Evaluation with 640-slice coronary computed tomography angiography (CCTA) of the prevalence of coronary artery variants and congenital anomalies: a retrospective study

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Aims and objectives

Coronary artery variants and congenital anomalies may be defined a coronary pattern with a characteristic (origin, number, number of ostia, course, etc.) which is rarely encountered in the general population. They are a vast group with different symptoms and pathophysiologic mechanisms. Some of them are incidental finding in asymptomatic patients, other present with chest pain, dyspnea, arrhythmia, syncope.

There are a number of classifications in the literature and, over the years, many studies have proposed a possible anatomical clinical classification, that divides them into "major" and "minor" according to their clinical relevance. Coronary artery variants and congenital anomalies are classified as major or clinically relevant, when induce angina pectoris, syncope, arrhythmia, myocardial infarct, sudden death (typically among young athletes under physical stress) and promote the onset and progression of coronary atherosclerosis. They have recently been suggested as the main cause of 5%-35% of sudden death in young people and responsible for 19% of sudden death in young athletes.

According to data present in the literature, which are based on angiographic findings performed for suspected coronary obstructive disease, coronary artery variants and congenital anomalies affect about 1.3% of the general population. In contrast, autopsy findings report a lower incidence (0.3-0.5%).

To date, conventional coronarography has been the gold standard for the diagnosis of coronary artery variants but the course of anomalous coronary arteries is usually difficult to determine at catheter angiography, which is obtained in a limited number of projections. Coronary computed tomography angiography (CCTA) has rapidly gained credibility thanks to the quality of the results obtained and its reproducibility. One of the strengths of MSCT of the coronaries is the three dimensional (3D) visualization of the epicardial vessels coronary artery, that is currently considered the ideal tool to visualize the complex and tortuous anatomy of coronary arteries. This study evaluated the prevalence of coronary artery variants and anomalies in patients imaged with 640-slice coronary computed tomography angiography (CCTA).
Methods and materials

Between July 2011 and December 2013, 806 patients with suspected coronary artery disease underwent 640-slice CCTA (Aquilion One, Toshiba Medical Systems, Tokyo, Japan). Prior the examination, patients with heart rate >65 bpm received an intravenous dose of beta-adrenergic blocking agent (atenolol; Tenormin®, AstraZeneca, Sweden) to a maximum of 12 mg, depending on heart rate and blood pressure response, except for those who had contraindications to a #-antagonist (severe heart failure, bronchial asthma, hypotension, bradycardia due to conditions such as atrioventricular block or sick sinus syndrome). Just prior to the scanning procedure patients, for patient with systolic blood pressure of above 100 mm Hg, were administered one dose of isosorbide dinitrate sublingually (5 mg of isosorbide dinitrate; Carvasin 5mg, Wyeth Lederle) to facilitate dilation of coronary arteries and enable acquisition of clear images even down to small branches of coronary arteries.

Two observers evaluated the images regarding coronary artery variants and anomalies; disagreement was solved by a consensus reading. For the evaluation were used original transverse images, curved planar reformations and volume rendered images. Firstly, three-dimensional volume rendered reconstructions were used to obtain general information regarding the status and anatomy of the coronary arteries; each vessel was analyzed in at least two planes, one parallel and one perpendicular to the course of the vessel. The coronary arteries were subdivided into 15 segments according to the modified American Heart Association classification.
Results

In the 806 patients, the prevalence of anatomical variants was left dominant circulation in 65 cases (8%), codominance in 80 (9.92%), absent left main in 32 (4%), presence of intermediate branch in 193 (24%). Because of the variability in arterial supply to the inferior wall, the concept of coronary dominance is important to understand. The most accurate definition of dominance would refer to the arterial supply to the atrioventricular node, but, the node itself is not directly visualized on CT and the artery that supplies the atrioventricular nodal branches in the crux cordis typically supplies the inferior wall through the PDA (posterior descending artery) as well. The artery that supplies the inferior portion of the posterior interventricular septum is considered to be the dominant artery. A right-dominant system will be considered one in which the PDA and a posterolateral branch arise from the distal RCA (right coronary artery). A left-dominant system is one in which the PDA and posterolateral branch arise from the distal circumflex artery. A codominant system is one in which the PDA arises from the distal RCA and a posterolateral branch arises from the distal circumflex to supply some of the inferior wall or one in which there are two PDA branches, one from the RCA and one from the LCX artery.

