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Interventions in Left Internal Mammary Artery

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ABSTRACT

Left internal mammary artery (LIMA) grafts are the preferred arterial grafts as they are more durable. LIMA grafts can develop stenosis most commonly at the distal anastomotic site and less frequently involve the ostium or body of LIMA. They may occur in the immediate post-operative period due to technical faults or occur several years later. LIMA graft interventions are more challenging because of its long and tortuous course and frequently tend to develop spasm and dissection. It might be the only method of revascularization in some patients and needs to be undertaken on and off. LIMA grafts have been used for retrograde revascularization of chronic total occlusion of native coronary arteries.

Keywords: Left internal mammary artery, Perforation, Avulsion, Self-reparative, Saphenous vein graft

INTRODUCTION

Left internal mammary artery (LIMA) grafts have better durability and the use of LIMA grafts is associated with better survival in coronary artery bypass grafting (CABG) patients. LIMA graft failure is uncommon but can occur in the immediate post-operative period or present delayed after several years. LIMA interventions are challenging in terms of technical difficulty, complications, and outcomes. Hence, they are less often attempted than percutaneous coronary intervention (PCI) of the native vessels whenever feasible. LIMA grafts are assessed non-invasively by CT angiogram with great degree of sensitivity and specificity. They can be assessed by transthoracic ECHO as well, but it is not commonly used nor validated in large scale. LIMA graft patency can be studied by coronary angiogram through the femoral or left radial route using the right coronary artery (RCA) or internal mammary artery (IMA) catheter. Care must be taken to prevent LIMA or subclavian dissection during the diagnostic angiogram.

LIMA GRAFT STENOSIS AND OCCLUSION

LIMA grafts are resistant to atherosclerosis, and it is rare (4%). Conventional risk factors such as smoking and hyperglycemia without diabetes have been associated with graft stenosis in post CABG >10 years. Statin use and low-density lipoprotein levels have been found to be protective. Graft failure in the early post-operative period has been found to be due to mainly technical errors during surgery resulting in dissection, hematoma, spasm, or stenosis.[1]

LESIONS IN LIMA GRAFT

LIMA is an elastomuscular artery measuring 2–3 mm diameter.

It has less risk of atherosclerosis and intimal hyperplasia and is the preferred conduit during CABG with excellent 10-year patency rates of 90–95%.[2]

LIMA lesions occur most commonly in the distal anastomotic site in about two-thirds in a study of 174 patients with LIMA intervention, the largest case series.[3] The lesions in the ostium are next common and rare in the body of LIMA.

LIMA INTERVENTIONS

The challenges in LIMA interventions are the long, tortuous course of LIMA makes it prone for spasm, dissection, and accordion effect.

The major complications in LIMA interventions [Table 1].

The reasons for failure of LIMA interventions are failure to cross with guidewire or balloon and inability to reach the lesion due to the length of LIMA. The regular guide catheter can also be shortened by cutting the proximal end and sliding over the introducer sheath. The techniques used to overcome this challenge are left radial approach, use of short 90 cm IMA guide catheter, and use a 150 cm balloon. The highly tortuous LIMA graft can impair distal flow due to spasm or accordion effect. The spasm is prevented using 300 μgm of nitroglycerine and verapamil 100 μgm through the guide catheter at the start of the procedure. A novel technique of using the transit catheter to check distal flow removing the angioplasty catheter and guidewire and after check angiogram, reintroducing the guide wire in vessel with severe accordion effect has been described.[4] Difficulty in delivery of stent in tortuous LIMA can be overcome using guide extension microcatheter[5] [Figure 1].

STRING PHENOMENON

There can be diffuse narrowing of distal LIMA which may occur due to competitive flow between LIMA and left anterior descending (LAD) in the absence of severe stenosis of LAD named as string phenomenon. Two reasons for the LIMA graft failure may be low diastolic flow and retrograde systolic flow. The decreased flow may decrease the size of LIMA which usually is dynamic and grows over time.[6]

There can be diffuse narrowing of distal LIMA occurring due to competitive flow between LIMA and LAD in the absence of severe stenosis of LAD. In a study of 105 patients studied angiographically 28 months following CABG, LIMA was patent in 94%, 6% exhibited string sign. Two of the patients reevaluated had lesions of borderline severity and FFR measured was >0.8, one had <50% stenosis with non-ligated large branch of LIMA, one patient had regression of the lesion, one patient had radial artery competitive flow done during re-do surgery, and one patient had sequential graft to non-obstructive lesion of the diagonal artery [Figure 2].[7]

LIMA RUPTURE

Freshly, implanted LIMA is prone for dissection and rupture when PCI is performed, a case report of a 71-year female undergoing hybrid revascularization of RCA following robotic minimal access surgery had a LIMA dissection while doing a diagnostic angiogram, stenting of the LIMA resulted in rupture and a redo saphenous vein graft (SVG) to LAD was performed as an emergency procedure.[8]

ABRUPT CLOSURE OF LIMA IN THE PERIOPERATIVE PERIOD

Acute graft closure of LIMA can occur in the immediate post-operative period or 3–6 months post-surgery. The incidence of SVG closure is about 20% in 1 year and 8% for LIMA grafts at 1 year. LIMA grafts are resistant to atherosclerosis and the 10-year patency rates of LIMA grafts are 90% as compared to 40–60% for SVGs [Figure 3].

