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ORIGINAL ARTICLE

Prevalence of Hepatic Artery Atherosclerosis and Factors Affecting Hepatic Artery Atherosclerosis in Patients with Abdominal Aorta Atherosclerosis

Abdominal Aorta Aterosklerozu Bulunan Olgularda Hepatik Arter Aterosklerozu Prevalansı ve Hepatik Arter Aterosklerozuna Etki Eden Faktörler

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ABSTRACT

Aim: To investigate hepatic artery (HA) atherosclerosis prevalence and factors affecting HA atherosclerosis in adults with abdominal aorta (AA) atherosclerosis detected by computed tomography angiography (CTA).
Methods: Undergoing CTA of AA for various reasons in 2020 at Hacettepe University Hospital, 296 adults with AA atherosclerosis were included. Presence and type of atherosclerosis in common HA, right, and left HA were evaluated. Celiac trunk anatomy, HA anatomy, presence of left gastric artery (LGA) atherosclerosis, calcium scores of other visceral branches of AA, and total AA atherosclerosis scores were evaluated in all patients. These parameters were compared between patients with and without HA atherosclerosis.
Results: HA atherosclerosis was found in 25 cases (8.4%). The most common Type of HA atherosclerosis was calcified plaque in common HA. Mean age of patients with HA atherosclerosis was statistically significantly higher than those without (70±7.67 vs. 66±9.3, p=0.041). There was a statistically significant correlation between HA anatomy and HA atherosclerosis (p=0.034). Post Hoc analyses revealed that HA atherosclerosis was more frequent in patients with Type-2 and Type-3 HA anatomy (p=0.027; p=0.044, respectively). Prevalence of LGA atherosclerosis was significantly higher in patients with HA atherosclerosis than those without (12% vs. 0.3%, p=0.002). Total renal artery (RA) calcium, superior mesenteric artery (SMA) calcium, splenic artery (SA) calcium, AA total atherosclerosis, and total iliac artery (IA) calcium score were significantly higher in patients with HA atherosclerosis than those without (p=<0.001, p=<0.001, p=<0.001, p=0.029, p=<0.001, respectively). In logistic regression analysis, SMA calcium (HR: 1.898, 95% CI: 1.002-3.607, p= 0.05), SA calcium (HR: 2.626, 95% CI: 1.485-4.643, p= 0.001), and total IA calcium scores (HR: 3.063, 95% CI: 1.162-8.077, p=0.024) were independent risk factors for HA atherosclerosis.
Conclusions: While HA atherosclerosis prevalence was 8.4% in adults with AA atherosclerosis. SMA, SA, and total IA calcium scores were found as independent risk factors for AA atherosclerosis.

Keywords: Abdominal aorta, atherosclerosis, celiac artery, CT angiography, hepatic artery

