ORIGINAL RESEARCH

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Retrospective Evaluation of Coronary Artery Fistulas with CT Angiography

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Abstract

Objective
Coronary artery fistula is the termination of the coronary artery branch in the cardiac chamber or pulmonary vein. In this study, we aimed to evaluate the type, origin, termination, and accompanying anomalies, if any, of coronary artery fistulas in patients who underwent coronary CTA in our clinic.

Material and Method
Coronary CTA examinations were performed on a 128-slice CT scanner. Images were evaluated using MPR, MIP and 3D VR reconstructions on the workstation. CTA image interpretation was performed independently by two radiologists with 15 and 2 years of experience in coronary CTA. In case of disagreement, a third radiologist was consulted.

Results
Coronary artery fistulas were found in 8 female and 6 male patients aged between 10 and 71 years, with a mean age of 39.07 years. Of the 15 fistula, 6 were coronacameral fistula, 7 were coronopulmonary fistula, 1 was between the left circumflex artery and the conal branch of the right coronary artery, and 1 was between the pulmonary trunk and the descending aorta. One patient was treated with coil placement in the interventional radiology department, while three cases were treated surgically. The other cases were followed up by the relevant clinics.

Conclusion
Coronary CT angiography provides three-dimensional images of the origin, course and termination of the fistula and is an important tool in guiding the patient's treatment plan.

Keywords: Coronary angiography, coronary artery fistulas, coronary CT angiography

Introduction

Normally, coronary arteries terminate within the capillary bed. Coronary artery fistula is the termination of coronary artery branch in a low-pressure vascular bed such as the cardiac chamber or pulmonary vein. It is seen in 0.1-0.5% of the population (1). They are mostly asymptomatic but can cause several life-threatening complications because of the defect in the nutrition of myocardium (2). In adults, some patients

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may remain asymptomatic for their entire lives, if the fistula is not hemodynamically significant. The variety of symptoms that occur depend on the origin, the place of termination, the length and the size of the fistula and the volume of blood stolen. More than 90% of them are congenital, although a few acquired cases may occur following chest trauma such as gunshot wounds or invasive cardiac procedure such as coronary artery bypass grafting, cardiac catheter angiography (3).

Coronary catheterization and coronary computerized tomography angiography (CTA) are the gold standards in diagnosing coronary artery fistulas. Coronary CTA is noninvasive and also able to detect coronary artery fistulas at a higher rate as compared to standard invasive coronary catheterization with angiography (4). CTA is an important tool in guiding the management of cases by showing the course, origin and termination of the fistula and associated vascular formations in 3 planes with volume-rendered images, as well as other associated anomalies.

Coronary artery fistulas can be grouped into two broad categories. The first one is coronary-cameral fistulas which are defined as abnormal connections between coronary arteries and any of the heart chambers. The second one is coronary arteriovenous malformations which are abnormal connections that occur between coronary arteries and parts of the systemic or pulmonary circulatory vessels. The most common fistula originates from the right coronary artery (RCA) and ends in the right ventricle (60%) (2).

Studies have shown that these aberrant coronary arteries, which form the malformation, have thicker tunica intima and media with tightly packed smooth muscle cells (5).

In symptomatic cases that cause hemodynamic problems, the aim of treatment is to embolize the artery feeding the fistula, either by surgery or by catheter angiography. It has been reported that precise access of coronary artery fistulas detected by 3D images in coronary CT angiography (CTA) will be more accurate (6).

In this study, we aimed to evaluate the type, origin, termination and accompanying anomalies, if any, of coronary artery fistulas in patients who underwent coronary CTA in our clinic.

Material and Method

We retrospectively reviewed 932 patients who underwent coronary CT angiography for various indications. Review of coronary CTA reports between March 2016 and January 2023 revealed fourteen patients diagnosed with coronary artery fistula.

Coronary CTA examination of the patients was performed using a 128-detector array CT scanner (Somatom Definition AS, Siemens Healthcare). In adults, after imaging with 3 mm slice thickness for coronary artery calcium scoring, ECG-gated (Electrocardiography-gated) CTA images with 0.5 mm slice thickness were obtained by administering an average of 70-80 ml of contrast material (at a rate of 5-6 ml/s) through antecubital vein followed by 50 ml of saline solution. A low dose (80 kVp) CTA protocol was used for children and the amount of contrast material was adjusted according to body weight. Bolus tracking technique was used to determine scan delay.

