European Journal of Radiology 84 (2015) 1910–1914

Contents lists available at ScienceDirect

European Journal of Radiology

journal homepage: www.elsevier.com/locate/ejrad

Association of aortic root calcification severity with the extent of coronary artery calcification assessed by calcium-scoring dual-source computed tomography

Xiaohan Hu [1], Claudia Frellesen [1], J.Matthias Kerl, Ralf W. Bauer, Martin Beeres, Boris Bodelle, Thomas Lehnert, Thomas J. Vogl, Julian L. Wichmann *

University Hospital Frankfurt, Department of Diagnostic and Interventional Radiology, Theodor-Stern-Kai 7, 60590 Frankfurt am Main, Germany

ARTICLE INFO

Article history:
Received 25 March 2015
Accepted 2 June 2015

Keywords:
Aortic root calcification
Coronary artery calcification
Calcium scoring
Coronary computed tomography angiography
Dual-source computed tomography

ABSTRACT

Purpose: To investigate the association between aortic root calcification (ARC) and coronary artery calcification (CAC) assessed by coronary artery calcium-scoring dual-source computed tomography (DSCT).
Materials and methods: We retrospectively analyzed 143 consecutive patients who underwent coronary artery calcium-scoring during coronary DSCT angiography. 57 patients had findings of ARC on calcium-scoring scans. ARC volume (ARCV) and Agatston coronary artery calcium score (CACS) were calculated. Chi-square test was used to assess differences of categorical variables between patients with and without ARC. Statistical significances between both groups were assessed with the independent-Sample t test.
Results: Compared with patients without ARC (n = 86), patients with ARC (n = 57) showed a significantly higher presence of CAC (87.7% vs. 24.4%; P < 0.001), and a higher mean CACS (700.6 ± 941.2 vs. 256.4 ± 724.3; P = 0.009) in patients with CAC. Patients with a calculated ARCV >40 mm^3 (n = 32) showed significantly higher rates of severe CAC (56.3% vs. 24.0%; P = 0.014) compared with patients with an ARCV < 40 mm^3 (n = 25). Compared with patients without CAC (n = 42), patients with CAC (n = 101) showed a significantly higher presence of ARC (83.3% vs. 50.5%; P < 0.001) and a higher mean ARCV (95.4 ± 116.2 mm^3 vs. 29.7 ± 33.0 mm^3; P = 0.003). Severe CAC (n = 24) correlated with an increased mean ARCV (122.3 ± 148.8 mm^3) compared to patients with minimal to moderate CAC (n = 33, mean ARCV: 61.9 ± 64.8 mm^3; P < 0.05).
Conclusions: The extent of ARC is directly associated with the presence and degree of CAC on calcium-scoring scans during coronary DSCT angiography.

1. Introduction

Multiple prior studies have demonstrated that coronary artery calcification (CAC) is an important independent predictor of coronary artery disease (CAD) [1,2]. Therefore, the Agatston coronary artery calcium score (CACS) is usually obtained using unenhanced calcium-scoring low-dose scans during coronary computed tomography angiography (cCTA) as an additional asset for diagnosing coronary artery disease [2,3]. Previous studies demonstrated that the presence and extent of calcification of the aortic and mitral valves are associated with CAC [4,5,6]. Mitral annular calcification is also independently associated with CAC [7] and cardiovascular events [8]. Furthermore, thoracic aortic calcification has been identified as a risk factor for CAD [9,10,11].

However, previous studies specifically assessing aortic root calcification (ARC) are scarce although this region is usually included during unenhanced calcium-scoring scans and angiographic cardiac CT scans. The aortic root is defined as the portion of the ascending aorta beginning at the aortic annulus and extending to the sinotubular junction, mainly including the aortic sinuses which give rise to the coronary artery. However, the current main focus regarding CT evaluation of the aortic root is preoperative planning of aortic valve replacement [12,13].

To our knowledge, two prior studies demonstrated a possible association between ARC and CACS [14,15]. But these studies did not specifically investigate the direct relationship but also included analysis of mitral annular calcifications or valve calcification. We sought to determine whether there is a significant association

* Corresponding author at: Fax: +49 0 69 6301 7258.
E-mail address: docwichmann@gmail.com (J.L. Wichmann).
[1] Xiaohan Hu and Claudia Frellesen contributedequally to this work and share first authorship.

http://dx.doi.org/10.1016/j.ejrad.2015.06.003

between the presence and severity of ARC and CAC which may be an additional indicator for CAD.

Thus, the purpose of this study was to investigate the association between ARC and CAC assessed by coronary artery calcium-scoring DSCT.

2. Materials and methods

2.1. Study population

Our retrospective study was approved by the institutional review board with a waiver for informed patient consent. We analyzed the unenhanced coronary calcium scans during dual-source cCTA in 179 consecutive patients with suspected CAD who underwent clinically indicated cCTA between January 2009 and July 2013. We excluded patients with a history of heart or bypass surgery or previously implemented coronary stents. Furthermore, we excluded individuals with a known history of aortic disease and cardiac valve disease including known cardiac valve calcification. The final study group consisted of 143 patients.

2.2. Determination of CAC and ARC

A second-generation 128-slice dual-source CT (Somatom Definition Flash, Siemens Healthcare, Forchheim, Germany) was used for the cCTA examinations. The scan range extended from the carina to the diaphragm to include the whole coronary tree. All scans were performed in the cranio-caudal direction. A collimation of 128 × 0.6 mm was used, pitch was set to 3.4. For the unenhanced calcium-scoring scans, a prospectively ECG-gated dose-saving technique with a fixed tube voltage of 120 kVp and a reference tube current output of 80 mAs was used. Automated tube current modulation and pulsing-window adaptation (CARE Dose 4D) were activated to reduce radiation exposure.

