Original Article

Percutaneous Transluminal Angioplasty to Left Internal Mammary Artery Grafts: Immediate and Long-term Clinical Outcomes

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Background: Increasing usage of the left internal mammary artery (LIMA) as the graft of choice in coronary artery bypass surgery has led to increased incidence of LIMA graft stenosis.

Methods: Thirteen patients with LIMA graft stenosis were identified from a review of our institutional database, with intervention approach either from the femoral (n = 6) or radial artery (n = 7). There were no LIMA orifice lesions and all patients presented with anastomosis site stenoses, except one individual who had combined LIMA shaft stenosis. Clinical outcomes were assessed.

Results: The procedural success rate was 92% (12/13). Conventional balloon dilation was performed in seven cases and stenting in five. Two patients developed LIMA body dissection during the procedure, with one requiring bail-out stenting and the other prolonged balloon inflation. The in-hospital major adverse cardiac events included 1 non-Q wave myocardial infarction (7.7%) but no deaths, emergency coronary artery bypass surgery or target lesion revascularization. In the one failure case, the patient died 1 month later at home. Angiographic follow-up of ten patients (83%) revealed a restenosis rate of 20% (2/10). The mean clinical follow-up duration was 34.5 ± 20.9 months. One patient expired 32 months later due to acute stroke with sepsis.

Conclusion: Percutaneous transluminal intervention of LIMA grafts can be performed safely from either the femoral or radial approach. High procedure success and low complication rates are achievable by an experienced cardiologist; long-term clinical results were excellent in our patients. It can be considered as an alternative therapeutic method for a stenosed LIMA graft.
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Key words: angioplasty, left internal mammary artery graft

The left internal mammary artery (LIMA) graft is the first choice for coronary artery bypass graft-

ing (CABG) surgery because of its superior long-term patency rate, lower frequency of reoperation

and lower prevalence of long-term myocardial infarction (MI) when compared to saphenous vein grafts.[1-4] However, some stenosis development does take place due to intrinsic atherosclerotic disease, distal anastomosis site stenosis or damage during the harvesting procedure. LIMA graft lesions are most commonly located at the distal anastomosis site, followed by the graft body.[5,6] Herein, we retrospectively reviewed a series of LIMA graft angioplasties and assessed the technical difficulties inherent to the procedure, as well as the angiographic and clinical follow-up outcomes.

METHODS

Patient population

Between January 1998 and May 2004, 4,838 consecutive Chinese patients underwent percutaneous transluminal coronary angioplasty at our hospital. Of these, 13 underwent percutaneous transluminal angioplasty (PTA) for a stenosed LIMA graft. The clinical characteristics of these 13 patients are presented in Table 1.

Definitions

Angiographic success was defined as < 50% luminal narrowing after angioplasty, with at least a 20% reduction of the original stenosis. Clinical success was defined as angiographic success and no mortality, fatal MI or emergency CABG surgery during the same hospitalization. Restenosis was defined as a luminal narrowing of > 50% at the previously dilated site. Major adverse cardiac events (MACE) were death, nonfatal MI (defined as a development of new Q wave or creatine phosphokinase MB fraction increase more than twice the upper normal limit), target lesion revascularization (TLR) and CABG.

Angioplasty procedure

All patients underwent either PTA or stenting of the LIMA graft, the operator decided whether to use a transradial or transfemoral approach. A 6 or 7-French (Fr) catheter sheath was placed either in the left radial or right femoral artery using a standard percutaneous technique. At the beginning of the procedure all patients were given weight-adjusted heparin to maintain desired prolongation of activated

