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Clinical outcome of reconstructing diffusely diseased left anterior descending artery with and without endarterectomy

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Abstract

Cardiac surgeons and interventional cardiologists continue to face difficulties while treating the diffusely damaged left anterior descending coronary artery (LAD). This study was performed to determine whether reconstructing diffusely diseased left anterior descending artery with endarterectomy or without endarterectomy to improve outcome and quality of life and to decrease morbidity and mortality. This an observational clinical study included with 100 patients who had coronary artery bypass grafting surgery. The patients were equally into group (A) had LAD artery reconstruction with endarterectomy; group (B) had LAD artery reconstruction without endarterectomy. The need for inotropes was more frequent among group A (with endarterectomy). Hospital stay was statistically significant higher among group A. Mortality was higher among group A. All mortality cases were due to cardiac cause except for 1 patient in group B (without endarterectomy) who died due to extensive cerebral ischemic stroke. There was no statistically significant difference between the two groups in EF (%) and incidences of pericardial effusion. Ventilation time and ICU stay were statistically significant higher among group A. Dyspnea were statistically significant reduced in the 6 months follow up in each group. There was no statistically significant difference between change in EF (%), LVEDD and LVESD in both groups. Only SWMA showed statistical significant more improvement in without endarterectomy group (B). Extensive reconstruction of the diffusely diseased LAD using a constructive procedure with or without endarterectomy can be performed safely and is a useful option for revascularization of the diffusely diseased coronary artery.

Keywords: Diseased Left Anterior Descending artery, Endarterectomy, bypass grafting surgery.

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1. Introduction

It is difficult to manage diffuse coronary artery disease (CAD) surgically. When treating diffuse CAD, routine coronary artery bypass graft (CABG) surgery carries a substantial risk of early graft occlusion because of limited distal flow and partial revascularization [1]. In diffuse disease, some writers propose that the best way to re-vascularize the complete left anterior descending coronary artery (LAD) system is to adopt the numerous successive anastomoses, or "bridging" technique [2]. It has been suggested for over a century that myocardial revascularization with coronary venous grafting may be a viable treatment option for diffuse coronary artery disease [3]. A persistent problem with CABG in widespread coronary heart disease is the absence of appropriate vascular targets. Achieving total revascularization of the damaged coronary arteries is the main objective of CABG. The most significant vessel is the LAD in particular, and inadequate revascularization of the LAD has been shown to be associated with a higher risk of death following CABG [4,5]. The most significant predictors of survival following CABG, according to the researchers, were remaining lesions of the circumflex or LAD arteries [3,5]. The diffuse distal coronary artery has been shown by others to be a highly effective independent predictor of death [6,7]. In the case of severe coronary lesions, surgical revascularization can be effectively supplemented by coronary endarterectomy and patch angioplasty for LAD rebuilding. extensive rebuilding of LAD (≥4 cm) reproducible methods include the use of an internal thoracic artery (ITA) graft in conjunction with or without endarterectomy [8]. When the LAD had a long hard fibrous plaque, a long soft plaque, and a badly calcified plaque, some authors conducted endarterectomy. Because there is less endothelium in the early phases and more myofibrointimal growth in the later stages, endarterectomy has the drawback of initiating the coagulation cascade. Therefore, for carefully chosen patients with diffuse atherosclerotic disease in the LAD, endarterectomy and patch angioplasty are useful techniques to achieve total revascularization. When the entire atherosclerotic plaque is

removed during an endarterectomy, as opposed to patch angioplasty, the long-term survival and short-term results are comparable, and there is a considerable decrease in the requirement for future procedures [8,9]. Revascularization surgery for CAD patients with diffusely damaged LAD presents a challenging surgical case. While some surgical centres favour LAD reconstruction without endarterectomy, others prefer LAD reconstruction with endarterectomy either through long-term direct LITA-to-LAD grafting or through LITA graft to on-lay saphenous vein graft-patch. Choosing any method is still debatable and depends on a number of criteria [10,11]. Therefore, this study aimed to determine whether reconstructing diffusely diseased left anterior descending artery with endarterectomy or without endarterectomy is preferable during coronary artery bypass grafting surgery to improve outcome and quality of life and to decrease morbidity and mortality.

2. Patients and Methods

This study included an observational prospective comparative clinical study included patients who had coronary artery bypass grafting surgery and their coronary angiography showing diffusely diseased left anterior descending artery attending our clinic in Suez Canal University hospital and Cardiac Surgery Department at Nasir Institute in the period between March, 2021 and February, 2022.

