ORIGINAL ARTICLE

Imaging of coronary artery anomalies using ECG-gated 64-row computed tomography angiography

Wael Abdulghaffar a, Fady Elganayni a, Ahmed H. Abou-Issa a,* Ayman Almorsy b

a Medical Imaging Department, Mansoura University, Egypt
b Adult Cardiac Department, King Abdullah Medical City, Holy Makkah, Saudi Arabia

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Abstract  Objective: To shed light on coronary artery anomalies among cardiac patients using ECG-gated 64-row MDCTA during assessment of coronary arteries.

Patients and methods: Study included 840 patients out of whom twenty-one patients have congenital coronary artery anomalies. Patients were examined using ECG gated 64-row MDCT; 80–100 ml contrast agent, followed by a 50 ml saline chaser injected at 5 ml/s, 350 ms gantry rotation time, 0.65 mm detector collimation, ECG tube current modulation and 100–120 kV. Post-processing was done on second workstation including 3D VR, MPR and CMPR images.

Results: Anomalies of the coronary arteries were diagnosed in twenty-one patients. The prevalence of congenital anomalies in this study was 2.5% and included: anomalous origin of right coronary artery in 4 cases (0.48%), anomalous origin of left circumflex artery in 3 cases (0.36%), myocardial bridging of LAD in 12 cases (1.4%) and coronary artery fistula in 2 cases (0.24%).

Conclusion: Coronary artery anomalies are not uncommon among cardiac patients. Myocardial bridging is the most common followed by anomalous origin and proximal course and lastly coronary artery fistula. 64-Row MDCTA is an excellent promising modality and should be the first non-invasive diagnostic tool to rule out such anomalies.

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1. Introduction

About 20% of coronary artery anomalies produce life-threatening symptoms, including arrhythmias, syncope, myocardial infarction, or sudden death (1). Coronary artery anomaly is the second most common cause of sudden death in young athletes (2). Some of the coronary anomalies are clinically significant, and such lesions include origin of the left main artery (LMA) or the left anterior descending artery (LAD) from the right sinus of Valsalva or the right coronary artery (RCA) arising from the left sinus. The subsequent course between the aorta and the pulmonary artery can result in compression of the vessel, myocardial ischemia, and sudden death.

Abbreviations: CMPR, curved multiplanar reformat; LAD, left anterior descending artery; LCX, left circumflex artery; LMA, left main artery; LVOT, left ventricular outflow tract; MPA, main pulmonary artery; MPR, multiplanar reformat; PA, pulmonary artery; RCA, right coronary artery; RVOT, right ventricular outflow tract; VR, volume rendering.

* Corresponding author. Address: Radiology Department, Alnoor Specialist Hospital, P.O. Box 6251, Holy Makkah, Saudi Arabia. Tel.: +966 2 5667623; fax: +966 2 5664314.
E-mail address: ahmharon@gmail.com (A.H. Abou-Issa).
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in both adults and teenagers (3–5). Similarly, a single coronary artery from the right sinus of Valsalva may result in compression of the LAD or its branches via compression between a dilated aortic root and pulmonary artery. Conversely, some have postulated that the slit-like origin of the anomalous vessel causes ischemia. The origin of the RCA from the left sinus of Valsalva or LAD also can lead to myocardial ischemia (6). The passage of the coronary artery between the aorta and the pulmonary artery may be an indication for coronary artery bypass surgery (7).

Anomalies of the coronary arteries may be found incidentally in 0.3–1% of healthy individuals (8). For several decades, premorbid diagnosis of coronary artery anomalies was made with angiography. However, it was recently reported that, among patients with anomalous coronary arteries identified consensually with 16-section multi-detector row CT, conventional angiographic findings alone allowed correct identification of the abnormalities in only 53% of cases (9). The reason for this discrepancy may be that coronary artery anomalies are very difficult to visualize at angiography, and even if they are visualized, their course may be delineated inaccurately.

Although coronary artery anomalies are far less common than acquired coronary artery disease, their impact on premature cardiac morbidity and mortality among young adults is not trivial. In a study by Eckart et al. (10) of 126 non-traumatic sudden deaths in young adults, cardiac abnormality was found in 64 cases (51%), with coronary artery abnormalities being the most common cardiac abnormality (39 of 64 patients; 61%).

