Owais et al., Int J Cardiovasc Res 2016, 5:3
http://dx.doi.org/10.4172/2324-8602.1000265

International Journal of Cardiovascular Research

Research Article

A SCITECHNOL JOURNAL

Early Term Results of Left Internal Mammary Artery Patch to Left Anterior Descending Artery and Left Internal Mammary Artery to On-Lay Saphenous Vein Patch in Diffusely Diseased Left Anterior Descending Artery: Which is Inferior and which is Superior?

Tamer Owais[1,3*], Ihab Abdelfattah[1], Abdulla Osama[1], Foad Rasekh[1], Evaldas Girdauskas[3], Mishal Ghandour[2] and Thomas Kuntze[3]

Abstract

Background: Surgical revascularization of CAD patients having diffusely-diseased LAD is a difficult surgical problem. Some centers prefer long direct LIMA-to-LAD grafting; others perform LIMA grafts to on lay SVG patch. Favoring either technique depends on multiple factors and is still questionable. This study was undertaken to compare the experience and early results of using direct LIMA-to-LAD anastomosing versus indirect anastomosing by LIMA-to on-lay SVGs during standard CABG.

Patients and Methods: This prospective study was done starting from March 2009-untill-March 2011, in Cairo university hospitals and Prince Sultan Cardiac Center, Riyadh, KSA, after obtaining the approval of the local ethical committees. We studied thirty patients with diffusely-diseased LAD. All were submitted for elective CABG using CPB under moderate hypothermia and 20-minutes intermittent blood-enriched aortic root antegrade cardioplegia. Patients were divided into two groups after proper matching regarding demographic data and surgical risks. In Group I (15 patients) underwent LIMA-to-LAD patch; while in group II (15 patients) underwent LIMA grafting on an on-lay SVG. Follow-up was done at first and twelfth month postoperatively, by regular clinical examination with echocardiography and other investigations as needed.

Results: Two patients died in each group (total mortality 13%). In group I, one died due to progressive refractory LV failure; and another one due to refractory ventricular arrhythmias. In group II, a diabetic patient died due to mediastinitis and a second patient died due to progressive liver failure. There were no MI, CHF, or CNS complications. Total morbidity was 20% (6 patients). Group I morbidity was 20% (3 patients) as recurrent attacks of supraventricular extrasystoles arrhythmias in 2 patients (13%); and mechanically-assisted ventilation for 36 hours in single patient (6%). Group II morbidity occurred in 3 patients (20%) as: left side moderate to-severe haemorrhagic pleural effusion in 2 patients (13%), and superficial wound infection in a single patient (6%). All patients expressed obvious post-operative improvement by clinical symptoms (absence of angina pains, 6 MWD) and echocardiographic follow-up (LVEF %). No statistical significance was found between results of the 2 groups regarding operative data (surgical time, CPB time, cross-clamp time), need for inotropics or IABCP, ICU events and hospital stay time.

Conclusion: LIMA-to-LAD could be safely-performed using long direct LIMA patch-LAD grafting; and via SVG on-lay patching on LAD too. Both procedures were technically-successful with sound safety, acceptable complications and early term results with no obvious superiority of LIMA patch to Venous patch on LAD.

Keywords

Coronary myocardial protection; Ischaemia; Venous grafts

***Corresponding author:** Tamer Owais, Department of Cardiac Surgery, Central Clinic Bad Berka, Robert-Koch Allee 9, 99437 Bad Berka, Germany, Tel: 00491622397476/ 0049036458541115; E-mail: tamerowaiss1976@yahoo.com

Received: February 17, 2016 **Accepted:** April 15, 2016 **Published:** April 21, 2016

Abbreviations: CHD: Coronary Artery Disease; LAD: Left Anterior Descending; LIMA: Left Internal Mammary Artery; MI: Myocardial Infarction; CHF: Congestive Heart Failure; CNS: Central Nervous System; SV: Saphenous Vein; CABG: Coronary Artery Bypass Grafting; CPB: Cardiopulmonary Bypass; PO: Postoperative; IABCP: Intraaortic Balloon Counterpulsation Statistical Significance if Result <0.05

Introduction

It is well-known that coronary artery bypass graft (CABG) surgery significantly increases life expectancy, and hence complete myocardial revascularization should be the main goal of the surgical intervention process [1-3]. Recently, there is a trend towards the increased use of percutaneous interventions by invasive cardiologists. Consequently, the number of high-risk and elderly patients referred for CABG operation has increased [4].

