Egyptian Journal of Radiology and Nuclear Medicine

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Prevalence of coronary artery fistula in adults performing coronary CT angiography among Egyptian population: a single center study

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Abstract

Background The prevalence of coronary artery fistula (CAF) among Egyptian population is increasing due to widespread availability of coronary CT angiography using high-end CT scanners. The purpose of this observational study was to determine the incidence and types of CAF detected among Egyptian population during routinely performed coronary CT angiography.

Results Among the 2263 retrospectively evaluated CT coronary angiography studies, CAF was detected only in 17 (0.75%) patients with proximal LAD being the commonest vessel of origin; in 5 cases (29.4%) and main pulmonary artery (MPA) the commonest site of fistula termination; in 3 cases (17.6%). Indeterminate site of fistula termination was present in two cases (11.7%) due to limited scan coverage.

Conclusions Multislice coronary CT angiography is a useful non-invasive imaging modality for diagnosis of CAF by demonstrating vessel of origin, course and site of termination, with CAF prevalence and types among Egyptian population being reported in this study based on routinely performed coronary CT angiography.

Keywords Fistula, Coronary, Multislice CT angiography

Background

Coronary artery fistula (CAF) is abnormal connection between coronary artery and cardiac chamber or great thoracic vessel with congenital forms being the commonest so far. Its prevalence (0.05–0.25%) has been reported previously by many authors based on retrospective analysis of large amount of coronary angiography studies performed to rule-out or to treat obstructive coronary artery disease [1, 2].

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Different vessels of origin have been reported regarding CAF including left anterior descending (LAD) artery, left circumflex (LCx) and right coronary artery (RCA) in decreasing order, and different sites of termination were also described with cardiac chambers (coronary-cameral fistula) being the commonest most frequently into right ventricle, while superior vena cava drainage was documented in minority of patients [3].

Although coronary angiography is still considered the gold standard for diagnosis of atherosclerotic coronary artery disease, its use in CAF diagnosis is less preferable due to complex nature of CAF, lack of three-dimensional (3D) images which outline the course of CAF in relation to adjacent structures. Furthermore, the dilution of injected contrast material during coronary angiography by the shunting effect of large fistulae decreases image

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quality and interferes with accurate assessment of draining site, and here it comes the value of CT [4].

With increasing number of coronary CT angiography studies performed to rule-out obstructive coronary artery disease as well as the widespread availability of high-end CT scanners, the number of detected CAF is increasing even in asymptomatic individuals or those with atypical ischemic symptoms owing to high spatial and temporal resolution of recent CT scanners together with 3D reconstructions which facilitates the evaluation of CAF regarding site of origin, course, and termination [5].

The reported incidence of CAF in patients undergoing coronary CT angiography is higher than in those undergoing invasive coronary angiography as the latter is being replaced nowadays by multislice CT in those with low to intermediate risk of having coronary artery disease [6].

The purpose of this study was to know the prevalence of CAF among Egyptian population detected by routinely performed coronary CT angiography at our institution, and to further analyze different sites of origin and termination, and to correlate the CT findings with clinical symptoms and any associated cardiac abnormality detected at performed coronary CT study.

Methods

Study design and population

This observational study was conducted retrospectively on 2263 adult patients referred to our institution to perform coronary CT angiography, aiming to rule-out obstructive coronary artery disease or malignant course of anomalous coronary arteries in younger population. At our institution we do not perform coronary CTA routinely in infants and young children due to CT scanner limitations regarding temporal resolution which is relatively low (175 ms) being unable to freeze coronary arteries' motion in such high heart rate age groups when compared to dual source CT scanners which have better temporal resolution. So, infants and children were excluded from this study. Those included were scanned over a period of three years; from May 2019 to May 2022. However, the study itself was performed over a period of 3 months thereafter by reviewing and analyzing CT angiography (CTA) studies of those patients stored at our local picture archiving and communication system (PACS) to detect CAF. The study was approved by our institutional ethical committee and the need for patient's consent was waived due to retrospective nature of the study.

