Coronary Artery Disease In A Rare Anatomical Scenario: Type IV Duplicated Left Anterior Descending Artery

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Introduction

Congenital coronary anomalies comprise a heterogeneous group of anatomical variations, most often identified incidentally during non-invasive imaging studies or invasive diagnostic and therapeutic procedures. Studies show that approximately 1.3% of individuals undergoing coronary angiography present some form of coronary anomaly.[1] Although most are considered benign, certain anomalies may be associated with myocardial ischemia, ventricular arrhythmias, and, in rare cases, sudden cardiac death. It is important to emphasize that coexistence with obstructive coronary artery disease (CAD) may amplify their clinical impact.

Among these variations, duplication of the left anterior descending (LAD) artery stands out due to its rarity and diagnostic relevance. According to the classification proposed by Spindola-Franco et al.[2] (Table 1), this anomaly is divided into four types based on the origin and course of the branches. In Type I, the most frequent form, the short and long LAD originate from the bifurcation of the main LAD artery; the short LAD artery follows the anterior interventricular groove and terminates early, whereas the long LAD artery runs parallel along the left ventricular surface before rejoining the distal groove. In Type II, the short and long LAD also arise from the bifurcation of the main LAD artery; however, the long LAD artery courses to the right of the anterior interventricular groove before reaching the apex. In Type III, the long LAD artery has an initial intramyocardial trajectory before emerging distally on the epicardial surface. Finally, in Type IV, the rarest type, a short LAD artery originates from the left coronary artery, while a long LAD artery arises anomalously from the right coronary artery (RCA) or its sinus of Valsalva.[2] This long branch follows an intraseptal course before emerging in the anterior interventricular groove and reaching the apex, occurring in approximately 0.2% of patients undergoing coronary angiography.[3]

Keywords

Coronary Artery Disease; Percutaneous Coronary Intervention; Drug-Eluting Stents; Interventional Ultrasonography

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In this context, we present the case of a patient who underwent percutaneous coronary intervention (PCI) for multivessel CAD, in whom a type IV LAD duplication was identified. This is a rare finding, with primarily diagnostic and prognostic relevance, illustrating the importance of accurately recognizing coronary anatomical variations during invasive evaluation.

Case Presentation

A 59-year-old female patient with a history of systemic arterial hypertension, type 2 diabetes mellitus, dyslipidemia, obesity, and chronic kidney disease. In December 2024, she experienced an acute myocardial infarction treated at another institution, where total occlusion of the RCA and the LAD artery was reported, in addition to a moderate lesion in the left circumflex artery (LCx). She underwent PCI with implantation of three drug-eluting stents in the RCA and one in the LCx in January 2025.

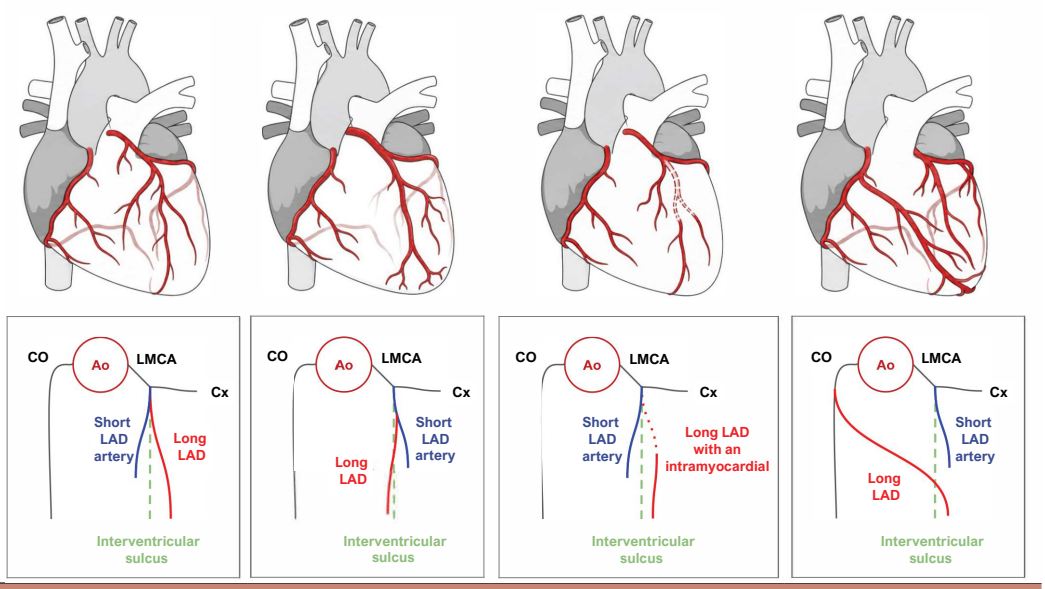
The initial echocardiogram showed preserved left ventricular ejection fraction (59%), eccentric hypertrophy, and mild hypokinesia of the inferior wall. Approximately three months after the intervention, the patient developed progressive dyspnea, orthopnea, and exertional angina (CCS functional class II). A repeat echocardiogram revealed a decrease in ejection fraction to 38%, akinesia of the inferior and inferoseptal walls, anteroseptal hypokinesia, and moderate mitral regurgitation.