Because the diffusely diseased nature of the LAD lesion(s) in the fragile elder patient subset is frequently encountered, complete myocardial revascularization may not be always satisfactorily-achieved by conventional bypass techniques [5].

Coronary endarterectomy in the LAD vessel is a procedure that has been proposed as a possible solution for revascularization of a diffusely-diseased LAD [5,6]. However, many surgeons are still avoiding the use of this procedure approach because of the conflicting and controversial opinions [7-9]. Technically, LAD-CE can be done by the traction technique or by the long-opening technique [10]. Following it, LIMA-LAD anastomoses are done either directly, or via a small hole in an on-lay saphenous vein graft. Both CE procedures were accused to be responsible for postoperative mortality ranging between 3-11% [4-7]; and postoperative MI ranging between 5-14% [5-9]. Moreover, LAD-CE was claimed to result in uncertain mid and long-term PO clinical results [8-11].

doi:http://dx.doi.org/10.4172/2324-8602.1000265

Owing to concerns in LAD-CE, cardiac surgeons shifted to focus on new techniques that can avoid its use or at least limit the length of the endarterectomized arterial segment [12-14]. Recently, different means of LAD reconstruction using long-segmental anastomoses; and indirect LAD patching to a long saphenous vein patch were introduced in this special subgroup of patients to afford complete myocardial revascularization [14-16].

Early results comparing these approaches are still conflicting, and only a limited number of studies have reported the comparative clinical outcome, patency rates, and the incidence of cardiac-related events during postoperative follow-up [11]. Due to these heterogeneous and composite nature of the (elder) patient populations (having many inter-influencing co-morbidity factors), these studies were not able to provide solid conclusions [15-19].

Objective

This comparative prospective study reviews our experience and early results of reconstruction of the diffusely-diseased LAD by conventional standard CABG. This study compares LIMA-to-LAD direct long anastomosing versus indirect LIMA grafting to an on-lay saphenous vein patch following long-opening LAD-CE.

Patients and Methods

Patient population

Between March 2011 and March 2013, thirty patients with diffusely diseased LAD among other coronary atherosclerotic lesions were included in the study. After making a long arteriotomy in the LAD, the vessel was reconstructed by a patch. Based on the LAD patch type, the patients were categorized into two groups:

Group I (18 patients): for which the LAD was reconstructed with a direct LIMA patch (Figure 1).

Group II (12 patients): for which the LAD was reconstructed using a saphenous vein on-lay patch, to which the LIMA was fixed (Figure 2).

Inclusion criteria

Patients with CAD with long-segment diffusely diseased LAD, who had an arteriotomy of at-least 3 cm length.

Exclusion criteria

Associated valvular heart surgery

Severe impairment of contractility with left ventricular ejection fraction (LVEF %) <40%.

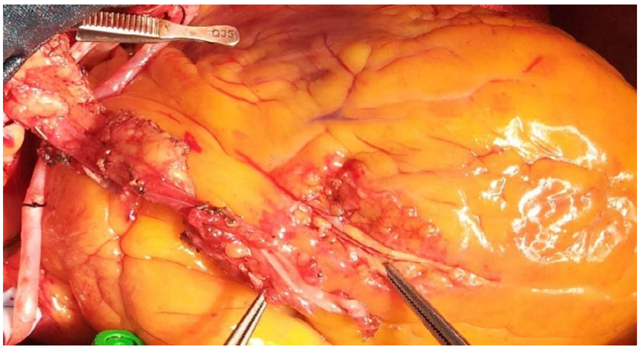

Figure 1: LIMA patch reconstruction of a long LAD arteriotomy.

