Section: General Medicine

Original Research Article

ASSOCIATION BETWEEN ULTRASONOGRAPHIC VISCERAL FAT THICKNESS AND LIPID PROFILE FOR EVALUATION OF CARDIOVASCULAR RISK IN TYPE 2 DIABETES MELLITUS PATIENTS

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ABSTRACT

Background: Type 2 diabetes mellitus (T2DM) is closely associated with visceral adiposity, dyslipidemia, and cardiovascular risk. Ultrasonographic measurement of visceral fat thickness (VFT) offers a non-invasive tool to assess cardiovascular risk factors in T2DM patients. To evaluate the association between ultrasonographic VFT and lipid profile parameters and to explore its potential role in predicting cardiovascular risk in patients with T2DM.

Materials and Methods: This observational study included 50 T2DM patients aged above 30 years with BMI >25 kg/m². Clinical assessments included anthropometry, lipid profile, renal parameters, blood sugar levels, and ultrasonographic measurement of VFT. Correlations between VFT and biochemical parameters were analyzed statistically. Participants were stratified into three VFT groups: <5.5 cm, 5.5–6.5 cm, and >6.5 cm.

Results: The mean VFT was 6.11 ± 0.97 cm. VFT positively correlated with total cholesterol (r=0.95, *p*=0.0001), triglycerides (r=0.97, *p*=0.0001), LDL (r=0.93, *p*=0.0001), and VLDL (r=0.92, *p*=0.0001), and negatively correlated with HDL (r=–0.94, *p*=0.0001). Patients with VFT >6.5 cm had significantly worse lipid profiles compared to those with lower VFT. A significant association was also observed between higher VFT and the presence of microalbuminuria (*p*=0.0001). Blood sugar parameters varied across VFT categories but were not statistically significant.

Conclusion: Increased VFT measured by ultrasonography strongly correlates with dyslipidemia and microalbuminuria in T2DM patients, suggesting its utility as a surrogate marker for cardiovascular risk stratification.

Keywords: Type 2 Diabetes Mellitus, Visceral Fat Thickness, Ultrasonography, Lipid Profile, Cardiovascular Risk, Dyslipidemia, Microalbuminuria.

INTRODUCTION

Type 2 diabetes mellitus (T2DM) is a chronic metabolic disorder characterized by hyperglycemia resulting from insulin resistance and/or impaired insulin secretion. The global burden of T2DM is rapidly escalating, with projections estimating that nearly 700 million individuals will be affected by 2045.[1] India, in particular, bears a significant share

of this epidemic and is often referred to as the "diabetes capital of the world".[1] The morbidity and mortality associated with T2DM are predominantly linked to cardiovascular complications, which remain the leading cause of death among diabetic individuals.[2]

Visceral adiposity plays a critical role in the pathogenesis of cardiovascular disease (CVD) in T2DM. Unlike subcutaneous fat, visceral fat acts as a metabolically active endocrine organ, secreting pro-inflammatory cytokines, adipokines, and free fatty acids that contribute to insulin resistance, dyslipidemia, endothelial dysfunction, and atherogenesis.[2,3] Accumulation of visceral fat is therefore directly correlated with increased cardiometabolic risk, independent of body mass index (BMI).[3]

Although computed tomography (CT) and magnetic resonance imaging (MRI) are considered gold standards for assessing visceral adipose tissue, their clinical application is limited by high cost, radiation exposure, and limited accessibility.[4,5] Ultrasonography has emerged as a simple, safe, non-invasive, and cost-effective alternative for measuring visceral fat thickness (VFT).[4] Studies have demonstrated that ultrasonographic measurement of VFT not only effectively estimates visceral obesity but also predicts cardiovascular and metabolic disease risk.[4,6]

Despite growing evidence linking visceral adiposity with adverse metabolic profiles, limited studies have explored the relationship between ultrasonographically measured VFT and cardiovascular risk markers specifically in Indian T2DM patients. Therefore, this study aims to evaluate the association between VFT and lipid profiles and to assess its potential as a surrogate marker for cardiovascular risk stratification in patients with Type 2 Diabetes Mellitus.

MATERIALS AND METHODS

Study Design and Setting

This observational, cross-sectional study was conducted in the Department of General Medicine at Maharajah's Institute of Medical Sciences (MIMS), Nellimarla, Vizianagaram, Andhra Pradesh. The study period spanned 18 months, from January 2023 to June 2024.

Study Population

A total of 50 patients with a confirmed diagnosis of Type 2 Diabetes Mellitus (T2DM) were enrolled. Eligible participants were aged over 30 years and had a body mass index (BMI) greater than 25 kg/m².

