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Comparison of Isolated Coronary Artery Bypass Grafting with Open Coronary Endarterectomy Followed by Coronary Artery Revascularization

Açık Koroner Endarterektomi Sonrası Koroner Arter Revaskülarizasyonunun İzole Koroner Arter Baypas ile Karşılaştırılması

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ABSTRACT Objective: The coronary endarterectomy combined with coronary artery bypass grafting (CABG) is an effective and well-accepted surgical strategy in diffuse coronary artery disease. This study aimed to analyze the early and mid-term results of the patients who underwent coronary endarterectomy combined with CABG. **Material and Methods:** This retrospective study was conducted between January 2012 and December 2014. A total of 24 patients who underwent coronary endarterectomy combined with CABG (Group-1) and also 84 patients who underwent isolated CABG (Group-2) were investigated. **Results:** The early mortality was similar in both groups (Group-1: 4.2%, Group-2: 4.8%; P=1.000). The aortic cross-clamping time (ACCT) and total perfusion time (TPT) in the Group-1 were longer than those in the Group-2 (ACCT: 108.75 min vs. 82.89 min; P=0.001; TPT: 157.44 min vs. 107.18 min; P= 0.001, respectively. Duration of intensive care unit was longer for the Group-1 than that for the Group-2 (7.21 days vs. 4.13 days; P=0.013, respectively). At the end of the follow-up time (Group-1: 38.96±3.61 vs. Group-2: 44.42±1.54 months), the cumulative survival rates including hospital mortality were similar between the two groups (Group-1: 79.2±8.3% vs. Group-2 77.4±7.2%, p=0.350). **Conclusion:** The coronary endarterectomy is an effective method in early and midterm results and outcomes. Open coronary endarterectomy with long arteriotomy should be applied to obtain complete revascularization in diffuse and calcified coronary disease in proper indication.

Keywords: Endarterectomy; coronary artery bypass

ÖZET Amaç: Diffüz koroner arter hastalığında koroner arter baypas greft (KABG) ile birlikte yapılan koroner endarterektomi etkili ve kabul edilmiş bir cerrahi stratejidir. Bu çalışmada koroner endarterektomi ve birlikte KABG yapılan hastaların erken ve orta dönem sonuçlarının incelenmesi amaçlandı. **Gereç ve Yöntemler:** Çalışma Ocak 2012-Aralık 2014 tarihleri arasındaki zaman diliminde retrospektif olarak planlandı. Koroner endarterektomi ve KABG yapılan 24 hasta (Grup-1) ile izole KABG yapılan 84 hasta (Grup-2) incelendi. **Bulgular:** Erken mortalite her iki grupta da benzerdi (Grup-1: %4,2 Grup-2: %4,8; p=1,000). Aortik kros klemp zamanı (AKKZ) ve total perfüzyon zamanı (TPZ) Grup-1'de, Grup-2'den daha uzundu (sırasıyla; AKKZ: 108,75 dk.'ya karşı 82,89 dk. p=0,001 ve TPZ 157,44 dk.'ya karşılık 107,18 dk. p=0,001). Yoğun Bakım Ünitesi'nde kalış süresi Grup-1'de Grup-2'ye göre daha uzundu (7,21 güne karşılık 4,13 gün p=0,013). Takip süresi sonunda (Grup-1: 38,96±3,61 aya karşılık Grup-2: 44,42±1,54 ay), hastane mortalitesini kapsayan kümülatif sağkalım oranları her iki grupta benzerdi (Grup-1: %79,2±8,3'e karşılık Grup-2: %77,4±7,2, p=0,350). **Sonuç:** Koroner endarterektomi, erken ve orta dönem sonuçlar ve izlem yönünden efektif bir yöntemdir. Açık koroner endarterektomi uzun segment arteriyotomi ile birlikte uygun endikasyonda diffüz ve kalsifik koroner arter hastalığında komplet revaskülarizasyonu sağlayabilmek amacıyla uygulanmalıdır.

Anahtar Kelimeler: Endarterektomi; koroner arter baypas

Coronary endarterectomy combined with coronary artery bypass grafting (CABG) is a surgical option that has been accepted with its early and long-term outcomes in diffuse and calcific coronary artery disease.[1-7] Patients with diffuse calcific diseases, who have also long-segment or consecutive coronary lesions constitute a controversial and more risky group for surgical revascularization.

