Research Article

Does Coronary Endarterectomy in the Left Anterior Descending Artery Increase Surgical Morbidity and Mortality?

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Abstract

Background: In this study, we investigated the effect of adjuvant coronary endarterectomy in the left anterior descending (LAD) artery on mortality and morbidity in subjects that underwent coronary artery bypass graft (CABG) surgery.

Methods: A total of 140 patients that underwent coronary endarterectomy (CE), performed as an adjuvant to CABG between November 2010 and November 2019, were assigned to one of two groups and examined. Early postoperative outcomes were compared between 30 patients that underwent CE in the LAD (LAD group) and 110 patients that underwent CE in the right and circumflex coronary arteries (non-LAD group).

Results: Atrial fibrillation, renal failure, and re-exploration due to bleeding were more frequent in the LAD group during the early postoperative period. The incidence of postoperative complications in the LAD group (56.7%) and in the non-LAD group (29.1%) were statistically significant (p=0.010). The mortality was 13.3% in the LAD group and 4.5% in the non-LAD group, although no statistically significant difference was found between the groups (p=0.099).

Conclusion: The subjects that underwent CABG and simultaneous LAD endarterectomy may have had higher rates morbidity and mortality due to the presence of a complex vascular structure and additional comorbid factors.

Keywords: Coronary artery bypass surgery; Coronary artery bypass grafting; Coronary endarterectomy; Mortality

Introduction

Since the first use of coronary bypass surgery, diffuse coronary artery disease has become a major challenge in coronary artery bypass grafting (CABG). As percutaneous interventions have become more common in recent years, patients referred for coronary bypass surgery are often more complicated [1-3]. In such cases, an inadequate arterial lumen often results in the need for coronary endarterectomy (CE) during surgical revascularization [4,5]. In the literature, the CE application rates in coronary surgery have been reported to range from 3.7% to 42% [6]. In this study, we evaluated the effect of CE in the left anterior descending (LAD) artery performed as an adjuvant to CABG on mortality and morbidity.

Materials and Methods

A total of 140 patients who underwent CABG between November 2010 and November 2019 were assigned to one of two groups: an LAD group and a non-LAD group. The outcomes were compared between 30 patients in the LAD group that underwent CE in the LAD and 110 patients in the non-LAD group that underwent CE in the right coronary artery (RCA) and the circumflex coronary artery. The following preoperative demographic characterestics were evaluated: age, gender, comorbid diseases, such as diabetes mellitus (DM), hypertension (HT), carotid artery disease, peripheral arterial disease (PAD), and chronic obstructive pulmonary disease (COPD), smoking state, and preoperative left ventricular ejection fraction (LVEF) parameters. The following operative factors were evaluated: duration of cardiopulmonary bypass (CPB), cross clamping (CC) time, types of grafts used, requirement for intra-aortic balloon pump (IABP) and positive inotropic support, and preoperative myocardial infarction (MI). New electrocardiogram (ECG) changes (new Qwave, new ST segment elevation), creatine kinase-muscle/brain (CK-MB) elevation, troponin elevation, and recent wall motion defect, detected by echocardiography during the initial 24 hours, were accepted as signs of preoperative MI. For postoperative evaluation, the need for positive inotropic support, intubation time, length of stay in the intensive care unit, length of hospital stay, and complication and mortality rates were examined. CABG surgery was performed under routine CPB (except for 1 case performed on a beating heart) with CC. CE was performed when a vessel diameter of 1.5 mm or more was present with no lumen available for bypass following an arteriotomy procedure or when the 1-mm probe could not be advanced distally due to narrow lumen. After CE, the appearance of distal tapering in the removed plaque was accepted as an effective endarterectomy. If the plaque could not be removed completely, the remaining amount was detached by extending the arteriotomy or by performing additional distal arteriotomy. During the postoperative intensive care follow-up, a regimen of clopidogrel (75 mg) + acetyl salicylic acid (100 mg) was initiated orally if there was no significant drainage (<100 ml/h) during the early postoperative period following extubation. Double antiplatelet therapy was routinely continued for 6 months in patients undergoing endarterectomy; after 6 months, single antiplatelet therapy was administered. The retrospective study protocol was approved by the institutional review board of our institution, the need for informed consent from each patient was waived.

Results

Mean patient age was 62.7 years in the LAD group and 61.1 years in the non-LAD group. There was no statistically significant difference between the two groups regarding risk factors (HT, emergency surgery, DM, smoking, COPD, PAD, carotid stenosis, chronic

renal failure). However, the number of patients with low LVEF (35% or lower) that underwent surgery was significantly higher in the LAD group (46.7%) than the non-LAD group (25.5%) (P=0.043). Table-1 shows the preoperative demographic characteristics of the cases.