Reconstructions were routinely performed in 40% and 75% phases of the R-R interval period. Images were evaluated on the workstation using MPR (Multiplanar Reformation), curved MPR, MIP (Maximum Intensity Projection) and VR (Volume Rendered) 3D postprocessing.

Interpretation of CTA images of the patients was performed independently by two radiologists with 15 years and 2 years of experience in coronary CTA. In case of disagreement on interpretation, consensus was reached with a third radiologist. Coronary artery fistulas, type, origin, ending and accompanying anomalies, if any, were reshaped on the workstation and interpreted on volume rendered images (Table 1).

This study was performed retrospectively and Ethics Committee approval was obtained with a letter dated 28.03.2023.

Results

Coronary artery fistula was diagnosed in 8 female and 6 male patients, aged between 12 and 71 and the median age was 49.5 years. Four of the cases were under the age of 18, 2 were girls and 2 were boys, and the median age was 12 years. There were ten cases in the adult group, of which 6 were female and 4 were male, and the median age was 54.5 years.

Of 14 patients, 13 had a single fistula and 1 had a double fistula, with a total of 15 fistulas.

Of the 15 fistulas, 6 were coronacameral fistula, 7 were corona-pulmonary fistula, 1 was corona coronary fistula between the left circumflex artery (LCX) and the conal branch of right coronary artery and 1 was

Table 1 Characteristics and treatment methods of coronary artery fistulas in our case group

CASE	AGE-GENDER	TYPE OF FISTULA	ORIGIN OF FISTULA	DIAMATER OF FISTULA	DRAINAGE OF FISTULA	COEXIST ANOMALIES	MANAGEMENT
1	10/Male	Corona-pulmonary	LAD	(2mm) in fistulized vessels associated with the LAD and pulmoner trunk	Pulmoner trunk	-	Follow -up
2	12/Female	Corona-camaral	LCX	4mm (LCX)	RV apex	-	Follow -up
		Corona -coronary	LCX	-4mm (LCX) -5mm (Conal artery)	RCA – conal artery		
3	12/Female	Corona-camaral	LAD	-5.5 mm (LAD)	RV	-	Follow -up
4	15/Male	Corona-pulmonary	LAD-Diagonal-2	4.7 mm (Diagonal branch)	Pulmoner trunk	Hypertrophied bronchial arteries in the mediastinum	Surgical treatment
5	20/Male	Corona-camaral	LAD-Septal	4.5mm (LAD)	RV	Pektus excavatus deformity	Coil embolization
6	23/Female	Corona-camaral	RCA	(2mm) in fistulized vessels associated with the RCA and RA	RA	-Dilatation of the left ventricle -Signal and enhancement changes in chronic ischemic pattern in RCA trace in cardiac MRI -FMF disease -ASD closure operation history	Follow -up
7	48/Male	Pulmonary-Desenden aorta	Pulmoner trunk	(3.5mm) in fistulized vessels associated with the aorta and pulmonary trunk	Desenden aorta		Follow -up
8	51/Female	Corona -coronary	LAD	7.5mm (LAD)	Pulmoner trunk	Soft plaque with severe -moderate stenosis proximal to Diagonal-1	Surgical treatment
9	54/Female	Corona-camaral	RCA-PDA	5mm (RCA)	LV	Calcific plaque with moderate stenosis proximal to Diagonal -1	Follow -up
10	55/Male	Corona-camaral	LCX	-8mm (LM) -16MM (LCX)	LA		Surgical treatment
11	57/Female	Corona-pulmonary	RCA	5mm (RCA)	Pulmoner trunk	-Enlargement of the pulmonary trunk -Superficial bridging in LAD	Follow -up
12	59/Male	Corona-pulmonary	LAD	(3 mm) in fistulized vessels associated with the LAD and pulmonary trunk	Pulmoner trunk	-Consistent with ischemia in the left ventricular inferolateral wall in scintigraphic evaluation	Follow -up
13	60/Female	Corona-pulmonary	RCA	(3 mm) in fistulized vessels associated with the RCA and pulmonary trunk	Pulmoner trunk	-	Follow -up
14	71/Male	Corona-pulmonary	LAD	4mm (LAD)	Pulmoner trunk	-Moderate stenosis secondary to mixed plaque in the LCX artery and secondary to diffuse calcified plaques in the coronary arteries 2068 agaston score was measured.	Follow -up

