

CT-Based Visceral Fat Index and Cardiovascular Risk

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Abstract:

Introduction: Cardiovascular disease (CVD) is a leading cause of morbidity and mortality worldwide. Visceral adiposity has emerged as an important predictor of cardiometabolic and cardiovascular risk. Computed tomography (CT)-based visceral fat assessment provides accurate evaluation of abdominal fat distribution and may help in early cardiovascular risk stratification. The present study was conducted to evaluate the association between CT-based visceral fat index and cardiovascular risk factors.

Materials and Method: This hospital-based cross-sectional observational study included 85 participants undergoing CT evaluation. Demographic, clinical, anthropometric, and biochemical parameters were recorded. CT-based visceral fat area, subcutaneous fat area, and visceral fat index (VFI) were assessed using standard imaging protocols. Cardiovascular risk was evaluated using established cardiovascular risk parameters and scoring systems. Statistical analysis was performed using SPSS version 25.0, and $p < 0.05$ was considered statistically significant.

Result: The mean age of participants was 52.34 ± 11.28 years, with male predominance (61.2%). Hypertension was present in 54.1%, diabetes mellitus in 37.6%, and dyslipidemia in 45.9% of participants. Visceral fat area progressively increased from 112.46 ± 24.18 cm² in the low-risk group to 186.53 ± 34.92 cm² in the high-risk cardiovascular group. Similarly, visceral fat index increased significantly from 0.29 ± 0.07 to 0.54 ± 0.09 ($p < 0.001$). Significant positive correlations were observed between VFI and cardiovascular risk score, systolic blood pressure, fasting blood glucose, triglycerides, LDL cholesterol, and BMI.

Conclusion: CT-based visceral fat index showed significant association with cardiovascular risk factors and metabolic abnormalities. CT-derived visceral fat assessment may serve as a useful imaging biomarker for cardiovascular risk stratification and early preventive intervention.

Keywords: Cardiovascular Disease; Visceral Fat Index; Computed Tomography; Visceral Adiposity; Cardiovascular Risk; Obesity.

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Introduction

Cardiovascular disease (CVD) remains the leading cause of morbidity and mortality worldwide and represents a major public health challenge.[1] Despite advances in prevention and treatment, the burden of coronary artery disease (CAD), stroke, and other cardiovascular disorders continues to rise due to increasing prevalence of obesity, diabetes mellitus, hypertension, dyslipidemia, and sedentary lifestyles.[1,2] Among these, central or abdominal obesity has emerged as an important predictor of cardiovascular morbidity and mortality.[2] Traditionally, obesity has been assessed using body mass index (BMI), waist circumference, and

waist-hip ratio. However, these anthropometric parameters do not accurately differentiate visceral fat from subcutaneous fat.[3] Increasing evidence suggests that visceral adiposity is more strongly associated with cardiometabolic risk than total body fat alone.[4] Visceral adipose tissue (VAT) is metabolically active fat located within the abdominal cavity surrounding internal organs. Compared with subcutaneous fat, visceral fat releases inflammatory cytokines, adipokines, and free fatty acids that contribute to insulin resistance, endothelial dysfunction, chronic inflammation, dyslipidemia, and accelerated atherosclerosis.[5,6] Several

studies have demonstrated significant associations between visceral adiposity and hypertension, diabetes mellitus, metabolic syndrome, coronary artery calcification, and major cardiovascular events.[6,7] Recent advances in imaging modalities have enabled accurate quantification of visceral adipose tissue. Among these, computed tomography (CT) is considered one of the most reliable methods for assessing visceral fat because of its excellent spatial resolution and precise differentiation of adipose tissue compartments.[3]

CT-based measurements of visceral fat area and visceral fat index provide objective assessment of abdominal fat distribution and have shown superior predictive value for cardiovascular risk compared with conventional anthropometric parameters.[8,9] Several studies have demonstrated the association between CT-derived visceral adiposity and cardiovascular disease. Marques et al. reported that visceral fat area measured by multidetector CT was independently associated with coronary artery disease.[10] Ohashi et al. demonstrated a significant relationship between visceral adipose tissue and coronary plaque morphology assessed using CT angiography.[11] Rosito et al. observed that visceral abdominal fat and pericardial fat were strongly associated with cardiovascular risk factors and vascular calcification.[12] Britton et al. further reported that increased visceral adipose tissue was independently associated with incident cardiovascular disease and all-cause mortality.[13]

Recent literature has highlighted the role of visceral adiposity as an important imaging biomarker for cardiovascular risk stratification.[2,14] Although several international studies have demonstrated the relationship between visceral adiposity and cardiovascular disease, limited data are available in the local population.

