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Management of Ostial Left Anterior Descending Intrastent Restenosis: The Value of IVUS in Diagnosing and Guiding PCI

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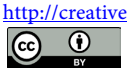


Abstract

Coronary ostial lesions remain among the most challenging lesions encountered in interventional cardiology because of their complex anatomy, frequent angiographic ambiguity, and high risk of procedural complications. Precise differentiation between true ostial disease, proximal vessel involvement, and left main coronary artery extension is crucial for optimal therapeutic planning. Intravascular imaging has emerged as an essential tool in this setting by providing accurate lesion characterization and guidance for intervention. We report the case of a 72-year-old man with multiple cardiovascular comorbidities, including diabetes mellitus, hypertension, chronic kidney disease requiring hemodialysis, and a history of multivessel percutaneous coronary intervention. He presented with recurrent deterioration of left ventricular systolic function and elevated NT-proBNP levels. Coronary angiography demonstrated a severe stenosis involving the ostium of the left anterior descending artery; however, angiographic assessment alone could not determine whether the lesion represented true ostial in-stent restenosis or extension into the distal left main coronary artery. Intravascular ultrasound was therefore performed and confirmed isolated ostial left anterior descending artery in-stent restenosis due predominantly to neointimal hyperplasia. The lesion was successfully treated using excimer laser coronary atherectomy followed by high-pressure balloon dilatation and paclitaxel-coated balloon angioplasty under intravascular ultrasound guidance. This case highlights the critical role of intravascular imaging in the diagnosis and treatment of complex ostial coronary lesions and illustrates a contemporary strategy for managing ostial in-stent restenosis while avoiding additional stent implantation.

Keywords

Ostium, In-Stent Restenosis, Intravascular Ultrasound, Excimer Laser Coronary Atherectomy, Drug-Coated Balloon, Percutaneous Coronary Intervention

1. Introduction

Coronary ostial lesions raise a number of diagnostic and therapeutic issues. The first step is to verify their presence and their severity. Ostia are often hidden and difficult to see, so taking time to multiply incidences is crucial to find the good incidence for analyze and treatment. Endocoronary imaging can offer a major help to estimate degree of stenosis and to guide treatment.

Our case is about a 72 years old male, active smoker, treated for hypertension, diabetes and dyslipidemia. He also had a chronic kidney disease with 3 times a week hemodialysis. He was implanted in 2019 with a permanent pacemaker and, in 2022, following the discovery of hypokinetic cardiomyopathy, with biomarkers elevation, he underwent PCI of proximal and mid LAD PCI, proximal and mid circumflex and marginal artery. The LV ejection fraction improved after that and in June 2025, he was admitted in our service for a new ejection fraction deterioration and reascension of NTproBNP.

His angiography (Figure 1) showed a stable bifocal moderate lesion of RCA, good results of anterior stentings, significant calcified *de novo* stenosis of a thin third marginal artery and above all, a very tight stenosis of ostial LAD, for which we cannot tell if it's intrastent or a proximal edge effect. Despite multiple incidences, the ostium remained difficult to perceive.

Caudale 30˚ Oblique 0˚, as in the image below (Figure 1), was the best incidence for diagnosis and treatment.