	LAD group		Non-LAD group		*P*
		%		%	
Age (mean)	62.7	-	61.1	-	*0.378*
Sex					
Male	24	80	90	81.8	*0.820*
Female	6	20	20	18.2	*0.790*
Emergency surgery	1	3.3	3	2.7	*0.759*
LVEF (%)	40.33		45.55		*0.183*
Diabetes mellitus	20	66.7	55	50	*0.157*
Hypertension	20	66.7	75	68.2	*0.875*
Chronic obstructive pulmonary disease	3	10	16	14.5	*0.764*
Peripheral arterial disease	6	20	18	16.4	*0.845*
Smoking	15	50	44	40	*0.439*
Carotid stenosis	3	16.7	15	13.6	*0.764*
Low LVEF (<35)	14	46.7	28	25.5	*0.043*

LVEF: Left ventricular ejection fraction (%).

Table 1: Demographic and clinical characteristics of the patients

Regarding the operative characteristics of the cases, there was no significant difference in the duration of CPB or CC time. Internal thoracic artery (ITA) harvesting was more frequent in the non-LAD group (96.4%) than the LAD group (83.3%); and the use of a saphenous vein patch was more frequent in the LAD group (26.7%) than the non-LAD group (1.8%). Multiple CE for multiple coronary arteries was performed more frequently in the LAD group (46.7%) than the non-LAD group (10%). For both study groups, CE was most commonly performed in the RCA, followed by the LAD, circumflex, and diagonal arteries.

Postoperative complications were observed significantly more frequently in the LAD group (56.7%) in comparison to the non-LAD group (29.1%) (p=0.010). Among these complications, postoperative atrial fibrillation (AF), renal failure, and re-exploration due to bleeding, were more frequent in the LAD group, and the difference was statistically significant. Mortality was higher in the LAD group (13.3% vs. 4.5%); however, the difference was not statistically significant (Table 2).

	LAD group		Non-LAD group		*P*
		%		%	
CPB time (minutes)	83.67	-	80.04	-	*0.624*
X-clamp time (minutes)	50.80	-	48.93	-	*0.597*
Mean number of bypasses (mean)	-	3.53	-	3.61	*0.951*
Saphenous patch	8	26.7	2	1.8	*0.031*
Multiple endarterectomy	14	46.7	11	10	*0.014*
Postoperative inotropic support	15	50	30	27.3	*0.032*
Postoperative IABP	3	10	7	6.4	*0.446*
Renal failure	5	16.7	1	0.9	*0.002*
Atrial fibrillation	7	23.3	8	7.3	*0.019*
Prolonged respiratory support	1	3.3	3	2.7	*0.821*
Peroperative MI	4	13.3	6	5.5	*0.221*
Re-exploration for bleeding	4	13.3	3	2.7	*0.038*
Postop complication	17	56.7	32	29.1	*0.010*
Intensive care stay length (days)	1.64	-	1.65	-	*0.208*
Hospital stay length (days)	7.8	-	-	7.9	*0.791*
Mortality	4	13.3	5	4.5	*0.099*

CPB: cardiopulmonary bypass; X-clamp: cross clamp; ITA: internal thoracic artery; LAD: left anterior descending artery; RCA: right coronary artery; CX: circumflex artery; IABP: intra-aortic balloon pump; MI: myocardial infarction

Table 2: Operative and postoperative patient data

Statistical Analysis

Statistical analyses were performed using SPSS software (version 17.0, SPSS, Chicago, IL, USA). The categorical data were expressed as percentage and frequency values; the continuous variables were expressed as mean, standard deviation (SD), and median values. An independent sample t-test was used to compare the continuous variables between the two groups. The Mann-Whitney U test was used to compare the continuous variables that did not meet the assumption of normal distribution. A Chi-square test was used to compare the categorical variables. Correlation of parametric variables was analyzed using Pearson's correlation coefficient test. A probability value (p) of 0.05 or lower was accepted as significant.

Discussion

CABG surgery is more complicated in patients with diffuse coronary artery involvement, particularly in patients with insulin-dependent DM, due to the complex coronary artery structure in these patients [3,4]. In these patients, the obstruction in the coronary artery is near-complete and involves a longer segment. Because standard coronary revascularization

techniques have been proven to be insufficient in these patients, CE is often required to achieve full revascularization and reduce the need for secondary interventions.