ÖZ

Amaç: Bu çalışmanın amacı bilgisayarlı tomografi anjiyografide (BTA) abdominal aorta (AA) aterosklerozu saptanan erişkin hastalarda hepatik arter (HA) aterosklerozu prevalansının ve HA aterosklerozuna etki eden faktörlerin araştırılmasıdır.
Gereç ve Yöntemler: Çalışmaya Hacettepe Üniversitesi Hastanesi'nde 2020 yılında çeşitli nedenlerle AA'ya yönelik BTA çekimi yapılmış ve AA aterosklerozu saptanmış 296 erişkin hasta dahil edilmiştir. Hastalarda ortak HA, sağ ve sol HA'da ateroskleroz varlığı ve tipi değerlendirilmiştir. Hastaların tümünde çölyak trunkus anatomisi, HA anatomisi, sol gastrik arter (SGA) aterosklerozu varlığı, AA'nın diğer dallarındaki kalsiyum skoru ve AA toplam ateroskleroz skoru değerlendirilerek bu parametreler HA aterosklerozu olan ve olmayan hastalar arasında karşılaştırılmıştır.
Bulgular: Olguların 25'inde (%8.4) herhangi bir HA aterosklerozu mevcuttu. HA aterosklerozunun en sık görülen tipi ortak HA'da kalsifik plak şeklindeydi. HA aterosklerozu olan olguların ortalama yaşı olmayanlardan istatistiksel anlamlı yüksekti (70±7.67 vs 66±9.3, p: 0.041). HA anatomisi ile HA aterosklerozu arasında istatistiksel anlamlı ilişki bulundu (p: 0.034). Post hoc analiz sonuçlarında tip 2 ve tip 3 HA anatomisine sahip olgularda HA aterosklerozunun daha sık olduğu saptandı (p değerleri sırasıyla 0.027 ve 0.044). HA aterosklerozu olan olgularda SGA aterosklerozu HA aterosklerozu olmayanlara göre istatistiksel anlamlı daha fazlaydı (%12 vs %0.3, p: 0.002). Toplam renal arter (RA) kalsiyum skoru, süperiyor mezenterik arter (SMA) kalsiyum skoru, splenik arter (SA) kalsiyum skoru, AA toplam ateroskleroz skoru ve toplam ilyak arter (İA) kalsiyum skoru HA aterosklerozu olan olgularda HA aterosklerozu olmayanlara göre istatistiksel anlamlı daha yüksekti (p değerleri sırasıyla <0.001, <0.001, <0.001, 0.029, <0.001). Lojistik regresyon analizinde HA aterosklerozu için bağımsız risk oluşturan parametreler SMA kalsiyum skoru (HR:1.898, %95 GA: 1.002-3.607, p: 0.05), SA kalsiyum skoru (HR: 2.626, %95 GA: 1.485-4.643, p: 0.001) ve toplam İA kalsiyum skoru (HR: 3.063, %95 GA: 1.162-8.077, p: 0.024) olarak bulundu.
Sonuçlar: Bu çalışmada AA aterosklerozu olan erişkinlerde HA aterosklerozu sıklığı %8.4 saptanmıştır. HA aterosklerozu için bağımsız risk oluşturan parametreler SMA, SA ve toplam İA kalsiyum skorları olarak bulunmuştur.

Anahtar Kelimeler: Abdominal aorta, ateroskleroz, BT anjiyografi, çölyak arter, hepatik arter

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INTRODUCTION

Atherosclerosis is a chronic disease affecting large- and medium-sized arteries, characterized by endothelial dysfunction, vascular inflammation, and accumulation of cholesterol and calcium in the arterial wall. It is a significant cause of mortality and morbidity in both developed and developing countries. Risk factors for atherosclerosis include hypertension, diabetes mellitus, dyslipidemia, smoking, and various genetic factors (1). Unlike other major branches of the abdominal aorta (AA), hepatic artery (HA) atherosclerosis has rarely been reported in the literature. Case reports on HA diseases predominantly described aneurysms and calcifications (2, 3). Atherosclerosis of the celiac trunk and HA are often asymptomatic and detected incidentally. Due to the dual blood supply of the liver through the portal venous system and HA, the likelihood of clinical manifestations of HA stenosis/occlusion is considerably low, except in liver transplant recipients, patients undergoing liver surgery (lobectomy/segmentectomy), or those with a history of portal vein thrombosis (4). Therefore, there is limited information in the literature regarding the prevalence of HA atherosclerosis.

This study aimed to investigate the prevalence of HA atherosclerosis in adults with AA atherosclerosis on computed tomography angiography (CTA).

MATERIALS and METHODS

Study Group

Adults with AA atherosclerosis undergoing CTA of the AA for various reasons in 2020 at Hacettepe University Hospital were included in this study. Patients with endovascular treatment for aortic aneurysms, those with metallic stents in the visceral branches of the AA or iliac arteries, patients whose imaging contained motion artifacts, and those with inadequate contrast enhancement in the HA were excluded. Patients with conditions that could affect hepatic perfusion, such as portal vein thrombosis, hepatic vein occlusion, or severe liver cirrhosis, were also excluded from the study.

Patients were evaluated after approval was obtained from Hacettepe University Health Sciences Research Ethics Committee (Decision number: SBA 25/209). The study was conducted under the principles of the Declaration of Helsinki.

