Coronary endarterectomy in the left anterior descending artery

Shuichiro Takanashi (MD)\textsuperscript{a,*}, Toshihiro Fukui (MD)\textsuperscript{a}, Yuji Miyamoto (MD)\textsuperscript{b}

\textsuperscript{a}Department of Cardiovascular Surgery, Sakakibara Heart Institute, 3-16-1 Asahi-cho, Fuchu-shi, Tokyo 183-0003, Japan
\textsuperscript{b}Department of Cardiovascular Surgery, Hyogo College of Medicine, Hyogo, Japan

Received 19 September 2008; accepted 24 September 2008
Available online 28 October 2008

KEYWORDS
Coronary artery disease;
Coronary vessels;
Heart surgery

Summary

Background: The diffusely diseased coronary artery is a challenge for cardiac surgeons. Although coronary endarterectomy is an option for surgical reconstruction of a diffusely diseased vessel, it has not been widely used. We assessed the early clinical and angiographic outcomes of patients undergoing coronary endarterectomy of the left anterior descending artery (LAD) with a patch plasty method using the left internal thoracic artery (LITA). Furthermore, we assessed the coronary artery velocity flow reserve (CFVR) of the endarterectomized LAD.

Methods: We retrospectively reviewed the records of 148 patients undergoing LAD endarterectomy using the in situ LITA. Direct endarterectomy was performed with a long segmental incision of the LAD that was reconstructed with the longitudinally incised LITA. The mean age at surgery was 65.1 ± 8.6 years. Previous myocardial infarction was observed in 58.1% of the patients. The mean Canadian Cardiovascular Society score was 2.4 ± 0.9. Postoperative angiography was performed in 134 patients (91.2%) during the same hospitalization (mean, 11.2 ± 9.0 postoperative days). CFVR in the LAD was measured early after the operation by transthoracic echocardiography.

Results: The mean number of distal anastomoses per patient was 4.2 ± 1.3. The mean length of reconstructed LAD with endarterectomy was 5.8 ± 1.5 cm. The operative mortality was 2.7%. Low cardiac output occurred in 6.1% of the patients. Perioperative myocardial infarction was observed in 12.2% of the patients, but severe ventricular arrhythmia was not encountered. The patency rate of the LITA to LAD was 94.0% by early angiographic examination. The mean CFVR in the endarterectomized LAD was 2.41 ± 0.66.

\* Corresponding author. Tel.: +81 42 3143111; fax: +81 42 3143133.
E-mail address: takehashi-s@gem.hi-ho.ne.jp (S. Takanashi).

0914-5087/S — see front matter © 2008 Published by Elsevier Ireland Ltd on behalf of Japanese College of Cardiology.
Conclusions: Coronary endarterectomy of the LAD with a patch plasty using the LITA is associated with acceptable mortality, morbidity, and angiographic patency. CVFR measured by transthoracic echocardiography showed a favorable functional status in the endarterectomized LAD. Endarterectomy is considered to be one of the available surgical methods for patients with a diffusely diseased LAD.

Introduction

Recently, the use of percutaneous coronary intervention (PCI) for treatment of coronary artery disease has progressively increased. A large number of simple stenoses in one or two coronary vessels can be treated by PCI. Therefore, the number of high-risk and severely diseased patients referred for coronary artery bypass grafting (CABG) has been relatively increasing. Coronary endarterectomy has been used to treat severely or diffusely diseased coronary arteries since the 1950s [1]. However, early experiences of this method were not associated with satisfactory clinical results [2—4]. More recently, the benefits of endarterectomy for the left anterior descending artery (LAD) have gradually become recognized because surgical techniques and technologies have evolved [5,6]. The greatest advantage of endarterectomy is that the myocardium supplied by the side branches (diagonal branches and septal perforators) of a diffusely diseased LAD can be relieved of ischemia. This advantage cannot be obtained using a conventional graft to the distal LAD alone because this is beyond the diffusely diseased segments. The aim of the present study was to review the clinical efficacy and angiographic features of endarterectomy for a diffusely diseased LAD.

