ESC European Society of Cardiology

European Heart Journal - Case Reports (2023) **7**, 1–7
https://doi.org/10.1093/ehjcr/ytad444

CASE REPORT
Coronary intervention

What eyes do not see the heart does not grieve over? The role of intracoronary imaging in acute myocardial infarction: a case report

Sara Blasco-Turrión *, Andrea Gómez-López, Francisco J. Morales-Ponce , Sara Casquero-Domínguez, and Rocío del Pozo-Contreras

Interventional Cardiology Unit, Puerto Real University Hospital, Calle Romería, 7, Puerto Real, Cádiz 11510, Spain

Received 23 January 2022; revised 16 August 2023; accepted 4 September 2023; online publish-ahead-of-print 8 September 2023

Background The evaluation of a three-dimensional structure with a two-dimensional imaging technique makes intracoronary diagnostic techniques essential, especially in the setting of acute myocardial infarction (AMI) when no apparent coronary lesions are detected. Expert consensus recommend their use in certain scenarios such as angiographically ambiguous disease and identification of the culprit lesion. Although both intravascular ultrasound and optical coherence tomography (OCT) allow the characterization of the atherosclerotic plaque and assess the immediate and long-term results of stent implantation, they have their own benefits and limitations that make them ideal for different types of coronary lesions.

Case summary We present the case of a lateral ST-elevation myocardial infarction with no evident coronary lesions in angiography, in which OCT not only allowed us to confirm a diagonal branch occlusion, but it also became crucial to locate the occlusion point and to guide the procedure, allowing complete revascularization of the culprit lesion that otherwise could have been missed.

Discussion To know the actual limitations of conventional coronary angiography to adequately assess coronary disease, intracoronary diagnostic techniques are key to evaluate the underlying mechanisms of the event, especially in the setting of AMI when no clear culprit lesion has been identified. They can be of great value to locate and revascularize acute occlusions that could go unnoticed on the angiogram, guiding the revascularization and stent implantation and, therefore, preventing myocardial injury that could become irreversible when coronary disease is not treated promptly.

Keywords Optical coherence tomography • Intravascular ultrasound • Acute myocardial infarction • Bifurcation disease • Occlusion • Primary PCI • Case report

ESC curriculum 3.1 Coronary artery disease • 3.2 Acute coronary syndrome • 3.4 Coronary angiography

Learning points

A patient who presented with a lateral wall ST-elevation myocardial infarction and no coronary lesions on the angiogram.

- To understand the different characteristics, as well as benefits and limitations, of the different intracoronary imaging techniques available.
- To understand the potential role of intracoronary diagnostic techniques such as optical coherence tomography in the setting of an acute myocardial infarction since conventional angiogram alone can lead us to misdiagnosis.