CT Protocol

CT scans were performed on a 192-slice CT scanner (Somatom Force, Siemens Healthineers, Erlangen, Germany). The scanning parameters were as follows: tube voltage, 130 kV; collimation, 192×0.6 mm; reconstruction increment, 1 mm; slice thickness, 1 mm; pitch, 0.8; and gantry rotation time, 1 s. The automatic exposure control algorithm (Care Dose4D) was used. A total of 100 ml of the contrast agent (Opaxol 350/100 mg/ml Opakim, Türkiye) was administered intravenously at a flow rate of 3 ml/s, followed by a 40 ml saline flush at a flow rate of 3 ml/s. Scan delay was triggered using automatic bolus tracking.

Image Analysis

CTA images were evaluated by a single observer with nine years of radiology experience. Celiac trunk anatomy was assessed according to Uflacker's classification (5), and HA anatomy was evaluated based on Michel's classification (6). The presence of atherosclerosis (calcified plaque, soft plaque, or wall irregularity) was recorded in the common HA (CHA), right hepatic artery (RHA), left hepatic artery (LHA), and left gastric artery (LGA). Calcium scores for the renal arteries (RA), superior mesenteric artery (SMA), splenic artery (SA), main iliac arteries (IA), internal IAs, and external IAs were determined using the scoring system proposed by Takx et al. (7) (Supplementary Table 1). The total RA calcium score and total IA calcium score were calculated by summing the individual artery scores. To determine the total AA atherosclerosis score, the AA calcium score was calculated using the scoring system proposed by Takx et al. (7), while aortic plaque thickness, wall irregularity, and plaque ulceration were evaluated based on the scoring system proposed by Jacobs et al. (8) (Supplementary Table 2). The scores obtained from these assessments were summed to determine the total AA atherosclerosis score.

Statistical Analysis

Statistical analyses were performed using SPSS v.23.0 (IBM Inc., Armonk, NY, USA). The normality of numerical data was assessed using the Kolmogorov-Smirnov and Shapiro-Wilk tests. Descriptive analyses were expressed as mean ± standard deviation for parametric variables, median and minimum-maximum values for non-parametric variables, and frequency and percentage for categorical variables. The independent sample t-test was used to compare parametric variables between patients with and without HA atherosclerosis, while the Mann-Whitney U test was used for non-parametric variables. The Chi-square test was applied to compare categorical variables. Binary logistic regression analysis was performed for parameters showing statistically significant differences between groups, and hazard ratios (HR) with 95% confidence intervals (CI) were calculated. A p-value of <0.05 was considered statistically significant.

RESULTS

A total of 296 patients (208 males, 88 females) were included, with a mean age of 66 years. The most common celiac trunk anatomies, according to Uflacker's classification, were hepatogastrosplenic trunk (Type-1, 263 cases) and gastrosplenic trunk (Type-5, 23 cases). According to Michel's classification, the most common HA anatomies were normal anatomy (Type-1, 206 cases) and RHA originating from the SMA (Type-3, 32 cases). HA atherosclerosis was present in 25 patients (8.4%) (Fig. 1). CHA atherosclerosis was observed in 22 cases (7.4%), RHA atherosclerosis in eight cases (2.7%), and LHA atherosclerosis in one case (0.3%). The most common type of CHA atherosclerosis was calcified plaque (n: 12), while the most frequent RHA atherosclerosis type was wall irregularity (n: 5). The only patient with LHA atherosclerosis exhibited wall irregularity. LGA atherosclerosis was detected in four patients (1.4%) (Table 1).

