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CASE REPORT

Diagnosis, Management, and Treatment of Coronary Artery Fistulas: Three Case Reports and Literature Review

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ABSTRACT

Coronary artery fistulas represent a form of congenital coronary arteriovenous malformation. They originate from coronary arteries and most commonly drain into the right atrium and right ventricle, with less frequent drainage into the coronary sinus or pulmonary trunk. Clinical manifestations are influenced by the extent of the left-to-right shunt, which can result in ischemia due to diversion of blood from the nearby myocardium, despite the absence of atherosclerotic coronary artery disease. Coronary angiography continues to be the primary method for diagnosis and enables the interventional closure of these fistulas. Current congenital heart disease guidelines recommend considering both symptoms and fistula size when determining the need for closure. This report represents three patients evaluated in our outpatient clinic who underwent successful treatment with percutaneous coil embolization.

Keywords: Coronary artery fistula, symptomatology, coil embolization

INTRODUCTION

A coronary artery fistula (CAF) is a type of congenital coronary arteriovenous malformation. It represents an uncommon abnormal connection between one or more coronary arteries and a cardiac chamber or a major vessel.[1] The overall incidence in the general population is approximately 0.002%. Among individuals undergoing coronary angiography (CAG), it is identified in about 0.2-0.6% of cases.[2] In nearly 50-60% of instances, CAF originates from the right coronary artery (RCA). The left anterior descending (LAD) coronary artery is the second most common origin, accounting for approximately 25-42% of cases, while the circumflex (Cx) coronary artery is involved in about 18%.[3] These fistulas most frequently drain into the right atrium (RA) and right ventricle (RV), with occasional drainage into the coronary sinus (CS) or pulmonary trunk. Although they are generally asymptomatic and without complications, the likelihood of adverse outcomes increases with age. Clinical manifestations depend on the extent of the left-to-right shunt, which can lead to myocardial ischemia due to diversion of blood away from the surrounding myocardium, despite the absence of atherosclerotic coronary artery disease.[4] In this report, we present three patients diagnosed with this rare congenital anomaly at our outpatient clinic. Through this case series and review, we aim to emphasize that physicians should be vigilant for CAFs when interpreting CAG images in patients with normal or non-obstructive coronary arteries, particularly in those presenting with symptoms, as these anomalies may be easily overlooked.

CASE REPORTS

The first patient was a 53-year-old woman with diabetes who had been experiencing stable angina pectoris for 6 months and was evaluated in our outpatient clinic. Her chest pain was retrosternal, exertional in nature, radiated to the left arm, and associated with dyspnea. During the exercise stress test, significant ST segment depression occurred alongside angina symptoms. CAG demonstrated normal coronary arteries, except for a CAF arising from the LAD artery. Multislice computed tomography (CT) imaging (Figure 1) revealed that the CAF was located between the second diagonal branch of the LAD artery and the main pulmonary artery (PA). Given the presence of typical angina and documented myocardial ischemia, percutaneous coil embolization of the fistula was planned.

The second patient was a 61-year-old woman with hypertension and a family history of cardiovascular disease, who presented with stable angina pectoris of three months' duration. Her chest pain was retrosternal, exertion-induced, and radiated to the neck. She was unable to complete the exercise stress test due to severe dyspnea and fatigue, achieving a maximum of 5 metabolic equivalent of tasks. CAG revealed normal coronary arteries except for two CAFs, originating

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from both the LAD artery and RCA. Multislice CT imaging (Figure 2) showed that one fistula was between the first septal branch of the LAD artery and the PA, while the other was between the conus branch of the RCA and the PA. Based on the presence of typical angina and confirmed myocardial ischemia, percutaneous coil embolization was planned for both fistulas.

The third patient was a 74-year-old man with diabetes who presented with new-onset angina pectoris and dyspnea that had persisted for 10 days. His symptoms were triggered by prolonged exertion. CAG showed normal coronary arteries except for a CAF originating from the Cx artery. Multislice CT imaging (Figure 3) revealed that the CAF was located between the Cx artery and the entry of the left inferior pulmonary vein (LIPV) into the left atrial cavity. Given the presence of typical symptoms consistent with unstable angina, percutaneous coil embolization of the fistula was scheduled. For all patients, secondary causes of ischemia-such as anemia, thyrotoxicosis, and severe hypertension-were excluded.