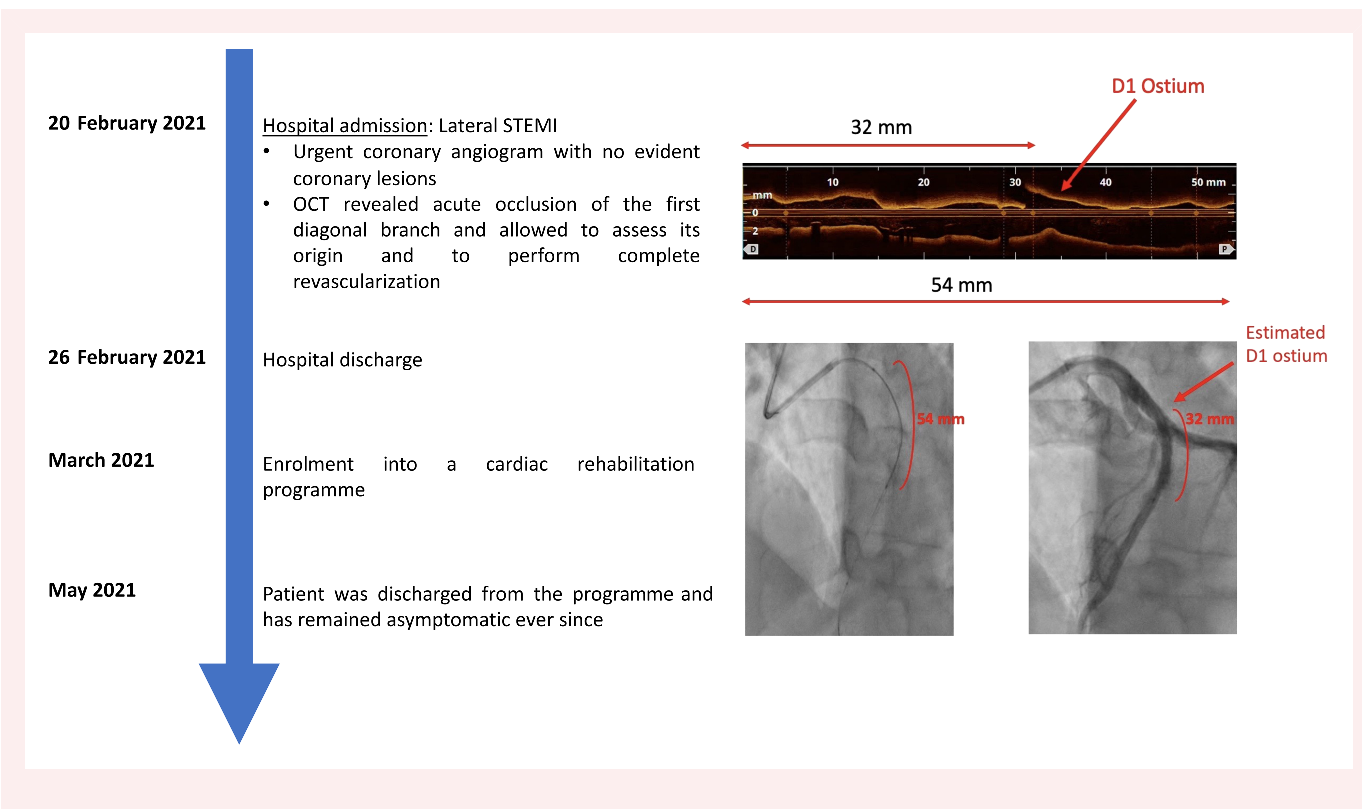
* Corresponding author. Tel: +34 660 12 42 02, Email: sarablasco.cardiologia@gmail.com
Handling Editor: Andrew Peter Vanezis
Peer-reviewers: Jonathan Adam Batty; Antonios Karanasos
Compliance Editor: Edwina McNaughton

Introduction

Coronary angiography is the gold standard technique to assess coronary heart disease. However, the evaluation of a three-dimensional structure with a two-dimensional imaging technique has its obvious limitations. Therefore, the introduction of intracoronary imaging techniques, such as optical coherence tomography (OCT) and intravascular ultrasound (IVUS), has become a turning point in percutaneous coronary interventions (PCIs), providing further information on tissue characterization, PCI guidance, and stent implantation optimization. Furthermore, the use of these techniques has been associated with improved clinical outcomes, essentially in the setting of complex lesions such as bifurcations or left main disease.[1–4]

Moreover, in the setting of acute myocardial infarction (AMI), the use of intracoronary diagnostic techniques has become beneficial to define the culprit lesion and optimize stent results, avoiding stent infraexpansion and malapposition that can lead to stent thrombosis.[4]

Summary figure



Case presentation

We present the case of a 46-year-old white male, with dyslipidaemia and active smoking as his only cardiovascular risk factors, with no medical history nor family history of heart disease. He presented to the emergency department with an acute onset of typical chest pain suggestive of angina. At presentation, the patient was hypotensive and tachycardic, showing a poor general condition with paleness and diaphoresis. The electrocardiogram showed ST-segment elevation in leads V4–V6 and ST-segment depression in the II, III, and AVF leads. Transthoracic echocardiography showed preserved ejection fraction and a hypokinesia of the anterolateral wall and all apical segments. Laboratory results showed a high-sensitive troponin-T peak value of 90 101 ng/L (normal range: <34.2 ng/L). A diagnosis of an ST-elevation myocardial infarction (STEMI) was made and the patient was transferred to the catheterization laboratory. A loading dose of aspirin (300 mg) and ticagrelor (180 mg) was administered.

