

Extensive endarterectomy and reconstruction of the left anterior descending artery: Early and late outcomes

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Objectives: Coronary endarterectomy has been shown to be an effective adjunctive technique of revascularization for diffuse coronary artery disease. A long arteriotomy and reconstruction of the left anterior descending artery (LAD) are occasionally required for complete extraction of the atherosclerotic plaque. The aim of this study was to examine early and late results of this technique and compare 2 different reconstruction methods.

Methods: We retrospectively reviewed 224 consecutive patients who underwent extensive LAD endarterectomy and reconstruction between January 1992 and March 2010. For reconstruction, 101 patients underwent saphenous vein patch and LAD grafting (group A) and 123 patients had left internal thoracic artery onlay patch grafting (group B). We compared early and late outcomes and assessed the association of the reconstruction method and long-term survival.

Results: The mean age was 66 and 67 years in groups A and B, respectively. Operative mortality was 3.0% and 4.1%, and the incidence of perioperative myocardial infarction in the LAD territory was 4.0% and 4.1% in groups A and B, respectively. There was no significant difference in early operative outcomes ($P > .05$). Actuarial 5-year survival was 78.6% and 87.1% and 10-year survival was 45.4% and 49.4% in groups A and B, respectively. Cox hazard proportional analysis showed that the reconstruction method did not have a significant impact on long-term survival.

Conclusions: Extensive LAD endarterectomy and reconstruction is a safe and feasible technique of revascularization for diffuse coronary artery disease. The reconstruction method should be based on the availability of conduits and length of the arteriotomy. (*J Thorac Cardiovasc Surg* 2012;143:1336-40)

An increasing number of patients with advanced coronary artery disease and diffusely complex atherosclerotic lesions are referred for coronary artery bypass grafting (CABG). Coronary endarterectomy has been shown to be a feasible and safe technique for diffusely diseased coronary arteries in several recent studies, although it was initially associated with an increased operative morbidity and mortality.¹⁻⁷ More recently, left anterior descending artery (LAD) endarterectomy has been shown to be safer than previously thought.⁸⁻¹¹ Unlike the right coronary artery, the LAD atherosclerotic core is narrow and delicate, which increases the risk of disruption under tension. Furthermore, the LAD has diagonal and septal branches that occur in 2 different planes. As a result, unidirectional traction on the plaque can cause shearing off of branches.¹² At the same time, the LAD warrants endarterectomy for the purpose of complete revascularization of those

important branches. Open coronary endarterectomy, involving a long arteriotomy, is necessary when plaque extraction is incomplete through a limited arteriotomy from undue resistance or when the plaque is fractured. The open technique under these circumstances provides adequate exposure to extract the atherosclerotic core. The basic principle of coronary endarterectomy is complete extraction of the plaque. Nishi and associates¹³ showed that the midterm angiographic results of open coronary endarterectomy with onlay patch grafting are better than those of the traction technique.

There are different strategies to reconstruct the LAD after extensive endarterectomy. Because of the prevalence of thrombosis, primary closure techniques have been abandoned. Saphenous vein grafting is used occasionally; however, the technique demonstrated poorer outcomes than left internal thoracic artery (LITA) grafting.¹⁴ Open LAD endarterectomy with saphenous vein patch reconstruction combined with LITA grafting was first reported by Fundaro and associates¹⁵ in 1987, with subsequent technical modifications introduced.^{16,17} LITA onlay patch grafting was established by Shapira and associates¹² in 1988. Tasdemir and colleagues¹⁸ suggested that the low incidence of atherosclerotic disease of the LITA conduit is advantageous for this technique. More recently, Barra and coworkers¹⁹ described an endarterectomized LAD reconstruction technique with plaque exclusion using the LITA onlay patch graft, which

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Abbreviations and Acronyms

CABG	= coronary artery bypass grafting
LAD	= left anterior descending artery
LITA	= left internal thoracic artery
PMI	= perioperative myocardial infarction

replaces 75% of the circumference of the endarterectomized arterial wall with the LITA patch. Our group¹¹ previously reported our midterm experience in LAD endarterectomy, which included all LAD endarterectomies.

In this study, we reviewed our results over an 18-year experience in the most severe disease, requiring open extensive endarterectomy and reconstruction of the LAD, and compared the outcomes of 2 different reconstruction methods.

PATIENTS AND METHODS

Study Design and Patient Data

This retrospective cohort study was conducted between January 1992 and March 2010, during which time 14,941 consecutive patients underwent CABG to the LAD at our institution. Of these patients, 639 (4.3%) underwent LAD endarterectomy in addition to CABG. Of them, 224 patients underwent extensive LAD endarterectomy with a long arteriotomy and reconstruction of the LAD, which accounts for 1.5% of the total CABG to the LAD. One hundred one patients had saphenous vein patch combined with LITA grafting (group A) and 123 patients had LITA onlay patch grafting (group B).

