7-14Mhz frequency linear probe. The linear array transducer, with a frequency of 7.5–12 MHz, was used to obtain clear and precise images of the carotid artery. The examination focused on the common carotid artery (CCA), which was visualized longitudinally in two dimensions. CIMT measurements were taken from the far wall of the CCA, as it provides the most reproducible and accurate results. Measurements were performed at three predefined locations on each side of the carotid artery:
Bulb Region: The area near the carotid bifurcation.

Midsection: Approximately 1 cm proximal to the bifurcation.
Proximal Section: About 2 cm away from the bifurcation.
The radiological consultant(s) identified and measured the intima-media thickness at these three locations. CIMT was defined as the distance between two echogenic lines: the leading edge of the lumen-intima interface and the leading edge of the media-adventitia interface. Each measurement was taken thrice, and the three highest readings at each site were averaged to obtain the mean CIMT value for that specific location. On completion of measurements for the right and left CCAs, the overall mean CIMT was calculated by averaging the measurements from all six locations (three on each side).

The procedure ensured that both anterior (near) and posterior (far) walls of the carotid arteries were adequately visualized and measured. Additional notes were made if any plaques or irregularities were detected during the ultrasonography, with plaques classified into four types:
- Type I: Thin rim over the surface, predominantly anechoic.
- Type II: Less than 25% echogenic components.
- Type III: Less than 25% hypoechoic components.
- Type IV: Predominantly echogenic.

ix. Outcome Measurement and Data Recording: The primary outcome (CIMT) and secondary outcomes (glycaemic control and anthropometric parameters) were recorded systematically in the paper-based data collection forms. All data were verified for completeness and accuracy at the end of each data collection session by the research team.

- **Statistical Analysis**: The data from paper-based data collection was initially entered into MS Excel and was imported into Stata 17.0. All the statistical and graphical analyses for this study were undertaken using Stata software version 17.0. Descriptive statistics were used for summarizing the data, while inferential statistics, including t-tests, ANOVA, and Pearson's correlation coefficient, were employed to assess relationships among variables. A significance level of 0.05 was used for all tests.

- **Funding:** There was no external funding for this study.
- **Conflict of Interest:** There was no conflict of interest in the design, implementation, or interpretation of findings for this study.

Results

A total of 80 participants diagnosed with Type 2 Diabetes Mellitus (T2DM) were included in the study. The mean age was 48.1 years (range: 38 to 58 years). Among them, 62.5% (n = 50) were males and 37.5% (n = 30) were females. Tobacco chewing was reported by 36.3% (n = 29) and alcohol use by 32.5% (n = 26) of participants. The duration of diabetes ranged from 1 to over 12 years, with the highest proportion (36.3%) having diabetes for 4–6 years, followed by 28.7% with 7–9 years of disease duration.

Table 1: Characteristics of Participants

	n	%
Gender		
Female	30	37.5
Male	50	62.5
Tobacco Chewing	29	36.3
Alcohol	26	32.5
Age (Mean, Min – Max)	**48.1**	**38 to 58**
Duration of DM (in Years)		
1-3 Years	9	11.3
4-6 Years	29	36.3
7-9 Years	23	28.7
10-12 Years	14	17.5
>12 Years	5	6.25

Anthropometric and clinical characteristics showed a mean BMI of 29.2 kg/m² (range: 22.9 to 34.5), indicating a predominance of overweight and obese individuals. The mean waist-to-hip ratio was 0.88 (range: 0.68 to 1.23). Mean systolic and diastolic blood pressures were 125 mmHg (range: 114–136) and 82 mmHg (range: 74–88), respectively. Mean fasting blood glucose was 136 mg/dL (range: 96–180), postprandial blood glucose was 193 mg/dL (range: 143–248), and mean HbA1c was 7.8% (range: 6.8–9.1).

