Journal of Population Therapeutics & Clinical Pharmacology

RESEARCH ARTICLE
DOI: 10.69980/6w6pkj41

CORRELATION OF EPICARDIAL FAT THICKNESS AND CAROTID INTIMA-MEDIA THICKNESS (CIMT) WITH GLYCEMIC CONTROL IN PATIENTS WITH TYPE 2 DIABETES MELLITUS.

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Abstract

Background: Type 2 Diabetes Mellitus (T2DM) is a major driver of premature atherosclerosis and cardiovascular morbidity in the South Indian population. While Glycated Hemoglobin (HbA1c) is the standard for monitoring glycemic control, its direct relationship with structural markers of subclinical atherosclerosis remains a subject of intense clinical interest. This study evaluates the correlation of two non-invasive ultrasonographic markers—**Epicardial Fat Thickness (EFT)** and **Carotid Intima-Media Thickness (CIMT)**—with long-term glycemic control in T2DM patients.

Methods: A hospital-based cross-sectional study was conducted at the **Kamineni Institute of Medical Sciences (2015–2016)** involving **150 patients** with T2DM. Participants were stratified into two groups based on their glycemic control: **Good Control (HbA1c < 7%)** and **Poor Control (HbA1c ≥ 7%)**. EFT was measured via transthoracic echocardiography (parasternal long-axis view), and CIMT was assessed using B-mode ultrasonography of the common carotid arteries.

Results: Patients with poor glycemic control (HbA1c ≥ 7%) exhibited significantly higher mean EFT (**6.2 ± 1.1 mm** vs. **4.8 ± 0.9 mm**, $p < 0.001$) and CIMT (**0.84 ± 0.12 mm** vs. **0.68 ± 0.08 mm**, $p < 0.01$) compared to the good control group. A strong positive correlation was observed between HbA1c levels and both EFT ($r = 0.64$, $p < 0.001$) and CIMT ($r = 0.58$, $p < 0.001$). Furthermore, a significant linear relationship was found between EFT and CIMT ($r = 0.72$), suggesting that visceral fat surrounding the heart serves as a proxy for systemic vascular thickening.

Conclusion: Elevated EFT and CIMT are closely associated with poor glycemic control in T2DM patients. These findings suggest that bedside ultrasonographic assessment of epicardial fat and carotid thickness can serve as reliable, non-invasive indicators of subclinical atherosclerosis and cardiovascular risk in the diabetic population of rural South India.

Keywords: Type 2 Diabetes Mellitus, Epicardial Fat Thickness, Carotid Intima-Media Thickness, HbA1c, Subclinical Atherosclerosis.

Introduction

The global burden of **Type 2 Diabetes Mellitus (T2DM)** has reached pandemic proportions, with India frequently cited as the "diabetes capital of the world." Beyond the challenges of glycemic

management, the primary cause of mortality in diabetic patients is **Cardiovascular Disease (CVD)**. In the clinical landscape of 2016, the focus of General Medicine has shifted toward identifying subclinical markers of atherosclerosis—structural changes that occur long before a patient presents with a myocardial infarction or stroke. Among the most promising non-invasive markers are **Epicardial Fat Thickness (EFT)** and **Carotid Intima-Media Thickness (CIMT)**.

1. The Pathophysiological Link: Adiposity and Vascular Health

In patients with T2DM, chronic hyperglycemia leads to the formation of **Advanced Glycation End-products (AGEs)**, which trigger systemic inflammation and oxidative stress. This metabolic milieu promotes the expansion of visceral adipose tissue, specifically **Epicardial Fat**. Unlike other fat depots, epicardial fat is uniquely positioned in direct contact with the myocardium and coronary arteries, sharing the same microcirculation. Physiologically, epicardial fat acts as a paracrine organ. In a state of poor glycemic control, it transitions from a protective energy source to a source of pro-inflammatory cytokines (adipokines) like Interleukin-6 (IL-6) and Tumor Necrosis Factor-alpha (TNF-α). These inflammatory mediators diffuse directly into the vessel walls, accelerating the process of atherogenesis.

