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Research paper

Regional calcified plaque score evaluated by multidetector computed tomography for predicting the addition of rotational atherectomy during percutaneous coronary intervention

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ABSTRACT

Background: Rotational atherectomy (rotablation) has been proposed as a potentially superior strategy for percutaneous coronary intervention (PCI) in complex and severely calcified lesions.
Objectives: We hypothesized that a per-lesion coronary artery calcium score determined by multidetector computed tomography (MDCT) would be useful for predicting the requriement for rotablation during PCI.
Methods: MDCT was performed in patients with stable angina pectoris who were scheduled for first PCI. In 116 consecutive subjects (168 target lesions) with successful PCI, MDCT and quantitative coronary angiography (QCA) data were retrospectively evaluated regarding their ability to predict rotablation.
Results: PCI without rotablation was performed in 105 patients (154 lesions), and rotablation was added in 11 patients (14 lesions). Patients with rotablation had significantly higher SYNTAX scores ($p = 0.007$) and total calcium scores ($p < 0.001$) than those without rotablation. Per-lesion, a lesion length ≥20 mm and diameter stenosis ≥74% on QCA as well as a per-lesion calcium score ≥453 and calcification arc ≥270 in MDCT predicted rotablation. After adjustment for potential confounding variables, a high per-lesion calcium score was an independent predictor of rotablation (odds ratio 31.3, 95% confidence interval 2.8-345, $p = 0.005$, sensitivity 93% and specificity 88%).
Conclusion: The extent of target lesion calcification in MDCT, a simple marker of calcified plaque, is useful for predicting the need for rotablation during PCI.
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1. Introduction

Complex and severely calcified lesions present unique challenges for percutaneous coronary intervention (PCI), as they typically result in a smaller final lumen diameter and less acute lumen gain after stenting compared with noncalcified lesions[1]. Furthermore, there is a risk of stent under-expansion, a lower procedural success rate, a more frequent rate of acute complications, such as acute dissection, and a greater propensity for restenosis[1,2]. In

Abbreviation list: PCI, Percutaneous Coronary Intervention; Rotablation, Rotational Atherectomy; AHA, American Heart Association; IVUS, Intravascular Ultrasonography; CAG, Cardiac Catheterization; MDCT, Multidetector Computed Tomography; CTA, MDCT Coronary Angiography; QCA, Quantitative Coronary Artery Analysis; SD, Standard Deviation; ROC, Receiver Operating Characteristic; AUC, Area Under the ROC Curve.

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contrast to PCI with stenting, rotational atherectomy (rotablation) removes part of the obstructive atheroma by differential cutting and is associated with less deep wall injury[3]. American Heart Association (AHA) guidelines indicate that rotablation is reasonable for fibrotic or heavily calcified lesions that cannot be crossed by a balloon catheter or adequately dilated before stent implantation[4]. Detailed assessment of calcified plaque during PCI requires invasive intravascular ultrasonography (IVUS)[5], but the IVUS catheter may not pass through the target lesion if the degree of luminal narrowing is high. Multidetector computed tomography (MDCT) determine coronary calcification non-invasively[6]. Scores such as the Agatston score[7] have been used to estimate calcified plaque burden. A high calcium score predicts the complexity of PCI and procedure-related complications[8].

We hypothesized that per-lesion coronary calcification would be useful ro predict whether subsequent intervention includes strategies such as rotablation.

2. Methods

Cardiac CT with determination of coronary calcium severity and contrast-enhanced coronary angiography was performed in 150 patients (208 target lesions) with stable angina pectoris who were scheduled for a first PCI from December 2010 to April 2014 at Showa University Hospital. The presence of stable angina pectoris was defined according to AHA guidelines. Patients with acute coronary syndrome or myocardial infarction as well as patients with PCI or coronary artery bypass grafting in the past were excluded from the study. All patients gave written informed consent, and the protocol was approved by our Institutional Review Board. The SYNTAX score was calculated based on angiographic findings, lesions with a bifurcation or severe tortuosity were defined as"complex"[9]. Successful PCI was defined as angiographically proven residual stenosis less than 50% and a stenosis reduction of at least 20%[3]. Out of the entire cohort, 116 consecutive subjects (168 target lesions) who underwent successful PCI (mean age 68 ± 10 years, 20% females) were included, and parameters to predicting the addition of rotablation during PCI were retrospectively evaluated.