After selective catheterization of the coronary ostium using a 6-French guiding catheter, a 260-cm-long, standard 0.014-inch coronary angioplasty guide wire was advanced. Using an external torque device, the wire was navigated to the distal portion of the fistula. A 1.7 F microcatheter (Headway 17 Advanced Microcatheter, Microplex®) was then threaded over the guide wire, through which Microplex 10® platinum endovascular embolization coils were delivered to occlude the fistula. The coils were deployed using a V-grip detachment controller. Coil diameter was selected to be 1.5-2 times the diameter of the narrowest part of the fistula to minimize the risk of migration. The number of coils used depended on the length of the fistula and the need to achieve full cessation of flow. Coils were deployed until complete occlusion was confirmed by angiography, with no contrast passing through the fistula. In the first patient, 2.5 × 4 cm, 2.0 × 4 cm, 3.0 × 4 cm, and 2.0 × 6 cm microcoils were placed. In the second patient, 2.5 × 6 cm, 2.0 × 2 cm, and 3.0 × 6 cm microcoils were placed. In the third patient, 2.5 × 6 cm, 2.0 × 4 cm, 2.0 × 4 cm, 1.5 × 2 cm, and 3.0 × 6 cm microcoils were placed. The procedure was concluded once the fistula tract was completely filled and no residual flow was observed. Follow-up angiography confirmed complete occlusion of the fistulas in all three patients (Figures 4a, 4b, 4c).

Aspirin monotherapy was started in all three patients. At the 1-month follow-up, anginal symptoms had subsided in all cases. The patients were monitored for 1 year without the emergence of new or worsening symptoms.

DISCUSSION

This case report and review article aim to highlight three considerations regarding CAFs. First, CAF should be considered in patients who present with typical cardiac symptoms despite having normal or non-obstructive coronary arteries. Second, both the symptom profile and/or the size of the fistula are important determinants when evaluating the need for closure. Third, percutaneous transcatheter closure (TCC) remains the primary treatment approach for CAFs when not contraindicated.

CAF accounts for up to half of all coronary artery anomalies and is considered the most hemodynamically significant among them.[5] As noted earlier, the most common origin of CAFs is the RCA, followed by the LAD and Cx arteries. While most CAFs involve a single connection, cases with multiple fistulas have also been documented.[6] In our series, the fistulas originated from the LAD and Cx arteries, with one case showing dual origins from both the RCA and LAD artery.

The drainage site of the fistula holds greater clinical significance than its origin, as it is directly related to the severity of symptoms. Approximately 90% of fistulas drain into the low-pressure regions of the cardiovascular system, most commonly the RV in 45% of cases, followed by the RA in 25%, the PA in 15%, and then the superior vena cava and CS, respectively.[7] In our series, two patients had fistulas draining into the

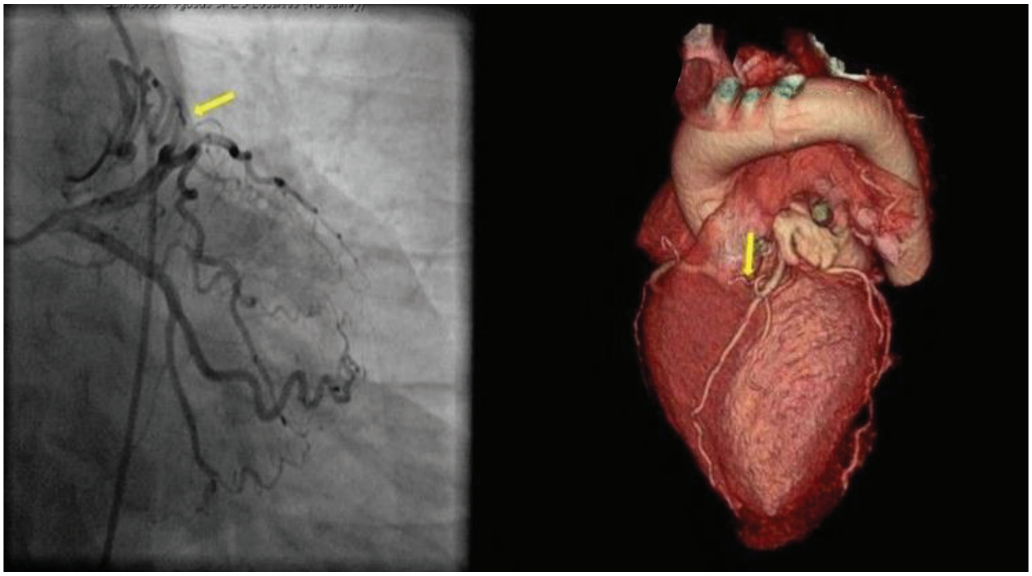


Figure 1. CAG and multislice CT images showing the CAF between the second diagonal branch of the LAD artery and the main PA

