ORIGINAL ARTICLE

A Cross-Sectional Study on Visceral Fat Estimation by Computed Tomography and Its Relationship to Diabetes and Coronary Artery Disease at Shalamar Hospital, Lahore

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ABSTRACT

Objective: This study aimed to estimate visceral abdominal fat using computed tomography (CT scan) and its relationship with two major metabolic conditions diabetes mellitus (DM) and coronary artery disease (CAD).

Study Design: A cross-sectional study.

Place and Duration of Study: The study was conducted at the Department of Cardiology, Shalamar Hospital, Lahore, Pakistan from 4th May 2024 to 10th August 2024.

Methods: A total of 68 adult patients, including both males and females diagnosed with either diabetes, CAD, or both, were recruited for the study. Abdominal CT scans were performed following standard hospital imaging protocols. Axial two-dimensional (2D) CT images were analyzed to quantify visceral adipose tissue (VAT) area in square centimeters (cm^2). The scans were interpreted by a trained radiologist to ensure accuracy and consistency in VAT estimation.

Results: Results showed that the mean age was approximately 51.88 years in females and 55.24 years in males. Mean visceral adipose tissue (VAT) was 179.63 cm^2 in the patients suffering from diabetes or coronary artery disease (CAD), and their visceral fat percentage was much higher than the VAT threshold. A statistically significant association was found between elevated visceral fat and the presence of diabetes mellitus. Additionally, male participants demonstrated a higher prevalence and quantity of visceral abdominal fat compared to females.

Conclusion: This study highlights a strong association between increased visceral adiposity and the presence of diabetes and coronary artery disease. These findings underscore the clinical importance of incorporating VAT assessment into routine screening protocols for at-risk individuals. Early identification and targeted management of excess visceral fat could play a crucial role in both the primary and secondary prevention of metabolic and cardiovascular diseases.

Keywords: *Coronary Artery Disease, Diabetes Mellitus, Intra-Abdominal Fat, Metabolic Diseases, Subcutaneous Fat.*

How to cite this: *Kazmi T, Tahir M, Farhat S, Hameed Z, Yousaf A. A Cross-Sectional Study on Visceral Fat Estimation by Computed Tomography and Its Relationship to Diabetes and Coronary Artery Disease at Shalamar Hospital, Lahore. Life and Science. 2025; 6(3): 350-355.doi: http://doi.org/10.37185/LnS.1.1.775*

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Introduction

Historically, fat, also known as adipose tissue, was considered to protect and encase the body. However, it currently has a crucial character as an energy store in the human body. The two main types of human adipose tissue, subcutaneous adipose tissue (SAT) and visceral adipose tissue (VAT), have different metabolic qualities (VAT). Although all of these tissue types are important, visceral obesity has received much attention due to its association with a number of diseases.[1] VAT secretes greater levels of

Received: July 23, 2024; 1st Revision Received: Jan 19, 2025
2nd Revision Received: Apr 08, 2025; Accepted: Apr 17, 2025

cytokines, chemokines, adipokines, and prostanoids; these secretome, in particular, activates inflammatory signaling and disrupts insulin sensitivity, signaling, and glucose regulation in metabolic tissues. This leads to a number of diseases, such as impaired glucose and lipid metabolism, insulin resistance, type 2 diabetes, hypertension, ischemic heart disease, non-alcoholic fatty liver disease (NAFD), and cancers.[2,3] To find out the body fat tissue different anthropometric measures have been used in clinical practice, such as skin fold thickness, waist-to-hip ratio, hip circumference, and body mass index (BMI). However, none of those indices can distinguish between muscle mass and fat content or the distribution among the compartments.[4,5]

According to different research, some radiological techniques provide information on lean and fat tissue, like ultrasonography, body impedance analysis, and dual-energy X-ray absorptiometry. However, it is still challenging to provide a quantitative assessment of the distribution of body fat.[6-9] To deal with the above-mentioned issues, computed tomography scan (CT scan) and magnetic resonance imaging (MRI) have both been used to determine the subcutaneous body fat and visceral adipose tissue distribution.[10,11] While both techniques have some pros and cons but they equally help to quantify the SAT and VAT precisely. CT scan has been a frequently used method to quantify both fat types, as the amount of fat has been measured at the level of the umbilicus. To use this strategy, the amount of radiation exposure is less due to less time consumption during a CT scan. One significant benefit of CT over MRI for VAT evaluation is that fat consistently exhibits very low attenuation, with minimal inter-individual variability. This permits the use of a somewhat restrictive threshold in the application of a region growth algorithm. In addition to this, there are specific contraindications of MRI, such as non-MRI-compatible implants and claustrophobia, as well as the high cost and long examination times, which can also limit the use of MRI in clinical practice.[12-14] The study was conducted to estimate the quantity of visceral fat by using CT scan and its relationship with diabetes, coronary artery disease or both, by using their abdominal CT scan images of software Analyze 14.0

Methods

The cross-sectional study was conducted at the Department of Cardiology, Shalamar Hospital, Lahore, Pakistan from 4th May 2024 to 10th August 2024 after taking ethical approval from the Institutional and Ethical Review Board of the institute vide letter no: IRB# CPMC/IRB-No/1467 held on 3rd May 2024.

