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ORIGINAL ARTICLE

Prevalence of Non-calcified Coronary Plaque on 64-Slice Computed Tomography Coronary Angiography in Patients with Zero and Low Coronary Artery Calcium Scores

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ABSTRACT

Objective: *To study the prevalence of non-calcified plaque causing significant coronary artery stenosis in patients with zero or low coronary artery calcium scores in a regional hospital in Hong Kong.*

Methods: *Computed tomography reports and clinical records (at least 3 years after computed tomography coronary angiography) of 336 consecutive patients with coronary artery calcium scores and computed tomography coronary angiography performed with a 64-slice multi-detector computed tomography scanner from January 2007 to December 2008 were retrospectively reviewed. Patients with zero and low coronary artery calcium scores were analysed for prevalence of atherosclerotic plaque and degree of arterial luminal stenosis.*

Results: *The records of 194 patients with zero (n = 130; 67.0%) and low (n = 64; 33.0%) coronary artery calcium scores were included. Non-calcified plaque was found in 20 (15.4%) patients with zero coronary artery calcium score and 49 (76.6%) patients with low coronary artery calcium score. Significant coronary artery stenosis (>50% luminal diameter stenosis) by non-calcified plaque was found in five (3.8%) patients with zero coronary artery calcium score and 18 (28.1%) patients with low coronary artery calcium score. Subsequent cardiac catheterization was performed in three patients with zero coronary artery calcium score (mean follow-up, 34.5 months; standard deviation, 6.3 months); the result was in agreement with computed tomography coronary angiography for one patient and two had overestimation of stenosis. Subsequent cardiac catheterizations were performed in 11 patients with low coronary artery calcium score; the results were in agreement with computed tomography coronary angiography for 10 patients and one had overestimation of stenosis.*

Conclusions: *Absence of coronary artery calcium does not exclude obstructive coronary artery disease. Low coronary artery calcium score is not reliable in predicting non-calcified plaque burden.*

Key Words: *Coronary angiography; Coronary artery disease; Plaque, atherosclerotic; Tomography, X-ray computed*

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中文摘要

64排CT冠狀動脈造影觀察冠狀動脈鈣化積分為零和低值的患者中非鈣化斑塊發生率

溫詠雪、李子飛、梁安祥、王耀忠

目的：探討香港一所分區醫院內冠狀動脈鈣化（CAC）積分為零和低值的患者中致冠脈狹窄的非鈣化斑塊的發病率。

方法：回顧2007至2008年期間連續336名接受64層多排螺旋CT冠狀動脈造影的病人的CT報告和臨床紀錄（冠狀動脈造影後至少3年）。分析了CAC積分為零和低值的患者動脈粥樣硬化斑塊的發生率和動脈管腔狹窄程度。

結果：共分析了194名病人的紀錄，當中包括130名（67.0%）CAC積分為零和64名（33.0%）低CAC積分的患者。CAC為零和低值的病人中，分別有20人（15.4%）和49人（76.6%）有非鈣化斑塊；另外分別有5人（3.8%）和18人（28.1%）出現顯著的冠狀動脈狹窄（多於50%管腔直徑狹窄）。CAC積分為零的病人中，最終3人接受心導管檢查（平均隨訪期為34.5個月；標準差6.3個月）；其中1人結果與CT冠狀動脈成像一致，但其餘2人均高估了狹窄程度。低CAC積分的病人中，最終11人接受心導管檢查；其中10人結果與CT冠狀動脈成像一致，其餘1人被高估了狹窄程度。

結論：冠狀動脈無鈣化並不能排除阻塞性冠狀動脈疾病。低CAC積分並不能可靠地預測非鈣化斑塊的狀況。

INTRODUCTION

Most published studies have reported that the total amount of coronary artery calcium (CAC), which is expressed as the 'Agatston score', predicts obstructive coronary arterial stenosis beyond standard risk factors.[1-5] A report from 2007 found that low but detectable CAC scores are significantly less reliable in predicting plaque burden than absence of CAC due to their association with non-calcified coronary artery plaque (NCAP).[1] Few reports have been published on the extent to which NCAP causes coronary artery stenosis and how well the absence of CAC predicts the absence of NCAP in an Asian population. We aimed to study the prevalence of NCAP causing significant coronary arterial stenosis in patients with zero or low CAC scores in an Asian population.