All calcium-scoring scan series were reviewed on a commercially available workstation (Syngo MMWP, Siemens Healthcare, Forchheim, Germany) using the dedicated calcium-scoring application. Quantity of CAC lesions, volume, mass and Agatston score were automatically calculated by the software after focal calcifications had been marked by a reviewer with more than 3 years of experience in cardiac CT. CAC was evaluated as minimal (Agatston score of 0–10), mild (10–100), moderate (100–400), and severe (>400).

ARC analysis was performed on the same workstation. Any calcification with a ring-like shape located directly at the aortic annulus was included as part of the ARC while the valve calcifications were excluded [1]. If a calcification exceeded the sinotubular junction but more than half of the calcification was located at the aortic root, it was still included as ARC. A region of interest was drawn manually comprising only the ARC and the resulting in-plane volume was calculated automatically by the software (Fig. 1). Each area was measured three times and the average was used. ARC volume (ARCV) was calculated with the following formula: Volume = Σ (area × slice thickness). In case a calcification was clearly located in right coronary sinus, left coronary sinus or noncoronary sinus, the location was noted. If the location could not be defined well, multiplanar 3D reconstructions were used for accurate identification of location.

2.3. Statistical Analysis

All statistical analysis was performed with commercially available statistical software (SPSS for Windows, version 17.0,SPSS, Chicago, IL). Descriptive statistics are listed as mean ± standard deviation. The Chi-square test was used to access the differences of categorical variables. Statistical significances were assessed using the independent samples *t*-test. One-way ANOVA analysis was used to obtain differences of multiple groups, and the pairwise comparison was performed with the LSD method. Spearman's analysis was used to calculate the correlation coefficients. Logistic regression analyses were used to calculate adjusted odds ratios (ORs) with 95% confidence intervals (CIs). Values of $P < 0.05$ were considered as statistically significant.

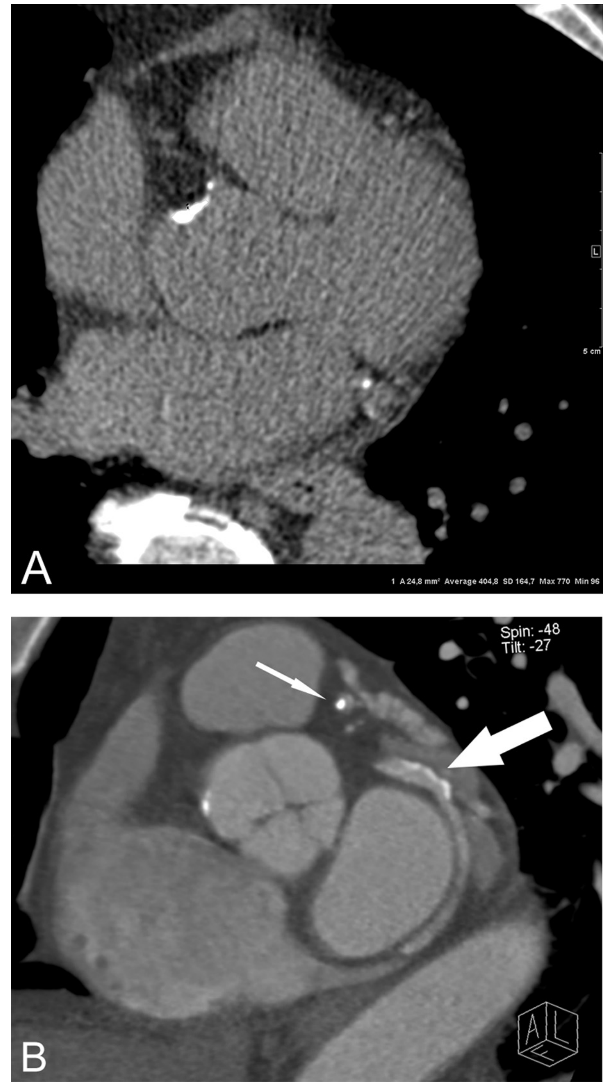

Fig. 1. Axial non-contrast calcium-scoring images of a 90-year old male patient with extensive aortic root calcification (ARC) adjacent to the aortic sinus which gives rise to the right coronary artery. ARC was manually traced with a freehand region-of-interest (ROI) procedure (A), resulting in an ARC volume of 24.8 mm^2. Multiplanar reconstructions of calcium-scoring images (B) also demonstrate a singular calcified plaque in the left anterior descending (LAD) artery (small arrow) and extensive clacifications of the circumflex branch (big arrow). The calculated Agatston score was 849.0, interpreted as severe.

3. Results

Our study population consisted of 143 patients (mean age, 60.6 years ± 12.4; age range), including 111 men (mean age 62.3 years ± 13.1) and 32 women (mean age 60.7 years ± 12.4) (Table 1). The mean patient body mass index was 26.2 kg/m^2 ± 6.5.

Compared with patients without ARC ($n = 86$), patients with ARC ($n = 57$) showed a significantly higher presence of CAC (87.7% vs. 24.4%; $P < 0.001$). The mean CACS in patients with ARC and CAC was 700.6 ± 941.21, and 256.4 ± 724.3 in patients with CAC