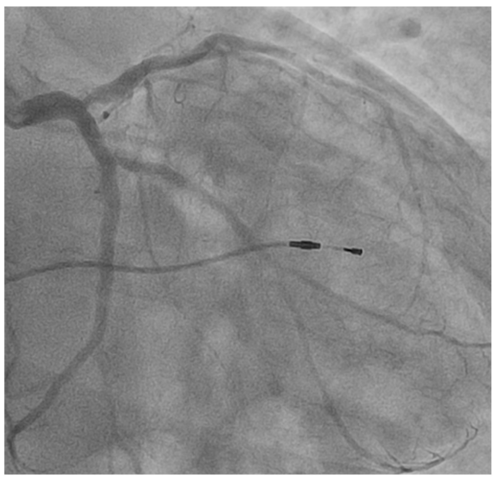
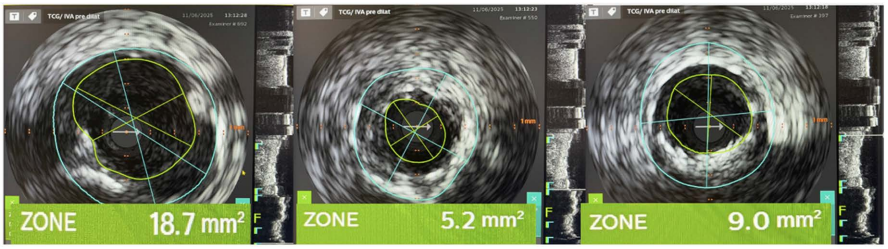


Figure 1. Angiography showing the ostia lesion (Caudal 30˚, Oblique 0˚).

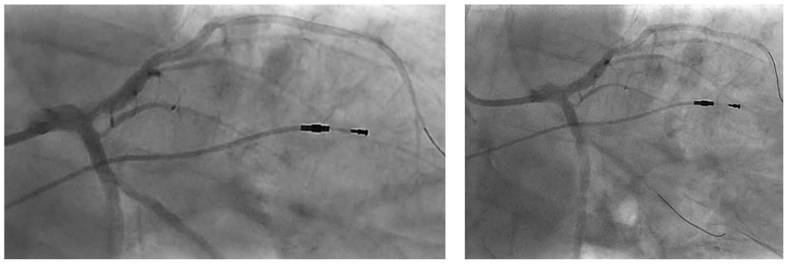


(a) (b) (c)

Figure 2. IVUS images showing luminal areas upstream (a), downstream (c) and in the target lesion (b).

We decided to use endocoronary imaging (**Figure 2(a)**) to help us with these issues. The luminal areas were: 18.7 mm^2 for left main (upstream) (**Figure 2(a)**), 5.2 mm^2 for ostial LAD (analyzed lesion) (**Figure 2(b)**) and 9 mm^2 for proximal LAD (downstream) (**Figure 2(c)**). Even if the cut-off of 4.5 mm^2 wasn't reached, we can consider that the ostial LAD is equivalent to the left main and that the cut-off should be closer to 4 mm^2. We realized an IVUS pullback that confirmed the intrastent localization, and the restenosis mechanism was undoubtly intimal hyperplasia.

The decision was then to treat this intrastent ostial LAD restenosis. We proceeded by 7F right radial access, using a 3.75 Extra backup and a 0.014 Run through extra floppy guidewire. We prepared the lesion using Laser photoablation (Philips ELCA Intensity / Frequency 70/70). The 0.9 mm optic catheter is ascended and guided to the lesion to treat. Saline heparined solution is connected to clean contrast debris, facilitate catheter progression, create a hydraulic barrier around the guide and cool down the treated site. For an optimal result, catheter progression has to be slow and progressive. Then, a protection run through extra floppy guidewire is placed in the circumflex artery. We inflated two non-compliant balloons into the lesion (4 × 15 and 4.5 × 15 mm), without any footprint. After angiography control (**Figure 3(a)**), we controlled the lesion preparation by IVUS that was satisfying, leading us to inflate an active Paclitaxel balloon 4 × 10 mm (Sequent Please Neo Braun) and finally recontrol the result for a last time (**Figure 3(b)**). These multiple controls enabled us to verify the absence of complication at each step (iatrogenic dissection of left main especially).



(a) (b)

Figure 3. Angiographic images showing results after ELCA (a) and final result after drug-coated balloon angioplasty (b) (caudal 30˚, Oblique 0˚).