METHODS

The clinical records and computed tomography (CT) scans of 336 consecutive patients with CAC scores and computed tomography coronary angiography (CTCA) performed with a 64-slice multidetector scanner (Aquilion 64; Toshiba Medical Systems Corp, Tochigi-ken, Japan) from January 2007 to December 2008 in a local hospital were retrospectively reviewed. All patients included in this study were outpatients who were referred for investigation of chest symptoms. All patients had both a prospective electrocardiogram (ECG)-gated non-contrast scan for CAC scoring and a retrospective ECG-gated contrast scan for detailed assessment of the coronary arteries and cardiac structures. The non-contrast scan was acquired with a slice thickness of 3 mm without overlap. The post-contrast scan was acquired with continuous helical acquisition at gantry rotation of 400 ms (temporal resolution = 200 ms) and slice thickness of 0.5 mm with pitch autoselected according to heart rate; 120 kVp; and 270 - 400 mA depending on the patients' weight, which ranged from 50 kg to 95 kg. The field of view was 320 mm with a pixel size of 0.39 mm^2. Beta-blockers were administered if a patients' resting heart rate was ≥65 beats per minute. For selected patients, sublingual nitroglycerin 0.4 mg was given before contrast injection. Intravenous contrast material (iopamidol 300 mg I/ml) was administered through an automated power injector at 4.5 ml/second for a total of 80-90 ml depending on body weight followed by a 40-ml saline chase bolus at 4.5 ml/second. Images were triggered to 120 HU

in the descending aorta and were acquired in 12 to 14 seconds. We analysed the axial, coronal, and sagittal maximum intensity projection volume-rendered images on a workstation (Vitrea Vital Images Inc, Minnetonka, MN, USA). The medical records of each patient for at least 3 years after CTCA were reviewed for medical history (coronary disease, diabetes, hypertension, hypercholesterolaemia, smoking history, and family history) and symptoms (chest pain and dyspnoea).

Patients were divided into two groups according to their CAC scores. The '0-CAC group' comprised patients with Agatston calcium score of zero and the 'low-CAC group' comprised patents with Agatston calcium score from 1 to 100. Presence of any NCAP and severity of coronary artery stenosis, expressed as percent underlying luminal diameter, were assessed in both groups of patients. For the degree of coronary artery stenosis, none refers to absence of stenosis on CT, mild refers to less than 50% of luminal diameter occlusion, and significant refers to more than 50% of luminal diameter occlusion.

Exclusion criteria were known myocardial infarction, previous coronary revascularisation, Agatston calcium score of >100, or limited coronary artery evaluation due to motion artefact.

RESULTS

Of 336 patients included during the study period, 194 patients with zero (n = 130; 67.0%) and low (1-100; n = 64; 33.0%) Agatston calcium scores were analysed for prevalence of atherosclerotic plaque and degree of arterial luminal stenosis. Demographic factors of the two groups are shown in the Table. There were more men than women in the two groups and more men in the low-CAC group than in the 0-CAC group. Patients in the low-CAC group were more likely to have traditional risk factors. There were significantly more smokers and patients with hypertension and hypercholesterolaemia in the low-CAC group ($p < 0.05$).

Table. Demographic factors of patients with zero coronary artery calcium score (0-CAC) and those with low coronary artery calcium score (low-CAC).

	0-CAC group (n = 130)	Low-CAC group (n = 64)
Age (years)	53.1 ± 11.3	61.5 ± 11.0
Sex		
Male	76 (58.5%)	44 (68.7%)
Female	54 (41.5%)	20 (31.3%)
Medical history		
Smoker	15.4%	26.6%
Hypertension	33.1%	50.0%
Diabetes mellitus	10.8%	18.8%
Hypercholesterolaemia	20.8%	40.6%

Figure 1 shows the maximally detected coronary artery stenosis in each patient with a CAC score from 0 to 100. Although all these patients were found to have either

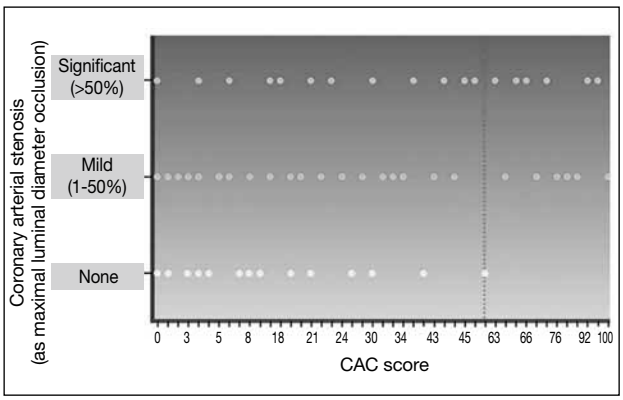

Figure 1. Modified scatter plot of maximum detected coronary artery stenosis in each patient with coronary artery calcium (CAC) score of 0-100. The dotted line indicates CAC of 55.