It has been known since the 1990s that patients who undergo CABG have more comorbid diseases.[8] This situation is more prominent in patients who have undergone coronary endarterectomy combined with CABG.[7] Diabetes mellitus (DM), chronic kidney disease (CKD), and peripheral artery disease are seen more frequently in the patients who have undergone coronary endarterectomy combined with CABG than in the ones who have undergone isolated CABG.[7] As more risky patients reffers to surgery, the percentage of the patients performed coronary endarterectomy combined with CABG has increased.[5]

This study retrospectively compared outcomes in early postoperative and mid-term survival of patients who underwent isolated CABG and endarterectomy combined with CABG for 3 years.

MATERIAL AND METHODS

One-hundred and eight patients who were operated between January 1, 2012, and December 31, 2014, were included in this study. Coronary endarterectomy combined with CABG was performed on 24 patients (Group-1), and isolated CABG was performed on 84 patients (Group-2). Demographic aspects, risk factors, and intraoperative and postoperative results of all patients were recorded. Data of the patients were obtained from patient files or electronic records, or via phone calls. Mid-term data were collected between January and March 2016. All of data were collected for 100% of the patients. The preoperative results of both groups are shown in (Table 1).

Exclusion criteria were simultaneous valve intervention, ascending aorta intervention, or carotid endarterectomy. Patients who underwent isolated redo CABG were included in this study.

Endarterectomy was performed in the cases whose target vessel showed long segment, thick calcific or diffuse involvement or consecutive lesions. Preoperative angiographic findings were mostly guided whether endarterectomy will be necessary. Presence of distal filling for any vessel antegradely or retrogradely was considered as a rule for endarterectomy. Perfusion scintigraphy was performed in some of the cases to evaluate the presence of viability to the area that supply by the target vessel. But last decision regarding endarterectomy was made intraoperatively.

Written informed consent was obtained from all the patients before the operations. The study protocol was approved by the Local Ethic Committee of Kartal Koşuyolu Heart Training and Research Hospital.

SURGICAL TECHNIQUE:

All the operations were performed under cardiopulmonary bypass with hypothermia (28-30°C) and cardioplegic arrest with cross-clamping. Cardiac arrest was provided single dose antegrade blood cardioplegia given aortic root needle. During the cross clamp period, myocardial protection was provided with continuous retrograde isothermal blood cardioplegia via coronary sinus in all cases.

In Group-1; long segment arteriotomy and open endarterectomy method was performed all the

TABLE 1: Preoperative patients' characteristics.

	Group-1 (n=24)	Group-2 (n=84)	p
Age Mean±SD (year)	64.04±9.65 (47-80)	63.13±9.44 (43-84)	**0.679**[1]
Women n,%	7 (29.2)	26 (31)	**1.000**[2]
DM n,%	11 (45.8)	38 (45.2)	**1.000**[2]
CKD n,%	1 (4.2)	5 (6)	**1.000**[3]
LVEF n,%			
>%50	8 (33.3)	56 (66.7)	
%30-50	11 (45.8)	23 (27.4)	**0.007**[4]*
<%30	5 (20.8)	5 (6)	

DM; Diabetes mellitus, CKD; Chronic Kidney Disease, LVEF; Left Ventricle Ejection Fraction.
*[1] Student t test [2] Continuity (yates) correction [3] Fisher's Exact test [4]Chi-Square tes *p<0.05*

target vessels. A 2- to 6-cm arteriotomy was made depending on the length of the plaque. The dissection plan of the plaque in the open segment was determined. The plaque was detached from the artery with the tip of the mosquito forceps, and the endarterectomized material was removed. Then, the plaque was gently held with the help of the vascular forceps and removed from first proximal closed and then distal closed segments as much length as possible. (Figure 1). While the endarterectomized material was removed in both closed segments; the surface of the heart was irritated using small surgical pads fastened with a clamp so as to be taken the plaque out of the vessel (Figure 1). Figure 2 demonstrated the extracted material which was obtained during endarterectomy procedure to RCA.

