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Research Article

Incidence of Coronary Atherosclerosis Plaques in Patients Showing Thoracic Aortic Calcifications on a Low Dose Chest CT Scan

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Abstract

Introduction: Thoracic aortic calcification (TAC) and coronary artery disease (CAD) share the same risk factors. The main objective of this study is to evaluate the incidence of CAD on coronary artery calcium scoring (CACS) and coronary computed tomography angiography (CCTA) when TAC are present on low dose chest computed tomography (LDCT).

Methods: Patients underwent a LDCT with either a CACS or CCTA. Visual assessment of TAC was done for the LDCT, while imaging reports were reviewed for CACS and CCTA findings.

Results: Among 504 patients, 50.2% underwent a CCTA and 49.8% a CACS. Out of the 504 patients, 280 patients (55.6%) had TAC. 71.4% of patients with TAC were males, and the mean age of patients with TAC was high (mean = 60.9 ± 10.2 years) compared to patients with no TAC (mean = 46.9 ± 8.4 years) ($p < 0.001$). The mean calcium score (mean = 262.6 ± 555.9 mg/Dl) and the rate of abnormal CCTA (81.3%) were higher in patients with TAC compared to non-TAC patients (36.8%) ($p < 0.001$).

Conclusion: Our study showed that patients with TAC had a positive CACS that was higher than the one in patients without TAC. Moreover, patients with TAC had abnormal findings on CCTA.

Keywords: Coronary Artery Calcium Scoring; Coronary Artery Disease; Coronary Computed Tomography Angiography; Thoracic Aortic Calcifications.

Introduction

Atherosclerosis is a systemic inflammatory disease that remains the leading cause of death worldwide [1]. It affects multiple vascular territories and is the origin of different pathologies including aortic atherosclerosis, coronary artery disease (CAD), and cerebrovascular disease. Since these pathologies have the same risk factors, the presence of atherosclerosis in one vascular territory may warrant the need to assess other vessels for signs of disease.

With the increased practice of low dose chest computed tomography (LDCT) for lung cancer screening and other lung diseases, thoracic aortic calcifications (TAC) are encountered more frequently. Unfortunately, these findings remain underreported [2]. Radiological examination is crucial for the screening of CAD and characterization of the plaque burden. The two most common non-invasive radiological modalities used are coronary artery calcium (CAC) scoring and coronary computed tomography angiography (CCTA).

The relationship between TAC and CAD was studied worldwide. In the USA, the MESA study showed that TAC have the same traditional risk factors as CVD and that descending TAC are a strong predictor of CAD [3-4]. Similar studies were conducted in Italy, Germany, Korea, and Israel [5-6]. However, no

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studies evaluated simultaneously the incidence of CAD by CAC score or CCTA when TAC were present.

The main objective of this study is to evaluate the incidence of CAD when TAC is present. Proving that a positive correlation exists between TAC and CAD would be beneficial in improving morbidity and mortality. In fact, it can permit early intervention by modification of risk factors and initiation of pharmacological treatment.

Materials and Methods

This was a retrospective unicentric study conducted among 504 patients who underwent a low dose CT thorax with either a CCTA or a CACS between 2016 and 2018.

Patients with a history of valve replacement, congenital malformations, prior myocardial infarction, percutaneous transluminal coronary angioplasty (PTCA) and coronary artery bypass graft (CABG) were excluded.

The study population was divided into two groups, the first cohort underwent LDCT with a CACS, while the second cohort underwent a LDCT with CCTA.

All imaging reports were reviewed and recorded. Imaging data was also reviewed for visual assessment of aortic calcifications.

The presence or absence of TAC and their location was reported based on the LDCT findings.

The CACS findings were reported, and when positive; the CACS was specified. The CCTA findings were recorded as positive or negative, and when present; the type of plaques was specified. Patient's age and gender were also recorded.

Image Acquisition

CACS

A non-contrast CT scan (NCCT) of the chest was acquired using the LightSpeed VCT (Volume CT) on a 64-slice volumetric scanner GE healthcare (VCT 64). Prospective gated, axial CT acquisitions were acquired without prior preparation of the patient regardless of their cardiac rhythm, with a slice thickness of 2.5 mm, a field of view of 22 cm, and a detector coverage of 20 mm. The tube voltage was set at 120 kV and the effective radiation dose was less than 3 mSv. The Agatston scoring method was used for the analysis of the CACS see in (figure 1).

