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Clinical Profile and Approach to Osteal LAD Lesion During Primary Angioplasty in Myocardial Infarction (PAMI)

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Abstract

Isolated Coronary Artery Stenoses (CAS) involving the ostium of the Left Anterior Descending (LAD) artery is very challenging, especially in a setting of primary Angioplasty in Myocardial Infarction (PAMI). Intimal atherosclerosis in the Left Main Coronary Artery (LMCA) bifurcation is primarily in area of low shear stress which is the lateral wall, close to the LAD and Left Circumflex (LCx). Thus, carina is usually free of disease, which can explain why single-stent strategy can be successful. However, precise stent placement is often difficult due to unwanted stent movement within vessel or its proximity to side branches. A decision must be made at the outset, to decide on the approach to be employed, to treat osteal LAD lesions. Limited data is available on patients undergoing primary PCI of osteal LAD lesions. Here, we present our experience and problems encountered during the management of osteal LAD lesions in the setting of PAMI.

Keywords: Osteal LAD lesion, Primary angioplasty, acute myocardial infarction, Stents.

Abbreviations: LAD-Left Anterior Descending, CA-Coronary Artery, LCx-Left circumflex, PAMI-Primary Angioplasty in Myocardial Infarction, AWMI-Anterior Wall Myocardial Infarction, STEMI-ST Segment Elevation Myocardial Infarction, CAG-Coronary Angiography, RCA-Right Coronary Artery, PTCA-Percutaneous Transluminal Coronary Angioplasty, LMWH-Low-Molecular Weight Heparin, DES-Drug Eluting Stents, ICCU-Intensive Cardiac Care Unit, TIMI-Thrombolysis In Myocardial Infarction, CPR-Cardiopulmonary Resuscitation, IABP-Intra-Aortic Balloon Pump, POS-Proximal Optimisation Technique, LVEF-Left Ventricular Ejection Factor, IVUS-Intra-Vascular Ultra Sonography, TMT-Treadmill ECG stress Test, OCT-Optical Coherence Tomography, FKB-Final Kissing Balloon, FFR-Fractional Flow Reserve, PS-Provisional Stenting, TLF-Target Lesion Failure, ST-Stent Thrombosis, MVO-Microvascular Obstruction, IRA-Infarct Related Artery, MVD-Multi-Vessel Disease, POBA-Plain Old Balloon Angioplasty, CABGS-Coronary Artery Bypass Surgery.

Introduction

Ostial Left Anterior Descending Coronary Artery (LAD) lesions were for long regarded as those clinical subset that are unsuitable for coronary stenting. An ostial stenosis is defined as angiographic narrowing of ≥ 70% located within 3 mm of a vessel origin. Ostial LAD artery lesion presenting with acute anterior wall myocardial infarction is not uncommon [1]. Ostial lesions tend to be more fibrotic, calcified and rigid. This causes increased vessel recoil post angioplasty, resulting in higher rates of repeat revascularization. It has been shown that >70% of LMCA lesions involve the distal bifurcation [2].

On conventional angiography, the lesion may appear localised to ostium of LAD, but in most cases, the plaque also extends into the LMCA or Left circumflex (LCx) artery. No specific guidelines have been formulated for Primary Angioplasty in Myocardial Infarction (PAMI) in ostial LAD lesions. Yakushiji, et al [3] have reported that osteal LAD plaque was continuous from LMCA in 96% cases and from the LMCA into circumflex ostium in 78% cases and from the LMCA into both LAD and circumflex in 74% cases. This evidence may be considered during ostial stenting of LAD or LCx [3,4]. Here we report two cases of osteal LAD stenting in PAMI, detailing the procedure and complications, both immediate and long term, for better understanding of the disease progression.

Case Reports

Case study-1

A 53-year old male, with history of hypertension and dyslipidemia presented with chest pain of 2hrs duration. Vitals were stable. ECG is suggestive of Anterior Wall Myocardial Infarction (AWMI) or anterior STEMI (ST Segment Elevation Myocardial Infarction). Patient was immediately transferred to cardiac catheterization lab after giving loading doses of aspirin (325 mg), ticagrelor (180 mg) and atorvastatin (80 mg). 2D Echo showed hypokinesia of anterior wall of left ventricle with preserved wall thickness. LV ejection fraction was 40%. There was no mitral valve regurgitation. Coronary Angiography (CAG) showed total thrombotic occlusion of LAD from ostium with mild non-occlusive plaques in mid LMCA and proximal segment of a non-dominant left circumflex artery (**Figure 1a, 1b**).