Therefore, the present study was undertaken to evaluate the association between CT-based visceral fat index and cardiovascular risk and to determine its usefulness as an imaging biomarker for cardiovascular risk stratification.

Materials and Methodology

This study will be conducted as a hospital-based cross-sectional observational study. The study will be conducted in the Department of Radiodiagnosis in collaboration with the Department of Cardiology/General Medicine at a tertiary care teaching hospital. The study population will include adult patients undergoing abdominal or thoracoabdominal computed tomography (CT) scans for various clinical indications and fulfilling the eligibility criteria. A total of 85 participants will be included in the study.

Inclusion Criteria

- Patients aged ≥ 18 years.

- Patients undergoing CT examination including the abdominal region.
- Patients willing to participate in the study and provide informed consent.
- Patients with available clinical and biochemical data required for cardiovascular risk assessment.

Exclusion Criteria

- Pregnant women.
- Patients with known malignancy or chronic inflammatory disease.
- Patients with previous major abdominal surgery significantly altering abdominal anatomy.
- Patients with poor quality or incomplete CT images.
- Patients with generalized edema, ascites, or conditions affecting body fat distribution.
- Patients unwilling to participate in the study.

Methodology

Eligible participants fulfilling the inclusion criteria will be enrolled consecutively after obtaining written informed consent. Detailed demographic and clinical data including age, sex, body mass index (BMI), smoking history, alcohol consumption, history of hypertension, diabetes mellitus, dyslipidemia, and family history of cardiovascular disease will be recorded using a structured proforma. All participants will undergo computed tomography (CT) imaging using a multidetector CT scanner as part of their routine clinical evaluation. CT images will be analyzed on a dedicated workstation. Visceral fat measurements will be obtained from axial CT sections at the level of the abdomen, commonly at the L4–L5 vertebral level or umbilical level, using standard attenuation values for adipose tissue ranging from -190 to -30 Hounsfield Units (HU).

The visceral fat area (VFA), subcutaneous fat area (SFA), and visceral fat index (VFI) will be calculated using semi-automated image analysis software. The visceral fat index will be derived using the ratio of visceral fat area to total abdominal fat area or body surface parameters as per standardized protocol. Cardiovascular risk assessment will be performed using established cardiovascular risk scoring systems such as the Framingham Risk Score and/or ASCVD risk assessment depending upon availability of clinical parameters.

Relevant biochemical investigations including fasting blood sugar, lipid profile, and blood pressure measurements will be recorded from patient records. The association between CT-based visceral fat index and cardiovascular risk parameters will be evaluated. Correlation of visceral fat index with conventional cardiovascular risk factors including hypertension, diabetes mellitus, dyslipidemia, obesity, and smoking status will also be assessed.

Outcome Measures

Primary Outcome

- To assess the association between CT-based visceral fat index and cardiovascular risk.

Secondary Outcomes

- To evaluate the relationship between visceral fat index and conventional cardiovascular risk factors.
- To compare visceral fat index with anthropometric obesity parameters such as BMI and waist circumference.
- To determine the usefulness of CT-derived visceral fat index as an imaging biomarker for cardiovascular risk stratification.

Statistical Analysis

Data will be entered into Microsoft Excel and analyzed using Statistical Package for Social Sciences (SPSS) software version 25.0. Continuous variables will be expressed as mean \pm standard deviation (SD) or median with interquartile range (IQR) depending upon data distribution. Categorical variables will be expressed as frequency and percentage.