Myocardial perfusion scintigraphy with dipyridamole demonstrated marked persistent hypoperfusion of the inferior wall and moderate transient hypoperfusion of the inferolateral wall, with an estimated ischemic burden of 11%. Given the persistence of symptoms and findings suggestive of ischemia, a new coronary angiography was performed at our institution. The examination revealed the RCA with overlapping stents, showing a moderate lesion in the proximal third extending to the beginning of the stent, followed by a 70% in-stent restenosis in the mid segment, and preserved stent results in the LCx (Figure 1).

During the procedure, an anomalous LAD originating from the right coronary sinus with a long course was identified – an artery not visualized in the previous angiographic study—without significant lesions (Figure 2).

Intracoronary ultrasound (IVUS) evaluation revealed underexpansion of the previously implanted stents in the proximal and mid segments of the RCA. Two new drug-eluting stents were implanted in the aforementioned segments, with good angiographic results and no complications. Adequate strut apposition and expansion were confirmed by IVUS (Figure 3).

Table 1 – Classification of Duplicated Left Anterior Descending Coronary Artery



Characteristics	Type I	Type II	Type III	Type IV
Origin of the short LAD artery	Bifurcation of the main LAD artery	Bifurcation of the main LAD artery	Left main coronary artery	Left main coronary artery
Origin of the short LAD artery	Bifurcation of the main LAD artery	Bifurcation of the main LAD artery	Left main coronary artery	RCA or right coronary sinus
Course of the long LAD	Epicardial, descending parallel to the short LAD artery in the anterior interventricular sulcus toward the apex	Epicardial, descending to the right of the anterior interventricular sulcus and returning to the distal anterior interventricular sulcus	Proximal intramyocardial (intraseptal); emerges in the distal anterior interventricular sulcus	Anômolo (intrasseptal ou pré-pulmonar); alcança o sulco interventricular anterior distal
Frequency	More common	Uncommon	Rare	Very rare (~0.2%)

LAD: left anterior descending (artery); LMCA: left main coronary artery; RCA: right coronary; LCx: left circumflex artery.

