



## Correlation between Aortic Wall Thickness and Coronary Artery Disease by 64 Slice Multidetector Computed Tomography

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### ABSTRACT

**Introduction:** Atherosclerotic cardiovascular disease is a dispersed pathology involving the coronary arteries, carotid arteries, aorta and peripheral arteries. It has been previously suggested that coronary and aortic atherosclerosis may be associated. Imaging of the aorta and the aortic wall can be performed by various imaging modalities including state-of-the-art multidetector computer tomography (MDCT). This study aimed to investigate a possible association between the MDCT-measured thickness of the thoracic aorta and the presence of coronary artery disease (CAD) as well as its severity.

**Methods:** Three hundred and fifty candidates of coronary computer tomography angiography (CTA) with signs and symptoms suggestive of CAD were recruited in Tabriz Parsian and Iran CTA Centers. Contrast-enhanced MDCT examinations were performed using a 64 detector scanner. Maximum aortic wall thickness in the mid-portion of descending thoracic aorta (region of pulmonary trunk to diaphragm) was measured perpendicular to the center of the vessel.

**Results:** CAD was confirmed in 189 cases (54%) and the remaining 161 cases served as controls. The mean age of the cases, as well as the percentage of male subjects was significantly higher in the CAD group. The mean aortic wall thickness was also significantly higher in the patient group ( $2.21 \pm 0.63$  mm vs.  $1.88 \pm 0.58$  mm;  $P < 0.001$ ). In multivariate analysis, however, the two groups turned up comparable as to the aortic wall thickness ( $P = 0.31$ ). The optimal cut-off point of aortic wall thickness was  $\geq 2$  mm in discriminating between CAD+ and CAD- groups, with a corresponding sensitivity and specificity of 65% and 57%, respectively. There was no significant association between aortic wall thickness and the severity of CAD (the number of significantly occluded coronary arteries).

**Conclusion:** Aortic wall thickness is apparently neither an independent predictor of CAD nor is it associated with the severity of CAD in candidates of CTA.

### Introduction

The importance of coronary artery disease (CAD) is obvious concerning the epidemiologic figures in general population. Based on Framingham study, risk of developing symptomatic CAD after 40 years of age is 49% for men and 32% for women.<sup>1</sup> Current data have shown association of presence of CAD and peripheral atherosclerosis. It has been reported that CAD is associated with carotid intima-media thickness, presence of atherosclerotic plaques in aorta, presence of calcifications in mitral ring,

and lower limb atherosclerosis.<sup>2</sup> In addition, there is a strong association between presence and burden of aortic plaques, and presence and extent of CAD.<sup>3,4</sup> Usefulness of measurement of arterial wall thickness has been shown for prediction of cardiovascular disease risk.<sup>5,6</sup> Takasu *et al* demonstrated that aortic plaque detected by enhanced CT scan is a better predictor of CAD compared to other non-dependent aortic parameters. They also concluded that aortic calcification seen in non-enhanced CT scan images is very specific for CAD.<sup>7</sup> Sensitivity of 64 slice

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multi-detector CT (64-MDCT) to detect coronary artery occlusion is estimated to be 83 to 99%, with specificity of 93 to 99% and negative predictive value (NPV) of 95 to 100%.<sup>8</sup> In a study by Belhassen *et al.*, carotid intima-media thickness (CIMT) < 0.55 mm and aortic intima-media thickness (AoIMT) < 3 were good predictors of absence of CAD. CIMT had sensitivity of 100%, specificity of 50%, and NPV of 100%. For AoIMT, sensitivity was found to be 98%, specificity 65%, and NPV 99%.<sup>2</sup> Jeltsch *et al.* demonstrated that aortic wall thickness of 3 mm can predict CAD with specificity of 96.6%, sensitivity of 27.5%, and positive predictive value of 93.3%. Aortic wall thickness of 2.4 mm was associated with specificity of 81%, sensitivity of 55%, and positive predictive value of 83.5%.<sup>9</sup> The aim of this study is to evaluate descending thoracic aorta wall thickness as a potential predictor of CAD by 64-MDCT. If this association is found to be strong, one can suggest additional coronary artery evaluations in cases of incidental finding of increased aortic wall thickness, to prevent and early diagnose coronary artery complications.

