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# Distribution of coronary atherosclerosis in patients with coronary artery disease

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**Abstract** The distribution of coronary atherosclerosis has not been fully clarified. We measured coronary artery calcium score (CACS) in 624 consecutive patients for the right coronary artery (RCA), left main trunk (LMT), left anterior descending coronary artery (LAD), and left circumflex coronary artery (LCx), then calculated total CACS. Coronary artery calcium score was measured using the Agatston method. We divided these patients into four groups: CACS 1–100 (Group A, $n = 267$), CACS 101–400 (Group B, $n = 160$), CACS 401–1000 (Group C, $n = 110$), and CACS >1000 (Group D, $n = 87$). In Group A, B, and C, the CACS in LAD was significantly higher than in the other three arteries ($P < 0.0001$). In Group D, the CACS was not significantly different between LAD and RCA ($P = 0.6930$). In Groups A, B, and C, coronary artery calcium (CAC) was more frequently found in LAD compared with other arteries ($P < 0.0001$). However, in Group D the prevalence of CAC was not significantly different among the three arteries ($P = 0.4435$). Coronary artery calcium was found more frequently in LAD than in the other coronary arteries in patients with mild to high CAC, but not in those with very high CAC.

**Key words** Coronary artery calcium · Coronary artery disease · Computed tomography · Topography

## Introduction

Coronary artery disease is a leading cause of death in developing and developed countries.[1] Coronary artery calcification (CAC) signifies the presence of coronary atherosclerosis, and a strong linear correlation exists between total coronary artery atherosclerotic plaque burden and the extent of coronary artery calcification.[2,3] Patients without detectable CAC have a very low rate of cardiac death or myocardial infarction over 3–5 years of observation.[4,5]

A large number of pathological observations demonstrate that coronary atherosclerosis is more prevalent in the left coronary artery system, in particular in the proximal segments, than in the right coronary artery system.[6,7] Sixty-four-slice computed tomography (CT) has emerged as a promising method for evaluating coronary artery disease.[8–12] We therefore used 64-slice CT to study the distribution of CAC in coronary arteries.

## Patients and methods

### Patients

From December 2005 through March 2007, 624 consecutive patients with coronary risk factors underwent 64-slice CT. We divided these patients into four groups; CACS 1–100 (Group A, $n = 267$), CACS 101–400 (Group B, $n = 160$), CACS 401–1000 (Group C, $n = 110$), and CACS >1000 (Group D, $n = 87$).

### Sixty-four-slice CT

All patients were scanned with a 64-slice CT scanner (SOMATOM Sensation 64 Cardiac, Siemens Medical Solutions, Erlangen, Germany). Patients with a heart rate >70 beats/min received oral metoprolol 20 mg before the 64-slice CT scan. To achieve coronary vasodilation we administered sublingual nitroglycerin 0.8 mg before the scan.

A native scan without contrast dye was performed to determine the total calcium burden of the coronary tree (sequential scan with $32 \times 0.6$-mm collimation, tube current 60 mAs at 120 kV). A total of 64 overlapping 3.0-mm slices per rotation were acquired with the use of a focal spot periodically moving in the longitudinal direction (z-flying focal spot). Tube current was modulated according to the ECG, with a maximum current of 200 mAs during a time

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period of approximately 330 ms centered at 375 ms before the next R wave, and reduced by 80% during the remaining cardiac cycle (care dose system).

### Sixty-four-slice CT image interpretation

Computed tomography data sets were transferred to an offline workstation (Aquarius NetStation, Terarecon, San Mateo, CA, USA) for image analysis. A single operator interpreted the CT scan data. Intraobserver agreement was very high ($\kappa = 0.90$). We measured coronary artery calcium score (CACS) in the right coronary artery (RCA), left main trunk (LMT), left anterior descending coronary artery (LAD), and left circumflex coronary artery (LCx), then calculated total CACS with dedicated software. The results were expressed as Agatston scores. Agatston score is a commonly used scoring method that calculates the total amount of calcium on the basis of the number, areas, and peak Hounsfield units of detected calcified lesions.[13]

Informed consent for clinical procedures and research protocol was received from all patients studied. The study was approved by an institutional review board.