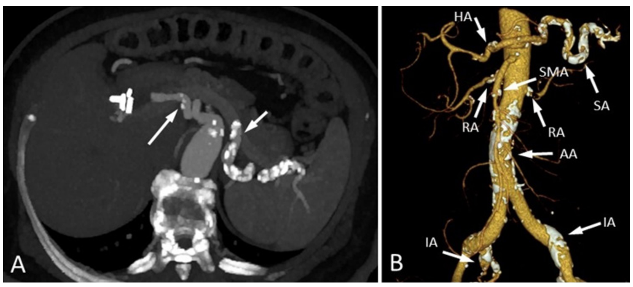

Figure 1. A 70-year-old female patient underwent an AA CTA exam for the suspicion of RA stenosis. (A) Axial plane maximum intensity projection (MIP) CT image shows calcified plaques in HA (long arrow) and SA (short arrow). (B) Coronal plane volume rendering technique (VRT) image demonstrates multiple calcified plaques in HA, SA, SMA, RAs, AA, and IAs. AA: Abdominal aorta, HA: Hepatic artery, IA: Iliac artery, SA: Splenic artery, SMA: Superior mesenteric artery

Table 1. Demographic and anatomical data, prevalence, and type of hepatic artery atherosclerosis

Characteristic	n=296 (%)
Sex (Male/Female)	208:88
Age (years) (mean±SD)	66±9.2
Celiac trunk anatomy, n (%)	
Type-1 (Hepatogastrosplenic trunk)	263 (88.9)
Type-2 (Hepatosplenic trunk)	6 (2)
Type-3 (Hepatogastric trunk)	3 (1)
Type-5 (Gastrosplenic trunk)	23 (7.8)
Type-6 (Celiac-mesenteric trunk)	1 (0.3)
HA anatomy, n (%)	
Type-1 (Normal anatomy)	206 (69.6)
Type-2 (Left HA from LGA)	24 (8.1)
Type-3 (Right HA from SMA)	32 (10.8)
Type-4 (Type 2+Type 3)	3 (1)
Type-5 (Accessory left HA from LGA)	13 (4.4)
Type-6 (Accessory right HA from SMA)	1 (0.3)
Type-7 (Type 5+Type 6)	2 (0.7)
Type-8 (Type 3+Type 5)	3 (1)
Type-9 (Common HA from SMA)	6 (2)
Unclassified	6 (2)
HA atherosclerosis, n (%)	
Present	25 (8.4)
Absent	271 (91.6)
Type of HA atherosclerosis, n (%)	**Common HA** Calcified plaque: 12 (54.4) Soft plaque: 3 (13.6) Wall irregularity: 7 (31.8) **Right HA:** Calcified plaque: 3 (37.5) Wall irregularity: 5 (62.5) **Left HA:** Wall irregularity: 1 (100)
LGA atherosclerosis, n (%)	4 (1.4)

HA: Hepatic artery, LGA: Left gastric artery, SD: Standard deviation, SMA: Superior mesenteric artery

The mean age of the patients with HA atherosclerosis was significantly higher than those without (70±7.67 vs. 66±9.3, p=0.041). No statistically significant difference was found in gender distribution (p=0.083) or celiac trunk anatomy (p=0.122) between groups. However, a significant correlation was observed between HA anatomy and HA atherosclerosis (p = 0.034). Post hoc analysis indicated that patients with Type-2 and Type-3 HA anatomy had a higher prevalence of atherosclerosis (p=0.027 and p=0.044, respectively). In patients with HA atherosclerosis, the prevalence of LGA atherosclerosis was significantly higher than in those without (12% vs. 0.3%, p=0.002). Total RA calcium score, SMA calcium score, SA calcium score, total AA atherosclerosis score, and total IA calcium score were significantly higher in patients with HA atherosclerosis than in those without (p values < 0.001, < 0.001, < 0.001, 0.029, and < 0.001, respectively) (Table 2).