CAG: Coronary angiography, CT: Computed tomography, CAF: Coronary artery fistula, LAD: Left anterior descending, PA: Pulmonary artery

PA, and one had a fistula draining into the junction of the LIPV and the RA. The remaining 10% of fistulas drain into the left side of the heart.[8] Additionally, there are reports in the literature describing CAF drainage into the pericardial space.[9] Aside from the drainage site, the shunt volume also shows a strong correlation with clinical presentation. One of our patients exhibited significant exertional dyspnea accompanied by pronounced contrast opacification on CAG. Although we did not perform a direct assessment of shunt volume, based on the symptoms and the presence of myocardial ischemia observed in stress testing, the shunt volume may retrospectively be considered clinically significant in all three patients.

Clinical Presentation

The majority of patients remain asymptomatic. When present, clinical manifestations may include exertional or resting dyspnea, angina pectoris, arrhythmias, thrombosis, embolism, myocardial infarction (MI), and heart failure. In rare instances, pericardial effusion and sudden death may be the initial presentation.[4,10,11] Some cases have reported aneurysm formation and spontaneous rupture of the fistula.[1] Breathlessness and signs of congestive heart failure are typically associated with a large left-to-right shunt, which is an uncommon finding in older individuals.[12] MI can also occur due to reduced blood flow distal to the fistula, even in the absence of coronary atherosclerosis. The mechanism thought to underlie this ischemia is coronary steal,[13] which leads to reduced perfusion of the adjacent myocardium.[14] In our cases, based on clinical symptoms and findings from the stress test, we concluded that myocardial perfusion was impaired and this contributed to MI.

Physical Examination

The primary finding on physical examination is a continuous murmur that is louder during diastole.[15] This murmur has as crescendo-decrescendo pattern. The site where the murmur is loudest can provide clues about the drainage location. If the murmur is loudest