In the urgent coronary angiogram no coronary occlusions nor culprit lesions were identified despite the use of several projections (*Figure 1* and Supplementary material online, *Videos S1* and S2). However, given that the chest pain persisted, and that the electrocardiogram changes remained evident, we did not settle for this result. Moreover, the absence of vessels in the lateral wall made us think that the culprit lesion could be an acute coronary occlusion of the first diagonal branch, but we were not able to locate its origin, and multiple attempts to cross with an Asahi Sion Blue guidewire to an invisible vessel were made without any success.

We then decided to perform an OCT study through the left anterior descending artery, detecting a coronary occlusion of a diagonal branch that was not visible on the angiogram and whose origin could not be located earlier (see Supplementary material online, *Video S3*). Since our catheterization laboratory did not have OCT co-registration software, another challenge was to identify the corresponding segment of the bifurcation through the integration of intracoronary imaging and the angiogram. This way, knowing the exploring length of the OCT catheter withdrawal (54 mm), the location of the bifurcation had to be estimated by transposing the distance from its distal edge to the ostium of the diagonal in the longitudinal reconstruction (32 mm), to the

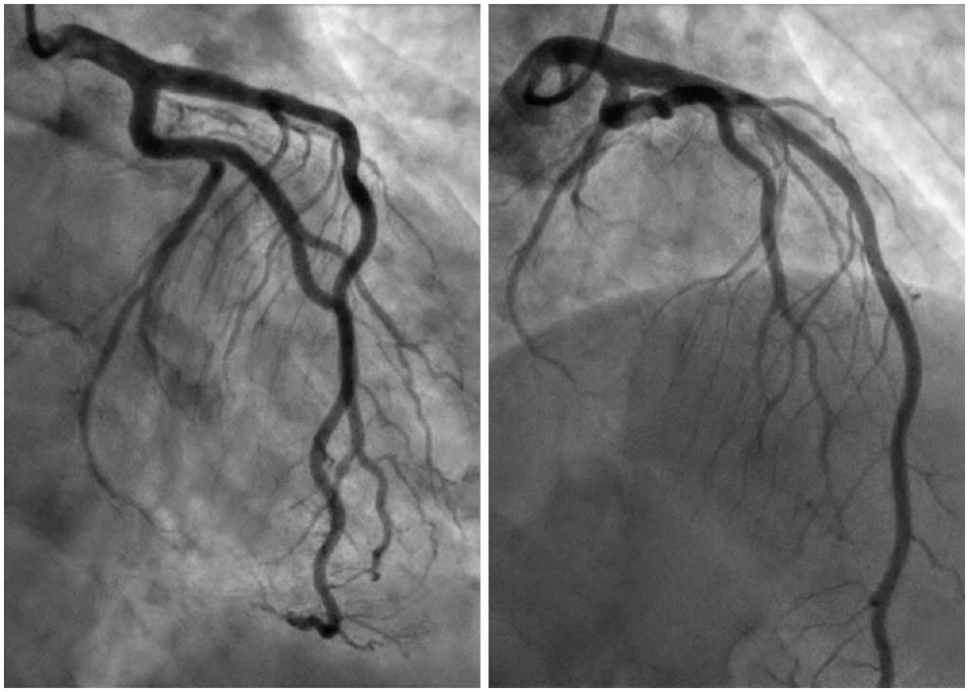


Figure 1 Initial conventional angiogram, with no apparent coronary lesions on the left main, left descending, and circumflex coronary arteries.