Coronary CT angiography scanning protocol

All patients were scanned using 320-row multislice CT scanner (Aquilion One, Canon Medical Systems, Otawara, Japan) installed at our institution according to our CT coronary angiography standard protocol, which involves heart rate control below 60 bpm using oral metoprolol at a dose of 50–150 mg given one hour prior to scan provided that there is no contraindication of its use, ECG-gated prospective volumetric acquisition of coronary arteries with scan range extending from carina down to cardiac apex after injection of tight bolus of non-ionic contrast material (50–90 ml) followed by 50 ml saline chaser through 18 g IV cannula inserted at right antecubital vein using dual head automatic injector (Stellant D, Medrad, USA) at injection flow rate of 4.5–6.5 ml/sec. according to kV used and patient's BMI. We usually use bolus tracking method (SureStart) to trigger CTA acquisition when contrast media arrives at descending aorta at mid-heart level using a pre-defined ROI with trigger threshold being set at 230 HU. Single heartbeat acquisition is a standard practice at our institution to get the benefit of low-dose acquisition with exposure window being set to include only 70–80% of R-R interval if heart rate is below 60 bpm and 30–80% of R-R interval if heart rate is above 60 bpm and below 70 bpm. We usually do not proceed with scan if heart rate is above 70 bpm as cardiac motion artifacts are most likely to be encountered which hinders accurate assessment of coronary arteries. Images are reconstructed thereafter using the following parameters: slice thickness: 0.5 mm, interval: 0.3 mm, smooth kernel (FC03).

Image post processing and analysis

Reconstructed axial images were transferred to workstation (Vitrea Fx, Vital Images, USA) for analysis of coronary arteries. Image analysis was done independently by one consultant radiologist who has eight years of experience in cardiac CT and blinded to previous interpretation results of all included patients. Axial images were analyzed for the presence of CAF which was defined as abnormal connection between any coronary artery segment with another vessel or cardiac chamber. After diagnosis of CAF, further analysis was performed to determine the site of origin, fistula course and site of termination together with presence of any aneurysmal dilatation or mural thrombosis along fistula course. Measurement of fistula diameters was done at coronary artery end and at the site of fistula termination using electronic caliper. CAF was considered large if its diameter exceeds 5 mm. Three-dimensional volume rendered images were created to obtain global overview of fistula regarding the size, course and site of termination. The rest of coronary arteries were evaluated as well using standard technique implicating scrolling throughout axial data set and creation of curved planar reformatted images to detected atherosclerotic plaques, measure degree of luminal stenosis to rule-out obstructive coronary artery disease. Any relevant associated findings