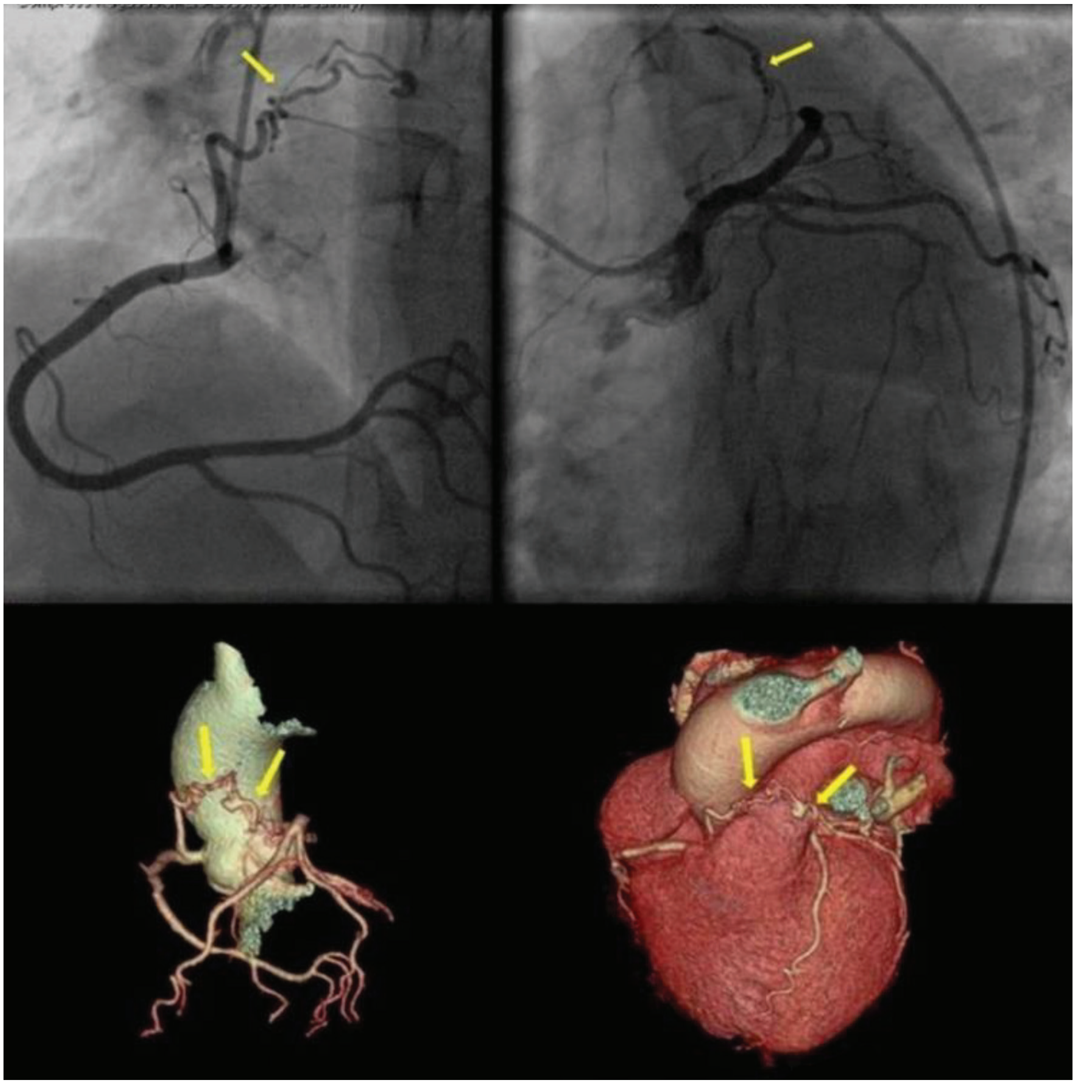


Figure 2. CAG and multislice CT images depicting the CAF between the first septal branch of the LAD artery and the PA; a second CAF between the conus branch of the RCA and the PA

CAG: Coronary angiography, CT: Computed tomography, CAF: Coronary artery fistula, LAD: Left anterior descending, PA: Pulmonary artery, RCA: right coronary artery at the lower sternal border, the fistula likely drains into the RA. When it is loudest near the left upper sternal border, drainage is into the PA is suggested. If the loudest point is near the apex, drainage into the left ventricle should be considered.[16,17] Additional signs such as an S3 gallop or rales may also be present depending on clinical conditions. Continuous murmurs can also occur in other conditions including patent ductus arteriosus, pulmonary arteriovenous fistula, ruptured sinus of Valsalva aneurysm, and systemic arteriovenous fistula.[18]