(RV: Right ventricle, LV: Left ventricle, LA: Left Atrium, RA: Right Atrium, LAD: Left Anterior Descending Artery, LCX: Left Circumflex Artery, RCA: Right Coronary Artery, FMF: Familial Mediterranean Fever, ASD: atrial septal defect)

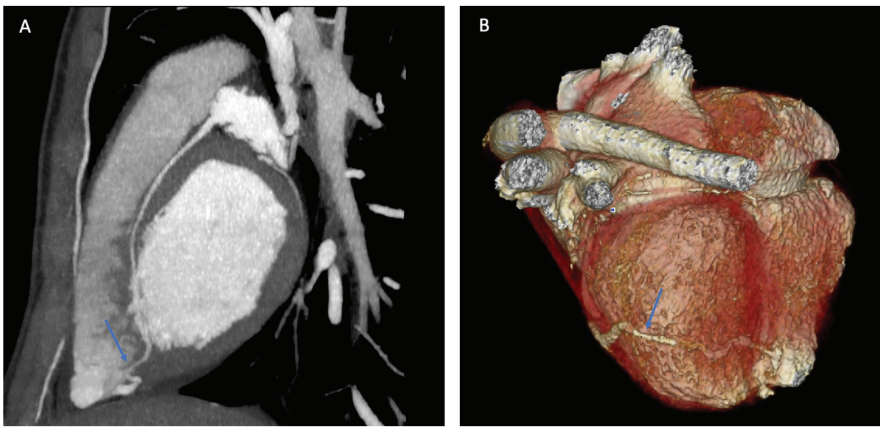

Figure 1
(A) Curved planar reformatted CT image and (B) three dimensions (3D) volume rendered (VR) CT image shows coronacamaral fistula between right ventricle apex and left anterior descending artery.

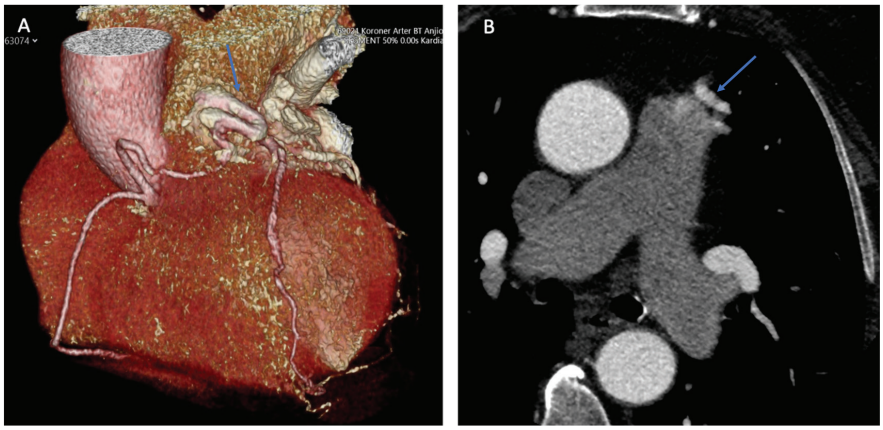

Figure 2
(A) Three dimensions (3D) volume rendered CT image shows corona pulmonary fistula between right descending artery and pulmonary trunk, (B) axial plan contrast-enhanced CT image shows the turbulent flow of the fistulous vessel.

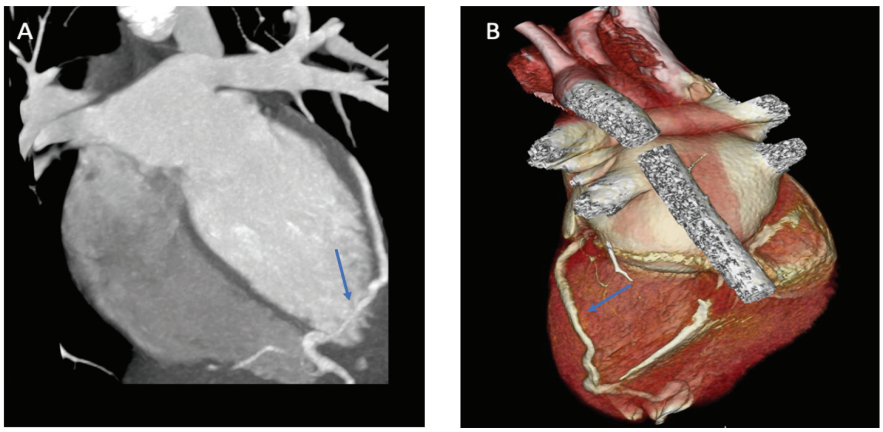

Figure 3
(A) MIP image and (B) Three dimensions (3D) volume rendered CT image shows the fistula between left circumflex artery and right ventricle apex.