Patients and methods

Study patients

Between April 2001 and March 2008, 148 patients underwent coronary endarterectomy of the LAD with the in situ left internal thoracic artery (LITA) at the Shin-Tokyo Hospital and the Sakakibara Heart Institute. The preoperative characteristics of the patients are shown in Table 1. The mean age at surgery was 65.1 ± 8.6 years. Previous myocardial infarction was observed in 58.1% of the patients. The mean Canadian Cardiovascular Society score was 2.4 ± 0.9. The study protocol was approved by the Institutional Review Committee of the Sakakibara Heart Institute, and informed consent was obtained from each patient with respect to the surgical method, postoperative angiography, and echocardiography.

Operations

The indications and surgical methods were partly described previously [7]. The target artery for performing coronary endarterectomy was the LAD. We carried out endarterectomy with the principle that the diffusely diseased LAD and its side branches (septal perforators and diagonal branches) affected by severe atheromatous plaque should be relieved of ischemia. In addition, we performed endarterectomy when there was no place in the LAD to be anastomosed to the LITA.
Coronary endarterectomy in the left anterior descending artery

Angiography and echocardiography

Postoperative angiography was performed to check for graft patency in all patients who provided informed consent. Early postoperative angiography was performed in 134 patients (91.2%).

The coronary flow velocity reserve (CFVR) was measured to evaluate the functional capacity of the LAD distal to the endarterectomized segment by transthoracic Doppler echocardiography in 8 patients. Adenosine triphosphate (0.14 mg/kg/min for 2 min) was used for hyperemia.

Definitions

Non-elective operations included both emergency and urgent cases. Operative death was defined as death within 30 days of surgery. Low-output syndrome was defined as the need for adrenaline or more than 5 μg/kg/min of dopamine or dobutamine. Perioperative myocardial infarction (POMI) was defined as a positive result for new Q waves in an electrocardiogram or a peak creatine kinase MB level of >10% of the total creatine kinase. Respiratory failure was defined as a requirement for prolonged ventilation (>48 h) or the presence of pneumonia. A postoperative cerebrovascular accident was defined as the occurrence of a new stroke or intracranial bleeding, and confirmed by computed tomography. In patients with preoperative stroke, postoperative stroke was defined as worsening of the neurologic deficit with new radiological findings.

Statistical analysis

All statistical analyses were performed using the StatView 5.0 software package (SAS Institute Inc., Cary, NC, USA). Continuous variables are reported as the mean ± standard deviation. Continuous variables were compared by Student’s t-test, while discrete variables were compared by the χ²-test or Fisher’s exact test. Differences were considered significant at p < 0.05.

Results

Clinical outcomes

A total of 148 patients underwent coronary endarterectomy of the LAD with the in situ LITA. The intraoperative data are listed in Table 2. The mean number of anastomoses per patient was 4.2 ± 1.3. Isolated CABG was performed in 138 patients (93.2%), and concomitant procedures
Fig. 1 Intraoperative photographs. (A) The left anterior descending artery was reconstructed with a long segmental patch anastomosis using the left internal thoracic artery. (B) A specimen of the endarterectomized core.

were performed in 9 patients (valve surgery in 3 patients, maze procedure in 5, and left ventricular restoration in 3). Off-pump CABG was performed in 121 patients (81.8%). The mean length of the endarterectomy of the LAD was $5.8 \pm 1.5$ cm. A representative case is shown in Fig. 1.

There were 4 operative deaths (2.7%). Low cardiac output syndrome was observed in 9 patients (6.1%). POMI was observed in 18 patients (12.2%), but severe ventricular arrhythmia was not encountered. The other postoperative outcomes are listed in Table 2.