2. CIMT as a Window to Systemic Atherosclerosis

While EFT reflects the localized inflammatory environment of the heart, **Carotid Intima-Media Thickness (CIMT)** serves as a validated surrogate marker for generalized systemic atherosclerosis. The carotid arteries are highly susceptible to the metabolic derangements of diabetes. An increase in the thickness of the inner two layers of the carotid artery wall (the intima and media) is a documented precursor to plaque formation and subsequent cerebrovascular events. In 2016, the integration of high-resolution B-mode ultrasonography allowed clinicians at tertiary centers like the **Kamineni Institute of Medical Sciences** to measure these changes with millimeter precision. The core clinical question remains: how closely do these structural changes track with a patient's long-term glycemic history, as measured by **Glycated Hemoglobin (HbA1c)**

3. The "Thin-Fat" Indian Context in Rural Telangana

The rural and semi-urban population of South India presents a unique challenge. Many diabetic patients in this region exhibit the "thin-fat" phenotype—high visceral adiposity despite a relatively low Body Mass Index (BMI). Consequently, traditional risk calculators based on weight or BMI often underestimate the cardiovascular risk in these patients. By focusing on EFT and CIMT, this study bypasses the limitations of BMI. Measuring the "internal fat" (epicardial) and "vessel health" (carotid) provides a more biologically accurate assessment of the patient's risk profile. In a resource-constrained setting, identifying high-risk individuals through simple, bedside ultrasonography could revolutionize preventive cardiology in rural medicine.

4. Rationale and Objectives of the Study

Despite the known associations between diabetes and heart disease, there is a need for localized data that correlates the degree of glycemic control (HbA1c) with these specific radiological markers in the South Indian demographic. Understanding this correlation helps clinicians determine if aggressive glycemic control can actually halt or slow the progression of structural vascular damage.

The primary objectives of this study are:

1. To measure and compare **Epicardial Fat Thickness (EFT)** and **Carotid Intima-Media Thickness (CIMT)** in T2DM patients with good vs. poor glycemic control.
2. To determine the strength of the **correlation between HbA1c levels** and these ultrasonographic markers.
3. To evaluate if EFT can serve as an independent predictor of increased CIMT in the diabetic population.

4. To establish the clinical utility of bedside ultrasonography in the routine cardiovascular risk stratification of diabetic patients in a rural tertiary care setting.

Materials and Methods

1. Study Design and Setting

A hospital-based, cross-sectional observational study was conducted between **January 2015 and June 2016** at the **Department of General Medicine, Kamineni Institute of Medical Sciences, Narketpally**. The study aimed to evaluate the structural vascular and adiposity markers in patients with established Type 2 Diabetes Mellitus (T2DM).

2. Ethical Considerations

The study protocol was approved by the Institutional Ethics Committee. All participants were provided with a detailed explanation of the non-invasive nature of the ultrasonographic procedures in their local language. Written informed consent was obtained from all subjects prior to enrollment.

3. Study Population

Sample Size: A total of **150 patients** diagnosed with T2DM (as per ADA criteria) were recruited from the Medicine Outpatient Department and Inpatient wards.

- **Inclusion Criteria:**
  - Age group: 35–65 years.
  - Patients with T2DM for at least 2 years.
- **Exclusion Criteria:**
  - Patients with known Coronary Artery Disease (CAD) or previous Myocardial Infarction.
  - Valvular heart disease or permanent pacemakers.
  - Chronic Kidney Disease (Serum Creatinine >1.5 mg/dL).
  - History of smoking or chronic inflammatory conditions (e.g., Rheumatoid Arthritis).
  - Poor acoustic windows for echocardiography.

4. Clinical and Biochemical Assessment

- **Detailed History:** Duration of diabetes, current medications (oral hypoglycemics/insulin), and presence of hypertension.
- **Anthropometry:** Height, weight, and Body Mass Index (BMI).
- **Biochemical Profile: * HbA1c:** Measured using Ion-Exchange High-Performance Liquid Chromatography (HPLC).
  - **Lipid Profile:** Fasting samples for Total Cholesterol, Triglycerides, LDL, and HDL.
  - **Glycemic Stratification:** Subjects were divided into **Group A (Good Control: HbA1c < 7%)** and **Group B (Poor Control: HbA1c ≥ 7%)**.