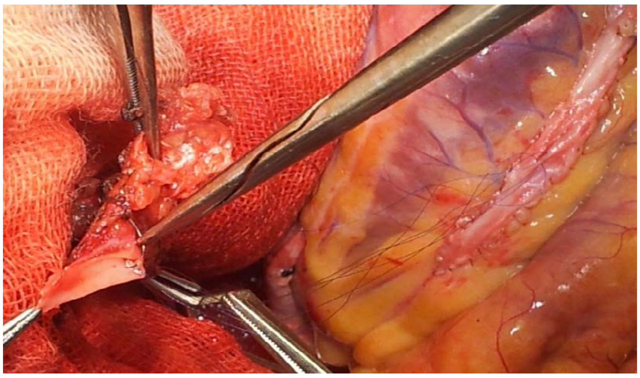

Figure 2: LIMA being anastomosed to a long on-lay SVG patch over LAD.

Follow-up

Results were obtained and comparatively studied during the first month postoperatively regarding mortality and morbidity using regular clinical examination visits combined by echocardiography and other investigations as needed.

Statistical analysis

Perioperative data values were collected in tables form in means ± SD. The Kaplan-Meier method was used to analyze actuarial survival and freedom from ischemic symptoms. Statistical analysis was performed using SPSS software (release 12.0.1 for Windows; SPSS, Chicago, Illinois). Statistical significance was assumed if a p value of 0.05 or less was achieved.

Results

Preoperative Demographic Data are shown in Table 1.

Operative data

The total operating room (OR) time was significantly higher in group II (SVG patch) compared to group I (LIMA patch). The same was also true for the cross clamp time, 82 ± 8 min for group II, compared to 63 ± 7 min for group I. Nevertheless there was no statistically significant difference between the two groups as regards the ICU stay.

Seventy eight percent (14/18 patients) of the LIMA patch group (group I) had a conventional on-pump CABG. Compared to the 83% (10/12) of on-lay SVG patch group (group II), the difference did not reach statistical significance (p=0.71)

Table 2 summarizes the operative data of the two groups.

In-hospital postoperative course

There was no difference of statistical significance between the two groups as to ICU events (regaining full consciousness, inotropic support, assistance by mechanical ventilation, stay time, mean blood units transfused), as well as mean ICU and hospital stay times (Table 3).

Morbidity and mortality

Mortality: Two patients died in each group (total mortality 13%). In group I, the first patient died due to progressive refractory left ventricular failure despite massive inotropic support and IABCP assistance; while the second patient died due to refractory ventricular arrhythmias (LV tachycardia then VF) not controllable by anti-arrhythmic medical therapy. In group II, the first patient (diabetic)

Variable	Group I (no 18) (LIMA patch)	Group II (no 12) (on-lay SVG patch)	p Value
Age (mean ± SD)	46 ± 3.5	42 ± 4.6	0.22
Female ratio %	9 (50 %)	5 (41.6 %)	0.13
Diabetes Mellitus	5 (27.7 %)	4 (33.3 %)	0.55
Systemic Hypertension	8 (44.4 %)	6 (50 %)	0.21
Ex-Cigarette smoking	12 (66.6 %)	7 (58.5 %)	0.16
Previous MI	4 (22.2 %)	3 (25 %)	0.23
LV Ejection Fraction%	47 ± 2.1	49 ± 2.5	0.42
LAD: Left Anterior Descending MI: Myocardial Infarction LV: Left Ventricle Values are expressed in mean ± SD : standard deviation			

Table 1: Preoperative patients demographics.

	Group I (18) LIMA patch	Group II (12) on-lay SVG patch	p value
Cross-clamp time (mean ± SD)	63 ± 7 min	82 ± 8 min	0.03*
Total OR time (mean ± SD)	190 ± 25 min	230 ± 15 min	0.04*
ICU stay (mean ± SD)	3.5 ± 1 days	4 ± 1 days	0.62
Type of CABG			0.71
on-pump	14 (78%)	10 (83%)	
off-pump	4 (22%)	2 (17%)	
CABG: coronary artery bypass graft; ICU: intensive care unit; OR: operating room; SD: standard deviation; * denotes statistical significance			

Table 2: Operative data.

Variable	Group I (no 18) (LIMA patch)	Group II (no 12) (on-lay SVG patch)	p Value
Inotropic Support (mean hours)	24 ± 1.2	26 ± 3.1	0.55*
IABCP	4 (26 %)	4 (26 %)	-
IABCP: Intraaortic Balloon Counterpulsation *: Result is not statistically-significant			

Table 3: Postoperative Data.