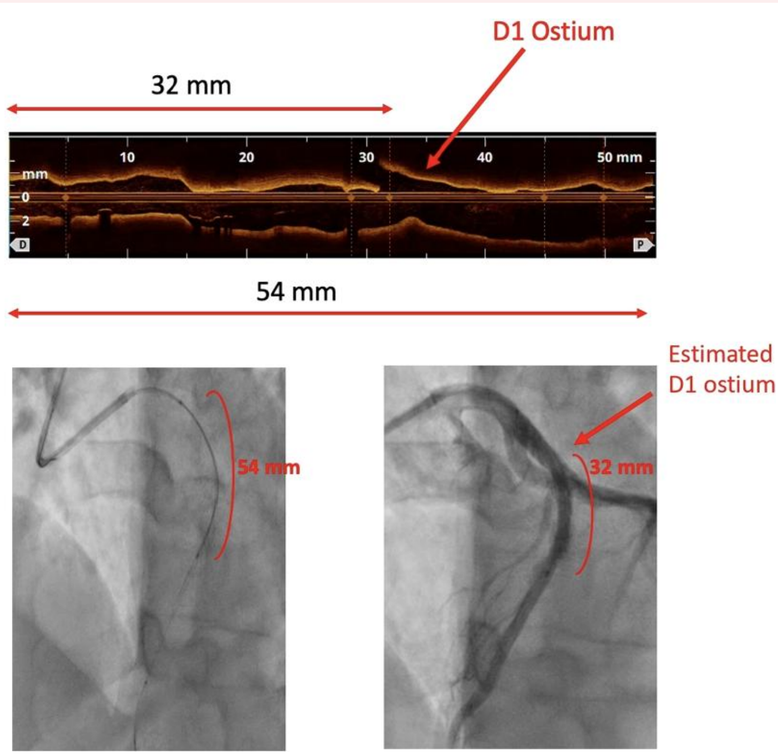


Figure 2 Optical coherence tomography key finding. Estimation of the location of the bifurcation knowing the exploring length of the optical coherence tomography catheter withdrawal (54 mm) and the distance from its distal edge to the ostium of the diagonal branch (32 mm from the second distal radiopaque marker on the angiography).