In the left anterior descending (LAD) anastomosis, left internal mammary artery (LIMA) graft was opened for almost 2–6 cm according to the arteriotomy length. The end to the side of the long segment of LIMA graft was directly anastomosed to LAD. No onlay saphenous patch was used for the anastomosis of LIMA to LAD. Saphenous grafts were used in all circumflex coronary artery (Cx) and right coronary artery (RCA) anastomoses,

Depending on the amount of drainage, unfractionated heparin was administered to the patients from postoperative day 0. The first dose was started in the postoperative eighth hour. After the patients were extubated, oral anticoagulant and antiaggregant were administered together. In some patients whom subtherapeutic anticoagulant levels were detected,

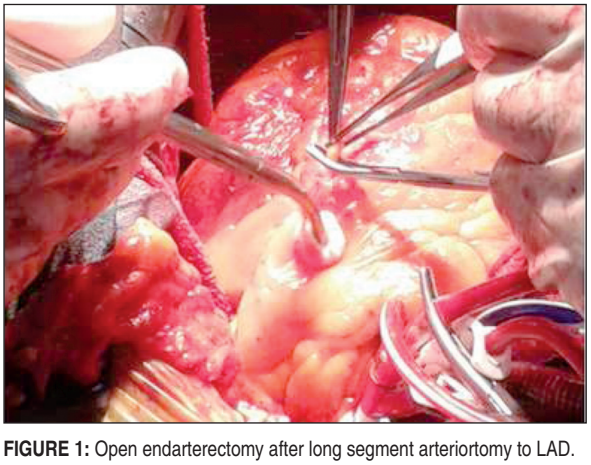

FIGURE 1: Open endarterectomy after long segment arteriortomy to LAD. LAD: Left anterior descending.

FIGURE 2: Material obtained after long segment open endarterectomy to right coronary artery.

low-molecular-weight heparin treatment was continued together with oral treatment after transferring the patients out of the intensive care unit (ICU). After discharge, anti-coagulant therapy was implemented two months in addition to antiaggregant treatment. The internationalized normalized ratio was kept between 2-2.5 during anticoagulant therapy.

STATISTICAL ANALYSIS

IBM SPSS Statistics version 22 (IBM SPSS, Turkey) was used for statistical analyses of data. The fitness of the parameters to a normal distribution was analyzed with the Shapiro-Wilk test. The normal distribution was found to be appropriate for the parameters. Besides descriptive statistical methods (average, standard deviation, and frequency), the Student *t* test was used to compare qualitative data fit to a normal distribution, and the Mann–Whitney *U* test was used to compare data that did not fit to a normal distribution. The chi-square, Fisher chi-square, continuity (Yates) correction, and Fisher-Freeman-Halton tests were used for qualitative data analysis. The Kaplan–Meier analysis and log-rank test were used for survival analysis. Statistical significance was defined by p-values of less than 0.05.

RESULTS

The preoperative characteristics of the patients are shown in (Table 1). Almost 45% of the patients had diabetes and 30% had women in both groups. The percentage of chronic kidney disease were similar. Patients with left ventricle dysfunction was significantly higher in the Group-1.

TABLE 2: Preoperative patients' characteristics.

	Group-1 (n=24)	Group-2 (n=84)	p
Number of Grafts *n,%*			
1	1 (4.2)	10 (11.9)	
2	7 (29.2)	41 (48.8)	**0.066**[1]
3	16 (66.7)	30 (35.7)	
4	0 (0)	3 (3.6)	
Use of LIMA *n,%*	24 (100)	82 (97.6)	**1.000**[2]
Use of IABP *n,%*	6 (25)	8 (9.5)	**0.078**[2]
30 day mortality	1 (4.2)	4 (4.8)	**1.000**[2]
Duration of ICU (day) *Mean±SD (median)*	7.21±7.51 (1-33)	4.13±3.69 (1-19)	**0.013**[3]*
Total drainage (cc) *Mean±SD*	1064.58±413.75 (500-2350)	902.98±385.85 (350-2350)	**0.078**[4]
TPT (min.) *Mean±SD*	157.96±44.34 (95-300)	107.18±31.88 (48-210)	**0.001**[4]*
ACCT (min.) Mean±SD	108.75±22.84 (58-153)	82.89±28.16 (28-147)	**0.001**[4]*

LIMA; Left internal mammarian artery, IABP; Intraaortic balloon pump, ICU; Internal Care Unit, TPT; Total perfusion time, ACCT; Aortic cross clamp time.
*[1]Fisher Freeman Halton test [2]Fisher's Exact test [3]Mann-Whitney U Test [4]Student t test *p<0.05.*

The intraoperative and postoperative results are shown in (Table 2). The average numbers of grafts were similar in both groups. Three grafts were used in 66% of Group-1 compared in 35% of Group-2. However, no difference between groups was found in terms of the number of grafts . Early mortality was similar in both groups. The 30-day mortality was 4.8% with 4 patients in the Group-2 and 4.2% with 1 patient in the Group-1 (P = 1.000). Duration of ICU, total perfusion time (TPT), and aortic cross-clamping time (ACCT) were significantly higher in the Group-1.