Variable	Group I (no 15)	Group II (no 15)	p Value
Mortality: total 4 (13%)	2 (13 %)	2 (13 %)	none
Morbidity: total 6 (20%)	3 (20%)	3 (20 %)	0.34*
– MI, CHF, serious CNS morbidity	none	None	-
– Supravent extrasystoles arrhythmia	2 (13%)	-	-
– Mechanical.Ventilation for 36 hours	1(6%)	-	-
– Intercostal tube re-insertion #	-	2 (13%)	-
– Superficial wound infection ^	-	1(6%)	-
MI: Myocardial Infarction CHF: Congestive heart failure CNS: Central nervous system Supravent: Supraventricular #: Right side moderate to-severe haemorrhagic pleural effusion ^: needing frequent dressing with wound debridement *: value is statistically-non-significant			

Table 4: Postoperative Morbidity and Mortality.

died due to mediastinitis and deep sternal wound infection; while the second patient (HCV+) died due to progressive liver-cell failure.

Morbidity: In both groups, there were no serious morbidity complications e.g.: MI, CHF, CNS. Total morbidity was 20% (6 patients). Group I morbidity was 20% (3 patients) as recurrent attacks of supraventricular extrasystoles arrhythmias (controlled by Amiodarone IV then orally) in 2 patients (13%); and mechanically-assisted PO ventilation for 36 hours in single patient (6%). Group II morbidity occurred in 3 patients (20%) as: intercostal tube re-insertion for left side moderate to-severe haemorrhagic pleural effusion in 2 patients (13%); and superficial wound infection needing frequent dressing and 2 times wound debridement in a single patient (6%) (Table 4).

Post-operative follow-up, 1 month and 1 year after hospital discharge

Patients in the two groups expressed obvious post-operative clinical improvement as detected by absence of anginal pains, better effort tolerance (by NYHA class, longer 6 MWD) and better cardiac contractility (LVEF%) by echocardiographic follow-up (Table 5).

Discussion

Nowadays, many Cardiac surgeons are confronted with the dilemma of the escalating number of patients having diffuse LAD lesions distal to a first major proximal lesion [7-11]. The presence of multiple atheromatous plaques usually complicates the surgical procedure and adversely influences the long-

m patency of LIMA graft [3-8]. A crucial question that cardiologists pose to cardiac surgeons in that situation is "Can we consider an LAD which is diffusely-diseased in angiocath films, surgically-graftable?" Classic surgeons' reply has always been "yes we can follow proper intraoperative evaluation by seeing, palpating, and occasionally opening the target vessels first" [20,21].

In 1957, Bailey et al., [22] introduced Coronary endarterectomy (CE) as a treatment modality for severely-atherosclerotic CAD (especially RCA) earlier before LIMA long patching, and even before CABG surgery became the standard therapy for CAD [22,23]. Various techniques were proposed as a solution including "jumping anastomoses" with creation of more than one route to bypass arterial blood to the diseased LAD territory [4-7]. Differently, LIMA-LAD grafting was done on top of a saphenous vein patch [8-11]. Despite

doi:http://dx.doi.org/10.4172/2324-8602.1000265

Variable	Group I (no 25) (LIMA-LAD after)	Group II (no 25) (LIMA-LAD on SVG patch)	p Value
Recurrence of anginal pain	none	none	-
Mean LVEF (%)	55 ± 1.4	57 ± 012	0.22*
Mean NYHA class	1 ± 0.3	1 ± 0.4	0.46*
6 minutes walking distance	200 ± 26	210 ± 9	0.21*
*: value is statistically-non-significant			

Table 5: Immediate postoperative Clinical Outcome.

all, the need for more modifications of conventional techniques still exists in order to confirm obtaining satisfactory long-term outcomes [11].