Dominant Right Coronary Artery (RCA) was normal. No collaterals to LAD could be demonstrated on RCA angiogram. It was decided to perform Percutaneous Transluminal Coronary Angioplasty (PTCA) of LAD from its ostium, which was the culprit artery. Initial bolus of integrilin (eptifibatide) and weight adjusted dose of Low-Molecular Weight Heparin (LMWH) was given intravenously. Thrombosuction of LAD with Thrombuster 6F catheter was done. Successful PTCA of LAD was performed after balloon dilatation with 2.5 mm x 10 mm NC balloon and stenting of LAD from ostium with a 3 mm x 18 mm Drug

Eluting Stents (DES). Final angiogram showed successful PTCA to LAD, with TIMI-3 flow, no residual stenosis, no dissection or flow limitation observed. Mild plaques in LMCA and LCx were similar to pre-PTCA angiogram (**Figure 1c,d**). Patient was hemodynamically stable and pain free. He was transferred to ICCU in stable condition.

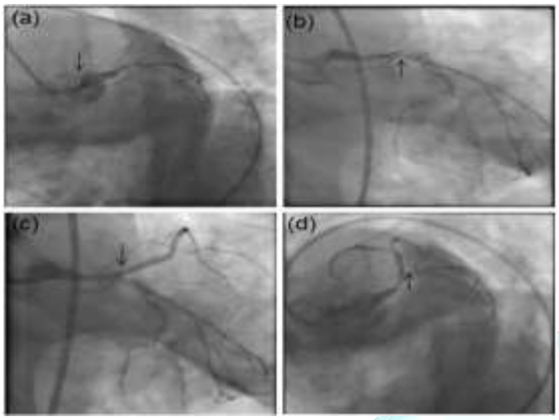

Figure 1: CAG showing total occlusion of LAD with haziness in proximal circumflex (a) and mild plaque in LMCA (arrows) (b) Post-PTCA to LAD, CAG image shows TIMI-3 flow in LAD (c) LCx and LM had few non occlusive plaques (arrows) (d).

However, immediately after transfer to Intensive Cardiac Care Unit (ICCU) he had a episode of projectile vomiting with hypotension and ST segment depression in V1 to V4 chest leads on ECG. Patient was rushed back to catheterization laboratory. Coronary angiography performed showed patent LAD stent, but LCx showed a sluggish flow with Thrombolysis in Myocardial Infarction (TIMI-2) probably due to plaque shift (**Figure 2a-c**). Patient developed cardiac asystole on table with a flat ECG trace. Repeat angiography now showed near total thrombotic occlusion in the LMCA and circumflex with sluggish flow in LAD (TIMI-1). Cardiopulmonary Resuscitation (CPR) was initiated and inotropic supports, along with temporary transvenous pacing and endotracheal intubation/ventilation. Intra-Aortic Balloon Pump (IABP) was inserted from the left femoral artery.

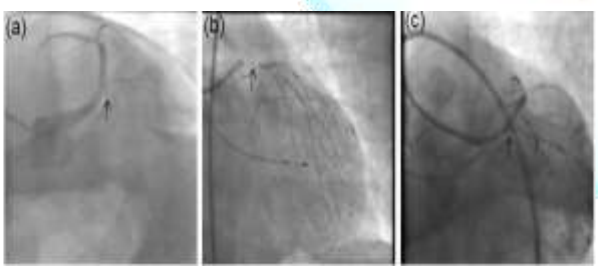

Figure 2: Repeat CAG shows patent stent in LAD (a-c) near total occlusion of circumflex artery (arrows).

Unfortunately, there was no response to any of the above measures. Decision was made to proceed immediately with PTCA to LCx and LMCA. Using Double Kiss (DK) crush technique, stenting of LCx was performed with a 3.0x15 mm DES and LM to LAD stenting done, overlapping the older LAD stent with a 3.5 x 18 mm DES. Proximal Optimisation Technique (POT) with a 4 x 10 mm NC balloon was done in the LMCA (**Figure 3a-d**). Patient's vital parameters improved soon after. Eventually patient was weaned off IABP, inotropic and ventilator supports in next 72 hrs. Subsequent recovery was uneventful. CAG repeated after 12 months showed patent stents in LMCA, LAD and LCx.

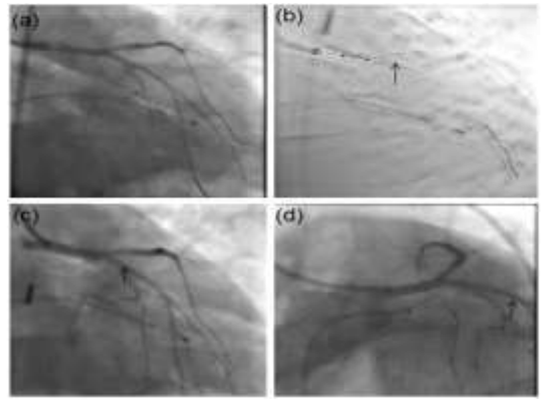

Figure 3: PTCA to Left circumflex and LMCA using DK crush method (a,b). Final CAG shows patent stents in LM and LCx and LAD (c,d) (arrows).

