

Reoperation for Coronary Artery Disease: Devised Management for Reoperation Including Digital Subtraction Angiography

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Between December 1990 and August 1999, a consecutive series of 494 patients underwent coronary artery bypass grafting, while 19 (3.8%) patients underwent isolated reoperative coronary bypass grafting. The mean age of 16 males and 3 females who underwent reoperation was 63.4 ± 6.4 years. The mean interval from the initial operation to reoperation was 50.7 ± 61.0 months (range 3 days to 16 years). There were neither operative nor in-hospital deaths. Post-operative graft patency was 96.9% in all the bypass grafts and 96.7% in the arterial grafts. Despite the small number of reoperations, the outcomes were favorable due to our devised management: the patients who had received coronary artery bypass grafting underwent intra-aortic digital subtraction angiography 7 days postoperatively to evaluate the early graft patency, which subsequently avoided reoperation 1 to 3 months after the initial operation when the pericardial adhesion was tight; in the primary operation, internal thoracic artery grafts were covered with thymus, and the pericardium was closed for an easy sternal re-entry; and in the reoperation, stenotic grafts were dissected and ligated after aortic cross-clamping, all sides of the heart were dissected to obtain a good operative field and to prepare for any cardiac accident, arterial grafts were used to avoid re-reoperation, and aprotinin was useful in reducing perioperative bleeding. The present findings suggest that intra-aortic digital subtraction angiography, appropriate preparation for follow-up surgery at the primary operation, and complete revascularization using arterial grafts at reoperation appear to have contributed to the satisfactory outcome in coronary reoperation. (*Ann Thorac Cardiovasc Surg* 2002; 8: 18–23)

Key words: reoperation, coronary artery bypass grafting, digital subtraction angiography, graft stenosis, atherosclerosis

Introduction

Presently in Japan, coronary artery bypass grafting (CABG) has become an established surgical procedure for coronary revascularization of an increasing number of patients. Although, a large number of coronary reoperations have already been reviewed in the United States,¹⁻⁷⁾ they are still uncommon in Japan.⁸⁾ Intimal hy-

perplasia causes early vein graft stenosis, and atherosclerosis causes late vein graft stenosis.^{5,9,10)} As a result, vein graft hyperplasia occurs in 30% of patients 5 to 8 years after CABG,¹¹⁾ and more than half of the vein grafts may become atherosclerotic within 10 years.¹⁾ Both vein graft stenosis and native coronary atherosclerosis are progressive phenomena in patients who underwent CABG previously, thus, reoperative coronary surgery is unavoidable and it is increasing also in Japan.

Recently, we compiled our experience of 19 coronary artery reoperations carried out over a period of 8 years and 9 months. The object of the present report is to review these patients and to evaluate our devised management of reoperative CABG to obtain a better outcome

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Table 1. Characteristics of patients undergoing a single operation and reoperation

	Single operation	Reoperation	Probability
Number of patients	475	19	
Gender male/female	367 / 108	16 / 3	NS
Age (years) range	30 - 84	47 - 77	
mean	63.9 ± 9.1	63.4 ± 6.4	NS
Previous myocardial infarction	356 (74.9%)	13 (68.4%)	NS
Heart failure	102 (21.5%)	4 (21.1%)	NS
Preoperative use of IABP	129 (27.1%)	6 (31.6%)	NS

IABP: intra-aortic balloon pumping, NS: not significant.

based on our experience.

Materials and Methods

Patients

Between December 1990 and August 1999, 494 consecutive patients underwent CABG at Tokyo Saiseikai Central Hospital, while 19 (3.8%) patients underwent reoperative CABG. In this series, the records of these 19 patients were reviewed. The 19 patients ranged in age from 47 to 77 (mean 63.4±6.4) years and 16 of them were males. The initial operation was performed at our hospital in 11 patients and at other hospitals in 8 patients. The mean interval from the initial operation to the reoperation was 50.7±61.0 months (range 3 days to 16 years): interval < 2 weeks in 4 patients; 2 weeks ≤ interval < 12 months in 3; 12 months ≤ interval < 60 months in 5; and 60 months ≤ interval in 5. Table 1 shows the characteristics of these patients compared with those of patients undergoing a single operation. Reoperations were indicated by findings of the coronary arteriogram: bypass graft stenosis alone in 13 patients; and a combination of graft failure and progression of the native coronary artery disease in 6.