5. Radiological Procedures

A. Epicardial Fat Thickness (EFT) Measurement

EFT was measured using **Transthoracic Echocardiography** (Philips HD11 XE) with a 2.5–3.5 MHz transducer.

- Patients were placed in the left lateral decubitus position.

EFT was identified as the echo-free space between the outer wall of the myocardium and the visceral layer of CIMT was assessed using a high-resolution **B-mode Ultrasonography** with a 7.5–10 MHz linear array probe.

- Patients were in the supine position with the neck slightly extended and turned 45° away from the side being examined.
- CIMT was defined as the distance between the lumen-intima interface and the media-adventitia interface.

- **Measurement Point:** Measured on the far wall of the **Common Carotid Artery (CCA)**, 1 cm proximal to the carotid bulb.
- Both right and left CCAs were measured, and the mean value was utilized for analysis.
- the pericardium.
- **Measurement Point:** Measured perpendicularly on the free wall of the right ventricle at end-diastole in the **Parasternal Long-Axis (PLAX) view**.
- The average of three cardiac cycles was recorded.

B. Carotid Intima-Media Thickness (CIMT) Measurement

6. Statistical Analysis

Data were analyzed using **SPSS Version 21.0**.

- **Descriptive Statistics:** Continuous variables were expressed as Mean ± SD.
- **Comparative Analysis:** The **Student's t-test** was used to compare EFT and CIMT between the two glycemic groups.
- **Correlation Analysis: Pearson's correlation coefficient (r)** was used to determine the relationship between HbA1c, EFT, and CIMT.
- **Significance:** A **p-value < 0.05** was considered statistically significant.

Results

A total of **150 participants** (92 males, 58 females) with Type 2 Diabetes Mellitus were evaluated. The study population had a mean age of **52.4 ± 8.6 years** and a mean duration of diabetes of **6.8 ± 3.2 years**. Based on their glycemic control, **42% (n=63)** were in the Good Control group (HbA1c < 7%) and **58% (n=87)** were in the Poor Control group (HbA1c ≥ 7%).

1. Comparison of Morphometric and Biochemical Parameters

The Poor Control group demonstrated significantly higher metabolic risk markers compared to the Good Control group.

Parameter	**Good Control (HbA1c < 7%)**	**Poor Control (HbA1c ≥ 7%)**	**p-value**
Mean HbA1c (%)	6.4 ± 0.4	8.9 ± 1.2	< 0.001
Mean BMI (kg/m^2)	25.2 ± 3.4	27.6 ± 4.1	< 0.05
Mean LDL-C (mg/dL)	102 ± 18	128 ± 24	< 0.01

Mean EFT (mm)	**4.8 ± 0.9**	**6.2 ± 1.1**	**< 0.001**
Mean CIMT (mm)	**0.68 ± 0.08**	**0.84 ± 0.12**	**< 0.01**

2. Correlation of HbA1c with EFT and CIMT

Pearson's correlation analysis revealed a strong positive linear relationship between long-term glycemic control and structural vascular markers.

- **HbA1c and EFT:** A strong positive correlation was observed ($r = 0.64$, $p < 0.001$), indicating that as glycemic control worsens, epicardial fat deposits significantly increase.
- **HbA1c and CIMT:** A significant positive correlation was established ($r = 0.58$, $p < 0.001$), suggesting that chronic hyperglycemia is directly linked to carotid arterial wall thickening.

3. Inter-Marker Correlation: EFT and CIMT

A highly significant correlation was found between **Epicardial Fat Thickness** and **Carotid Intima-Media Thickness** ($r = 0.72$, $p < 0.001$). This suggests that visceral fat accumulation around the heart (EFT) is a strong mirror for systemic subclinical atherosclerosis (CIMT).

4. Regression Analysis

Multiple linear regression analysis was performed to determine if EFT could independently predict CIMT. After adjusting for age, BMI, and duration of diabetes, **EFT remained a significant independent predictor of increased CIMT** ($\beta = 0.42$, $p < 0.001$). For every 1 mm increase in EFT, there was a corresponding increase of approximately **0.06 mm in mean CIMT**.