2.1. Inclusion criteria

Patients in the age range of 18 to 65. Both genders are involved. A diffusely diseased left anterior descending coronary artery is seen by a coronary angiography, with segments of an apparently normal but likely diseased channel between areas of substantial stenosis {≥70% narrowing} in the same artery.

2.2. Exclusion criteria

Echocardiography showing left ventricular ejection fraction <40% or loss of myocardial viability even after stress ECHO. Redo cardiac surgery. Emergency CABG surgery. Associated valvular heart surgery. Patients with liver, renal, or multi-organ failure were excluded.

2.3. Sample size

Sample size was estimated according to certain equations:

$N= 2 (Z_\alpha + Z_\beta)^2 \text{ X } P^- Q$

(Where: N = sample size; Zα = the value of standard normal distribution for type I error probability for sided test and equals 1.96; Zβ = the value of standard normal for desired statistical power 80% and equals 0.84; P- = prevalence of diffusely diseased LAD; Q-= 1- P-).

So, according to the calculation the sample size was 100 cases. These 100 patients were divided into two groups:

Group A: 50 patients who had LAD artery reconstruction with endarterectomy.

Group B: 50 patients who had LAD artery reconstruction without endarterectomy.

2.4. Ethical Consideration

An approval of the study was obtained from Suez Canal University Academic and Ethical Committee (IRB #4432/2021). Written informed consent of all the participants was obtained. This work has been completed in compliance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

2.5. Preoperative evaluations

Full history taking, complete clinical examination, laboratory and radiological investigations were performed. Dobutamine stress echocardiography was done for patients with kinetic segments to assess its viability. Coronary angiography was done for each patient. The number of diseased vessels and site of lesions were estimated.

2.6. Intra-operative procedures

The intraoperative anaesthetic technique was the same for all patients and consists of Fentanyl 5-10 µg/Kg and endotracheal intubation was facilitated. Anesthesia in all patients was maintained with inhalation Isuflorane 0.5-1.0%. Cardioplegia was infused into the ascending aorta with a pressure of 200 mmHg. Induced cardiac arrest was usually achieved within one minute. Surgical technique was done using dissection was carried out in this manner along the entire course of the artery. After identification of the Great saphenous vein; preparation of the internal thoracic artery for distal anastomoses was then performed, before initiation of cardiopulmonary bypass. According to the decision for each case, with the reconstruction of the diffusely diseased LAD artery with or without endarterectomy performed last to avoid tension and potential injury.

For the diffusely diseased LAD artery:

- In group (A): Using a spatula and tiny forceps, the adventitia were separated to reveal the atheromatous core. In order to avoid competitive flow through the native coronary artery, the proximal end of the endarterectomy was placed distant to the most proximal lesion. The non-diseased segment was included in the distal incision, and the endarterectomized LAD will be rebuilt either by venous patch angioplasty followed by LIMA anastomosis on the patch, or by direct anastomosis of the left internal mammary artery (LIMA).
- In group (B): With the non-diseased LAD segment, an extended arteriotomy was performed, removing all significant plaques from the neo-coronary lumen and leaving all patent perforators and diagonals in the reconstructed coronary. Just distal to the closest critical lesion, angioplasty was terminated in order to avoid competing flow. Left internal mammary artery (LIMA) direct anastomosis, or venous patch angioplasty followed by LIMA anastomosed on the patch excluding the atheromatous plaques from the lumen of the LAD, was used to reconstruct the diffusely diseased LAD. At the conclusion of the procedure, 75% of the newly formed LAD originated from the LIMA and 25% from the native artery floor.

The Immediate Anticoagulation regimen to surgery in patients with LAD reconstruction with endarterectomy including heparin (LMWH) was used in the first two days post-operative and dual antiplatelet therapy (DAPT). Warfarin was added to group (A) patients (with endarterectomy) according to surgeon's preference.

2.7. Statistical analysis

Windows 10 was used to conduct the data analysis using IBM SPSS Statistics® 22. For continuous parametric variables, the descriptive data were expressed as mean ± standard deviation; for categorical and dichotomous variables, the expressions were count/total and percentages (%). Fisher's Exact test, Chi square test, and independent t-test were employed. A P value is deemed significant when it is less than 0.05.