Case Study-2

A 62-year-old female with history of diabetes and hypertension presented with chest pain of 3 hrs duration. ECG is suggestive of acute anterior wall myocardial infarction. 2D-Echo showed anterior wall hypokinesia with Left Ventricular Ejection Factor (LVEF) of 35%. Patient was given loading dose of aspirin (325 mg), ticagrelor (180 mg) and atorvastatin (80 mg). Coronary angiography showed total thrombotic occlusion of ostial LAD, minor plaques in ostium of a large dominant LCx (**Figure 4a, 4b**). Thrombosuction of LAD with EXPORT 6F catheter was done. Intra-Vascular Ultra Sonography (IVUS) showed stenosis mainly involving LAD ostium with calcification and minor plaque extension into the LMCA. A 3 x 12 mm Flextome cutting balloon was used to prepare ostial LAD lesion and then stented with 3.5 mm x 18 mm DES. Final result showed good stent apposition in LAD with mild haziness noticed in the ostium of the LCx, likely due to carinal shift (**Figure 4c, 4d**).

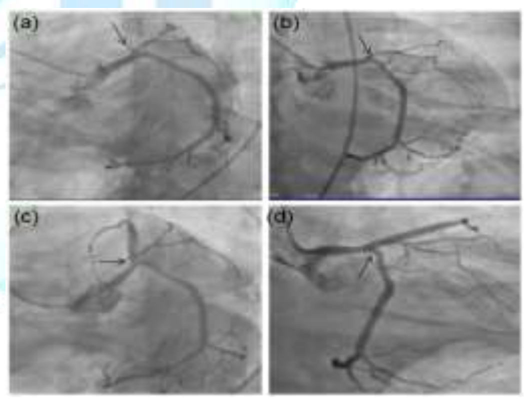

Figure 4: CAG shows total ostial occlusion of LAD (a) with minor plaques in ostium of dominant circumflex (b) (arrows). Post PTCA image showing appropriate coverage of ostium of LAD with stent (c) and persistent minor plaque in ostium of LCx (d) (arrows).

Post-PTCA IVUS assessment showed well apposed stent in LAD with few stent struts overhanging or protruding into lumen of LMCA (**Figure 5a-d**). She made a good recovery and was later discharged. However, she developed exertional angina 8 months later. ECG and troponin-I levels were normal. Treadmill ECG stress Test (TMT) was strongly positive at 5 minutes of exercise. 2D-Echo was normal. Repeat coronary angiography showed 90% ostial circumflex stenosis, with mild increase in LMCA plaque lesion when compared to the previous CAG. The stent in the LAD was patent with TIMI-3 flow (**Figure 6a, 6b**).

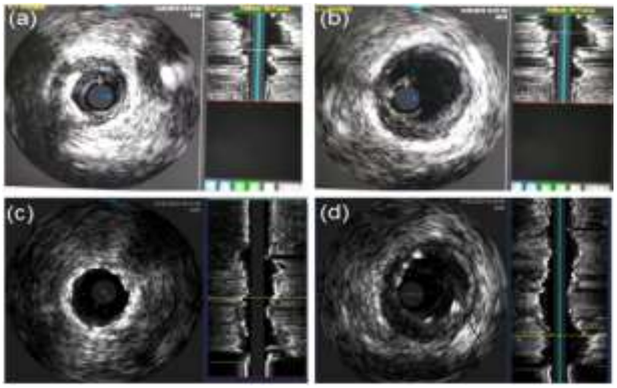

Figure 5: IVUS assessment of LMCA and ostial LAD shows critical calcified lesion admixed with thrombus in LAD (a) LMCA also showed atheroma (b) not visualised on angiography. IVUS assessment of LAD post-PTCA shows well apposed stent in LAD (c) with few struts overhanging into LMCA beyond LAD ostium (d).

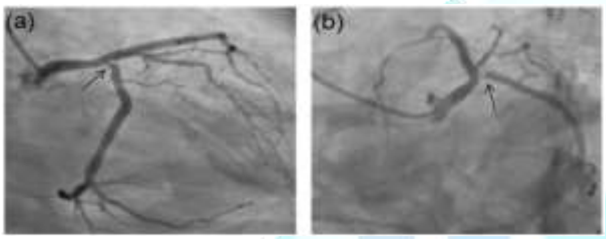

Figure 6: Repeat CAG was done 8 months later for exertional angina, which shows critical ostial circumflex lesion with patent LAD stent (a, b) (arrows).