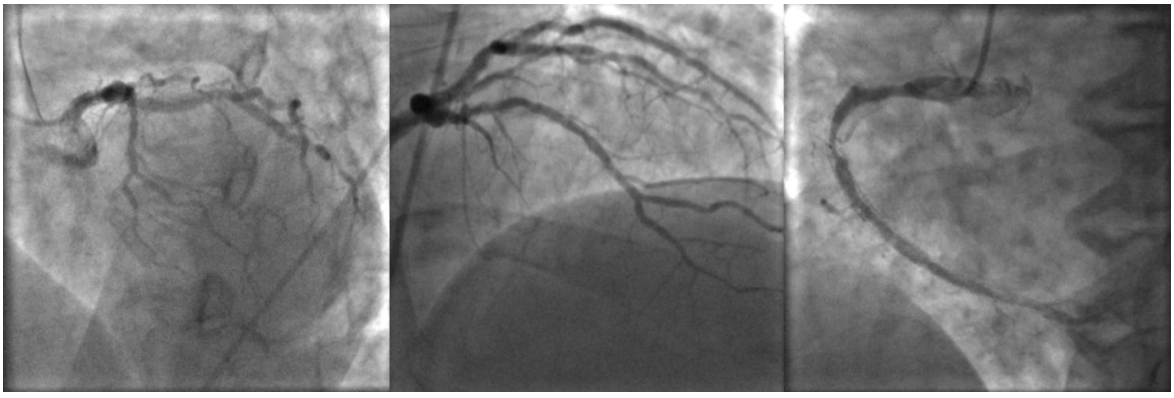


Figure 1 – *Coronary angiography. Images in left anterior oblique cranial (A), right anterior oblique cranial (B), and left anterior oblique (C) projections: (A–B) visualization of the left main coronary artery, the short LAD artery, and the circumflex artery, with the previously implanted stent preserved; (C) visualization of the right coronary artery, showing a 50% lesion in the proximal third, a stent implanted from the proximal to the mid segment, and up to 70% in-stent restenosis in the mid segment.*

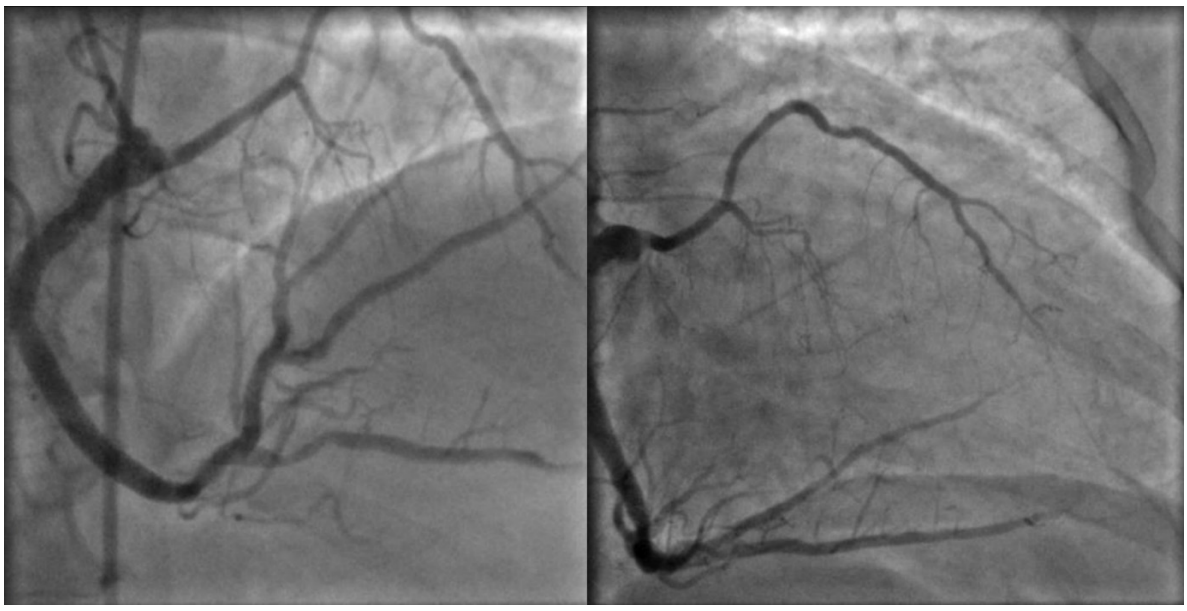


Figure 2 – *Coronary angiography. Visualization of an anomalous LAD artery originating from the right coronary artery*

To achieve a better understanding of the coronary anatomy, a coronary computed tomography angiography (CCTA) was performed, which confirmed the presence of a type IV dual LAD according to the Spindola-Franco classification. The examination demonstrated a short, thin vessel originating from the left main coronary artery and terminating before reaching the left ventricular apex, as well as a long vessel originating from the proximal third of the RCA, following an intraseptal course before emerging in the anterior interventricular groove and extending to the apex (Figure 4). The long LAD artery displayed a small calcified plaque in the mid segment, without significant obstruction, and no malignant courses were identified.

