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Peri-aortic Fat Deposition and It's Relation with Lower Limb Peripheral Arterial Disease: A CTA-Based Study

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ABSTRACT
Introduction: Peripheral artery disease (PAD) is when atherosclerotic plaques narrow the arterial lumen leading to decreased blood flow to the lower limbs. PAD is associated with systemic atherosclerosis and other metabolic risk factors. Peri-aortic fat deposits are associated with increased incidence of PAD, and they can be detected by CTA. The aim of this study is to evaluate the association between peri-aortic fat deposition and lower limb PAD using CTA. Methods: This was a cross-sectional study conducted in Cardiac Center, Erbil, Kurdistan Region of Iraq between June 2024 and January 2025. The sample size included 50 participants who underwent CTA for the evaluation of the abdominal aorta and lower limb arterial system. Data entry and analysis were performed using IBM SPSS (Statistical Package for Social Sciences). Results: Mean periaortic fat area was significantly different between BMI subgroups and in those with dyslipidemia, diabetes mellitus, renal impairment, and IHD compared to patients without these comorbidities. Mean aortic diameter was found to be significantly different between age ($p = 0.033$) and smoking subgroups (0.006). periaortic fat area ($p < 0.001$, $\rho = 0.562$) and periaortic fat density ($p = 0.001$, $\rho = 0.473$) had significant moderate positive correlations with the degree of the most severe lesion in the lower limbs. Conclusion: Peri-aortic fat measured by CTA was positively correlated with metabolic parameters (HbA1c, serum lipids and creatinine) as well as the severity of peripheral arterial lesions.

KEYWORDS: Peri-aortic, Peripheral Arterial Disease, CTA, computed tomography.

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INTRODUCTION
Peripheral arterial disease (PAD) refers to decreased perfusion to the lower limbs, leading to thigh or calf pain during exertion, termed claudication.[1] The reduced circulation is usually due to atherosclerosis, narrowing the arterial lumen and limiting blood flow to the lower limbs.[1] The risk factors for PAD include the general risk factors for CAD; diabetes, hypertension, smoking, and dyslipidemia.[2] In addition, obesity has long been established as an independent risk factor for PAD.[3]

PAD most commonly presents asymptomatically. However, it reflects systemic atherosclerosis in the body including coronary arterial disease (CAD) and cerebrovascular disease (CVD).[4] Therefore, screening for PAD is important to catch undiagnosed atherosclerosis and prevent its complications, as well as to treat PAD before it progresses to the development of symptoms.[5]

One method of screening for PAD is the ankle brachial index (ABI). It is a non-invasive technique that consists of dividing the systolic blood pressure of lower extremity to the systolic blood pressure of the upper extremity.[6] However, this method has a low sensitivity (15-79%). Especially in older individuals with diabetes.[7]

Adipose tissue deposits around blood vessels are associated with local inflammatory processes leading to calcification and subclinical atherosclerosis.[8] There are studies linking peri-aortic fat deposits with other metabolic risk factors, such as dyslipidemia and diabetes, and the incidence of CAD.[8] Previous studies have also shown that patients with peri-aortic fat deposits are more likely to have low ABI and intermittent claudication.[9] There is a link between visceral adipose tissue (VAT) and thoracic adipose tissue (VAT) and adverse vascular events.[10]

CT angiography (CTA) is a non-invasive technique that can measure the peri-aortic fat tissue and aortic calcification.[11] The aim of this study is to evaluate the association between peri-aortic fat deposition and lower limb PAD using CTA. The objectives are to measure peri-aortic adipose tissue area using the concentric circle method around the abdominal aorta on CT imaging, assess the degree of lower limb peripheral arterial stenosis using CTA, and analyze the correlation between the amount and density of peri-aortic fat with both cardiovascular risk factors and the presence and severity of peripheral arterial disease.

METHODOLOGY
Study Design, Setting, and Duration:
This study employed a cross-sectional study design. The study was conducted at the Erbil Cardiac Center, located in Erbil city, Kurdistan Region, Iraq. The study was conducted between June 2024 and January 2025.