Optical Coherence Tomography (OCT) was performed which showed well endothelialized LAD stent with excellent ostial coverage and stent apposition, but with few struts overhanging LCx ostium and presence of mixed plaque partially occluding the ostium of the circumflex (**Figure 7a-c**). Using DK crush technique, LCx stenting was done with 3.0 x 12 mm DES and LM to LAD stenting with 3.5 x 12 mm DES with final kissing balloon angioplasty and POT in LM. Patient was hemodynamically stable and was discharged after three days. She is on a regular follow-up and is asymptomatic.

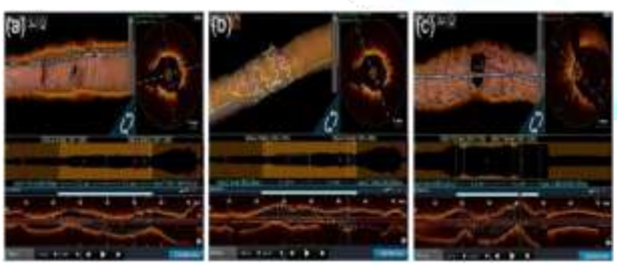

Figure 7: OCT analysis showing good coverage of LAD ostium with stent strut overhanging into the LMCA (a) and extending across ostium of circumflex (b) OCT evaluation of circumflex post PTCA by DK crush technique showing excellent stent coverage at ostia of LAD and LXc (c).

Discussion

Ostial LAD lesions have been an enigma for a long time. Various techniques have been described to treat osteal lesions, with good short and long-term results. A large percentage of ostial LAD plaques are not confined, but also extend into distal LM and/or LCx. Various imaging techniques such as IVUS and OCT give an excellent perspective with regards to plaque morphology, location and its extension. Objective of revascularisation in PAMI is complete and rapid establishment of TIMI-3 flow in culprit vessel to reduce myocardial injury. Primary PCI is the preferred reperfusion strategy in patients with STEMI within 12 hrs of symptom onset, provided it can be performed expeditiously. Coronary stenting is the technique of choice during PAMI. Focal stenting of culprit lesion at ostium seems to be obvious choice, but this may result in disastrous short or long term consequences as demonstrated by above two cases. Aggressive lesion preparation in fibrotic, calcific ostial lesions using cutting balloons and non-compliant or high pressure balloons is essential for proper stent deployment.

Extension of dissection into LMCA or circumflex, plaque shift into circumflex ostium, carinal shift, thrombus embolization and inability to recognize primary plaque rupture extending into adjacent vessels are some of the problems associated with osteal PTCA. Relying only on visual assessment during angiography before performing osteal PTCA has its drawbacks. Hence, intravascular imaging may be the better option in such cases. However, intravascular imaging may not be available or not cost-effective and is often time consuming especially in emergency situation like primary angioplasty. Other factors such as coronary dominance also play a role in prognosis. Dominant left coronary circulation interventions have poor post-revascularisation outcomes due to dependence of one single coronary artery supplying a large myocardial territory [5].

Various techniques of both single vessel and bifurcation stenting have been described [6-8]. Floating-stent technique [9]. Szabo method [6] “inverted" provisional T stenting, T-stent and small protrusion (TAP stenting), ‘V’ stenting, the cross-over stenting with or without Final Kissing Balloon (FKB), Culotte, DK crush and new dedicated ostial stents (e.g. CAPELLA SIDEGUARDTM) are some of the techniques in use. POT is recommended in all cases after Stent side-cell re-cross and kissing balloon inflation.

Plaque shift has been considered as the main underlying mechanism for side-branch compromise following main vessel stenting, but current IVUS studies suggest that side branch ostial stenosis after stent implantation may also be as the result of carina shift, a phenomenon that may not result in functional flow limitation. In such cases, side branch balloon dilatation should be performed when there is a suboptimal result at the side branch ostium on angiogram. Fractional Flow Reserve (FFR) assessment in patients with evidence of severe side-branch ostial compromise on angiography after cross-over stenting is often needed to assess the degree of vessel compromise.