### Materials and Methods

380 patients with age over 40, referred to coronary CTA were included in this analytical prospective study. The study was done in Tabriz Parsian and Iran CT angiography centers over a 17 month period. Exclusion criteria were history of coronary stent (17 patients), severe calcification of coronary arteries that interferes with CTA diagnosis (12 patients), and presence of thoracic aortic aneurysm (1 patient). Based on this criteria 350 patients finally entered the study. MDCT evaluations were done using Siemens Somatom Sensation 64 (Siemens Healthcare, Malvern PA). Axial 0.6 mm images synchronized with patient ECG were acquired and reconstructed as sagittal and coronal images using MIP and MPR techniques and Curved Multiplanar Reformat. Additional 3D reconstructions were done using VRT, Inspace and vessel view. Reconstructed images were reviewed for presence of CAD. Coronary artery occlusion was considered as greater than 50% narrowing in the artery (significant involvement). Maximum wall thickness in mid-portion of descending thoracic aorta (between pulmonary trunk and diaphragm) was measured perpendicular to the center of the aorta. Window of 1000 with center of 250 was used for this measurement. Concerning that differentiating aortic wall layers is not possible in images acquired by MDCT, maximal wall thickness (and not intima-media thickness) was used.

Data acquired from the study were reviewed using descriptive statistical methods (prevalence, percentage, mean  $\pm$  SD), and analyzed by *t*-test for quantitative data, or chi-square for qualitative data. Correlation between parameters was evaluated using Pearson's *r* Correlation. Multivariate logistic regression model was used to predict continuous variables. Receiver operating characteristic (ROC) curve was used to determine the cutting point for best specificity and sensitivity. Statistical analysis was

done using SPSS 16. *P* less than 0.05 was considered significant.

### Results

Based on coronary CTA findings, CAD was diagnosed in 189 patients (54%) and 161 patients (46%) were considered negative for CAD. 69 patients (36.5%) had no coronary artery with significant involvement (0VD). In 59 patients (31.2%) one coronary artery (1VD), in 35 patients (18.5%) 2 arteries (2VD), and in 26 patients (13.8%) 3 arteries (3VD) were significantly involved. In age group of 40-49, 70 cases (43.5%) had CAD and 28 cases (14.8%) were disease free. In age group of 50-59, 51 cases (31.7%) had CAD and 57 cases (30.2%) were diagnosed with no CAD. In age group of 60-69, 29 cases (18%) had CAD and 61 cases (32.3%) were disease free. In age group of  $\geq 70$ , 11 cases (6.8%) were diagnosed with CAD and 43 cases (22.8%) were disease free. Mean age of group with CAD was  $60.9 \pm 10.58$  (min 40, max 85) years, and mean age of non-diseased group was  $52.61 \pm 9.74$  (min 40, max 79) years. Using *t*-test for independent groups, mean age of CAD group was significantly greater than non-diseased group ( $P < 0.001$ ). 99 males (52.4%) and 90 females (47.6%) were studied in the CAD group, and there were 59 males (36.6%) and 102 females (63.4%) in non-diseased group. Based on the results of chi-square test, percentage of males was significantly higher in the CAD group compared to non-diseased group ( $P = 0.003$ ). Mean aortic wall thickness in CAD group was  $2.21 \pm 0.63$  mm (min 1, max 4.6 mm), and mean aortic wall thickness in non-diseased group was  $1.88 \pm 0.58$  mm (min 1, max 4 mm). Using *t*-test for independent groups, mean aortic wall thickness in CAD group was significantly higher than mean aortic wall thickness in non-diseased group ( $P < 0.001$ ; Figure 1). ROC curve for age and aortic wall thickness to discriminate CAD and non-diseased group is shown in Figure 2. Area under age curve was 0.72 ( $P < 0.001$ ), and area under aortic wall thickness curve was 0.65 ( $P < 0.001$ ). The best age cutting point to discriminate CAD and non-diseased group was 56.5 years with sensitivity of 66% and specificity of 68%. The best aortic wall thickness cutting point to discriminate CAD and non-diseased group was 2 mm with sensitivity of 65% and specificity of 57%. In logistic regression model percentage of males (Exp (B)=0.32,  $P < 0.001$ ), and mean of age (Exp (B)=1.09,  $P < 0.001$ ) were higher in CAD group compared to non-diseased group. In this model mean aortic wall thickness was not significantly different in two groups (Exp (B)=1.26,  $P = 0.31$ ). There was a positive and significant correlation between age and aortic wall thickness in CAD group (Pearson's  $r = 0.42$ ,  $P < 0.001$ ) (Figure 3A). Also a positive and significant correlation between age and aortic wall thickness was found in non-diseased group (Pearson's  $r = 0.56$ ,  $P < 0.001$ ; Figure 3B). Mean age of 0VD group was  $58.74 \pm 9.92$  years (min 40, max 82), for 1VD group  $60.69 \pm 11.35$  years (min 40, max 82), in 2VD group  $61.91 \pm 10.19$  years (min 46, max 85),