Table 2: Association between different variables and the prevalence of hepatic artery atherosclerosis

Variables	Patients with HA atherosclerosis (n=25)	Patients without HA atherosclerosis (n=271)	p
Age (years) (mean±SD)	70±7.67	66±9.3	**0.041[a]**
Sex (Male/Female)	14:25	194:271	**0.083[b]**
Prevalence of HA atherosclerosis according to celiac trunk anatomy, n (%)			**0.122[b,1]**
Type-1	24 (9.1)	239 (90.9)	
Type-2	0	6 (100)	
Type-3	1 (33.3)	2 (66.7)	
Type-5	0	23 (100)	
Type-6	0	1 (100)	
Prevalence of HA atherosclerosis according to HA anatomy, n (%)			**0.034[b,2]**
Type-1	12 (5.8)	194 (94.2)	
Type-2	5 (20.8)	19 (79.2)	
Type-3	6 (18.7)	26 (81.3)	
Type-4	0	3 (100)	
Type-5	0	13 (100)	
Type-6	1 (100)	0	
Type-7	1 (50)	1 (50)	
Type-8	0	3 (100)	
Type-9	0	6 (100)	
Unclassified	0	6 (100)	
Patients with LGA atherosclerosis, n (%)	3 (12)	1 (%0.3)	**0.002[c]**
Total RA calcium score (median, [range])	2 [0-6]	1 [0-6]	**<0.001[d]**
SMA calcium score (median, [range])	1 [0-3]	0 [0-3]	**<0.001[d]**
SA calcium score (median, [range])	2 [0-3]	0 [0-3]	**<0.001[d]**
Total AA atherosclerosis score (median, [range])	5 [3-8]	4 [2-9]	**0.029[d]**
Total IA calcium score (median, [range])	11 [2-18]	6 [0-18]	**<0.001[d]**

AA: Abdominal aorta, HA: Hepatic artery, IA: Iliac artery, LGA: Left gastric artery, RA: Renal artery, SA: Splenic artery, SD: Standard deviation, SMA: Superior mesenteric artery

[a] Independent sample t-test, [b] Chi-square test, [c] Fisher's exact test, [d] Mann-Whitney U test

[1]As there were not enough cases in the Types-2, 3, and 6 anatomy groups, a comparison of HA atherosclerosis was only made between patients with Type-1 and Type-5 anatomy.

[2]Post Hoc analysis indicated that patients with Type-2 and Type-3 HA anatomy had a higher prevalence of atherosclerosis (p= 0.027 and p= 0.044, respectively).

Binary logistic regression analysis revealed that SMA calcium score (HR: 1.898, 95% CI: 1.002-3.607, p=0.05), SA calcium score (HR: 2.626, 95% CI: 1.485-4.643, p=0.001), and total IA calcium score (HR: 3.063, 95% CI: 1.162-8.077, p=0.024) were independent risk factors for HA atherosclerosis.

In this study, only the presence of calcified plaque in other branches of the AA was evaluated. In patients with AA atherosclerosis, calcified plaque was found most frequently in the main IAs and internal IAs. The frequency of calcified plaque was lower in the SA and SMA than in other branches (Table 3).

Table 3. Prevalence of the calcified plaque in other branches of the abdominal aorta

Branch of the abdominal aorta	Calcified plaque present n (%)	Calcified plaque absent n (%)
Splenic artery	89 (30.1)	207 (69.9)
Superior mesenteric artery	89 (30.1)	207 (69.9)
Right renal artery	125 (42.2)	171 (57.8)
Left renal artery	122 (41.2)	174 (58.8)
Right common iliac artery	252 (85.1)	44 (14.9)
Right external iliac artery	110 (37.2)	186 (62.8)
Right internal iliac artery	204 (68.9)	92 (31.1)
Left common iliac artery	244 (82.4)	52 (17.6)
Left external iliac artery	110 (37.2)	186 (62.8)
Left internal iliac artery	213 (%72)	83 (28)

DISCUSSION

In our study, the prevalence of HA atherosclerosis in adult patients with AA atherosclerosis was found to be 8.4%. The most common type of HA atherosclerosis was calcified plaque in the CHA. In logistic regression analysis, SMA calcium score, SA calcium score, and total IA calcium score were found to be independent risk factors for HA atherosclerosis.