Surgeons opposing CE wide-use expressed fears founded on the extreme value of achieving LAD patency considering it one of the main goals for a successful CABG surgery [17-20]. They expressed fears and recommended limiting CE use because they thought it was notorious for inducing myo-fibro-intimal proliferation. This, later on, could negatively affect early and long-term clinical and angiographic results [11] as the endarterectomized arterial wall acts as a scaffold for a new thrombus formation [9]. They explained that unlike the RCA, the LAD atherosclerotic core is narrow and delicate, and LAD has diagonal and septal branches that occur in 2 different planes. Unidirectional traction on the plaque can cause shearing off branches [24], and hence the risk of disruption under tension is increased. They recommended warranting LAD-CE for the purpose of complete revascularization of those important branches [24].

On the other hand, CE supporters stated that under proper perioperative anticoagulant cover, normal endothelial covering can act, within reasonable time, to heal and limit possible thrombosis [9,12]. An appealing solution against shearing-off the important LAD branches (diagonals and septals), by retraction during CE is by replacing the procedure of negotiating the thrombus via a small opening *"Traction Technique"* by the more-invasive *"long-Opening CE"*. The *"Open CE Technique"* is specially-effective when plaque extraction is incomplete or when there's fear to fracture a delicate plaque [12]. Using a long arteriotomy (instead of undue and dangerous longitudinal traction during *"Traction Technique"*), provides enough safe exposure to extract the atherosclerotic core. They finally declared that LAD-CE is safer than was previously thought [7-10,26].

Different strategies were reported for reconstructing the LAD after extensive CE [11-14]. Open LAD endarterectomy with saphenous vein patch reconstruction combined with LIMA grafting was first reported by Fundaro et al. [27] in 1987, with subsequent technical modifications introduced [16,19]. In 2005, Nishi et al. [25], showed that midterm angiographic results of LIMA-to-LAD grafting via SVG patch after "Open CE". Results were better compared to using the traditional traction technique. They concluded that CE using the open technique was safer and had acceptable operative risk.

In this study, and conforming with previously-reported opinions [10,25,26], we opted to perform LAD-CE before reconstructing LIMA-LAD anastomosis in all patients. Our indicating guidelines for applying LAD-CE followed certain standards. We, as well as others [28-31] endorsed this opinion after suspecting no or minimal flow past LAD in preoperative angio films, in presence of a viable myocardium. This should be confirmed intraoperatively when an initial LAD arteriotomy reveals a severely-occluded LAD or when a 1-mm probe can't be passed inside it. We carried out CE via a longer (2 cms or more) arteriotomy within a reasonable dissection time that matched well with other series [9-11,31,32]. The provided optimum visibility allowed total plaque removal, despite the acceptably-prolonged aortic cross-clamp time.

It was reported by many surgeons [3-8,10,23] that a serious limitation of LAD-CE is a factor that is related to the surgeon, who must adequately-dissect and then remove the entire plaque as much as possible until its clearly-tapering distal end is seen. Absence of distal tapering means that the arteriotomy should be extended for more distance. In this study we followed the same concept of carrying out the LAD arteriotomy until the distal tapering end is clearly-seen. Although the small arteriotomy combined with the traction technique has the advantage of a shorter cross-clamp time, it has the disadvantage of the possibility to leave part of the atheroma un-removed with consequent jeopardizing postoperative patency of the anastomosis. It was our policy to reassure that the entire plaque is removed with proper distal tapering. The success of our LAD-CE was confirmed by the acceptable blood back flow through the distal and the septal branches upon giving a dose of cardioplegia. This good flow could raise the saphenous SVG patch cover of the LAD in group II patients. Furthermore, anastomotic patency was proved postoperatively by the total disappearance of anginal pain, the higher LVEF%, the NYHA clinical step-up, and the longer 6 minutes-walking distance. The same conclusions were also reported by other surgeons [17,19,29,30].

The use of direct LIMA-to-LAD on-lay patch grafting was established by Shapira et al. [28] in 1988. Tasdemir et al. [12] suggested that the low incidence of atherosclerotic disease of the LIMA conduit is advantageous for this technique. Barra et al. [1] then described plaque exclusion using the LIMA on-lay patch graft, replacing 75% of the LAD circumference with the LIMA patch. However, concerns of higher future thrombosis, LAD stenosis or obstruction, caused the "primary closure" technique (closing the native LAD walls directly after CE) to be less-favorable and even abandoned [14]. On the contrary, LIMA direct patching to an endarterectomized LAD was reported to have acceptable results by other surgeons [26,30]. The key to the success of the On-lay patch technique was that the length of the longitudinally-incised LIMA should be exactly matching the length of the superficial arteriotomy made along the diseased LAD so that the tip of the arteriotomy incision extends to the "disease-free" distal portion of the LAD vessel [12].