CE was first performed in two patients in 1975 by Bailey et al [7]. However, the outcomes were unsatisfactory because it was not initially performed as an adjunct to CABG [8,9]. Due to the high mortality and morbidity rates reported in studies conducted in the 1960s and 1970s, CE was not the preferred treatment option [6]. In later years, high postoperative MI and mortality rates have rendered this technique unfavorable [8,10]. However, recent studies have reported positive outcomes for both mortality and graft patency rates [11,12].

In related studies, the mortality rates in patients undergoing CE have been reported to range between 0-15% [3,12]. Studies comparing cases that underwent CE with those undergoing standard CABG have reported both favorable and unfavorable outcomes. Some studies have reported higher preoperative MI and higher in-hospital mortality rates in cases that underwent CE in comparison to the standard CABG cases [2,6]. In their meta-analysis, Wang et al. reviewed 30 studies published from 1970 to 2015, and found higher 30-day mortality and postoperative complication rates in patients that underwent CABG+CE [13]. Consequently, they recommended that CE should be performed only when required. Similarly, Trivulpati et al. compared groups of patients that did and did not undergo CE, and found a higher mortality rate in the CE group (8.6% vs. 4.6%) [6]. In their meta-analysis, Soylu et al. reviewed 30 studies and found that CE significantly increased the 30-day mortality rate and preoperative and postoperative MI [14].

In addition to the studies that reported unfavorable results, there are studies that have reported low mortality rates. Shapira et al. compared 151 patients that underwent CE with a control group, and found mortality rates as low as 2% in the CE group [15]. Two other studies also compared a CE group and a control group; Okur et al. reported mortality rates of 1.5% in the CE group and Nemati et al. reported mortality rates of 1.25% in the CE group [8,16].

Implementation of CE in these patient groups, surgical technique, vessel structure, and the number of vessels involved are also important topics of debate. CE performed in extremely thin vessels has been shown to result in lower patency rates as well as increased mortality and morbidity rates due to prolonged CC time. Shapira et al. recommended that vessels with an outer diameter >1.5 mm or a luminal diameter >1.5 mm following the endarterectomy procedure should be preferred for CE. They noted that CE performed in very thin vessels has a higher risk of graft occlusion during the early postoperative period due to the inability to completely remove the plaque in the vessel [15].

Several studies have reported higher mortality and morbidity rates following multiple CE in comparison to single CE. Brenowitz et al. compared a conventional CABG surgery group with a group that underwent adjuvant CE, and found higher mortality rates among patients undergoing multiple CE [17]. They reported mortality rates as low as 4% in the conventional CABG group, 6.3% in the single CE group, and 10.4% in the multiple CE group. Similarly, Soylu et al. reported that CE performed in multiple vessels was associated with higher mortality rates in comparison to single CE [10]. However, Zhu et al. did not report

multiple CE as an additional risk factor [11].

The site of CE has also been reported to be significant with regard to mortality and morbidity [1,11,18]. Silberman et al. compared a group of patients undergoing CE in LAD with patients undergoing CE in other vessels; they found higher operative mortality in the LAD group [19]. In contrast, Byrne et al. achieved mortality and morbidity rates as low as 3% in LAD group that included 196 patients [1]. Abrahamaov et al. compared a group of patients undergoing CABG alone to groups of patients undergoing adjuvant CE in LAD and RCA. While they did not find a statistically significant difference between the three groups regarding 30-day mortality, they did report that CE performed in RCA was a determinant factor for the development of late MI and postoperative low cardiac output [18]. In their case series of 188 patients undergoing CE in LAD, Nishigava et al. reported the 30-day mortality as 1.1% [9]. In another series that included 290 patients undergoing off-pump surgery, Zhu et al. did not find any difference between the three groups (CE in different vessel groups: LAD:60, CX:42, and RCA:217) with regard to early postoperative period mortality and morbidity [11].

