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Original Article

Left Internal Mammary Artery Versus Reversed Saphenous Vein Graft as Conduit to Left Anterior Descending Artery in South Indian Patients with Coronary Artery Disease Undergoing Coronary Artery Bypass Surgery

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Abstract

Introduction: Coronary artery disease is the most common adult disease, and the most common cause for stable/unstable angina, acute myocardial infarction, ischemic cardiomyopathy with congestive heart failure, and sudden cardiac death. Coronary artery bypass grafting (CABG) remains the most durable revascularization procedure for coronary artery disease.

Materials and Methods: A total of 40 patients of South Indian origin, with uncomplicated coronary artery disease with good LV function (left ventricular ejection fraction [LVEF] (%) 47.77 [4.94]), who were divided into two equal and comparable groups, underwent elective classical CABG in 2009. Group I had left internal mammary artery (LIMA) grafted to left anterior descending (LAD), whereas reversed saphenous vein graft (rSVG) was used in Group II. LAD diameter was 1.486 (0.19) mm. All were ventilated, with minimal inotropic support, when indicated and discharged by 7-10 days. Cardiac enzymes (troponin-T and CKMB) were analyzed 6 and 12 h after surgery and on discharge. In pre- and post-operative angina class, LVEF was assessed by clinical assessment and 2D echocardiography. Follow-up was done clinically by 2D echocardiography at 1 and 3 months.

Results: There were 2 mortalities in each group, due to low cardiac output. Group II had improvement in angina class and New York Heart Association (NYHA) Functional class, in immediate post-operative period, whereas improvement in angina class observed in Group I, during long-term post-operative follow-up. LVEF showed significant improvement Group I 59.4 (3.84) compared to Group II 52.88 (3) at 3 months follow-up. Cardiac enzyme levels were found to be significantly elevated in Group II at the time of discharge.

Conclusion: In this study, we conclude that LIMA is a better conduit than rSVG for LAD in South Indian patients undergoing CABG, in terms of improvement in angina and NYHA functional class, cardiac enzyme status and LVEF, although rSVG may give early improvement of angina class and functional class, due to smaller caliber of native LAD in our patient population.

Key words: Coronary artery disease, Coronary artery bypass grafting, Left internal mammary artery, Reversed saphenous vein graft

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INTRODUCTION

Coronary artery disease is the most common disease encountered in adults. The clinical presentation is as a result of atherosclerotic disease of the coronary arteries and includes syndromes of stable and unstable angina, acute myocardial infarction (MI), ischemic cardiomyopathy

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with congestive heart failure and is the most common cause of sudden cardiac death.[1] Coronary artery bypass grafting (CABG) still remains the most durable means of revascularization in patients of coronary artery disease.[2]

Vineberg used the left internal mammary artery (LIMA) for his eponymous procedure in the 1950s and reports of the LIMA as a direct coronary artery graft appeared in the late 1960s. The following Favoloro's Publication, in 1968, of a series of patients in whom saphenous vein was used as a conduit, veins eclipsed arteries as conduits for coronary artery bypass and the current success of the coronary artery bypass operation was built upon the use of saphenous vein grafts (SVG).[3] The benefits of a LIMA graft to the left anterior descending (LAD) coronary artery were established in 1986.[4]

Different strategies and conduits are available for revascularization of the diseased artery out of which graft to LAD artery has always played a major role in the short- and long-term outcomes of this operation.[3,5]

It has become clear apparent that the long-term patency of vein graft is poor, with consequent recurrent angina and impairment of ventricular function. In spite of its shortcomings, the saphenous vein remains the most commonly used conduits in coronary bypass grafting due to its ease of harvest, ready availability, versatility, resistance to spasm, and thoroughly studied long-term results. Advances in the understanding of the pathological processes and techniques in harvesting SVG have again raised the possibility of using vein graft as more and more complex cases are taken up for CABG where the hemodynamic instability constraints and early revascularization are of paramount importance.[6]

In view of these facts, this study was planned to evaluate the use of reversed saphenous vein graft (rSVG) or LIMA as graft conduit for bypassing LAD artery disease and compare the pre- and post-operative results in using these grafts in terms of improvement in angina and NYHA functional class, LVEF and cardiac enzyme levels, in South Indian patients undergoing CABG for coronary artery disease.