Sixty-eight individuals, both male and female, who had been referred for an abdominal CT examination were included in this study. For three months from May 4th 2024 to August 10th 2024, abdominal CT scan pictures of patients with diabetes and coronary artery disease were acquired at the Shalamar Hospital's Department of Cardiology in Lahore.

A CT scan was used to provide two-dimensional (2D) pictures of the abdomen. The radiologist used the hospital's CT scan protocol to do the CT scan. Medical imaging software called Analyze 14 was used for CT scans. This software makes it simple to compute and outline the area of visceral fat. As part of the diagnostic procedure, multiplanar reconstructions (MPRs) were carried out using visceral fat measurements from clinical and literature sources. We chose a section that connects the umbilicus to the posterior-inferior area of the L4/L5 disc. After opening the loaded data in the form of CT scan pictures in the segmentation tool, we chose the semi-automatic tool, as indicated in point 1 of Figure 1, to determine the visceral fat area.

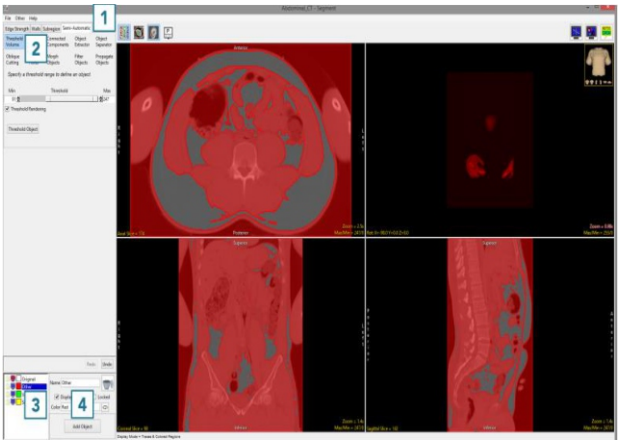

Fig.1: Freehand draw to extract other tissues obtained from Analyze 14.0

By using Analyze 14 the area of interest can be easily tracked and separate different areas from the same area and different colors can also differentiate them. The area that is traced for VAT gets a colour and shows the area of interest. In order to save this specific area, in the next step, the object can be locked to calcite to calculate its area. In Figure 2 the green areas show the visceral adipose tissue in the abdominal CT scan image.

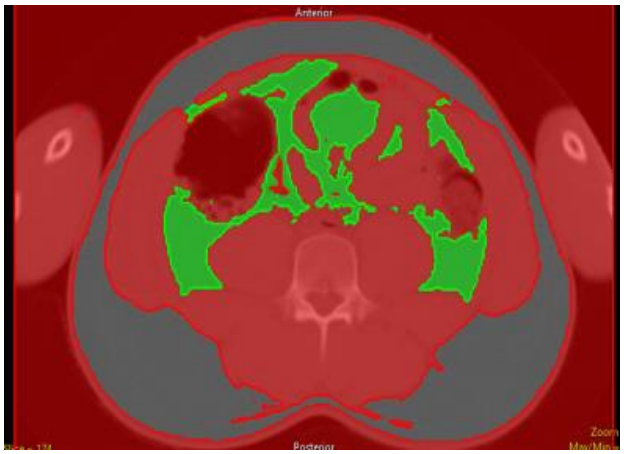

Fig.2: Segmentation, a green region showing visceral adipose tissues (VAT)

All data were analyzed on SPSS version 22. Data were recorded on a questionnaire. According to the Japan Society for the Study of Obesity and the widely accepted criteria in clinics, the cut-off value for visceral adipose tissue (VAT) was set at 100 cm2 at the umbilical level, measured by CT images.[15]

Results

A total of 68 participants (17 females, 51 males) were included in the analysis. The mean age was approximately 51.88 ± 7.68 years in females and 55.24 ± 9.14 years in males.

Table 1 shows a significant difference between the visceral fat among diabetic patients. Most patients suffering from diabetes or coronary artery disease have their visceral abdominal fat levels above the cutoff threshold of 100 cm^2.

Table 1: Cross Tabulation of coronary artery disease (CAD) and Diabetes with Visceral Adipose Tissue VAT (cm^2)

Diseases	Category	VAT		*Chi-Square*	*P*-value
		≥ 100 cm^2	< 100 cm^2		
CAD	Yes	43	-	3.544	0.060
	No	23	2		
Diabetes	Yes	50	-	5.724	0.017
	No	16	2		

Table 2: Gender-wise comparison of Visceral Adipose Tissue VAT (cm^2)

Gender	VAT		*Chi-square*	*P*-value
	≥ 100 cm^2	< 100 cm^2		
Male	50	1	0.687	0.407
Female	16	1		

Gender-wise comparison of visceral adipose tissue in Table 2 clearly shows that men tend to have a higher tendency to accumulate visceral abdominal fat. The *P*-value of gender-wise comparison of visceral fat is non-significant due to the small sample size in our study.

