CARDIOVASCULAR

Coronary Endarterectomy and Stent Removal in Patients With In-Stent Restenosis

Toshihiro Fukui, MD, Shuichiro Takanashi, MD, and Yasuyuki Hosoda, MD

Department of Cardiovascular Surgery, Shin-Tokyo Hospital, Chiba, Japan

Background. **In-stent restenosis (ISR) remains the major limitation of coronary stent implantation. Controversies exist regarding optional treatment for ISR. Recently, we developed aggressive surgical options, coronary endarterectomy and stent removal, in this complex setting.**

Methods. **Between April 2001 and March 2004, 11 consecutive patients who presented with angina and angiographically severe ISR were treated with coronary endarterectomy and stent removal with concomitant multivessel coronary bypass grafting. There were 10 men and 1 woman. The age ranged from 43 to 75 years old (mean 64.1 ± 9.6 years). The mean number of target vessel interventions was 1.6 ± 0.7. Data were analyzed retrospectively.**

Results. **The target vessel was the left anterior descending artery (LAD) in all patients. The mean interval from the last intervention was 4.8 ± 1.9 months. The mean number of target vessel interventions was 1.6 ± 0.7. The mean LAD incision length was 57.3 ± 11.0 mm. The left internal mammary artery (LIMA) was grafted in situ, as an on-lay patch. Procedural success without in-hospital complications was achieved in all cases, except one patient with low output syndrome. Postprocedure angiography demonstrated that all LIMA patches and LAD arteries were patent and left ventricular functions were preserved.**

Conclusions. **Coronary endarterectomy and stent removal with on-lay LIMA patch is a safe and effective technique used in patients with ISR involving diffuse target vessel disease.**

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Intracoronary stents reduce restenosis as compared to balloon angioplasty. However, in-stent restenosis (ISR) remains to be an important clinical problem. Although ISR can be treated with balloon angioplasty, the recurrence rate is significantly high, especially in diffuse ISR. Recently, various interventional treatments have been used for the treatment of ISR including balloon angioplasty [1, 2], directional coronary atherectomy [3, 4], rotational atherectomy [5, 6], additional stenting [7, 8], and radiation treatment [9, 10]. However, the optimal management of ISR is still unknown. Drug-eluting stents have resulted in a decreased restenosis rate for the treatment of de novo coronary stenosis [11–13] and have also been used in patients with ISR. However, interventional methods are often inadequate for use in patients with severe ISR [14]. Moustapha and colleagues [15] reported that coronary artery bypass grafting had a better outcome in patients with ISR, rather than the use of interventional methods.

Coronary endarterectomy is a procedure that may be done concomitantly with coronary artery bypass grafting. This procedure is suitable for diffuse coronary artery disease, in conditions unsuitable for bypass grafting. There were once negative evidences that endarterectomy was associated with a high perioperative risk and poorer long-term results [16, 17]. But recent reports stated the safety and efficacy of bypass grafting with positive angiographic and clinical results [18, 19]. However, there have been only a few reports about coronary endarterectomy for the treatment of ISR [20, 21]. We reviewed our experience of coronary endarterectomy for the treatment of ISR and evaluated the advantages of this procedure in reconstruction of the complicated coronary artery stenosis.

Patients and Methods

Patient Population

Between April 2001 and March 2004, we performed coronary artery bypass surgery on 762 patients. Ninety-eight patients (12.9%) were treated previously with coronary stent implantation by interventional cardiologists. Eleven patients underwent coronary endarterectomy and stent removal before bypass grafting. Patient characteristics are listed in Table 1. The age range was from 43 to 75 years old (mean 64.1 ± 9.6 years). The mean Canadian Cardiovascular Society (CCS) functional class was 2.4 ± 0.8. Degree of in-stent narrowing ranged from 75% to 99%, and there was no patient with complete occlusion of the left anterior descending artery (LAD). The mean preoperative ejection fraction (EF) was 58.0 ± 10.7%. Anterior left ventricular wall motions were normokinetic in all patients, except one patient (patient 1) whose anterior wall motion was severely hypokinetic. Interval from the latest intervention ranged from 2 to 8 months (mean 4.8 ± 1.9 months). The mean number of target vessel interventions was 1.6 ± 0.7.

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Address reprint requests to Dr Fukui, Department of Cardiovascular Surgery, Shin-Tokyo Hospital, 473-1 Nemoto, Matsudo City, Chiba 271-0077, Japan; e-mail: tm-fukui@gem.hi-ho.ne.jp.