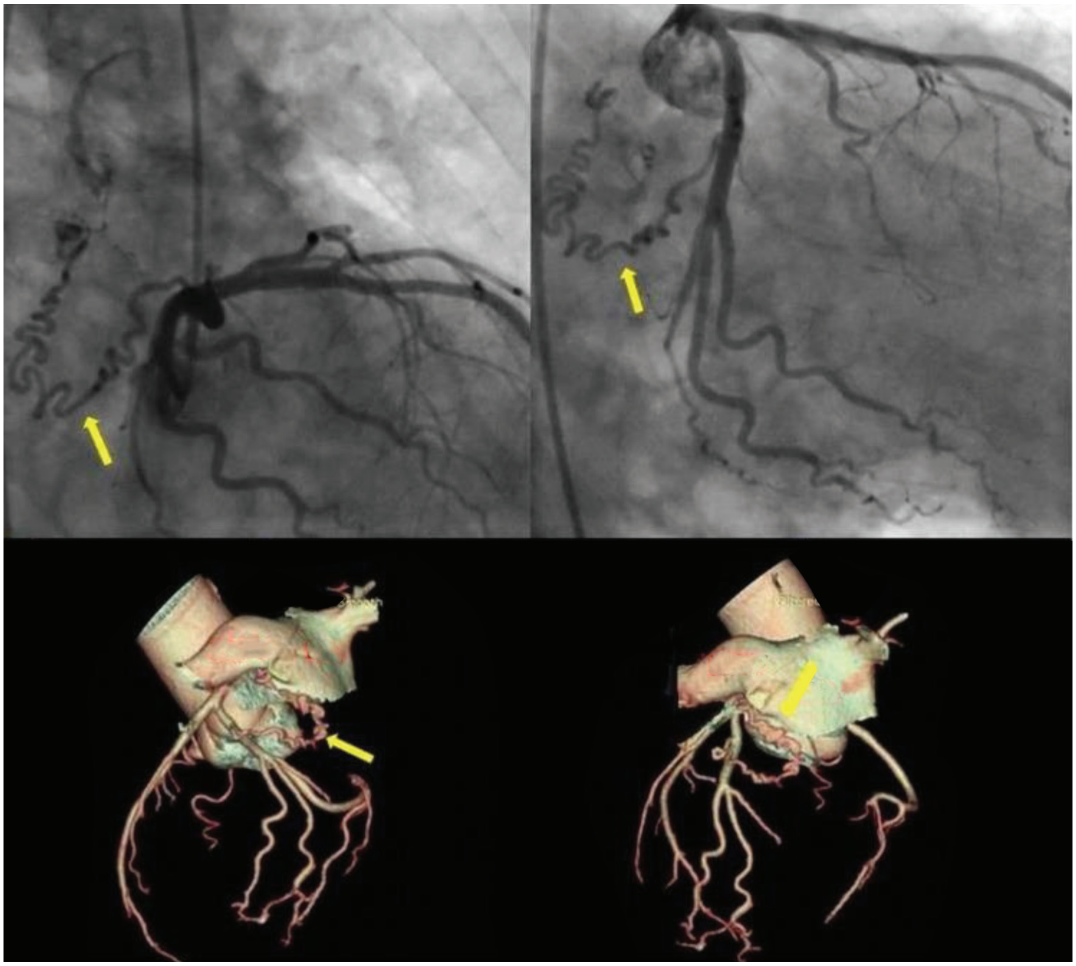


Figure 3. CAG and multislice CT images of the CAF between the Cx artery and the opening of the LIPV into the left atrial cavity

CAG: Coronary angiography, CT: Computed tomography, CAF: Coronary artery fistula, Cx: Circumflex, LIPV: Left inferior pulmonary vein

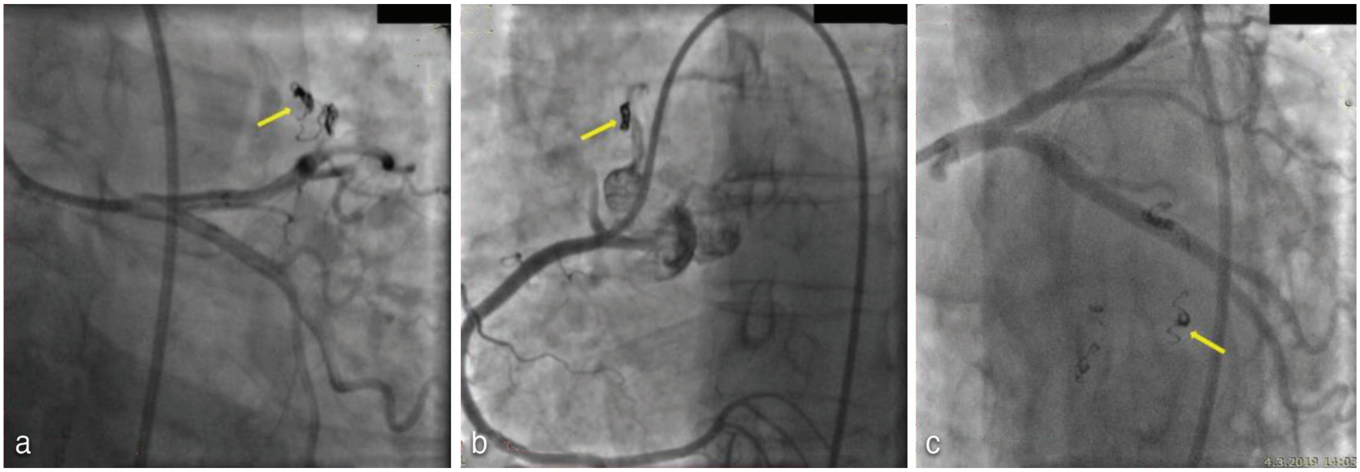


Figure 4. (a, b, c) CAG images following the procedure

CAG: Coronary angiography

Therefore, further evaluation with various cardiac imaging techniques is necessary for differential diagnosis.