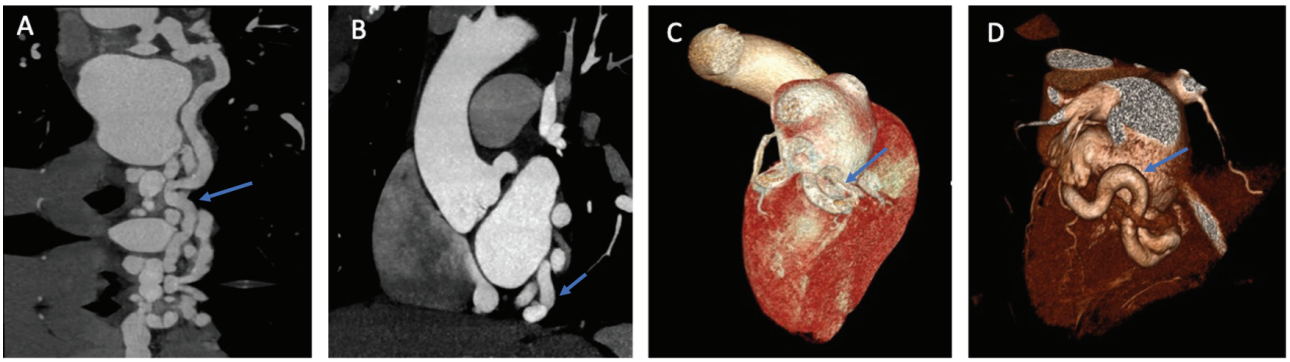

Figure 4
(A-B) MIP image, (C-D) 3D VR CT image shows images show marked increase in LCX artery diameter and tortuosity.

between the pulmonary trunk and the descending aorta (Figure 1-4).

Among the coronacameral fistulas, 3 of them ended in the right ventricle, 1 in the right atrium ,1 in the left atrium and 1 in the left ventricle. Of the coronacameral fistulas ending in the right ventricle, 2 originated from the left anterior descending artery (LAD) Left Anterior Descending Artery) and 1 from the LCX artery.

Of the 7 fistulas ending in the pulmonary trunk, 4 were originating from LAD, 2 from RCA, and 1 from second diagonal branch of LAD.

The diameter of the tortuous vascular structures developing secondary to the fistula varied between 2 mm and 16 mm.

The patient who had a coronacameral fistula between the LAD and the right ventricle was treated by placing a coil in the interventional radiology department without complications. Surgical operation was performed in the cases with a corona-pulmonary fistula between LAD diagonal branch-pulmonary trunk and LAD-pulmonary trunk, and in the case with coronacameral fistula between LCX artery and right ventricle, and the procedures were terminated without complications. Other cases were followed up by the relevant clinics.

In 2 cases, ischemic changes were accompanied by arterial tracing in the ventricular wall, one of which was verified by cardiac MRI and the other by scintigraphy. In addition to ischemic changes, left ventricular enlargement was found on cardiac MRI, and there was a history of Familial Mediterranean Fever (FMF) and atrial septal defect (ASD) closure operation in the patient's history (Table 1).

In 3 cases, there were soft and calcific plaque formations that caused moderate stenosis in other arterial structures unrelated to the fistula. Dilatation of the pulmonary trunk and superficial bridging in the LAD were observed in 1 patient. The patient who was treated with coil embolization had accompanying pectus excavatum deformity. In 1 other case, there were accompanying hypertrophic bronchial arterial structures in the mediastinum.

Discussion

The mean age of the cases in our group was 49.5 years and 6 were male and 8 were female. The most common fistula type was coronary to pulmonary trunk, and the width of the tortiosis vascular structures secondary to the fistula ranged from 2mm to 16mm.
In our case group, invasive procedures were performed in 4 cases in total. The dilatation level in the diameters of the arteries participating in the fistula was remarkable in the operated cases (LM 8mm, LCX 16mm, Diagonal artery reached 4.7mm in diameter). Although the LAD diameter (4.5 mm) was similar to the cases in the follow-up group, it was treated with coil embolization due to ischemic changes in the accompanying ECG. Other cases were included in the follow-up group considering the absence of findings such as ECG changes, heart failure, and arrhythmia. In those the diameter of the arteries related to the fistula was 3-4 mm on average and reaching a maximum of 5 mm.