and mean age for 3VD group was  $65.77 \pm 9.76$  years (min 49, max 85). In one-way analysis of variance, mean age of the patients in these groups was significantly different ( $P=0.03$ ). In Tukey's HSD post-hoc test, this difference remained significant only between 0VD and 3VD groups ( $P=0.02$ ). In 0VD group we had 28 males (40.6%) and 41 females (59.4%), in 1VD group 33 males (55.9%) and 26 females (44.1%), in 2VD group 22 males (62.9%) and 13 females (37.1%), and in 3VD group 16 males (61.5%) and 10 females (38.5%). Based on chi-square test there was no significant difference between these groups ( $P=0.09$ ). Mean aortic wall thickness was  $2.15 \pm 0.58$  mm (min 1 max 3.7 mm) in 0VD group, it was  $2.20 \pm 0.61$  mm (min 1 max 3.9 mm) for 1VD group,  $2.18 \pm 0.79$  mm (min 1.1, max 4.6 mm) for 2VD group, and  $2.40 \pm 0.57$  mm (min 1.4, max 3.8) for 3VD group. In on-way analysis of variance mean aortic wall thickness was not significantly different in these groups ( $P=0.38$ ; Figure 4). Mean aortic wall thickness for CAD and non-diseased cases in age groups is

shown in Table 1. Based on *t*-test for independent groups, mean aortic wall thickness was not significantly different in any of these age groups.

### Discussion

In this research correlation of maximal wall thickness of descending thoracic aorta with presence and severity of CAD was studied. Previously it has been shown that atherosclerotic cardiovascular disease is a disseminated condition in which aorta, coronary, carotid, and peripheral

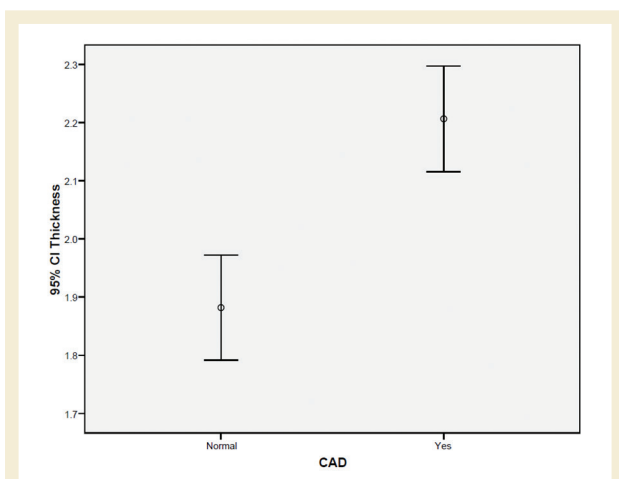


Figure 1. Mean aortic wall thickness (mm) in CAD and non-diseased group

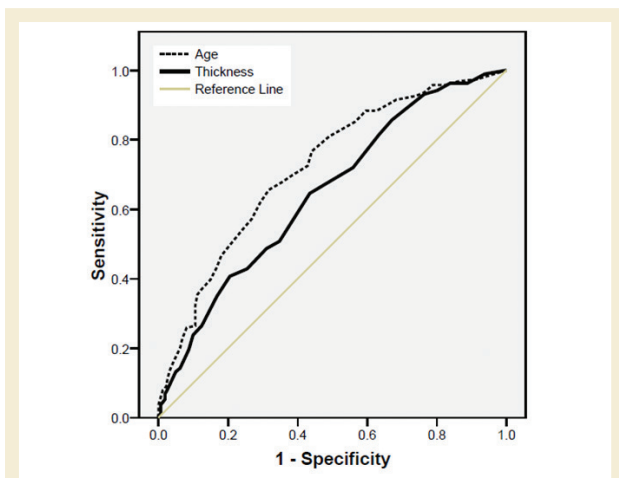


Figure 2. ROC curve for age and aortic wall thickness to discriminate CAD and non-diseased group

