

# Coronary Endarterectomy With Off-Pump Coronary Artery Bypass Surgery

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**Background.** The aim of this study is to review our experience in coronary artery endarterectomy performed without cardiopulmonary bypass.

**Methods.** Between May 1998 and June 2000 off-pump coronary endarterectomy was performed on 11 patients who had unstable angina pectoris. The mean ejection fraction (EF) was  $26.3 \pm 4.4$ , and all of the patients were New York Heart Association (NYHA) III or IV. Off-pump open left anterior descending (LAD) endarterectomy was performed on 7 patients, and closed endarterectomy of the right coronary artery (RCA) was done on the remaining 4.

**Results.** There were no deaths. None of the procedures was converted to on-pump operation; all the endarterectomies and bypasses were performed on the beating heart. All patients were completely revascularized, the

left internal mammary artery was bypassed to the LAD in all operations, and all other grafts were of saphenous vein. At the end of the first year all bypasses to the endarterectomized arteries were patent. The overall patency rate was 95.6%. The mean postoperative EF was  $34.7 \pm 9.1$ , which was significantly higher than the preoperative one ( $p < 0.05$ ). At the end of the first year 9 patients were NYHA I or II and all were angina free in Canadian Cardiovascular Society class 0 or I.

**Conclusions.** Endarterectomy without cardiopulmonary bypass can be performed in patients with severe left ventricular dysfunction who are expected to benefit from the complete revascularization.

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Complete revascularization is the most important goal of coronary artery bypass surgery [1–5]. If the atheromatous disease is segmental, the anastomosis performed to a nondiseased segment will be lifesaving. However in diffuse atheromatous disease, anastomosis is difficult to perform; therefore the plaque should be removed in order to facilitate the anastomosis.

Coronary artery endarterectomy was first introduced in 1957 for the treatment of diffuse coronary artery disease [6]. Endarterectomy carries a higher perioperative risk and compared with bypass grafting alone the long-term outcome is worse.

In recent years off-pump coronary bypass surgery has become the preferred technique especially in high-risk patients [7, 8]. Although it may be difficult to work on a beating heart, off-pump bypass surgery has important advantages. It does not have the inflammatory, neurologic, and renal adverse effects of cardiopulmonary bypass (CPB). Fewer blood transfusions and less ventilatory support are required so the related complications are fewer.

This present study was undertaken to review our total experience with patients undergoing coronary artery endarterectomy without cardiopulmonary bypass.

## Material and Methods

Off-pump coronary artery bypass surgery was performed on 162 patients in the Cardiovascular Surgery Department of Ankara University School of Medicine Hospital between May 1998 and June 2000. Endarterectomy was done in 11 of these patients. The left anterior descending coronary artery (LAD) was the target vessel in 7 and the right coronary artery (RCA), in 4. In none of the patients was endarterectomy performed on two separate arteries. The patients were advised of the details of the study and informed consents were obtained. Institutional Review Board approval was also received.

Preoperative and postoperative angiography, echocardiography, and myocardial scintigraphy with dipyridamole were performed on all patients. Ischemia was present on myocardial scintigraphy in all of these patients with unstable angina.

After preoperative evaluation we decided to perform complete revascularization off pump in all patients. In 7 patients the LAD was totally occluded but no significant stenotic lesion ( $>50\%$ ) was present in RCA; additionally a 1- to 2-cm distal segment retrograde filling was present in the LAD with a diameter of 0.5 to 1 mm. Arteriotomy was done at the most suitable segment of LAD. If a 1-mm probe could not be passed through, an open endarterectomy was performed. Blind RCA endarterectomy was performed on the remaining 4 patients.

