JACC: CASE REPORTS VOL. 30, NO. 16, 2025

IMAGING

CLINICAL CASE

Multimodality Imaging in a Patient With MINOCA and Anomalous Coronary Artery

Ignazio Alessio Gueli, MD, PhD,[a,b] Giancarlo Trimarchi, MD,[a,b] Michele Coceani, MD,[b] Giancarlo Todiere, MD, PhD,[b] Carmelo De Gori, MD,[b] Andrea Barison, MD, PhD,[a,b] Umberto Paradossi, MD,[b] Michele Emdin, MD, PhD,[a,b] Alberto Aimo, MD, PhD,[a,b] Alberto Clemente, MD[b]

ABSTRACT

BACKGROUND Myocardial infarction with nonobstructive coronary arteries (MINOCA) is a heterogeneous condition requiring multimodal imaging for accurate diagnosis and management. Identifying the underlying etiology is crucial for guiding treatment.

CASE SUMMARY A 60-year-old man with hypertension and no prior coronary artery disease presented with angina. Single-photon emission computed tomography revealed ischemia in the mid-basal septum, and coronary computed tomography angiography (CCTA) identified an anomalous septal artery with an interarterial course. Three years later, he was admitted with non-ST-segment elevation myocardial infarction. Coronary angiography showed no obstructive lesions, but cardiac magnetic resonance confirmed a recent infarction in the mid-septum. A retrospective review of prior CCTA suggested acute occlusion of the anomalous septal artery.

DISCUSSION This case underscores the role of multimodal imaging in MINOCA, particularly in patients with coronary anomalies.

TAKE-HOME MESSAGE CCTA and cardiac magnetic resonance are complementary in identifying the underlying cause of MINOCA and optimizing patient management. (JACC Case Rep. 2025;30:104198) © 2025 The Authors. Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

HISTORY OF PRESENTATION AND PAST MEDICAL HISTORY

A 60-year-old Caucasian man with a history of arterial hypertension and no other relevant cardiovascular risk factors was assessed at the Cardiology Outpatient Clinic for angina on effort. His physical examination, electrocardiogram, and echocardiogram results were unremarkable.

A single-photon emission computed tomography (SPECT) identified a small area of ischemia (summed difference score: 5) in the basal septum and mid-inferoseptum (Figure 1). Coronary computed tomography angiography (CCTA) was then performed. Coronary atherosclerotic plaques were excluded, but an anomalous origin from the right aortic sinus was found for both the left coronary artery and the small septal branch, with a retroaortic and interarterial

From the [a]Health Science Interdisciplinary Center, Scuola Superiore Sant'Anna, Pisa, Italy; and the [b]Fondazione Toscana G. Monasterio, Pisa, Italy.

The authors attest they are in compliance with human studies committees and animal welfare regulations of the authors' institutions and Food and Drug Administration guidelines, including patient consent where appropriate. For more information, visit the Author Center.

Manuscript received January 15, 2025; revised manuscript received April 8, 2025, accepted April 12, 2025.

ISSN 2666-0849 https://doi.org/10.1016/j.jaccas.2025.104198

ABBREVIATIONS AND ACRONYMS

ACS = acute coronary syndrome

CCTA = coronary computed tomography angiography

CMR = cardiac magnetic resonance

MI = myocardial infarction

MINOCA = myocardial infarction with nonobstructive coronary arteries

SPECT = single-photon emission computed tomography

course, respectively (Figures 2 and 3). The patient was subsequently diagnosed with inducible myocardial ischemia and coronary artery anomalies. He was prescribed bisoprolol 5 mg once daily. At follow-up, his anginal symptoms were well controlled.

Three years later, the patient was admitted to the emergency department for persistent chest pain lasting 2 hours. Upon admission, the electrocardiogram excluded ST-segment elevation and repolarization abnormalities suggestive of acute ischemia. Physical examination was unremarkable, and transthoracic echocardiogram did not show significant regional wall motion abnormalities. Nonetheless, the dynamic elevation of high-sensitivity troponin T over 3 hours (58-180 ng/L, reference value <14 ng/L) was observed, leading to a diagnosis of non-ST-segment elevation myocardial infarction.

TAKE-HOME MESSAGES

- The integration of coronary angiography, cardiac magnetic resonance, single-photon emission computed tomography, and coronary computed tomography angiography provides comprehensive insights into the etiology of myocardial infarction with nonobstructive coronary arteries (MINOCA), especially in cases involving coronary anomalies.
- Coronary anomalies, such as an anomalous origin of a coronary artery, should not be dismissed without thorough investigation, as they may contribute to myocardial infarction under specific circumstances, such as acute vessel occlusion.