According to Lüscher et al., [26], combining "open CE" to long LIMA-LAD on-lay patching had satisfactory early and late clinical outcomes and luminal patency of endarterectomized vessels. They attributed their better results to: 1st under direct vision, a long arteriotomy exposes the whole arterial lumen with its side branches containing atherosclerotic occlusive material hence optimizing its complete removal avoiding negligence of any residual material. 2nd, LIMA on-lay patch grafting forms a new coronary lumen so that LIMA wall makes up about 75% of the circumference of the reconstructed vessel, hence globally enlarging the newly present lumen. 3rd reason is that LIMA provides better vasomotor function, particularly the capacity to adjust the flow rate in proportion to the distal runoff, a widely known

doi:http://dx.doi.org/10.4172/2324-8602.1000265

paracrine function of living endothelium that produces and releases prostacyclin and other endothelium-dependent relaxation factors.

Ogus et al. [11], and Fitzgibbon et al. [33] did not use SVGs patches to enlarge the LIMA and then implant LAD. They considered it more time consuming, and even accused it of adversely-influencing the flow patterns by inducing subsequent turbulence due to the change in compliance of the three different components: the native artery, SVG, and LIMA. This repeated discrepancy, in turn, causes a decrease the flow velocity ending by SVG atherosclerosis, failure, with recurrence of angina. However, supporters of SVG patching stated that SVG patches have the added value of enlarging the diameter of a severely-stenosed LAD. The ample length and the easy-harvesting were reported to add to its size-merits [13-19]. Fear against its postoperative thrombosis/occlusion, is not well-founded as Warfarin ± Salicylates anticoagulation regimen (classically-needed following LAD-CE) is usually-effective to prevent its occurrence. In our study, the absence of serious postoperative thromboembolic complications further confirmed our hypothesis. The same perception was also reported by others [13,16,17].

In our study, there were no differences as to operative data (operative time, CPB time, ischemic time), CPB-weaning data (need for inotropics, DC shocks, IABCP), or postoperative data (ICU and hospital stay times). The measured values were of no statistical significance. Added to that, the follow-up data concerning the clinical condition showed an obvious improvement (mean NYHA class, LVEF%, and the 6 minutes walking distance). These findings were also reported in other series [7-11].

Our mortality and morbidity complications were mostly attributed to PO dysrhythmias. It was reported by many surgeons [2-6,11,15,23,33] that suture lines lying close to the LV apex are arrhythmogenic in nature. Due to proper bordering of our distal suture line secured from the apical zone, most of the arrhythmias could be medically dealt with and controlled. The average mortality rate in our study is matching with other rates reported for LAD-CE in the literature (average early and a mid-term survival rates between 71% and 92%) [4-11] and hence is acceptable. The higher mortality in the other series can be attributed to the larger patient sample included and the generally-younger patient selection. General reasons for the lesser-morbidity-mortality are multifactorial: Advances in patient selection/management, expert angiocath performance/interpretation, meticulous surgical technique with equidistant stitch placement avoiding intimal cracking by hesitation or multi-needle passaging, intimal dissection or disruption due to harsh graft handling, effective CPB and cerebro-myocardial protection (inotropics/IABCP), optimized ICU facilities and care, in addition to adequate PO anticoagulation and platelet-inhibition protocol. Our 2-year survival rate is in agreement with previous reports that reporting.

Postoperative MI did not occur in any of our patients, contrary to other series like [8,10,15,23] who reported rates of MI ranging between 2.5-6%. Recent CE studies are reporting lower rates similar to our study [23-34].

Study Limitations

Our study is limited by the fewer patient number and the relatively short postoperative follow-up (1 month). The absence of follow up coronary angiography weakens the argument as well. Because of the short term follow up, we decided to rely on echocardiographic findings and clinical examination as well.

Conclusion

LIMA-to-LAD following long-opening LAD, could be safely-performed using direct LIMA-LAD grafting; and via SVG on-lay patching. Both procedures were technically-successful to revascularize diffusely-diseased LAD vessel with sound safety and acceptable complications and without statistical superiority or inferiority of one over the other in the early term.