Table 1. Characteristics of the 13 Patients

Pt. no.	Age & gender	Clinical symptom	Graft age (ms)	Lesion site	% DS before	After	Angiographic F/U (ms)	Approach route	% DS at F/U	Long-term outcome
1	61/M	SA	26	An	91	0	53	TF	20	Survival
2	65/M	SA	5.5	An	77	0	24	TF	23	Survival
3	59/M	SA	3	An	65.3	26	32	TF	20	Death
4	29/M	SA	6	An	75.5	12.4	36	TF	15	Survival
5	48/M	SA	3	An	81.9	19.7	7	TF	71.5	Survival
6	65/M	UA	198	An	73.3	12.4	–	TR	–	Survival
7	56/M	UA	6.5	An	99	14.8	16	TR	40	Survival
8	69/M	SA	6.5	An	80.7	10.6	24	TR	7.6	Survival
9	60/M	CHF	84	An	77.2	1.8	6	TR	74.9	Survival
10	81/M	Non-Q	3.3	An	83	30	–	TR	–	Survival
11	47/M	UA	12	An+S	100	100	–	TF	–	Death
12	49/M	UA	4	An	71.5	16.1	7	TR	15.7	Survival
13	68/M	UA	71	An	71	19	14	TR	45	Survival

Abbreviations: An: anastomosis site; CHF: congestion heart failure; Non-Q: non-Q wave myocardial infarction; SA: stable angina; S: shaft; TF: transfemoral; TR: transradial; UA: unstable angina.

clotting time. A 6-Fr guiding catheter Kimny Mini-radio Force™ (Boston Scientific SciMed, Maple Grove, MN, USA), Judkins Right 4 (Boston Scientific SciMed) or LIMA guiding catheter (Cordis Corporation, USA) was used in the angioplasty, as well as two different 0.014-inch guide wire systems: Hi-Torque Floppy II™ (Guidant Corporation, Santa Clara, CA, USA) or Choice PT wire (Boston Scientific SciMed). When the lesion was not dilated fully by balloon, stenting was implanted to increase the diameter further. All patients received aspirin 100 mg and those who underwent stenting were treated with either ticlopidine 250 mg bid or clopidogrel 75 mg qd for 4 weeks. The heparin was discontinued at the end of the procedure.

Clinical and angiographic follow-up

Retrospective chart review was performed to obtain information with respect to the baseline clinical characteristics, procedural information and in-hospital events. Telephone contact or office visits were used for clinical follow-up and results were recorded. Angiographic follow-up was performed for recurrent symptoms of ischemia. A repeat angioplasty was conducted if angiographic restenosis occurred.

RESULTS

Angiographic results and procedural complications

The angiographic characteristics of the patients are summarized in Table 1. Of the 13 recruited individuals, the approach was via the right femoral artery in six and the left radial artery in seven cases. The LIMA was grafted to the left anterior descending artery in 12 patients and to the diagonal branch in one patient.

Success was achieved in all but one case (92%; 12/13), with reduction of the mean luminal stenosis from $78.9 \pm 9.2\%$ to $13.6 \pm 9.6\%$ (mean different 65.3, 95% confidence interval 55.9 to 74.7; Fig. 1). Conventional balloon angioplasty was used in seven patients successfully and additional stenting in five. No deaths or emergency CABGs were associated with the procedure, except one non-Q wave MI.
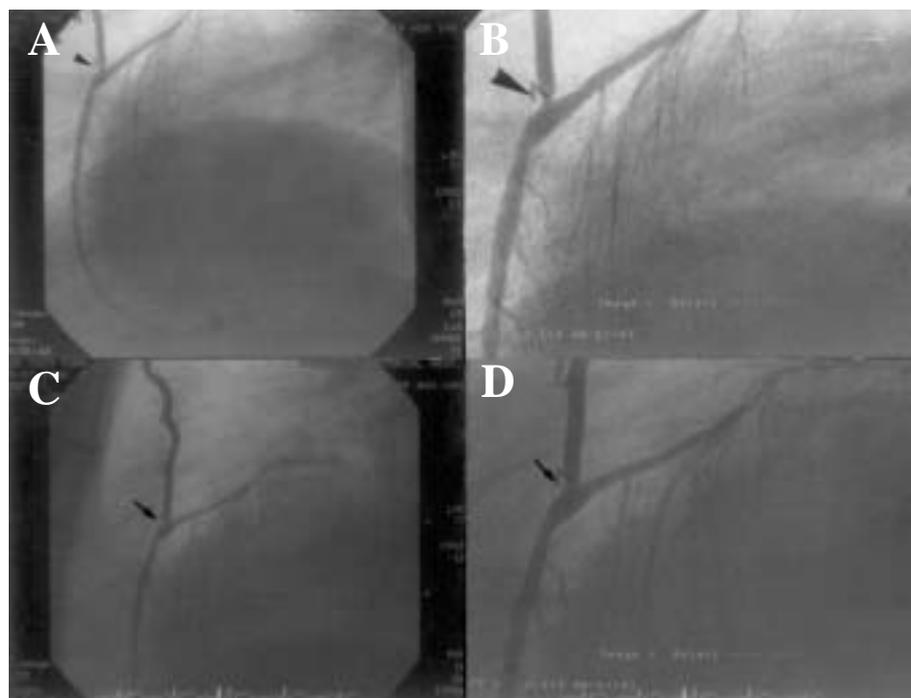
Fig. 1 (A), (B) Left anterior oblique caudal angiogram showing a significant LIMA graft anastomosis stenosis (black arrow head). (C), (D) Left anterior oblique caudal angiogram of LIMA graft anastomosis after successful balloon angioplasty (black arrow). LIMA: left internal mammary artery.

