The Heart Surgery Forum #2007-1058
11 (2), 2008 [Epub April 2008]
doi: 10.1532/HSF98.20071058

Online address: http://cardenjennings.metapress.com

Results of Adjunctive Coronary Endarterectomy in 548 Patients

Serdar Akgun,[1] C. Selim Isbir,[2] Tekin Yildirim,[3] Ali Civelek,[2] Sinan Arsan[2]

[1]Medicana Bahcelievler Hospital, Department of Cardiovascular Surgery; [2]Marmara University School of Medicine, Department of Cardiovascular Surgery; [3]Gaziosmanpasa Hospital, Department of Cardiovascular Surgery, Istanbul, Turkey

ABSTRACT

Coronary endarterectomy is a controversial procedure that plays a particular role in the treatment of coronary artery disease. We retrospectively investigated the results for 548 patients who underwent coronary endarterectomy as an adjunctive therapy for coronary artery bypass graft surgery during the period between 1996 and 2004. We assessed short-term outcomes and identified risk factors for adverse outcomes. Mean patient age was 67.9 ± 9.3 years and mean angina class was 2.7 ± 0.3. The mean number of distal anastomoses was 3.8 ± 1.1 patients (73.4%) had single and 151 (27.6%) multiple coronary artery endarterectomies. Of the 151 patients who underwent multiple endarterectomies, 97 (17.7%) had endarterectomies in 2 coronary arteries, 40 (7.2%) in 3 coronary arteries, 11 (2%) in 4 coronary arteries, 2 (0.36%) in 5 coronary arteries, and 1 (0.18%) in 6 coronary arteries. Postoperative mortality was 6.2% (34 patients). The predictors for early mortality were recent myocardial infarction and left ventricular dysfunction. Our results suggest that adjunctive coronary endarterectomy can be accomplished with acceptable results but with higher mortality rates than ordinary coronary artery bypass grafting. Adjunctive coronary endarterectomy should be considered as a last option for the surgical treatment of diffuse coronary disease.

INTRODUCTION

Since the first report of coronary endarterectomy (CE) by Bailey almost 50 years ago [Bailey 1957], the procedure has remained controversial. In recent years the patient population has changed dramatically, and cardiac surgeons are now faced with more diffuse and distal vessel diseases. The so-called nongraftable vessels remain one of the most vexing problems in cardiac surgery. Results of alternative therapies such as transmyocardial revascularization and stem cell therapy continue to be investigated [Epps 2002; Klein 2004; Gowdak 2005], but CE plays a particular role in the treatment of coronary artery disease under these difficult circumstances.

Initial results of CE in several institutions showed high postoperative morbidity and mortality and discouraged the wide use of this procedure. Reported rates of perioperative myocardial infarction are 4.9% to 13.1%, and the overall mortality of 4%-10% is higher than that reported for conventional coronary bypass surgery [Brenowitz 1988; Oelert 1988; Scheld 1988]. However, a recent trend toward decreased morbidity and mortality with the aid of improved myocardial protection and better postoperative care has encouraged surgeons to use CE more widely in conditions unsuitable for grafting.

The aim of the present study was to retrospectively review our experiences with CE to determine the factors associated with morbidity and mortality in a large group of patients.

Received February 11, 2007; received in revised form January 24, 2008; accepted January 25, 2008.

Correspondence: Sinan Arsan, Medicana Bahcelievler Hastanesi, Kardiyovaskuler Cerrahi, Eski Londra Asfalti No. 2, Bahcelievler, Istanbul, Turkey; 90 212 455 37 72; fax: 90 212 556 09 21 (e-mail: sinanarsan@superonline.com).

MATERIALS AND METHODS

Between 1996 and 2004, 3558 isolated coronary artery bypass graft (CABG) surgeries were performed by our group. Of these, 548 (15.4%) required CE. Patients who had concomitant procedures were excluded from the study.