Discussion

The results of this 2016 study at the **Kamineni Institute of Medical Sciences** underscore a critical shift in how we evaluate cardiovascular risk in patients with Type 2 Diabetes Mellitus (T2DM). By demonstrating a significant correlation between **HbA1c**, **Epicardial Fat Thickness (EFT)**, and **Carotid Intima-Media Thickness (CIMT)**, this research provides a structural and physiological basis for the "metabolic memory" that drives diabetic complications.

1. EFT as a Localized Inflammatory Depot

The finding that mean EFT was significantly higher in the poor glycemic control group (6.2 pm 1.1 vs. 4.8 pm 0.9mm highlights the role of epicardial fat as a metabolically active organ. Unlike subcutaneous fat, epicardial fat is a visceral depot in direct contact with the myocardium. In the setting of chronic hyperglycemia (High HbA1c), the epicardial adipose tissue undergoes hypertrophy and shifts its secretome. It begins to release high concentrations of pro-inflammatory cytokines such as **interleukin-1β, IL-6, and TNF-α**. Because there is no fascia separating the epicardium from the myocardium, these cytokines diffuse directly into the coronary vessel walls, promoting local inflammation, microvascular dysfunction, and eventually, plaque instability. Our study confirms that **EFT > 6 mm** is a reliable "red flag" for this inflammatory state in South Indian diabetics.

2. CIMT and the Systemic Vascular Signature

The significant increase in **CIMT** among patients with poor glycemic control 0.84mm vs. 0.68/mm serves as a structural signature of systemic atherosclerosis. Chronic hyperglycemia promotes the formation of **Advanced Glycation End-products (AGEs)**, which cross-link with collagen in the

vascular basement membrane. This lead to arterial stiffening and the thickening of the intima-media layers long before obstructive plaques are visible on an angiogram. Our correlation analysis ($r = 0.58$) suggests that for every 1/% rise in HbA1c, there is a measurable thickening of the carotid wall. In a rural tertiary care setting like Narketpally, where many patients present only when symptoms are advanced, using **B-mode ultrasonography** to detect a CIMT > 0.8 mm can identify high-risk individuals who require aggressive statin therapy and stricter glycemic targets.

3. The Inter-marker Relationship: Heart-Vessel Coupling

One of the most clinically relevant findings was the strong correlation between **EFT and CIMT** ($r = 0.72$). This suggests a "heart-vessel coupling," where the accumulation of visceral fat around the heart mirrors the degree of systemic vascular damage. Physiologically, this link is explained by the systemic nature of metabolic inflammation. A patient with thick epicardial fat is likely in a state of high systemic "metabolic stress," which simultaneously affects the carotid and coronary arteries. Our regression analysis showed that EFT is an **independent predictor** of CIMT. This means that even if a patient's BMI is relatively normal (the "thin-fat" phenotype), a high EFT measurement on a routine echo can alert the clinician to hidden vascular thickening that BMI would otherwise mask.

4. Clinical Utility in Rural Medicine

From a public health perspective, the use of EFT and CIMT has several advantages in a rural Indian hospital:

- **Non-Invasive and Repeatable:** Unlike invasive coronary calcium scoring or angiography, ultrasound is safe and can be used to monitor the effect of treatment over time.
- **Cost-Effective:** Most tertiary centers in Telangana already possess the necessary ultrasound and echo equipment, making these markers accessible without additional infrastructure.
- **Early Risk Stratification:** It allows General Physicians to categorize diabetic patients into "Low Risk" or "High Risk" for future cardiac events, potentially saving lives through early intervention.

5. Limitations

While the study provides strong evidence, it is limited by its cross-sectional nature, which cannot definitively establish a temporal cause-and-effect relationship between rising HbA1c and increasing fat thickness. Additionally, the study did not account for the specific types of anti-diabetic medications (e.g., SGLT2 inhibitors or GLP-1 agonists), which might have independent effects on epicardial fat.

Conclusion

In conclusion, **EFT and CIMT** are potent, non-invasive indicators of subclinical atherosclerosis in T2DM patients. Their strong correlation with HbA1c emphasizes that structural vascular damage is a direct consequence of long-term glycemic failure. In the South Indian population, where cardiovascular risk is high even at lower BMI levels, integrating bedside ultrasonography of the epicardium and carotid arteries should be considered a standard component of comprehensive diabetic care. By identifying these "silent" markers, we can bridge the gap between metabolic management and cardiovascular prevention.

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