Table 3 shows the endarterectomized target vessels. A total of 26 endarterectomy procedures were performed on 24 patients. LAD endarterectomy was performed on 12 patients (50%), RCA endarterectomy was performed on 7 patients (29.1%), Cx endarterectomy was performed on 1 patient (4.1%), LAD and RCA endarterectomy was performed on 1 patient (4.1%), and LAD and Cx endarterectomy was performed on1 patient (4.1%) (Table 3).

Figure 3 shows the preoperative and postoperative coronary angiography images of the patient who underwent right coronary artery endarterectomy.

The Kaplan–Meier analysis was used to evaluate the survival rates including hospital mortality of both groups (Figure 4). For all of 108 patients, the average follow-up was 43.52±1.48 months and the cumulative survival rate was 77.1±6.3%.

In Group-1, the mean follow-up time was 38.96±3.61 months and the cumulative survival rate was %79.2±8.3. Five of the 24 cases (20.8%) were died on the follow-up period. The last death was seen in the 11th month.

In Group-2, the mean follow-up time 44.42±1.54 months and the cumulative survival rate was 77.4±7.2%. Twelve of the 84 cases (14.3%) were died on the follow-up period. The last death was seen in the 46th month.

No difference was found between survival rates analyzed using the log-rank test between Group-1 and Group-2 (p=0.350).

TABLE 3: Target vessels of the patients performing coronary endarterectomy in Group-1 (n=24).

	n	%
LAD	12	50
RCA	7	29.1
Cx	3	12.5
LAD and RCA	1	4.1
LAD and Cx	1	4.1

LAD: Left anterior descending, RCA:Right coronary artery, Cx Circumflex artery.

DISCUSSION

The most important result of the present study was that the early mortality and mid-term survival results (approximately 3.5 years) were similar in both groups.

The early mortality rate was 4.2% in the Group-1 and 4.8% in the Group-2. No differences was found statistically. In the literature the early mortality rates after coronary endarterectomy has been reported as 2.8-6%, which is similar to the present study results.[1-7,9]

Open endarterectomy and long-segment anastomosis were preferred in all cases of the Group-1. Use of both close and open endarterectomy technique in the same series successfully has been demonstrated.[6,7] Open endarterectomy is more time-consuming and may require more experience. Moreover, the obstructive plaque can be removed almost entirely by long-segment anastomosis. On the contrary, long-segment anastomosis increases the duration of the surgery. The ACCT and TPT were found to be higher in the patients who underwent coronary endarterectomy compared with those who did not in the present study. This result was similar to the result reported in the literature.[1,4,10,11]Additionally, angiographic results were significantly in favor of open endarterectomy in midterm period.[12] After control coronary angiography; stenoses or occlusion free anastomoses have been found 76.1% of patients with long arteriotomy and on-lay patch anastomoses

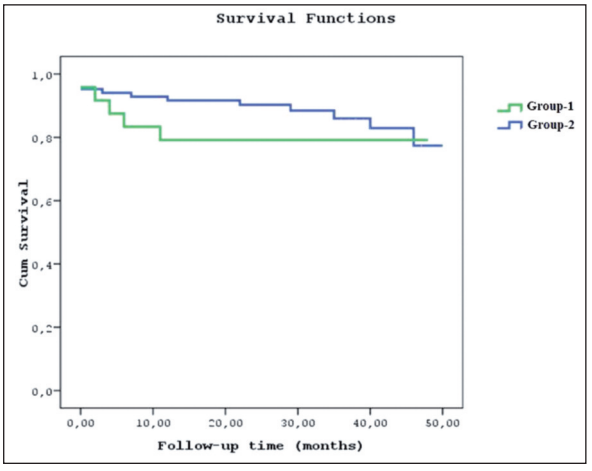

FIGURE 4: Survival as a function of years for patients in Group-1 and Group-2.

in a mean 20 months whereas 38.1% of the patients with short arteriotomy and closed traction method in a mean 24 months.[12]