Patient Demographics

Patient characteristics are listed in Table 1. The mean patient age was 67.9 ± 9.73 years (range 41 to 79 years), and 123 of the 548 patients (22.5%) were female. Diabetes was present in 126 of 548 patients (22.9%), hypertension in 299 of 548 (54.5%), and hyperlipidemia in 178 of 548 (20.9%). A total of 28 patients presented emergently; 128 (23.3%) had a recent myocardial infarction (less than 3 weeks earlier); and 103 (18.7%) had a left ventricular ejection fraction of less than 30%. A family history of heart disease was present in 287 patients (52.3%). Mean angina class was 2.7 ± 0.3.

Surgical Technique

The main indication for CE remains the presence of diffusely diseased distal coronary arteries that are unsuitable for grafting. Cardiopulmonary bypass was used in 548 patients. Mild-moderate systemic hypothermia (28°C-32°C) and antegrade isothermic blood cardioplegia were used as induction steps for myocardial protection. The blood cardioplegia was

Table 1. Preoperative Demographic and Clinical Characteristics of Coronary Endarterectomy (CE) Patients (N = 548)*

Age, y	67.9 ± 9.3
Sex	
Male	425 (77.5%)
Female	123 (22.5%)
Angiographic findings	
3-Vessel disease	474 (86.4%)
2-Vessel disease	67 (12.2%)
1-Vessel disease	7 (1.2%)
Left main stenosis	136 (24.8%)
Cardiac profile	
Emergency presentation	28 (5.1%)
Left ventricular ejection fraction	0.44 ± 0.19
Left ventricular dysfunction (<%30)	103 (18.7%)
Recent myocardial infarction	23.3% (128)
Mean angina class	2.7 ± 0.3
Noncardiac comorbidities	
Chronic obstructive pulmonary disease	117 (21.3%)
Diabetes mellitus	126 (41.2%)
Hypertension	299 (54.5%)
Hyperlipidemia	154 (28.1%)
Peripheral vascular disease	74 (13.5%)

*Values are presented as mean ±SD or n (%) of CE patients.

delivered through each of the vein grafts performed during the operation. For most of the procedures, we used angiographic views to schedule the CE before the surgery, but the final decision to perform endarterectomy was made by the surgeon intraoperatively after the coronary arteriotomy was made.

There are 2 basic endarterectomy techniques. In closed-traction CE (CCE), a relatively short incision is made at the anticipated graft anastomosis site. In open-traction endarterectomy (OCE), the arteriotomy is extended through a nondiseased lumen. Some authors also describe these techniques as "limited" and "extended." The atheroma is first pulled out with 2 fine forceps, and the traction and counter-traction are continued until the complete dissection of the atheromatous segment. Care is taken to perform the endarterectomy in 1 attempt for 1 vessel through the short incision. We usually prefer to remove the plaque distally. Proximal traction is applied when the plaque covers the major septal and diagonal branches. Maximum care must be taken not to leave intimal flaps.

If the attempt to extract the whole segment fails and disruption of the atheromatous plaque occurs, conversion to the OCE technique is often required. In such cases the entire length of the whole stenotic segment should be opened, extending all the way to the apex for the left anterior descending artery (LAD), which is then closed along the vein patch. We used both techniques (Figure 1 and 2), sometimes with satisfactory results. For such extensive lesions, we seldom used the left internal mammary artery (LIMA). We generally preferred to use a saphenous vein graft (SVG) in OCE to the LAD and other heavily calcified, tiny vessels. LIMA was used in most CCE to the LAD. We generally did not use dissectors

Figure 1. Endarterectomy material from the right coronary artery with the posterior descending artery.

and loops for CE. Postoperatively, low molecular weight heparin and later warfarin were used in addition to aspirin.

Statistical Analysis

Values are presented as mean ±SD or percentage of patients. SPSS statistical software (version 13.0) was used for univariate and multivariate analyses to determine the potential independent predictors of adverse outcomes.

