Prevalence of Coronary Artery Fistula in a Single Center of China

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To the Editor: Coronary artery fistula (CAF), an unusual coronary anomaly, was first described in 1841 and it is defined as the abnormal communication between the coronary artery and the cardiac chamber or the great vessels.[1] Most CAFs are congenital, but acquired forms have been reported.[2] The traditional diagnostic tool for CAFs is conventional coronary angiography (CAG), and the incidence of CAF in patients who underwent CAG is 0.06–0.13%.[3,4] However, CAG is an invasive examination, and the complex configuration of the anomalous vessels and their anatomic relations with the surrounding structures may be obscured on two-dimensional angiography images, which may limit precise evaluation of the prevalence of CAFs by CAG.[5] In recent years, other techniques in cardiologic diagnostic imaging have been developed, such as transthoracic echocardiography, transesophageal echocardiography, magnetic resonance angiography, and multi-slice computed tomography (MSCT).[6] Recently, MSCT has changed coronary diagnostics. MSCT offers great spatial resolution with the possibility of performing curved multiplanar reconstructions, maximum intensity projections (MIPs), and volume rendering (VR). The complex coronary anatomy can be readily visualized with MSCT.[7] To date, few reports focused on the value of MSCT evaluation of CAFs. This study aimed to evaluate the prevalence, morphological features, and classification of CAF detected on MSCT in patients from a single Chinese tertiary referral medical center.

In total, 10,223 consecutive patients who were suspected of having coronary artery disease underwent MS-CT coronary angiography (MS-CTCA) from January 2012 to November 2017 in Tongji Hospital, Wuhan, China. The CTCA reports and images of all the 10,223 patients were retrospectively reviewed by two experienced radiologists through the picture archiving and communication system. Moreover, the medical records of these patients were reviewed. The study was approved by the institutional review board and the requirement for informed consent was waived because of the retrospective design.

The MSCT system (Discovery CT 750 HD; GE Healthcare, USA) was used to scan all patients. In all patients with a heart rate (HR) >70 beats/min, β-blocker (metoprolol tartrate; AstraZeneca, UK) was orally administered at a dose of 50–100 mg to achieve a target HR ≤70 beats/min at least 2 h before CT examination. On arrival, an 18G intravenous line was inserted in the right antecubital vein for administration of contrast agent. The scanning range was from the level of 1 cm below tracheal carina to the level of 1 cm below the cardiac apex. The scan was acquired by bolus injection of 50–70 ml (adjusted according to body mass index) of iodixanol (Visipaque™ 320 mg/ml, GE Healthcare, UK) at a flow rate of 5 ml/s, followed by 40 ml of normal saline at the same speed. Coronary computed tomography angiography was performed using a retrospective electrocardiogram (ECG)-triggering protocol. Scanning was triggered automatically when CT value of the descending aorta achieved 260–300 HU. The scanning parameters on the Discovery CT 750 HD scanner were as follows: detector collimation: 64 × 0.625 mm and gantry rotation time: 350 ms. Tube current and mean voltage (resulting from variable switching between 80 and 120 kVp) were adapted to individual body mass index. Images were reconstructed with 0.625 mm-thick sections during 40–75% R-R interval and 10% R-R interval increments using 50% adaptive statistical interactive reconstruction-assisted high-definition kernel.

All CTCA images were transferred to a dedicated workstation (ADW 4.6; GE Healthcare, USA). Axial views, VR, MIP, and curved multiplanar reformations were used to identify the origin, fistula tracts, aneurysm of fistula tract (defined as dilatation 1.5 times the diameter of adjacent vessel), combined anomalies, and the relations with the adjacent structures. The CTCA images were evaluated by two experienced radiologists who were blinded to each other's results. Besides, CAG was performed on 11 patients with CAFs.