DIFFERENTIAL DIAGNOSIS AND INVESTIGATIONS

The patient underwent coronary angiography, which confirmed the anomalous origin of the left main coronary artery and ruled out obstructive epicardial coronary disease (Figure 4, Video 1). A diagnosis of myocardial infarction with nonobstructive coronary arteries (MINOCA) was then made.

After the angiography, troponin levels decreased rather slowly. Three days after admission, cardiac magnetic resonance (CMR) was performed, and it revealed myocardial edema and late gadolinium enhancement in the subendocardial region of the mid-inferior septum, indicating a recent myocardial infarction (MI) (Figure 5). A reevaluation of the coronary angiography did not show any septal branch supplying the mid-inferior septum, suggesting the possibility of an acute occlusion of the small septal artery, which was identified in the previous computed tomography arising from the right coronary sinus and having an interarterial course. An acute occlusion or embolization of this septal artery could explain the infarction.

MANAGEMENT

The patient was ultimately diagnosed with septal MI likely due to the occlusion of a septal branch originating from the right coronary sinus and with an interarterial course. However, a repeat CCTA was not

VISUAL SUMMARY Imaging Workup in MINOCA With Anomalous Coronary Artery

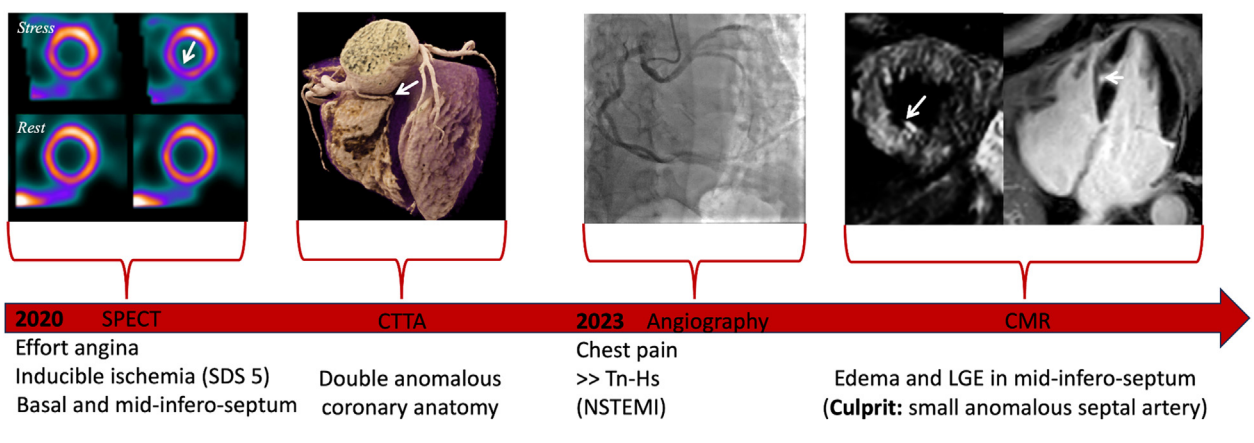
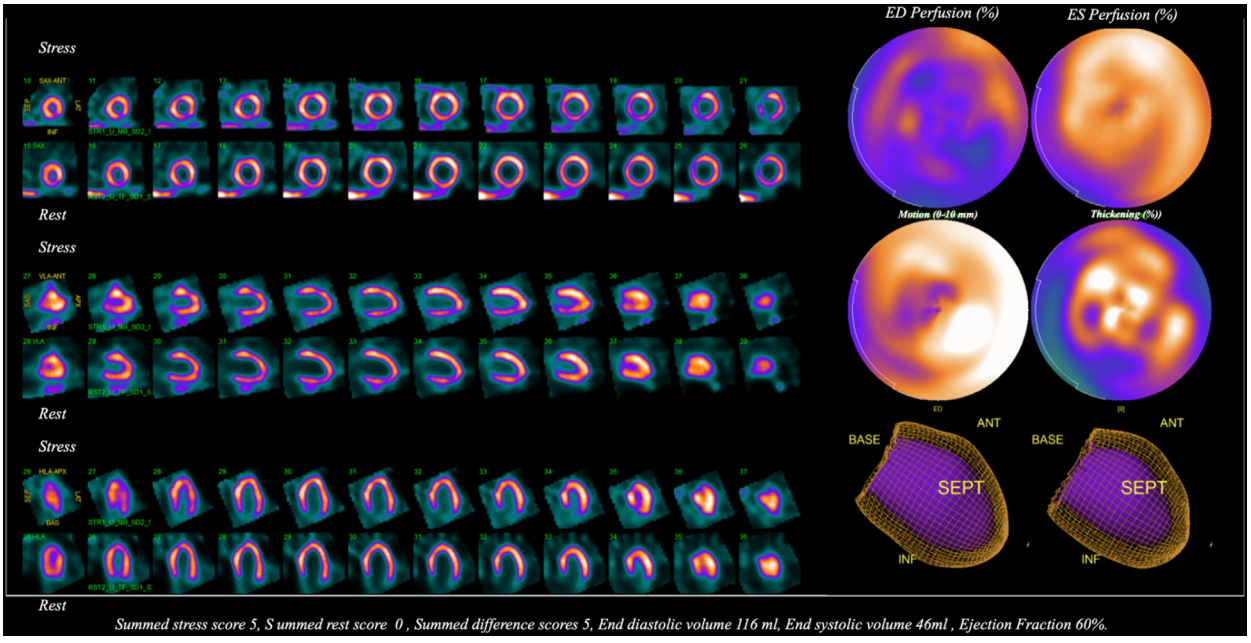
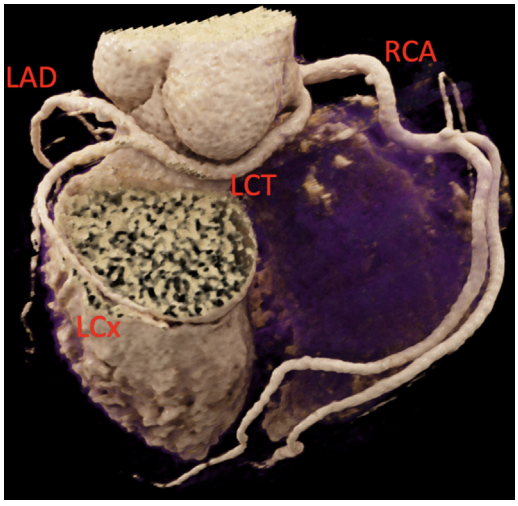