In two of the 12 successes (cases 6 and 7), the LIMA body was dissected in an attempt to advance the wire through a very tortuous vessel. One patient required two additional stents and the other prolonged balloon inflation. Final sequential angiography revealed good distal run-off. The former patient had elevated CPK-MB fractions (3x) the next day. The one failure (case 11) was due to a very tortuous LIMA and subtotal occlusion at the anastomosis site, which blocked guidewire access across the lesion. The patient was scheduled to undergo elective bypass surgery but he hesitated and expired suddenly 1 month later.

Follow-up data

Angiographic follow-up was performed in ten cases (83%). The mean follow-up duration was 22 ± 15.1 months (range 6-53). Balloon-only treatment was adopted for six patients and stenting for four. Angiographic restenosis was found in two patients (20%). One received balloon angioplasty only and the other received stenting. The former was treated with additional stenting, while balloon dilation was used in the latter. Clinical follow-up information was collected from 12 patients. Mean follow-up duration was 34.5 ± 20.9 months (range 6-76). One patient (case 3) expired 32 months after the procedure due to acute stroke with sepsis and the others remained symptom free.

DISCUSSION

Increasing usage of LIMA as the conduit in CABG grafts has increased incidence of stenosis in either the internal mammary artery (IMA) itself or the anastomosis. An IMAGE trial revealed that early LIMA to left anterior artery anastomosis site stenosis (> 50%) was found in 9% of patients undergoing conventional median sternotomy bypass surgery.[7] Re-operation for patients with coronary artery disease incurs increased risk of morbidity, with a mortality rate as high as 5% in experienced centers.[8] Given the increased mortality and morbidity associated with repeat bypass surgery, PTA to LIMA stenosis appears to be a viable alternative treatment. Hearne et al.,[5] Gruberg et al.[6] and Ishizaka et al.[9] have reported that IMA grafts underwent PTA mostly at the distal anastomosis (77%-87%). In our series, all procedures involved stenoses at the anastomosis

sites. Several studies have described angioplasty of an IMA graft with reported success rates between 73% and 97%,[5,6,9-12] similar to that determined in our study. The single failure in the present investigation was caused by severe tortuosity of the IMA and tight stenosis of the body followed by subtotal occlusion of the anastomosis site, which blocked guidewire access across the lesion. Furthermore, it has been confirmed elsewhere that vessel tortuosity is a significant predictor of angioplasty failure.[5,11] Two possible reasons for the development of such tortuosity are: (1) coiling of a long IMA between the orifice and the anastomosis; and, (2) existence of severe IMA tortuosity prior to the bypass surgery. A tortuous IMA increases trauma to the vessel wall, which can result in dissection during the wiring procedure. Two of our patients developed abrupt closure and needed re-dilation. Using a wire coated with a hydrophilic material that facilitates passage through an extremely tortuous IMA may reduce the risk of this complication.

