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ORIGINAL ARTICLE

Regional fat distribution as a predictor of carotid atherosclerosis: Insights from mediastinal and cervical fat analysis

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Abstract

Objective

Atherosclerosis is a leading cause of cardiovascular diseases such as myocardial infarction and stroke. Obesity, particularly regional fat distribution, is known to play a significant role in the pathogenesis of atherosclerosis. The aim of our study is to investigate the relationship between the anterior mediastinal fat tissue areas, posterior cervical subcutaneous fat tissue thickness, and the presence of carotid plaque.

Methods

This retrospective study included 273 patients who underwent carotid CT angiography between 2021 and 2023. Patients under 18 years, with malignancy, or within adequate image quality were excluded. Anterior mediastinal fat tissue area was measured manually on axial CT images, and posterior cervical subcutaneous fat thickness was measured on sagittal images. Statistical analyses included the Mann-Whitney U test, Spearman's correlation, and logistic regression.

Results

There was a significant positive correlation between mediastinal fat area and carotid plaque presence ($r_s = 0.3417$, $p < 0.05$). The optimal cut-off value for mediastinal fat area to detect carotid plaque was 575 mm^2, with 78.79% sensitivity and 62.67% specificity. No significant correlation was found between cervical fat thickness and carotid plaque presence.

Conclusion

The anterior mediastinal fat tissue area is a moderate predictor of carotid plaque presence and can be easily measured during routine CT scans. This measurement may help identify patients at risk of atherosclerosis and guide further diagnostic evaluations.

Keywords: Carotid artery stenosis; fatty tissue; atherosclerosis; cardiovascular risk; computed tomography

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Introduction

Atherosclerosis is the leading cause of cardiovascular diseases, including myocardial infarction and stroke, and remains a significant global health issue [1]. According to the World Health Organization, atherosclerosis accounts for 32% of all deaths, making it the primary cause of mortality worldwide [2]. The pathogenesis of atherosclerosis is closely linked to chronic inflammation, driven by risk factors such as dyslipidemia, diabetes, obesity, hypertension, and smoking [3].

In both developed and developing countries, obesity is among the most preventable contributors to morbidity and mortality related to atherosclerosis. Consequently, recent research has increasingly focused on understanding the pathophysiological connections between obesity and cardiovascular conditions such as hypertension, dyslipidemia, and glucose intolerance. Current evidence suggests that fat distribution may be a more accurate indicator of cardiovascular risk than overall obesity itself [4].

Abdominal visceral fat accumulation, in particular, has been identified as a key factor in the heightened risk of cardiometabolic and inflammatory events [5,6]. In addition to this, studies have increasingly explored the role of specific fat depots, such as pericardial, epicardial, and perivascular fat, in cardiovascular risk, revealing associations with atherosclerosis [7,8,9]. Adipose tissue, known to secrete proinflammatory mediators, plays a crucial role in activating macrophages, T cells, and cytokines, thereby fostering an inflammatory environment that promotes the development of atherosclerosis [10].

Thus, beyond the commonly used measures like body mass index (BMI) or total fat volume, the distribution of fat in specific regions is critical for understanding the link between obesity and atherosclerosis. Regional fat measurements, including abdominal visceral fat and epicardial fat, often require specialized imaging techniques. In contrast, our study focuses on more easily accessible measures, specifically the anterior mediastinal fat tissue area and posterior cervical subcutaneous fat tissue thickness, to assess their relationship with the presence of carotid plaque.To our knowledge, no previous research has investigated the association between mediastinal fat tissue area, posterior subcutaneous fat tissue, and carotid plaque formation.

Methods

This study was approved by our hospital's institutional review board. We retrospectively screened patients who underwent carotid CT angiography between 2021 and 2023 using our hospital's Picture Archiving and Communication System (PACS). The inclusion criteria required that the scans contain the level where the aorta

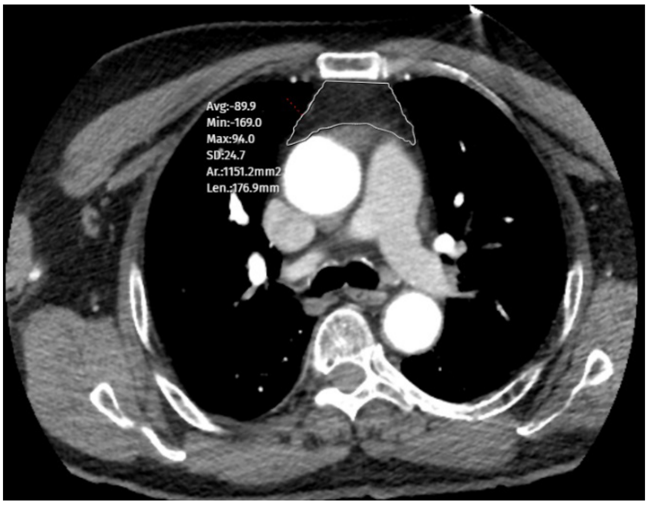

Figure 1: The measurement of the anterior mediastinal fat tissue area on the axial CT image.

and pulmonary artery are side by side, as this is the reference level for measuring the anterior mediastinal fat tissue area. Patients under 18 years of age, those with a history of malignancy or thoracic surgery, or those whose image quality was compromised due to artifacts were excluded from the study.

