

## OUTCOME OF LONG SEGMENTAL RECONSTRUCTION (LSR), OF THE LEFT ANTERIOR DESCENDING ARTERY (LAD) WITH THE LEFT INTERNAL MAMMARY ARTERY (LIMA), IN PATIENTS UNDERGOING CORONARY ARTERY BYPASS GRAFT (CABG) SURGERY FOR DIFFUSE CORONARY ARTERY DISEASE (CAD) AFFECTING THE LAD

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### ABSTRACT

**Objective:** To determine the outcome of long segmental reconstruction (LSR), of the Left Anterior Descending Artery (LAD) with the Left Internal Mammary Artery (LIMA), in patients undergoing Coronary Artery Bypass Graft (CABG) surgery for diffuse Coronary Artery Disease (CAD) affecting the LAD.

**Study Design:** Descriptive cross-sectional study.

**Place and Duration of Study:** Department of Adult Cardiac Surgery, Armed Forces Institute of Cardiology & National Institute of Heart Diseases (AFIC/NIHD), Rawalpindi, from Sep 2011 to Jun 2017.

**Methodology:** The study included all patients with diffuse CAD affecting the LAD, in whom conventional bypass grafting of the LAD was not possible. The long LAD reconstruction was avoided in those showing severe calcification of the atheroma or a long segmental stenosis with a lumen of less than 0.5mm on preoperative angiography. Patients having severe multi-organ dysfunction, significant valvular pathology and predominantly non viable myocardium in the LAD territory were also excluded. Patients were followed up for mean period of 24 months for evaluation of early mortality and morbidity, angina status and survival.

**Results:** Fifty-eight consecutive cases of LSR of the LAD were evaluated. The mean length of the LSR was 4.88 + 1.4cm (range 2.5 to 7.5cm). Seven (12.07%) had critical left main stem stenosis, 11 (18.97%) presented with unstable angina, 2 (3.45%) underwent emergency bypass graft surgery for post infarction angina, 17 (29.31%) had myocardial infarction (MI) in the past. There were 2 (3.45%) early deaths and 2 (3.45%) cases of non-fatal MI. At 24 months follow-up there were no late deaths; there was 1 (1.79%) case of late MI whereas 52 of the survivors (92.86%) had no angina; three (5.36%) had angina CCS I and 1 (1.79%) had angina CCS II.

**Conclusion:** LSR of the diffusely diseased LAD with LIMA onlay patch grafting had acceptable operative risks and satisfactory results at 24 months in terms of mortality and relief from angina.

**Keywords:** Angina, Diffuse coronary artery disease, Left anterior descending artery, Long segmental reconstruction, Mortality, Outcome.

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### INTRODUCTION

The past 2 decades has seen a phenomenal increase in the number of percutaneous coronary interventions (PCIs), worldwide. Presently, a significant proportion of cardiac surgical referrals comprises of diffuse coronary artery disease (CAD) where conventional coronary artery bypass grafting (CABG) is not possible. Medical management of diffuse CAD, affecting the LAD in particular, is associated with high mortality

within 1 year of diagnosis,<sup>1</sup> and incomplete revascularization with residual stenosis is a strong predictor of early death after CABG surgery<sup>2-4</sup>.

The technique of long segmental reconstruction (LSR) involving a long arteriotomy of the diffusely atheromatous coronary artery and its reconstruction with the left internal mammary artery (LIMA) is an endeavour to achieve complete revascularization in patients with diffuse CAD. The prime advantage of this method is that it combines the preservation of the intima of the native coronary artery with the utilization of the left internal mammary artery (LIMA) to recon-

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struct the coronary artery in a manner that leaves the bulk of the plaque outside the lumen of the newly constructed vessel.

## METHODOLOGY

The descriptive study was conducted at the Armed Forces Institute of Cardiology and National Institute of Heart Diseases (AFIC/NIHD), Rawalpindi, from September 2011 to June 2017. Fifty-eight patients with diffuse atheromatous disease of the LAD underwent LSR measuring 2.5 cm or longer, by the same surgeon, in order to ensure uniformity of the procedure. Conventional grafting with the great saphenous vein was utilized to revascularize the circumflex and the right coronary artery (RCA).

Excluded from the study were patients with severe multi-organ dysfunction, reoperations, those having predominantly nonviable antero-septal myocardium, patients who required coronary endarterectomy (CE) or surgery for associated valvular or left ventricular (LV) aneurysmal disease.

Patient demographics are shown in table-I.

Patients were counseled about the LSR or possible CE of the LAD and informed consent obtained.

The decision to perform LSR was generally made preoperatively when the coronary angiogram showed diffuse stenotic lesions in the LAD. Presence of calcification or segments with either complete occlusion or diameter smaller than 1 mm would prompt us to plan endarterectomy rather than LSR. However, the final decision was often an intra-operative one, after physically assessing the nature of the plaque.