In other published series of IMA graft angioplasty, angiographic restenosis constituted 8%-30% of balloon angioplasties.[5,9-12] In our study, angiographic follow-up was obtained in ten patients and restenosis in two. This 20% restenosis rate was comparable to that demonstrated in other investigations. Compared with the reported restenosis rates of saphenous vein graft angioplasty (38%-52%),[13-15] long-term outcome appears significantly improved using the IMA-based variant. Sharma et al.[16] reported a restenosis rate of 23.5% for stenting in IMA grafts, while Gruberg et al.[6] demonstrated 33% TLR in their stenting group, which was higher than that of balloon angioplasty only. The Gruberg result does not support the proposed benefit of stenting in IMA grafts. The lower restenosis rate of IMA grafts when compared to saphenous grafts may be due to the resistance of the former to accelerated atherosclerosis.[17] Yang et al.[18] revealed that smooth muscle cells from the IMA have less pronounced growth activity in response to serum or platelet-derived growth factor-BB (PDGF-BB) than vein grafts, despite normal PDGF receptor expression and function. Otherwise, cyclin-dependent kinase inhibitors (p27^{Kip1} and p21^{Cip1}), which cause cell cycle arrest in cultured cells in G1, are less downregulated in IMA grafts when compared to vein grafts, therefore diminishing smooth muscle cell proliferative response in IMA

grafts. This may account for the difference in prolif-erative vascular response between IMA and vein grafts, and possibly in the restenosis process after balloon angioplasty in these vessels.

Conventional PTA to LIMA grafts via the femoral artery approach required prolonged bed rest to obtain stable hemostasis and avoid vascular com-plication. High success and low complication rates have been demonstrated in transradial LIMA graft angiography and PTA.[19-21] This may reduce the risk of vascular complication at the LIMA ostium due to the use of a smaller guiding catheter, immediate mobilization and shorter hospitalization. In our small series, the transradial approach was successful in all seven patients, which suggests that LIMA graft PTA is also feasible from a transradial approach.

In conclusion, in the present 13 patients studied, the PTA to LIMA graft appears to be a safe, feasible and beneficial procedure, with success achieved in 12 individuals (92%) and angiographic restenosis in two of ten (20%). A transradial or femoral approach is effective, and transradial cases had less vascular complications. Presence of total or subtotal occlusion and vessel tortuosity are predictors of angioplasty failure and vessel dissection.

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經皮下動脈執行左內乳動脈繞道移植血管成型術：
立即及長期臨床報告

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背　景： 冠狀動脈繞道手術，經常使用左內乳動脈作為移植血管，因此導致此移植血管狹窄
的機會越來越多。

方　法： 回溯整理 13 位左內乳動脈移植血管狹窄的病人，6 位經由股動脈及 7 位經由撓動脈
著手，除了一位合併有內乳動脈幹狹窄，均為吻合處狹窄，分析其臨床的結果。

結　果： 成功率為 92% (12/13)，7 位病人施行單純氣球擴張術，另外 5 位病人施行支架置放
術；有 2 位病人術中發生內乳動脈剝離，1 位病人須加置放支架，另外 1 位病人則延
長氣球充氣的時間；沒有病人於住院中發生死亡、緊急繞道術或標的血管再擴張，1
位病人發生非 Q 波心肌梗塞 (7.7%)；失敗的那 1 位病人於術後 1 個月死亡。有 10 位
病人施行血管攝影追蹤，再狹窄機率為 20% (2/10)，臨床追蹤平均 34.5±20.9 個月，
1 位病人於術後 32 個月死於腦中風併敗血症。

結　論： 我們的病人，不管是經由股動脈或經由撓動脈，施行左內乳動脈繞道移植血管成功
率高及併發症低，長期臨床追蹤結果良好，值得考慮成為開刀手術外的另一選擇。
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關鍵詞： 血管成型術，左內乳動脈繞道移植血管