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CT virtual intravascular endoscopy assessment of coronary artery plaques: A preliminary study

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ABSTRACT

Purpose: The purpose of this study was to investigate the potential value of CT virtual intravascular endoscopy (VIE) in the visualization and assessment of coronary plaques in patients suspected of coronary artery disease.
Materials and methods: 20 (13 men, 7 women, mean age 54 years) consecutive patients with suspected coronary artery disease undergoing 64-slice CT angiography were included in the study. Four main coronary artery branches were assessed with regard to the presence of coronary plaques based on 2D axial, multiplanar reformation, 3D volume rendering and VIE visualizations. The coronary plaques were characterized into calcified, noncalcified and mixed plaques. The intraluminal appearances of these coronary plaques were demonstrated with VIE images and correlated with 2D and 3D images to determine the diagnostic value of VIE for the assessment of the plaques.
Results: VIE was able to identify and demonstrate the intraluminal appearances of coronary plaques in 18 patients involving 32 coronary artery branches which were shown as an irregularly intraluminal protruding sign in extensively calcified plaques and smooth protruding appearance in noncalcified or focally calcified plaques. An irregular intraluminal appearance was also noticed in the presence of mixed plaques due to variable components with different CT attenuations contained within the plaques. VIE accurately confirmed the degree of coronary stenosis or occlusion despite the presence of heavy calcification.
Conclusion: VIE could be used as a complementary tool to conventional CT visualizations for the analysis of luminal changes and assessment of disease extent caused by the coronary plaques.

1. Introduction

The feasibility of multislice CT (MSCT) for the diagnosis of coronary artery disease (CAD) was initially demonstrated with 4-slice CT [1,2]. However, image evaluation was impaired in many cases due to limited spatial and temporal resolution. With the introduction of 16-slice CT, image quality in coronary MSCT has become more consistent with improved results achieved [3–6]. Shorter examination times are possible with further improved diagnostic accuracy with 64-slice MSCT due to improved spatial and temporal resolution compared to 16-slice CT [7–11]. Several meta-analyses of 64-slice CT studies reported sensitivities of 93% and specificities of 96% (in 6 studies) [9], sensitivities of 97% and specificities of 88% (in 15 studies) [10], and sensitivities of 86% and specificities of 96% (in 19 studies) [11]. These reports concluded that MSCT, especially with 64- or more slice CT has high diagnostic accuracy for the detection of CAD and could be used as an effective alternative to invasive coronary angiography in selected patients.

Apart from the calcium detection, MSCT also allows noninvasive detection of plaque morphology and composition (calcified versus noncalcified atherosclerotic plaque), as well as the assessment of the extent of remodelling [12–14]. Atherosclerotic plaque size and geometry play an important role in the natural progression of the disease process and may have important clinical predictive value. Schmid et al. [14] in their recent report concluded that a significant increase of the amount of noncalcified plaque was observed with 64-slice MSCT over a mean interval follow-up of 17 months, indicating that MSCT may be used as a tool to study the progression of coronary atherosclerosis. Recent emerging data support the idea of the prognostic value of MSCT. In two prospective studies comprising 1127 and 100 patients, respectively, Min et al. and Pundziute et al. [13,15] reported that MSCT provides prognostic information over base-line clinical risk factors in patients with known or suspected CAD. However these studies were based on conventional 2D visualization to assess the coronary plaques, and no 3D, especially 3D intraluminal views were generated to demonstrate the intraluminal appearance of coro-

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nary plaques. Thus, the purpose of this study was to investigate the potential value of MSCT angiography in the visualization of coronary plaques using CT-generated virtual intravascular endoscopy (VIE). VIE has been previously reported to be valuable in the evaluation of aortic aneurysms and stent grafts [16,17]. We expanded the application of VIE to the assessment of coronary artery disease and examined whether VIE could provide additional information about CAD, particularly the coronary plaques when compared to conventional 2D and 3D images.

2. Materials and methods

2.1. Study patients

The study population consisted of 25 consecutive patients who were presented to the cardiac clinic at Ramsay Health-Rumah Sakit Surabaya Internasional, Surabaya, Indonesia, and were referred for the further evaluation of suspected CAD (chest pain complains, or abnormal test results). Exclusion criteria were renal insufficiency (serum creatinine level >1.5 mg/ml) or known allergic reaction to iodinated contrast medium, atrial fibrillation or other arrhythmias or inability to follow breath-hold commands. Patients who had undergone bypass surgery or coronary stents were also excluded from the study. Based on the above criteria, 20 patients comprised the study (13 men, 7 women, mean age, 54 ± 8 years). All patients gave written informed consent to the study protocol, which was approved by the local ethics committee.