During outpatient follow-up, the patient remained on optimized medical therapy, including dual antiplatelet therapy for six months. Her clinical course was marked by complete remission of angina and significant improvement in heart failure symptoms, with only mild exertional dyspnea persisting during routine activities.

Discussion

Type IV LAD duplication is an extremely rare congenital anomaly, generally identified as an incidental finding on cardiac imaging. Its angiographic appearance may resemble unusual bifurcations or other anomalous courses on coronary angiography. In such cases, CCTA plays a fundamental role by characterizing the origin and course of the artery, allowing differentiation between typically benign variants — such as intraseptal, retroaortic, or prepulmonic courses — and those associated with a higher risk of arrhythmia and sudden cardiac death, particularly the interarterial course, in which the vessel passes between the aorta and the pulmonary artery.[4]

In the present case, the anomaly coexisted with multivessel CAD, in a clinical context suggestive of restenosis, later confirmed angiographically, along with significant ventricular dysfunction. This scenario is likely related to the extensive territory supplied by the dominant RCA, which exhibited significant in-stent obstructive disease, as well as to the anomalous origin of the LAD artery from the right coronary sinus.

The use of IVUS was essential to identify the mechanism of RCA restenosis and is recommended by national and international guidelines in this setting. The method demonstrated stent underexpansion, enabling differential diagnosis from other causes such as intimal hyperplasia or neoatherosclerosis. Additionally, intravascular imaging techniques assist in therapeutic planning for repeat intervention, defining the need for a new stent and determining its diameter and length. This strategy is crucial to reduce the need for repeat revascularization procedures and, consequently, major adverse cardiac events during follow-up.[5,6]

It is worth emphasizing that the integration of non-invasive imaging methods (echocardiography, scintigraphy, and CCTA) with invasive techniques (angiography and IVUS) is central to the characterization and management of patients with CAD and coronary anomalies. In situations such as the one described, this combined approach allows identification of the mechanisms of restenosis after PCI and recognition of rare, detailed anatomical variants of the LAD, avoiding misinterpretation and guiding safer, individualized revascularization strategies.[7]

Conclusion

Type IV LAD artery duplication is a rare anatomical variant, generally asymptomatic and benign, whose clinical relevance increases when it coexists with CAD, as it may lead to misinterpretation on angiography and mimic occlusion of