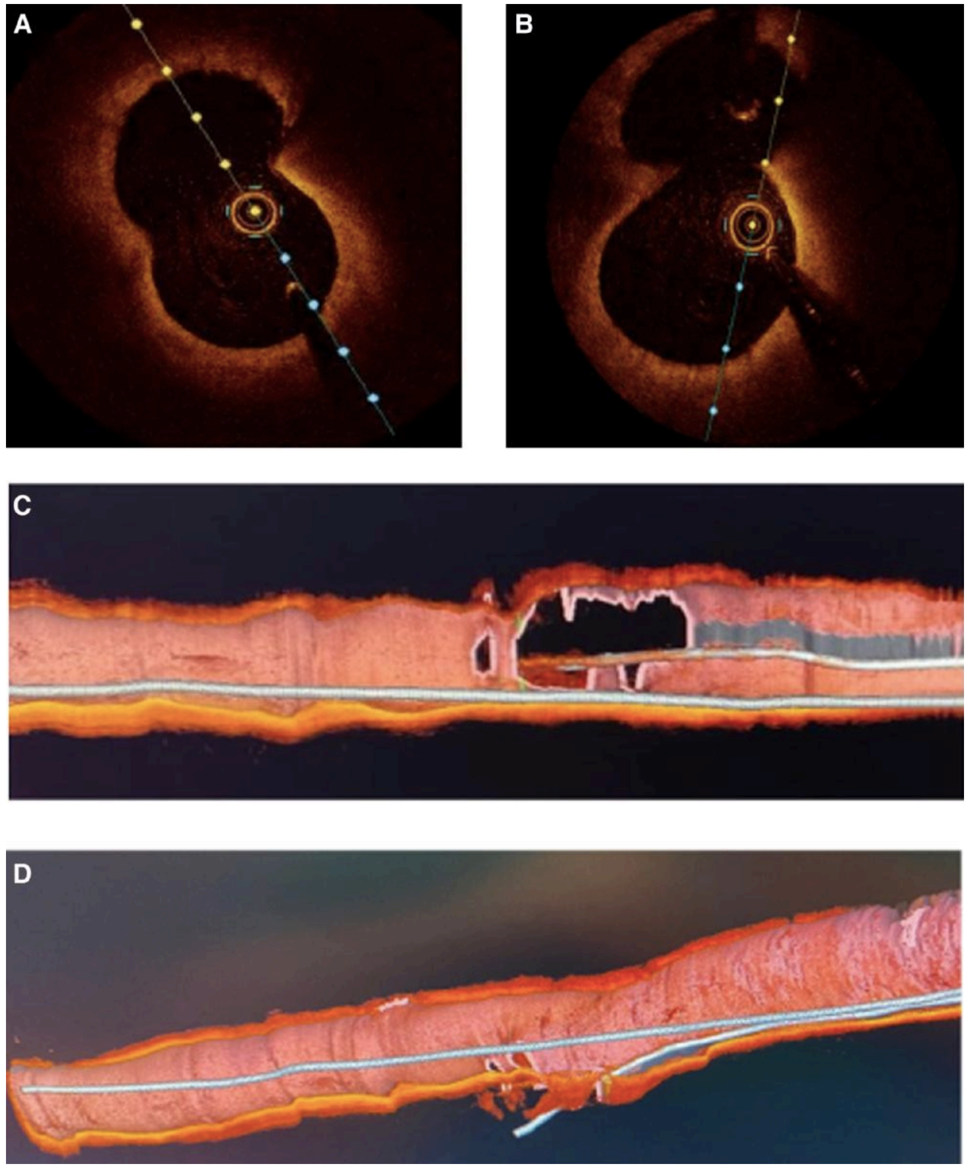


Figure 3 (*A*) Cross-sectional optical coherence tomography study of the left anterior descending artery, showing the origin of a diagonal branch, not visible on the conventional angiogram. (*B*) Cross-sectional optical coherence tomography study, confirming the location of a second guidewire on the diagonal coronary artery true lumen. (*C* and *D*) Optical coherence tomography three-dimensional reconstruction, confirming the origin of the diagonal branch and reassuring the correct position of the guidewire.

angiogram from the second distal radiopaque marker to proximally (*Figure 2*). Then, an Asahi Sion Blue guidewire was advanced through the theoretical course of the diagonal, but angiographic flow was not evident yet (see Supplementary material online, *Video S4*), so a second run of OCT was performed to reassure the adequate position of the guidewire (*Figure 3* and Supplementary material online, *Video S5*). At this point, several 'blinded' dilations with a semi-compliant 2.0 × 15 mm balloon were performed, achieving thrombolysis in myocardial infarction (TIMI) Grade 3 flow on a diagonal branch of medium size and long course. Finally, a Resolute Onyx 2.5 × 30 mm drug-eluting stent was implanted with good angiographic result and final TIMI Grade 3 flow (*Figure 4* and Supplementary material online, *Video S6*).

The patient received double antithrombotic therapy for 12 months, followed by single antithrombotic therapy thereafter. The patient showed an uneventful recovery and was discharged after 4 days. At 2 years' follow-up, no events occurred.

Discussion

Although coronary angiography is the gold standard technique to assess coronary artery disease and to perform percutaneous revascularization procedures, evaluating a three-dimensional structure with a two-dimensional image has its limitations[1,5] with an important interobserver variability, even when quantitative coronary analysis is used.

A two-dimensional image cannot adequately delimit plaque severity and eccentricity, since the lumen area may remain unaffected until the lesion reaches at least 40% area of stenosis due to outward