2. Discussion

Coronary ostial lesions remain among the most challenging scenarios encountered in contemporary interventional cardiology. Their management requires precise anatomical characterization and careful procedural planning because even minor inaccuracies in diagnosis may lead to inappropriate treatment strategies and adverse clinical outcomes [1] [2]. This challenge is particularly evident when lesions involve the ostium of the left anterior descending artery (LAD), where distinguishing true ostial disease from distal left main coronary artery (LMCA) involvement or proximal stent edge restenosis may be difficult using angiography alone [1]. The present case illustrates how intravascular ultrasound (IVUS) can fundamentally alter both diagnostic understanding and therapeutic decision-making in a patient presenting with severe ostial LAD in-stent restenosis (ISR).

Ostial coronary lesions represent approximately 5% - 10% of all coronary stenoses and are characterized by unique anatomical and biomechanical features [1]. The coronary ostium is exposed to complex hemodynamic forces, including turbulent blood flow, elevated shear stress gradients, and increased vessel wall strain. These factors contribute not only to a higher propensity for atherosclerotic plaque formation but also to a greater risk of restenosis after percutaneous coronary intervention (PCI) [3]. In addition, the proximity of the ostium to the aortic root frequently creates angiographic ambiguities that may hinder accurate lesion assessment [1].

Angiographic evaluation of ostial lesions is notoriously difficult. Foreshortening, vessel overlap, catheter-induced distortion, and the absence of a clear proximal reference segment often complicate interpretation [1]. Even with multiple angiographic projections, differentiation between a true ostial lesion, distal left main disease, and proximal vessel involvement may remain uncertain. This limitation is particularly important because therapeutic strategies differ considerably depending on the exact lesion location [2]. A lesion extending into the left main coronary artery may require a completely different approach from an isolated LAD ostial restenosis. In the present case, despite extensive angiographic assessment and the use of multiple projections, uncertainty persisted regarding whether the stenosis represented true intrastent restenosis confined to the LAD ostium or disease extending into the distal left main coronary artery. Such uncertainty justified the use of intravascular imaging [1] [4].

Over the last two decades, IVUS has become an indispensable tool for the assessment of complex coronary lesions [1] [5]. Compared with conventional angiography, IVUS provides tomographic visualization of the vessel wall and permits accurate measurement of lumen dimensions, plaque burden, stent expansion, and lesion length [5]. It is particularly valuable in left main and ostial lesions where angiographic assessment is frequently unreliable [4] [6]. In our patient, IVUS clearly demonstrated that the lesion was confined to the ostium of the LAD and did not involve the distal left main coronary artery. This information was crucial because it allowed the operators to avoid unnecessary treatment of the left main artery and

to focus exclusively on the diseased segment.

Beyond lesion localization, IVUS also identified the underlying mechanism of restenosis. Understanding the pathophysiology of ISR is essential because treatment success depends largely on addressing the causal mechanism [7] [8]. In-stent restenosis remains a significant limitation of PCI despite major advances in stent technology [3]. Although the incidence of ISR has substantially decreased with contemporary drug-eluting stents, it still occurs in approximately 5% - 10% of treated lesions and remains associated with recurrent symptoms, repeat revascularization, and increased healthcare costs [3] [7].

Several mechanisms may contribute to ISR. Historically, neointimal hyperplasia represented the predominant mechanism, particularly following bare-metal stent implantation. Excessive smooth muscle cell proliferation and extracellular matrix deposition result in progressive luminal narrowing within the stented segment [8]. In contemporary practice, additional mechanisms include stent under expansion, stent fracture, geographic miss, edge restenosis, neoatherosclerosis, and chronic inflammatory reactions [7] [8]. Each mechanism has different therapeutic implications. Therefore, identifying the precise cause of ISR has become a central objective of intravascular imaging [4].

In the present case, IVUS demonstrated a well-expanded stent without evidence of fracture or significant malapposition and identified neointimal hyperplasia as the dominant mechanism of restenosis. This finding supported a treatment strategy aimed at debulking and modifying the hyperplastic tissue rather than implanting an additional stent layer. Such an approach is particularly attractive in ostial lesions where repeated stenting may compromise future interventions and increase procedural complexity [7].