Among the 10,223 cases, CAFs were diagnosed in 34 patients (male: 20; female: 14; age range: 21–79 years, mean: 49.0 ± 18.9 years). A total of 5474 cases were found with coronary ischemia, and CAFs were diagnosed in 12 patients (12/5474, 0.22%). The incidence of CAF was 0.33% (34/10,223) by MSCT. Among the 34 patients, fourteen (41.7%) patients underwent CTCA because of chest tightness, chest pain, palpitation, and/or syncope;

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ten (29.4%) patients for preoperative evaluation (operation for lung, breast, bladder, or prostate cancer); five (14.7%) patients were suspected of CAF detected by cardiac ultrasonography; and three (8.8%) patients were presented with abnormal ECG findings. Among the 34 CAF patients, nine patients had hypertension, two had diabetes, two had a history of smoking, while three patients had a history of drinking.

Among the 34 CAF patients, 25 (73.5%) patients were diagnosed with coronary pulmonary artery fistulas (CPAFs) (male: 16, female: 10; age range: 24–79 years, mean: 53.0 ± 18.5 years) [Figures 1 and 2], three (8.8%) patients were diagnosed with coronary right atrium fistulas [Figure 3], two (5.9%) patients were diagnosed with coronary superior vena cava (SVC) fistulas [Figure 4], two (5.9%) patients were diagnosed with coronary right ventricular fistulas, one (2.9%) patient was diagnosed with coronary left atrium fistula, while one (2.9%) patient was diagnosed with coronary left ventricular fistula [Figure 5].

The origin of CAFs from the left coronary artery (LCA) was found in 18 (52.9%) cases, from the right coronary artery (RCA) in 12 (35.3%) cases, and from both LCA and RCA in four (11.8%) cases. Among the 18 cases that originated from the LCA, 11 (32.3%) cases originated from the LAD [Figures 1 and 4], three (8.8%) cases originated from the left main artery (LMA), two (5.9%) cases originated from the left circumflex artery (LCX) [Figures 3 and 5], and two (5.9%) cases originated from the left coronary sinus. Among the 12 cases that originated from the RCA, seven (20.6%) cases originated from the proximal RCA, two (5.9%) originated from the distal RCA [Figure 3], and three (8.8%) from the right coronary sinus. Among four cases originating from both LCA and RCA, two cases were from the LAD and proximal RCA [Figure 2], one case was from the LCX and proximal RCA, whereas one from conus branch of LCA and RCA.

In 21 (61.7%) patients, the fistula was shown as one vessel that could be traced; in three (8.8%) patients, the fistula was shown as two vessels; and in ten (29.4%) patients, the fistula was shown as innumerable multiple vessel networks. Eight of the 34 (23.5%) cases were associated with aneurysm of fistula tract. Twelve (35.3%) cases were associated with coronary artery atherosclerosis; of which, seven (20.6%) showed coronary artery stenosis (>50%), eight (23.5%) cases had cardiac enlargement, four (11.8%) cases presented with coronary myocardial bridge, and one patient (2.9%) had pericardial effusion.

Among the 34 CAF patients diagnosed by CTCA, 11 cases (male: five; female: six; age range: 21–67 years) performed invasive CAG, which included seven cases of CPAFs, three cases of coronary right atrium fistulas, and one case of coronary SVC fistula. The results of CTCA were consistent with that of CAG, but the coexistent abnormalities could not be visualized well by CAG except coronary artery stenosis. Nine patients performed operation to ligate the fistula and treated other abnormalities such as aneurysm of fistula tract and coronary artery stenosis.

CAFs are rare malformations that are highly variable. Zhou *et al*.[8] reported the incidence to be 0.19% in a large cohort of 17,548 patients. The study of Zhou *et al*.[9] indicated the incidence to be 0.21% in 48,533 patients from three hospitals. This study has shown that the incidence of CAF found by MS-CTCA is 0.33% in the 10,223 consecutive patient population, which is consistent with the incidence of 0.34% indicated by Liu *et al*.[10] Some CAF patients coexist abnormalities including coronary artery stenosis, cardiac