3. Results

The current study showed No statistical significant differences between the study groups regarding age, sex, and dyspnea **(Table 1)**. Concerning postoperative ICU course; IABP was more frequent among with endarterectomy (group A). Arrhythmias and signs suggestive of PMI showed no statistically significant difference between the two groups. Ventilation time and ICU stay were statistically significant higher among group A (with endarterectomy) **(Table 2)**. The differences were statistically significant in inotropes **(Figure 1)**. Wound infection and stroke were more frequent among group B without endarterectomy, mortality was more frequent among group A with endarterectomy but with no statistically significant difference. Hospital stay was statistically significant longer among with endarterectomy group A. Wound infection was of superficial type in all patients with wound infection. Stroke was of ischemic type in all patients with stroke. All mortality cases were due to cardiac cause except for 1 patient in the without endarterectomy group who died due to extensive ischemic stroke **(Table 3)**. There was no statistically significant difference between the two groups in EF (%) and incidences of pericardial effusion at time of discharge **(Figure 2)**. Among those who survived, In the 6 months follow up postoperative the presence of angina and dyspnea, EF (%), LVEDD, LVESD, and SWMA showed no statistically significant difference between the two groups **(Table 4, Figure 3)**. EF (%) was higher, LVEDD and LVESD were less, and SWMA was less in the 6 months follow up Echo among both groups but with no statistical significance. There was no statistically significant difference between change in EF (%), LVEDD and LVESD in both groups. Only SWMA showed statistical significant more improvement in without endarterectomy group **(Table 5)**.

4. Discussion

A diffusely damaged left anterior descending coronary artery (LAD) precludes full revascularization following coronary artery bypass grafting, which may result in a poor prognosis. One approach of revascularization for treating diffusely damaged coronary arteries is long segmental repair, which can be performed with or without endarterectomy [2,6]. Multiple drug-eluting stent implantations have been carried out in various institutions to treat coronary arteries that are diffusely damaged [8,9]. Nevertheless, there is a chance that stent insertion could hinder the flow to the side branches and cause in-stent restenosis. Surgeons have developed and used the long-patch reconstruction of the LAD approach, either with or without endarterectomy, to get around these challenges, and they have produced results that are both clinically and angiographically practical [12]. We designed this prospective study to determine whether reconstructing a diffusely diseased left anterior descending artery with endarterectomy or without endarterectomy is going to improve outcomes and decrease morbidity and mortality. We aimed to compare the postoperative outcomes of surgical reconstruction of extensively diseased LAD with and without endarterectomy. In our patients, regarding morbidity and mortality, mortality was higher among group A (With endarterectomy) but without statistically significant difference (8% in group A & 4% in group B). Superficial Wound infection and ischemic stroke were more frequent among group B (Without endarterectomy) but with no statistical significance. All mortality cases were due to cardiac cause except for 1 patient in group B (without endarterectomy) who died due to extensive cerebral ischemic stroke. Incomplete endarterectomy has been associated to poor results, and reconstruction of the LAD with endarterectomy may cause intimal disruption and influence the results of surgery [10].

A previous study **Takanashi et al.** [13] revealed that medical records of 148 individuals who used the in situ LITA during a LAD endarterectomy. A lengthy segmental incision of the LAD was made during the direct endarterectomy, and the reconstruction was made using the longitudinally incised LITA. Acceptable mortality, morbidity, and angiographic patency are linked to coronary endarterectomy of the LAD with a patch plasty utilising the LITA. Mortality occurred in six patients in group 1 (4.4%) and 5 patients in group 2 (n= 3.7%). Blood transfusion was significantly higher in group 2, and one patient had pancreatitis in group 1. One patient had a stroke in group 2 (0.7%), and two patients had delayed recovery in each group (P> 0.99). One patient in group 2 had postoperative MI (0.7%). After matching, there was no significant difference in the outcomes between both groups (Table 3). Mortality occurred in six patients in group 1 (4.4%) and 5 patients in group 2 (n= 3.7%). Blood transfusion was significantly higher in group 2, and one patient had pancreatitis in group 1. One patient had a stroke in group 2 (0.7%), and two patients had delayed recovery in each group (P> 0.99). One patient in group 2 had postoperative MI (0.7%). After matching, there was no significant difference in the outcomes between both groups (Table 3). Mortality occurred in six patients in group 1 (4.4%) and 5 patients in group 2 (n= 3.7%). Blood transfusion was significantly higher in group 2, and one patient had pancreatitis in group 1. One patient had a stroke in group 2 (0.7%), and two patients had delayed recovery in each group (P> 0.99). One patient in group 2 had postopera-
tive MI (0.7%). After matching, there was no significant difference in the outcomes between both groups (Table 3). An earlier study **Fayad and Amr** [14] demonstrated that six patients in group 1 (4.4%) and five patients in group 2 (n = 3.7%) experienced mortality. Group 2 had substantially more blood transfusions, whereas group 1 had a patient with pancreatitis. Two patients in each group experienced a delayed recovery (P > 0.99), and one patient in group 2 suffered a stroke (0.7%). Postoperative MI affected one patient (0.7%) in group 2.