MATERIALS AND METHODS

Our study included 40 patients of South Indian origin, who underwent elective classical CABG for uncomplicated coronary artery disease with good LV function from January to December 2009, after obtaining clearance from institutional Ethics Committee, at Sri Venkateswara Institute of Medical Sciences, Tirupati. The patients were randomized into two equal and comparable groups. In Group I, all 20 patients had LIMA used as conduit for grafting LAD, whereas Group II included 20 patients where rSVG was used for grafting LAD because these patients were hemodynamically not stable at the time of surgery to allow LIMA harvesting.

Exclusion Criteria

The following group of patients will not be included in the study:

- Patients of MI undergoing emergency surgery
- MI or unstable angina pectoris within 2 months before coronary angiography
- Ischemic complications of MI: Acute mitral regurgitation, ventricular septal defect, and left ventricular aneurysm
- Failed (percutaneous transluminal coronary angioplasty)
- Redo CABG
- History of (deep vein thrombosis)
- Associated valvular heart disease
- Diffuse disease of LAD or LAD <1.5 mm
- Sequential grafting of LAD
- Bilateral internal mammary artery grafting.

Pre-operative Canadian Cardiological Society (CCS) angina class, Class II NYHA functional class were noted, and LVEF was assessed by 2D echocardiography. Baseline ECG was also taken for all patients.

In all patients, general anesthesia was induced by midazolam, fentanyl, and propofol. Ventilation was controlled with oxygen and anesthesia maintained by inhalational isoflurane, propofol, and fentanyl. After induction, in Group I, poststernotomy, the LIMA was harvested, where it was decided to use for grafting LAD, using a pedicle technique. Just before dividing LIMA distally systemic heparinization was done at 3 mg/kg. In Group II, saphenous vein was harvested by open dissection started either in the upper thigh, above the knee or at the ankle. Following the vein harvesting, systemic heparinization was done at 3 mg/kg.

All operations were performed under cardiopulmonary bypass with moderate cooling and topical pericardial ice slush. Extracorporeal circulation was initiated with Sarns 9000 heart-lung machine (3M Health Care, Ann Arbor, MI, USA) using Edwards membrane oxygenator. A Sarns aortic cannula and two-stage venous cannula was used to institute coronary bypass. Cold blood cardioplegia was administered after cross clamping aorta. LIMA or rSVG was used as a conduit to bypass LAD, while for other diseased vessels rSVG was used. Once cross clamp was released, patients were gradually weaned off cardiopulmonary bypass (CPB)

and reversal of heparinization was done by full correction with protamine. Pump time and cross clamp time with a diameter of recipient vessel, patency of distal artery with the number of graft used were noted. Postoperatively inotropic support was given and if indicated.

During the immediate post-operative period, the cardiac enzyme (troponin T, CPK-MB) study was done immediately, after 6 and 12 h and at the time of discharge. Troponin T test was considered significant rise and positive if it measured >0.1 ng/ml. CPK-MB was done by qualitative assay using commercial kit in semi auto analyzer Stat fax 3300 (normal <10 IU/L).

Recovery period was closely monitored including morbidity and mortality. In well-recovered patients improvement in pre- and post-angina class and ejection fraction by echocardiography done on Philips IE 33 machine by a single cardiologist was noted at the time of discharge, then on first follow-up after 1 and 3 months of surgery.

All the data were statically evaluated using Microsoft Excel 2007 version. The values are represented as mean Standard deviation and range. Means of continuous variables were compared with paired student's *t*-test. A $P < 0.05$ was considered significant.

RESULTS

The study included 40 patients who underwent classical CABG for uncomplicated coronary artery disease from January 2009 to December 2009, of which 36 (90%) were males and 4 (10%) were females. The age ranged from 42 to 74 years (56.1 [8.91]). 14 were diabetic, 27 were hypertensive and 4 had COPD. Patients were divided into two groups of 20 patients each depending on the conduit used to graft LAD (LIMA or rSVG).