While the incidence of coronary artery fistula is between 0.5-1% in the literature, this rate was slightly higher in our study and was 1.5%. We thought that this was related to the fact that the hospital where the study was performed was accepted as a reference

hospital in the region and problematic cases were frequently referred.

According to our case series experience, in cases of coronary fistula, while the patient's symptoms determined the surgical decision, the diameter of the artery involved in the fistula was also very useful in determining the treatment procedure.

There was no obvious gender trend in the literature in coronary artery fistula disease, and in our study, female were 57% and male were 43%. While this rate was 54% male and 46% female in Zhou K.'s study, it was 27% male and 63% female in Serap Baş' study (7,8).

Coronary cameral fistula is the most common type of coronary artery fistula in children, accounting for 75.0 % – 100.0 % of cases [10]. Coronary cameral fistula in children most commonly originates from the right coronary artery, followed by the left coronary artery (9). In our study, 50% of fistulas in our pediatric age group were coronacamaral type and associated with the right ventricle (one from LCX, the other from LAD). The other half had Coronary-Pulmonary Artery Fistula (one from LAD, one from diagonal branch of LAD).

In previous studies, the most common drainage sites in coronary artery fistula cases were right ventricle, right atrium, pulmonary artery, coronary sinus, left atrium, left ventricle, and superior vena cava (SVC) (10). Our study showed that 53.3% of the cases drained into the pulmonary trunk, which is similar to the study of Serap Baş (52.9%), while the rate of coronopulmonary fistula was 28% in the study of Zhou K. et al. (7,8). In our study, pulmonary trunk drainage was followed by right ventricle (20%), right atrium (6.6%), left ventricle (6.6%), left atrium (6.6%), coronary artery (6.6%).

It is difficult to cannulate all fistula-derived arteries during invasive coronary angiography, and it can be problematic to follow complex fistula tracts and optimally depict their anatomical relationships on two-dimensional fluoroscopic images. Coronary CT angiography is superior to catheter angiography in revealing the fistula tract and its relationships, as it allows 3D evaluation (11).

In our series of 14 cases, surgical operation was performed in 3 cases and transcatheter closure (TCC) in 1 case, while the others were followed up with medical treatment. Considering the fact that CAFs (Coronary Artery Fistula) are mostly asymptomatic, the first-line treatment is mainly medical therapy with follow-up over time (12). Surgical treatment is generally preferred in the presence of the need for bypass graft or surgical valve repair/replacement, distally located and highly tortuous CAFs, angina symptoms with single and large diameter fistulae, and volume overload (13). The biggest advantage of TCC over surgery is that no cardiopulmonary bypass or median sternotomy is performed, bleeding, ischaemia, infection, arrhythmia, cosmetic concerns are less and recovery time is faster (14).

Conclusion

CAFs can have complex anatomy; Therefore, CT angiographic evaluation, which allows three-dimensional imaging during the pre-treatment examination, provides very important data. While the treatment procedure is usually medical therapy, it may vary between invasive options depending on the patient's symptoms and risk factors in the light of CT angiography data.

Limitations of the Study

We had some limitations, the most important of which was that we did not know the current status of the patients under follow-up and the number of our cases was not sufficient to perform a statistical study. Also since conventional angiography was not performed on every patient in our case group, we did not have the chance to compare catheter angiography and CT angiography data.

Conflict of Interest Statement

The authors declare that they have no competing interest.

Ethical Approval

This study was carried out retrospectively and Ethics Committee approval was obtained from Ege University with a letter dated 28.03.2023- E.1201728. The study was conducted in accordance with the principles set forth in the Declaration of Helsinki.

Consent to Participate and Publish

Written informed consent was obtained from the participants of this study.

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Availability of Data and Materials

Data available on request from the authors.

Authors Contributions

ZAO: Data curation; Formal analysis; Investigation; Methodology; Validation; Visualization; Writing-original draft.

SB: Conceptualization; Formal analysis; Investigation; Methodology; Project administration; Resources; Supervision; Validation; Writing-review & editing.

AC: Investigation; Validation; Writing-original draft.

NC: Formal analysis; Investigation; Visualization; Writing-original draft.

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