FIGURE 1 **Single-Photon Emission Computed Tomography**



These images showing a small area of ischemia (<8% of extension, summed difference score: 5) at the basal and inferoseptal mid-segment.

FIGURE 2 **Coronary Computed Tomography Angiography 3D-Cinematic Rendering**



This image shows the anomalous origin of the LCT from the right sinus of Valsalva and retroaortic course. CCTA = coronary computed tomography angiography; LAD = left anterior descending; LCT = left common trunk; LCx = left circumflex artery; RC = right coronary artery.

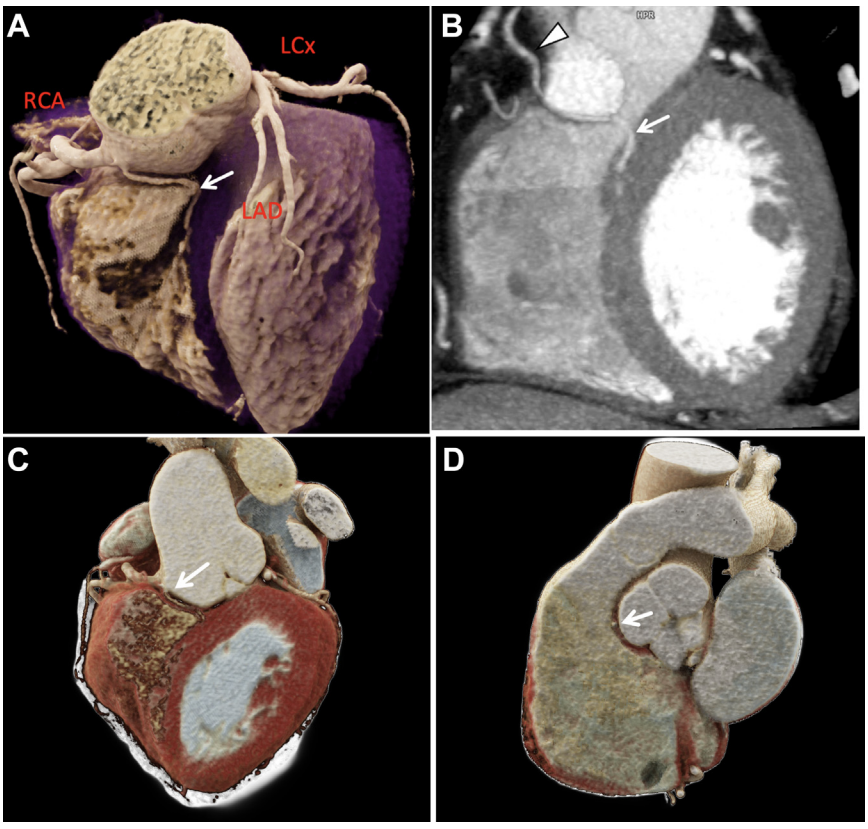
performed after the event, as the initial scan had already provided a detailed anatomical assessment, and unfortunately, it was not available soon during patient hospitalization.

