Incidence of anomalous origin of coronary artery in 1879 Chinese adults on dual-source CT angiography

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Background and Objective. Dual-source CT (DSCT) has been used to detect coronary artery anomalies. The purpose of this study was to assess the incidence of anomalous origin of the coronary artery in Chinese adults.

Methods. We summarised all patients who underwent DSCT coronary angiography (CTCA) from December 2006 to February 2008, and data of anomalous origin of the coronary artery in Chinese adults were recorded.

Results. 1879 patients underwent CTCA during that period; 24 patients with an anomalous origin of the coronary artery were detected, giving an incidence of 1.3%. Fifteen patients had an anomalous origin of the right coronary artery (12 from left coronary sinus, 3 high takeoff), eight patients had an anomalous origin of the left coronary artery (LCA from posterior sinus of Valsalva in three cases, LCX from the right coronary sinus, LCX from RCA, high takeoff, LCA from right coronary sinus, and single coronary artery in one case, respectively), and one patient had an anomalous origin of both coronary arteries (high takeoff).

Conclusion. The incidence of anomalous origin of the coronary artery in Chinese adults in this study is 1.3%. DSCT can clearly visualise the anomalous origin and course of the coronary artery and is a useful screening modality.

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Congenital coronary anomalies are relatively common, occurring at a rate of approximately 0.2 to 1.3% based on adult angiographic series.¹ Most anomalies are not of clinical significance. Nevertheless, some anomalies are related to angina, dyspnoea, syncope, acute myocardial infarction, even to sudden death.¹⁻³ With the rapid improvement of the multidetector computed tomography (MDCT) technique, it can now clearly visualise the anatomy of the coronary arteries, and give an even better description of the smaller branches of coronary arteries, such as the sinus node artery.^{1-5,6-8} Dual-source computed tomography (DSCT), with two arrays consisting of an X-ray tube and detectors arranged at a 90° angle to each other and with a gantry rotation time of 330 ms, allows a temporal resolution of 83 ms at the centre of gantry rotation when half-scan image reconstruction algorithms are used.^{9,10} DSCT's high temporal resolution and the spatial resolution of 0.4 mm, compared with 64-slice CT (165 ms of temporal resolution), improve the diagnostic accuracy of CT coronary angiography (CTCA) and image quality of CTCA in patients with atrial fibrillation and fulfil the requirements for implementing cardiac CT in routine clinical algorithms.¹¹ We report the incidence of congenital coronary anomalies in a group of 1881 patients who underwent DSCT studies between December 2006 and February 2008, and we discuss the clinical significance of detecting them.

Materials and Methods

Subject population

Between December 2006 and February 2008, 1881 patients (1017 men, 864 women, age range of 25 to 91 years, mean age of 60±11 years) suspected of coronary artery disease or valve disease under-

went dual-source CTCA. The average heart rate during scanning was 76 ± 14 beats/min. Exclusion standards for CT were: allergy to iodine-containing contrast medium, renal insufficiency (creatinine level higher than 120 mmol/l), pregnancy, haemodynamic instability, respiration motion artifact, and previous bypass surgery. Beta-blockers were not administered prior to the scan for all patients.

Scan protocol and image reconstruction

All subjects provided written informed consent before the examination. All CT examinations were performed on a DSCT scanner (Somatom Definition, Siemens AG, Medical Solutions, Forchheim, Germany). The patients were centrally placed in the scanner to ensure that the entire heart was covered with the smaller field-of-view of the second tube detector array. Coronary angiography scan was started by continuously injecting a bolus of 80 ml of Ultravist (370 mg I/ml, Schering, Germany) followed by 40 ml saline solution into an antecubital vein via an 18-gauge catheter (injection rate 5 ml/s). Contrast agent application was controlled by a bolus tracking technique. A region of interest was placed into the aortic root, and image acquisition started 5s after the signal attenuation reached the predefined threshold of 100 Hounsfield Units (HU). ECG pulsing for radiation dose reduction was applied in all patients. A retrospective gating technique was used to synchronise the data reconstruction with the ECG signal. The software automatically selected the optimal systolic and diastolic data according to the lowest motion velocity of

each coronary artery with the following parameters: slice thickness of 0.75 mm, a reconstruction increment of 0.5 mm, a medium soft-tissue convolution kernel (B26f), and image matrix 512×512 pixels. In each patient, additional 10 or 20 CT data were reconstructed in 10% or 5% steps of the R-R interval. Images were reconstructed from the contrast-enhanced DSCT scan with a slice thickness of 1.0 mm, a reconstruction increment of 1.0 mm, and using a medium soft-tissue convolution kernel (B26f). Depending on the individual anatomy, the reconstructed field-of-view (FOV) was adjusted to encompass the heart exactly (image matrix 256×256 pixels).