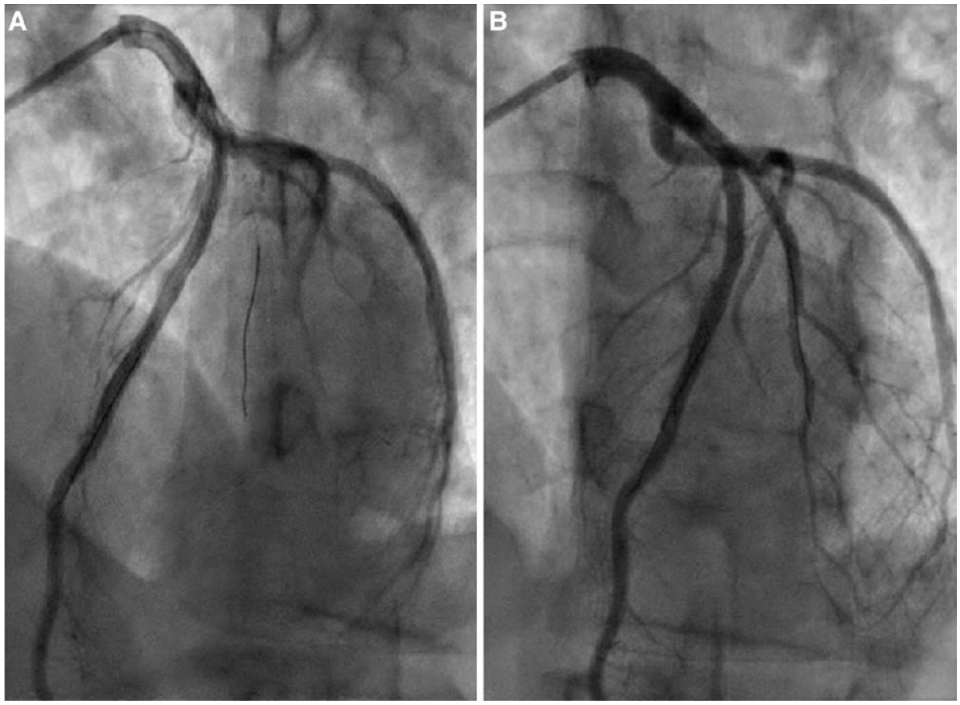


Figure 4 (*A*) Coronary angiogram, showing the guidewire through the diagonal coronary artery, but still TIMI Grade 0 flow. (*B*) Coronary angiogram after revascularization, showing a well-developed diagonal coronary artery with TIMI Grade 3 flow.

remodelling.[6] Moreover, conventional angiogram does not provide information about haemodynamics repercussion (in contrast to Pressure-Wire) nor tissue characterization (in contrast to IVUS and OCT). It is also challenging in the setting of long diffuse disease, as no healthy reference segment is available, or in ostial lesions in which technical issues such as catheter-induced spasm and non-coaxial or non-selective injections can occur.[1,3,4,7,8] In addition, conventional angiography tends to underestimate lumen dimensions and the boundaries of the plaque, which can directly cause a mismatch in sizing and lesion coverage and, therefore, stent failure and impaired clinical outcomes.[9]

This way, the introduction of several intracoronary diagnostic techniques has become a turning point in percutaneous coronary revascularization, allowing the identification of lesions that, otherwise, may have gone unnoticed, delineating plaque characteristics, guiding the revascularization, and offering a precise analysis of stent implantation,[10] especially in challenging lesions such as bifurcational or left main disease, where stent optimization is crucial to achieve the best clinical outcomes.

In the setting of AMI, the most common case is that in which an acute coronary occlusion is detected and reperfusion achieved easily. However, nearly up to 10% of the patients have no obstructive coronary lesions on the angiogram and around 25% of STEMI are caused by plaque erosion without evident disruption of the fibrous cap.[4] In fact, it has been reported that in nearly 14% of the patients presenting with an AMI, the culprit lesion cannot be identified.[11] This can arise from transitory events, clinical cases indistinguishable from AMI, such as myocarditis or takotsubo syndrome, or coronary lesions that are very difficult to detect, such as the ostial occlusion of coronary branches. Thus, the absence of coronary lesions on the angiogram is not always conclusive and does not always translate into a non-ischaemic aetiology. Therefore, intracoronary imaging is sometimes crucial, allowing the identification of the culprit lesion when no apparent coronary occlusions are detected or if multivessel disease is present.