Diagnosis

Ischemic changes can be observed on electrocardiography (ECG) due to reduced myocardial perfusion. Although rare, atrial fibrillation and left or right ventricular hypertrophy may also be present. In our cases, no ECG abnormalities were detected at rest; however, significant ST segment depression appeared during the stress test in the first patient.[1,17,19] Echocardiography may show chamber enlargement caused by volume overload or myocardial dysfunction-either regional or global-resulting from ischemia.[17,18,20] In the third patient, echocardiography revealed global hypokinesis in the absence of atherosclerotic coronary artery disease.

Additional cardiac imaging methods include multislice CT and magnetic resonance imaging (MRI).[18] Compared to MRI, CT is more practical to perform, being faster and offering higher resolution. It clearly visualizes the boundaries of the fistulas, and with the latest multislice CT scanners, even smaller coronary branches can be detected. We chose multislice CT to delineate the anatomy. The primary limitation of CT is radiation exposure. MRI can also be used to visualize the anatomy and detect ischemic myocardium through stress thallium studies.[21] Among these options, CAG remains the primary diagnostic method and also enables interventional closure of the fistulas. Figure 5 shows the diagnostic algorithm for CAFs.

Management and Treatment

CAFs can be classified as small (mild), medium (moderate), or large based on their diameter being <1, ≥1-2, or >2 times the largest diameter of the coronary vessel not supplying the CAF, respectively.[22] Since most fistulas are small and hemodynamically insignificant, a follow-up approach may be suitable, especially for small fistulas that are incidentally found and asymptomatic.[19] The 2008 American College of Cardiology and American Heart Association guidelines for managing adults with congenital heart disease (Figure 6) emphasize symptom presence and/or fistula size as key criteria for closure. Proximal CAFs tend to be large, whereas distal fistulas are usually smaller and more tortuous. Large CAFs should be closed regardless of symptoms (class 1, level of evidence, C). Closure is also recommended for mild to moderate fistulas if symptoms are associated with documented MI, arrhythmias, unexplained ventricular dilation or dysfunction, or if complicated by endocarditis (class 1, level of evidence, C). Small, asymptomatic fistulas should not be treated (class 3, level of evidence, C). Clinical monitoring with echocardiography every 3-5 years may be helpful in these patients to detect the onset of symptoms, arrhythmias, or progression in size or chamber enlargement that could affect management (class 2a, level of evidence, C).[23] Because CAFs tend to enlarge with age, early closure is advised in symptomatic patients.[24] The management algorithm for CAFs is presented in Figure 6. Since all three of our patients were symptomatic, we opted for closure of the fistulas.

Treatment options include either surgical intervention or TCC. Due to higher morbidity risk and longer hospital stay associated with open-heart surgery, we selected TCC for our patients. Several contraindications exist for TCC, such as very young age (because of small coronary arteries), a large and wide fistula, aneurysmal formation, the presence of large vascular branches that risk accidental embolization, and the requirement for other concurrent cardiac surgery.[22,25] None of our patients had any contraindications for TCC. Catheter-based closure methods include detachable balloons, stainless steel coils, controlled-release coils, controlled-release patent ductus arteriosus coils, patent ductus arteriosus plugs, regular and covered stents, and various chemicals.[16] We used controlled-release coils and successfully closed the CAFs.

Complications may arise from catheter manipulation, such as coronary artery spasm, dissection, and perforation. Coil migration can occur due to high flow in large CAFs or of coils are undersized. This can be prevented by choosing coils that are 10-20% larger than the fistula diameter.[1] Patients with cardiovascular risk factors-such as hypertension, diabetes mellitus, advanced age, hyperlipidemia, and tobacco use-are more prone to long-term complications after CAF closure, including MI and cardiomyopathy.[22,26] These factors also influence prognosis. MI is a significant complication, occurring in about 10% of patients with large CAFs following closure. Aneurysmal dilation of proximal coronary artery segments that develop in large distal CAFs is at risk of thrombus formation due to stagnant flow after successful closure.[22] In such cases, initiating long-term oral anticoagulation indefinitely may be advisable.