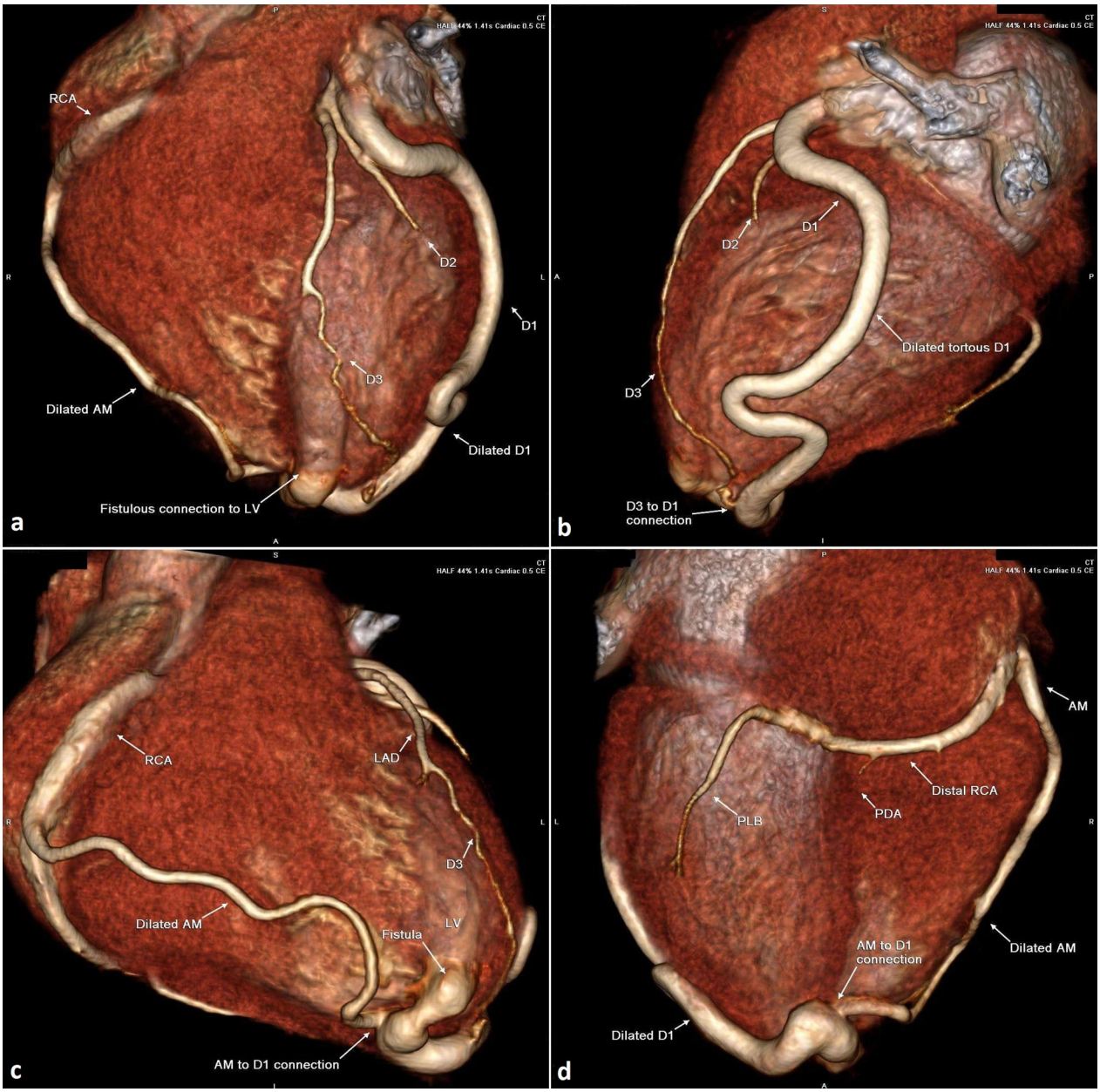

Fig. 1 Large first diagonal branch coronary artery fistula with LV apex in 20-year-old male with typical chest pain. Semitransparent 3D volume rendered images show ectatic tortuous first diagonal branch of LAD that runs over anterior and lateral walls of LV and ends by forming large fistulous connection with LV apex (**a**, **b**). Ectatic RV acute marginal branch is evident due to intercoronary communication with first diagonal branch just proximal to its fistulous connection with LV apex (**c**, **d**)

were documented as well including cardiac chamber or great vessel dilatation.

Results

Among the 2263 patients included in this study, CAF was diagnosed only in 17 (0.75%) patients including 12 males (70.6%) and 5 females (29.4%), their age ranged from 20 to 58 years with a mean of 31.6 ± 12.3 SD.

Analysis of presenting symptoms among those diagnosed with CAF by coronary CTA revealed atypical chest pain in 7 patients (41.1%), dyspnea in 5 patients (29.4%) and typical chest pain in 4 patients (23.5%). The remaining case complained of palpitation.

Different vessels of origin were encountered during analysis of CAF, the commonest vessel of origin was proximal LAD (29.4%) followed by distal LCx (23.5%)