Angiographic results

Early postoperative angiography was performed in 134 patients (91.2%). Complete patency of both the LITA and LAD was observed in 126 patients (94.0%). A representative case is shown in Fig. 2. Occlusion of both the LITA and LAD was observed in 3 patients. Occlusion of the LITA with a patent LAD was observed in 2 patients and occlusion of the distal LAD with a patent LITA was observed in 3 patients. Among these 8 patients with anastomosis failure, 6 received immediate PCI. Furthermore,
Table 2  Intraoperative and postoperative data of patients undergoing endarterectomy of the left anterior descending artery.

<table>
<thead>
<tr>
<th>Number or mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anastomoses per patient</td>
</tr>
<tr>
<td>Length of endarterectomy (cm)</td>
</tr>
<tr>
<td>Off-pump procedure</td>
</tr>
<tr>
<td>Operation time (min)</td>
</tr>
<tr>
<td>Postoperative intubation time (h)</td>
</tr>
<tr>
<td>Intensive care unit stay (day)</td>
</tr>
<tr>
<td>In-hospital stay (day)</td>
</tr>
<tr>
<td>Operative death</td>
</tr>
<tr>
<td>Low output syndrome</td>
</tr>
<tr>
<td>Perioperative myocardial infarction</td>
</tr>
<tr>
<td>Atrial fibrillation</td>
</tr>
<tr>
<td>Severe ventricular arrhythmia</td>
</tr>
<tr>
<td>Respiratory failure</td>
</tr>
<tr>
<td>Re-exploration for bleeding</td>
</tr>
<tr>
<td>Stroke</td>
</tr>
<tr>
<td>New need of hemodialysis</td>
</tr>
<tr>
<td>Mediastinitis</td>
</tr>
</tbody>
</table>

there was only 1 patient with POMI among the 8 patients and the mortality was zero.

Echocardiographic results

A total of 139 patients (93.9%) had both preoperative and postoperative data for the left ventricular ejection fraction. There was no significant difference between the preoperative and postoperative data (54.4 ± 12.1% vs. 53.3 ± 11.0%; p = 0.1022). Postoperative color-Doppler enhanced transthoracic echocardiography was performed in 8 patients (Fig. 3). The peak and mean CFVR values at the distal LAD were 2.43 ± 0.70 and 2.41 ± 0.66, respectively (Table 3). These findings demonstrate that the CFVR was sufficiently preserved in the endarterectomized LAD.

Discussion

A principal goal in CABG is to achieve complete revascularization of diseased coronary arteries [9]. In particular, the LAD is a very important vessel because incomplete revascularization of the LAD has been proven to be a predictor of worse mortality after CABG [10]. However, the diffusely diseased LAD remains a challenge for both PCI and CABG. Diffusely diseased coronary arteries have been treated by endarterectomy from the beginning of coronary artery surgery [1]. Recent publications have revealed that endarterectomy is a safe procedure and demonstrated favorable long-term outcomes [5,6,11,12]. In our experience, endarterectomy has been performed with good clinical outcomes and angiographic results.

In the present study, the mortality rate of patients undergoing endarterectomy was 2.7%,
which is similar to other reports [5,6,11,12]. The relatively higher mortality for endarterectomy compared with conventional CABG may arise through associated comorbidities and risk factors rather than the use of endarterectomy per se.

The major aim of endarterectomy is to establish sufficient blood supply to side branches (diagonal branches and septal perforators) that suffer from diffusely lying plaque. Simple anastomosis to the distal LAD cannot achieve sufficient blood supply to these important side branches. Endarterectomy can eradicate the sequence of plaques and directly supply blood flow to these vessels. Another advantage of endarterectomy is the ability to obtain an anastomosis site when there are severe calcifications or soft plaques that do not allow the performance of

<table>
<thead>
<tr>
<th>Table 3</th>
<th>Color-Doppler parameters by transthoracic echocardiography.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Heart rate</td>
</tr>
<tr>
<td>Baseline</td>
<td>73.6 ± 11.3</td>
</tr>
<tr>
<td>Hyperemia</td>
<td>74.5 ± 13.7</td>
</tr>
</tbody>
</table>

Coronary flow velocity reserve (peak) = 2.43 ± 0.70.
Coronary flow velocity reserve (mean) = 2.41 ± 0.66.
Coronary endarterectomy in the left anterior descending artery

Coronary endarterectomy of complex intimal lesions allows anastomoses to be created more easily.