With regard to the different intracoronary imaging techniques, both IVUS and OCT are superior to angiography in guiding and optimizing most procedures. Both allow the characterization of the atherosclerotic plaque and assess the immediate and long-term results of stent implantation.[2,12] However, while IVUS uses ultrasound and has better penetration to the adventitia (5–6 vs. 1–2 mm), OCT utilizes near-infrared light with a ×10 higher resolution (10–20 vs. 100 μm), which allows it to detect mild malapposition, edge dissections, or tissue coverage of stent struts. Also, OCT is better for tissue characterization (especially calcium load assessment) and thrombus detection. However, one of its main issues is that additional contrast is needed to eliminate blood cells from the lumen, and pre-dilation may be necessary.[3] Thus, OCT should be the method of choice to identify the underlying mechanisms of an acute event (plaque rupture, plaque erosion, wall haematoma, thrombus, dissection, etc.) or stent failure mechanisms such as stent thrombosis or restenosis. It is also useful to assess calcium burden and calcium fracture after plaque modification techniques (intravascular lithotripsy or rotational atherectomy) to improve stent expansion, and in bifurcational disease to reassure the adequate position of the guidewires and establish the best technical approach, since thrombosis and restenosis rates are higher in this type of lesions. On the other hand, IVUS tends to be the method of choice in aorto-ostial lesions and left main disease and can be of great use in the reperfusion of chronic total occlusions (CTOs).

In the setting of AMI, intracoronary imaging not only allows the identification of the culprit lesion as it easily visualizes thrombus, but it also delimitates the underlying cause of the event even if it is not an acute coronary occlusion (coronary spontaneous dissection, stress cardiomyopathy, plaque erosion) guiding the ulterior optimal medical treatment.

Therefore, the use of intracoronary imaging is recommended in case of ambiguous angiographic findings or multivessel disease to identify the culprit lesion, left main disease, complex bifurcation lesions, or to assess the mechanism of stent failure.

In our case, the patient presented to the emergency room with a lateral STEMI and, even though, the conventional angiogram did not show apparent coronary lesions, the clinical presentation and unresolved electrocardiogram findings induced us to run OCT, confirming the coronary occlusion of a first diagonal branch that, after revascularization, proved to be a well-developed artery. In this case, OCT was the technique of choice given its better resolution to identify culprit lesions.

Although OCT has proved its benefits in the characterization of coronary lesions and PCI guidance, one of its main limitations had been its difficulty in matching the position of the cross-sectional OCT images with the angiographic views, especially when no anatomical landmarks are present, or in case of angiographic angulation, shortening, or vessel overlap. This has led to the development of co-registration systems, which allow a concomitant visualization of the cross-sectional OCT and angiogram images to locate the lesions helping stent implantation strategy, reducing mismatch in stent sizing and lesions coverage, and ultimately leading to better clinical outcomes. This would have been useful in our case, but since we did not have a co-registration system, this 'home-made' technique allowed us to locate the ostium of the occluded diagonal branch and achieve complete revascularization avoiding significant myocardial damage.

An intriguing issue is the fact that we were not able to see a stump in angiography, but the ostium of the diagonal branch did not show any sign of thrombus in OCT. Although we cannot exclude the fact that we did not use appropriate projections in angiography, it is plausible that the coronary occlusion was located a few millimetres away from the ostium, and that the different rates of contrast infusion (5 mL/s for OCT runs and 3 mL/s for angiography) could have played a role in the appearance of the ostium of the diagonal, resulting in a higher filling of the ostium with contrast in the OCT technique compared with angiography, especially in a context of no-flow in the diagonal branch.

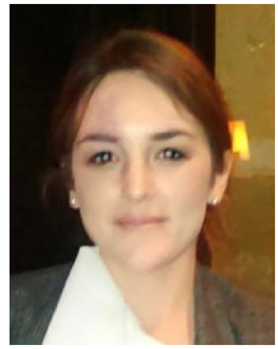
Conclusion

Knowing the actual limitations of conventional coronary angiogram, the use of intracoronary diagnostic techniques is key to identify lesions that, otherwise, could go unnoticed, delineating plaque characteristics and guiding the revascularization, especially when assessing challenging lesions such as bifurcational or left main disease, and preventing myocardial injury that could potentially become irreversible.

In our case, OCT was crucial not only to unmask an unnoticed branch occlusion on the angiogram in a STEMI patient but to guide the revascularization with successful results.

Therefore, intracoronary imaging techniques such as OCT not only after but before the revascularization may be of great value to locate and revascularize occluded vessels when they are not visible in angiography. This imaging technique proved to be determinant to identify the occlusion point at a suspected but not visible bifurcation, reassuring guidewire progression through the true lumen of the ostium of the branch.