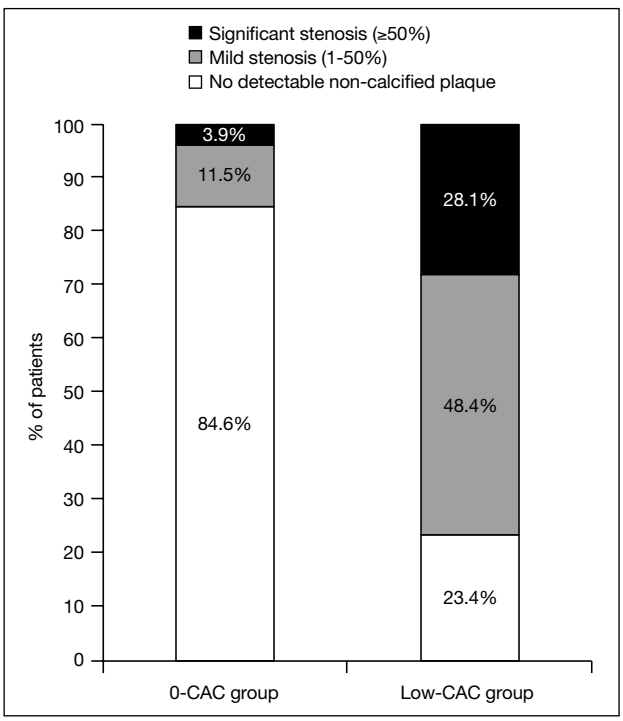

Figure 2. Distribution of maximum coronary luminal diameter stenosis in patients with zero (0-CAC) and low (low-CAC) coronary artery calcium scores ($p < 0.05$).

zero or low CAC scores, their coronary artery plaque severity varied widely. Patients with CAC score of up to 55 could have normal CTCA.

NCAP was found in 20 (15.4%) patients in the 0-CAC group and 49 (76.6%) patients in the low-CAC group. There were significantly more patients with mild and significant stenosis in the low-CAC group than in the 0-CAC group ($p < 0.05$), as shown in Figure 2.

Significant coronary artery stenosis (>50% luminal diameter stenosis) due to NCAP was found in five (3.8%) patients in the 0-CAC group and 18 (28.1%) patients in the low-CAC group. In the 0-CAC group, subsequent cardiac catheterization was performed in three of five patients (mean follow-up, 34.5 months; standard deviation, 6.3 months); the result was in agreement with CTCA for one patient (Figure 3) and two patients had overestimation of stenosis. For patients in the low-CAC group, subsequent cardiac catheterizations were performed in 11 of 18 patients; the results were in agreement with CTCA for 10 patients and one patient had overestimation of stenosis.

Figure 3. A multiplanar reformatted computed tomography coronary angiography image of a 44-year-old woman with zero coronary artery calcium score showing soft plaque causing 55% diameter stenosis on the mid-portion of the left descending coronary artery (arrow). This was confirmed in subsequent conventional coronary angiogram.

One patient in the 0-CAC group died from an acute coronary event within the 3-year follow-up period.

DISCUSSION

Although CAC is generally associated with obstructive stenosis and absence of calcium is correlated with absence of stenosis,[2] our results indicate that CAC score cannot be used to entirely exclude the presence of obstructive coronary artery disease; even a zero CAC score cannot rule out significant coronary artery stenosis. This finding is in agreement with studies performed in other populations.[1] We found that 3.8% of patients with absence of calcium had significant coronary artery stenosis by NCAP, while 28.1% of patients with low CAC score demonstrated significant coronary artery stenosis. Thus CAC score should not be the sole criterion to exclude coronary artery disease.

There are several limitations to this study. Our data were derived retrospectively from a single centre, and patients may have been subject to referral bias. Significant risk factor differences between the two groups may have confounded the results. Eight radiologists with various experience in cardiac imaging performed the scans. Most of the patients had no traditional angiographic correlation due to normal CT findings, so they were followed up clinically and received medical treatment.

CONCLUSIONS

The prevalence of significant coronary artery stenosis by NCAP in patients with zero CAC and low CAC scores were 3.9% and 28.1%, respectively on CTCA. Absence of CAC did not exclude obstructive coronary artery disease. Low CAC scores were not reliable in predicting non-calcified plaque burden, because up to 28.1% of patients with low CAC scores had significant coronary artery stenosis.

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