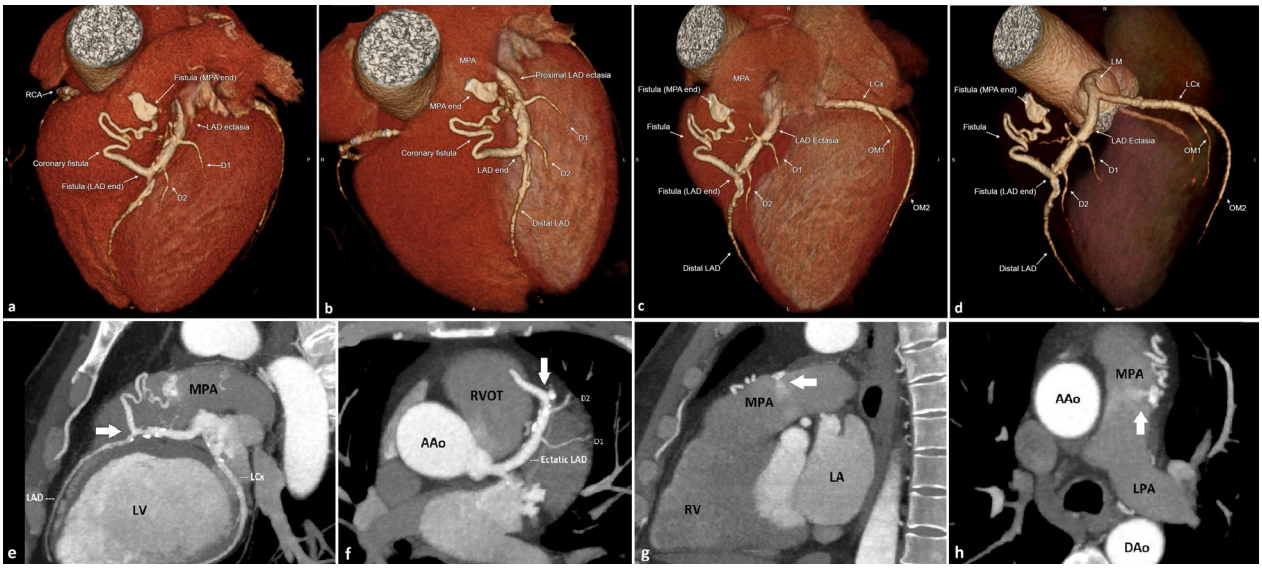

Fig. 2 Sizeable proximal LAD coronary artery fistula with MPA in 52-year-old male patient with typical chest pain. 3D volume rendered images (**a**–**c**) showing sizeable tortuous coronary artery fistula arising from ectatic proximal LAD and draining into MPA by sizably noted contrast blush. Tilted semitransparent 3D volume rendered image (**d**) shows the vessel of origin, fistula size and course and draining site as well. Sagittal oblique MIP image (**e**) showing the sizeable coronary artery fistula arising from ectatic proximal LAD (arrow) attaining tortuous course and draining into MPA with atherosclerotic plaques noted within LAD as well. Axial MIP image (**f**) shows the vessel of origin clearly (arrow). Sagittal oblique and axial MIP images (**g**, **h**) show abnormal contrast jet inside MPA (arrows) at the site of fistulous connection

with only one case (5.8%) CAF being arising from diagonal branch of LAD (Fig. 1). The remaining vessels of origin are proximal and distal RCA as well as distal LAD.

The sites of termination of the detected CAF included main pulmonary artery (Fig. 2) being the commonest in 5 cases (29.4%), superior vena cave in 3 cases (17.6%), right atrium in 3 cases (17.6%) and right ventricle in 2 cases (11.7%). The remaining sites of termination are left ventricle (LV), and coronary sinus with indeterminate site of fistula termination noted in one case (5.8%) due to limited scan coverage where the fistulous tract extends above the proximal limit of scan range probably draining into bronchial artery.

The largest CAF as regard diameters was found among young population below 30 years of age whom typical ischemic symptoms were found mostly due to stealing effect. On the other hand smaller fistulae were observed at older age group above 40 years of age and they were complaining of atypical ischemic symptoms with their CAF being most likely discovered incidentally. The large-sized CAF was found to be arising from proximal segments of LCX & RCA as well as distal segment of LCX (Fig. 3) together with the diagonal branch, whereas the small-sized CAF were arising from MPA and distal RCA. MPA was the commonest sites of termination of small-sized fistula whereas the large-sized fistulae were terminating into SVC, right atrium, RV and LV cavities. Details of the 17 cases diagnosed with CAF are demonstrated in Table 1 whereas the analysis of morphological characteristics of CAF in this study is shown in Table 2.