Image reformation and analysis

After removing the patient, all reconstructed images were transferred to a dedicated workstation (3D Workplace, Siemens AG, Medical Solutions) equipped with dedicated cardiac post-processing software (syngo Circulation, Siemens AG, Medical Solutions). Image post-processing was performed using techniques of maximum intensity projection (MIP), multiplanar reformation (MPR), and volume rendering (VR) for the optimal phase data. Two radiologists (L.J.Z and C.S.Z., who had five years and three years of experiences in CT angiography, respectively) assessed all cases in consensus, including image quality, the origin, orifice, and course of anomalous coronary arteries. They were classified into two types: benign and malignant anomalies.¹² Benign anomalies included LCX originating from the right sinus of the Valsalva, single

Table 1. Summary of coronary anomalies detected by using DSCT in this study.

Types	Cases and percentage		
	Cases (n)	Anomaly (%)	All (%)
Anomalous origin of RCA	15	62.5	0.80
RCA originating from left sinus of Valsalva*	12	50.0	0.64
High takeoff**	3	12.5	0.16
Anomalous origin of LCA	8	33.3	0.43
High takeoff	1	4.2	0.05
LCX originating from right sinus of Valsalva	1	4.2	0.05
LM originating from posterior sinus of Valsalva	3	12.6	0.16
LCX originating from RCA	1	4.2	0.05
LCA originating from right sinus of Valsalva	1	4.2	0.05
Single coronary artery	1	4.2	0.05
Anomalous origin of LCA and RCA	1	4.2	0.05
High takeoff	1	4.2	0.05

* Malignant anomalous origin of coronary artery, ** one patient with high takeoff of RCA originating from above the left sinus of Valsalva and with an interarterial course, which is also regarded as a malignant anomalous origin of the coronary artery. RCA=right coronary artery, LCA=left coronary artery, LCX=left circumflex artery.

Figure 1. Anomalous origin of the right coronary artery. A) Oblique MIP image; B) VR image display RCA originating from the left sinus of Valsalva (arrow) with an interarterial course. RCA=right coronary artery, LAD=left anterior descending artery, LCX=left circumflex artery, D1=the first diagonal artery, AO=aorta.

coronary artery, three coronary arteries originating from the right or left sinus of the Valsalva, and high takeoff, while malignant ones included coronary artery fistula, left coronary artery originating from

the pulmonary artery, and coronary artery originating from the opposite sinus of the Valsalva or coronary arteries with an interarterial course.

Results

Of 1881 patients undergoing DSCT, 1879 patients were included into this study, including 102 patients with arrhythmia. Image quality of coronary arteries was assessable for all patients. Anomalous origin of coronary arteries was diagnosed in 24 patients. Of these 24 patients, 12 had a clinical history of chest pain or shortness of breath, three patients had documented coronary artery diseases, three patients had hypertension, and the remaining six patients had no symptoms.

Numbers and percentages of different coronary origin anomalies in this study were listed in table 1; figures 1 to 5 illustrate typical findings of some coronary anomalies in this study. According to the classification of benign and malignant coronary origin anomalies, 12 patients had malignant coronary origin anomalies of the right coronary artery originating from the left sinus of the Valsalva (ARCAOLS) with an interarterial course; one patient had a high takeoff of the RCA superior to the left sinus of the Valsalva with an interarterial course, which was regarded as a malignant coronary origin anomaly in this study. The remaining 11 patients had benign coronary origin anomalies. Eight patients had coexisting myocardial bridging (MB) in the left anterior descending artery (single MB in six patients, two MBs in two patients).

Figure 2. Anomalous origin of the right coronary artery. A VR image shows the high takeoff of RCA originating from above the left sinus of Valsalva and an interarterial course. Note myocardial bridging in mid LAD (long arrows).

Figure 3. A high takeoff of the right coronary artery. A VR image shows the RCA originating from the ascending aorta (arrow). RCA=right coronary artery, LAD=left anterior descending artery.