The common causes of acute early closure of LIMA grafts [Table 2].

Acute closure of LIMA in the early post-operative period is challenging as patient clinically is often unstable. It occurs

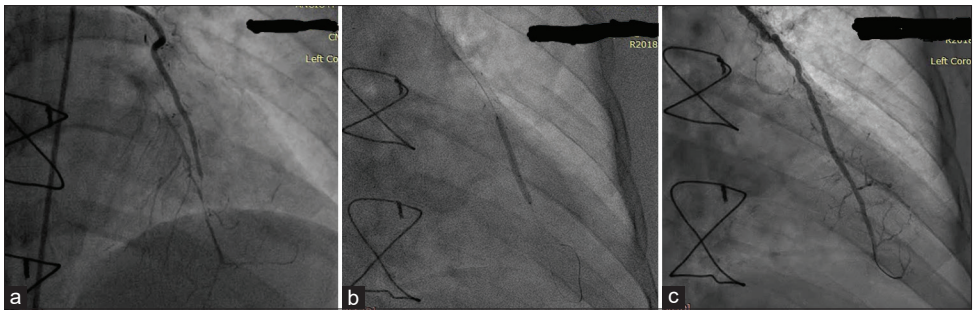

Figure 1: (a) Left internal mammary artery (LIMA) distal anastamotic lesion. (b) LIMA distal anastamotic lesion treated with balloon predilatation. (c) LIMA distal anastamotic lesion treated with drug-eluting stent.

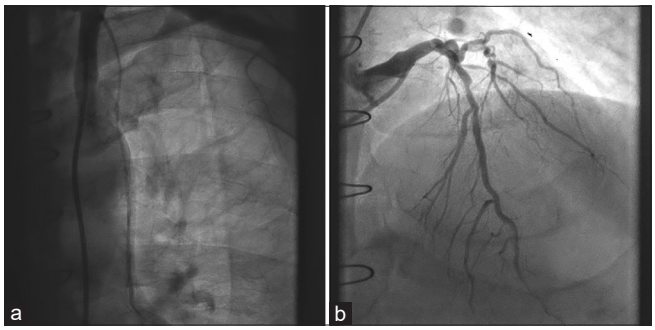

Figure 2: (a) String like left internal mammary artery (LIMA). (b) Left anterior descending not tight stenosis causing string like LIMA.

Table 1: Major complications of LIMA interventions.
1. Guide catheter induced dissection of LIMA 2. Dissection of subclavian artery 3. Perforation 4. Slow-flow or no-flow 5. Accordion effect due to its tortuous nature 6. Challenges in wiring, device delivery due to tortuosity and long length
LIMA: Left internal mammary artery

Table 2: Major causes of Acute failure of LIMA grafts.
1. Technical problems in the harvesting, preparation or anastomoses of LIMA 2. Failure to ligate a large branch of LIMA 3. Thrombosis 4. Spasm 5. Haematoma 6. Competitive flow of a stenosis which is not very tight 7. Stenosis distal to the anastomoses 8. Sequential grafting with a vessel with moderate stenosis 9. Grafting the target vessel in a rigid, calcific spot 10. Diffusely thin distal vessels 11. Presence of subclavian stenosis 12. Discontinuation of DAPT 13. Minimally invasive CABG
LIMA: Left internal mammary artery, CABG: Coronary artery bypass grafting, DAPT: Double anti platelet Therapy

in 5–10% of cases resulting in perioperative myocardial infarction (MI). LIMA acute occlusion may be due to thrombosis, dissection, spasm, or stenosis due to surgical suture. The options are to open the native vessel and when this is not feasible, a re-do CABG is more formidable and LIMA interventions may be the only option.[9] Early stenosis of LIMA distal anastomoses is usually due to surgical suture and edema and responds to POBA and carries high risk of coronary perforation.[10] A case series has described 30% incidence of perforation of LIMA anastomotic PCI when performed as emergency in the early post-operative period.[11] The line- There are case reports of DES implantation in the early post operative period.[12] There has been a case report of deploying a covered stent (Papyrus) in the anastomotic site in the immediate post-operative period to prevent the challenge of avulsion or perforation.[13]