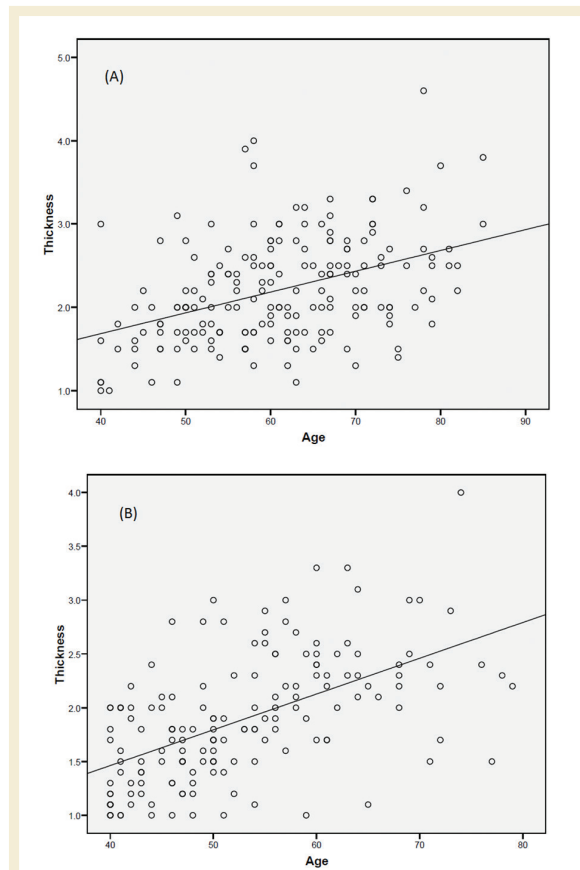


Figure 3. Correlation between age and aortic wall thickness (mm) in CAD group (A), and non-diseased group (B)

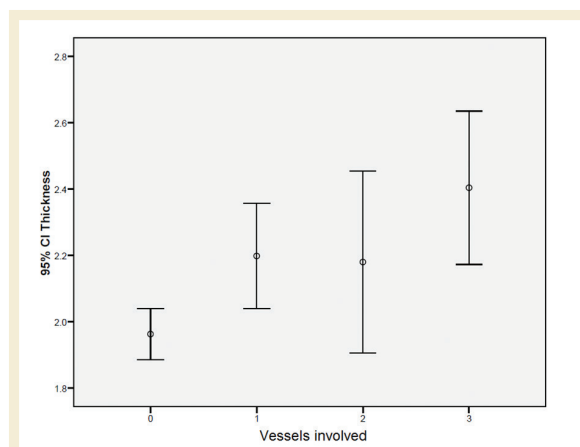


Figure 4. Mean aortic wall thickness (mm) based on number of diseased coronary vessels

**Table 1.** Mean aortic wall thickness (mm) in CAD and non-diseased groups based on age groups

Age group	CAD Group (n=189)	Non-diseased Group (n=161)	P
40-49 years	1.71±0.55	1.56±0.43	0.14
50-59 years	2.14±0.58	1.97±0.51	0.10
60-69 years	2.29±0.55	2.33±0.47	0.72
≥70 years	2.49±0.67	2.37±0.73	0.60