RESULTS

The operative data are presented in Table 2. The mean number of grafts was 3.8 ± 1.1 The mean cardiopulmonary bypass time and cross-clamp times were 81.8 ± 27.5 and 43.3 ± 19.3 minutes. LIMA was used to bypass LAD in 128 patients (23.5%).

A total of 397 patients (73.4%) underwent single CE. Of these 397 single endarterectomies, 279 (50.8%) involved

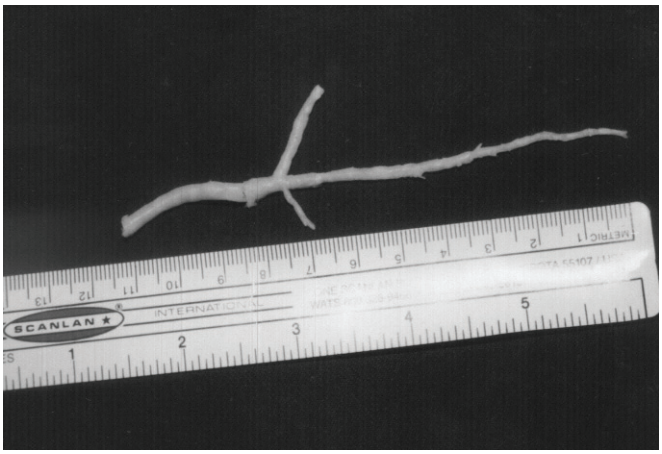

Figure 2. Endarterectomy specimen extracted from the left anterior descending artery, including the first diagonal and septal branches.

Table 2. Operative Data for Coronary Endarterectomy (CE) Patients (N = 548)*

No. of grafts per patient	3.8 ± 1.1
Cardiopulmonary bypass time, min	81.8 ± 27.5
Aortic cross-clamp time, min	43.3 ± 19.3
Left interior mammary artery graft	128 (23.5%)
Single CE	397 (73.4%)
Left anterior descending artery system	79 (12.5%)
Circumflex artery system	39 (9.8%)
Right coronary artery system	279 (50.8%)
Multiple CE	151 (27.6%)
2 Coronary arteries	97 (17.7%)
3 Coronary arteries	40 (7.2%)
4 Coronary arteries	11 (2%)
5 Coronary arteries	2 (0.36%)
6 Coronary arteries	1 (0.18%)
Total number of endarterectomies	771
Left anterior descending artery system	223 (28.9%)
Circumflex artery system	77 (17.1%)
Right coronary artery system	423 (54.8%)

*Values are presented mean ±SD or n (%) of patients.

Table 3. Postoperative Complications in Coronary Endarterectomy (CE) Patients (N = 548)*

Operative mortality	34 (6.2%)
Cardiac morbidity	
Myocardial infarction	41 (7.4%)
Inotropic medication	118 (21.6%)
Intraaortic balloon pump	51 (9.3%)
Cardiac arrhythmia	
(atrial fibrillation, ventricular tachycardia)	131 (23.9%)
Noncardiac morbidity	
Neurologic complications	21 (3.8%)
Infectious complications	12 (2.1%)
Sternal dehiscence	1.2% (7)
Multiple organ failure	23 (4.1%)
Reexploration for bleeding	13 (2.3%)
Gastrointestinal bleeding	7 (1.2%)
Acute renal failure	26 (4.7%)

*Values are presented as mean ±SD or n (%) of patients.

the right coronary system, 79 (12.5) the LAD system, and 39 (9.8%) the circumflex system. Multiple coronary endarterectomies were performed in 151 (27.6%) patients. Of these 151 patients, 97 (17.7%) had endarterectomies in 2 coronary arteries, 40 (7.2%) in 3 coronary arteries, 11 (2%) in 4 coronary arteries, 2 (0.36%) in 5 coronary arteries, and 1 (0.18%) in 6 coronary arteries.