A heparin bolus of 70 IU/kg is recommended during the procedure to maintain an activated clotting time >250 sec and help prevent catheter-related thrombotic complications. However, there is limited data regarding the use of long-term antiplatelet or anticoagulant therapy following coil embolization. Most recommendations are derived from case series and expert opinions. The usual antithrombotic treatment after coil embolization of CAFs involves single antiplatelet therapy with low-dose aspirin.[27] In certain cases, such as patients who have other indications for anticoagulation, therapeutic anticoagulation with vitamin K antagonists or direct oral anticoagulants may be continued. Combining anticoagulation with aspirin might be considered, especially when coil size is small or residual flow persists.[22] For more complex cases, including large fistulas or those with aneurysmal components, dual antiplatelet therapy with aspirin and clopidogrel, or anticoagulation, may be necessary to reduce thrombotic risk. These recommendations aim to balance protection against thrombosis with the risk of ischemic complications, with treatment decisions individualized according to fistula features and patient comorbidities.

Prognosis and Follow-up

Patients who have undergone closure of a CAF generally show a good prognosis regardless of the closure technique used. Prognosis mainly depends on the shunt volume and associated clinical factors such as heart failure, pulmonary hypertension, and the extent of the myocardial ischemia.[28] Recurrence rates after percutaneous closure range from 9% to 19%, while surgical closure has a recurrence rate of about 25%.[29] Echocardiographic follow-up is advised 1 month after either percutaneous or surgical closure. If the patient remains symptom-free, follow-up intervals can be lengthened. Patients should

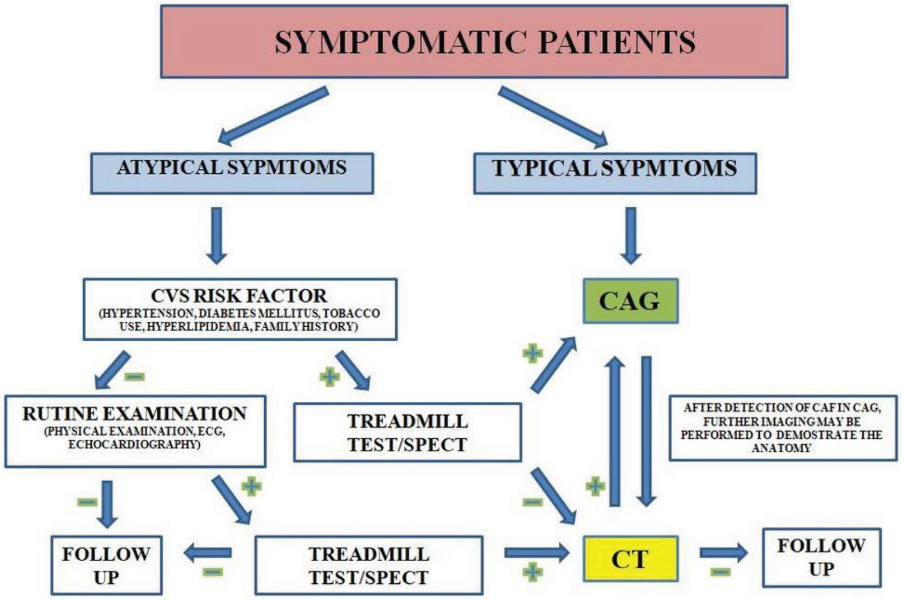
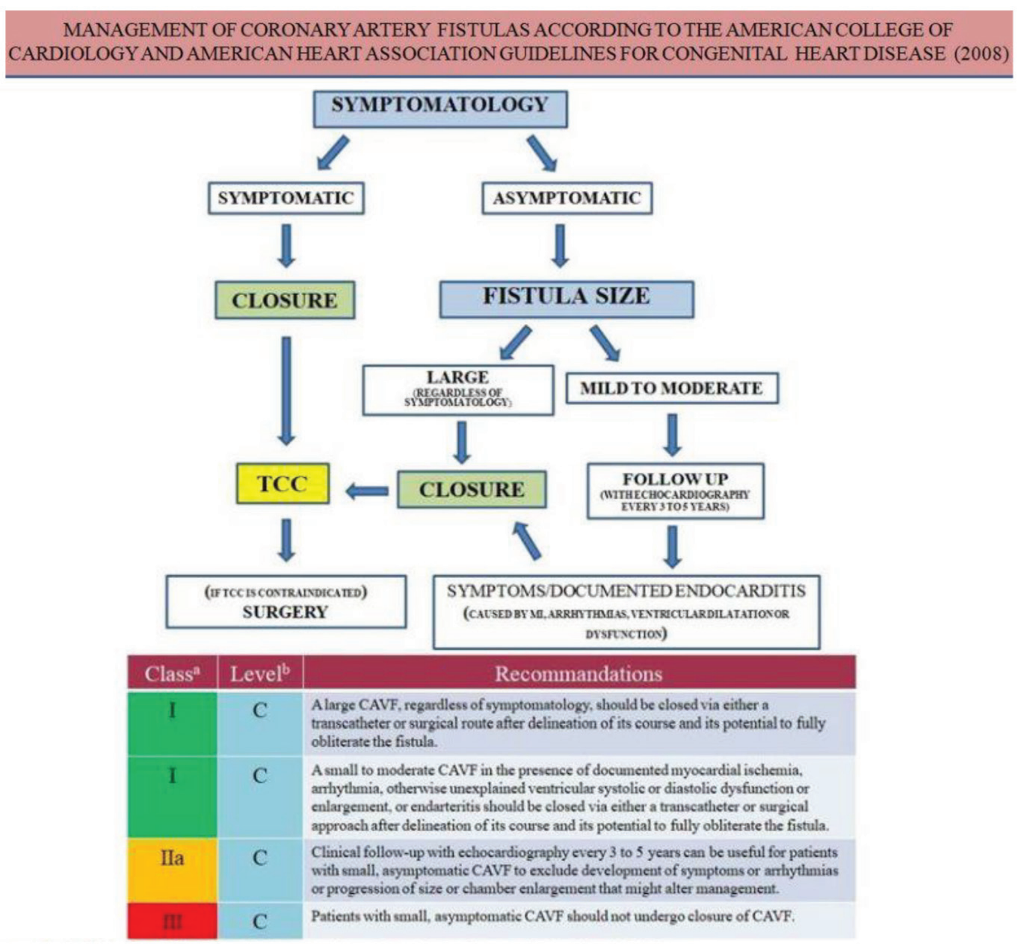