Discussion

In our study we assessed the visceral fat estimation and their relationship with diabetes and coronary artery disease (CAD). Our study results showed that the mean visceral adipose tissue (VAT) is 179.63 cm^2 ± 63.68, showing that patients suffering from diabetes or coronary artery disease (CAD) have a visceral fat percentage that was much higher than the VAT threshold. Our results are parallel with the results of a study conducted by Pimanov S and his co-workers which shows VAT area was 179.23 cm^2.[16] On the other hand, Tanaka et al. study conducted in 2019 discovered that VAT area of the study population was 113.3 cm^2, which is also above the threshold level but comparatively smaller than our results but still highlighting possible involvement of VAT in metabolic disorders.[17]

Results also indicated a significant difference between diabetes and the amount of visceral fat. Most of the patients, who are suffering from diabetes (*P*=0.017), have visceral abdominal fat above the cutoff point. Conversely, the CAD artery does not show association with the amount of visceral fat (*P*=0.060). These findings align with

existing studies demonstrating an association between visceral fat mass and diabetes, and also with pre-diabetes.[18-20] In one study, Kim EH et al. also found that participants with type 2 diabetes had substantially higher VFA (123.5 38.7 cm2 vs. 106.4 37.8 cm2 in men and 98.2 35.5 cm2 vs. 63.9 32.5 cm2 in women). The odds ratios (ORs) of VFA > 120 cm2 in men and 80 cm2 in women were 1.72 and 3.56, respectively. Higher baseline VFA levels were substantially related to an increasing likelihood of type 2 diabetes.[21]

Contrary to our findings, a study by Karlsson et al. on a large cohort indicates visceral fat is linked not only with type 2 diabetes but also with myocardial infarction.[22] Similar results were found in a study showing, in a systematic review and meta-analysis that integrated the different researches with various imaging methods for epicardial adipose tissue thickness (EAT) evaluations, it was determined that epicardial adipose tissue thickness (EAT) is linked with obstructive CAD.[23] A study conducted in Korea in 2019 assessed fat accumulation by examining the visceral and subcutaneous fat ratio (V/S ratio) and its relationship with diabetes and hypertension. The results of this study are inconsistent with our findings, indicating that no relationship was identified between the V/S ratio and either diabetes or hypertension.[24]

The current study also revealed that men tend to have a higher prevalence of visceral abdominal fat when compared to women (*P*=0.407). These findings are also supported by Gao Y et al. in which they found that significantly higher VAT and VAT/SAT ratio in patients with obstructive coronary artery disease than those in the non-obstructive coronary artery disease (NO-CAD) group (161.53±61.54 vs. 140.01±61.20, *P*=0.016; 0.95±0.33 vs. 0.70±0.25, *P*<0.001), Additionally, this study also indicated a greater prevalence of visceral obesity in men than in women.[25] In addition to this, a study conducted in Northern China found that similar results showed that, compared with women, men had a significantly higher median VATA (120.9 vs. 67.2 cm^2), VATI (39.1 vs. 25.6 cm^2/m^2), and a significantly higher percentage of visceral adiposity (VATA ≥ 100 cm^2) (60.8 vs. 30.4%).[26] However, in contrast to our results, some other studies suggested a more positive association between visceral adipose tissue and diabetes mellitus in women as compared to men.[27,28]

Limitations of our study include a small sample size and a single setup study. In addition to this, a cross-sectional study design was used in this research due to time constraints. Most of the patients have both diabetes and CAD. The sample size was relatively very small, i.e., 68 patients. We have not considered confounders such as age, gender, race, and ethnicity in this study. It is suggested that more studies should be conducted on large samples in multiple settings. However, this research may increase people's awareness about the significance of the amount of visceral fat as a risk factor and predictor for coronary artery disease and diabetes

Conclusion

In conclusion, the current study shows that the amount of visceral fat has a strong relationship with diabetes and coronary artery disease. Furthermore, these results can serve as a reference for future research aimed at establishing programs for the prevention and management of various chronic metabolic diseases and coronary artery diseases (CAD). Visceral fat estimation is significant for early detection and screening of diabetes and coronary artery disease because it's a strong predictor of these conditions, even in individuals with normal BMI. Excessive visceral fat, or abdominal fat, is associated with increased insulin resistance, inflammation, and other metabolic disturbances that raise the risk of both diabetes and cardiovascular disease.

Acknowledgement: None

Conflict of Interest: The authors declare no conflict of interest

Grant Support and Financial Disclosure: None

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Author Contributions

TK: Writing the original draft, proofreading, and approval for final submission
MT: Conception and design of the work
SF: Manuscript writing for methodology design and investigation
ZH: Data acquisition, curation, and statistical analysis
AY: Revising, editing, and supervising for intellectual content