We found 56 coronary anomalies in 46 patients, given that 9 patients had more than one anomaly, with a prevalence of 5.7% (46/806). Anomalies of the coronary artery were found in 24 cases (3%), that included 6 anomalous origins of the right coronary artery (RCA), of whom 2 arose from the ascending aorta, 2 from the left sinus of Valsalva, 2 from the left coronary artery (LCA); 7 anomalous origin of LCA, of whom 2 arose from the ascending aorta, 1 with origin from the right anterior sinus of Valsalva, 2 with separate origins of the LAD and the circumflex artery (CX) from the left sinus of Valsalva, 1 with origin of CX from the RCA; 11 anomalies of course, of whom 3 had an interposed or interarterial course, 5 with retroaortic course.

The most common of these coronary anomalies is ectopic origin of a coronary artery from the coronary sinus opposite its normal perfusion territory and is particularly important to recognize because some forms can be associated with angina and an increased risk of sudden cardiac death. In general, the origin of the ectopic coronary artery is not problematic, but the course that the abnormal coronary artery takes to its perfusion territory can have important consequences. Indeed, a coronary artery that arises from the contralateral sinus of Valsalva has four potential paths it may take to its perfusion territory: prepulmonic (anterior to the right ventricular outflow tract), retroaortic (posterior to the aortic root), septal (through the proximal interventricular septum, analogous to a right superior septal perforator) or interarterial (between the aorta and pulmonary artery). The former two scenarios (i.e., prepulmonic and retroaortic) are considered benign coronary anomalies, putting the patient at little risk of an adverse event but it is important to recognize the retroaortic course in patients with aortic valve disease as this artery may be inadvertently compressed during aortic valve or aortic root surgery. The transeptal...
course is considered a relatively benign course but has been reported as potentially fatal. An interarterial course is considered malignant, as the anomalous coronary artery may be compressed between the aorta and the pulmonary artery, resulting in compromised blood flow to the myocardium, and is therefore usually an indication for surgical repair.

Intrinsec coronary anomalies were found in 32 cases (3.9%), of whom 25 myocardial bridges, 6 aneurysm and 1 duplications of the LAD. Myocardial bridging is defined as an intramyocardial course of a major epicardial coronary artery; the most common site of bridging is in the middle segment of the LAD artery. Myocardial bridging is considered a relatively benign finding; however, may rarely cause severe ischemia and acute coronary syndrome, coronary spasm, rupture of ventricular septum, arrhythmia and sudden death. The likelihood of ischemia increases with the depth of the bridged segment. Myocardial bridging commonly involves the mid portion of the LAD but may involve the RCA, LCX, diagonals or obtuse marginals. This entity is easily detected on CT, particularly on the cross-section thin MIP images.

Duplication of the LAD consists of a short LAD that terminates in the proximal anterior interventricular groove and a long LAD that enters the distal anterior interventricular groove and reaches the apex of the heart. It is important to recognize this variant as the LAD is often used for revascularization procedures and recognizing this variant can aid the surgeon in the correct positioning of the distal arteriotomy site.
Fig. 1: Curved planar reformations reveals a CX taking origin from RCA and coursing posterior to the aortic root

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**Fig. 2:** MPR and Volume rendered images reveal anomalous origin of the RCA from the ascending aorta

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Fig. 3: Curved planar reformations reveals anomalous origin of the RCA from the left sinus of Valsalva with interarterial course

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Fig. 4: MPR reveals a myocardial bringing involving the mid portion of the LAD

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Fig. 5: Volume rendered image reveals trifurcation of the LM into LAD, CX and RI.

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Conclusion

The present study shows that 640 slice CCTA provides correct visualization of coronary artery anatomy and, thus, is able to provide correct visualization of coronary artery variants and anomalies.
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