A total of 771 coronary endarterectomies were performed; 423 (54.8%) involved the right coronary artery system, 223 (28.9%) involved the LAD system, and 77 (17.1%) involved the circumflex system. The OCE technique was used for 123 endarterectomies (15.9%) and the CCE technique for 648 (84.1%). The mean number of grafts was 3.8 ± 1.1 LIMA grafts were used to reconstruct the LAD in 128 patients (23.3%).

Early Morbidity

Observed hospital complications are presented in Table 3. Perioperative myocardial infarction occurred in 41 patients (7.4%). Perioperative myocardial infarctions were mostly localized to the endarterectomized field. Intraaortic balloon pump was used in 51 (9.3%) of patients with low cardiac output, and inotropic medication was used in 118 (21.6%) of patients. Cardiac arrhythmia, including atrial fibrillation an ventricular tachycardia and fibrillation, occured in 131 (23.9%) of patients.

Early Mortality

There were 34 early deaths in the study group. Postoperative early mortality was 6.2%. Operative mortality was 2.5% (14 patients) for single-vessel and 3.7% (20 patients) for multivessel CE. Causes of mortality were low cardiac output in 22 patients, multiorgan failure in 11 patients, and stroke in 1 patient. Of 22 patients with low cardiac output and multiorgan failure, 11 had perioperative myocardial infarction. Among patients treated by our group, early mortality in the endarterectomy group (6.2%) was not similar to the total mortality (2.8%) in the isolated CABG patient population.

In univariate analysis, we found that female sex, diabetes mellitus, recent myocardial infarction, severe peripheral arterial disease, severe left ventricular dysfunction (ejection fraction less than 30%), multiple CEs, and prolonged cross-clamp and cardiopulmonary bypass time were associated with increased risk of early mortality. In multivariate analysis the predictors for early mortality were recent myocardial infarction and left ventricular dysfunction. These findings are consistent with those reported for previous studies.

DISCUSSION

As the number of patients with diffuse coronary artery disease increases, CE might become an important tool in CABG surgery [Mills 1998; Ferraris 1999; Sundt 1999; Sirivella 2005]. The aim of CE is to perform as complete a revascularization as possible in coronary arteries with diffuse atherosclerotic disease. Adjunctive CE patients represent a highly selective group of patients undergoing CABG. The patients scheduled for adjunctive CE to achieve complete myocardial revascularization made up 15.4% of whole isolated CABG population, a percentage similar to that in previously published studies [Mills 1998; Ferraris 1999; Sundt 1999, Sirivella 2005].

Our results indicate that CE can be carried out with acceptable rates of mortality and morbidity. Although the mortality rate of our study (6.2%) is higher than that in other reported studies, patients who need this surgery are at high risk, and it is certain that mortality rates are lower for conventional CABG patients. In our clinical practice the mortality rates for CE patients are 6.2%, and those for CABG patients who do not need CE are 2.8%.

Our results indicate that the type of graft and the location and extent of the endarterectomized territory did not influence

early mortality in contrast to the general and already reported worse outcomes associated with adjunctive CE of the LAD. This finding is similar to those of previously published reports [Brenowitz 1988; Sundt 1999]. Although most surgeons might expect that multiple CEs are associated with worse operative mortality rates than single CE, multivariate analysis of our data did not show any association between the number of endarterectomized arteries and mortality rates.

The LIMA graft is used less frequently with CE than with CABG without CE. At the beginning of this study we chose to use the SVG because our goal in performing CE is complete removal of the calcified plaque, an approach that resulted in much longer endarterectomies and occasional preference of the LIMA graft. As the study progressed we adapted our procedure to use more LIMA grafts with small CCE arteriotomies. It is widely accepted, however, that LIMA grafts have better graft patency rates than SVGs, indicating that better results are associated with LIMA grafts.

The use of OCE versus CCE did not influence the rates of in-hospital mortality and perioperative myocardial infarction in our patients. We believe that if the proximal lumen is heavily calcified, OCE is safer than CCE because it prevents the occlusion of major side branches such as septal perforators in the LAD. We therefore recommend OCE in patients with proximal calcifications requiring endarterectomy.