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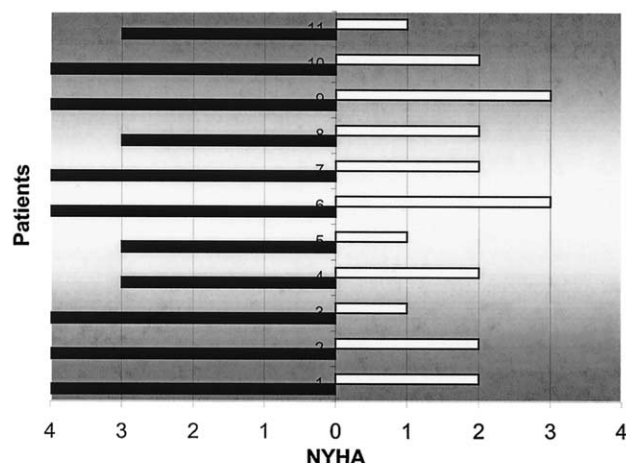


Fig 1. Preoperative and postoperative clinical status of the patients according to New York Heart Association (NYHA) classification. (White bars = postoperative; black bars = preoperative.)

There were 9 male and 2 female patients between 49 and 67 years of age (mean  $57.3 \pm 9.1$ ). Four of them were in New York Heart Association (NYHA) class III and 7 were NYHA class IV (Fig 1). The mean ejection fraction (EF) measured by ventriculography was  $26.3 \pm 4.4$  (the best EF was 31; Table 1).

#### Operative Technique

Preoperatively just after anesthesia induction an intraaortic balloon pump (IABP) was inserted in all patients and a median sternotomy was performed. Minimally invasive techniques were not used. Left internal mammary artery (LIMA) and saphenous vein grafts were prepared for grafting. To provide better access to lateral and posterior target vessels the pericardium was retracted by two or three deep sutures and two sponges were placed under the heart. The patient was situated in a slight right lateral decubitus and 20-degree Trendelenburg position. A nonprimed bypass circuit and a perfusionist were available in the operating room. Heparin, 100 U/kg, was also administered to keep the activated clotting time (ACT) between 200 and 300 seconds. During the operation an autotransfusion device was used for blood recovery.

Neither a heart stabilizer nor intraluminal shunts were used. A  $\beta$ -blocker (1 to 5 mg metoprolol) was administered intravenously to the patients whose hemodynamic status was suitable to keep the heart rate between 50 and 60 beats per minute. Silicone snare sutures were placed proximal and distal to the anastomosis in order to provide a bloodless field; in some operations bulldog clamps were used.

In all LAD endarterectomies a large arteriotomy was made to visualize all the branches. In none of the patients was closed endarterectomy performed. After the long arteriotomy the plaque was removed using a dissector assuring visualization of the limits of the endarterectomy without any blind traction. Dissection was also continued

Table 1. Preoperative Data

Characteristic	Number
Age (mean), years	$57.3 \pm 9.1$
Gender (male/female)	9/2
Ejection fraction	$26.3 \pm 4.4$
CCS angina class	
I	—
II	—
III	—
IV	11
NYHA class	
I	—
II	—
III	4
IV	7
Number of vessels diseased	
1	5
2	5
3	1
Prior MI	
Anterior	7
Anterolateral	2
Inferior	2
Risk factors	
Diabetes mellitus	10
Hypertension	6
Hyperlipidemia	4
Smoking	7
Family history	6

CCS = Canadian Cardiovascular Society; MI = myocardial infarction; NYHA = New York Heart Association.

to all diseased diagonal and septal branches. After the open endarterectomy a long segment of LIMA was sutured to the open LAD with an 8-0 polypropylene suture.

In the RCA, closed endarterectomy was performed. The plaque was dissected by blind traction and the saphenous vein was anastomosed to the RCA with a 8-0 polypropylene suture.

After each distal anastomosis, the proximal anastomosis was performed by using a side-biting clamp. The operative data are shown in Table 2.

#### Follow-Up

Coronary artery angiography and myocardial scintigraphy were done on all patients at the end of the first year. Echocardiography was performed preoperatively and postoperatively and every 3 months in the first year. Preoperative and postoperative clinical evaluation was done by the same physician according to NYHA and Canadian Cardiovascular Society (CCS) classifications.

#### Statistical Analysis

All data were expressed as the mean  $\pm$  standard deviation. The statistical evaluation of the results has been made according to the *t* test for paired samples.