All procedures were performed using cardio pulmonary bypass and moderate hypothermia. Intermittent ante grade and retrograde tepid blood cardioplegia was used for myocardial protection. After bypassing the stenosis in the circumflex and right coronary artery territories the LAD was exposed for anastomosis. The extent of the longitudinal arteriotomy incision in the LAD, already determined preoperatively, was

confirmed intra-operatively, using the site of distinctive bends and diagonal branches along the LAD as landmarks. The incision in the LAD was extended distally across all the stenotic plaques until the disease-free distal segment was reached. At times this would be confirmed by calibrating the coronary lumen with a coronary probe. The proximal extent of the arteriotomy was downstream to a critical stenosis. The mean length of the arteriotomy was  $4.88 \pm 1.4$  cm (range 2.5-7.5 cm). The pedicled LIMA was then incised to match the length of the LAD arteriotomy and anastomosed as an onlay graft using 7-0 polypropylene suture in a continuous over-and-over fashion. Fibrous or mildly calcific plaques confined to the roof of the LAD were trimmed with Potts scissors to lay open the coronary artery.

Asprin 300 mg was given orally or via nasogastric tube within 6 hours of arrival in the postoperative intensive-care unit and then 100 mg per day continued indefinitely.

The data was gathered and analyzed prospectively. This included patient-demographics, operative data, early mortality and morbidity, as well as clinical outcome such as death, MI, anginal status, medications and re-admissions over a follow-up period of 24 months. Early mortality and peri operative MI was defined as death and MI within 30 days of surgery while late mortality, MI and recurrent angina were the noted events at 24 months follow-up.

Continuous variables were documented as mean  $\pm$  standard deviation or median, while categorical variables were presented as percentages. SPSS version 23 was used for statistical analysis.

## RESULTS

The cross-clamp time was on average 35 minutes longer than in conventional CABG surgery. All LAD reconstructions were done using the LIMA, and saphenous vein grafts were anastomosed to the other diseased coronaries. IABP was inserted in 7 (12.07%), and 28 patients (48.28%) required inotropic support in the early postoperative period for haemodynamic support.

Intra- and post-operative data are shown in table-II & III, respectively.

There were 2 (3.45%) early deaths. Both were females with diabetes. One patient had a pre-operative

**Table-I: Demographic characteristics of patient.**

Characteristics	Frequency (%)
Age	
Mean	59.38
Range	42-73
Gender	
Male	46 (79.31)
Female	12 (20.69)
Hypertension	42 (72.41)
Diabetes Mellitus	39 (67.24)
Dyslipidemia	23 (39.65)
Smoking	21 (36.21)
Previous MI	17 (29.31)
History of CCF	4 (6.9)
Unstable Angina	11 (18.96)
Emergency CABG	2 (3.45)
Left Main stem disease	7 (12.07)
LVEF <35%	6 (10.34)

**Table-II: Intra-Operative variables.**

Characteristics	Frequency (%)	Mean $\pm$ SD
Cross-Clamp time (min)		74.1 $\pm$ 18.3
No. of Distal Anastomoses		
2	3 (5.2%)	
3	32 (55.2%)	
4	21 (36.2%)	
5	2 (3.4%)	
Length of LAD Reconstruction (cm)		4.88 $\pm$ 1.40

operative LVEF of 30% and underwent emergency surgery with an IABP for post-infarction angina. She could not be weaned from bypass due to intractable ventricular dysrhythmias. The other patient developed multi-organ dysfunction and sepsis, and died 8 days later. Two patients (3.45%) suffered non-fatal peri-operative MI; one had an anteroseptal infarct and the other had an inferior infarct. Three (5.17%) had transient atrial fibrillation and 4 (6.90%) had premature ventricular contractions for 2 to 3 days after surgery. Three patients (5.17%) underwent mediastinal re-exploration for increased bleeding and 4 (6.90%)

required prolonged ventilatory support for more than 48 hours. The median post-operative ICU stay was 23 hours. Three patients (5.17%) had superficial sternal wound infection.

**Table-III: Post-operative data.**

Characteristics	Frequency (%) (n=58)	Mean $\pm$ SD /Median
Early ICU Stay (Hrs)		Median: 23
Mean Hospital Stay (days)		6.75 $\pm$ 1.806
Early death	2 (3.45%)	
Non-fatal peri-operative MI	2 (3.45%)	
New onset atrial fibrillation	3 (5.17%)	
Ventricular dysrhythmias	4 (6.90%)	
Mechanical ventilation >48 hrs	4 (6.90%)	
Resternotomy for bleeding	3 (5.17%)	
Stroke	Nil	
Sternal wound infection	3 (5.17%)	
<b>At 24 Months</b>		
Death	Nil	
MI	1 (1.79%)	
<b>Angina</b>		
CCS I	3 (5.36%)	
CCS II	1 (1.79%)	

All patients were followed up for a mean period of 24 months. They were contacted by telephone and enquired about symptoms, functional status including ability to work, offer regular prayers, and carry out the routine choruses expected of their respective age groups. They were asked to report in the out-patient department at regular intervals for review of symptoms and medication, clinical examination, and relevant investigations. Amongst those who were offering regular prayers at neighborhood mosques before surgery, we have recognized the importance of the ability to continue with the same as an important yardstick of their functional status, after surgery.