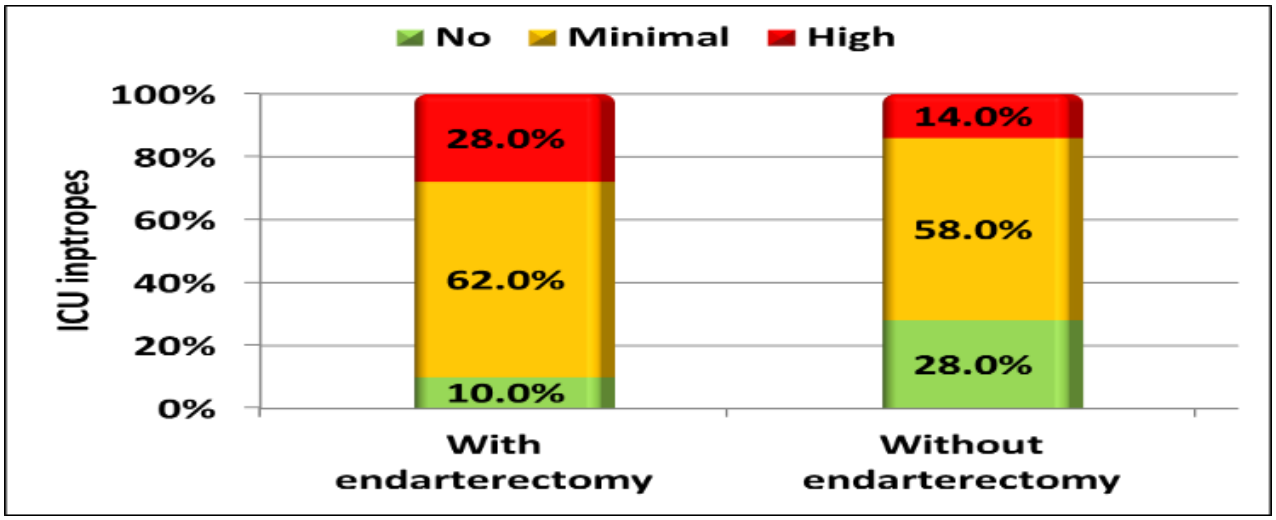

Figure 1: ICU inotropes between the study groups.

Table 1: Demographic and clinical characteristics among the studied patients

Variables		Group (A)With endarterectomy (Total=50)	Group (B) Without endarterectomy (Total=50)	p-value
Age (years)	**Mean±SD**	**58.2±4.1**	**56.9±3.8**	**^ 0.960**
	Range	**42.0–65.0**	**44.0–65.0**	
Sex (n %)	**Male**	**45 (90.0%)**	**41 (82.0%)**	**# 0.249**
	Female	**5 (10.0%)**	**9 (18.0%)**	
Dyspnea	**Class I**	**2 (4.0%)**	**7 (14.0%)**	**§ 0.343**
	Class II	**31 (62.0%)**	**26 (52.0%)**	
	Class III	**17 (34.0%)**	**17 (34.0%)**	
	Class IV	**0 (0.0%)**	**0 (0.0%)**	

^ Independent t-test. # Chi square test. § Fisher's Exact test.