2. Objective

The aim of our study is to shed light on coronary artery anomalies among cardiac patients using electrocardiography (ECG)-gated multi-detector 64-row computed tomography angiography (MDCTA) during the assessment of coronary arteries on MDCTA.

3. Patients and methods

This retrospective study included 840 patients out of whom twenty-one patients (15 male, 6 female; mean age 55 years; range 18–65 years) have congenital coronary artery anomalies. The patients were referred to radiology department from cardiology and cardiac surgery departments between October 2007 and October 2011. Exclusion criteria for CT were as

<table>
<thead>
<tr>
<th>Types of the Anomaly</th>
<th>Subtype of the anomaly</th>
<th>Proximal course</th>
<th>No (n = 21)</th>
<th>Frequency 2.5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) Origin</td>
<td>Anomalous origin of RCA</td>
<td>Inter-arterial</td>
<td>4</td>
<td>0.84%</td>
</tr>
<tr>
<td></td>
<td>Anomalous origin of LCX</td>
<td>Retro-aortic</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>(B) Course</td>
<td>Myocardial bridging</td>
<td></td>
<td>12</td>
<td>1.4%</td>
</tr>
<tr>
<td>(C) Termination</td>
<td>Coronary artery fistula</td>
<td></td>
<td>2</td>
<td>0.24%</td>
</tr>
</tbody>
</table>

Table 1   Congenital coronary artery anomalies and their prevalence in our study.

Fig. 1    Anomalous RCA with inter-arterial (malignant) course in a 25 YOM complains of chest pain during exercise. (A) 2D MPCR shows take-off of RCA from left coronary sinus, passes between RVOT and aorta with acute angle at origin (arrow). (B) 2D sagittal oblique reformat shows oval configuration of RCA suggesting compression between RVOT and aorta. (C and D) 3D VR and catheter angiography show origin of LMA and RCA from left coronary sinus however, relation to other cardiac structures cannot be appreciated, arrowhead in D indicates catheter tip.
follows: previous allergic reactions to iodine contrast media, severe renal insufficiency, hemodynamic instability, atrial fibrillation, inability to follow breath-hold commands. Patients with a baseline heart rate exceeding 65 beats per minute received 50–200 mg of oral beta blocker (propranolol), unless underlying contraindications were present. The study was approved by our institutional ethics committee and written informed consents were taken from all participating patients.

4. CT technique

The patients were examined by using a multi-detector row CT scanner (VCT GE healthcare) that acquires sixty-four channels of data at an X-ray tube rotation time of 350 ms (VCT GE healthcare). After attachment of the leads for ECG recording, patients were examined in a supine position by using a breath hold technique. First, a fast localization CT scan was obtained to determine the scanning range.

After that patient circulation time from the cannula to the ascending aorta was determined using a test bolus of 20 mL contrast agent (non-ionic contrast media 370) at a flow rate of 5 mL/s and a saline chaser bolus of 30 mL at a flow rate of 5 mL/s using a dual-head power injector. For coronary angiography, 80–100 mL contrast agent was injected in an antecubital vein via an 18-gauge catheter at a flow rate of 5 mL/s, followed by a 50 mL saline chaser at same flow rate.

CT coronary angiography was performed using the following scanning parameters: craniocaudal scan direction, 350 ms gantry rotation time, detector collimation of 0.65 mm, tube voltage of 100–120 kV and ECG gated tube current modulation was applied to reduce radiation exposure.

Post-processing technique: retrospective ECG-gated CTA is essential for optimal image acquisition and reconstruction of evenly spaced phases of the cardiac cycle. Image reconstructions of the raw data were performed at different percentage of cardiac cycle by 10% from 0% to 90% of the R-to-R interval. Images were evaluated using 3 mm thin-slab maximum intensity projections (MIP), multiplanar reconstructions (MPR), curved multiplanar reconstructions (CMPR), and volume-rendering (VR) techniques on a post-processing workstation (GE Advantage 4.3). Both 3D VR and MPR images are used to assess the origin, course and termination of the coronary arteries. Dynamic studies were performed for patients with myocardial bridging to assess degree and severity of dynamic compression during systole.