The treatment of ISR remains a subject of ongoing debate. Current therapeutic options include repeat drug-eluting stent implantation, drug-coated balloons (DCB), cutting or scoring balloons, intravascular lithotripsy in selected cases, rotational atherectomy, orbital atherectomy, and excimer laser coronary atherectomy (ELCA) [2] [7] [9]. The choice of therapy should be individualized according to lesion morphology, restenosis mechanism, and anatomical characteristics [7] [8].

Repeat stenting with a new-generation drug-eluting stent has historically been considered an effective treatment for ISR. However, this strategy inevitably creates additional metallic layers within the vessel. Multiple stent layers may increase vessel rigidity, impair future revascularization options, and promote recurrent restenosis [7] [10]. These disadvantages become particularly relevant in ostial lesions where precise stent positioning is critical and where excessive metal burden may affect adjacent structures. Consequently, contemporary interventional practice increasingly favors stent-sparing approaches whenever feasible [2] [7].

Drug-coated balloons have emerged as an attractive alternative for ISR treatment [9]-[11]. These devices allow local delivery of antiproliferative drugs without leaving a permanent metallic scaffold. Paclitaxel remains the most widely used drug because of its high lipophilicity and rapid tissue uptake [11]. Following bal-

loon inflation, paclitaxel is rapidly absorbed into the vessel wall, where it exerts potent antiproliferative and anti-inflammatory effects that inhibit smooth muscle cell proliferation and reduce neointimal growth [11].

Several randomized trials and meta-analyses have demonstrated the efficacy of DCB angioplasty in ISR. Studies such as PACCOCATH ISR [11], PEPCAD II [11], ISAR-DESIRE 3 [12], and RIBS IV [13] have shown that DCB therapy provides excellent angiographic and clinical outcomes comparable to those achieved with repeat drug-eluting stent implantation in selected patients [10] [12] [13]. Current European guidelines therefore recognize DCB angioplasty as a standard treatment option for ISR [2] [9].

Nevertheless, successful DCB treatment depends heavily on adequate lesion preparation. Unlike stents, DCBs provide no mechanical scaffolding. Consequently, optimal lesion expansion must be achieved before drug delivery. Consensus documents recommend achieving residual stenosis below 30%, maintaining TIMI 3 flow, and avoiding significant dissections before DCB application [9]. Inadequate lesion preparation is one of the most important predictors of treatment failure [9].

In our patient, lesion preparation was achieved through a combination of ELCA and high-pressure non-compliant balloon dilatation. The rationale for selecting ELCA deserves particular attention. Excimer laser coronary atherectomy represents a unique atherectomy technology based on the emission of ultraviolet light pulses at a wavelength of 308 nm [14]. Unlike rotational or orbital atherectomy, ELCA acts through photochemical, photothermal, and photomechanical mechanisms, resulting in vaporization of intracellular water and disruption of pathological tissue at the microscopic level [14].

ELCA has several characteristics that make it particularly attractive for ISR treatment. First, it effectively ablates neointimal hyperplastic tissue while preserving the underlying stent structure [14] [15]. Second, because tissue vaporization occurs at the microscopic level, the technique generates minimal mechanical stress on the vessel wall. Third, ELCA can facilitate subsequent balloon expansion by reducing tissue burden and modifying lesion compliance [15]. Finally, it may reduce the risk of significant dissections compared with purely mechanical debulking techniques [14].

Although ELCA is not routinely used in all catheterization laboratories, it has demonstrated utility in several complex scenarios including ISR, underexpanded stents, chronic total occlusions, thrombotic lesions, and balloon-uncrossable lesions [14] [15]. Multiple observational studies have reported favorable procedural success rates and acceptable safety profiles [15]. In the present case, the mechanism of restenosis was predominantly hyperplastic rather than heavily calcific, making ELCA a particularly suitable strategy.