Table 2: Postoperative ICU course between the study groups

Variables		Group A--With endarterectomy (Total=50)	Group B-Without endarterectomy (Total=50)	p-value
Ventilation time (hours)	**Mean±SD**	31.2±25.5	20.3±19.2	**^ 0.018***
	Range	7.0–105.0	6.0–95.0	
Need for IABP		4 (8.0%)	1 (2.0%)	§ 0.362
Arrhy smias	**Any type**	18 (36.0%)	16 (32.0%)	673# 0.
	Supraventricular	14 (28.0%)	15 (30.0%)	826# 0.
	Ventricular	4 (8.0%)	1 (2.0%)	§ 0.362
PMI	**Total patients**	7 (14.0%)	4 (8.0%)	# 0.831
	CE	7 (14.0%)	4 (8.0%)	# 0.831
	ECG	5 (10.0%)	1 (2.0%)	# 0.547
	Echo	4 (8.0%)	1 (2.0%)	§ 0.679
ICU stay (days)	**Mean±SD**	4.4±1.7	3.4±1.6	**^ 0.002***
	Range	2.0–9.0	1.5–9.0	

*Data presented as n (%) unless mentioned otherwise. ^ Independent t-test. # Chi square test. § Fisher's Exact test. *Significant. N.B: Multiple pictures suggestive of PMI may be having been present in the same patient.*

Table 3: Early postoperative morbidity and mortality between the study groups

Variables		Group A--With endarterectomy (Total=50)	Group B-Without endarterectomy (Total=50)	p-value
Wound infection		4 (8.0%)	5 (10.0%)	§ 0.999
Stroke		1 (2.0%)	3 (6.0%)	§ 0.617
Mortality		4 (8.0%)	2 (4.0%)	§ 0.679
Hospital stay (days)	**Mean±SD**	10.5±3.4	8.1±3.9	^ **<0.001***
	Range	5.0–22.0	4.0–24.0	

*Data presented as n (%) unless mentioned otherwise. ^Independent t-test. §Fisher's Exact test. *Significant*

Table 4: Follow up after 6 months findings between the study groups

Variables		Group (A)With endarterectomy (Total=46)	Group (B)Without endarterectomy (Total=48)	p-value
Angina (Class I)		4 (8.7%)	1 (2.1%)	§ 0.199
EF (%)	**Mean±SD**	52.4±4.8	53.3±4.1	^ 0.320
	Range	42.0–62.0	43.0–62.0	
LVEDD (cm)	**Mean±SD**	5.7±0.5	5.6±0.6	^ 0.234
	Range	4.7–6.6	4.2–6.7	
LVESD (cm)	**Mean±SD**	4.2±0.5	4.0±0.6	^ 0.160
	Range	3.0–5.1	2.6–5.2	
SWMA	**Normokinetic**	38 (82.6%)	42 (87.5%)	# 0.485
	Hypokinetic	8 (17.4%)	6 (12.5%)	

CP: Cardiopulmonary. Data presented as n (%) unless mentioned otherwise. ^Independent t-test. #Chi square test. §Fisher's Exact test.