Study sample:

A convenient sampling method was used to recruit 50 patients who meet the inclusion criteria during the study period. The inclusion criteria included patients of both sexes who underwent CTA for the evaluation of the abdominal aorta and lower limb arterial system. The exclusion criteria were patients with contraindications to CT imaging, patients with severe renal impairment, and patients with known allergy to iodinated contrast media.

Data Collection:
The study involved the following key steps:

1. Patient Questionnaire: A structured questionnaire was used to collect demographic data, medical history, and cardiovascular risk factors (e.g., diabetes, hypertension, dyslipidemia, smoking status, and BMI).
2. Measurement of Peri-aortic Fat: Peri-aortic adipose tissue was assessed using CT images. The measurement was performed at the level of the abdominal aorta, using a concentric circular method to calculate the area and density of peri-aortic fat.
3. Assessment of Peripheral Arterial Disease: Lower limb arterial stenosis was evaluated using CTA. The degree of stenosis as classified based on standard CTA grading (e.g., mild, moderate, severe, or occlusive disease).

Multidetector computed tomography angiography (MDCTA) was used to perform imaging from the abdominal aorta down to the distal lower limb arteries. A standard contrast-enhanced protocol was followed for all cases.

Statistical Analysis:
Data entry and analysis were performed using IBM SPSS Statistics for Windows, Version 26.0 (Released 2019; IBM Corp., Armonk, New York, United States). Categorical data was presented as frequencies and percentages, and numerical variables were described in the form of means ± standard deviations. Independent sample T-tests were performed to assess the differences in means between 2 subgroups, and Kruskal-Wallis ANOVA tests were done to compare the difference in means between 3 or more categories, with Dunn's multiple comparisons tests being performed to perform intra-group comparisons. Pearon's and Spearman's correlation tests were also performed to assess the associations between numerical variables and the associations between numerical and ordinal variables, respectively. A p-value < 0.05 was considered statistically significant.

Ethical Considerations:
Ethical approval was obtained from the Ethical Committee of KHCMS. Written informed consent was obtained from all participants prior to inclusion, and patient confidentiality and anonymity were strictly maintained throughout the study.

RESULTS

This study included 50 participants. The mean age was 64.1 ± 8.9 years, with the most common age group being patients 60-69 years of age (42.0%). 58.0% of our participants were male. As for socioeconomic status, most patients fell under the middle socioeconomic status category (86.0%). Regarding BMI, 60.0% of the patients were overweight, and the remaining 40.0% had a normal BMI. Most participants were non-smokers (44.0%). These basic characteristics are summarized in Table (1).

Table (1). Basic Characteristics of the Study Participants.

Characteristic	Frequency (n.)	Percentage (%)
Age		
<60	15	30.0
60-69	21	42.0
≥ 70	14	28.0
Gender		
Female	21	42.0
Male	29	58.0
Socioeconomic status		
Low	4	8.0
Middle	43	86.0
High	3	6.0
BMI		
Normal (18.5-24.9 kg/m2)	20	40.0
Overweight (25.9-29.9 kg/m2)	30	60.0
Smoking		
Non-smoker	22	44.0
Ex-smoker	20	40.0
Current smoker	8	16.0

The most common chronic disease in our participants was ischemic heart disease (60.0%), followed by hypertension (50.0%). The chronic diseases in our sample are summarized in Figure (1). 32.0% of our patients were on statins, 72.0% were on anti-platelet therapy, and 42.0% were taking anti-diabetic medications. In addition, biochemical measurements were performed for the patients, including HbA1c, lipid profile, hemoglobin level, and creatinine. These measurements are summarized in Table (2).