Cine coronary angiography was done in 10 cases of congenital artery anomalies. They included 6 cases of myocardial bridging, 3 cases of anomalous origin and one case of coronary artery fistula.

5. Result

Our study included 840 patients referred for coronary CTA from October 2007 to November 2011 from cardiology and cardiac surgery departments in Alnoor Specialized Hospital, Holy Makkah. Congenital anomalies of the coronary arteries were diagnosed in twenty-one patients as follow: anomalous origin of right coronary artery from the left coronary cusp in 4 cases (presented clinically by typical angina in all cases and recurrent syncope in 3 patients), anomalous origin of left circumflex artery from the right coronary cusp in 3 cases (presented clinically by atypical chest pain in 2 cases and exertional dyspnea in one case), myocardial bridging in 12 cases (presented by palpitation in 8 cases and positive exercise stress test in 6 cases) and coronary artery fistula in 2 cases (presented...
Fig. 3 myocardial Bridge in 45YOM complains of intermittent chest pain. (A and B): 2D CMPR show intra-myocardial course with full encasement of D2 segment (arrows) during end-systole (phase 30%) and end-diastole (phase 0%) respectively. Milking effect and step down-step up appearance is noted during systolic contraction (A), however, no occlusion or significant dynamic compression noted.

by angina pain, fainting attacks and exertional dyspnea). Table 1 summarizes the different variety of congenital anomalies of coronary arteries in our study:

The prevalence of congenital artery anomalies in our study was 2.5% and included: anomalous origin of right coronary artery from the left coronary cusp in 4 cases; 0.48% (Fig. 1). Anomalous origin of left circumflex artery from the right coronary cusp in 3 cases; 0.36% (Fig. 2), myocardial bridging of LAD in 12 cases; 1.4% (Fig. 3) and coronary artery fistula in 2 cases; 0.24% (Fig. 4).

In this study, the myocardial bridging was the most common congenital anomaly and was seen in 12 cases. All cases were seen in the left anterior descending (LAD), 10 cases in the middle LAD segment and 2 cases in distal third of LAD.

In our study the anomalous origin of the coronary arteries was the second most common abnormality and was seen in 7 cases. Four cases have anomalous origin of the RCA from the left coronary cusp with inter-arterial (malignant) course in all cases. Three cases have anomalous origin of the LCX from the right coronary cusp with retro-aortic course.

Anomalies in termination were seen in 2 cases of coronary artery fistula: one case was seen between the right coronary and right ventricle and was small and the seconded case was large and seen between LAD and pulmonary artery (Fig. 4).

Cine coronary angiography was done in 10 cases of congenital anomalies. They included 6 cases of myocardial bridging, 3 cases of anomalous origin and case of coronary artery fistula. The correlation accuracy between coronary CTA and cine coronary angiography was 100%.

6. Discussion

According to the data present in the literature, the prevalence of coronary artery anomalies is about 0.3–1.2% in angiography (11), and in 0.3% of patients at autopsy (12). In our study, the prevalence of coronary artery anomalies is 2.5% among cardiac patients presented in this study.

The RCA typically arises from the right sinus of Valsalva. It courses anteriorly between the pulmonary trunk and the auricle of the right atrium before entering the right atrioventricular groove. The origin and course of RCA are not always as described, with various congenital anomalies of RCA documented (5,13). Among these anomalies is a right coronary artery that arises from the left sinus of Valsalva and then courses between the pulmonary trunk and the aorta (inter-arterial) before continuing within the right atrioventricular groove. Such a variant has been called “malignant” (14–15). The RCA arises from the left sinus of Valsalva as a separate vessel or as a branch of a single coronary artery in 0.03%–0.17% of patients who undergo angiography. The most common course of an anomalous RCA arising from the left sinus of Valsalva is inter-arterial; this variant can be associated with sudden cardiac death in up to 30% of patients (16). It has been postulated that, when dilation of the aorta occurs during exercise, the anomalous slit-like ostium for the RCA in the left sinus becomes narrower, possibly limiting coronary blood flow and resulting in myocardial infarction (17).