The same problem of complex stenosis that happens in on-pump coronary bypass also occurs during off-pump coronary bypass operations. In high-risk patients with diffuse atherosclerotic lesions it may be necessary to perform CE off-pump, sometimes involuntarily. Our group was probably the first to report the use of off-pump CE [Naseri 1999], followed by Bedi and Kalkat [1999].

Univariate analysis of our data showed that female sex, diabetes mellitus, recent myocardial infarction, left ventricular dysfunction, peripheral arterial disease, multiple CEs, and longer cross-clamp and cardiopulmponary bypass times were associated with early mortality. In multivariate analysis, left ventricular dysfunction and recent myocardial infarction were the only predictors for early mortality. These findings are consistent with other reports in the literature. Brenowitz and colleagues [1998] also reported age, diabetes mellitus, reoperation, female sex, and left ventricular dysfunction as predictors of early mortality. In their recent study, Triuvoipati et al [2005] observed that female sex, renal impairment, nonelective surgery, left ventricular dysfunction, and peripheral arterial disease were associated with early mortality. Sirivella [2005] reported that the predictors of hospital mortality were prolonged cardiopulmonary bypass time, recent myocardial infarction, and left ventricular dysfunction. Our results are also consistent with their findings. In our study, we observed that perioperative myocardial infarction was more frequent in diabetics. This association may be related to both the diffuse disease pattern and the increased risk of reperfusion injury in diabetic patients. Although this study does not have any data indicating that ischemia-reperfusion injury is more frequent in CE, reperfusion injury is one possible explanation for increased perioperative myocardial infarction in diabetics.

One of the major drawbacks of CE is increased risk of coagulation due to the lack of endothelium and increased myocyte proliferation in the endarterctomized arterial wall. Those endarterectomized arteries tend to be thrombosed. Nishi et al [2005] reported better results with OCE than CCE with long arteriotomies and on-lay patch bypass grafting. Their results were comparable with those of other studies, and they and others concluded that long arteriotomies with on-lay patch reconstruction prevent intimal proliferation and thus preserve graft patency [Fukui 2005; Nishi 2005; Santini 2005; Tiruvoipati 2005]. Our group widely used this reconstruction technique during the first years of the study. Truvoipati et al [2005] and O'Neil et al [2005] reported that preoperative aspirin and statin use was beneficial for decreasing mortality. We believe that postoperative anticoagulation is also important in CE, and in our CE patients we start anticoagulation with low molecular weight heparin immediately after surgery and then maintain patients on a lifelong regimen of warfarin and aspirin.

Our study has several limitations. It is a retrospective, not a randomized study, and there is no control group. Because it was difficult to create a control group with comparable and similar variables to the CE group, adequate statistical power was not obtained, a limitation that is inherent to these types of studies. Compared to previously reported studies, ours has one of the largest populations of patients who underwent adjunctive CE. Other shortcomings of this study are the lack of follow-up data and assessment of graft patencies. We had almost full follow-up information for patients without sufficient numbers of control angiographies, and we sought to present early results of adjunctive CE in a more appropriate way. However long-term results as determined by survival appeared satisfactory [Sirivella 2005].Our main intention, however, was to encourage our colleagues to review their own opinions and results regarding CE.

Adjunctive CE in experienced hands is a well-established therapy for coronary artery disease. The results of this study indicate that CE can be carried out with an acceptable but higher operative risk when applied in a highly selective manner to only a small percentage of target vessels not otherwise graftable. Nevertheless, we prefer to use CABG without CE whenever possible. Adjunctive CE can be recommended with a word of caution as a last option for completely occluded coronary arteries with poor distal flow pattern. We believe that CE is a technique deserving better credit and further research use.

REFERENCES

Bailey CP, May A, Lemmon WM. 1957. Survival after coronary endarterectomy in man. J Am Med Assoc 164(6):641-6.