Inclusion Criteria

Patients diagnosed with Type 2 Diabetes Mellitus.
Age >30 years, of either sex.
BMI >25 kg/m².
Presence of dyslipidemia.

Exclusion Criteria

Pregnant women.
Patients with hypothyroidism, hypertension, or renal failure.
Smokers and alcoholics.
Patients receiving thiazolidinedione therapy.

Data Collection

A detailed clinical evaluation was performed for all participants, including medical history, measurement of blood pressure, weight, height, waist circumference, and hip circumference. Waist-to-hip ratio (WHR) was calculated, and a WHR ≥0.90 in males and ≥0.80 in females was considered significant.

Biochemical Investigations

Lipid Profile: Total cholesterol, triglycerides (TGL), high-density lipoprotein (HDL), low-density lipoprotein (LDL), and very-low-density lipoprotein (VLDL) were measured in a fasting state using enzymatic methods (Zak's method).

Blood Sugar Parameters: Fasting blood sugar (FBS), postprandial blood sugar (PPBS), and random blood sugar (RBS) levels were recorded.

Renal Function Tests: Serum creatinine and blood urea levels were analyzed.

Microalbuminuria: Presence of microalbuminuria was noted.

Measurement of Visceral Fat Thickness

Visceral fat thickness (VFT) was measured using ultrasonography.

Patients were examined in a fasting state after bowel preparation.

In the supine position, with full expiration, a 3.5–5 MHz convex probe was placed along the midline, 5 cm above the umbilicus.

VFT was defined as the distance between the posterior wall of the rectus abdominis muscle and the anterior wall of the aorta.

Three measurements were taken for each patient, and the mean value was recorded to ensure accuracy.

Statistical Analysis

All collected data were tabulated and analyzed using appropriate statistical software. The chi-square test was employed to assess categorical variables. Pearson's correlation coefficient was used to determine relationships between VFT and biochemical parameters. A *p*-value of less than 0.05 was considered statistically significant.

Ethical Considerations

Informed written consent was obtained from all participants prior to enrollment. Institutional Ethics Committee approval was secured before the initiation of the study. Participant confidentiality was strictly maintained.

RESULTS

The present observational study included 50 patients diagnosed with Type 2 Diabetes Mellitus (T2DM) who were assessed for the association between visceral fat thickness (VFT), lipid profiles, glycemic status, and renal parameters.

Demographic and Anthropometric Characteristics

Among the participants, the predominant age group was 51–60 years, accounting for 36% of the study population. Males represented a slightly higher proportion (56%) compared to females (44%). The majority of the individuals (64%) were overweight (BMI 25–29.9), followed by 26% in the obesity class I category (BMI 30–34.9), and 10% with BMI >35. The mean BMI was 29.59 ± 3.65 kg/m² (Table 1).

Distribution of Visceral Fat Thickness

The mean VFT was 6.11 ± 0.97 cm. VFT was categorized into three groups: <5.5 cm (38%), 5.5–6.5 cm (36%), and >6.5 cm (26%) (Table 2).

Association Between VFT and Lipid Profile

Statistical analysis revealed strong and significant positive correlations between VFT and several lipid parameters: total cholesterol (r = 0.95, p = 0.0001), triglycerides (TGL) (r = 0.97, p = 0.0001), LDL (r = 0.93, p = 0.0001), and VLDL (r = 0.92, p = 0.0001). Conversely, a significant inverse correlation was found between VFT and HDL levels (r = –0.94, p = 0.0001) (Table 3).

Further stratification of lipid profile by VFT categories demonstrated that individuals with VFT >6.5 cm had markedly elevated lipid levels. Total cholesterol increased from 193.05 ± 7.81 mg/dL in the <5.5 cm group to 240.84 ± 4.33 mg/dL in the >6.5 cm group (p = 0.0001). Similar trends were observed for LDL (127.15 ± 10.06 to 174.53 ± 3.47 mg/dL), VLDL (24.68 ± 3.07 to 38.15 ± 1.34 mg/dL), and TGL (127.84 ± 5.57 to 182.53 ± 8.33 mg/dL), while HDL decreased significantly across categories (p < 0.0001 for all) (Table 6).

Glycemic Parameters

The mean fasting blood sugar (FBS), postprandial blood sugar (PPBS), and random blood sugar (RBS) levels were 129.52 ± 11.32 mg/dL, 248.84 ± 56.71 mg/dL, and 215.96 ± 42.81 mg/dL respectively (Table 4). Stratified analysis showed minor variations across VFT groups; however, these differences were not statistically significant (Table 7).