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Abbreviations and Acronyms

CPB = cardiopulmonary bypass
EF = ejection fraction
INR = international normalized ratio
ISR = in-stent restenosis
LAD = left anterior descending artery
LIMA = left internal mammary artery
PCI = percutaneous coronary intervention
PTCA = percutaneous transluminal coronary angioplasty

Surgical Technique

The indication for coronary endarterectomy and stent removal is as follows:

1. A long segmental stenosis at the stent implantation site with diffuse distal arteriosclerosis.
2. A septal perforator or a diagonal branch of the left anterior descending artery that may be relieved from ischemia by endarterectomy.
3. Sequential bypass grafting of a diagonal branch and distal LAD cannot be applied because of small distal target or severe disease with arteriosclerosis at anastomosis site.

Cardiopulmonary bypass (CPB) and aortic cross clamp was used in 4 patients. An arterial cannula was inserted through ascending aorta and venous cannula by right atrial appendage using two-stage cannula. Cardioplegic solution was administered in both antegrade and retrograde fashion. Before endarterectomy, the other coronary vessels were bypassed as usual. Endarterectomy and bypass grafting to the stented vessel was then performed for LAD in all patients. Coronary arteriotomy was started from the distal end of the stent and extended proximally and distally. After the adventitia of the stented artery was carefully dissected and incised, the intima and neointima of the stented artery was removed. The distal incision was extended to nondiseased site. The internal mammary artery graft (LIMA) was incised longitudinally to match the length of the arteriotomy and running 8-0 polypropylene sutures were used for the anastomosis. Several threads were tied and extended in order to avoid purse string effect.

An off-pump technique was used in 7 patients. A Starfish heart positioner and an Octopus tissue stabilizer (Medtronic Inc., Minneapolis, MN) were used. A bloodless field was obtained using a proximal silastic snare suture and a CO_2 blower.

The postoperative anticoagulation protocol was as follows:

1. Continuous intravenous infusion of low molecular weight heparin (5000 U/day) was started after the operation. This anticoagulation was continued until warfarin was effective.
2. Low-dose aspirin (100 mg/day) and warfarin (maintained with target international normalized ratio [INR] of 2.0) were started after the initiation of oral ingestion.
3. After 3 months, warfarin was stopped but aspirin was continued permanently.

Follow-Up

Medical records were reviewed and mortality and morbidity of each patient was identified. Postoperative complications included the following: myocardial infarction (new Q wave in electrocardiogram or creatine kinase MB >10%), low cardiac output (a newly placed intraaortic balloon pumping or the use of inotropic agents, dopamine or dobutamine, $>5\ \mu g \cdot kg^{-1} \cdot min^{-1}$), ventricular tachycardia or fibrillation, bleeding requiring reexplora-

Table 1. Preoperative Patient Characteristics

Patient Number	Age	Gender	UAP	CCS Class	Diseased Vessel	Preoperative EF (%)	Degree of In-Stent Narrowing (%)	Time From Latest Intervention (Months)	History of Target Vessel Interventions	Number of Stented Arteries
1	53	Male	Yes	4	Triple	29	75 ~ 90	2	stenting 3 times	1 (LAD)
2	66	Male	No	2	Double	57	99	5	stenting 1 time, BA 1 time	3 (LAD, Cx, RCA)
3	43	Male	No	3	Triple	61	75 ~ 90	3	stenting twice	2 (LAD, RCA)
4	67	Male	Yes	2	Triple	65	90	5	stenting 1 time	2 (LAD, RCA)
5	70	Female	No	1	Double	63	90	7	stenting twice	2 (LAD, RCA)
6	62	Male	No	2	Triple	63	75 ~ 90	2	stenting 1 time, BA 1 time	1 (LAD)
7	60	Male	Yes	2	Triple	50	75 ~ 90	6	stenting 1 time	1 (LAD)
8	63	Male	No	2	Triple	66	75	4	stenting 1 time	3 (LAD, Cx, RCA)
9	75	Male	Yes	3	Triple	56	75 ~ 90	5	stenting 1 time, BA 1 time	3 (LAD, Cx, RCA)
10	72	Female	No	2	Triple	64	75 ~ 90	6	stenting 1 time	2 (LAD, Cx)
11	74	Female	No	3	Triple	64	90	8	stenting 1 time	1 (LAD)

BA = balloon angioplasty; CCS = Canadian Cardiovascular Society; Cx = circumflex artery; EF = ejection fraction; LAD = left anterior descending artery; RCA = right coronary artery; UAP = unstable angina pectoris.