### Statistical analysis

Ages are expressed as medians and interquartile ranges. Discrete variables were expressed as counts or percentages, and compared with a chi-square test for independence or Fisher's exact probability test. Because the data for the coronary calcium score did not show a normal distribution, the Kruskal–Wallis test was used to determine differences among the four coronary arteries in each group. The Wilcoxon test was used to determine the differences between the two arteries in each group. A $P$ value of less than 0.05 was considered to be statistically significant.

## Results

Clinical characteristics of studied patients are shown in Table 1. Figure 1 shows the CACS in each group. In Group A, CACS in LAD was significantly higher than in the other three arteries (median [interquartile range]: LAD 17.0 [3, 38], RCA 0 [0, 8], LCx 0 [0, 1], LMT 0 [0, 0], $P < 0.0001$). In Group B, CACS in LAD was significantly higher than in the other three arteries (median [interquartile range]: LAD 99 [39, 149], RCA 28 [2, 77], LCx 2 [0, 34], LMT 0 [0, 28], $P < 0.0001$). In Group C, CACS in LAD was significantly higher than in the other three arteries (median [interquartile range]: LAD 281 [160, 374], RCA 147 [51, 263], LCx 57 [9, 140], LMT 23 [0, 93], $P < 0.0001$). However, in Group D CACS was not significantly different between LAD and RCA (median [interquartile range] LAD 783 [480, 1003], RCA 617 [342, 1120], LCx 251 [095, 577], LMT 76 [0, 208], $P < 0.0001$, LAD vs RCA $P = 0.6930$).

Figure 2 shows the prevalence of coronary calcium in each coronary artery. In Group A, coronary artery calcium (CAC) was more frequently found in LAD than in the other arteries (LAD 79.4%, RCA 35.2%, LCx 26.2%, LMT 24.3%, $P < 0.0001$). In Group B, CAC was more frequently found in LAD than in the other arteries (LAD 94.4%, RCA 78.1%, LCx 52.5%, LMT 45.0%, $P < 0.0001$). In Group C, CAC was more frequently found in LAD than in the other arteries (LAD 99.1%, RCA 90.9%, LCx 83.6%, LMT 60.0%, $P < 0.0001$). However, in Group D the prevalence of CAC was not significantly different among the three arteries (LAD 97.7%, RCA 98.7%, and LCx 94.3%; LAD vs RCA $P > 0.9999$, LAD vs LCx $P = 0.4435$). The prevalence of CAC in LMT was lower than in the other arteries in each group ($P < 0.0001$).

**Table 1.** Clinical characteristics of patients

| | CACS | | | | |
|---|---|---|---|---|---|
| | 1–100 | 101–400 | 401–1000 | >1000 | *P* |
| *n* | 267 | 160 | 110 | 87 | |
| Age, years | 67 [61, 73] | 72 [64, 77] | 73 [66, 77] | 72 [65, 75] | <0.0001 |
| Male | 162 (60.7%) | 98 (61.3%) | 72 (65.5%) | 60 (69.0%) | 0.4818 |
| Angina | 213 (79.8%) | 120 (75.0%) | 79 (71.8%) | 60 (69.0%) | 0.1393 |
| MI | 54 (20.2%) | 40 (25.0%) | 31 (28.2%) | 27 (31.0%) | 0.1393 |
| Hypertension | 114 (42.7%) | 90 (56.3%) | 68 (61.8%) | 52 (59.8%) | 0.0008 |
| Hyperlipidemia | 109 (40.8%) | 83 (51.9%) | 62 (56.4%) | 61 (70.1%) | <0.0001 |
| Diabetes mellitus | 44 (16.5%) | 50 (31.3%) | 39 (35.5%) | 34 (39.1%) | <0.0001 |
| Active smoker | 74 (27.7%) | 54 (33.8%) | 37 (33.6%) | 34 (39.1%) | 0.2016 |
| Obesity | 50 (18.7%) | 36 (22.5%) | 26 (23.6%) | 25 (28.7%) | 0.2439 |
| CKD | 14 (5.2%) | 9 (5.6%) | 11 (10.0%) | 12 (13.8%) | 0.0313 |
| Therapy | | | | | |
| Aspirin | 60 (22.5%) | 34 (21.3%) | 25 (22.7%) | 22 (25.3%) | 0.9124 |
| Statin | 115 (43.1%) | 60 (37.5%) | 43 (39.1%) | 36 (41.4%) | 0.6973 |
| ARB/ACE-I | 146 (54.7%) | 82 (51.3%) | 58 (52.7%) | 48 (55.2%) | 0.8965 |
| CCB | 115 (43.1%) | 65 (40.6%) | 50 (45.5%) | 42 (48.3%) | 0.6745 |
| BB | 37 (13.9%) | 18 (11.3%) | 17 (15.5%) | 16 (18.4%) | 0.4620 |