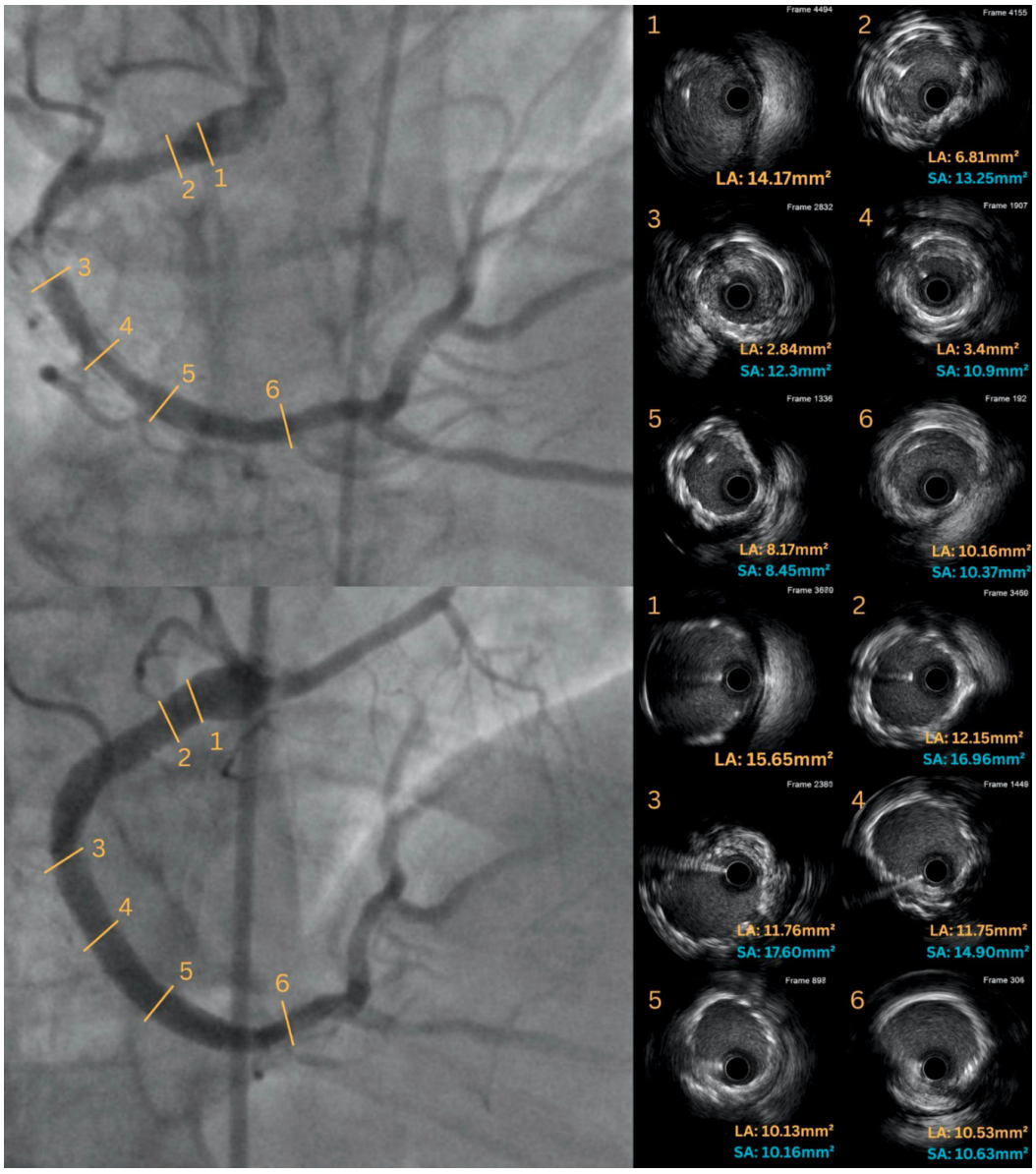


Figure 3 – *Intravascular ultrasound of the right coronary artery. Pre-angioplasty: stent with underexpansion of its struts. Post-angioplasty: implantation of one drug-eluting stent (4.0 × 38 mm) in the mid right coronary artery and one drug-eluting stent (4.0 × 33 mm) in the proximal right coronary artery, with overlap and adequate strut expansion.*

a major vessel. This clinical case illustrates how an integrated diagnostic and therapeutic approach – using both invasive and non-invasive methods, including IVUS and CCTA to define the mechanism of restenosis and the anomalous anatomical course – was essential for understanding the case and guiding appropriate therapeutic management.

Author Contributions

Conception and design of the research, acquisition of data and analysis and interpretation of the data: Cruz ARC, Martins BL, Caliano MH, Magalhães PS, Centemero MP; writing of the manuscript: Cruz ARC, Martins BL, Caliano MH, Magalhães PS, Bandeira D, Costa RA, Centemero MP; and critical revision of the manuscript for intellectual content: Bandeira D, Costa RA, Centemero MP.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