The number of patients with left ventricle dysfunction was higher in the Group-1 in the present study ($p = 0.007$). In literature; higher percentage of left ventricular dysfunctions in patients with endarterectomy as seen in our study or similar ventricular functions in patients with or without endarterectomy have been reported.[1,3,7,9,10] Although the patients with left ventricle dysfunction was higher in the Group-1, low mortality rates were seen in both groups. As taken into consider the high percentage of women patients and diabetes for both groups, which were well-known two preoperative risk factors, this result is thought to

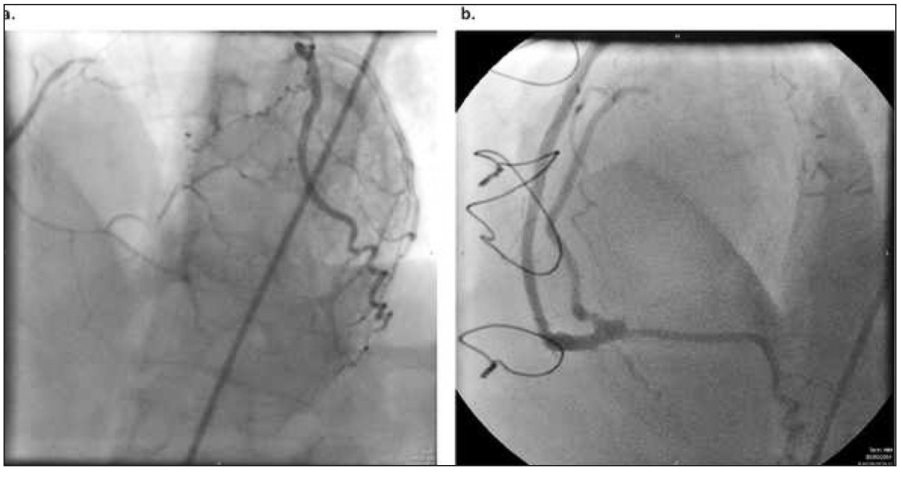

FIGURE 3: Right coronary endarterectomy **a)** Preoperative angiography. Retrograde poor filling of total occluded right coronary artery from left system in late phase, **b)** Postoperative coronary angiography after 27 months.Good filling of both saphenous graft and native vessel.

be related to the myocardial protection provided by the application of retrograde blood cardioplegia besides the effectiveness of endarterectomy. A study showing the early and long-term results of 224 patients who underwent long-segment LAD endarterectomy demonstrated that reliable and acceptable results might also be related to the application of retrograde cardioplegia, hence supporting the present findings.[13]

Duration of ICU stay was found to be higher in the Group-1; similar results are reported in the literature.[3,7,11] It has been stated that longer duration of ICU stay in endarterectomy patients are related to lung injury and prolonged intubation time due to longer operation time.[1] The present study did not investigate the prolonged mechanical ventilation time and inotrope usage. On the other hand, the average drainage amounts and intra-aortic balloon pump usage rates were similar in both groups.

The mid-term survival rates were similar in both groups. The survival rate in the two groups was 79.2% and 77.4%, respectively in the 3.5-year follow-up (P = 0.350). Our mid-term results study were comparable to the results reported in the literature. The 5-year survival rates of the patients who underwent coronary endarterectomy combined with CABG were reported as 70%–86% in previous studies.[3,5,7,10,14]

The limitations of the present study included having a relatively lower number of patients who underwent endarterectomy, not investigating percutaneous interventions, and all operations performed by a single surgeon. Some surgeons avoid endarterectomy because of perioperative complications. Main purpose of CABG operation is to be performed complete revascularization. To decide whether endarterectomy should be performed on a diffuse vessels mainly depends on experience of the surgeon, the anatomy of the lesion and the presence of comorbid diseases. For these reasons the balance between the potential benefits and the harmful effects of the endarterectomy should be adjusted for every patients with diffuse disease.

In conclusion, coronary endarterectomy combined with CABG is a safe method for treating multiple, diffuse and calcific coronary artery disease. Even though the rate of left ventricle dysfunction were higher and the duration of ICU period were longer in the Group-1; the early mortality and in about 3.5 years follow-up were similar in both groups. We believe that open endarterectomy with long arteriotomy can be performed to obtain complete revascularization in proper indications.

Conflict of Interest

Authors declared no conflict of interest or financial support.

Authorship Contributions

Mehmet Erdem Toker, Babürhan Özbek, Serkan Çelik, Hidayet Demir, İsmail Demir designed and performed the study and did the analysis and interpretation. All the authors participated in writing and critical revision of the manuscript and have approved of the final version.

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