Atherosclerosis is a chronic disease affecting large and medium-sized arteries and is a significant cause of morbidity and mortality in both developed and developing countries. The right and left HAs are the primary sources of blood supply to intrahepatic bile ducts, and their stenosis or occlusion can lead to ischemic biliary complications (9, 10). HA atherosclerosis detected during liver transplantation or liver surgery has been reported in the literature (2, 11, 12). Assessment of HA atherosclerosis in liver transplant candidates is critical, as recipients of grafts from donors with HA atherosclerosis have a risk of vascular complications of approximately 2-9%. Progression of atherosclerosis in the donor HA after transplantation may lead to HA stenosis/occlusion. Therefore, cases with severe atherosclerosis in the CHA are often not suitable for liver transplant donors (12).

There is insufficient data in the literature regarding the significance of HA atherosclerosis in individuals without underlying health issues. One study of liver biopsies in diabetic patients found an association between hepatic arteriosclerosis and biliary ductular proliferation, duct loss, cholestasis, and elevated alkaline phosphatase levels (13). It is well established that arteriosclerosis occurs more frequently in the presence of atherosclerosis. Therefore, patients with HA atherosclerosis are thought to be at risk of cholestasis and elevated liver enzymes due to arteriosclerosis-related damage to the bile ducts.

Only one study in the literature has investigated the prevalence of HA atherosclerosis. In a postmortem study of 201 patients (mean age 69 years) by Vauthey et al. in 1987, HA atherosclerosis was found in 7.8% of patients at autopsy and in 7% of patients at arteriography. This study reported a positive correlation between HA atherosclerosis and systemic atherosclerosis ($p<0.001$), but it is not clear which branches of the AA were examined in the assessment of systemic atherosclerosis (14). The prevalence of HA atherosclerosis found in our study is higher than in the study by Vauthey et al. In our study, we also evaluated the calcium scores of AA branches and analyzed the relationship between these scores and HA atherosclerosis. SMA, SA, and total IA calcium scores were found to be independent risk factors for HA atherosclerosis (p values 0.05, 0.001, and 0.024, respectively). Our results show a positive correlation between systemic atherosclerosis and HA atherosclerosis, similar to the study by Vauthey et al.

Age is a risk factor for atherosclerosis (15). Similarly, in our study, the age of patients with HA atherosclerosis was higher than those without (70±7.67 vs. 66±9.3, $p=0.041$). However, age was not found to be an independent risk factor for HA atherosclerosis in logistic regression analysis.

When the relationship between HA anatomy and HA atherosclerosis was analyzed, it was found that the prevalence of HA atherosclerosis was higher in patients with Type-2 and Type-3 anatomy ($p=0.034$). HA atherosclerosis was found in 20.8% of patients with Type-2 anatomy and 18.7% of patients with Type-3 anatomy. The prevalence of HA atherosclerosis was 5.8% in patients with Type-1 anatomy, which is the most common HA anatomy. The change in HA branching pattern in patients with Type-2 and Type-3 anatomy may have led to a change in wall shear stress. A decrease in wall shear stress has been shown to increase the prevalence of atherosclerosis (16). Reduced wall shear stress in HA in patients with Type-2 and Type-3 HA anatomy may have led to an increase in the prevalence of HA atherosclerosis. Knowing that the prevalence of HA atherosclerosis is increased in liver transplant donor candidates with Type-2 and Type-3 HA anatomy is essential in the evaluation of these patients. However, logistic regression analysis did not identify HA anatomy as an independent risk factor for HA atherosclerosis, probably due to the small number of cases.

HA atherosclerosis was higher in patients with LGA atherosclerosis than those without ($p=0.002$). However, the presence of LGA atherosclerosis was not found to be an independent risk factor for the HA atherosclerosis in logistic regression analysis. This finding may be due to the insufficient number of patients with LGA atherosclerosis. Given that LGA is a small-calibre vessel and our study was based on CTA images, small soft plaques in the LGA may not have been detected in this study. Therefore, the prevalence of LGA atherosclerosis in our study may have been underestimated.