2.1. PCI

PCI was performed through the femoral artery approach by inserting a 7 or 8 Fr guiding catheter under intravenous administration of 10000 IU heparin.On the basis of AHA guidelines[4], if an IVUS catheter could not be passed through a stenosis, if IVUS demonstrated near-circumferential calcification, or if the lesion did not expand following balloon angioplasty, the final decision for rotablation was left to the discretion of the interventionalists who were unaware of results of CT and quantitative coronary angiography (QCA). Rotablation (Boston Scientific Corporation, Natick, MA, U.S.A.) was performed using burr sizes from 1.25 to 2.25 mm. The recommended burr speed was 180,000–200,000 rpm with each sequence being less than 30 seconds, and care was taken to prevent any drop in rotational speed >5000 rpm. It was advised to use incremental burr sizes to achieve a burr-to-artery ratio of at least 0.7.

2.2. QCA analysis

Coronary artery stenosis severity was assessed by QCA with CAAS software (Version 5.10, Pie Medical Imaging, Maastricht, Netherlands). Lesion length (mm), minimum vascular diameter (mm), reference vascular diameter (mm), and percent diameter stenosis (%) in the target lesion were measured using the CAAS system.

2.3. Computed tomography

Coronary calcium and contrast-enhanced coronary CT angiography (coronary CTA) data sets were acquired using a 128-slice single-source CT system (Somatom Definition AS+; Siemens Medical Solutions, Forchheim, Germany). To quantify coronary calcification, the Agatston score was determined in non–contrast-enhanced data sets using the Calcium Score module of the SYNAPSE VINCENT software (Fujifilm Co. Tokyo, Japan). For coronary CTA in case of a heart rate >70 beats/min, intravenous beta blockers were given and a retrospective, ECG-gated acquisition protocol was used in all patients. Collimation was $2 \times 64 \times 0.6$ mm; rotation time was 300 ms; tube voltage 120 kV; effective tube current 800 mA, and pitch 0.3. Raw CT data were reconstructed using algorithms optimized for retrospectively ECG-gated segmental reconstruction with 0.6 mm slice thickness and 0.3 mm increment. The optimal cardiac phase displaying tminimum motion artifact was individually determined.

2.4. Agatston score

The extent of calcification was measured for each patient (total calcium score), vessel (per-vessel calcium score), and target lesion (per-lesion calcium score)[7,8]. Coronary calcium was defined as any plaque of least three contiguous pixels with a density >130 Hounsfield units (HU)[10]. Per-lesion calcium scores were calculated by multiplying the target lesion area by a density factor derived from the maximal HU within this area, as described by Agatston[7].

2.5. Coronary CTA

The target lesion length was measured on longitudinal reconstructions of each lesion ans was defined as the extent of ≥75% luminal diameter stenosis in coronary CTA at the site of the PCI target lesion.

The severity of lesion calcification was assessed by determination of the number of quadrants involving calcium on an arterial cross-section as follows (Fig. 1): (grade 1) non-calcified (no calcification); (grade 2) one calcification arc <90°; (grade 3) calcification arc ≥90 and < 180 (A) or multiple calcifications with visible residual lumen (B); (grade 4) calcification arc ≥180 and < 270; and (grade 5) calcification arc ≥270 with (A, B) or without visible residual lumen visible (C) according to a previous study[6]. The degree of target lesion calcification was defined as the highest grade of plaque calcification patterns of any cross-section within this area. Some typical cases are presented in Figs. 2 and 3.

2.6. Statistical analysis

All continuous variables are presented as the mean ± SD. Differences between groups were tested using an unpaired Student's t-test or the χ^2 test. Associations among predictors for the addition of rotablation during PCI were formally tested by multivariable logistic regression analysis. Pearson's correlation analysis was performed to assess dependence. A receiver operating characteristic (ROC) analysis was performed to define cut-off values, and the cut-off values were defined by minimizing the expression of $(1-\text{sensitivity})^2 + (1-\text{specificity})^2$. The statistical analysis was completed using IBM SPSS for Windows version 20 (SPSS Inc., an IBM Company, Chicago, IL). A probability value of <0.05 was considered significant.

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