Table 2: Distribution of participants based on Risk factors (n= 80)

	Mean	Minimum	Maximum
Waist-to-Hip Ratio	0.88	0.68	1.23
Systolic Blood Pressure (mmHg)	125	114	136
Diastolic Blood Pressure (mmHg)	82	74	88
BMI (Mean, Min to Max)	29.2	22.9	34.5
Fasting Blood Glucose (mg/dL)	136	96	180
Postprandial Blood Glucose (mg/dL)	193	143	248
Glycated Haemoglobin (HbA1c)	7.8	6.8	9.1

Table 3: Distribution of participants based on CIMT (n= 80)

	Right Side	Left Side
IMT - Common Carotid Near Wall (mm)	0.77	0.77
IMT - Common Carotid Middle Wall (mm)	0.77	0.771
IMT - Common Carotid Far Wall (mm)	0.77	0.778
Mean CIMT Side (mm)	0.77	0.773

CIMT measurements revealed similar values on both sides of the carotid artery. The mean CIMT on the right side was 0.77 mm, and on the left, it was 0.773 mm. Among the participants, 73.8% (n = 59) were categorised as low-risk, while 26.3% (n = 21) fell into the high-risk category based on CIMT values. Among the 80 participants, the majority (73.8%, n = 59) were classified as being in the low-risk category, while 26.3% (n = 21) fell into the high-risk category based on their CIMT values.

Table 4: Distribution of participants based on Type of Plague (n= 80)

	n	%
Plaque Type		
No Plaque	62	77.5
Type I: Thin rim, anechoic	8	10
Type II: <25% echogenic	4	5
Type III: <25% hypoechoic	4	5
Type IV: Predominantly echogenic	2	2.5

Plaque assessment showed that 77.5% (n = 62) had no detectable plaque. Type I plaques (thin rim, anechoic) were observed in 10% (n = 8), Type II (<25% echogenic) and Type III (<25% hypoechoic) each in 5% (n = 4), and Type IV (predominantly echogenic) in 2.5% (n = 2) of participants (Table 4).

Table 5: Correlation between CIMT and Risk Factors

	Correlation Coefficient	P-value
CIMT		
BMI	0.313	0.005
Waist Hip Ratio	0.672	< 0.0001
Hb1AC	0.664	< 0.001
Total Cholesterol	0.413	0.003

Statistical analysis showed significant positive correlations between CIMT and multiple risk factors. CIMT was significantly correlated with BMI ($r = 0.313$, $p = 0.005$), waist-to-hip ratio ($r = 0.672$, $p < 0.0001$), HbA1c ($r = 0.664$, $p < 0.001$), and total cholesterol ($r = 0.413$, $p = 0.003$). These findings suggest that poorer glycaemic control and adverse anthropometric profiles are associated with increased CIMT (Table 5).

Discussion

The present study demonstrated significant correlations between carotid intima-media thickness (CIMT) and various metabolic parameters, including body mass index (BMI), waist-to-hip ratio (WHR), glycated hemoglobin (HbA1c), and total cholesterol. These findings suggest that adiposity, glycaemic control, and lipid metabolism play crucial roles in the progression of early atherosclerosis in patients with Type 2 Diabetes Mellitus (T2DM).

Among all the variables analyzed, waist-to-hip ratio (WHR) exhibited the strongest correlation with CIMT on both the right ($r = 0.692$, $p < 0.0001$) and left ($r = 0.662$, $p < 0.0001$) sides, indicating that central obesity is the most significant determinant of vascular thickening in this population. This strong positive correlation underscores the impact of visceral fat accumulation on vascular health, suggesting that individuals with higher WHR are at a greater risk of developing atherosclerotic changes.

Glycated hemoglobin (HbA1c) also showed a strong positive correlation with CIMT, particularly on the left side ($r = 0.783$, $p < 0.001$), compared to the right side ($r = 0.639$, $p < 0.001$). This suggests that poor long-term glycaemic control significantly contributes to arterial thickening, with higher HbA1c levels being strongly associated with increased CIMT.

Total cholesterol demonstrated a moderate correlation with CIMT, with a stronger association on the right side ($r = 0.391$, $p = 0.003$) compared to the left side ($r = 0.213$, $p = 0.013$). This suggests that dyslipidaemia plays a significant role in vascular remodeling, although its influence on CIMT appears to be weaker than that of WHR and HbA1c.

BMI exhibited the weakest correlation with CIMT in this study, with $r = 0.311$ ($p = 0.005$) for the right side and $r = 0.309$ ($p = 0.005$) for the left side. While BMI is widely used as an indicator of general obesity, its relatively weaker association with CIMT suggests that central adiposity (WHR) may be a more relevant marker for predicting vascular thickening than overall body weight.