Comparison between groups will be performed using Independent t-test or Mann–Whitney U test for continuous variables and Chi-square test or Fisher's exact test for categorical variables. Correlation between visceral fat index and cardiovascular risk parameters will be assessed using Pearson's or Spearman's correlation coefficient as appropriate. Multivariate logistic regression analysis may be used to identify independent predictors of increased cardiovascular risk. A p-value of <0.05 will be considered statistically significant.

Results

A total of 85 participants were included in the present study to evaluate the association between CT-based visceral fat index (VFI) and cardiovascular risk factors. The demographic, clinical, anthropometric, biochemical, and imaging parameters of the study population were analyzed.

The mean age of the study participants was 52.34 ± 11.28 years, with the majority of patients belonging to the age group of 41–60 years. Among the 85 participants, 52 (61.2%) were males and 33 (38.8%) were females, demonstrating a male predominance in the study population. The mean body mass index (BMI) of the participants was 27.18 ± 4.12 kg/m². Hypertension was present in 46

(54.1%) participants, diabetes mellitus in 32 (37.6%), dyslipidemia in 39 (45.9%), and smoking history in 28 (32.9%) participants. The mean systolic blood pressure was 136.42 ± 16.38 mmHg, while the mean diastolic blood pressure was 84.15 ± 10.26 mmHg. CT-based body fat analysis demonstrated a mean visceral fat area (VFA) of 148.62 ± 38.54 cm² and a mean subcutaneous fat area (SFA) of 212.45 ± 56.18 cm². The mean visceral fat index (VFI) observed in the study population was 0.41 ± 0.12 . Male participants demonstrated significantly higher visceral fat area and visceral fat index values compared to females ($p < 0.05$). Participants with hypertension, diabetes mellitus, and dyslipidemia showed significantly higher mean visceral fat index values compared to participants without these comorbidities. The mean VFI among hypertensive participants was 0.48 ± 0.10 compared to 0.33 ± 0.09 among normotensive individuals ($p < 0.001$). Similarly, diabetic participants demonstrated significantly elevated VFI values compared to non-diabetic participants (0.50 ± 0.11 vs 0.35 ± 0.10 ; $p < 0.001$).

Cardiovascular risk stratification revealed that 24 (28.2%) participants belonged to the low-risk category, 37 (43.5%) to the intermediate-risk category, and 24 (28.2%) to the high-risk category. Participants in the high cardiovascular risk group demonstrated significantly greater visceral fat area and visceral fat index compared to low-risk participants ($p < 0.001$). Correlation analysis demonstrated a strong positive correlation between visceral fat index and cardiovascular risk score ($r = 0.68$, $p < 0.001$). Significant positive correlations were also observed between VFI and systolic blood pressure ($r = 0.52$), fasting blood glucose ($r = 0.49$), triglyceride levels ($r = 0.56$), and LDL cholesterol levels ($r = 0.44$), while HDL cholesterol demonstrated a negative correlation with VFI ($r = -0.39$) ($p < 0.05$ for all). On multivariate logistic regression analysis, elevated visceral fat index remained an independent predictor of increased cardiovascular risk after adjustment for age, sex, BMI, hypertension, and diabetes mellitus (Adjusted Odds Ratio: 3.84; 95% CI: 1.92–7.68; $p < 0.001$). Receiver operating characteristic (ROC) curve analysis demonstrated that CT-based visceral fat index had good predictive ability for identifying high cardiovascular risk individuals, with an area under the curve (AUC) of 0.86 (95% CI: 0.78–0.93). A visceral fat index cutoff value of 0.44 demonstrated sensitivity of 82.1% and specificity of 76.4% for prediction of high cardiovascular risk.