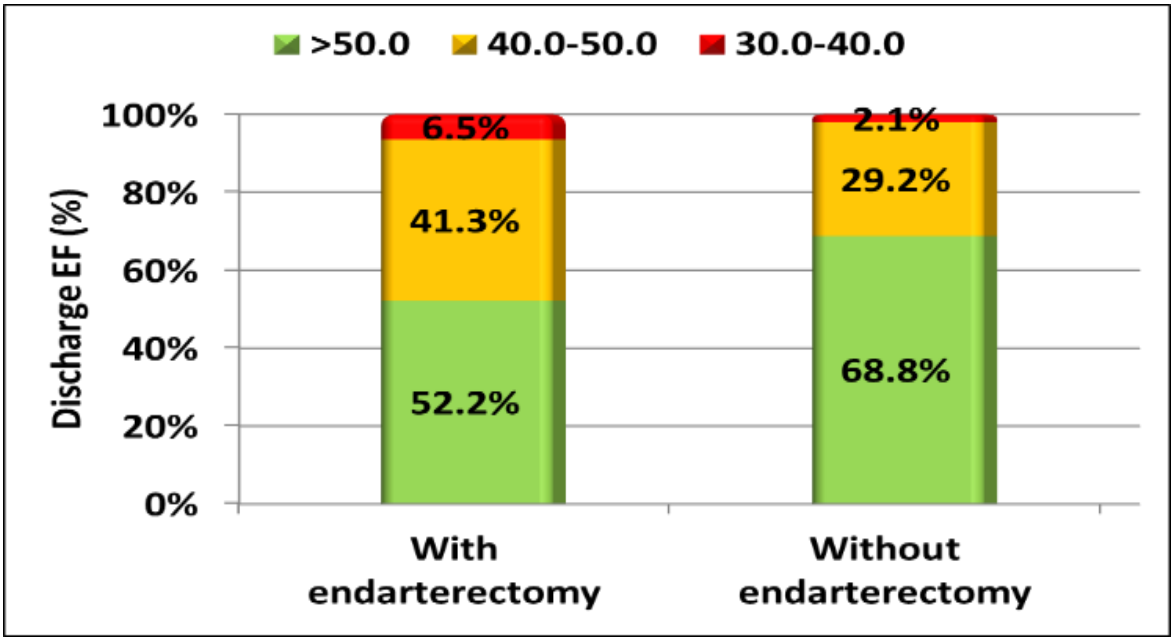

Figure 2: Discharge EF between the study groups

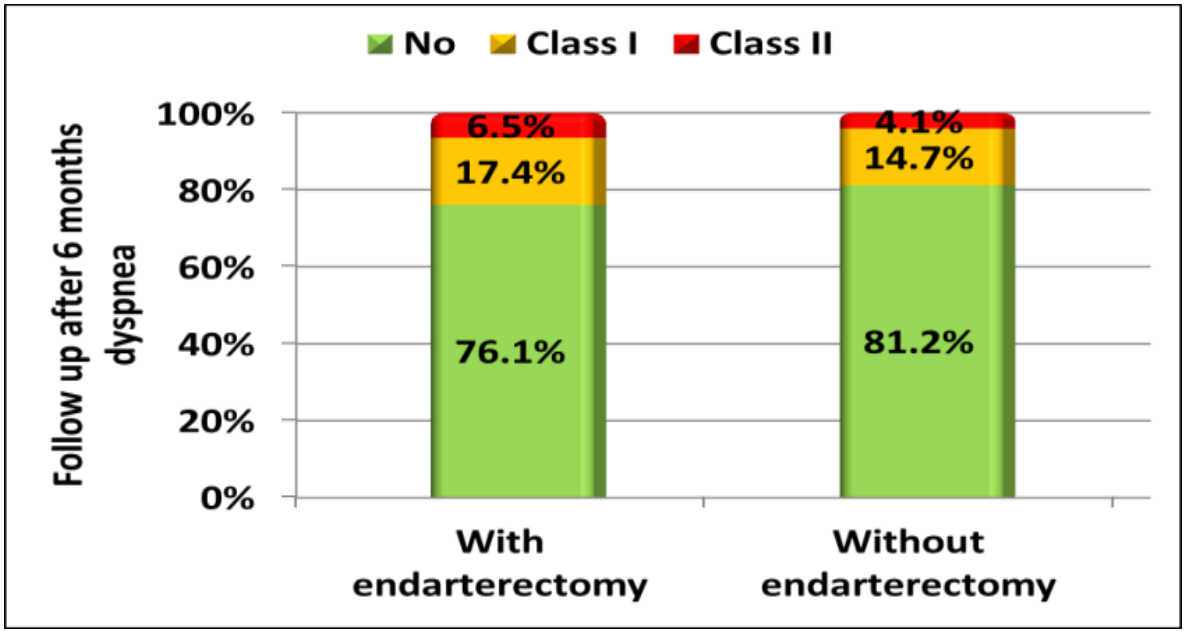

Figure 3: Follow up after 6 months dyspnea between the study groups

Table 5: Comparison between preoperative and 6 months follow up EF, LVEDD, LVESD, and SWMA.

Time		Group A--With endarterectomy	Group B- Without endarterectomy	^p-value (groups)
EF (%)				
Preoperative	**Mean±SD**	51.1±5.8	51.9±5.9	^ 0.486
	Range	40.0–60.0	35.0–60.0	
Month-6	**Mean±SD**	52.4±4.8	53.3±4.1	^ 0.320
	Range	42.0–62.0	43.0–62.0	
Change	**Mean±SD**	0.9±3.8	1.3±3.3	^ 0.644
	Range	-7.0–10.0	-4.0–8.0	
LVEDD (cm)				
Preoperative	**Mean±SD**	5.9±1.3	6.0±0.6	^ 0.679
	Range	0.2–7.0	4.5–7.1	
Month-6	**Mean±SD**	5.7±0.5	5.6±0.6	^ 0.234
	Range	4.7–6.6	4.2–6.7	
Change	**Mean±SD**	-0.1±1.2	-0.4±0.1	^ 0.199
	Range	-0.6–5.9	-0.6–-0.1	
LVESD (cm)				
Preoperative	**Mean±SD**	4.7±0.5	4.5±0.6	^ 0.230
	Range	3.5–5.6	3.0–5.8	
Month-6	**Mean±SD**	4.2±0.5	4.0±0.6	^ 0.160
	Range	3.0–5.1	2.6–5.2	
Change	**Mean±SD**	-0.4±0.2	-0.5±0.2	^ 0.457
	Range	-0.8–0.1	-0.8–-0.1	
SWMA				
Preoperative		16 (32%)	14 (28%)	§ 0.644
Month-6		8+4 (24%)	6+1 (14%)	§ 0.195
Change		-4 (25%)	-7 (50%)	§ **0.036***