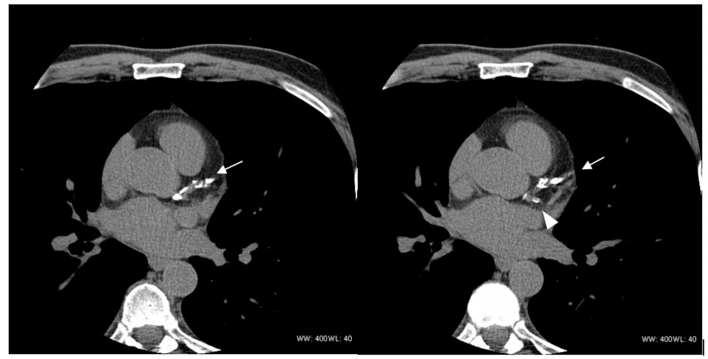

Figure 1: CACS scan depicting coronary calcifications along the left anterior descending artery (arrow) and at the level of the circumflex artery (arrowhead).

CCTA

A contrast-enhanced CT scan of the chest was acquired using the VCT 64. Gated, helical acquisitions were obtained with a slice thickness of 0.6 mm and a detector coverage of 40 mm. The tube voltage was set at 120 kV and the effective radiation dose was under 20 mSv see in (figure 2).

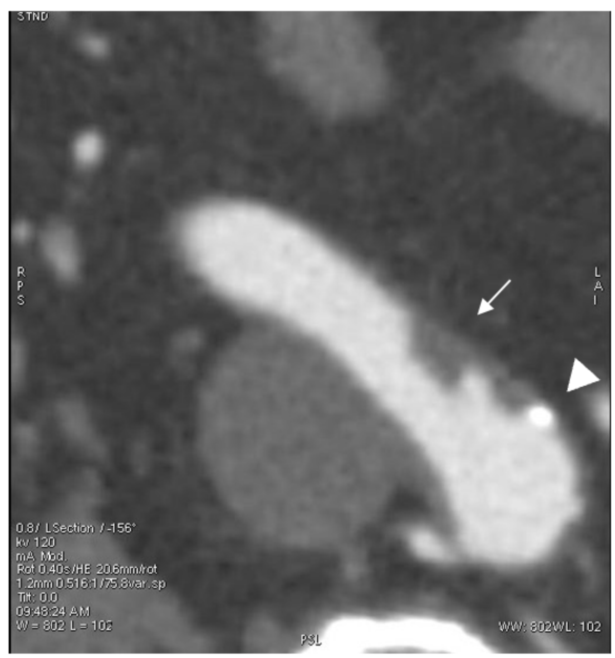

Figure 2: CCTA displaying fibrofatty (arrow) and fibrocalcific (arrowhead) plaques at the level of the LA

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Statistical analysis

Data was analysed using the IBM SPSS version 25. A descriptive analysis was enrolled, and the variables were presented as per their type. The categorical variables were presented as frequency and proportions (example: gender, TAC). The continuous variables were presented as the frequency, mean, median and standard deviation (example: age, calcium level).

The analysis was enrolled to test the difference between:

- TAC and CACS.
- TAC and CCTA findings.

The tests used in the analysis included Chi-square test, Fisher exact test, and a Mann-Whitney test.

A statistically significant correlation was set at 5% (p-value less than 0.05).

Results

Out of the 504 patients, 50.2% underwent a CCTA and 49.8% a CACS. 280 patients (55.6%) had TAC. Among the patients with TAC, 50.4% underwent a CACS and 49.6% a CCTA. The patients were equally distributed between the two exams in function of the TAC.

TAC

The studied population was distributed between 79% of males and 21% of females. There was a statistically significant difference between TAC and gender ($p < 0.001$). Among the 280 patients with TAC, 71.4% were males and 28.6% were females. Whereas, among the 224 without TAC, 88.4% were males and 11.6% were females see in (table 1).

