Aortic Calcification Detected in a Mass Chest Screening Program Using a Mobile Helical Computed Tomography Unit

— Relationship to Risk Factors and Coronary Artery Disease —

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Background There is a significant relationship between calcification of the aortic arch (Arch) detected by chest X-ray examination and coronary artery disease (CAD), but the relationship between risk factors, CAD and aortic calcification detected during a mass screening program using a mobile helical computed tomography (CT) unit remains unknown.

Methods and Results In total 2,623 subjects (1,347 men, and 1,276 women; mean age, 52.9 ± 13.8) underwent an examination for lung cancer and tuberculosis using a mobile helical CT unit. The frequency of calcification was 19.6% in the Arch, 2.7% in the ascending aorta, and 10.1% in the descending aorta, values that were positively associated with age in both genders. Hypertension and smoking were significantly related to calcification of the thoracic aorta. There was a significant relationship between CAD and aortic calcification. The odds ratio of aortic calcification for patients with CAD increased as the number of calcified segments increased.

Conclusions These results suggest that detection of calcification in the thoracic aorta during a mass chest screening using a mobile helical CT unit can be used to evaluate the risk of CAD. (*Circ J* 2004; 68: 538–541)

Key Words: Aortic calcification; Mass screening; Mobile helical CT

Aortic calcification can be detected by chest X-ray, especially calcification in the aortic arch (Arch), and previous studies have shown a significant relationship between cardiovascular disease and calcification of the Arch.^{1–5} The development of computed tomography (CT) has enabled the non-invasive imaging of the cardiovascular system and calcification of the coronary arteries (CAC) and aorta can now be detected more reliably. Previous studies have revealed a strong relationship between coronary artery disease (CAD) and CAC detected by CT.^{6–13} The recent progression to multislice spiral CT and electron-beam CT (EBCT) has enabled noninvasive detection of significant coronary stenosis and occlusions^{14,15} and in a study of subjects who underwent EBCT examination for evaluation of CAC, the prevalence of aortic calcification was 23%.¹⁶ Another study showed that aortic calcification detected by CT was significantly related to age, hypertension (HT), diabetes mellitus (DM), smoking, alcohol consumption, hyperlipidemia, body weight, and, especially, vascular disease.¹⁷ The mobile helical CT unit was established in Japan in 1994, enabling the performance of large-scale medical examinations wherever they were needed and since 1995 it has been used to screen for lung cancer.^{18,19} We reported that there was a strong relationship between CAC and CAD in men under 60 years of age in the population undergoing mass screening using the mobile helical CT unit²⁰ and 11 cases with asymptomatic aortic aneurysm

have been detected.²¹ However, the prevalence of aortic calcification amongst the general population remains unknown and therefore, we investigated the frequency of calcification of the thoracic aorta and its relationship to risk factors and CAD.

Methods

The Chiba Anti-Tuberculosis Association advertised a mass screening program for lung cancer and tuberculosis and between 1995 and 1999 there were 2,633 participants who underwent CT screening after giving informed consent for this study. Ten subjects with aortic aneurysm, aortic dis-

Fig 1. CT image from the mass screening program. Shows calcification of the coronary arteries (left anterior descending branch (LAD), circumflex branch (LCX)) and descending aorta (Des).

(Received November 28, 2003; revised manuscript received March 10, 2004; accepted March 17, 2004)

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Fig2. Frequency of aortic calcification at different segments. Whole population (black bars), men (gray bars), women (white bars).

Fig3. Frequency of aortic calcification at different segments in men according to age group. Ascending aorta (white bars), aortic arch (black bars), descending aorta (gray bars). Subjects in each age group are presented in parentheses.

Fig4. Frequency of aortic calcification at different segments in women according to age group. Ascending aorta (white bars), aortic arch (black bars), descending aorta (gray bars). Subjects in each age group are presented in parentheses.

section, or aortitis, or who were undergoing dialysis were excluded, giving a total of 2,623 subjects (1,347 men, 1,276 women; age range, 15–90 years; mean age, 52.9 ± 13.8) for the present study.

The mobile helical CT unit consisted of a remodeled bus with a built-in CT scanner (CT-W950SR, Hitachi Medical Corporation, Tokyo, Japan). CT scanning was performed at a tube voltage of 120 kV, a tube current of 50 mA, with 10 mm-thick consecutive sections, 10 mm/s table speed, and slight breathing. The scanning range was from the apex of the lung to the diaphragm and the total scanning time was approximately 30 s, with radiation exposure of 3.6 mSv.