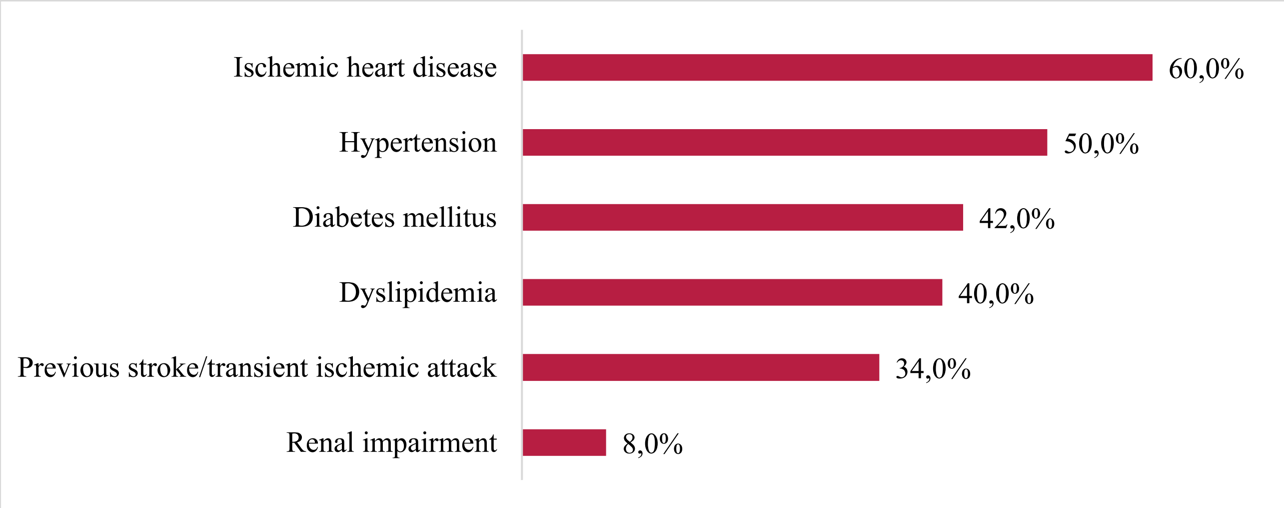

Figure (1). Prevalence of Chronic Diseases in Study Participants.

Table (2). Biochemical measurements in the study participants.

Biochemical measurement	Mean	Standard deviation
HbA1c (%)	6.2	1.0
Triglycerides (mg/dL)	145.8	23.4
Total cholesterol (mg/dL)	184.2	32.0
LDL (mg/dL)	94.5	18.0
HDL (mg/dL)	44.9	8.2
Hemoglobin (g/dL)	12.8	1.4
Creatinine (mg/dL)	1.1	0.2

CTA was performed to image the area from abdominal aorta to the distal lower limb arteries. Periaortic fat area, periaortic fat density, and aortic diameter at the level of these measurements were all measured, and are summarized in Table (3).

Table (3). CTA measurements in the study participants.

CTA measurement	Mean	Standard deviation
Periaortic fat area (mm^2)	214.7	32.0
Periaortic fat density (HU)	-52.1	6.4
Aortic diameter (mm)	18.0	1.6

The distribution of arterial disease at the level of the aorta and iliac arteries is summarized in Figure (2). The peroneal artery was the most commonly afflicted, with 92% of participants having a lesion in their peroneal artery, followed by the anterior tibial artery, in which lesions were found in 90% of patients. Only 6% of patients had no vascular lesions in the lower limbs, while 40% had a total arterial stenosis in one of their vessels. Likewise, the distribution of vascular disease in the lower limb arteries on CTA is summarized in Figure (3).