Aneurysmal dilatation was noted among three cases (17.6%) having large CAF all of which were arising from LCX. Subtotal thrombosis was found in one patient having proximal RCA fistula with SVC who also had anomalous origin of RCA from left coronary cusp with malignant interarterial course (Fig. 4). Significant atherosclerotic coronary artery disease was encountered among 3 out of 17 patients (17.6%) with significant atherosclerotic lesions being located at LAD & RCA, interestingly noted that all three cases with significant atherosclerotic disease had small CAF between proximal LAD & MPA. Large fistulae draining into right sided cardiac chamber or SVC was associated with right sided cardiac chambers dilatation whereas the remaining CAF was not associated with any significant cardiac chamber dilatation.

Discussion

This study revealed that the prevalence of CAF among Egyptian patients underwent coronary CT angiography was 0.75% which is higher than the prevalence reported during invasive coronary angiography by many authors. This could be explained that many of CAF are most likely to be asymptomatic particularly the smaller ones and discovered incidentally during coronary CT angiograms done to rule-out atherosclerotic CAD. Such incidence is higher than what was reported by Zhou et al. [5] who

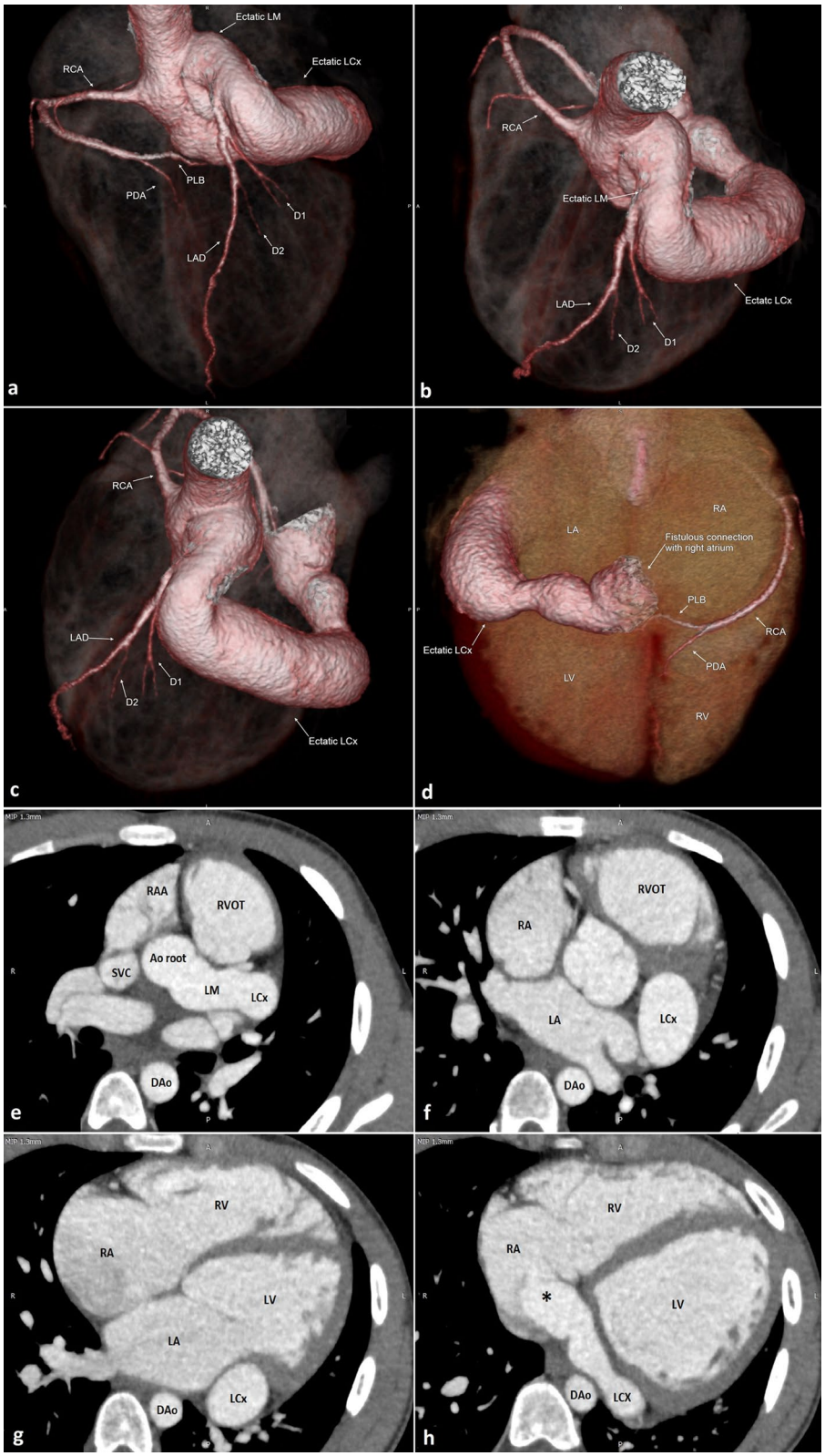

Fig. 3 Large distal LCx coronary artery fistula with right atrium in 22-year-old male patient with dyspnea. Semitransparent 3D volume rendered image (**a–d**) showing markedly ectatic left main coronary artery and LCx due to abnormal large fistulous connection between distal LCx and right atrium. Axial thin MIP images showing markedly ectatic left main coronary artery as well as LCx (**e**, **f**), the latter runs within left atrioventricular groove (**g**) and finally shows large fistulous connection with right atrium (asterisk in **h**). There is biventricular dilatation as well