Discussion

In this study, 13 malignant anomalous origins of coronary arteries were found, including 12 patients with ARCAOLS with an interarterial course and one patient with high takeoff of the RCA originating from above the left sinus of Valsalva and with an interarterial course. Of 24 anomalous origins of coronary arteries, ARCAOLS seems to be the most common type, accounting for 50% of all coronary anomalies in this study. The findings agreed well with results using conventional coronary angiography,¹² that is, ARCAOLS is the most common type of anomalous origin of coronary arteries. The congenital coronary anomaly has clinical importance because nonfatal or fatal myocardial infarction and sudden death occur in up to 30% of the patients. There are three subtypes of anomalous origins of the RCA from the sinus of Valsalva based on the path of the anomalous artery: retroaortic, interarterial, and anterior to the pulmonary trunk.¹ In the majority of patients, the RCA courses between the aortic root and the pulmonary artery; the subtype possesses the highest risk of exercise-induced ischaemia, myocardial infarction, and sudden death, and is regarded as malignant. The causes of myocardial ischaemia remain unclear, but the acute angle take-off and kinking of the RCA as it arises from the aorta, the flap-like closure of the anomalous coronary orifice, compression of the RCA between the aorta and the pulmonary artery, and spasm of the anomalous RCA have been thought to be possible

Figure 4. Anomalous origin of the left coronary artery (anterior to the pulmonary trunk). A VR image shows the left coronary artery originating from the right sinus of Valsalva, coursing anterior to the pulmonary trunk (arrow). PA=pulmonary artery.

mechanisms.³ Other rare anomalous origins of coronary arteries, such as the left coronary artery originating from the pulmonary artery, were not present in this study. Although other benign anomalous origins of coronary arteries were associated with few clinical symptoms, some instances can cause clinical symptoms; for example, in the patients with pulmonary hypertension, clinical symptoms resulted from a widened pulmonary artery compressing the anomalous left coronary artery coursing anterior to the pulmonary artery. So, it has important clinical relevance to detect and dynamically evaluate ARCAOLS by using a DSCT scanner, which can provide important information for surgeons to help achieve an accurate management; and also provide the appropriate lifestyle suggestions for patients to reduce risk factors of myocardial ischaemia.

Conventional coronary angiography is regarded as the gold standard to diagnose coronary artery disease. However, identification of coronary artery anomalies is frequently difficult with conventional coronary angiography because of the lack of 3D information relating to the course of the RCA to the great vessels, the costs and the fact that it is much more invasive than MDCT. Echocardiography has the potential to identify most coronary anomalies of clinical significance, but its ability to identify small-calibre vessel segments of 2 mm or less is limited. Cardiac MRI could convey similar findings; however, it has lower availability and its own inherent limitations (e.g., pacemakers and

Figure 5 Single coronary artery. A VR image shows a single coronary artery originates from the right sinus of Valsalva, then divides into two branches (arrow) with distribution of RCA and left coronary artery. RCA=right coronary artery, LAD=left anterior descending artery, LCX=left circumflex artery.

claustrophobic patients). Recently, MDCT has been widely used to detect the coronary anomalies because of its excellent spatial and temporal resolution and it may play a pivotal role in the diagnostic work-up of these patients.^{9,10} DSCT allows a temporal resolution of 83 ms at the centre of gantry rotation when half-scan image reconstruction algorithms are used. This temporal resolution makes it feasible to dynamically evaluate the changes of coronary arteries during the cardiac cycle. Altogether, 102 patients (5.4%, 102/1881) with arrhythmia were included in this study, though ECG editing was applied in most patients. DSCT can clearly visualise the anomalous origin of a coronary artery, the course, and provide three-dimensional spatial information on adjacent structures, which are important for clinicians to make an accurate decision.

We acknowledge the following study limitations. First, none of the patients with coronary anomalous origin in this study underwent conventional coronary angiography, the gold standard. Second, we did not evaluate anomalous origin of coronary arteries using a dynamic CT technique.

Last, the incidence of multiple ostia is low in this study partly because multiple ostia of RCA were often overlooked; however, the type of coronary anomaly has no clinical relevance unless coronary angiography is performed.

In conclusion, the incidence of anomalous origin of coronary artery for Chinese adults is 1.3% in this study. DSCT can clearly visualise anomalous origin and course of coronary artery as a useful screening modality and provide important information for surgeons and patients.

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