Non-invasive demonstration of coronary artery anomaly performed using 16-slice multidetector spiral computed tomography

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Coronary artery anomalies are some of the most confusing, neglected topics in cardiology. Presently, no techniques are able to routinely screen those morphological alterations which can create potentially life-threatening complications, especially in young healthy subjects. Many efforts have been made to non-invasively image the coronary arteries using magnetic resonance, electron beam computed tomography, and recently multidetector computed tomography (MDCT). Even though interesting results have been reported, these techniques have hardly become an adequate substitute for conventional catheter coronary angiography. A new generation of MDCT scanners with 16 arrays of detectors and a higher temporal and spatial resolution have recently been introduced. We report a case of an anomalous coronary artery origin documented using a 16-slice MDCT scanner.

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Introduction

Coronary artery anomalies are some of the most confusing, neglected topics in cardiology[1]. According to the literature, coronary anomalies affect ~1% of the general population; this percentage has been calculated on the basis of the results of cineangiograms performed for suspected obstructive disease[1-4]. One of the main issues in diagnostic cardiology is the assessment of the coronary artery anatomy and patency. Many efforts have been made in the last decade to reach a reasonable accuracy in the non-invasive assessment of the coronary artery anatomy using several techniques, such as magnetic resonance imaging (MRI), electron beam computed tomography (EBCT) and, in the last 4 years, multidetector computed tomography (MDCT)[5-8]. Even though interesting results have been reported, these techniques have hardly become an adequate substitute for conventional catheter coronary angiography.

When scanning the heart for the purpose of retrospective coronary imaging, single-detector spiral computed tomography does not allow enough continuous volume coverage in a reasonable scan time[9,10]. Coronary imaging has become feasible following the introduction of MDCT scanners that provide a half-second gantry rotation time, a 4-detector-array and almost submillimeter in-plane spatial resolution. In fact, it is possible to cover the entire cardiac volume within one breath-hold[10]. Despite its high spatial resolution per *z*-axis coverage, MDCT at higher heart rates has been limited by the relatively low effective temporal resolution (250 ms with the half-rotation algorithm) compared to other non-invasive modalities such as EBCT and MRI[7,11,12]. Several limits mainly concerning the spatial resolution hinder both EBCT and MRI[5,7,13-15]. MDCT can rely on a higher in-plane and longitudinal resolution.

A new generation of MDCT scanners (16-MDCT) with more detector arrays, a faster gantry rotation time, a higher scan speed (temporal resolution) and a thinner slice thickness (spatial resolution) has been recently introduced[16]. Early clinical reports refer a good performance of these systems[16,17]. This generation of MDCT scanners is soon expected to play a major role in the management of the patient with suspected coronary artery disease. It is reasonable to expect that the same technique should be employed for the detection of coronary artery anomalies.

In this paper we report a case of an anomalous coronary artery origin documented using a 16-MDCT scanner. A few technical issues will also be concisely discussed.

Case report

The patient (F.T.) was a 54-year-old man with mild non-specific complaints and a long lasting antihypercholesterolemic drug therapy. The patient underwent 16-MDCT (Sensation 16, Siemens Medical Solutions, Forchheim, Germany) for the assessment of the coronary artery patency. The patient gave informed consent for the procedure. Two scans were performed: the first non-enhanced scan was performed for calcium scoring purposes, while the second contrast medium enhanced scan was performed for coronary artery evaluation. The overall examination time was 15 min.

Multidetector computed tomography scan parameters. The initial heart rate of the patient was 60 b/min with sinus rhythm; therefore it was not necessary to reduce it by oral administration of fast-acting β-blockers (100 mg metoprolol as a protocol).

Calcium scoring multidetector computed tomography scan. The calcium scoring scan was performed with a spiral continuous acquisition and a retrospectively gated reconstruction. The good correlation between the calcium scoring performed using both EBCT and MDCT has already been reported[18]. With this protocol the scan is synchronized afterwards and the ECG signal recorded during the scan. The acquisition was performed with an ECG-pulsed protocol in order to reduce radiation exposure. Reconstruction was retrospectively gated at -400 ms before the next R wave. The effective slice width was 3.0 mm while the image reconstruction index was 3.0 mm (contiguous slices).

Coronary angiography multidetector computed tomography scan. For vessel enhancement a volume of 140 ml, at a rate of 4 ml/s of iodinated non-ionic contrast medium (iomeprol 350 mgI/ml, Iomeron, Bracco Imaging, Milan, Italy) was injected through an antecubital vein with automatic power injector (EnVision, MedRad, Pittsburgh, PA, USA). The acquisition was performed according to an ECG pulsing protocol[19]. The main scan parameters were: number of detectors/collimation 12/0.75 mm, feed/rotation 2.78 mm, rotation time 420 ms, tube voltage 120 kV, tube current 450 effective mAs, and cranio-caudal direction.

Images were reconstructed using retrospective ECG gating. Three conventional reconstruction windows were positioned during the diastolic cardiac phase starting at -350, -400 and -450 ms before the next R wave. The effective slice width was set at 1.0 mm while the image reconstruction index was 0.6 mm. The total longitudinal range of 120 mm was scanned in 20 s.

Reconstructed images were sent to a dedicated post-processing workstation (Leonardo, Siemens Medical Solutions, Forchheim, Germany) where calcium scoring assessment, multiplanar reconstructions, multiple intensity projections and three-dimensional volume rendering were performed.