ACE-I, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker; BB, β-blocker; CACS, coronary artery calcium score; CCB, calcium channel blocker; CKD; chronic kidney disease; MI, myocardial infarction

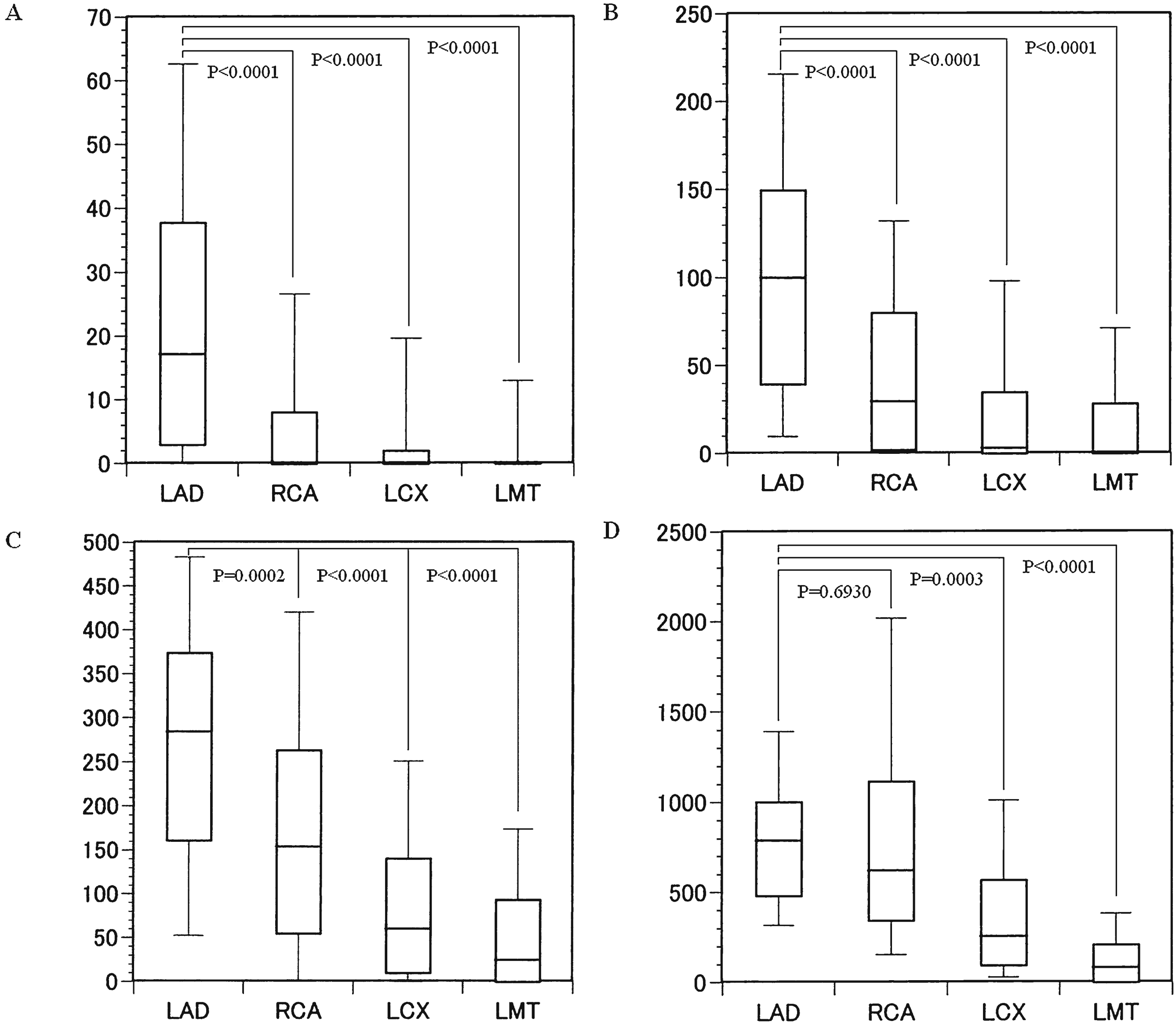


**Fig. 1.** Coronary artery calcium score for each coronary artery. **A** Group A; **B** Group B; **C** Group C; **D** Group D. *LAD*, left anterior descending artery; *RCA*, right coronary artery; *LCx*, left circumflex artery; *LMT*, left main trunk

## Discussion

Our results showed that atherosclerosis was more prevalent in LAD than in the other coronary arteries in patients with mild to high CAC, but not in those with very high CAC. The CAC provides an accurate estimate of total coronary plaque burden,[14–16] and has been found to be the most powerful predictor of cardiac events, providing independent and incremental information over risk factor-based assessment of the asymptomatic patients.[4,5] Histopathological studies demonstrate increased atherosclerosis susceptibility of the left coronary artery, especially of the left anterior descending coronary artery, compared with the right coronary artery.[17] Recent angiographic, intravascular, and CT studies have also confirmed these findings.[18–20]

Several studies show that in the majority of patients, CAC was first found to appear in the proximal part of the LAD, followed by the right and circumflex coronary artery, then involving more distal parts and the main stem. During follow-up, the changes of CAC did not differ within the coronary tree but were related to the typical predilection site of coronary atherosclerosis in the proximal left coronary segments. Progression was evenly distributed in the right coronary artery, whereas in the left coronary artery it was mainly related to the proximal part of the LAD and circumflex coronary artery.[15–18,20,21] However, the precise pathogenetic mechanism still remains uncertain. Coronary artery hemodynamic studies suggest that differences of phasic flow, shear stress, and wall stress between LCA and RCA may be implicated in their different susceptibility to atherosclerosis.[22] Our study demonstrates the usefulness of