The patient's clinical profile also influenced therapeutic decision-making. Chronic kidney disease requiring hemodialysis is associated with accelerated atherosclerosis, diffuse coronary disease, increased calcification, and higher rates of restenosis following PCI [3]. Dialysis patients represent a particularly high-risk population

with elevated rates of adverse cardiovascular events. In these patients, minimizing procedural complexity and reducing the duration of dual antiplatelet therapy whenever possible may provide significant clinical benefits [2] [3].

The combination of ELCA, careful lesion preparation, and DCB angioplasty offered several advantages in this context. It avoided implantation of additional metallic layers, preserved future treatment options, reduced the risk of repeated restenosis, and potentially allowed shorter antiplatelet therapy duration compared with repeat stenting strategies [7] [9] [10]. Furthermore, the use of IVUS throughout the procedure provided continuous reassurance regarding procedural safety, particularly concerning the absence of left main dissection or stent-related complications [1] [4] [5].

The role of intravascular imaging in contemporary PCI continues to expand. Evidence from multiple randomized studies has demonstrated that IVUS-guided PCI improves procedural optimization and clinical outcomes compared with angiography-guided intervention alone [4] [6]. Benefits include better stent expansion, lower rates of target lesion failure, reduced restenosis, and fewer repeat revascularizations [6]. These advantages appear especially pronounced in complex lesions such as left main disease, bifurcations, long lesions, and ISR [1] [6].

Recent European Society of Cardiology guidelines have further strengthened recommendations supporting intravascular imaging [2]. IVUS-guided PCI now carries a Class I recommendation in several complex anatomical settings because of its proven ability to improve both procedural and long-term outcomes [2] [6]. As a matter of fact, since 2024, ESC classified IVUS-guided angioplasty as Class I, level of evidence 1 for left main lesions, true bifurcation lesions and long lesions. The present case provides a practical illustration of these recommendations. IVUS was not merely an adjunctive imaging modality but rather the cornerstone of diagnosis, treatment selection, procedural guidance, and final result assessment [1] [4] [6].

Another important aspect highlighted by this case is the value of repeated imaging throughout the intervention. IVUS was used not only before treatment but also after lesion preparation and at the conclusion of the procedure. This stepwise approach enabled verification of adequate tissue modification, optimization of balloon sizing, and exclusion of procedural complications. Such a strategy is increasingly recognized as best practice in complex PCI procedures [4] [6].

Finally, this case illustrates the growing trend toward physiology- and imaging-guided personalized coronary intervention. Rather than applying a standardized treatment algorithm, modern PCI increasingly relies on detailed lesion characterization to tailor therapy to individual anatomical and pathological features [1] [4]. In our patient, the combination of IVUS-defined neointimal hyperplasia, ostial lesion location, previous stent implantation, and high-risk clinical profile naturally led to a stent-sparing strategy combining ELCA and DCB angioplasty [7] [10] [15].

Concerning active balloons, their use after satisfactory and uncomplicated lesion preparation offers several advantages: avoidance of additional stent layers in

ISR lesions, reduction of technical challenges in bifurcation settings (left main coverage, carina shift and side branch compromise), and the possibility of shortening DAPT duration in selected high-risk patients such as ours [9] [11].

3. Conclusion

The present case highlights the central role of IVUS in the management of complex ostial coronary lesions and demonstrates how intravascular imaging can fundamentally influence both diagnosis and therapeutic strategy [1] [5] [6]. IVUS enabled accurate differentiation between isolated ostial LAD ISR and left main involvement, identified neointimal hyperplasia as the mechanism of restenosis, guided lesion preparation, and ensured procedural safety [4] [5]. The combination of excimer laser coronary atherectomy and paclitaxel-coated balloon angioplasty represented an effective stent-sparing approach that avoided the disadvantages associated with additional stent implantation [10] [11] [15]. This experience reinforces the importance of intravascular imaging-guided PCI and supports the growing role of DCB-based strategies in selected cases of coronary in-stent restenosis [2] [9]. Further follow-up will be necessary to assess sustained efficacy and long-term outcomes.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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