Renal Function and Microalbuminuria

The mean serum creatinine and blood urea values were 0.88 ± 0.06 mg/dL and 27.46 ± 4.69 mg/dL, respectively (Table 5). Participants with microalbuminuria (n = 12) exhibited significantly higher VFT (7.05 ± 0.83 cm) compared to those without microalbuminuria (5.80 ± 0.81 cm), with a p-value of 0.0001. A similar significant increase was observed in BMI among microalbuminuric subjects (33.16 ± 4.60 vs. 28.46 ± 2.42; p = 0.0001).

When renal function was examined across VFT categories, no significant variations were noted in serum creatinine or blood urea levels, which remained relatively consistent (Table 8).

Table 1: Demographic and Anthropometric Characteristics of Participants (N = 50)

Parameter	Value
Age group (51–60 years)	36%
Gender – Male	56%
Gender – Female	44%
BMI 25–29.9 (Overweight)	64%
BMI 30–34.9 (Obesity Class I)	26%
BMI >35 (Obesity Class II)	10%
Mean BMI	29.59 ± 3.65 kg/m²

Table 2: Visceral Fat Thickness (VFT) Distribution

VFT Category (cm)	Frequency (%)	Mean VFT ± SD
<5.5	38%	-
5.5 – 6.5	36%	-
>6.5	26%	6.11 ± 0.97 cm

Table 3: Correlation Between VFT and Lipid Profile Parameters

Lipid Parameter	Correlation Coefficient (r)	p-value
Total Cholesterol	0.95	0.0001
Triglycerides (TGL)	0.97	0.0001
Low-Density Lipoprotein (LDL)	0.93	0.0001
Very Low-Density Lipoprotein (VLDL)	0.92	0.0001
High-Density Lipoprotein (HDL)	–0.94	0.0001

Table 4: Blood Sugar Parameters (Mean ± SD)

Blood Sugar Parameter	Mean ± SD (mg/dL)
Fasting Blood Sugar (FBS)	129.52 ± 11.32
Postprandial Blood Sugar (PPBS)	248.84 ± 56.71
Random Blood Sugar (RBS)	215.96 ± 42.81

Table 5: Renal Function and Microalbuminuria

Parameter	Mean ± SD
Serum Creatinine	0.88 ± 0.06 mg/dL
Blood Urea	27.46 ± 4.69 mg/dL
VFT with Microalbuminuria	7.05 ± 0.83 cm

VFT without Microalbuminuria	5.80 ± 0.81 cm
BMI with Microalbuminuria	33.16 ± 4.60
BMI without Microalbuminuria	28.46 ± 2.42

Table 6: Lipid Profile Parameters Stratified by VFT Category

Lipid Parameter	<5.5 cm	5.5–6.5 cm	>6.5 cm	p-value
Total Cholesterol	193.05 ± 7.81	221.05 ± 7.90	240.84 ± 4.33	0.0001
HDL	45.47 ± 2.01	40.55 ± 1.09	37.01 ± 1.29	0.0001
LDL	127.15 ± 10.06	155.44 ± 6.33	174.53 ± 3.47	0.0001
VLDL	24.68 ± 3.07	33.22 ± 1.86	38.15 ± 1.34	0.0001
Triglycerides (TGL)	127.84 ± 5.57	153.27 ± 10.27	182.53 ± 8.33	0.0001

Table 7: Blood Sugar Levels Stratified by VFT Category
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Table 8: Renal Function Parameters Stratified by VFT Category

Parameter	<5.5 cm	5.5–6.5 cm	>6.5 cm
Serum Creatinine (mg/dL)	0.88 ± 0.05	0.88 ± 0.065	0.89 ± 0.06
Blood Urea (mg/dL)	27.21 ± 4.80	28.22 ± 5.00	26.76 ± 4.28

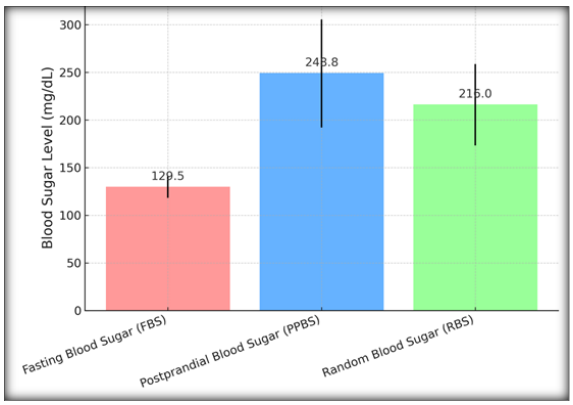

Figure 1: Blood Sugar Parameters (Mean ±SD)