The patient was started on dual antiplatelet therapy and high-dose statin, and the β-blocker was switched to metoprolol. During hospitalization, the patient developed atrial fibrillation, which recurred after pharmacological cardioversion. The patient was discharged on metoprolol (100 mg twice daily), ramipril (5 mg once daily), rivaroxaban (20 mg once daily), and atorvastatin (80 mg once daily). Given the presence of atrial fibrillation and the suspicion of an embolic myocardial infarction, transesophageal echocardiography was performed excluding thrombosis of the left atrial appendage and aortic atheroma, making it an unlikely embolic source.

OUTCOME AND FOLLOW-UP

Approximately 2 months after the MI, the patient underwent successful electrical cardioversion. At the 1-year follow-up visit from MI, the patient was clinically stable and asymptomatic.

FIGURE 3 Coronary Computed Tomography Angiography



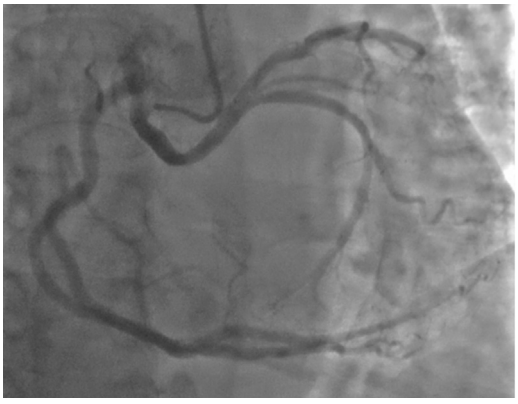
These images (A to C) showing the anomalous origin of the LCT from the right sinus of Valsalva and retroaortic course and the common origin of the first septal branch (white arrow) from the right sinus of Valsalva and interarterial course and the coronal artery (arrowhead) (B). (D) The interarterial course of the first septal branch. CCTA = coronary computed tomography angiography; LCT = left common trunk; LCx = left circumflex artery; RC = right coronary artery.

DISCUSSION

MINOCA encompasses diverse clinical entities associated with significant morbidity and mortality.[1] Current guidelines recommend classifying MINOCA as a working diagnosis and determining its etiology through multimodal imaging.[2] Recent studies highlight the utility of a diagnostic workup based on CMR[3,4] and invasive coronary imaging.[5,6] CMR effectively excludes nonischemic causes, such as myocarditis and Takotsubo syndrome, and also supports risk prediction.[3] CCTA may also be helpful in the diagnostic workup of MINOCA,[7] especially when CMR and angiography findings are discordant.

We present the case of a patient with non-ST-segment elevation myocardial infarction in whom coronary angiography revealed the presence of an anomalous origin of the left coronary artery from the right coronary sinus and no evidence of coronary obstructions. CMR enabled a precise definition of the recent infarction area, and reevaluation of a previous CCTA revealed a vessel that was no longer visible on coronary angiography. Therefore, the occlusion of this vessel, whether due to a functional mechanism (such as thrombosis from a ruptured plaque, extrinsic compression along its course, or vasospasm), was considered the cause of the MI. In our case, intracoronary imaging was not performed because of the small caliber of the occluded septal branch, which would have made catheter engagement and imaging technically unfeasible. Moreover, the spatial resolution of CCTA is insufficient to assess plaque characteristics in such a small vessel. In our patient, spontaneous coronary artery dissection was considered unlikely based on the absence of typical angiographic signs, such as

FIGURE 4 Coronary Angiogram



This image confirms the anomalous origin of the left main coronary artery from the right sinus of Valsalva without significant luminal stenosis.

contrast staining, multiple lumens, or long linear dissections.