Table 1: Demographic and Clinical Characteristics of Study Participants (n = 85)

Variables	Frequency (n)	Percentage (%) / Mean \pm SD
Age (years)	—	52.34 ± 11.28
21–40 years	18	21.2%
41–60 years	46	54.1%

>60 years	21	24.7%
Male	52	61.2%
Female	33	38.8%
BMI (kg/m ²)	—	27.18 ± 4.12
Hypertension	46	54.1%
Diabetes Mellitus	32	37.6%
Dyslipidemia	39	45.9%
Smoking History	28	32.9%
Systolic Blood Pressure (mmHg)	—	136.42 ± 16.38
Diastolic Blood Pressure (mmHg)	—	84.15 ± 10.26

Table 2: CT-Based Visceral Fat Parameters and Cardiovascular Risk Categories

Parameters	Low Risk (n=24)	Intermediate Risk (n=37)	High Risk (n=24)	p-value
Visceral Fat Area (cm ²)	112.46 ± 24.18	146.82 ± 28.74	186.53 ± 34.92	<0.001
Subcutaneous Fat Area (cm ²)	198.34 ± 42.15	214.68 ± 51.22	228.45 ± 60.14	0.041
Visceral Fat Index (VFI)	0.29 ± 0.07	0.41 ± 0.08	0.54 ± 0.09	<0.001
BMI (kg/m ²)	24.96 ± 3.18	27.54 ± 3.62	29.82 ± 4.21	<0.001

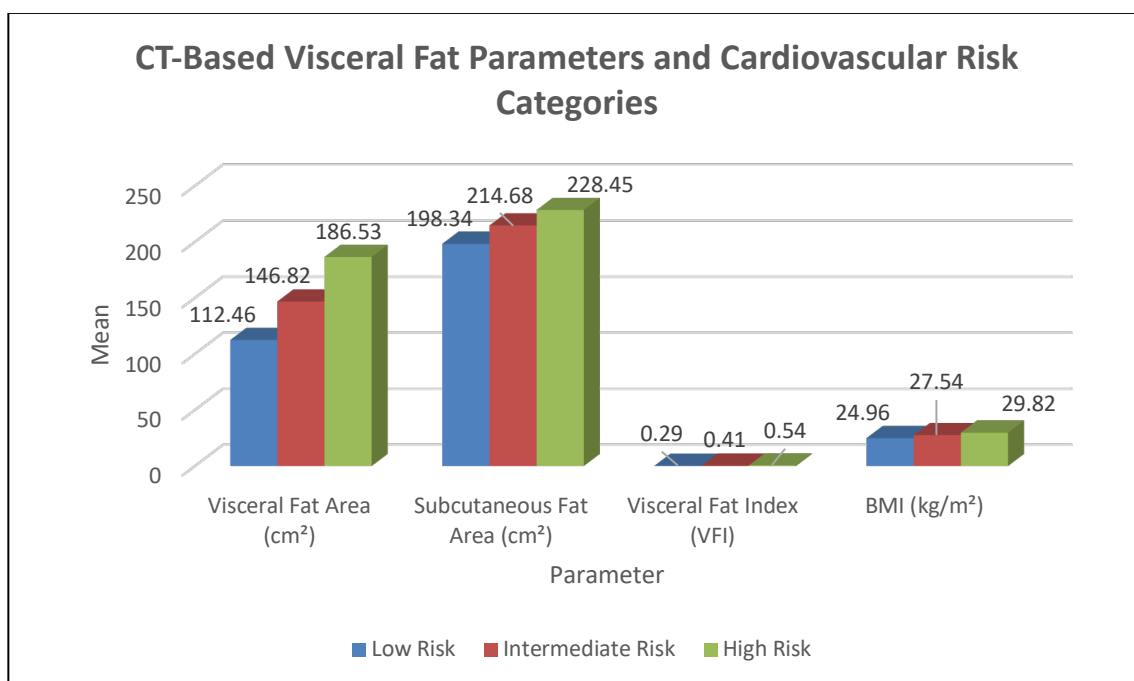


Figure 1: CT-Based Visceral Fat Parameters and Cardiovascular Risk Categories

Table 3: Correlation of Visceral Fat Index with Cardiovascular Risk Parameters

Parameters	Correlation Coefficient (r)	p-value
Cardiovascular Risk Score	0.68	<0.001
Systolic Blood Pressure	0.52	<0.001
Fasting Blood Glucose	0.49	<0.001
Triglyceride Levels	0.56	<0.001
LDL Cholesterol	0.44	0.002
HDL Cholesterol	-0.39	0.006
Body Mass Index (BMI)	0.47	<0.001