In Group I, 13 had triple vessel disease (TVD), 5 had double vessel disease (DVD) and 2 had single vessel disease (SVD), whereas in Group II, 15 had TVD, 4 had DVD and one had SVD. The CPB time in Group I ranged from 60 to 155 min (113.65 [28.09]) and 90 to 192 min (127.95 [27.2]) in Group II. Aortic cross clamp time ranged from 35 to 108 min (80.45 [24.54]) in Group I and 55 to 145 min (98.85 [19.79]) in Group II. Group I had 3.55 (1.099) mean number of total grafts, whereas Group II had 3.5 (0.68). The LAD diameter (mm) was 1.497 (0.18) in Group I and 1.475 (0.213) in Group I (Table 1). 2 patients had to be re-explored due to bleeding. There were totally 4 mortalities with 2 in each group due to low cardiac output and multiple organ dysfunction syndrome.

In Group I, 4 patients were in NYHA Class I, 10 in Class II, 5 in Class III and 1 in Class IV, preoperatively, with improvement in functional class during post-operative period, with 4 in Class I, 13 in Class II and 1 in Class III at discharge and 10 in Class I and 8 in Class II at 3 months post-operative period. In Group II, 4 patients were in NYHA Class I, 13 in Class II, 2 in Class III and 1 in Class IV, preoperatively, with improvement in functional class during post-operative period, with 6 in Class I, 10 in Class II and 2 in Class III at discharge and 8 in Class I and 12 in Class II at the end of 3 months. There was an early improvement shown in NYHA functional class in Group II but at the end of 3 months, Group I had better functional class.

In Group II, 2 patients were in CCS Angina Class I, 10 in Class II, 6 in Class III and 2 in Class IV, preoperatively, with improvement in angina during post-operative period, with 7 in Class I, 8 in Class II and 3 in class III at discharge and 15 in Class I and 3 in Class II at 3 months post-operative period. In Group II, 1 patients were in CCS Angina Class I, 8 in Class II, 9 in Class III and 1 in Class IV, preoperatively, with improvement in angina during post-operative period, with 12 in Class I, 4 in Class II and 2 in class III at discharge and 12 in Class I and 6 in Class II at the end of 3 months. There was early improvement shown in CCS Angina class in Group II but at the end of 3 months, Group I had significantly better improvement in angina (Table 2).

LVEF improvement was noted in both groups in the long term with a comparable drop in LVEF at discharge. In Group I, LVEF (%) was 48.5 (5.29) preoperatively and 46.6 (2.3) on discharge, and improved to 55.14 (3.53) at

Table 1: Patient demographics, CPB time, cross clamp time, total grafts done and LAD diameter

Demographics	Mean±SD		
Age (years)	56.1 (8.91)		
Sex (male/female)	36/4		
Comorbidities			
DM	14		
Hypertension	27		
COPD	4		
Disease parameters and surgical data	**Group I (LIMA)**	**Group II (rSVG)**	***P* value**
CAD			
TVD	13	15	
DVD	5	4	
SVD	2	1	
CPB time (min)	113.65 (28.09)	127.95 (27.2)	>0.05
Aortic cross clamp time (min)	80.45 (24.54)	98.85 (19.79)	>0.05
Total grafts	3.55 (1.099)	3.5 (0.68)	>0.05
LAD diameter (mm)	1.497 (0.18)	1.475 (0.213)	>0.05

TVD: Triple vessel disease, DVD: Double vessel disease, SVD: Single vessel disease, LAD: Left anterior descending artery, LIMA: Left internal mammary artery, rSVG: Reversed saphenous vein graft, SD: Standard deviation

1 month and 59.4 (3.84) at 3 months post-operative visit. In Group II, LVEF (%) was 47.05 (4.58) preoperatively and 45.36 (3.18) on discharge, and improved to 49.84 (2.85) at 1 month and 52.88 (3) at 3 months post-operative visit (Figure 1).

Cardiac enzyme analysis showed that 1 patient had troponin T positive test in pre-operative period while 3 patients who expired in post-operative period also had positive troponin T test in post-operative period, out of which 2 were in Group I and 1 in Group II. CPK-MB test was <10 IU/L in 14 patients of Group I and in 11 patients of Group II (Table 3).