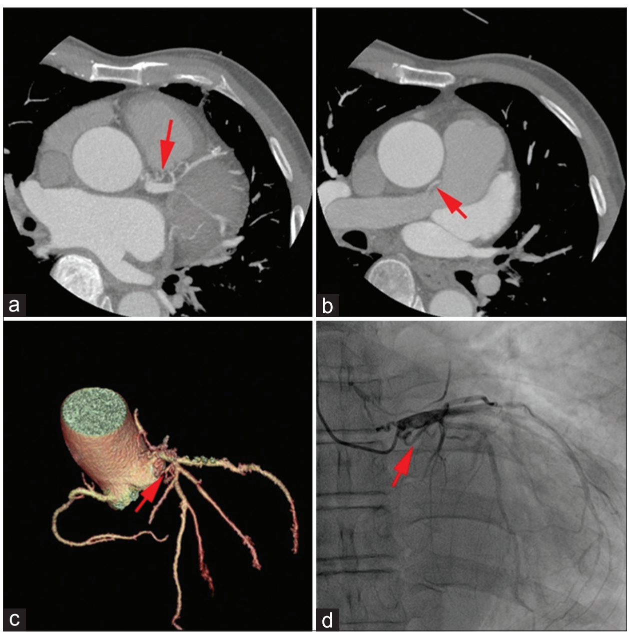

Figure 1: CAF originating from the LAD and draining into the PA in a 67-year-old male with palpitation. (a and b) Maximum intensity projection image shows fistula vessel (red arrow) from the LAD to PA, and the red arrow indicates the origin (a) and drainage site (b) of fistula vessel. (c) Volume rendering image shows tortuous fistula vessel (red arrow) communicating with the LAD and the PA. (d) CAG image shows tortuous fistula vessel (red arrow) originating from proximal LAD. CAF: Coronary artery fistula; LAD: Left anterior descending artery; PA: Pulmonary artery.

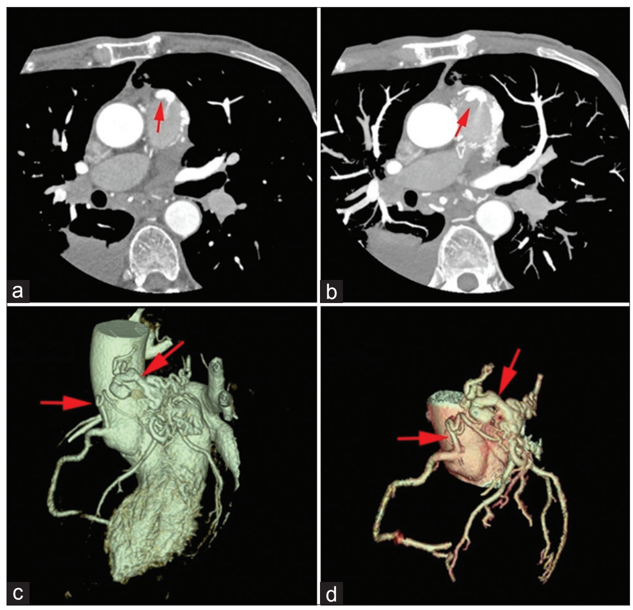

Figure 2: CAF originating from the proximal RCA/LAD and draining into the PA in a 65-year-old male lung cancer patient for preoperative evaluation. (a and b) Contrast agents flow from high-pressure RCA/LAD to relatively low-pressure main PA, and a, b figures show a high-density jet flow (red arrow) directly injecting directly into the main PA and tortuous and dilated vessels around the PA. (c and d) Volume rendering images show tortuous and dilated fistula vessels communicating with the RCA/LAD and the PA, the left red arrow shows the fistula vessel from RCA, and the right red arrow shows the fistula vessel from LAD. CAF: Coronary artery fistula; RCA: Right coronary artery; LAD: Left anterior descending artery; PA: Pulmonary artery.