*^Independent t-test. § Fisher's Exact test. *Significant. N.B: Mortality cases due to cardiac cause were considered failure to improve (deterioration).*

Following matching, the results of the two groups (group 1 (n = 138) consisted of patients who underwent plaque exclusion and patching, and group 2 (n = 137) consisted of patients who underwent endarterectomy and patching) did not differ significantly. A previous study **Myers et al.** [15] examined 224 consecutive patients who had substantial repair and LAD endarterectomy. For reconstruction, 123 patients got left internal thoracic artery onlay patch grafting (group B) and 101 patients had saphenous vein patch and LAD grafting (group A). They evaluated the relationship between the reconstruction technique and long-term survival and contrasted early and late results. In groups A and B, the perioperative myocardial infarction incidence in the LAD area was 4.0% and 4.1%, respectively, and the operational mortality was 3.0% and 4.1%. The presence study showed chest pain and dyspnea were statistically significant reduced in the 6 months follow up in each group. EF (%) was higher, LVEDD and LVESD were less, and SWMA was less in the 6 months follow up Echo among both groups but with no statistical significance. There was no statistically significant difference between

change in EF (%), LVEDD and LVESD in both groups. Only SWMA showed statistical significant more improvement in without endarterectomy group. An earlier study **Kato et al.** [16] indicated that even in patients with diffusely damaged coronary arteries, lengthy segmental LAD reconstruction with or without endarterectomy utilising the LITA produced good long-term outcomes and tolerable early surgical results. Using endarterectomy or plaque exclusion and patching, certain investigators found that the results of reconstructing severely damaged LAD are satisfactory and similar for both techniques. They said that there is an increased surgical risk associated with extended reconstruction of the LAD coronary artery. However, with acceptable mid-term results, the operation increases the likelihood of a full revascularization in patients with an unfavourable anatomical substrate. For widespread coronary artery disease, an effective and safe method of revascularization is the extensive LAD endarterectomy and reconstruction. The length of the arteriotomy and the availability of conduits should determine the reconstruction strategy [14]. It is important to note that there is an alternative technique for reconstructing the LAD using the LIMA that does not require endarterectomy [17]. This technique involves suturing the LIMA onlay graft inside the coronary in a way that prevents atheromatous plaques from entering the coronary artery lumen. 25% of the original coronary artery remains in the newly rebuilt artery, which is composed primarily of the LIMA wall. They saved this technique, though, for non-calcified plaques because highly calcified plaques may not heal well enough to suture. By using this technique, they reduce the number of endarterectomy procedures performed, which in turn lowers the postoperative cascade of thrombosis and myofibrointimal hyperplasia because no portion of the coronary artery is stripped of its endothelium. Patients are typically treated with antiplatelet, antithrombotic, or a combination of both medications to prevent graft occlusion and to reduce the rate of redo coronary re-vacuum and mortality [18]. When aspirin or aspirin plus clopidogrel was compared to a vitamin K antagonist or clopidogrel plus aspirin was compared to aspirin alone, numerous authors observed no difference in primary graft patency [18-20].

5. Conclusion

Extensive reconstruction of the diffusely diseased LAD using a constructive procedure with or without endarterectomy can be performed safely and is a useful option for revascularization of the diffusely diseased coronary artery. Endarterectomy carried suboptimal results. Complete extraction of the atherosclerotic plaque is an essential prerequisite for endarterectomy, as worst outcomes are associated with incomplete endarterectomy. Reconstructing a diffusely diseased LAD requires a strategy that is specific to the features and extent of the atherosclerotic plaque. It is advised to conduct a lengthy investigation to see how these methods affect graft patency and survival.

Conflict of interest

The authors declare no conflict of interest.

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Author contribution

Authors contributed equally in the study.

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