Data are in Mean±SD format

arteries are involved.<sup>10,11</sup> In two studies by Rohani *et al* and Couturier *et al* it has been demonstrated that thoracic aortic wall thickness, measured through trans-esophageal echocardiography, is positively correlated to severity of angiographic involvement of coronary vessels in CAD patients.<sup>12,13</sup> Meenakshisundaram *et al*, in a study on 40 patients with CAD and 30 normal cases, showed that thoracic aortic intima-media thickness measured by trans-esophageal echocardiography is correlated to CAD.<sup>14</sup> Also in other similar studies it has been concluded that atherosclerosis of thoracic aorta and CAD is associated with each other.<sup>15-20</sup> Tarzamni *et al* showed that histopathologic severity of atherosclerosis in ascending aorta/aortic arch is correlated to severity of CAD.<sup>21</sup> In our study maximal wall thickness of mid-portion descending thoracic aorta was significantly greater in CAD group compared to non-diseased group (2.21±0.63 mm vs. 1.88±0.58,  $P<0.001$ ). In this study aortic wall thickness measurement was done using MDCT, and presence or absence of CAD was diagnosed by CT angiography. Jeltsch *et al* in a similar study determined thoracic aortic wall thickness in 160 cases with probable CAD using MDCT. In their study mean aortic wall thickness was significantly higher in the CAD group (2.72 mm compared to 1.88 mm).<sup>9</sup> Jang *et al* measured maximal thoracic aortic wall thickness using MDCT in 120 cases with suspected CAD. Mean of aortic wall thickness was significantly higher in the diseased group (4.13 mm compared to 3.40 mm).<sup>22</sup> Our results were in par with results of these two studies. Using ROC curve it was shown that the best cutting point to discriminate CAD from non-diseased cases is the aortic wall thickness of  $\geq 2$  mm (sensitivity of 65% and specificity of 57%). In the study of Jeltsch *et al* this cutting point was considered to be  $\geq 3$  mm (sensitivity of 27.5% and specificity of 96.6%).<sup>9</sup> Although the cutting points in studies are different, it must be remembered that in our study we balanced sensitivity and specificity to find the cutting point, but in the other study sensitivity was sacrificed for better specificity. In univariate analysis mean aortic wall thickness was significantly higher in CAD group, but after controlling the effect of age and sex (which were both significantly different between two groups), this difference proved to be non-significant in multivariate analysis.

On the other hand, positive and significant correlation was found between aortic wall thickness and age of cases. Besides, there was no significant difference for mean aortic wall thickness among age groups. Thus it seems that

increased aortic wall thickness in CAD patients is mainly due to higher ages of the patients. Jeltsch *et al* demonstrated that there is a direct and significant correlation between age and aortic wall thickness.<sup>9</sup> A similar association of aortic wall thickness and age or sex of patients with CAD has been shown in other studies.<sup>23-27</sup> Using MDCT, Mao *et al* demonstrated that ascending aortic wall thickness is significantly related to age and male sex of patients with CAD. They suggested that for the study of atherosclerotic changes in CAD patients, the effect of age and sex must be controlled.<sup>28</sup> Results of current study confirm these conclusions. In This study there was no significant correlation between aortic wall thickness and severity of CAD (based on number of involved vessels). Also in the study of Jeltsch *et al* mean aortic wall thickness was not significantly different between patients with obstructive or non-obstructive CAD.<sup>9</sup> It must be mentioned that atherosclerosis process is very complex and is related to many factors in different vessels. Various arteries in different points are under different hydrostatic pressures, and vessel wall thickening patterns are different among them. It has also been shown that other factors (besides ages, sex, and race) can have effect on aortic wall thickness including hypertension, lipid profile, diabetes mellitus, anthropometric parameters such as height, BMI, and history of smoking.<sup>29-31</sup>

This study has had some limitations. Cases were included from patients that were referred to coronary CT angiography with some symptoms, so the non-diseased group was not completely normal. Also, as mentioned above, other factors besides age and sex can have effect on aortic wall thickness. Controlling possible effects of these factors can solidify results of the study. Measurement of other parts of aorta, including ascending part, aortic arch and abdominal aorta were not included in this study and could have had better results compared to this study.<sup>21</sup> It has also been shown that atherosclerotic aortic plaques are more correlated to CAD.<sup>7</sup> In addition using CT angiography as a gold standard to detect CAD status has its own limitations.

In conclusion, although aortic wall thickness after controlling age and sex parameters was not significantly correlated with the presence of CAD, its mean was higher in CAD patients for most age groups. Concerning that evaluating aortic pathologies, coronary arteries, and pulmonary emoli (Triple Rule-out protocol) in chest CT scans is easy with little extra expenses, it can be



recommended based on the findings of the current study.

**Ethical issues:** This study was reviewed and confirmed by the ethics committee of Tabriz University of Medical Sciences.

**Conflict of interests:** The authors declare no conflicts of interest.

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