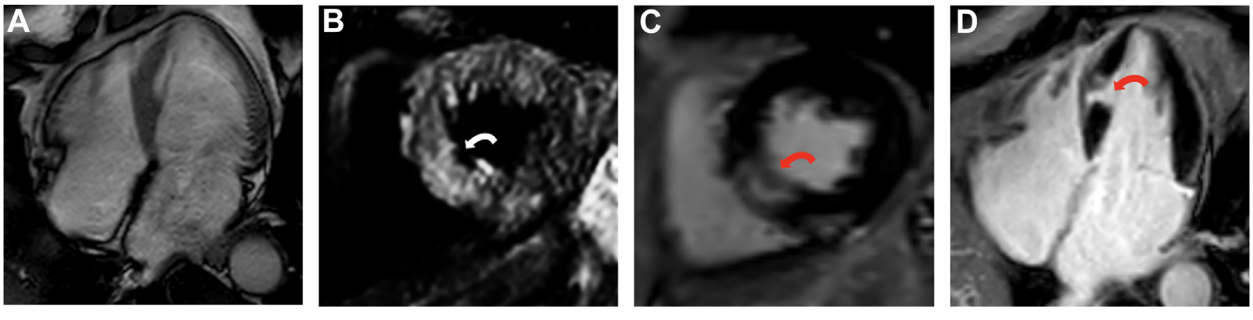
In 5% to 15% of acute coronary syndrome (ACS) cases, patients have unobstructed coronary arteries, termed MINOCA.[8] While ACS with obstructive coronary disease has well-defined management protocols, there is no universal diagnostic workup for MINOCA. Accurate differentiation of the underlying etiologies, such as MI, acute myocarditis, or Takotsubo syndrome,[9] is crucial for guiding investigations and treatment. Studies advocate the use of invasive and noninvasive imaging techniques, particularly CMR, for accurate diagnosis and prognosis of both ischemic and nonischemic disorders.[4] This is particularly important in the context of MINOCA, where timely and appropriate identification of the underlying cause can significantly influence patient outcomes and therapy decisions and help tailor treatment strategies to prevent future cardiac events.

Our patient displayed chest pain and elevated myocardial necrosis enzymes, leading to the diagnosis of ACS. Coronary angiography did not reveal any coronary artery stenosis and showed the already known anomalous origin of the left coronary artery from the right coronary sinus with a retroaortic course.

The ischemic etiology was confirmed by CMR, which displayed subendocardial late gadolinium enhancement (ischemic pattern) at the basal segment of the inferior interventricular septum (segment 9), according to the American Heart Association's 17-segment model. The value of CMR in the workup for MINOCA is supported by a meta-analysis that utilized CMR studies as a diagnostic tool in patients initially suspected of having MINOCA.[10] This study found myocarditis to be a leading cause, excluding MINOCA, in over a quarter of the cases.[10]

In our case, CMR played a crucial role in distinguishing between ischemic and nonischemic causes, prompting the evaluation of other possible causes of MINOCA such as coronary vasospasm and coronary thromboembolism. Testing for coronary spasm or microvascular dysfunction could have provided additional insights, particularly given the ischemia detected in the same region on the previous

FIGURE 5 Cardiac Magnetic Resonance Imaging



In cine steady-state free precession, the long-axis view showed a normal volume of the left ventricle with biatrial dilatation (A). In T2-weighted short tau inversion recovery and LGE sequence, the short-axis view showed acute myocardial edema (B, curved white arrow) and ischemic LGE in the mid-inferoseptum (C; curved red arrow). In the LGE sequence, the long-axis view showed a subendocardial ischemic scar at the level of the inferoseptal mid-segment (D; curved red arrow). LGE = late gadolinium enhancement.

SPECT. However, this was not performed given the acute phase, as well as the presence of an infarct-related lesion on CMR.

Indeed, the presence of recent MI on CMR, localized to the territory of this small septal branch, strongly suggests that this vessel was the culprit lesion. We concluded that an acute occlusion was the most likely mechanism, potentially due to in situ atherothrombosis and prolonged vasospasm, facilitated by its course, while embolism from atrial fibrillation appeared less probable.