These results align with findings from previous studies. Paul et al. reported that diabetic patients with central obesity (high waist circumference) had significantly higher CIMT values (0.90 ± 0.14 mm) compared to those with normal waist circumference (0.70 ± 0.11 mm). Another study found that patients with a waist-to-hip ratio >0.9 (men) and >0.85 (women) had significantly elevated CIMT values (0.88 ± 0.15 mm). These results, along with the present study, support the hypothesis that abdominal obesity is a key contributor to vascular dysfunction and increased atherosclerotic risk in T2DM.[12]

A significant positive correlation was also observed between CIMT and glycated hemoglobin (HbA1c) ($r = 0.639$, $p < 0.001$ for the right side; $r = 0.783$, $p < 0.001$ for the left side), indicating that poor glycaemic control accelerates vascular changes in diabetes. This is consistent with the findings of Gateva et al., who reported that CIMT correlated significantly with fasting blood glucose levels and was a strong predictor of diabetes progression and cardiovascular risk[13]. Furthermore, Brohall and Odén demonstrated that diabetic patients exhibited significantly higher CIMT than non-diabetics, suggesting that hyperglycaemia plays a direct role in vascular remodeling.[14]

Fusaro et al. found that adolescents with Type 1 Diabetes Mellitus exhibited increased CIMT, which was independently associated with total cholesterol levels and systolic blood pressure percentiles, highlighting the impact of lipid metabolism and blood pressure on vascular health[15]. Similarly, Gómez-Marcos et al. reported that diabetics had the greatest CIMT compared to hypertensive patients and controls, emphasizing the need for early cardiovascular risk assessment in this population[16]. Aftab's study also demonstrated a significant positive correlation between CIMT, age, and proteinuria, indicating that older age and renal impairment contribute to increased atherosclerotic risk. Furthermore, Guo et al. found that dyslipidemia and poor glycemic control were positively correlated with increased CIMT in T2DM patients, suggesting a higher risk for atherosclerosis and cardiovascular disease.

This finding aligns with Zhou et al., who found that increased visceral fat area (VFA) was an independent risk factor for CIMT ($OR = 1.364$, $P < 0.05$) in a study of 1,372 T2DM patients in Western China[17]. Their study also identified waist circumference as a major contributor to CIMT

progression, further supporting the present study's results, which demonstrated a stronger association between CIMT and WHR than with BMI. Guo et al. found a similar association in their study, where HbA1c, fasting plasma glucose (FPG), and triglycerides were positively correlated with CIMT ($P < 0.05$)[18]. Additionally, Aftab et al. observed that dyslipidemia, specifically triglycerides and total cholesterol/HDL ratio, correlated positively with CIMT in T2DM patients.[19]
Zhou et al. also found that BMI was a significant but weaker predictor of CIMT (OR = 1.186, $P < 0.05$) compared to visceral fat area (VFA) and smoking[17]. Their study emphasized that VFA rather than BMI is a better marker for early vascular changes, which is consistent with the findings of the present study where WHR exhibited the strongest correlation with CIMT. Furthermore, Zhou et al. identified smoking as the most important risk factor for increased CIMT (OR = 5.759, $P < 0.05$), followed by female sex, waist circumference, and chronic kidney disease (CKD)[17]. While smoking was not assessed in the present study, its role in CIMT progression should be considered in future research. Additionally, the influence of renal function markers on CIMT, as highlighted in Zhou et al., was not analyzed in the present study but represents an important avenue for further investigation.[17]

Conclusion

This study found that Carotid Intima Media Thickness (CIMT) is significantly associated with poor glycaemic control and adverse anthropometric indicators in patients with Type 2 Diabetes Mellitus. Higher BMI, waist-to-hip ratio, HbA1c levels, and total cholesterol were all positively correlated with increased CIMT, indicating early subclinical atherosclerosis. These findings highlight the importance of using CIMT as a non-invasive marker to detect early vascular changes in diabetic patients. Regular CIMT assessment, along with strict control of blood glucose and body composition, may help in timely identification of cardiovascular risk and guide preventive management in this high-risk population.

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