2.2. Scan protocols of MSCT coronary angiography

Multislice CT scans were performed with a 64-slice scanner (GE Medical Systems, Lightspeed VCT, 64 mm × 0.625 mm) with the following protocols: beam collimation 0.625 mm, pitch 0.2–0.26, reconstruction interval of 0.4 mm, with tube voltage of 120 kVp and tube current ranging from 300 to 650 mA (tube current modulation). Non ionic Contrast medium (iopamiro 370 or Visipaque 320, 60–80 ml) was injected onto the ante-cubital vein at 5 ml/s for the first 40–60 ml, and 3.5 ml/s for the remaining 20 ml followed by 50 ml of saline chasing at 5 ml/s, and the scan was performed with a bolus tracking technique (Smart Prep™) with a CT attenuation of 220 HU as the triggering threshold at the ascending aorta to initiate the scan.

Axial images were reconstructed with a slice thickness of 0.625 mm in 0.4 mm increment resulting in isotropic volume data with a voxel size of 0.4 mm × 0.4 mm × 0.4 mm. Retrospective electrocardiographic-gating protocol was used to acquire the volume data achieving a temporal resolution of 165 ms in the centre of the gantry rotation. Volume data were reconstructed at 70–80% RR interval to minimize the artifacts. For patients with a heart rate more than 70 bpm, a beta-blocker was used to slow down the heart rate.

2.3. Generation of virtual intravascular endoscopy images

Original DICOM data (digital imaging and communication in medicine) were transferred to a workstation equipped with Ana-

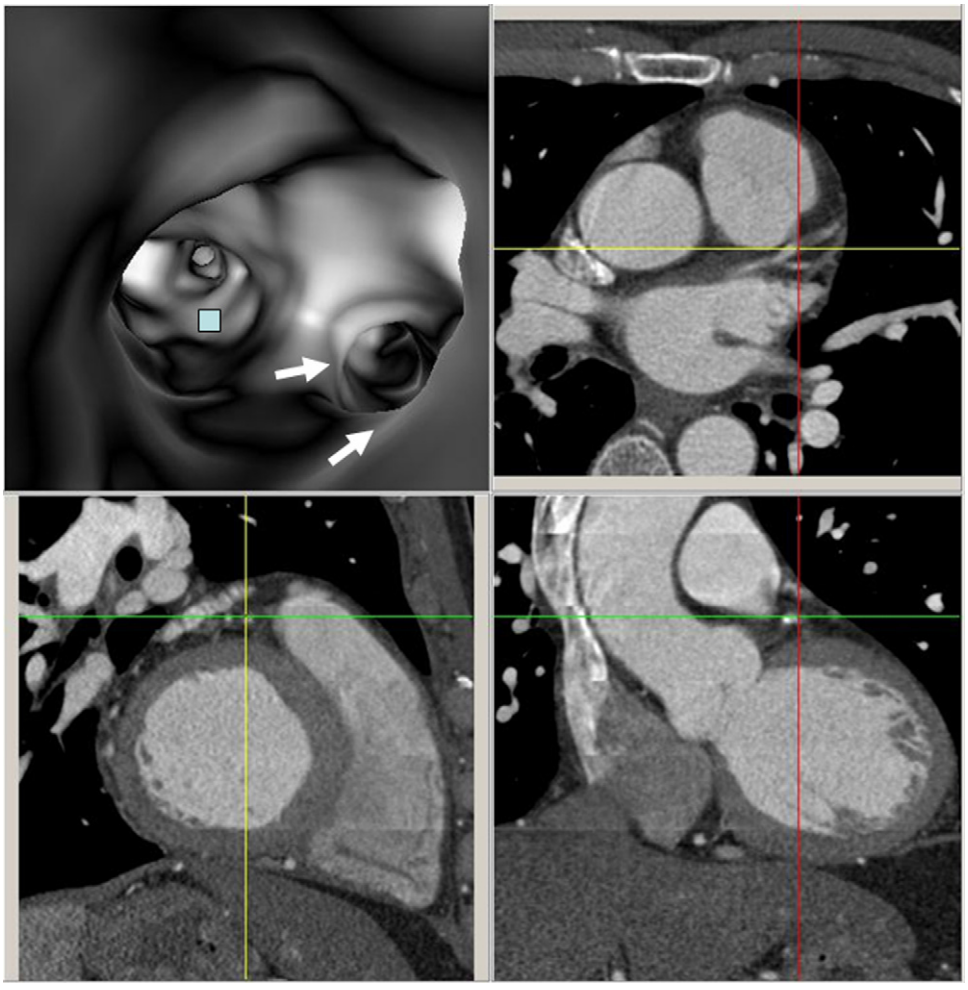

Fig. 1. Virtual intravascular endoscopy view of the left anterior descending (square box) and left circumflex (arrows), and this is confirmed by the corresponding orthogonal views (axial image on the top right, coronary and sagittal views on the bottom row).