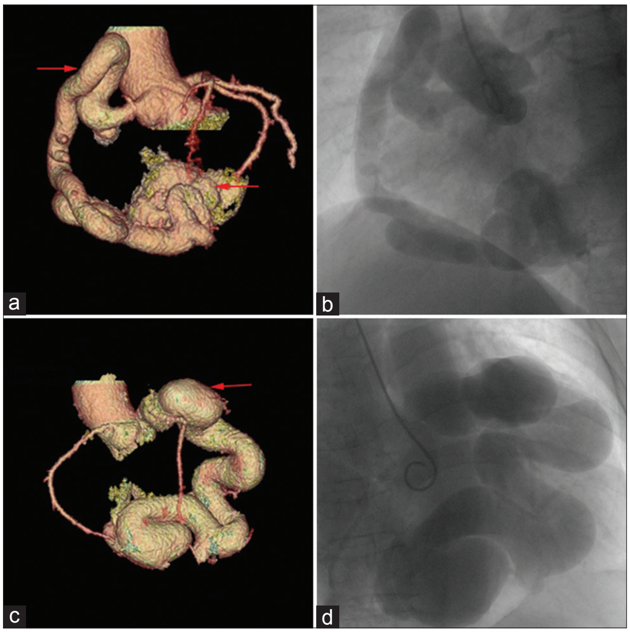

Figure 3: (a and b) CAF originating from the RCA and draining into the RA in a 51-year-old female patient with chest pain. VR and CAG images show tortuous and dilated RCA communicating with RA, the left red arrow in Figure a indicates the tortuous and dilated RCA, and the right red arrow in Figure a indicates the drainage site of the right atrium. (c and d) CAF originating from the LCX and draining into the RA in a 47-year-old female patient with abnormal cardiac US findings. VR and CAG images show tortuous and dilated LCX communicating with RA, the red arrow in Figure c indicates the tortuous and dilated LCX. CAF: Coronary artery fistula; RCA: Right coronary artery; RA: Right atrium; LCX: Left circumflex artery.

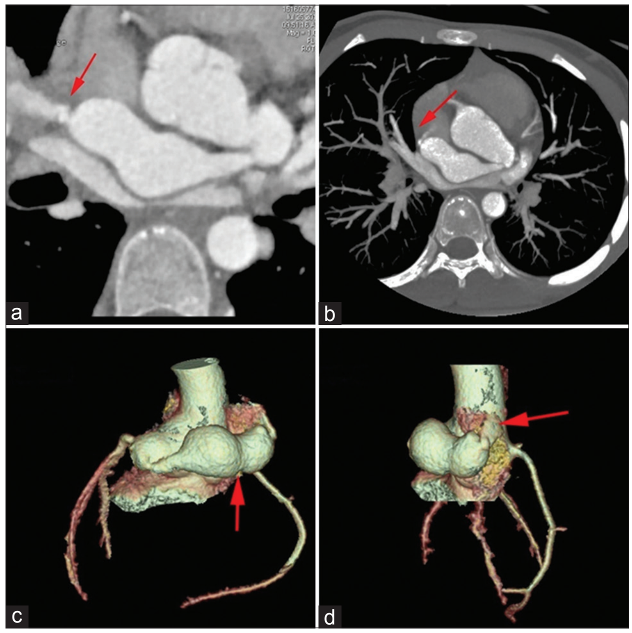

Figure 4: CAF originating from the LAD and draining into the SVC in a 25-year-old male with chest tightness. Contrast agents flow from high-pressure LAD to relatively low-pressure SVC. (a and b) Axial image, maximum intensity projection images show aneurysm in the LAD and a high-density jet flow (red arrow) directly injecting into the SVC. (c and d) Volume rendering images show aneurysm in the LAD (red arrow in Figure c) and the fistula drainage into SVC (red arrow in Figure d). CAF: Coronary artery fistula; LAD: Left anterior descending artery; SVC: Superior vena cava.

enlargement, and pericardial effusion, the abnormalities of which may cause discomfort such as chest tightness or pain, which urge the patients for diagnosis and treatment.[11,12] However, as shown in this study and some literature, many CAF patients did not have typical symptoms and accidently found by CTCA. Therefore, the true prevalence of CAFs is highly speculative since many CAFs may never be detected.

Previous literature indicated that the most frequent drainage sites of fistula, in descending order, are the right ventricle, right atrium, coronary sinus, and pulmonary vasculature.[13] Lin *et al*.[14] reported that more than 90% of fistulas drained into the venous circulation and the most common drainage site is the right ventricle. Contrary to the previous literature, the most common drainage site of CAFs in the present study was pulmonary artery, accounting for 73.5%, followed by right atrium, SVC, right ventricle, left atrium, and left ventricle, which was consistent with some recent studies of Zhou *et al*., Abdelmoneim *et al*., and Zhang *et al*., which showed that CPAF was the most common type of CAFs.[8,15,16]