Lead author biography



Sara Blasco-Turrión, who graduated from Universidad Autónoma de Madrid in 2014, has completed a 5-year cardiology residency programme and a 2-year fellowship programme on Interventional Cardiology and is currently performing her clinical and research activities at University Clinic Hospital in Valladolid. Her training includes several master's degrees focused on cardiac imaging and cardiac critical care, and her research is currently focused on interventional cardiology techniques such as percutaneous treatment of severe tricuspid regurgitation and transcatheter aortic valve replacement. Several publications have arisen from her research, including 8 publications in JCR-indexed journals and 35 presentations in national and international congresses.

Supplementary material

Supplementary material is available at *European Heart Journal – Case Reports* online.

Consent: We confirm that we have written consent for the submission and publication of image(s)/associated text.

Conflict of interest: None declared.

Funding: The authors have no competing financial interest that could have influenced the present report.

Data availability

The data underlying this article are available in the article and in its online Supplementary material.

References

1. Pinilla Echeverri N, Sibbald M, Sheth T. Utilidad de técnicas de imagen en la valoración de la enfermedad coronaria—tomografía de coherencia óptica. *Rev Colomb Cardiol* 2019; **26**:198-204.
2. Samir A, Elguindy A. The role of intracoronary imaging in acute coronary syndromes: OCT in focus. *Glob Cardiol Sci Pract* 2016;**2016**:e201636.
3. Räber L, Mintz GS, Koskinas KC, Johnson TW, Holm NR, Onuma Y, *et al.* Clinical use of intracoronary imaging. Part 1: guidance and optimization of coronary interventions. An expert consensus document of the European Association of Percutaneous Cardiovascular Interventions. *EuroIntervention* 2018;**14**:656–677.
4. Johnson TW, Räber L, Di Mario C, Bourantas CV, Jia H, Mattesini A, *et al.* Clinical use of intracoronary imaging. Part 2: acute coronary syndromes, ambiguous coronary angiography findings, and guiding interventional decision-making: an expert consensus document of the European Association of Percutaneous Cardiovascular Interventions. *EuroIntervention* 2019;**15**:434–451.
5. Swallow RA, Court IA, Calver AL, Curzen NP. The limitations of coronary angiography: identification of a critical coronary stenosis using intravascular ultrasound. *Int J Cardiol* 2006;**106**:123–125.
6. Schoenhagen P, Ziada KM, Vince DG, Nissen SE, Tuzcu EM. Arterial remodeling and coronary artery disease: the concept of "dilated" versus "obstructive" coronary atherosclerosis. *J Am Coll Cardiol* 2001;**38**:297–306.
7. Lozano Í. A debate: ecografía intravascular y tomografía de coherencia óptica en la revascularización percutánea. Perspectiva de la experto en IVUS. *REC Interv Cardiol* 2021;**2**:288–290.
8. Aparisi Á, Cubero-gallego H, Tizón-marcos H. Imagen intracoronaria: revisión y utilidad clínica [Intracoronary imaging: review and clinical use]. *REC Interv Cardiol* 2022;**4**: 228–237
9. van der Sijde JN, Guagliumi G, Sirbu V, Shimamura K, Borghesi M, Karanasos A, *et al.* The OPTIS Integrated System: real-time, co-registration of angiography and optical coherence tomography. *EuroIntervention* 2016;**12**:855–860.

10. Méndez I, Pozo E, Benedicto A, Olivera MJ, Ascensión A, Jiménez-Borreguero LJ, *et al.* Searching for the culprit vessel in acute myocardial infarction beyond angiography: role of cardiac magnetic resonance. *Circulation* 2014;**130**:e32–e34.
11. Larson DM, Menssen KM, Sharkey SW, Duval S, Schwartz RS, Harris J, *et al.* "False-positive" cardiac catheterization laboratory activation among patients with suspected ST-segment elevation myocardial infarction. *JAMA* 2007;**298**: 2754–2760.
12. Kim Y, Johnson TW, Akasaka T, Jeong MH. The role of optical coherence tomography in the setting of acute myocardial infarction. *J Cardiol* 2018;**72**: 186–192.