The optimal technique for performing endarterectomy remains controversial [13]. There are two surgical methods, designated the closed and open methods. The closed method is carried out by traction of the endarterectomized intima through a small arteriotomy. Although it does not take much time, and anastomosis of the graft is easy, there are several possible disadvantages [14]. These disadvantages include the possibilities that diagonal branches and septal perforators may be torn off despite gentle traction, and that the distal end of the lumen may become occluded with a thrombus or dissection owing to insufficient endarterectomy. On the other hand, although the open method (long arteriotomy and total removal of plaque under direct visualization) requires a longer time, the openings of the side branches and distal end of the LAD can be directly observed and confidently endarterectomized using this method. Furthermore, we can fix the divided intima of the distal LAD to secure the distal flow using this method. We have adopted the open method with good results [6].

Recent investigations have shown that endarterectomy without use of cardiopulmonary bypass (off-pump CABG) can be performed safely [15,16]. We also performed endarterectomy safely and effectively in 121 patients (81.8%) using the off-pump method. Consistent with the findings of the other investigations, we also found that coronary collaterals offer protection against myocardial infarction during off-pump surgery [17]. We consider that a severe diffusely diseased LAD can withstand longer ischemic times because significant collaterals have developed in this situation.

The long open incision in the LAD was reconstructed with the LITA in the present study. We prefer using the LITA for reconstruction, rather than a saphenous vein graft or other arterial grafts, because of the superior patency rate of the LITA [10]. In our study, a perfect patency rate of the LITA and LAD was obtained in 126 patients (94.0%). We consider that this rate is satisfactory in these severely diseased LADs. Occlusion of the LITA without occlusion of the LAD was observed in 2 patients. We speculate that these cases arose owing to flow competition between the LITA and the native LAD because the most proximalstenotic lesion was endarterectomized. Occlusion of the LAD with or without occlusion of the LITA was observed in 8 patients. We think that these occlusions occurred through local hypercoagulation. The major causes for suboptimal results after coronary endarterectomy are related to triggering of the coagulation cascade by a lack of endothelium in the early stages [18]. Tight management of antiplatelet and anticoagulation should be given after endarterectomy. In addition, PCI should be considered when an electrocardiogram is abnormal, even if the hemodynamic condition is stable after the operation.

There was no significant difference between the preoperative and postoperative ejection fractions. We did not have any data regarding local functional improvement of the anteroseptal myocardium. As an alternative, we examined the local coronary flow functional status in the endarterectomized LAD. Color-Doppler contrast-enhanced echocardiography was successfully performed before and after an adenosine provocative test to evaluate the flow dynamics of the endarterectomized LAD, and demonstrated that sufficient CFVR was obtained in the endarterectomized LAD. These results show that endarterectomy of the LAD using the in situ LITA can yield sufficient blood supply in the large territory of the myocardium. We have been adopting this diagnostic tool in increasing numbers of patients for functional assessment of the endarterectomized LAD and to collect further data.

Study limitations

The limitations of the present clinical study are as follows: (1) the number of patients was small, (2) we only had CFVR data in 8 patients, (3) we did not carry out long-term clinical follow-up, and (4) this was a retrospective observational study and not randomized.

Conclusions

Coronary endarterectomy of the LAD with a patch plasty using the LITA is associated with acceptable mortality, morbidity, and angiographic patency. CVFR measured by transthoracic echocardiography demonstrated that a favorable functional status was achieved in the endarterectomized LAD. Endarterectomy is considered to be one of the available surgical methods for patients with a diffusely diseased LAD.

References