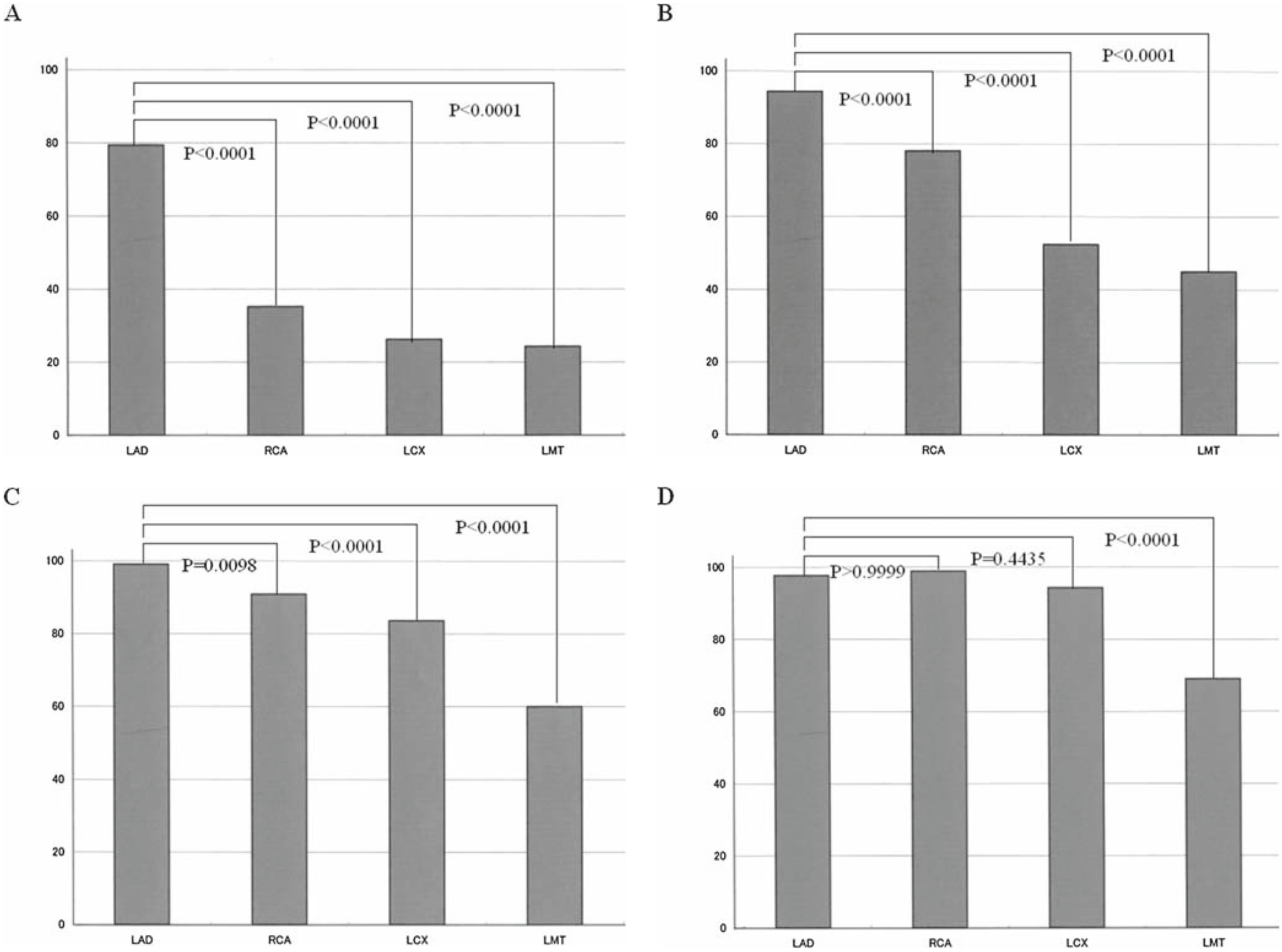


**Fig. 2.** Prevalence of coronary calcium in each coronary artery. **A** Group A; **B** Group B; **C** Group C; **D** Group D. *LAD*, left anterior descending artery; *RCA*, right coronary artery; *LCx*, left circumflex artery; *LMT*, left main trunk

topography of coronary calcium by 64-slice CT in predicting the natural history of coronary atherosclerosis in patients with variable degrees of coronary atherosclerosis.

There are some limitations in our study. First, the CACS results may be influenced by the overall length of each artery and one would expect the LAD to yield the highest scores. However, no established method of normalization exists. Second, coronary calcification provides only an indirect measure of the extent and severity of coronary artery disease, which can only be accurately estimated using invasive techniques. It is well described that calcification represents only approximately 20% of atherosclerotic plaque volume and coronary calcification may not be present in early atherosclerotic lesions.[23] In conclusion, our results show that coronary atherosclerosis is found more frequently in LAD than in the other coronary arteries in patients with mild to high CAC, but not in those with very high CAC, which means that LAD is more susceptible to atherosclerosis than the other coronary artery trees.

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