In our study, the anomalous origin of the coronary arteries is second most common anomalies with total frequency of about 0.48%. In all cases; the RCA arises from the left coronary sinus as a separate vessel, then courses between the pulmonary trunk and the aorta (inter-arterial course) before continuing within the right atrioventricular groove. The malignant course of anomalous RCA and absence of significant atherosclerotic disease explain the typical angina in these patients.

Anomalous LCX artery is the artery that most commonly arises from a separate ostium within the right sinus or as a proximal branch of the RCA (approximately 0.32–0.67% of the population) (18). In 69% of these cases, the circumflex artery arose from a separate ostium in the right coronary sinus of Valsalva, and in 31% of cases it originated as a branch of the RCA. It may be an isolated anomaly with the LAD originating normally from the LMA, or may be associated with other branch anomalies, such as origin of the LAD from the anomalous LCX (19). Several reports have shown that this anomalous LCX artery passes behind the aortic root. Retro-aortic course of LCX means passage of the artery adjacent to posterior aortic wall, in the groove between the atrium and aorta; fortunately, this anomaly has not been associated with death (20).

In this study, the LCX arises from the right coronary sinus in 3 cases with frequency of 0.36%. In all cases the proximal LCX courses posterior to the aortic root before reaching the left side and continuing within the left atrioventricular groove.

Myocardial bridging is caused by a band of myocardial muscle overlying a segment of a coronary artery. It is most commonly localized in the middle segment of the LAD. There is some discrepancy between the prevalence of myocardial bridging at angiography (0.5–2.5%) and that at pathologic analysis (15–85%) (21). The cause for this discrepancy is presumed to be the fact that myocardial bridging often occurs without overt symptoms, so that patients are rarely referred
for coronary angiography (22). In some cases, however, myocardial bridging is responsible for angina pectoris, myocardial infarction, life-threatening arrhythmias, or even death (23).

The standard of reference for diagnosing myocardial bridges is coronary angiography, at which a typical “milking” effect and a “step down–step up” phenomenon induced by systolic compression of the tunneled segment may be seen, while coronary CTA shows the intra-myocardial course of the involved arterial segment (24).

In this study, myocardial bridging is the most common congenital anomalies and diagnosed in about 12 cases with total frequency of about 1.4%. All cases of myocardial bridging are localized to LAD artery and the middle third is most common location (10 cases) and followed by distal third (2 cases).

Coronary artery fistula is a condition in which a communication exists between one or two coronary arteries and either a cardiac chamber, the coronary sinus, the superior vena cava, or the pulmonary artery. This condition is seen in approximately 0.1–0.2% of all patients who undergo selective coronary angiography (25). It more commonly involves the RCA (60% of cases) than the LCA (40%). In less than 5% of cases, fistulas originate from both the LCA and the RCA. In coronary artery fistula, the involved coronary artery is dilated because of increased blood flow and is often tortuous to an extent determined by the shunt volume (26). In terms of morphologic features, the fistula is variable at its drainage site, with either single or multiple communications or a maze of fine vessels that form a diffuse network, or plexus, with extensive intramural distribution. The drainage site of the fistula has a greater clinical and physiologic importance than does the artery of origin. The most common site of drainage is the right ventricle (45% of cases), followed by the right atrium (25%) and the pulmonary artery (15%). The fistula drains into the left atrium or left ventricle in less than 10% of cases (27,28).

This study included two patients with coronary artery fistula with total frequency of about 0.24%. One patient has small fistula between the RCA and right ventricle and another patient has large fistula between LAD and pulmonary arteries. In the patient case; LAD artery is hypertrophied, tortuous with flow related aneurysms and drains into the pulmonary artery, the patient was presented by exertional chest pain and dyspnea and fainting attacks.

7. Conclusion

Coronary artery anomalies are not uncommon among cardiac patients. Myocardial bridging is the most common followed by anomalous origin and anomalous proximal course of the coronary arteries and lastly coronary artery fistula. ECG gated 64 MDCTA is an excellent method to diagnose congenital coronary artery anomalies and should be the first non-invasive diagnostic tool to rule out such anomalies.

References