Table 1 Details of CAF detected by coronary CT angiography

Case no.	Age	Sex	Symptoms	Vessel of origin	Site of termination	Fistula size
1	20	M	Typical chest pain	Proximal LCX	SVC	Large
2	26	M	Typical chest pain	Proximal LCX	SVC	Large
3	21	M	Dyspnea	Distal LCX	SVC	Large
4	33	F	Atypical chest pain	Proximal RCA	Indeterminate	Small
5	44	F	Dyspnea	Distal LCX	RA	Large
6	56	M	Atypical chest pain	Proximal LAD	MPA	Small
7	58	M	Atypical chest pain	Proximal LAD	MPA	Small
8	22	M	Palpitations	Proximal RCA	RA	Large
9	20	M	Dyspnea	Distal LCX	Coronary sinus	Large
10	35	M	Dyspnea	Distal LCX	RA	Large
11	41	F	Atypical chest pain	Proximal LAD	MPA	Small
12	38	F	Typical chest pain	Proximal LAD	MPA	Large
13	32	M	Dyspnea	Distal LAD	RV	Large
14	20	M	Typical chest pain	Diagonal	LV	Large
15	23	M	Atypical chest pain	Distal RCA	RV	Small
16	21	M	Atypical chest pain	Distal RCA	RV	Small
17	28	F	Atypical chest pain	Proximal LAD	MPA	Small

RV right ventricle, *LV* left ventricle, *SVC* superior vena cava, *LCx* left circumflex, *LAD* left anterior descending, *MPA* main pulmonary artery, *RCA* right coronary artery

Table 2 Morphological analysis of detected coronary artery fistula

	Case ($N=17$)
Vessel of origin	
Proximal LAD	5
Distal LAD	1
Proximal LCx	2
Distal LCx	4
Proximal RCA	2
Distal RCA	2
Diagonal	1
Site of termination	
Main pulmonary artery	5
Right atrium	3
Right ventricle	2
Left ventricle	2
Superior vena cava	3
Coronary sinus	1
Indeterminate	1
Fistula size	
Large	10
Small	7
Presence of associated significant atherosclerotic CAD	
Present	3
Absent	14

LAD left anterior descending, *LCx* left circumflex, *RCA* right coronary artery, *CAD* coronary artery disease

reported CAF in 0.19% of their studied population using dual source CT scanner. Higher prevalence of CAF was detected by Ouchi et al. [6] among patients undergoing CT coronary angiography, they reported a prevalence of 0.91% among larger population (6789) over a period of six years.