Option of provisional side-branch stenting should be considered when patient is significantly symptomatic with fresh ECG changes suggestive of coronary ischaemia or haemodynamic instability. FFR evidence of physiologically significant lesion or life-threatening arrhythmias have good corroborative value. Poor outcomes include >75% lesion in side-branch, TIMI flow <3, dissection, residual ostial circumflex vessel with MLA <4 mm^2 after stenting or FFR <0.8 after provisional stenting. In complex lesions with pre-PTCA evidence of critical disease in both LAD and circumflex ostia, planned bifurcation stenting is a better option. If circumflex lesion is >70% and extends for more than 10 mm beyond ostium, bifurcation stenting is a clear choice.

Ostial stent deployment is often complicated by the influence of cardiac and respiratory motion, which causes the stent to oscillate back and forth during the cardiac or respiratory cycle. Breath-holding, shallow-breathing, pharmacological agents (such as esmolol, adenosine and atropine) or rapid ventricular pacing are some of the techniques in use to aid in accurate stent deployment at the ostium. Other methods include low-pressure inflation of the balloon on which the stent is mounted. This stabilizes the stent within the stenosis, while permitting adjustment of the stent to osteal location prior to deployment.

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LAD stent can also be stabilized by simultaneous balloon placement in the side branch to prevent unwanted stent movement. Excessive protrusion of LAD stent into LMCA makes re-wiring, balloon-stent crossing into side-branch difficult if bifurcation stenting is planned. This is further compounded in trifurcations with moderate sized ramus or early obtuse marginal branch (>2 mm) which may get compromised due to jailing of vessels.

DK crush technique is superior to Provisional Stenting (PS), minicrush and culotte [10] in certain side branch anatomy. Results of DK CRUSH-V study, 2019 have shown that Target Lesion Failure (TLF) at 3 years after DK crush stenting was 8.3% compared to 16.9% for PS in unprotected left main distal bifurcation lesions. Furthermore, definite or probable Stent Thrombosis (ST) rates at 3 years were 0.4% in the DK crush group compared to 4.1% in the PS group. DK crush technique is associated with a significant reduction in both primary and secondary endpoints for patients with complex bifurcation lesions [10]. However, DK crush technique has many steps and is challenging to perform. It involves a steeper learning curve before optimal results are achieved. Teaching and adequate practice along with intravascular image interpretation is mandatory for optimal results.

Deferred stenting in primary PCI has also been investigated as an option to reduce Microvascular Obstruction (MVO) and preserve microcirculatory function. Ostial LAD occlusion in setting of STEMI is treated immediately to establish TIMI-3 flow using thrombosuction, balloon dilatation, and/or GPIIb /IIIa inhibitors, and subsequently after few hours, with IVUS or OCT imaging and stenting if required.

Learning Points from the Cases

- One should not ignore stenosis or thrombus in the side-branch when treating the occluded main (culprit) artery as restenosis rates at the ostium of the side branch is high .Furthermore, disease of LAD ostium is usually continuous with ostial disease of LAD and LCx and vice versa. Performing a bifurcation stenting could have averted potential complications in the first case. Once TIMI-3 flow is established in Infarct Related Artery (IRA), re-assessment of anatomy and need for intra-vascular imaging should be considered.
- In STEMI, PTCA to IRA is the preferred reperfusion strategy. Multi-Vessel Disease (MVD) is present in about 50% of patients with STEMI. Intervention should be performed on culprit vessel or all major occlusive lesions (>50% stenosis). Non-culprit lesions may also be biologically active, inflamed and potential targets for thrombosis. It is imperative to emphasize the importance of clinical judgment when deciding on performing multi-vessel PCI or staged multivessel PCI, or just Plain Old Balloon Angioplasty (POBA) or referral for Coronary Artery Bypass Surgery (CABGS).
- In the presence of persistent ischaemia after culprit vessel PTCA or when patient continues to have chest pain or is haemodynamically unstable or if the operator is uncertain regarding the culprit vessel involved or the non-culprit lesion appears unstable or thrombotic, it is imperative to revascularize the most critical lesions, even if it implies performing a more complex bifurcation stenting [11].
- Mild to moderate side-branch stenosis post stenting due to plaque or carinal shift or spasm should not be neglected, even if there are no symptoms or ECG changes. Imaging of side-branch or FFR can help in assessment of severity of lesion in order to decide on various treatment options.

Conclusion

Each case is different and strategy should be customised based on anatomy and pathophysiology of the lesion with institutional or operator expertise. Simple ostial LAD lesions can be managed with focal stenting only. It is apparent that one may adopt a more aggressive approach and perform stenting from LMCA to LAD based on the main vessel and side branch anatomy. Crossover stenting is commonly used technique to treat significant distal LM or ostial LAD disease, in the absence of angiographically significant ostial LCx disease. Adequate lesion preparation prior to stenting is mandatory in all cases. However, low threshold to bifurcation stenting in the event of complications will have better short as well as long term results.

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