Table 2. Operative and Postoperative Data

Mortality (%)	0
Operation time (min)	167 ± 22
Duration of intubation (hours)	11 ± 9
Duration of ICU stay (hours)	62 ± 30
Duration of hospitalization (days)	17.4 ± 3.2
Total number of vessels bypassed	23
Grafts	
LIMA	11
Saphenous vein	12
Preoperatively inserted IABP	11
IABP duration (hours)	54 ± 12
Inotrope requirement (hours)	62 ± 10
Postoperative bleeding (mL)	440 ± 210
Total unit of blood products transfused (per patient)	
Blood	0.8 ± 0.3
Platelets	1.8 ± 0.7
Fresh frozen plasma	1.2 ± 0.4

IABP = intraaortic balloon pump; ICU = intensive care unit;  
LIMA = left interval mammary artery.

## Results

There were no in-hospital deaths. All the operations were carried out without cardiopulmonary bypass. Also in none of the operations did the heart arrest or fibrillate; the endarterectomies and bypasses were performed on the beating heart.

The mean operating time was  $167 \pm 22$  minutes. The LIMA was used in all operations, and anastomosed to the LAD; additionally, saphenous vein was used as a second or third graft. The LAD and D1 were the bypassed arteries in 3 patients, the circumflex (Cx) and RCA were the other arteries bypassed in addition to the LAD (Table 3). Complete revascularization was achieved in all operations.

In all cases IABP was inserted just after induction of anesthesia. IABP counterpulsation was continued until the patient was hemodynamically stable. Mean duration of IABP use was  $54 \pm 12$  hours. During weaning hemodynamic instability was not encountered in any patient and none of them needed reinstitution of the IABP support. No complications occurred because of the IABP. Six patients during the operation and an additional 2 in the intensive care unit (ICU) required inotropic support.

Table 3. Bypasses Performed

Bypasses	Endarterectomy	Number of Patients	Number of Anastomoses
LAD	LAD	3	3
LAD,D1	LAD	2	4
LAD,Cx,D1	LAD	1	3
LAD,RCA	LAD	1	2
LAD,RCA	RCA	1	2
LAD,RCA,D1	RCA	3	9

Cx = circumflex artery; D1 = diagonal branch 1; LAD = left anterior descending artery; RCA = right coronary artery.

After cessation of the inotropic agents none of the patients needed resumption of the drugs during the remaining hospitalization. Dobutamine was the drug of choice in all patients, epinephrine was also administered to 4.

Postoperative electrocardiograms showed no specific changes and the myocardial enzymes did not increase.

None of the patients was reexplored for bleeding. The total amount of drainage was  $440 \pm 210$  mL and  $0.8 \pm 0.3$  U of donor blood was transfused (Table 2). Heparin, 5,000 U twice daily, was started after cessation of bleeding and continued up to the seventh postoperative day. Acetyl salicylic acid, warfarin, and clopidogrel were also added in some patients on the second day. All the patients were discharged with acetyl salicylic acid, warfarin, and clopidogrel in addition to their other drugs. Warfarin and clopidogrel were discontinued after 6 months.

With the exception of 1 patient who had chronic obstructive pulmonary disease, all were extubated in the first 24 hours. She was extubated on the second postoperative day (postoperative 38th hour) and did not need reintubation. The mean ICU stay was  $62 \pm 30$  hours. One patient who was weaned off the IABP on the 66th hour had the longest stay in the ICU. He was transferred to the ward on the fifth day (102nd postoperative hour). The mean hospital stay was  $17.4 \pm 3.2$  days for the cohort.

The preoperative mean EF was  $26.3 \pm 4.4$  and improved to  $34.7 \pm 9.1$  by the end of the first year. The difference was significant between the preoperative and the 1-year postoperative EF ( $p < 0.05$ ).

All LIMA-LAD anastomosis were patent on follow-up angiograms performed 1 year after the operation; no narrowing in the lumen was present. One saphenous vein to a diagonal branch (D1) anastomosis was occluded in an angina-free patient (patency rate 92.8%). Successful percutaneous transluminal coronary angiography (PTCA) and stent implantation was performed in this case. The overall graft patency at the end of the first year was 95.6%.

At the end of the first year 3 patients were NYHA class I, 6 were NYHA class II, and 2 were NYHA class III (Fig 1). None of them had angina pectoris, all were CCS class 0 or I.