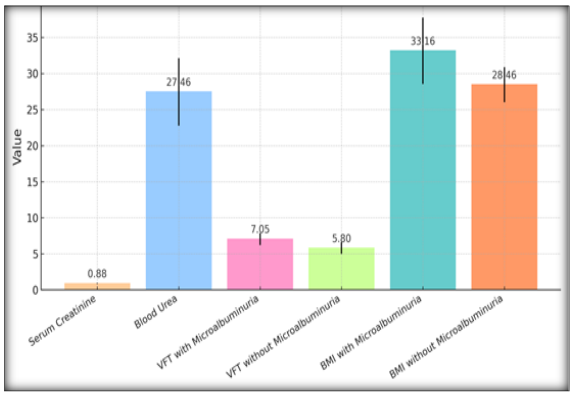

Figure 2: Renal Function and Microalbuminuria (Mean ±SD)

DISCUSSION

The present study explored the association between ultrasonographically measured visceral fat thickness (VFT) and lipid profile parameters in patients with Type 2 Diabetes Mellitus (T2DM). The findings demonstrate that increased VFT is significantly associated with dyslipidemia and microalbuminuria, suggesting a strong linkage between visceral adiposity and cardiovascular risk among diabetic individuals.

In this study, the mean VFT was 6.11 ± 0.97 cm. Stratification of patients based on VFT revealed a progressive worsening of lipid profile parameters with increasing visceral fat thickness. Patients with higher VFT values exhibited significantly elevated levels of total cholesterol, LDL, VLDL, and triglycerides, while HDL levels were markedly reduced. These observations are consistent with earlier findings where ultrasonographic measurement of visceral adiposity was shown to predict metabolic disturbances and early cardiovascular risk even in non-obese populations.[7,8]

The strong positive correlations observed between VFT and total cholesterol, triglycerides, LDL, and VLDL reaffirm that visceral fat acts as a metabolically active organ, releasing free fatty acids and pro-inflammatory cytokines that contribute to dyslipidemia.[9] Conversely, the significant inverse relationship between VFT and HDL levels further highlights the detrimental metabolic effects of increased visceral adiposity.[9,10]

Although variations in blood sugar levels were noted across different VFT categories, these differences were not statistically significant. This suggests that while visceral fat accumulation strongly influences lipid metabolism, its direct effect on glycemic control may be influenced by additional factors such as pharmacotherapy and insulin sensitivity.[11]

Renal function, assessed through serum creatinine and blood urea levels, remained relatively stable across different VFT groups. However, a significant association was identified between increased VFT and the presence of microalbuminuria, indicating that higher visceral fat burden may contribute to early renal endothelial dysfunction. Previous research has also linked visceral adiposity to early renal changes and microvascular complications in diabetic and hypertensive patients.[12]

Moreover, studies have emphasized that visceral fat accumulation has a stronger association with arterial stiffness and cardiac remodeling compared to

subcutaneous fat.[10] Mao et al. found that visceral fat was more strongly associated with arterial stiffness than abdominal subcutaneous fat area in Chinese patients with T2DM,[10] while Wang et al. demonstrated a relationship between metabolic visceral fat scores and left ventricular hypertrophy in diabetics.[9]

Strengths and Limitations

A key strength of this study is the use of ultrasonography for visceral fat assessment, offering a safe, cost-effective, and widely accessible method without radiation exposure. However, the study's relatively small sample size and cross-sectional nature limit the ability to infer causality. Further large-scale prospective studies are warranted to validate these observations and determine whether interventions aimed at reducing visceral adiposity translate into improved clinical outcomes.

CONCLUSION

This study highlights a strong association between increased ultrasonographic visceral fat thickness (VFT) and adverse lipid profiles, as well as the presence of microalbuminuria in patients with Type 2 Diabetes Mellitus. Elevated VFT correlated positively with total cholesterol, LDL, VLDL, triglycerides, and negatively with HDL, suggesting that visceral adiposity plays a critical role in enhancing cardiovascular risk. The findings support the utility of VFT as a simple, non-invasive marker for early identification of high-risk individuals. Incorporating VFT measurement into routine clinical assessment for diabetic patients could aid in timely interventions, improving long-term metabolic and cardiovascular outcomes. Further prospective studies are needed to validate these observations.

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