The CT data were stored on magnetic-optical disks and analyzed on a monitor. In this study, software to evaluate aortic calcification in quantity was not installed in the monitoring system, so 2 doctors visually examined all slices twice at separate times for the presence or absence of calcification (Fig 1). The mean time required for analysis was approximately 2 min and in terms of detecting aortic calcification, there was no discrepancy between either the 2 doctors or the 2 separate examinations.

We questioned the participants about risk factors (ie, history of HT, DM, hyperlipidemia, smoking, and alcohol use) and being diagnosed with CAD, and we only included

Table 1 Contributions of Risk Factors to Aortic Calcification Determined by Logistic Regression

Independent variable	Significance	Odds ratio (95% CI)
Ascending aorta		
HT	<i>p</i> <0.0001	3.23 (1.93–5.42)
Smoking	<i>p</i> <0.0001	3.44 (1.93–6.14)
Aortic arch		
HT	<i>p</i> <0.0001	2.78 (2.13–3.62)
Smoking	<i>p</i> <0.001	1.46 (1.10–1.94)
Descending aorta		
HT	<i>p</i> <0.0001	2.12 (1.55–2.89)
DM	<i>p</i> <0.001	1.99 (1.20–3.32)
Smoking	<i>p</i> <0.05	1.58 (1.10–2.28)

DM, diabetes mellitus; HT, hypertension.

The independent variables significantly related to aortic calcification are presented in this table.

those participants who had been medically diagnosed or treated for HT, DM, or hyperlipidemia. Participants who had quit smoking or the drinking of alcohol more than 1 year prior to the screening were considered to be non-smokers and nondrinkers. The category of CAD included participants who had been definitively diagnosed as having CAD on coronary angiography (CAG). Participants whose history of CAD was uncertain, those with a history of myocardial infarction (MI) or coronary intervention (ie, percutaneous transluminal coronary angioplasty (PTCA) or coronary artery bypass graft (CABG)) were also included in the category of CAD. We examined the frequency of calcification of the Arch, and in the ascending (Asc) and descending aorta (Des). In addition, we investigated the relationship between aortic calcification in these segments and risk factors and CAD.

Statistical analyses were performed using SPSS software (SPSS Japan Inc). Logistic regression analysis was used to evaluate the individual contribution of the risk factors to calcification of the thoracic aorta. Fisher's exact test was used to investigate the relationship between CAD and calcification of the thoracic aorta. All tests of significance were two-tailed and significance was defined as *p*<0.05.

Results

The frequency of aortic calcification was 2.7% (men, 3.9%; women, 1.5%) in the Asc, 19.6% (men, 20.0%; women, 19.2%) in the Arch, and 10.1% (men, 10.2%; women, 10.1%) in the Des (Fig 2) and these values increased with age in both genders (Figs 3,4). The relationship between risk factors and calcification of the Arch, and the Asc or Des is presented in Table 1. HT and smoking were significantly related to aortic calcification in all segments that were examined; DM was significantly related to calcification of the Des. Table 2 shows the relationship between CAD and aortic calcification. There were 14 cases that corresponded to the category of CAD (9 men, 5 women), including 10 cases with a history of MI, 2 cases of angina pectoris (AP) with PTCA, and 2 cases of AP with CABG. A significant relationship was observed between CAD and aortic calcification in all segments that were examined. The odds ratio of aortic calcification for patients with CAD was 6.04 (95% confidence interval, 1.33–27.51) in the Asc, 5.53 (1.91–16.0) in the Arch, and 9.07 (3.16–26.06) in the Des. This value increased to 7.74 (1.69–35.39) for both the Asc and Arch, to 9.28 (2.02–42.66) for both the Asc and Des, to 9.88 (3.39–28.78) for both the

Table 2 Relationship Between Coronary Artery Disease (CAD) And Aortic Calcification, Determined by Fisher's Exact Test

	Significance	Odds ratio (95% CI)
Asc	<i>p</i> <0.05	6.04 (1.33–27.51)
Arch	<i>p</i> <0.05	5.53 (1.91–16.0)
Des	<i>p</i> <0.0001	9.07 (3.16–26.06)
Asc + Arch	<i>p</i> <0.05	7.74 (1.69–35.39)
Asc + Des	<i>p</i> <0.05	9.28 (2.02–42.66)
Arch + Des	<i>p</i> <0.0001	9.88 (3.39–28.78)
Asc + Arch + Des	<i>p</i> <0.05	10.70 (2.32–49.37)

Asc, ascending aorta; Arch, aortic arch; Des, descending aorta.