In our study, only calcified plaques were evaluated in terms of atherosclerosis in AA branches other than HA, and soft plaques were not assessed. Therefore, in this study, the prevalence of atherosclerosis in other branches of the AA was calculated based on the presence of calcified plaque, which may lead to an underestimation of the prevalence of atherosclerosis in other branches of the AA. However, even when only the presence of calcified plaque was assessed, the prevalence of atherosclerosis in the HA was lower than the prevalence of atherosclerosis in other branches of the AA. Similarly, the prevalence of atherosclerosis in the LGA (1.4%), one of the celiac trunk branches, was lower than in other branches of the AA. The prevalence of atherosclerosis in the SA was the same as in the SMA. These results suggest that the prevalence of atherosclerosis in the SA, HA, and SGA, the branches of the celiac trunk, is quite different from each other. The branching pattern of the celiac trunk may lead to different wall shear stress in these vessels, and the high wall shear stress in the HA and SGA may make these vessels less affected by atherosclerosis.

Our study has several limitations. Our study was performed on CTA images, and calcium scores were evaluated

Supplementary Table 1: Definitions used for visual scoring of calcifications (7)

Location	Grades			
	0 (Absent)	1 (Mild)	2 (Moderate)	3 (Severe)
Coronary per LM, LAD, LCX, and RCA	Absent	1–2 calcifications	3–4 calcifications or 1 calcification extending >0.5 cm	>4 calcifications or 1 calcification extending >1 cm
Aorta per ascending, arch, and infra renal	Absent	1–3 calcifications	4–6 foci or 1 calcification ≤1 cm	>6 foci or 1 calcification extending >2 cm
Aorta descending	Absent	1–5 calcifications	6–10 calcifications or 1 calcification ≤1 cm	>10 calcifications or 1 calcification extending >2 cm
Supra-aortic per brachiocephalic artery, common carotid artery, and subclavian artery	Absent	1–2 calcifications	3–4 calcifications or 1 calcification extending >0.5 cm	>4 calcifications or 1 calcification extending >1 cm
Infra-aortic per common iliac artery, internal iliac artery, external iliac artery, and femoral artery	Absent	1–3 calcifications	4–6 calcifications or 1 calcification extending >1 cm	>6 calcifications or 1 calcification extending >2 cm
Aortic valve	Absent	Minor calcification that was minimally visible	Localized calcification extending >0.5 cm	Severe aortic valve calcification involving all three cusps or extending >1 cm
Renal artery	Absent	1–2 calcifications	3–4 calcifications or 1 calcification extending ≤0.5 cm	>4 calcifications or 1 calcification extending >1 cm
Splenic artery	Absent	1–3 calcifications	4–5 calcifications or 1 calcification >1 cm	>5 calcifications or 1 calcification >1.5 cm

Supplementary Table 2: Definitions Used for the Grading of AA Atherosclerosis Score (8)

Aortic wall abnormalities	Grades			
	0	1	2	3
Plaque thickness (0–2)	Absent	<5 mm	≥5 mm	
Wall irregularity (0–2)	Absent	<50% Wall circumference	≥50% Wall circumference	
Plaque ulceration (0–1)	Absent	Present		
Wall calcification (0–3)	Absent	≤Foci	4–5 Foci or 1 calcification extending for ≥3 slices *	>5 Foci or >1 calcification extending for >3 slices

*A 5-mm slice thickness is used

semiquantitatively due to the lack of a non-contrast phase. The relationship between systemic diseases (such as diabetes mellitus) and HA atherosclerosis was not assessed. As our study was performed on CTA images, it may not have been sufficient to detect small soft plaques, especially in thin arteries. Therefore, the prevalence of HA atherosclerosis found in our study needs to be confirmed by angiographic and postmortem studies in larger groups of patients.

CONCLUSION

Our study showed that HA atherosclerosis occurs in 8.4% of adults with AA atherosclerosis, with calcified plaque in the common HA being the most common form. Advanced age and specific types of HA anatomy (Type-2 and Type-3) were associated with a higher prevalence of HA atherosclerosis. Furthermore, SMA, SA, and total IA calcium scores emerged as independent risk factors for HA atherosclerosis. These findings reinforce the correlation between systemic atherosclerosis and HA involvement.

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