Reoperation

To perform reoperative coronary surgery safely, we usually expose the femoral artery and vein for a possible cannulation prior to sternotomy. In addition, an oscillating saw for re-sternotomy is used for the lifted sternum by pulling previously laid wires. After dissection of the ascending aorta and right atrium for cannulation, cardiopulmonary bypass is established. When there is inadequate space for aortic cannulation due to the prior proximal anastomoses of the vein grafts, a femoral artery is preferred for arterial access. After all sides of the heart are dissected to obtain a good operative field, cardiac arrest is induced

by aortic cross-clamping and the antegrade infusion of high potassium cold cardioplegia. Then the stenotic grafts are all ligated. We try to replace all vein grafts with 50% or greater degrees of stenosis, and to graft new to stenotic native coronary arteries. Both distal and proximal anastomoses are performed during a continuous single period of aortic occlusion to avoid cerebral complications. Aprotinin at a dose of 2,000,000 units, when it was not used at the initial operation, is administered to reduce intraoperative and postoperative bleeding.

Initial operation

Before closing a sternotomy, the pericardium is always closed directly or with an equine pericardial sheet to reduce the possibility of injuring the heart at re-sternotomy. All internal thoracic artery (ITA) grafts are covered with thymus, and hemo-clips are placed on the thymus above the ITA grafts as markers. Aprotinin is not used, to avoid possible anaphylactic shock when it is re-administered at reoperation.

Intra-aortic digital subtraction angiography (IA-DSA)

The patients who received CABG undergo a routine aortography 7 days postoperatively by introducing the catheter through a brachial artery to evaluate the early graft patency. When the graft to the key recipient coronary artery is occluded and the coronary artery is still patent, reoperative CABG is planned within a few days (Fig. 1). Thereby, re-CABG can be avoided at 1 to 3 months after an initial CABG when the pericardium adheres to the heart most tightly.

Statistical analysis

Quantitative variables are presented as the mean±standard deviation (SD) of the mean. Univariate analysis was performed on all discrete data using Student's paired *t* test and unpaired *t* test as appropriate. Nominal variables were

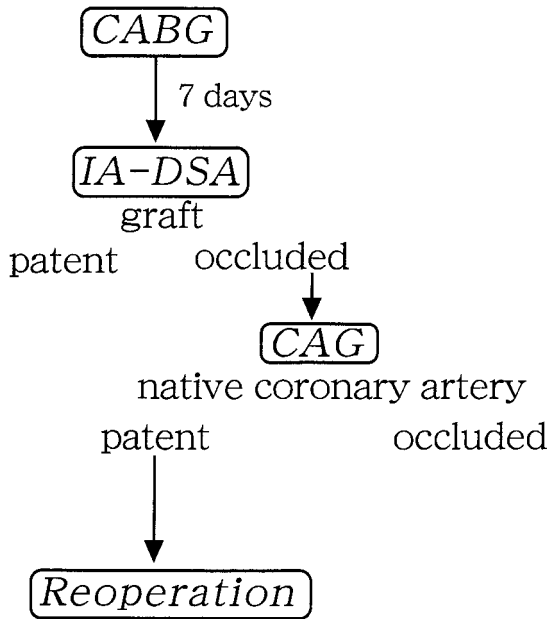


Fig. 1. The flowchart of intra-aortic digital subtraction angiography. CABG: coronary artery bypass grafting, IA-DSA: intra-aortic digital subtraction angiography, CAG: coronary arteriography.

analyzed using the chi-square test, and Fisher's exact test. A *p* value of less than 0.05 was considered statistically significant. Postoperative survival is expressed by the Kaplan-Meier method.

Results

In 6 of 19 patients, CABG was performed emergently or urgently. No patients had other concomitant cardiac procedures. Among 19 patients of the present series, a femoral artery was used for arterial access in 8. The status of the prior bypass grafts at reoperation is shown in Fig. 2: 34 occluded grafts, 8 stenotic grafts, and 5 patent grafts without stenosis. Reoperation was indicated by the findings of IA-DSA in 2 patients.

Operation performed

The average number of grafts per patient was 2.2 ± 1.0 and that of arterial grafts per patient was 1.3 ± 0.8 . Among 19 patients, 15 (78.9%) received arterial grafts (Table 2). The ITAs have been used for coronary revascularization with increasing frequency, and 2 patients in an earlier series received saphenous vein grafts alone. In addition, the other 2 patients received vein grafts alone due to the finding that there was a malignant disorder in 1 patient and no appropriate arterial grafts remained unused at reoperation in the other patient. In addition to the 6 left ITAs and 5 right ITAs, 9 right gastroepiploic arteries were used.