All CT scans were acquired using the same 128-multidetector CT scanner (GE Healthcare), with intravenous contrast administered via bolus injection. A radiology specialist with 11 years of experience performed all measurements on a high-resolution monitor. We divided the patients into two groups: those with carotid plaque and those without [11]. The anterior mediastinal fat tissue area was measured on the

Figure 2: The measurement of the posterior cervical subcutaneous fat thickness on the sagittal CT image.

axial plane. A free-hand region of interest (ROI) was used to manually measure the mediastinal fat tissue at the level where the aorta and pulmonary artery are situated in the anterior compartment, and these measurements were recorded in square millimeters (mm^2) (see Figure 1). For posterior cervical subcutaneous fat tissue thickness, measurements were taken in the sagittal plane. The thickness was assessed at the level of the C7 vertebra, where a perpendicular line was drawn from the bone margin to the skin (see Figure 2).

We performed statistical analyses using the NCSS (Number Cruncher Statistical System) 2007 software (Kaysville, Utah, USA). Descriptive statistics such as maximum, minimum, and mean values of mediastinal fat area and cervical fat thickness were calculated for both groups. The Shapiro-Wilk test was applied to determine whether the data followed a normal distribution. As the data were not normally distributed, group comparisons were conducted using the Mann-Whitney U test. Additionally, Spearman's rank correlation coefficient was used to assess relationships between carotid plaque presence, mediastinal fat area, and cervical fat thickness. Logistic regression analysis was performed to examine the impact of mediastinal fat area and cervical fat thickness on carotid plaque presence, adjusting for confounding factors such as age and gender. A p-value of less than 0.05 was considered statistically significant.

Results

A total of 273 patients were included in our study, consisting of 114 women and 159 men. The average age was 59 for men and 61 for women. When we divided the patients into two groups based on the presence of carotid plaque, 198 patients had carotid plaque while 75 did not. Table 1 summarizes the age, anterior mediastinal fat area, and cervical fat thickness statistics for both groups.

According to the Spearman correlation analysis, we found a moderate correlation between the presence of carotid plaque and the mediastinal fat tissue area (rs = 0.3417), indicating a significant relationship between these variables (Figure 3). However, the correlation between carotid plaque and cervical fat thickness was weaker (rs = 0.1390) (Figure 4). Additionally, the correlations of age with carotid plaque presence, mediastinal fat tissue area, and cervical fat thickness were found to be very weak.

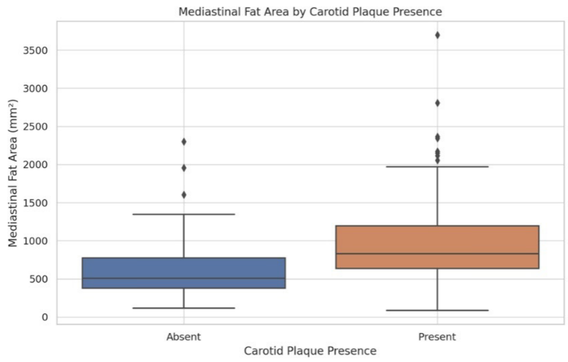

Figure 3: This plot compares the mediastinal fat area between patients with and without carotid plaque.

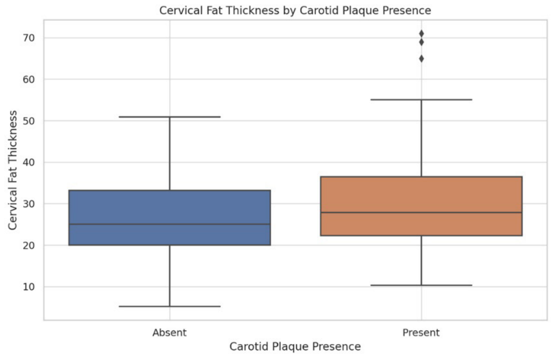

Figure 4: This plot compares the cervical fat thickness between patients with and without carotid plaque.

In the logistic regression analysis, an increase in mediastinal fat area was significantly associated with a higher likelihood of carotid plaque presence (p = 0.000045). Being male was also significantly related to

Table 1: Summary statistics of age, anterior mediastinal fat area and cervical fat tissue thickness between individuals with and without carotid plaque

	Number	Age Mean±SD	Anterior mediastinal fat area Mean±SD	Cervical fat tissue thickness Mean±SD
Carotid Plaque Absent	**75**	**59.36±9.34**	**623.27±405.05**	**26.08±9.76**
Carotid Plaque Present	**198**	**60.56±8.36**	**954.61±522.34**	**29.75±10.92**

a higher likelihood of having carotid plaque ($p = 0.045$). However, no significant relationship was observed between cervical fat thickness and the presence of carotid plaque ($p = 0.219$). The ROC analysis showed that the area under the curve (AUC) for mediastinal fat tissue area in detecting carotid plaque was 0.721 (95% CI), as shown in Figure 5. The optimal cut-off value for mediastinal fat area, determined by the Youden index, was 575 mm². At this cut-off, the sensitivity was 78.79%, and the specificity was 62.67%.