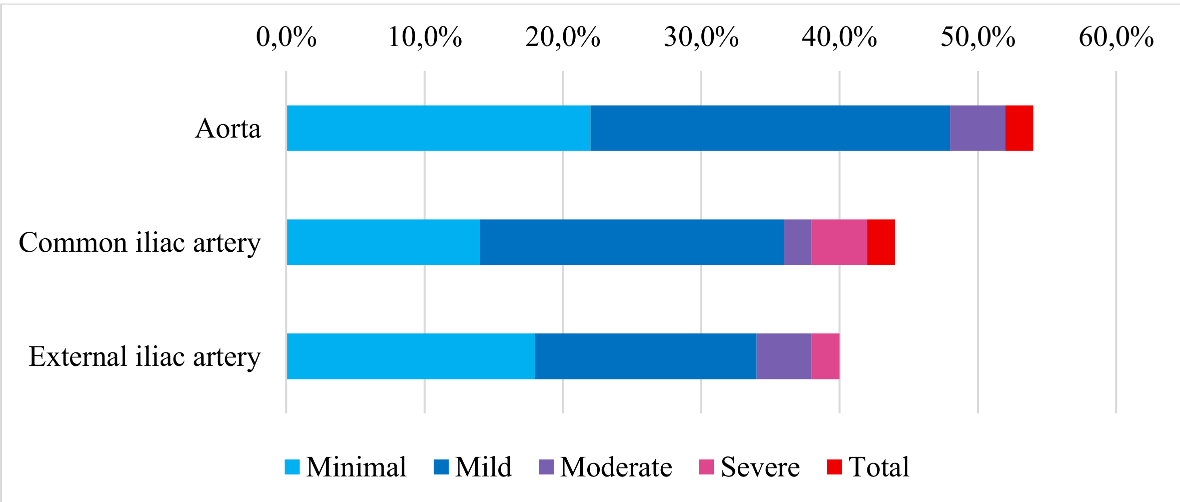

Figure (2). Distribution and Severity of Stenosis in Aortic and Iliac Arteries.

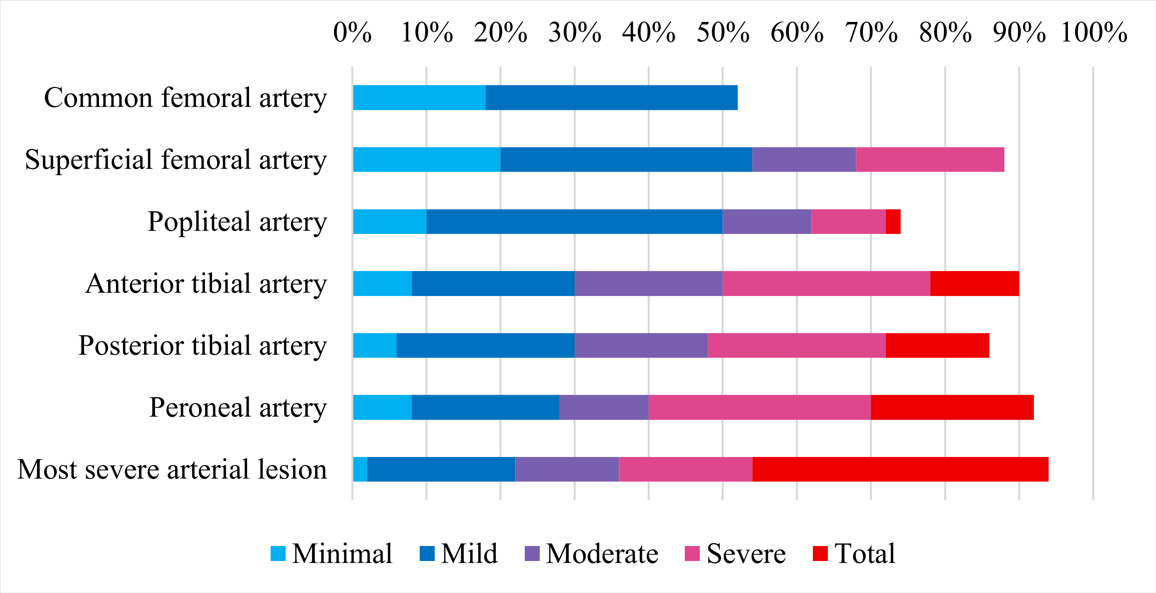

Figure (3). Distribution and Severity of Stenosis in the Arteries of the Lower Limb.