		Thoracic Aortic Calcification		**Total (N = 504)**	**P-value**
		No (N = 224)	**Yes (N = 280)**		
Gender	**Male**	198	200	398	0.000*
		88.4%	71.4%	79.0%	
	Female	26	80	106	
		11.6%	28.6%	21.0%	
Age	**Mean**	46.97	60.86	54.69	0.000¥
	Standard Deviation	8.45	10.17	11.69	
	Min - Max	29 - 79	35 - 87	29 - 87	
Age	**Age < 54**	185	78	263	0.000*
		82.6%	27.9%	52.2%	
	Age ≥ 54	39	202	241	
		17.4%	72.1%	47.8%	
*Chi-square test ¥ Mann Whitney test					

Table 1: Demographic characteristics by TAC

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The mean age of the studied population was 54.7 ± 11.7 years. There was a statistically significant difference between TAC and age ($p < 0.001$). In patients with TAC, the mean age was higher (mean = 60.9 ± 10.2 years) compared to patients with no TAC (mean = 46.9 ± 8.4 years) ($p < 0.001$). When stratifying the population by median age (54 years), the results showed that 72.1% of TAC patients were older than 54 years, whereas, 82.6% of patients without TAC were 54 years of age ($p < 0.001$).

TAC was located at the level of the aortic arch predominantly (87.9%), followed by the thoracic descending aorta (47.9%), and the ascending aorta (32.9%). 51.8% of patients had calcifications in one segment of the thoracic aorta, 27.9% in two, and 20.4% had calcifications in all three segments.

TAC and calcium scoring

The mean calcium score in the studied population (251 patients) was 172.8 ± 450.1 mg/dL. It was higher in patients with TAC (mean = 262.6 ± 555.9 mg/Dl) compared to patients without TAC (mean = 57.7 ± 209.7 mg/Dl) ($p < 0.001$).

Among the patients with TAC, 74.5% had a positive CACS. In patients without TAC, 40% had positive calcium result. The risk of having TAC and a positive calcium score was 4.375 (95% [CI] 2.556 – 7.488). The sensitivity of Calcium scoring in TAC was 61.4% and the specificity was 45% see in (table 2).

		Thoracic Aortic Calcification		Total (N = 251)	P-value	OR	95% CI
		No (N = 110)	Yes (N = 141)				
Calcium Score	Mean	57.70	262.59	172.80	0.000	------	------
	SD	209.66	555.93	450.12			
	Min - Max	0 - 1569	0 - 3962	0 - 3962			
Calcium Result	Negative	66	36	102	0.000	4.375	2.556 - 7.488
		60.0%	25.5%	40.6%			
	Positive	44	105	149			
		40.0%	74.5%	59.4%			
Sensitivity		61.4%					
Specificity		45.0%					
* Chi-square test ¥ Mann Whitney test							

Table 2: TAC and calcium score

TAC and CCTA

The rate of abnormal CCTA was higher in patients with TAC (81.3%) compared to patients without TAC (36.8%) ($p < 0.001$). Moreover, the rate of having fibrocalcific plaques on CCTA was higher in TAC patients (50.4%) compared to patients without TAC (18.4%) ($p < 0.001$). The incidence of fibrofatty plaques on CCTA was lower in TAC patients (2.9%) compared to patients without TAC (12.3%) ($p = 0.004$). The rate of having mixed plaques on CCTA was higher in TAC patients (28.1%) compared to non-TAC patients (6.1%) ($p < 0.001$). The risk of having TAC and an abnormal CCTA results was 0.134 (95% [CI] 0.076 – 0.238). The sensitivity of CCTA test in TAC was 61.1% and the specificity was 38.2% see in (table 3).

		TAC		Total (N = 253)	P-value	OR	95% CI
		No (N = 114)	Yes (N = 139)				
CCTA Result	Abnormal	42	113	155	0.000*	0.134	0.076 - 0.238
		36.8%	81.3%	61.3%			
	Normal	72	26	98			
		63.2%	18.7%	38.7%			
CCTA Fibrocalcific	No	93	69	162	0.000*	4.493	2.519 - 8.013
		81.6%	49.6%	64.0%			
	Yes	21	70	91			
		18.4%	50.4%	36.0%			
CCTA Fibrofatty	No	100	135	235	0.004¥	0.212	0.068 - 0.662
		87.7%	97.1%	92.9%			
	Yes	14	4	18			
		12.3%	2.9%	7.1%			
CCTA Fibrocalcific / Fibrofatty	No	107	100	207	0.000*	5.961	2.549 - 13.940
		93.9%	71.9%	81.8%			
	Yes	7	39	46			
		6.1%	28.1%	18.2%			
Sensitivity (CCTA)		61.1%					
Specificity (CCTA)		38.2%					
*Chi-square test ¥ Fisher Exact test							

Table 3: TAC and CCTA

Discussion

Between the 504 patients evaluated, 280 had TAC. Out of the 280 patients with TAC, the majority (71.4%) were males. The incidence of CVD in men is superior to the one in pre-menopausal women. According to Lloyd-Jones et al, the lifetime risk of CAD was one in two in men and one in three in women [7]. However, after menopause, the incidence increases [8]. This can be explained by the protective effects of estrogen [9].