Nakamura *et al*.[17] reported that 50% of CAF cases arise from the RCA, 42% from the LCA, and 5% from the RCA and LCA. Yun *et al*.[18] investigated that 39% of CAFs arise from RCA, 38% from LCA, and 23% origin from both RCA and LCA. In contrast to the above studies, our study shows that the CAFs originated from the RCA in 35.3% of patients, the LCA in 52.9%, and the RCA and LCA in 11.8%; thus, LCA is the most common origin of artery of CAFs in the present study, which is consistent with studies of Liu *et al*. and Abdelmoneim *et al*.[10,15]

Clear guidelines for the treatment of CPAFs had not yet been established. Both surgical and percutaneous embolization were reported to be effective and safe.[15,19] In the present study, 11 CAF patients performed CAG and nine of them underwent surgical treatment, the operation ligated the CAF and treated other abnormalities such as aneurysm and coronary artery stenosis. No serious postoperative complications were observed. We found that the results of CTCA were consistent with the findings of CAG. It is worth noting that CAG is an invasive examination and has a mortality of 0.1%,[20] while MSCT is demonstrated to permit noninvasive visualization of CAFs. Moreover, MS-CTCA could provide high-resolution images and could perform VR, curved multiplanar reconstructions, and MIP reformations. The cardiac and vascular anatomy could be obtained from VR images. The use of multiplanar reformatted images clearly demonstrates the origin, termination of fistula vessels, and small defects of the pulmonary wall. Besides, small, tortuous or dilated vessels close to the surface of the PA were clearly demonstrated from the MIP images,[10] and these were the important characteristic of CAFs in CTCA. Therefore, MSCT could provide more information than CAG for the diagnosis of coexistent abnormalities.

We acknowledged that the study has several limitations. First, this work is a single-center retrospective study. Second, only 11 patients had undergone CAG and only nine of them underwent surgical treatment, so we lacked sufficient data to confirm the diagnosis of CAF and compare the diagnostic accuracy of MS-CTCA with CAG, and more data are needed for future studies.

In conclusion, the incidence of CAFs detected by MS-CTCA in the present study was 0.33%. CAFs were observed to originate

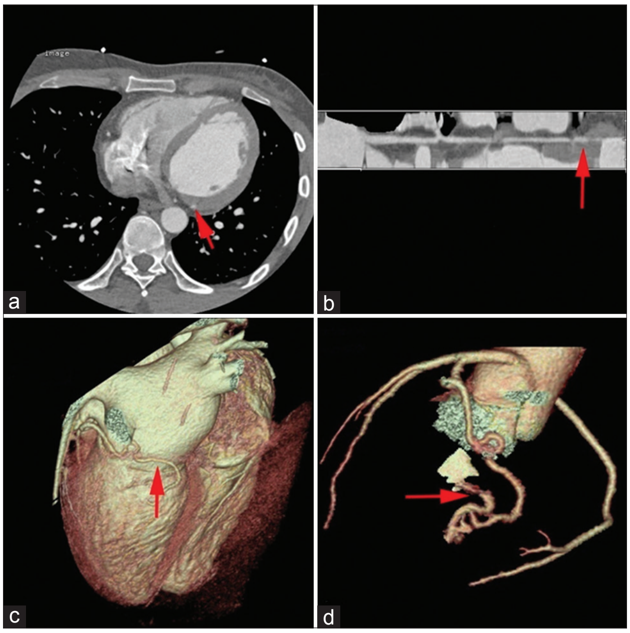

Figure 5: CAF originating from the LCX and draining into the LV in a 31-year-old male with chest tightness and pain. (a-d) Axial image, curved multiplanar reformation and volume rendering images show fistula originating from the LCX and draining to LV. The red arrow in Figure a and b indicates the drainage site in LV, the red arrow in Figure c shows the fistula vessel from LCX, and the red arrow in Figure d shows fistula originating from the LCX and draining to LV. LCX: Left circumflex artery; LV: Left ventricle.

predominantly from the LCA and drainage mostly to pulmonary artery. MS-CTCA is a reliable noninvasive tool that diagnoses CAFs and provides detailed anatomical information of coexisting abnormality.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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