Results

The scan was successful. During both calcium scoring and angiographic scans the heart rate was 45 b/min. This allowed optimal scan conditions for the sampling of relevant data during the heart cycle. The calcium scoring scan revealed two spots along the left anterior descending coronary artery where further angiographic study revealed the presence of non-stenotic remodeled atherosclerotic plaques. The calcium score was 37.3 (equivalent Agatston score) in both lesions along the left anterior descending coronary artery. A score between 10 and 400 indicates a moderate plaque burden and is associated with an intermediate, although significant risk of future cardiac events, especially for scores > 100.

The angiographic scan was successful and the gating window at -400 ms was chosen for further post-processing. The relatively low calcium along the coronary arteries allowed us to use the multiple intensity projection technique in order to better visualize the path of the main vessels (Fig. 1A). The left main, left anterior descending, circumflex and right coronary arteries were all adequately visualized (Figs. 1B and 1C). The configuration of the right coronary artery appeared anomalous. In fact, the origin of the right coronary artery was located at the sinus of the left main coronary artery

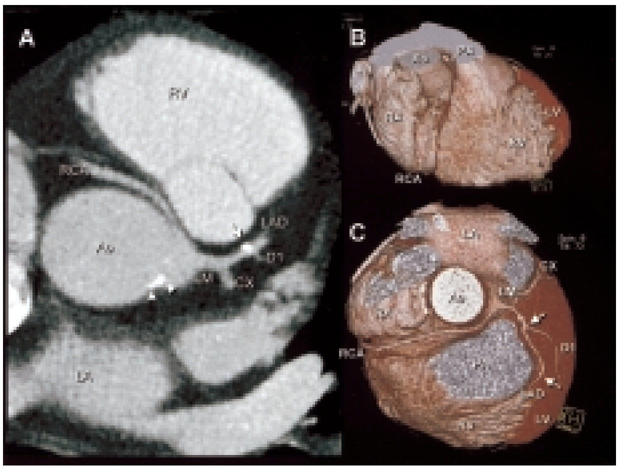

Figure 1. *In* A *an axial image with a multiple intensity projection algorithm is displayed. The origin of the right coronary artery (RCA) is located between the anterior wall of the ascending aorta (Ao) and the posterior wall of the pulmonary artery (PA). In* B *and* C *the data-set is displayed with a three-dimensional volume rendered algorithm. The proximal and mid configurations of the RCA are displayed. A few atherosclerotic lesions with calcification may be seen on the left anterior descending coronary artery (LAD)* (arrows) *and at the level of the aortic wall* (arrowheads). *CX = circumflex coronary artery; D1 = diagonal 1; LA = left atrium; LM = left main coronary artery; LV = left ventricle; RA = right atrium; RV = right ventricle.*

(Fig. 1). Then the artery ran horizontally between the ascending aorta and the pulmonary artery to find its normal course.

Discussion

Non-invasive imaging techniques such as MRI, EBCT, and transesophageal ultrasound have already been applied for the detection of coronary artery anomalies[20-24]. In the present case a new generation MDCT scanner with 16 detector arrays was used[17].

The entire coronary artery system may originate from a single ostium (solitary coronary ostium) in the aorta. This solitary ostium is either located in the left or right coronary sinus of the aorta. When the left main coronary artery originates from the proximal right coronary artery, or vice versa, the anomalous artery takes one of four aberrant pathways to reach its proper vascular territory. These pathways are type A (i.e. anterior to the right ventricular outflow tract), type B (i.e. between the aorta and pulmonary trunk), type C (i.e. through the crista supraventricularis portion of the septum), and type D (i.e. dorsal to the aorta)[20]. The anomaly described is a type B variant. Anomalous coronary arteries (origin, course and structure) have a higher incidence in the population of patients with sudden death[25]. The incidence in routine necropsy is 1% while in the population of patients with the sudden death syndrome it is 4-15% in the United States[2-4,26]. The specific importance of single types of coronary artery anomalies is not known[3]. The incidence does not seem to be related to gender.

The age of the patient and his clinical complaints allowed us to exclude any involvement of this arterial anatomical anomaly in possible ischemic acute processes. Moreover, the only possibility for correction of these anomalies is surgical. In the presented case there was no indication for this kind of procedure.

To better understand the improvements provided by this new generation of MDCT scanners, the main differences in the angiographic scan between the latest (16-MDCT) and previous generations (4-MDCT) will be described. There are four main improvements entailed in this new generation of 16-MDCT scanners: 1) the increase in the number of detector arrays from 4 to 16; 2) the decrease in the scan time from 40 to 21 s, with an increase in the scan range from 120 to 140 mm; 3) the collimation (minimum thickness of the axial slice) has been reduced from 1 to 0.75 mm; 4) the gantry rotation time has been reduced from 500 to 420 ms, improving the temporal resolution for a single heart cycle from 250-125 to 210-105 ms depending on the heart rate[17].

From the clinical point of view, these improvements result in a more "affordable" breath-hold and in a higher capability of resolving small structures such as the coronary arteries and their branches with less sensitivity to motion artifacts. The limit heart rate is also higher and patients with up to 75-80 b/min could be scanned with acceptable results.

In conclusion, this preliminary report shows the good potential of a new generation of 16-slice MDCT scanners in the non-invasive assessment of coronary artery malformations.

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