Mortality and morbidity

There was no in-hospital death. Perioperative myocardial infarction (new postoperative Q waves or S-T T-wave

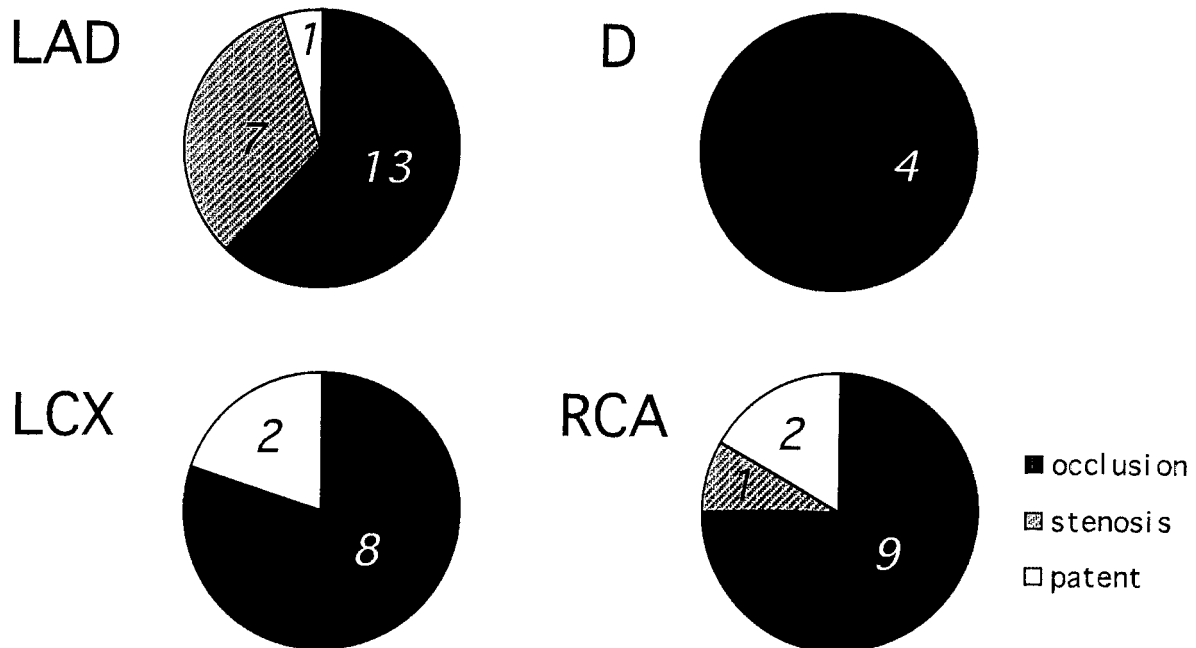


Fig. 2. Status of the prior bypass grafts at reoperation. LAD: left anterior descending artery, D: diagonal branch, LCX: left circumflex artery, RCA: right coronary artery.

Table 2. Number of grafts at single operations and reoperations

	Single operation	Reoperation	Probability
Number of grafts per patient	3.1 ± 1.1	2.2 ± 1.0	<i>p</i> <0.001
Number of arterial grafts per patient	1.4 ± 0.9	1.3 ± 0.8	NS
Ratio of using arterial grafts	78.7%	78.9%	NS

NS: not significant.

changes accompanied with cardiac enzyme elevation) occurred in 2 patients. No re-exploration for bleeding was required. There were no neurological complications. The incidence of wound complications was 1. There was no complication of repeat median sternotomy. A postoperative intra-aortic balloon pump was required in 1 patient.

Postoperative angiographic findings

A coronary arteriogram performed at discharge demonstrated that the patency of all grafts and that of the arterial grafts were 96.9% and 96.7%, respectively.

Late results

All patients were followed up completely. The mean follow-up interval was 36.7±22.2 months (range 9 to 84 months). During the period of follow-up, 1 patient died of heart failure 20 months after the operation and 2 died due to a noncardiac course: 1 died of pancreas cancer 16 months after the reoperation and the other died of lung cancer 50 months postoperatively. Following reoperation, 1 patient underwent a percutaneous transluminal coronary angioplasty (PTCA) for a native coronary stenosis 1

Table 3. Symptomatic status before and after reoperation

NYHA class	Number of patients	
	Before reoperation	After reoperation
I	0	16
II	1	3
III	14	0
IV	4	0

Symptomatic status before reoperation and after reoperation (at discharge) are compared.

NYHA: New York Heart Association.

month postoperatively. Figure 3 shows the actuarial survival curve estimated by the Kaplan-Meier method and Figure 4 shows the freedom from cardiac death estimated by the same method.

Functional class

In all patients, the functional class (New York Heart Association) before reoperation improved at discharge as showed in Table 3.