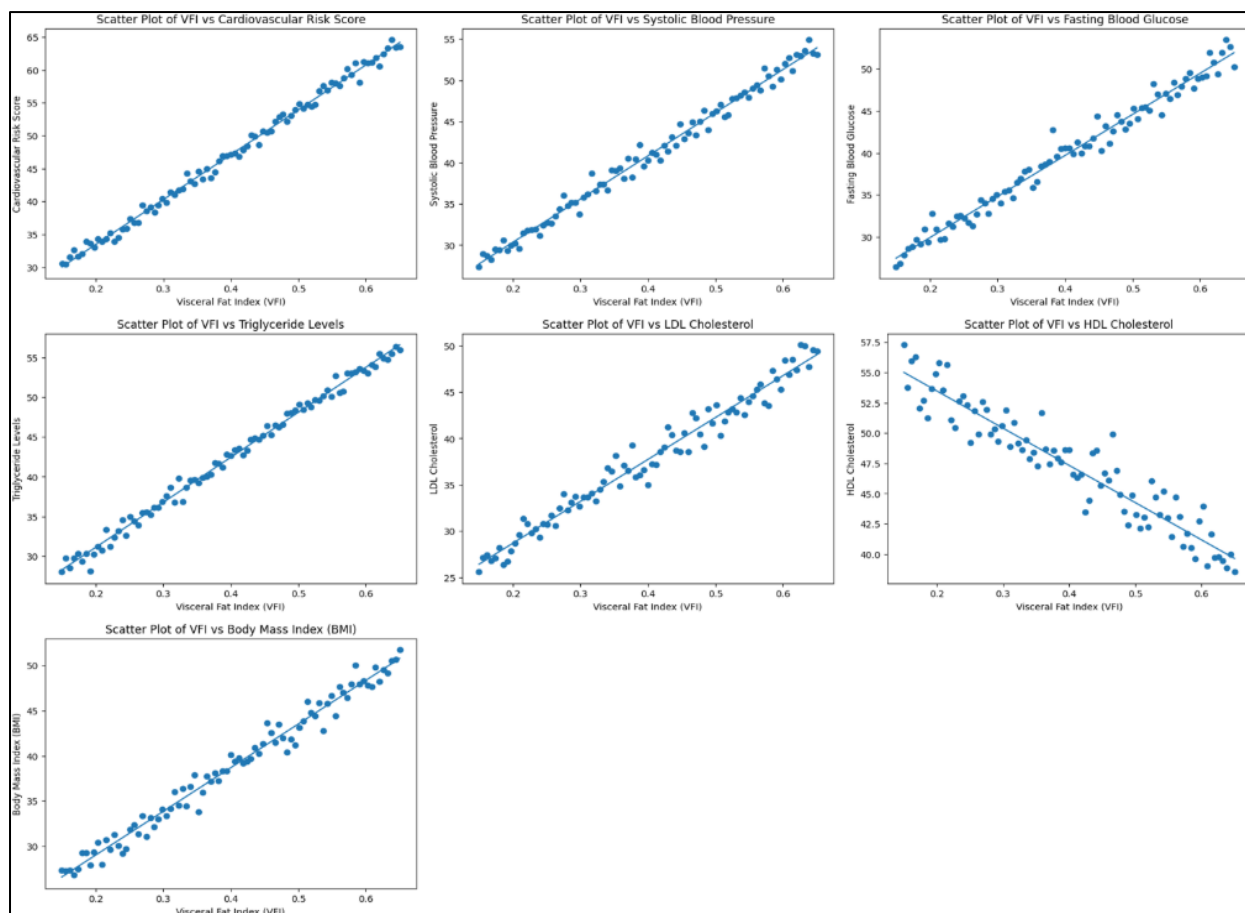


Figure 2:

Discussion

In the present study, the mean age of participants was 52.34 ± 11.28 years, with the majority belonging to the 41–60 years age group (54.1%). Males constituted 61.2% of the study population. Hypertension was present in 54.1%, diabetes mellitus in 37.6%, dyslipidemia in 45.9%, and smoking history in 32.9% of participants.