Arch and Des, and to 10.70 (2.32–49.37) for all segments.

Discussion

It is possible to detect Arch calcification by chest X-ray examination;^{1–5} calcification of the Asc and Des is often not detected because of cardiac and mediastinal shadows. CT scanning does not have this drawback and thus allows easier and more precise diagnosis of aortic calcification and morphological abnormalities. In the present study, the frequency of aortic calcification at the examined segments increased with age. Calcification of the Asc was the least commonly detected in the various age groups. It is reported elsewhere that the aortic intimal change caused by atherosclerosis presents as a thickened aortic wall on enhanced CT, and that it is significantly associated with the extent of aortic calcification.²² In addition, the frequency of aortic intimal change is least frequently observed in the Asc.²² Those findings suggest that atherosclerosis is not likely to exist in the Asc. It is also known that atherosclerosis tends to develop in the meandering and bifurcating region of the aorta where the shear stress is weakened^{23,24} and therefore, we believe that the reason for the difference in the frequency of aortic calcification according to location is related to the difference in shear stress at the different segments.

Iribarren et al showed that age, HT and smoking were independently associated with Arch calcification¹ and we observed the same association in this study. However, other studies have shown that DM and hyperlipidemia are also related to aortic calcification^{4,17} and we think this discrepancy is related to differences of race and the eating habits of subjects with DM and hyperlipidemia. Our previous study showed that DM was significantly related to CAC²⁰ but in the present study, DM was related to calcification in the Des only. It has been reported that aortic intimal change is most commonly observed in subjects with HT, and that HT accompanied by DM and hyperlipidemia tends to accelerate the intimal change.²² Such findings suggest that the effect of DM on aortic calcification is weaker than that on CAC, and also suggest that DM and hyperlipidemia are factors those do not cause atherosclerosis directly, but rather accelerate the progress of atherosclerosis caused by HT.

It has been shown that the aortic intimal change presented on enhanced CT is significantly related to aortic calcification,²² and other studies have revealed that the aortic wall volume evaluated by intimal thickness is related to the severity of coronary artery stenosis.^{25,26} In the present study, there were only 14 cases of CAD, but despite the small number of cases, a strong relationship between CAD and aortic calcification at the different segments was observed, demonstrated by an increase in the odds ratio.

The finding of this study, that progression of atherosclerosis is related to CAD, confirms those of previous studies. We have already shown that there is a strong relationship between CAD and the CAC detected by CT^{6-13,20} and furthermore, in a long-term follow-up, a previous study revealed that among an asymptomatic population, subjects with CAC had a higher morbidity and mortality of CAD than those without CAC.²⁷ Other studies suggest that evaluation of the CAC score in the examination using EBCT can predict the long-term prognosis of CAD;²⁸⁻³¹ however, a study of the influence of aortic calcification on long-term prognosis has never been performed. It is also uncertain whether the presence of aortic calcification is definitive for detecting CAD in the asymptomatic population. Therefore, a longitudinal study to confirm the influence of aortic calcification on long-term morbidity of CAD in an asymptomatic population is required.

We previously reported on 11 cases (0.16%; n=6,971) with asymptomatic aortic aneurysms detected during a mass chest CT examination.²¹ In this study, all subjects underwent a chest X-ray examination prior to the CT screening, but there was only 1 patient suspected of having an aortic aneurysm on the chest X-ray examination, and the remaining 10 patients were diagnosed with aortic aneurysm by the CT screening. Furthermore, the cost of CT screening to detect asymptomatic aortic aneurysms is approximately three-tens that of a chest X-ray examination,²¹ all of which suggests that a mass chest CT screening is an accurate and cost-effective method of screening for asymptomatic aortic aneurysms.

Conclusion

Mass screening for lung cancer using a mobile helical CT unit is available for the general population of Japan and our results suggest that detection of aortic calcification in such programs is effective for evaluating the risk of CAD.

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