All major coronary arteries have been reported to give rise to CAF. The commonest vessel of origin in this study was LAD which was involved in 6 cases (35.2%) having CAF. Such observation goes well with studies done by Ouchi et al. [6] who reported the same issue in 67.7% of their CAF cases.

As regard the site of CAF termination, the commonest drainage site in this study was found to be the main pulmonary artery (MPA) in 5 cases (29.4%), which is in agreement with the studies done by Ouchi et al. and Pan et al. who also found that MPA was the commonest site of CAF drainage being involved in 82.3% and 73.5% of their CAF cases, respectively [2, 6].

Indeterminate site of CAF termination was found in one case in this study, the fistula arises from proximal segment of LAD and ascends superiorly extending outside the upper limit of scan coverage probably ending at bronchial artery which has been reported by different authors [7, 8]. This issue requires further increase in the upper limit of scan range to include at least the aortic arch if there is high clinical suspicion of CAF to ensure optimal coverage of the site of CAF termination.

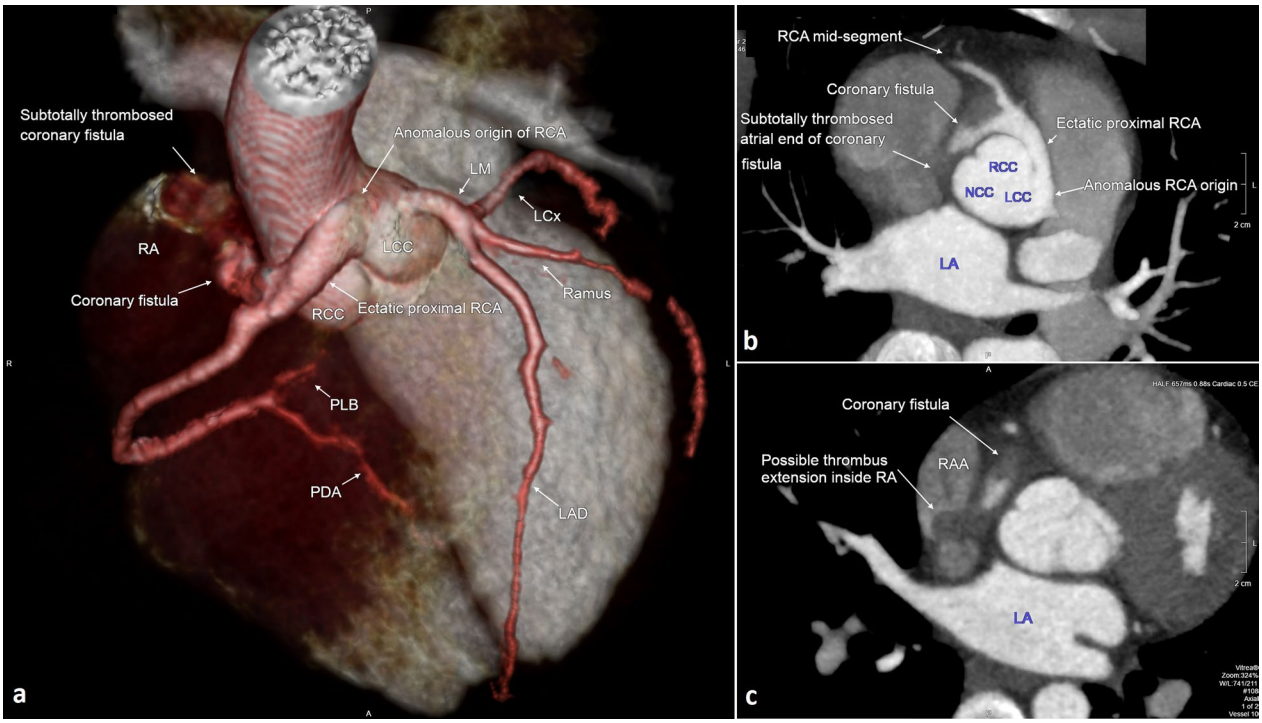

Fig. 4 Subtotally thrombosed large proximal RCA fistula with right atrium together with anomalous origin of RCA in 21-year-old male with palpitations. Semitransparent 3D volume rendered image (**a**) showing anomalous origin of ectatic RCA arising from left coronary cusp with faintly opacified coronary artery fistula draining into right atrium due to subtotal thrombosis. Axial oblique MIP image (**b**) at the level of aortic root shows the anomalous origin of RCA and its malignant interarterial course with subtotal thrombosis of proximal RCA fistula. Axial oblique MIP image (**c**) at higher level reveals the remaining length of the subtotally thrombosed proximal RCA coronary fistula with its draining site into right atrium with possible extension of thrombus tail inside right atrium

Atherosclerotic coronary artery disease has been reported by Zho et al. [5] to be present among patients diagnosed with CAF as it was present in 18.2% of their cases. Our study showed that atherosclerotic coronary artery disease was present in 3 out of 17 cases (17.6%) with atherosclerotic lesions being located close to fistula origin only in one case (Fig. 2) and at non-involved vessels in the remaining two cases. Different authors had reported significant atherosclerotic lesions close to origin of CAF, this could be due to the rapid shunting of blood across the fistula specially the larger ones which results in endothelial injury close to fistula origin and intimal hyperplasia with resultant luminal stenosis [9, 10].

Subtotal thrombosis of CAF was noted in one case in this study with proximal RCA being the vessel of origin. Interestingly noted that RCA in the same patient had anomalous origin arising from left coronary cusp with malignant interarterial course (Fig. 4). We believe that this is an extremely rare association and to the best of our knowledge there is no reported similar case in the literature.