A recent report of LIMA avulsion occurring 4 weeks postoperatively managed with drug-eluting stent (DES) implantation has been described.[14]

LATE OCCLUSION OF LIMA GRAFT

LIMA grafts are resistant to atherosclerosis, have high nitric oxide production, have high anti-thrombotic properties such as tissue plasminogen activator, lower vasoconstrictor effect, and rapid lipolysis and less lipid synthesis, and are the reason that they remain as gold standard conduit for LAD.[1]

A case report of acute occlusion of LIMA presenting as acute anterior wall MI, 15 years after surgery with total occlusion in mid portion, has been reported and IVUS showed atherosclerotic plaque and flow was established by implanting a DES.[15] A case of chronic total occlusion (CTO) intracoronary stent restenosis of DES in the LIMA-LAD anastomoses has been described treated successfully by drug-eluting balloon.[16]

SELF-REPARATIVE NATURE OF LIMA GRAFTS

LIMA grafts have been found have self-reparative property. A case report of unsuccessful PCI of LIMA due to residual disruption on check angiogram later was found to be fully recanalized.[17]

PCI OF CTO USING LIMA AS CONDUIT

PCI of CTO has been done using LIMA as conduit in 2% of cases of CTO PCI registry and has lower success rate of 70% versus 81% through other conduits and 5% incidence of complications with LIMA as compared to 6% with non-LIMA conduits. The use of left ventricular assist device (24%), IVUS (45%), and guide extension catheters (40%) was higher in the LIMA conduit CTO interventions. The most common target vessel was RCA intervention through LIMA conduit in more than half of the cases.[18]

OUTCOMES OF LIMA PCI

In the ACC NCDR CATH PCI registry, 2009–2011, PCI of LAD lesions following bypass surgery was performed in 12,824 patients. LIMA interventions were more common in women, patients with no prior MI and insulin requiring DM. PCI of LIMA was associated with >50% residual stenosis and increased mortality as compared to SVG interventions on follow-up of more than 2.8 years.[19]

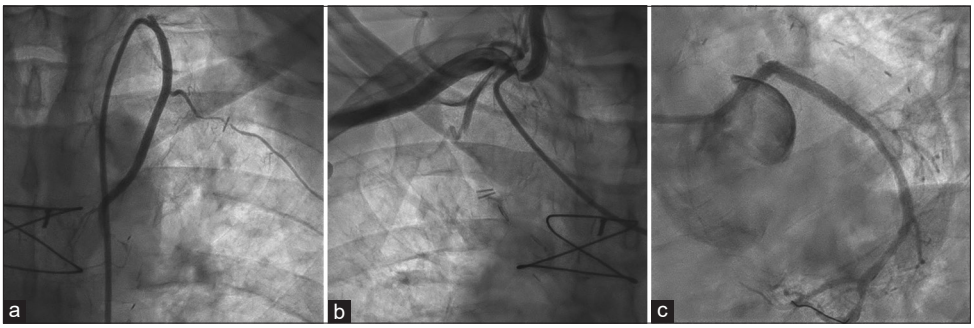

Figure 3: (a) 100% Blocked left internal mammary artery in the early post-operative period, (b) 100% blocked right internal mammary artery in the same patient, and (c) post-percutaneous coronary intervention with drug-eluting stent for dominant left circumflex in the patient, 100% ostial left anterior descending chronic total occlusion left on medical treatment.

Yeo *et al*. in their study of 10,051 PCI done on grafts to LAD, 30% LIMA, and 67.7% SVGs from US Cath PCI Registry showed equal procedural success of 91% for LIMA interventions and 93% for SVG interventions, but dissection was more common in LIMA PCI (2.8%) as compared to SVG interventions (0.7%). In-hospital mortality was similar, SVG-3%, and LIMA 2.7%. Lower mortality, lower rates of MI, and TVR were noted in LIMA interventions at 1 year as compared to venous graft interventions.[20]

In a study of 21 patients of LIMA intervention by Pati *et al*. from NIMS, India, the commonest presentation was chronic coronary syndrome. Failure to deliver stent occurred in 19% of patients and slow flow in 20%. The procedure success was 80.95%.[21]

CONCLUSION

The interventions in LIMA are generally undertaken in the immediate post-operative period due to graft failure mainly due to technical reasons and in the later stages atherosclerotic lesions may develop. The LIMA interventions require higher use of adjunct devices such as microcatheter and guide extension catheters. There is a higher incidence of complications during PCI in LIMA as compared to SVG PCI or that of the native arteries. Recent data on LIMA interventions quote a high success rate with acceptable level of complications. LIMA can be used as a retrograde conduit for PCI of native vessel CTO lesions.

Declaration of patient consent

Patient's consent not required as patients identity is not disclosed or compromised.

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Conflicts of interest

There are no conflicts of interest.

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