Comparable findings were reported by Roth et al. [15], who observed that cardiovascular diseases caused approximately 17.9 million deaths globally in 2015, accounting for nearly 31% of all global deaths. Ischemic heart disease contributed to 8.92 million deaths and stroke to 6.33 million deaths worldwide. Similarly, Naghavi et al. [16] reported that ischemic heart disease accounted for approximately 9.48 million deaths globally in 2016, with higher mortality among males and older age groups. Han and Lean [17] reported that central obesity is strongly associated with hypertension, dyslipidemia, insulin resistance, and increased cardiovascular morbidity, supporting the high prevalence of metabolic abnormalities observed in our study. In the present study, the visceral fat area increased significantly from 112.46 ± 24.18 cm² in the low-risk group to 186.53 ± 34.92 cm² in the high-risk cardiovascular group. Similarly, visceral

fat index increased from 0.29 ± 0.07 in low-risk participants to 0.54 ± 0.09 in high-risk participants ($p < 0.001$). Han and Lean [17] emphasized that visceral obesity contributes significantly to endothelial dysfunction, inflammation, insulin resistance, and atherosclerosis, thereby increasing cardiovascular risk. Farzadfar et al. [18], in a study involving nearly 3 million participants, reported that global mean serum cholesterol levels were 4.64 mmol/L in men and 4.76 mmol/L in women. The authors further reported that elevated cholesterol levels contributed to approximately 4.4 million deaths annually worldwide. These findings support the strong association between visceral adiposity and cardiovascular risk observed in our study. In the present study, visceral fat index showed a strong positive correlation with cardiovascular risk score ($r = 0.68$, $p < 0.001$). Significant positive correlations were also observed with systolic blood pressure ($r = 0.52$), fasting blood glucose ($r = 0.49$), triglycerides ($r = 0.56$), LDL cholesterol ($r = 0.44$), and BMI ($r = 0.47$). HDL cholesterol showed a negative correlation with VFI ($r = -0.39$). Han and Lean [17] reported that visceral adiposity is closely associated with hypertension, elevated triglycerides, reduced HDL cholesterol, insulin resistance, and metabolic syndrome. Farzadfar et al. [18] also demonstrated that elevated cholesterol levels re-

main a major contributor to ischemic heart disease and stroke globally. Roth et al. [15] similarly identified obesity, hypertension, dyslipidemia, and diabetes mellitus as major contributors to cardiovascular disease burden worldwide. The present study demonstrated that increased CT-based visceral fat index was significantly associated with adverse cardiovascular risk profiles and metabolic abnormalities.

Han and Lean [17] emphasized that BMI alone may underestimate cardiovascular risk because it does not accurately reflect visceral adiposity. Naghavi et al. [16] reported that cardiovascular diseases remain among the leading causes of mortality globally despite advances in healthcare, highlighting the importance of early identification of obesity-related risk factors. Roth et al. [15] further emphasized that effective prevention and management of obesity and metabolic abnormalities are essential to reduce the increasing burden of cardiovascular disease worldwide.

Conclusion

The present study demonstrated a significant association between CT-based visceral fat index and cardiovascular risk factors. Increased visceral fat index was associated with higher prevalence of hypertension, diabetes mellitus, dyslipidemia, and elevated cardiovascular risk scores. Significant positive correlations were observed between visceral fat index and multiple cardiometabolic parameters. CT-derived visceral fat assessment may serve as a useful imaging biomarker for cardiovascular risk stratification and early preventive intervention.

Limitations of the Study

The present study was conducted with a relatively small sample size and at a single center, which may limit the generalizability of the findings. Being a cross-sectional observational study, causal relationships between visceral fat index and cardiovascular risk could not be established. Long-term cardiovascular outcomes were not assessed. Additionally, lifestyle factors such as diet and physical activity were not evaluated in detail.

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