Limitations

The major limitation of this study is data collection was done only from a single center lacking pediatric population, who were scanned at other centers having dual source CT scanners which have better temporal resolution overcoming challenges of high heart rate in children. Combining data obtained from those centers together with our data would yield a higher prevalence of CAF among Egyptian population considering CAF are common in those population. Moreover, asymptomatic individuals who did not have coronary CT angiography were not included in this study who may have small CAF that could also increase the overall prevalence as well. Furthermore, standard coronary CTA protocol used in this study missed fistula drainage site in one patient which would be possible to know if scan protocol was tailored for coronary fistula detection by increasing upper extend of scan range. The absence of gold standard coronary angiography correlation is another limitation to know the accuracy of CTA results regarding CAF detection.

Conclusions

The prevalence of CAF among Egyptian population who underwent coronary CT angiography is (0.75%) based on single-center retrospective analysis, with LAD being the commonest vessel of origin and MPA the commonest site of termination. Moreover, Coronary CT angiography is useful non-invasive imaging modality for diagnosis of CAF outlining vessel of origin, size and site of termination clearly.

Abbreviations

3D	Three-dimensional
AM	Acute marginal
CAD	Coronary artery disease
CAF	Coronary artery fistula
CT	Computed tomography
CTA	Computed tomography angiography
HU	Hounsefield unit
IV	Intravenous
Kv	Kilovoltage
LAD	Left anterior descending
LCX	Left circumflex
LPA	Left pulmonary artery
LV	Left ventricle
MIP	Maximum intensity projection
MPA	Main pulmonary artery
PDA	Posterior descending artery
PLB	Posterolateral branch
RA	Right atrium
RCA	Right coronary artery
RPA	Right pulmonary artery
RV	Right ventricle
RVOT	Right ventricular outflow tract
SVC	Superior vena cava

Acknowledgments

Not applicable.

Author contribution

Not applicable due to single author. The author read and approved the final manuscript.

Funding

No funding was received for this research work.

Availability of data and materials

The datasets used and analyzed in this study are available from author upon reasonable request.

Declarations

Ethics approval and consent to participate

This study was approved by the Research Ethics Committee of Faculty of Medicine at Tanta University in Egypt. The consent to participate in this study was waived due to retrospective nature of the study.

Consent for publication

All patients included in this research gave written informed consent to publish the data contained within this study.

Competing interests

Author declares no competing interests.

Received: 4 October 2022 Accepted: 31 December 2022
Published online: 09 January 2023

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