All preoperative, in-hospital, and postdischarge data were collected from the medical records and the Brigham and Women's Hospital cardiac surgery database according to definitions from The Society of Thoracic Surgeons adult cardiac database version 2.52. Recent myocardial infarction was defined as a myocardial infarction that occurred 1 to 7 days before surgery. Old myocardial infarction was defined as a myocardial infarction that occurred more than 7 days before surgery. Perioperative myocardial infarction (PMI) was defined as new electrocardiographic or echocardiographic changes with creatine kinase MB more than 100 ng/mL.

Long-term survival data were collected from the national Social Security Number Database. This study was approved by the Institutional Review Board of Brigham and Women's Hospital and individual patient consent was waived.

Indications for LAD Endarterectomy

In practice, we perform endarterectomy for a diffusely diseased coronary artery in which we cannot pass a 1-mm probe. Importantly, this approach is not always predictable. We occasionally find that coronary arteries cannot be revascularized with a plain CABG procedure after making an arteriotomy, contrary to preoperative angiographic findings. In such cases, there is no other option than endarterectomy. In principle, we do not perform endarterectomy for nonviable myocardium, although viability studies were not performed systematically in the preoperative workup. We consider endarterectomy unless we are certain about nonviability.

Surgical Procedure

All procedures were performed with median sternotomy and cardiopulmonary bypass. Deep hypothermic circulatory arrest was required in only 1 patient, for proximal anastomosis on a calcified ascending aorta.

After the coronary arteriotomy, an endarterectomy spatula was used to identify the plane of dissection and then to mobilize the plaque proximally and distally. A 1-mm probe was advanced gently through the plane of dissection to break away resistant adhesions. A combination of gentle traction on the plaque and countertraction on the adventitia is useful to extract the plaque. When proper distal tapering of the specimen was not achieved, the arteriotomy was extended distally for complete extraction of the plaque. The proximal end of the endarterectomy should be distal to the most proximal lesion, to avoid competitive flow through the native coronary artery, to the level of the first diagonal branch at most. The length of endarterectomy did not vary between groups of LAD reconstruction techniques: it had to be considered complete in both groups. The atherosclerotic plaque varies from soft to extremely calcified and adherent. This characteristic dictates the length of the arteriotomy inasmuch as adherent plaques cannot be removed easily through a limited arteriotomy to at least the distal two thirds of the length of the LAD. If this was the case, the arteriotomy was extended to allow for complete extraction of the atherosclerotic core.

After complete extraction, retrograde cardioplegic solution was given to flush out any debris that may have embolized distally. A visible flow of retrograde cardioplegic solution through the diagonal and septal branches is indicative of successful endarterectomy.

The saphenous vein patch was applied to the endarterectomized LAD with a long arteriotomy and the LITA was then applied to either the middle of the vein patch or the proximal end of the LAD arteriotomy (Figure 1). LITA onlay patch grafting was used for a relatively short arteriotomy after confirming that there was no tension on the graft.

Postoperative Management

Continuous intravenous unfractionated heparin (500 units/h) was initiated after chest tube output dropped below 50 mL for 2 consecutive hours and was continued for 24 hours. Aspirin was started on the day of the operation. Before 1999, warfarin was administered for at least 3 months after the operation. Since 1999, clopidogrel has been used for 1 year after the operation instead of warfarin.

Statistical Analysis

The continuous variables are expressed with mean \pm standard deviation or median if the variables were not normally distributed. For comparison of the 2 groups, an unpaired *t* test, Wilcoxon rank sum test, or Fisher's exact test was used as deemed appropriate. The Kaplan-Meier method and Breslow test were used to analyze long-term survival. Cox hazard proportional models were constructed to assess the adjusted association between the LAD reconstruction method and long-term survival. Stepwise selection was used for selecting the covariates in the model. All statistical tests were 2-tailed. Statistical analyses were performed using SPSS version 18 (SPSS, Inc, Chicago, Ill).

RESULTS

Preoperative Characteristics

The mean age of the entire study population was 66.2 \pm 10.2 years, 84% of whom were male. None of the patients had an acute myocardial infarction within 24 hours before the operation. The preoperative characteristics of each group are shown in Table 1.

Intraoperative Data

The mean number of grafts was 3.2 \pm 0.8 and 3.3 \pm 0.9 in groups A and B, respectively ($P = .206$). The cardiopulmonary bypass times were 174 \pm 59 and 138 \pm 50 minutes ($P < .001$) and the aortic crossclamp times were 131 \pm 49

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