At 24-months, there was no late mortality. One, 68-year-old male patient (1.79%) was admitted for anteroseptal MI, 19 months after surgery. His coronary angiogram revealed stenosis beyond the toe of the LSR with a patent LIMA and a 4cm LSR. PCI of the native LAD was done. Three patients (5.36%) reported with angina CCS I. They declined graft-studies due to the mild nature of symptoms. One patient (1.79%) had angina CCS II and underwent PCI to the distal RCA.

## DISCUSSION

LSR of the LAD is done in a subset of patients with severe atheromatous CAD in whom conventional anastomosis of conduit to coronary artery is not possible. Due to this reason we have not attempted to compare our results with those of conventional CABG involving discrete coronary stenoses. We further maintain that CE addresses an even more aggressive form of CAD and entails removal of coronary endothelium as an adjunct complication of plaque extraction. This potentially increases the risk of early graft failure as a result of increased thrombogenicity and the development of intimal flaps<sup>5,6</sup> as well as late graft closure due to intimal proliferation<sup>7,8</sup>. Although excellent results of CE have been quoted<sup>9-13</sup> we believe that the all-important septal and diagonal branches of the LAD are better preserved with LSR than with CE which further improves graft longevity due to better run-off through these branches.

Our technique of "trimming back" the fibrous and even moderately calcific plaque in the roof of the LAD improves visualization of the septal and diagonal branches allowing accurate placement of sutures through the coronary wall avoiding damage to these structures. This also enables the bulk of the plaque to be left outside the lumen of the newly constructed LAD under direct vision and ensures uniform placement of sutures in the same plane resulting in consistent tension across the roof of the reconstructed LAD that comprises of the thin and supple LIMA. We have found that this technique prevents the formation of constricting bands

across the width of the LIMA which may contribute to turbulence in the flow. It has also enabled us to perform LSR in some of those patients who would have otherwise been candidates for CE in the earlier part of our surgical practice.

However, CE is still done when the calcification is dense and circumferential or the plaque so soft or ulcerated that suturing might cause embolization of plaque debris. We have noticed that bigger plaques, particularly ones extending to the floor of the coronary are exteriorized with difficulty, using the over-and-over suturing technique, even if the needle is passed through the floor of the coronary artery. A look into the lumen reveals a long queue of vertical segments of suture hugging the plaque in the side walls of the reconstructed vessel. It is in such cases that Barra's U-shaped suturing might provide better cosmetic and hemodynamic results. We tend to perform CE in arteries with a heavy plaque burden in the side-walls and the floor.

The use of LIMA, with its intrinsic advantages of freedom from atherosclerosis<sup>14</sup>, remodeling according to the distal run-off<sup>15</sup>, and the release of endothelial vasodilators improves graft patency and slows progression of the atheromatous process in the native coronary<sup>16,17</sup>. The exteriorization of the major bulk of the plaque has been shown to significantly decrease the incidence of neointimal proliferation<sup>18,19</sup>. More than 2/3<sup>rd</sup> of the circumference of the reconstructed LAD is composed of the LIMA and the rest is made up of the floor of the native LAD. The lumen of this reconstructed segment closely approximates that of the LIMA and the native LAD, allowing better flow patterns<sup>15,20,21</sup>.

The incidence of early death is 3.45% in our study. This is in comparison to 0.5% quoted by Fukui *et al*<sup>6</sup>, 0.9% by Prabhu *et al*<sup>22</sup>, 1.3% by Kato *et al*<sup>23</sup>, 1.9% by Ogus *et al*<sup>19</sup>, 3.7% by Barra *et al*<sup>18</sup>, and 5.1% by Tasdemir *et al*<sup>24</sup>. The occurrence of peri-operative MI in this study was 5.1% in comparison to 2.7% reported by Fukui *et al*<sup>6</sup>, 6.7% by Kato *et al*<sup>23</sup>, 6.9% by Ogus *et al*<sup>19</sup>, 6.3% by Barra *et al*<sup>18</sup> and 10.1% by Tasdemir *et al*<sup>24</sup>.

One limitation of this study is the lack of long-term follow-up; however our mid-term results at 24 months are quite encouraging, with no mortality, 1 case (1.79%) of late MI and 92.86% of survivors being free from angina. These outcomes compare favorably with those quoted in contemporary literature<sup>6,18,19,23</sup>.

Another limitation is the absence of post-operative angiography to confirm native vessel and graft patency. The main reason for this was the absence of symptoms, significant enough, to prompt the patients to volunteer for elective coronary angiography. However, studies<sup>19,23,25</sup> that included coronary angiography as part of their routine post-operative assessment, have reported encouraging mid- and long-term results.

## CONCLUSION

This study suggests that LSR of the LAD is a safe and effective technique to accomplish complete coronary revascularization in patients suffering from diffuse coronary artery disease where conventional coronary artery bypass grafting is not possible. The immediate post-operative as well as mid-term results at 2 years compare favorably with international data.

## CONFLICT OF INTEREST

This study has no conflict of interest to be declared by any author.

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