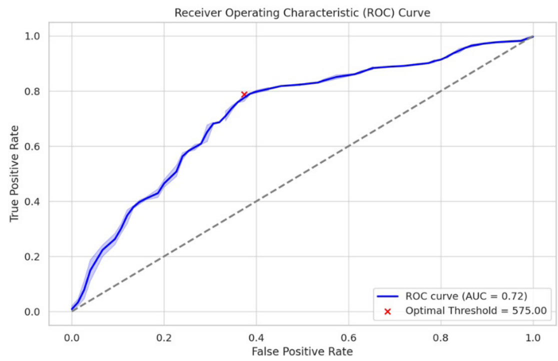

Figure 5: The Receiver Operating Characteristic (ROC) curve analysis for anterior mediastinal fat area.

Discussion

Obesity is characterized by abnormal fat accumulation due to excessive energy intake, and it is well established that obesity significantly increases the risk of myocardial infarction and stroke through its contribution to atherosclerosis. Adipose tissue plays a key role in promoting vascular inflammation by producing adipokines and inflammatory mediators, which affect vascular elasticity and atherogenesis. These mediators influence gene expression and cell functions in endothelial cells, arterial smooth muscle cells, and macrophages, fostering atherosclerosis development [12, 13].

In recent years, the focus has shifted towards the importance of local fat accumulation, independent of total fat volume or BMI. Research has emphasized the roles of epicardial and perivascular fat in particular, highlighting their significant local effects as cardiovascular risk factors [13,14]. However, it is known that these measurements are not routinely included in diagnostic screening reports and often require dedicated workstation assessments. For this reason, we aimed to investigate the relationship between carotid plaque presence and two parameters that can be easily measured in routine practice: anterior mediastinal fat tissue and posterior cervical subcutaneous fat thickness.

In daily practice, non-contrast thoracic CT scans are frequently performed for various reasons, such as pain, cough, infection, and nodule follow-up. Given that we consistently evaluate the anterior mediastinal fat tissue in these scans, we sought to determine whether it could serve as an indicator of atherosclerosis. The key finding of our study is that the anterior mediastinal fat tissue area demonstrated moderate performance in predicting the presence of carotid plaque, with a threshold value of 575 mm² proving to be significant. This finding suggests that during routine thoracic CT evaluations, measuring the anterior mediastinal fat tissue area can help identify patients at risk for carotid plaque. This information could be shared with clinicians to recommend further evaluation via carotid Doppler ultrasound, particularly in male patients, potentially reducing the incidence of carotid stenosis and embolic stroke.

A study by Bekin Sarıkaya et al. found no significant relationship between thoracic aortic plaque and mediastinal fat area [15], but their study had a smaller sample size and examined thoracic aortic plaques, which are less clinically significant compared to carotid plaques [16]. Thus, we believe our study adds important value to the literature.

When evaluating thoracic CT, cervical CT, and cervical spinal MRI, we routinely use the sagittal plane. During this process, posterior cervical subcutaneous fat thickness can be easily measured. In a study by Piche et al., the relationship between posterior cervical subcutaneous fat thickness and body mass index (BMI) was explored, and fat thickness measured at the C7 level was found to have the strongest correlation with BMI ($r=0.583$, $p<0.05$) [17]. Based on these findings, we measured the subcutaneous fat thickness at the C7 level in our study. However, no significant relationship was found between the presence of carotid plaque and subcutaneous fat thickness in our analysis. The literature includes studies suggesting that cervical subcutaneous fat accumulation is associated with cardiovascular disease risk factors, independent of BMI and visceral fat tissue [18,19]. However, the lack of association in our study may be attributed to the multifactorial nature of atherosclerosis pathophysiology, which involves numerous factors beyond fat tissue alone. Therefore, we believe that further studies are needed in this area.

Our study has certain limitations. First, selection bias may be present, as the measurements were taken from carotid CT angiographies performed for specific complaints and symptoms. Second, biochemical blood inflammation markers and lipid profiles of the patients were not evaluated. Including these parameters could yield more detailed results. Additionally, while we excluded patients with malignancies, other systemic inflammatory conditions such as diabetes mellitus and hypertension were not excluded from the study.

Conclusion

In conclusion, despite certain limitations, our study demonstrated a positive correlation between increased anterior mediastinal fat and the presence of carotid plaque. Routine evaluation of anterior mediastinal fat tissue during thoracic CT may help identify individuals at risk for atherosclerosis. Referral for carotid Doppler ultrasound in at-risk individuals, particularly men, could facilitate early detection and intervention, potentially reducing complications related to carotid stenosis and embolic stroke.

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Ethical Declaration: Ethics approval for the study was obtained from the Umraniye Research and Training Hospital Scientific Research Ethics Committee (date: 11/07/2024, no: 210)

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