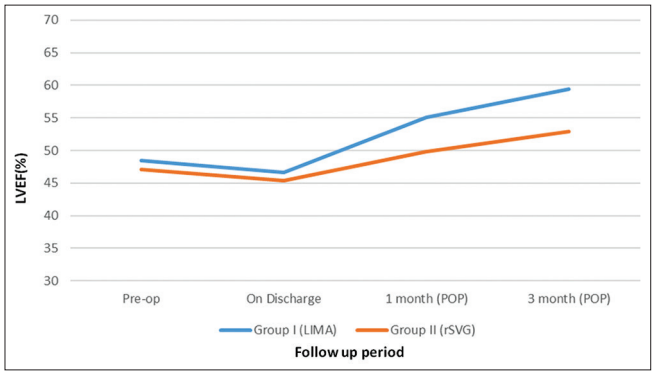

Figure 1: LVEF (%) changes in both groups during pre-operative period, on discharge, 1 and 3 months post-operative period

DISCUSSION

The number of patients undergoing coronary revascularization is rapidly increasing in recent years. Many studies have demonstrated the superiority of the Internal Mammary Artery compared to SVG as bypass graft to LAD artery (LAD).[5-9] The long-term patency of LIMA graft to LAD is exceptional in studies, while SVG occlusion, intimal hyperplasia, and atherosclerosis are inhibiting factors for using SVG for LAD.[10] Internal thoracic artery (LIMA, RIMA) has been proven to be an excellent conduit for use in CABG, favorable performance of LIMA when anastomosed to LAD partly results from endothelium-derived relaxing factor and prostacyclin produced by this artery which may be an important factor in the high patency of internal thoracic artery.[9]

CABG with SVG may result in progression of stenosis of the recipient coronary artery. This is less likely after CABG with internal thoracic artery grafts. This difference may be due to the ability of the pedicled internal thoracic artery graft to regulate flow. Thus, competitive flow in the native coronary artery is minimized.[7,11] Saphenous veins used as conduits has been affected due to early changes in the graft which leads to its failure however it is still the most common conduit for bypassing the diseased artery.[4] Aggressive pharmacologic strategies are being used to maximize early

Table 2: NYHA Functional class and CCS angina class changes in both groups during pre-operative, on discharge 1 and 3 months post-operative period

Parameter	*n*=20		*n*=18			
	Pre-operative		On discharge		3 months post-operative	
	Group I (LIMA)	Group II (rSVG)	Group I (LIMA)	Group II (rSVG)	Group I (LIMA)	Group II (rSVG)
NYHA functional class						
I	4	4	4	6	10	8
II	10	13	13	10	8	10
III	5	2	1	2	0	0
IV	1	1	0	0	0	0
CCS angina class						
I	2	1	7	12	15	12
II	10	8	8	4	3	6
III	6	9	3	2	0	0
IV	2	2	0	0	0	0

LIMA: Left internal mammary artery, rSVG: Reversed saphenous vein graft, NYHA: New York Heart Association, CCS: Canadian cardiological society

Table 3: Patient distribution as per CPK-MB levels - pre-operative, on discharge, 1 and 3 months post-operative period

CPK-MB level	Group I (LIMA)				Group II (rSVG)			
	Pre-operative	On discharge	1 month	3 months	Pre-operative	On discharge	1 month	3 months
<10 IU/L	14	0	0	16	11	0	0	12
10-50 IU/L	6	4	4	2	8	0	1	7
>50 IU/L	0	16	16	-	1	20	18	-

LIMA: Left internal mammary artery, rSVG: Reversed saphenous vein graft

and late venous graft patency. Prospective randomized trials have shown that early aspirin administration reduces vein graft occlusion in the 1st year after CABG.[8] Administration of aspirin within 48 h after CABG also reduces early post-operative complications including mortality, MI, stroke, renal failure, and bowel infarction. More recently, it has been recognized that lipid-lowering agents reduce the progression of native coronary artery and graft atherosclerosis, as well as subsequent cardiovascular events. Aggressive use of statins to achieve a low-density lipoprotein cholesterol <100 mg/dl decreased by one-third the number of grafts affected with atherosclerosis at angiographic follow-up, and also decreased the need for repeat revascularization.[11]

In our study, 40 patients were equally distributed into two groups of LIMA to LAD and SVG to LAD. Singh *et al.*[6] in their study of internal mammary artery versus SVG, LIMA group had 33 patients, while SVG group had 43 patients, with the age group of 39 to 72 years. In our study, the mean range of patients was between 42 and 74 years. Our study showed improvement in NYHA class after 90 days, but significant improvement was seen in CCS-FC, more so in patients were LIMA was used as conduit to bypass LAD. However, Goldman *et al.*[10] did not show significant improvement in CCS-FC between SVG and LIMA graft group but suggested that symptomatic improvement in angina symptoms was seen in those patients who had a wider diameter of recipient vessel at the time of grafting.