Although various techniques, including laser, gas, and cardioplegic solution, have been tried since CE was first introduced, currently, manual CE is the most common technique [1,8]. This technique can be performed either open or closed. In the closed technique, standard arteriotomy is performed on the coronary artery; the plaque is dissected and removed by applying traction. Smooth tapering of the excised plaque is significant since it completely removes the plaque, even at the most distal part. This is very important in terms of preventing graft thrombosis during the early postoperative period. In the open CE technique, arteriotomy extends from the affected segment to the healthy segment, and all the visible plaque is removed. Afterwards, a bypass procedure is completed either by making a long direct anastomosis or by making anastomosis to the saphenous patch. If more than one arteriotomy is performed, the proximal arteriotomy site is anastomosed to the graft, and the distal arteriotomy site is closed with a saphenous patch. Nishi et al. compared a group of patients undergoing closed CE to another group receiving a long anastomotic patch of ITA in addition to open and long CE in 127 patients [20]. They observed that the angiographic patency rate was higher in the group of patients receiving a long anastomotic patch of ITA in addition to open and long CE. Angiographically, they found higher patency rates in the group receiving CE+long anastomosis. The patency rate at the end of the 21-month follow-up period was 89.1% in the open CE group and 81% in the closed CE group. Nishi et al. stated that this CE method would aid in avoiding overlooking the atheroma plaque localized to the side branches, in particular, and that the new arterial wall created with ITA would provide an advantage. Similarly, in their meta-analysis, Soylu et al. also reported that open CE yielded better outcomes than closed CE in terms of early mortality [10]. Moreover, deficiency in the release of factors, such as prostacyclin and nitric oxide, following endothelial damage would increase the tendency toward thrombosis during the early postoperative period. Therefore, harvesting the ITA should be preferred especially for LAD [12,15]. Furthermore, the ITA graft remains clear even when the forward flow is decreased. It can also adjust to various flow speeds due to the release of endothelial factors, such as prostacyclin and nitric oxide. These factors would increase the patency rate of an ITA graft in the long-

term [15,21]. We performed ITA anastomosis on a saphenous patch following long arteriotomy in 8 cases.

Several studies have reported better outcomes after CE is performed using the off-pump technique. Vohra et al. performed off-pump CABG+CE on 70 patients, and reported a low 30-day mortality rate (2.85%) [22]. Nishigava et al. performed CE+long anastomosis with a beating heart in their series (including 188 cases), and reported a low mortality rate (1.1%) as well as a patency rate of 91.6% during the early postoperative period [9]. However, it is also true that the off-pump technique should only be used in appropriate cases because of the diffuse involvement of the arteries in the patient population undergoing CE. Since our mean bypass rate was 3.6, we preferred to use off-pump surgery in only one case in comparison to the rest of the cases in our series.

There is no standard regarding the type of anti-platelet and anti-aggregant therapy to be administered after CE. Intravenous heparin infusion, low molecular weight heparin (LMWH), dipyridamole, dextran, and warfarin have been recommended for the early postoperative period [14,16]. However, administration of clopidogrel+acetylsalicylic acid is currently accepted as sufficient [3]. Continuation of double anti-platelet therapy for 3 months to a year and then switching to single anti-platelet therapy has been reported as being efficient in terms of graft patency [5]. We switched to single anti-platelet therapy following continuous double anti-platelet therapy for 6 months.

In addition to the higher mortality rates observed in patients undergoing CE, the need for a postoperative mechanic and positive inotropic support requirement is also greater [14]. Although recent studies have reported somewhat equal mortality rates, it is a fact that the patient population undergoing CE has a more complex vessel structure than those who do not receive CE. This complex involvement results in more bypass procedures and a longer CPB time [16]. Consequently, higher preoperative MI and mortality rates are observed. It has been emphasized that the higher mortality rate in cases undergoing CE is related to the endarterectomy technique and prolonged CC time, and it results from a higher prevalence of comorbid factors, such as DM, in these patients [6]. These comorbid situations cause higher mortality rates and higher postoperative complication rates in this patient population.

In our study, we observed a higher rate of postoperative complications in the LAD group. During the postoperative period, inotropic support requirement ($p=0.032$), renal failure ($p=0.002$), AF ($p=0.019$), and re-exploration due to bleeding ($p=0.038$) were all significantly more frequent among the patients undergoing CE the LAD group in comparison to the non-LAD group. Moreover, the postoperative mortality rate trended higher in the LAD group, although the difference did not reach a statistically significant level ($p=0.099$). This outcome can be partly explained by the fact that the number of patients with preoperative low LVEF was significantly higher in the LAD group (46.7% vs. 25.5%, $p=0.043$) and that multiple CE was performed in more patients in the LAD group (46.7% vs. 10%). Furthermore, the frequency of DM was somewhat high (53%) in both study groups; however, there was no statistically significant difference in DM between the LAD group and the non-LAD group (66.7% vs. 50%, respectively). This indicates that we performed surgical vascularization in a patient population that had a more complicated vascular structure.

Our study has several limitations. First, our study was the lack of angiographic follow-up in patients undergoing CE. Second, this was a retrospective observational study at a single center. Third, the number of patients was relatively small.

Conclusion

It should be noted that, due to increased mortality and morbidity, the postoperative period can be more complicated in cases undergoing CE in LAD as an adjunct to standard CABG due to factors, including vascular complexity and the presence of additional comorbidities, such as DM.

Declaration of Conflict of Interest

The authors declare that there is no conflict of interest concerning the conduct or publication of this study.

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