CCTA, previously performed for the diagnostic workup of chest pain on effort, provided more detailed coronary anatomy, identifying a small septal branch originating from the right coronary sinus with an interarterial course, supplying the infarcted area. Therefore, the multimodal approach elucidated the ischemic nature of the localized lesion at the basal inferior interventricular septum and indicated the potential involvement of the septal branch supplying the affected myocardial territory. In the context of MINOCA, CCTA can be highly valuable in identifying perfusion defects that signal ischemia. It can also detect high-risk plaque features, identify coronary artery dissection, and provide a better evaluation of coronary anatomy. In our case, CMR showed a recent infarction in the basal and mid-inferior septum without a clear angiographic correlate. Only the CCTA identified a small septal vessel originating from the right coronary sinus and running interarterially, supplying the affected myocardial territory. Therefore, while CMR is crucial for determining the ischemic or nonischemic nature of the lesion, CCTA is essential for characterizing vascular anatomies that are difficult to visualize with angiography. Otherwise, the previous SPECT identified a small area of ischemia in the same infarcted area. In the context of MINOCA, this suggests that CCTA should be used, particularly when there is a lack of a clear correlation or a discrepancy between CMR findings and angiography.

CONCLUSIONS

We report a case where CCTA revealed an anomalous origin of the small septal artery as the cause of a recent infarction. Integrating anatomic imaging (coronary angiography/CCTA) with morphofunctional imaging (CMR/SPECT) aids in accurate diagnosis and management. This case underscores the importance of multimodal imaging, particularly in the context of anomalous coronary anatomy and discrepancies between CMR findings and angiography.

FUNDING SUPPORT AND AUTHOR DISCLOSURES

The authors have reported that they have no relationships relevant to the contents of this paper to disclose.

ADDRESS FOR CORRESPONDENCE: Dr Ignazio Alessio Gueli, Cardiology and Cardiovascular Medicine Division, Fondazione G. Monasterio CNR - Regione Toscana, Via Giuseppe Moruzzi 1, Pisa 56124, Italy, Institute of Life Sciences, Scuola Superiore Sant'Anna, Piazza Martiri della Libertà 33, Pisa 56127, Italy. E-mail: igueli@ftgm.it.

REFERENCES

1. Trimarchi G, Teresi L, Licordari R, et al. Transient left ventricular dysfunction from cardiomyopathies to myocardial viability: when and why cardiac function recovers. *Biomedicines*. 2024;12:1051.

2. Byrne RA, Rossello X, Coughlan JJ, et al. 2023 ESC guidelines for the management of acute coronary syndromes. *Eur Heart J*. 2023;44:3720–3826.

3. Liang K, Bisaccia G, Leo I, et al. CMR reclassifies the majority of patients with suspected MINOCA and non MINOCA. *Eur Heart J Cardiovasc Imaging*. 2023;25:8–15.

4. Liang K, Nakou E, Del Buono MG, Montone RA, D'Amario D, Bucciarelli-Ducci C. The role of cardiac magnetic resonance in myocardial infarction and non-obstructive coronary arteries. *Front Cardiovasc Med*. 2022;8:821067.

5. Borzillo I, De Filippo O, Manai R, et al. Role of intracoronary imaging in myocardial infarction with non-obstructive coronary disease (MINOCA): a review. *J Clin Med*. 2023;12:2129.

6. Sucato V, Testa G, Puglisi S, Evola S, Galassi AR, Novo G. Myocardial infarction with non-obstructive coronary arteries (MINOCA): intracoronary imaging-based diagnosis and management. *J Cardiol*. 2021;77:444–451.

7. Rampidis GP, Kampaktsis PN, Kouskouras K, et al. Role of cardiac CT in the diagnostic evaluation and risk stratification of patients with myocardial infarction and non-obstructive coronary arteries (MINOCA): rationale and design of the MINOCA-GR study. *BMJ Open*. 2022;12:e054698.

8. Barr PR, Harrison W, Smyth D, Flynn C, Lee M, Kerr AJ. Myocardial infarction without obstructive coronary artery disease is not a benign condition (ANZACS-QI 10). *Heart Lung Circ*. 2018;27:165–174.

9. Del Buono MG, Montone RA, Iannaccone G, et al. Diagnostic work-up and therapeutic implications in MINOCA: need for a personalized approach. *Future Cardiol*. 2021;17:149–154.

10. Hausvater A, Smilowitz NR, Li B, et al. Myocarditis in relation to angiographic findings in patients with provisional diagnoses of MINOCA. *JACC Cardiovasc Imaging*. 2020;13:1906–1913.

KEY WORDS angiography, anomalous coronary arteries, cardiac magnetic resonance, coronary computed tomography angiography, myocardial infarction with nonobstructive coronary arteries, single photon emission computed tomography

APPENDIX For supplemental videos, please see the online version of this paper.