## Comment

Incomplete revascularization is one of the important factors that affect operative and late mortality. It is reported that incomplete revascularization increases perioperative and late infarction incidence, increases the reoperation rate, and impairs the left ventricular function. Proper revascularization of the coronary arteries, especially the LAD, is the most important determinant of the patient's prognosis [1-4, 9].

Bailey and colleagues [6] first reported the results of coronary artery endarterectomy in 1957. Longmire and coworkers [10] in 1958 and Effler and coworkers [11] in 1964 followed. In the early years because of high operative mortality and increased incidence of perioperative infarction surgeons avoided endarterectomy. During

those years patients with diffuse LAD disease were not operated on or incomplete revascularization was performed. After improvement of the endarterectomy techniques endarterectomy of the coronary arteries became more acceptable [12-17].

Both open and closed endarterectomy can be performed on the LAD. Because the LAD is a three-dimensional structure, open endarterectomy is preferred to closed [18]. After an open LAD endarterectomy there are several methods for reconstructing the arteriotomy. One is an anastomosis of a long saphenous vein graft to the LAD. This technique is the simplest one, but the advantages of the LIMA are missed. The other method is the direct closure of a part of the arteriotomy and anastomosis of the LIMA graft to the remaining part. The disadvantage of this method is that the primarily repaired part is highly thrombogenic. The third technique is reconstruction of the arteriotomy with a vein patch and anastomosing the LIMA onto it. This reconstruction is also highly thrombogenic. The last technique, which we prefer, is a long anastomosis of the LIMA to the LAD. This is also time consuming and requires experience.

Cardiopulmonary bypass has many side effects on the body. Most of these effects are reversible in normal patients. But the CPB may have irreversible and even fatal effects in patients who have reduced ejection fraction. Ventricular function is one of the most important factors in coronary bypass surgery mortality [19]. Because of these adverse effects, surgeons began to perform bypass operations without CPB in selected patients [7, 8]. In concert with the general trend, off-pump bypass surgery has become the first choice of coronary bypass operations for high-risk patients in our clinic.

There are few reports of endarterectomies performed in off-pump bypass operations. Tamim and associates [20] reported 2 cases in which inflow cannulation could not be done because of severe aortic calcification. They performed endarterectomy to both LAD and RCA in both instances. Naseri and colleagues [21] reported 10 endarterectomies in 7 patients without cardiopulmonary bypass.

All the patients in our group had severe ventricular dysfunction. The mean ejection fraction was very low (34.7%). Their mean age was  $57.3 \pm 9.1$  years. Mortality and morbidity of coronary bypass surgery is very high for this group of patients. Some were even candidates for heart transplantation.

The patients in our group were CCS class IV and they all had unstable angina pectoris. Myocardial scintigraphy with dipyridamole showed ischemic myocardial areas rather than fixed perfusion defects. They were expected to benefit from the off-pump coronary bypass operation. Off-pump bypass surgery was performed and LAD open-endarterectomy in 7 and RCA endarterectomy in 4 was performed. None experienced perioperative myocardial infarction. All the grafts to the endarterectomized arteries were patent in the follow-up angiograms done at the end of the first year. The patency of all the grafts was 95.6%. Myocardial scintigraphy and echocardiographies

showed significant improvement in myocardial perfusions and ventricular functions.

Although endarterectomy and off-pump coronary bypass surgery have high mortality and morbidity they can be lifesaving in selected group of patients. Experience of the surgical team and selection criteria of the patients are very important in this regard. Endarterectomy without cardiopulmonary bypass can be performed in patients with severe left ventricular dysfunction who are expected to benefit from the complete revascularization.

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## Southern Thoracic Surgical Association: Fiftieth Annual Meeting

The Fiftieth Annual Meeting of the Southern Thoracic Surgical Association (STSA) will be held November 6-8, 2003, in Tampa, Florida.

Members wishing to participate in the Scientific Program should submit an abstract by April 7, 2003, 5:00 PM Central Daylight Time. Abstracts must be submitted electronically. Instructions for the abstract submission

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