Age is a non-modifiable risk factor of atherosclerosis. Savji et al showed a significant increase in the prevalence of atherosclerosis in each vascular territory with advanced age [10]. Our findings are concurrent with this study. We showed that TAC was more common after the age of 54 with a mean age of 60 years. In fact, in this study, 72.1% of patients with TAC were older than 54 years. On the other hand, 82.6% of patients younger than 54 years of age did not have TAC.

TAC was found in each of the three segments of the thoracic aorta. The aortic arch was the most common location of TAC. This location is more prone than others due to the turbulence of flow, and absence of vasa vasorum [11].

In our study, out of the 141 patients with TAC 74.5% had a positive calcium score. Moreover, 60% of patients with no TAC had a negative CACS. It is also interesting to note that the patients with TAC had a higher CACS, for instance, the mean CACS in patients with TAC was 262.6 as compared to a mean of 57.7 in patients without TAC.

Statistically, this calculates to an odds ratio (OR) of 4.375, indicating that patient with TAC were 4.3 times more likely to have coronary calcifications.

These findings are in accordance with the MESA study and can be explained by the similarity of risk factors for both TAC and CAD and the systemic properties of atherosclerosis [12]. Furthermore, Brodov et al demonstrated that TAC are an independent predictor of CAC conversion and proposed an earlier repeat of CACS in patient with advanced TAC [13]. Also, Hu and his colleagues established that the presence and extent of aortic root calcification was associated with the presence and severity of CAC on CACS [14].

Similarly, we found that the percentage of abnormal findings on CCTA was higher in patients with TAC. As a matter of fact, our analysis revealed that 81.3% of patients with TAC had calcic or fibrofatty coronary plaques. Moreover, individuals with TAC were approximately five times more likely to have calcic plaques or mixed plaques on CCTA (OR of 4.49 and 5.96 respectively). Although not much evaluated, the correlation of TAC and abnormal CCTA was demonstrated in some studies. Jang et al measured the association between thoracic aortic changes and CAD severity assessed by CCTA. They quantified TAC, measured aortic wall thickness, calculated aortic distensibility and compared it to the extent of coronary stenosis. They concluded that LDCT evaluation of the thoracic aorta could be a modality of screening for CAD [15]. Similarly, Cecere and his colleagues assessed the prevalence of CAD using CCTA among patients with aortic, carotid and femoral atherosclerosis. They observed positive correlation between polyvascular atherosclerosis and abnormal CCTA [5].

Additionally, age was a significant risk factor for the development of CVD. Among 132 patients older than 54 years of age, 84.7% had both TAC and an abnormal CCTA. This fortifies results from previous studies [10].

Moreover, numerous studies reviewed the relationship between abdominal aortic calcification and CVD. For example, An and colleagues demonstrated that calcification of the abdominal aorta indicates a high probability of CAD and in this instance abdominal CT could lead to early detection of CAD [16]. Interestingly, Pickhardt et al assessed the ASCVD risk with automated body composition biomarkers during abdominal CT. Their study showed that quantification of aortic calcium can all help in predicting CVD [17]. The main limitation of our study was that the sample chosen was not representative of the general population and monocentric. More females should be included and stratification by age and menopausal status would also be helpful.

Moreover, the severity of TAC was not assessed. Consequently, no correlations were made between the extent of TAC and CAD severity.

Conclusion

In conclusion, this study showed that TAC was common and could be visualized on LDCT. They were more prevalent in men compared to premenopausal women. The incidence of TAC increased with age. The aortic arch territory was more frequently affected. Patients with TAC had a positive CACS that was higher than the one in patients without TAC. Moreover, patients with TAC had abnormal findings on CCTA. Finally, the results of our analysis suggested that TAC are a strong predictor for CAD. Our data agrees with previous studies. When present, risk stratification by assessment of TAC may provide important information for management of CAD and other atherosclerotic diseases. As the use of chest CT scan and particularly LDCT is significantly increasing for lung cancer screening and other pathologies even in the emergency settings. Since the information on TAC is readily discernable, once CT examination is completed, without the use of additional time, radiation or reformatting, it is therefore important to report TAC as it can previse CAD and thus reduce the burden, morbidity and mortality of CAD and other CVD.

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