References

1. Barra JA, Bezon E, Mondine P, Resk A, Gilard M, et al. (2000) Coronary artery reconstruction for extensive coronary disease: 108 patients and two year follow-up. Ann Thorac Surg 70: 1541-1545.
2. Bell MR, Gersh BJ, Schaff HV (1992) Effect of completeness of revascularization on long term outcome of patients with three-vessel disease undergoing coronary artery bypass surgery. A report from the Coronary Artery Surgery Study (CASS) Registry. Circulation 86: 446-457.
3. Myers WO, Schaff HV, Gersh BJ, Fisher LD, Kosinski AS, et al. (1989) Improved survival of surgically treated patients with triple vessel coronary artery disease and severe angina pectoris. A report from the Coronary Artery Surgery Study (CASS) registry. J Thorac Cardiovasc Surg 97: 487-495.
4. Sirivella S, Gielchinsky I, Parsonnet V (2005) Results of coronary artery endarterectomy and coronary artery bypass grafting for diffuse coronary artery disease. Ann Thorac Surg 80: 1738-1744.
5. Brenowitz JB, Kayser KL, Johnson WD (1988) Results of coronary artery endarterectomy and reconstruction. J Thorac Cardiovasc Surg 95: 1-10.
6. Djalilian AR, Shumway SJ (1995) Adjunctive coronary endarterectomy: improved safety in modern cardiac surgery. Ann Thorac Surg 60: 1749-1754.
7. Qureshi SA, Halim MA, Pillai R, Smith P, Yacoub MH (1985) Endarterectomy of the left coronary system. Analysis of a 10 year experience. J Thorac Cardiovasc Surg 89: 852-859.
8. Sundt TM 3rd, Camillo CJ, Mendeloff EN, Barner HB, Gay WA Jr (1999) Reappraisal of coronary endarterectomy for the treatment of diffuse coronary artery disease. Ann Thorac Surg 68: 1272-1277.
9. Gill IS, Beanlands DS, Boyd WD, Finlay S, Keon WJ (1998) Left anterior descending endarterectomy and internal thoracic artery bypass for diffuse coronary disease. Ann Thorac Surg 65: 659-662.
10. Byrne JG, Karavas AN, Gudbjartson T, Leacche M, Rawn JD, et al. (2004) Left anterior descending coronary endarterectomy: early and late results in 196 consecutive patients. Ann Thorac Surg 78:867-873.
11. Ogus TN, Basaran M, Selimoglu O, Yildirim T, Ogus H, et al. (2007) Long-term results of the left anterior descending coronary artery reconstruction with left internal thoracic artery. Ann Thorac Surg 83: 496-501.
12. Taşdemir O, Kiziltepe U, Karagöz HY, Yamak B, Korkmaz S, et al. (1996) Long-term results of reconstructions of the left anterior descending coronary artery in diffuse atherosclerotic lesions. J Thorac Cardiovasc Surg 112: 745-754.
13. Sankar NM, Satyaprasad V, Rajan S, Bashi VV, Cherian KM (1996) Extensive endarterectomy, onlay patch, and internal mammary bypass of the left anterior descending coronary artery. J Card Surg 11: 56-60.
14. Fukui T, Takanashi S, Hosoda Y (2005) Long segmental reconstruction of diffusely diseased left anterior descending coronary artery with left internal thoracic artery with or without endarterectomy. Ann Thorac Surg 80: 2098-2105.
15. Santini F, Casali G, Lusini M, D'Onofrio A, Barbieri E, et al. (2002) Mid-term results after extensive vein patch reconstruction and internal mammary grafting of the diffusely diseased left anterior descending coronary artery. Eur J Cardiothorac Surg 21: 1020-1025.
16. Santini F, Casali G, Lusini M, D'Onofrio A, Barbieri E, et al. (2002) Mid-term results after extensive vein patch reconstruction and internal mammary grafting of the diffusely diseased left anterior descending coronary artery. Eur J Cardiothorac Surg 21: 1020-1025.
17. Aranki SF (1993) A modified reconstruction technique after extended anterior descending artery endarterectomy. J Card Surg 8: 476-482.