Bedi HS, Kalkat MS. 2000. Endarterectomy on a beating heart: comment on: Ann Thorac Surg 1999;68(2):630-1. Ann Thorc Surg 70(1):338-40

Brenowitz JB, Kayser KL, Johnson WD. 1988. Results of coronary endarterectomy and reconstruction. J Thorac Cardiovasc Surg 95(1):1-10.

Brenowitz JB, Johnson WD, Kayser KL, Saedi SF, Dorros G, Schley L. 1998. Coronary artery bypass grafting for the third time or more: results of 150 consecutive cases. Circulation 78(3 Pt 2):1166-70.

Epps WM, Francalancia N. 2002. Transmyocardial laser revasacularization (TNR) and its role in the treatment of patients with coronary artery disease and angina. Curr Surg 59(3):253-7.

Ferraris VA, Harrah JD, Moritz DM, Stritz D, Ferraris SP. 1999. Long-term angiographic results of coronary endarterectomy for the treatment of diffuse coronary arte disease. Ann Thorac Surg 68(4):1272-7.

Fukui T, Takanashi Sİ, 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(6):2098-105.

Gowdak LH, Schettert IT, Rochitte CE, et al. 2005. Cell therapy plus transmyocardial laser revascularization for refractory angina. Ann Thorac Surg 80(2):712-4.

Klein HM, Ghodsizad A, Borowski A, et al. 2004. Autologous bone marrow-derived stem cell therapy in combination with TMLR. A novel therapeutic option for end stage coronary heart disease: report on 2 cases. Heart Surg Forum 7(5):E416-9.

Mills NL. 1998. Coronary endarterectomy: surgical techniques for patients with extensive distal atherosclerotic coronary disease. Adv Card Surg 10:197-227.

Naseri E, Arsan S. 1999. Coronary endarterectomy on beating heart [Letter]. Ann Thorac Surg 68(2):630-1.

Nishi H, Miyamato S, Takanashi S, et al. 2005. Optimal method of coronary endarterectomy for diffusely diseased coronary arteries. Ann Thorac Surg 79(3):846-52; discussion 852-3.

Oelert H, Hake U, Schmiedt W, Iversen S, 1988. Prerequisite coronary endarterectomy for coronary bypass gafting. Adv Cardiol 36:62-4.

O'Neil-Callahan K, Katsimaglis G, Tepper MR, et al. 2005. Statins decrease perioperative cardiac complications in patients undergoing noncardiac vascular surgery: the Statins for Risk Reduction in Surgery (StaRRS) study. J Am Coll Cardiol 45(3):336-42.

Santini F, Casali G, Lusini M, et al. 2002. Mid-term results after extensive vein patch reconstruction and internal mammary artery grafting of the diffusely diseased left anterior descending coronary artery. Eur J Cardiothorac Surg 21(6):1020-5.

Scheld HH, Gorlach G, Evers J, Moosdorf R, Hehrlein FW, Walter PJ. 1988. Use of endarterectomy as an adjunct to coronary artery bypass. Adv Cardiol 36:65-70.

Sirivella S, Gielchinsky I, Parsonnet V. 2005. Results of coronary endarterctomy and coronary bypass grafting for diffuse coronary artery disease. Ann Thorac Surg 80:1738-45.

Sundt TM 3rd, Camillo CJ, Mendeloff EN, Barner HB, Gay WA Jr. 1999. Reappraisal of coronary endarterectomy fot the treatment of diffuse coronary artery disease. Ann Thorac Surg 68(4):1272-7

Tiruvoipati R, Loubani M, Lencioni M, Ghısh S, Jones PW, Patel RL. 2005. Coronary endarterectomy: impact on morbidity and mortality when combined with coronary artery bypass surgery. Ann Thorac Surg 79(6):2999-3003.

Tiruvoipati R, Loubani M, Peek G. 2005. Coronary endarterectomy in the current era. Curr Opin Cardiol 20(6):517-20.