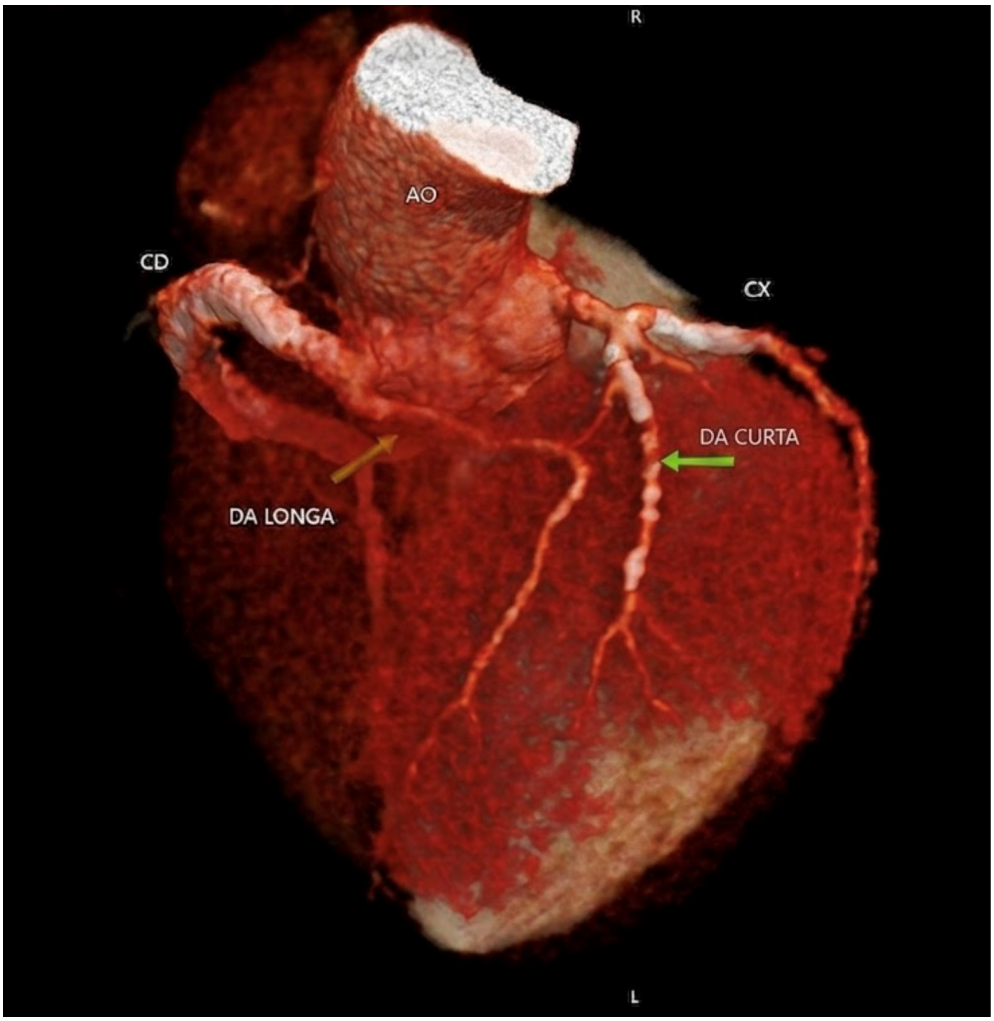


Figure 4 – *CCTA. Duplicated LAD artery (long course – type IV LAD artery), showing anomalous origin from the proximal third of the right coronary artery. Its proximal third follows an intraseptal course, without luminal narrowing; the mid third reaches the anterior interventricular groove and displays a calcified plaque causing mild luminal reduction; the distal third reaches the apex, with no plaques or luminal narrowing. AO: Aorta; RCA: Right Coronary Artery; LCx: Left Circumflex Artery; Long LAD: Long Left Anterior Descending Artery; Short LAD: Short Left Anterior Descending Artery.*

Sources of Funding

There were no external funding sources for this study.

Study Association

This study is not associated with any thesis or dissertation work.

Ethics Approval and Consent to Participate

This study was approved by the Ethics Committee of Instituto Dante Pazzanese de Cardiologia under protocol number 8.270.800. All procedures in this study were in accordance with the 1975 Helsinki Declaration, updated in 2013. Informed consent was obtained from all participants included in the study.

Use of Artificial Intelligence

The authors did not use any artificial intelligence tools in the development of this work.

Availability of Research Data

The underlying content of the research is contained within the manuscript.

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