18. Beretta L, Lemma M, Vanelli P, DiMattia D, Bozzi G, et al. (1992) Coronary "open" endarterectomy and reconstruction: short- and long-term results of the revascularization with saphenous vein versus IMA-graft. Eur J Cardiothorac Surg 6: 382-386.
19. Lemma M, Beretta L, Vanelli P, Santoli C (1992) Open coronary endarterectomy, saphenous vein patch reconstruction, and internal mammary artery grafting. Ann Thorac Surg 53: 1151-1152.
20. Ladowski JS, Schatzlein MH, Underhill DJ, Peterson AC (1991) Endarterectomy, vein patch, and mammary bypass of the anterior descending artery. Ann Thorac Surg 52: 1187-1189.
21. The Society of Thoracic Surgeons Database. The 8th year Minnetonka, MN: Summit Medical, December 1998.
22. Schaff HV, Gersh BJ, Pluth JR, Danielson GK, Orszulak TA, et al. (1983) Survival and functional status after coronary artery bypass grafting: results of 10–12 years after surgery in 500 patients. Circulation 68: 200-204.
23. Bailey CP, May A, Lemmon WM (1957) Survival after coronary endarterectomy in man. J Am Med Assoc 164: 641-646.
24. Myers PO, Tabata M, Shekar PS, Couper GS, Khalpey ZI, et al. (2012) Extensive endarterectomy and reconstruction of the left anterior descending artery: early and late outcomes. J Thorac Cardiovasc Surg 143: 1336-1340.
25. Parsonnet V, Gilbert L, Gielchinsky I, Bhaktan EK (1976) Endarterectomy of the left anterior descending and mainstem coronary arteries: a technique for reconstruction of inoperable arteries. Surgery 80: 662-673.
26. Nishi H, Miyamoto S, Takanashi S, Minamimura H, Ishikawa T, et al. (2005) Optimal method of coronary endarterectomy for diffusely diseased coronary arteries. Ann Thorac Surg 79: 846-852.
27. Lüscher TF, Diederich D, Siebenmann R, Lehmann K, Stulz P, et al. (1988) Difference between endothelium-dependent relaxation in arterial and in venous coronary bypass grafts. N Engl J Med 319: 462-467.
28. Fundaro P, Di Biasi P, Santoni C (1987) Coronary endarterectomy combined with vein patch reconstruction and internal mammary artery grafting: experience with 18 patients. Texas Heart Inst J 14:389-394.
29. Shapira N, Lumia FJ, Gottdiener JS, Germon P, Lemole GM (1988) Adjunct endarterectomy of the left anterior descending coronary artery. Ann Thorac Surg 46: 289-296.
30. Loop FD (1988) Resurgence of coronary artery endarterectomy. J Am Coll Cardiol 11: 712-713.
31. Sommerhaug RG, Wolfe SF, Reid DA, Lindsey DE (1990) Early clinical results of long coronary arteriotomy, endarterectomy and reconstruction combined with multiple bypass grafting for severe coronary artery disease. Am J Cardiol 66: 651-659.
32. Mills NE (1998) Coronary endarterectomy: surgical techniques for patients with extensive distal atherosclerotic coronary disease. Adv Cardiac Surg 10:197–227.
33. Raanani E, Kogan A, Shapira Y, Sagie A, Kornowsky R, et al. (2004) Surgical reconstruction of the left main coronary artery: fresh autologous pericardium or saphenous vein patch. Ann Thorac Surg 78: 1610-1613.
34. FitzGibbon GM, Leach AJ, Keon WJ, Burton JR, Kafka HP (1986) Coronary bypass graft fate. Angiographic study of 1,179 vein grafts early, one year, and five years after operation. J Thorac Cardiovasc Surg 91: 773-778.

Author Affiliations

Top

[1]*Department of Cardiothoracic Surgery, Kasr El Aini Faculty of Medicine, Cairo University, Egypt*

[2]*Department of Cardiothoracic Surgery, Prince Sultan Cardiac center, Riyad, Kingdom of Saudi Arabia*

[3]*Department of cardiac surgery, Central Clinic of Bad Berka, Germany*