In our study 90 days, LV ejection fraction in Group I (LIMA) improved from 48.5 (5.29) to 59(3.84), whereas in Group II (rSVG), it improved from 47.05 (4.58) to 52.88 (3.0). Berger *et al.*[12] study divided the post-operative group into patent and occluded arterial group based on post-operative coronary angiography and could not show significant in improvement in immediate post-operative period. Edwards *et al.*[13] concluded that EF is also an independent factor to predict mortality after CABG and found that LIMA group with EF<50% ejection fraction in pre-operative improved significantly in post-operative period compared to SVG with low ejection fraction.

Evaluation of cardiac enzymes after cardiac surgery was also evaluated in our study which showed rise of CK-MB in all post-operative CABG patients. However, we found that Troponin T test was not positive in all post-operative CABG patients and was more sensitive in predicting fatal outcome after CABG as all patients who expired in our study had positive Troponin T test. This is also confirmed by Costa *et al.*[14] as well as by Januzzi *et al.*[15] in their study of comparison of cardiac Troponin T and Creatine Kinase-MB for patient evaluation after cardiac surgery.

The most common lesion in LIMA group was proximal and mid LAD, while the most common lesion in SVG group was in proximal LAD, which also has an influence on the patency of graft as was suggested by Boylan *et al.*[7] and Edwards *et al.*[13] who stressed the importance of tightness of lesion as well as diameter of grafted vessel as predictor of long-term patency of the graft.

Diabetes, hypertension, and COPD were major comorbid factors in our study which has been also in studies by Goldman *et al.*,[8] Edwards *et al.*,[13] and Boylan *et al.*[7]

We had 10% mortality in LIMA group and 5% mortality in SVG group which is almost similar with other contemporary studies by Boylan *et al.*[7] and Edwards *et al.*[13] However, Boylan had more mortality in SVG group compared to LIMA group but his study did not have any mention about short- and long-term mortality after CABG while in our study mortality was in the immediate post-operative period of CABG, the reason may be due to limited period of our study.

In fact, Edwards *et al.*[13] showed that LIMA patency in post-operative period is an issue for immediate deaths in post CABG patients and is dependent on harvesting techniques, lumen size, post-operative hemodynamic, and use of inotrope.

All the studies which used either LIMA to LAD or SVG to LAD found more long-term benefit using LIMA graft.[7-10,12,13] In our study, we also found strong indication of using LIMA to LAD due to improvement in angina class and LV function, but the final confirmation is possible only after direct visualization by angiography to see patency of either LIMA or SVG grafts, this has been a limitation in our study as no patient underwent post CABG coronary angiography.

We conclude that, whenever possible LIMA should be used as a bypass conduit in LAD lesion due to its long-term benefits in improving the symptoms as well as LV function, however meticulous harvesting techniques, good anastomosis, wide recipient coronary artery and proper hemodynamic management can make it the best bypass conduit in the patients of LAD disease undergoing CABG.

Our study had several limitations and shortcomings including small study population, shorter period of follow-up, and inability to demonstrate long-term graft patency by coronary angiography.

CONCLUSION

In this study, we conclude that LIMA is a better conduit than rSVG for LAD in South Indian patients undergoing

CABG, in the long term, in terms of improvement in angina and NYHA functional class, cardiac enzyme status and LVEF, although rSVG may give early improvement of angina class and functional class, due to smaller caliber of native LAD in our patient population. Hence, we stress on the meticulous harvesting of LIMA and its usage in LADs which are at least more than 1.25 mm in diameter.

Clinical outcome of the study is comparable with the contemporary literature which also recommends the LIMA as first and best option and SVG as the next best option for LAD, and we also suggest the same options for South Indian patients undergoing CABG.

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