One way ANOVA tests were performed to assess the differences in mean periaortic fat density, periaortic fat area, and aortic diameter between age, socioeconomic status, and smoking subgroups. No significant differences were found between these subcategories for periaortic fat density and fat area. T-tests were used to assess the significance in the differences of mean periaortic fat area, periaortic fat density, and aortic diameter between genders, BMI subgroups, and those with or without various comorbidities. Mean periaortic fat area was significantly different between BMI subgroups and in those with dyslipidemia, diabetes mellitus, renal impairment, and IHD compared to patients without these comorbidities. In addition, a statistically significant difference was noted in the mean periaortic fat density between BMI subcategories, and between patients with or without hypertension, renal impairment, and IHD. This is shown in Table (4).

Table (4). Differences in Mean Periaortic Fat Area, Periaortic Fat Density, and Aortic Diameter.

Categories	Mean	Standard deviation	P-value
Periaortic fat area (mm^2)			
Normal BMI	200.2	25.7	0.007
Overweight	224.4	32.5	
No dyslipidemia	205.4	27.4	0.01
Dyslipidemia	228.7	33.9	
No diabetes mellitus	201.1	27.5	<0.001
Diabetes mellitus	233.5	28.5	
No renal impairment	211.1	30.0	0.005
Renal impairment	256.7	26.2	
No IHD	194.2	24.1	<0.001
IHD	228.4	29.5	
Periaortic fat density (HU)			
Normal BMI	-55.4	6.6	0.002
Overweight	-49.8	5.3	
No hypertension	-54.0	6.6	0.038
Hypertension	-50.2	5.8	
No renal impairment	-52.6	6.4	<0.001
Renal impairment	-46.0	1.6	
No IHD	-54.5	6.8	0.029
IHD	-50.5	5.8	

Perason's correlation tests were used to determine the association between various biochemical parameters and CTA measurements of periaortic fat and aortic diameter. A significant correlation was found between HbA1c ($p < 0.001$, $r = 0.568$), triglycerides ($p <0.001$, $r = 0.531$), total cholesterol ($p < 0.001$, $r = 0.494$), LDL ($p < 0.001$, $r = 0.504$), HDL ($p < 0.001$, $r = -0.599$), and creatinine ($p < 0.001$, $r = 0.608$) levels and periaortic fat area. In addition, significant correlations were also noted between periaortic fat density and HbA1c ($p = 0.014$, $r = 0.347$), LDL ($p = 0.032$, $r = 0.303$), HDL ($p = 0.002$, $r = -0.433$), and creatinine ($p < 0.001$, $r = 0.598$) levels and periaortic fat density on CTA. Furthermore, periaortic fat area was found to have a significant moderate positive correlation with periaortic fat density ($p = 0.001$, $r = 0.442$).

Spearman tests were performed to assess the correlation of CTA measurements of periaortic fat and aortic diameter and the degree of arterial disease in our participants. Our results showed that periaortic fat area ($p <0.001$, $\rho = 0.562$) and periaortic fat density

($p = 0.001$, $\rho = 0.473$) had significant moderate positive correlations with the degree of the most severe lesion in the lower limbs. In addition, periaortic fat area and density also had significant weak to moderate positive correlations with the degree of aortic stenosis ($p = 0.002$, $\rho = 0.429$; and $p = 0.013$, $\rho = 0.349$, respectively), common iliac artery stenosis ($p = 0.003$, $\rho = 0.414$; $p = 0.001$, $\rho = 0.460$) and external iliac artery stenosis ($p = 0.003$, $\rho = 0.414$; $p = 0.003$, $\rho = 0.415$).

DISCUSSION:

Our sample included 50 participants, with a mean age of 64.1 ± 8.9 years, which is similar to other studies we've examined in this discussion.[8,9] In our sample, the peroneal artery was the most common artery afflicted with PAD, followed by the anterior tibial artery and then the superficial femoral artery. There was a relatively low prevalence of aorto-iliac disease in our patients. In a study done in Singapore assessing the distribution of PAD in patients undergoing intervention for limb threatening ischemia, the anterior tibial artery was the most commonly treated site, followed by the femoropopliteal arteries, with a relatively low prevalence of lesions in the peroneal artery.[12] This could be attributed to the fact these patients, unlike our sample, had critical limb ischemia while our sample had more varying degrees of PAD, and in part due to the different imaging techniques employed (CTA vs angiography through catheterization). Alghanimi et al, in a CTA study, reported that the femoropopliteal segment was the most commonly afflicted in their sample, followed by the infrapopliteal vessels.[13] A study in West India reported that the anterior tibial artery was the most commonly affected, followed by the peroneal artery and the superficial femoral artery in East Indians, however, the overall most diseased vessels in all the examined ethnicities were the anterior tibial artery, followed by the posterior tibial artery and then the peroneal artery.[14] Hence, the different ethnicities of the samples could also in part explain the differences noted.