Figure 5. Diagnostic algorithm for CAF

CAF: Coronary artery fistula, CT: Computed tomography, CAG: Coronary angiography, CVS: Cardiovascular, SPECT: Single photon emission computed tomography



Class[a]	Level[b]	Recommandations
I	C	A large CAVF, regardless of symptomatology, should be closed via either a transcatheter or surgical route after delineation of its course and its potential to fully obliterate the fistula.
I	C	A small to moderate CAVF in the presence of documented myocardial ischemia, arrhythmia, otherwise unexplained ventricular systolic or diastolic dysfunction or enlargement, or endarteritis should be closed via either a transcatheter or surgical approach after delineation of its course and its potential to fully obliterate the fistula.
IIa	C	Clinical follow-up with echocardiography every 3 to 5 years can be useful for patients with small, asymptomatic CAVF to exclude development of symptoms or arrhythmias or progression of size or chamber enlargement that might alter management.
III	C	Patients with small, asymptomatic CAVF should not undergo closure of CAVF.

Figure 6. Management strategy for CAF

[a]Class of recommendation, [b]Level of evidence, CAF: Coronary artery fistula, TCC: Transcatheter closure, MI: Myocardial infarction, CAVF: Coronary arteriovenous fistula

also be monitored for bacterial endocarditis, which has an estimated annual risk of 0.25% per patient.[30]

CONCLUSION

CAF accounts for up to half of all coronary artery anomalies. It should be considered in patients presenting with typical cardiac symptoms despite having normal or non-obstructive coronary arteries. CAG remains the gold standard for diagnosis. A follow-up approach is suitable for managing asymptomatic, small, and hemodynamically insignificant fistulas. The decision to close a fistula depends on symptom presence and/or fistula size. Percutaneous TCC is the preferred intervention unless there are contraindications.

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Authorship Contributions: Concept: M.Y., S.N.M., Design: M.Y., S.N.M., Data Collection or Processing: D.Y.Ö., E.E., Literature Search: D.Y.Ö., M.Y., Writing: D.Y.Ö., M.Y.

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