Our sample revealed a statistically significant association between periaortic fat parameters (area and density) and cardiovascular disease risk factors and cardiovascular disease; we found a significantly higher mean periaortic fat area in patients with higher BMI, dyslipidemia, diabetes mellitus, renal impairment, and IHD, as well as a significant difference in mean periaortic fat density in higher BMI categories, and patients with hypertension, renal impairment, and IHD. Furthermore, HbA1c, triglycerides, total cholesterol, LDL, HDL, and creatinine demonstrated significant correlations with periaortic fat area and density. Lee et al reported that greater abdominal periaortic fat and lower fat attenuation indices were associated with a higher prevalence of metabolic syndrome components.[15] Another study also reported a significant inverse correlation between the fat attenuation index and BMI, total cholesterol, and triglycerides, as well as a correlation with the fat volume. In addition, they reported a higher fat volume in obese individuals, and in obese individuals, periaortic fat volume was found to be more common in those with metabolic syndrome; similarly, the fat attenuation index was found to be associated with metabolic syndrome, with an area under the curve for predicting the presence of metabolic syndrome of 0.79.[16] Britton et al, utilizing data from the Framingham Heart Study, reported a higher prevalence of thoracic periaortic adipose tissue with increasing BMI, as well as a high periaortic adipose tissue being associated with a more adverse cardiometabolic profile and prevalent cardiovascular disease. In addition, it was associated with a lower HDL level in women.[17] Lehman et al reported an association between thoracic periaortic fat and hypertension, diabetes, and metabolic syndrome, although only the associations with hypertension and diabetes in men remained after adjusting for visceral adipose tissue. In addition, they also reported correlations with BMI, triglycerides, HDL, total cholesterol, and blood glucose.[8] In addition, a study in China, utilizing multivariate logistic regression, revealed an association between abdominal periaortic fat volume and coronary artery disease that was independent of general obesity, abdominal obesity, and clinical risk factors.[18] Futhermore, Akbay et al reported that periaortic adipose tissue volume was significantly higher in patients with severe coronary artery disease.[19] Hence, periaortic fat parameters may be associated with traditional cardiovascular risk factors and cardiovascular disease, as well as serve as a novel marker for better risk stratification for cardiovascular disease in patients.

Our sample revealed that periaortic fat area had a significant moderate positive correlation with the degree of lower limb arterial disease and aorto-iliac stenosis. In addition, a similar correlation was found between PAD and periaortic fat density. Fox et al, also utilizing the Framingham Heart Study, performed regression analysis revealing that periaortic fat volume was associated with a higher likelihood of the patient having intermittent claudication as well as a low ankle brachial index. These associations held even after adjusting for clinical covariates, BMI, and visceral abdominal obesity.[9] Unfortunately, no other studies could be found assessing this association.

To our knowledge, there is a lack of literature on radiologic peri-aortic fat parameters and its associations with cardiovascular disease, including peripheral artery disease, particularly in our region, hence making this current study provides valuable insight and serves as a building block for future studies. Our study was limited by the relatively small sample size, and the convenience sampling approach. Future studies with larger samples and cohort designs could better serve to delineate the associations laid out above.

CONCLUSION

Peri-aortic fat area and density, measured by CTA, was positively correlated with metabolic parameters (HbA1c, serum lipids and creatinine) and cardiovascular disease and risk factors. In addition, they were also correlated with the degree of severity of the lower limb lesions and stenosis in the aortic, common iliac and external iliac arteries.

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