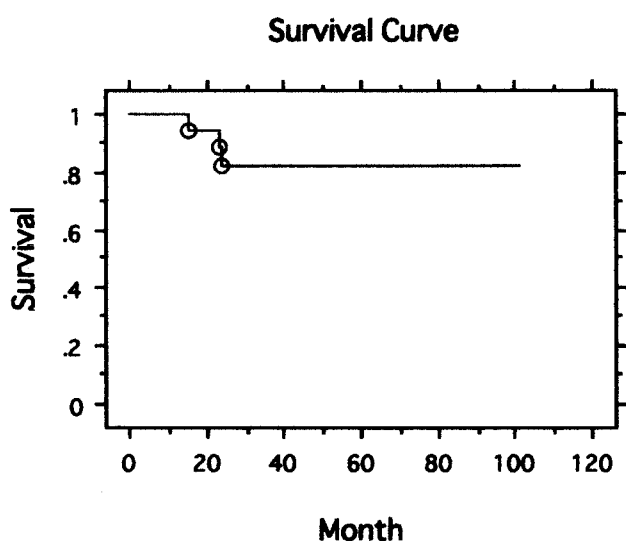


Fig. 3. Survival of patients who underwent coronary reoperation.

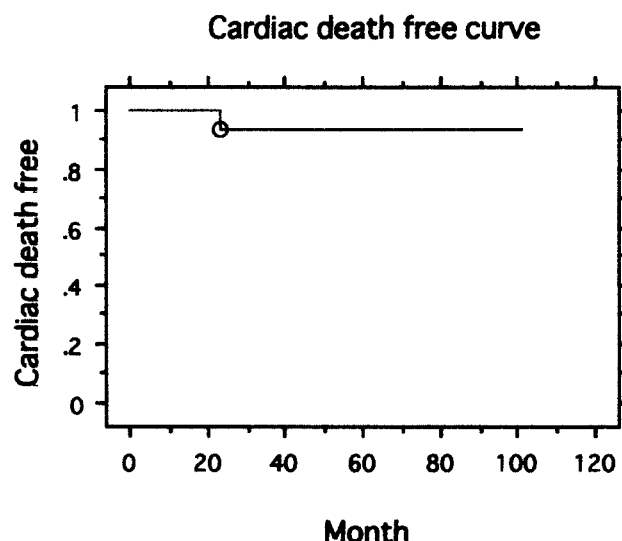


Fig. 4. Freedom from cardiac death of patients who underwent coronary reoperation.

Discussion

In the United States, more than 15,000 patients have had reoperative coronary surgery, however, in Japan only several institutions have experienced greater than 50 reoperations. The reasons are considered to be that CABG became common in Japan 10 years later than in the United States, and coronary intervention is more common than CABG in Japan, and in addition, Japanese cardiovascular surgeons may hesitate to perform reoperations due to less experience of reoperative CABG.

In general, operative mortality at or due to coronary reoperation ranged from 2.0 to 6.9%,^{1,2,4,9)} and was higher than that at or due to initial operation. Both in-hospital mortality and postoperative graft patency in the present study were favorable and similar to those at the initial operation, although the number of subjects was too small to make any definitive conclusions.

It appears that these good outcomes may be attributed to our devised management for reoperation.

IA-DSA

One of the most important problems in reoperative CABG is early reoperation due to early graft failures. Usually, pericardial adhesion is very tight 1 to 3 months after a cardiac operation, thus, cardiac dissection is difficult, and, moreover, it is quite difficult to expose the prior patent bypass grafts without injuring them. Therefore, reoperation at that time is not preferred. When the pre-discharge coronary arteriogram shows that a graft to the key coronary artery is stenotic or occluded, it is unclear whether the reoperation should be performed then in spite of severe pericardial adhesion or should it be delayed until the adhesion becomes looser after 1 to 2 months. In our institution, the patients who had received CABG underwent routine IA-DSA 7 days postoperatively to evaluate the status of the bypass graft. When an early graft failure was detected in IA-DSA, a coronary arteriography was immediately performed to investigate the patency of the target native coronary arteries. Thereafter, urgent reoperation within a few days was planned if necessary. In this series, 4 patients who showed failure in an arterial graft to the left anterior descending artery, underwent reoperation within 2 weeks following initial surgery. Of these 4 patients, 2 had no chest pain, no significant change on cardioelectrogram, and no elevation of CPK, with a stable hemodynamic condition, however, IA-DSA demonstrated the occlusion of a bypass graft to the left ante-

rior descending artery. Only the finding of IA-DSA indicated reoperation of the 2 patients and subsequently avoided a repeat operation when pericardial adhesion was tight.

Preparation for sternal re-entry

We must always prepare for the forthcoming reoperation when performing an initial CABG, since a CABG is not a curative but a palliative operation. At the time of the primary operation, ITA grafts were covered with thymus, on which hemo-clips were placed as markers of ITA grafts. The pericardium was always closed for an easy approach at reoperation. This was the preparation for an easy sternal re-entry to avoid injury to patent bypass grafts.

Stenotic vein grafts

At reoperation, patent but stenotic vein grafts may be at high risk during cardiac dissection. Atherosclerotic veins that have continuous antegrade flow are predisposed to embolization producing fatal infarction. Totally occluded atherosclerotic vein grafts do not embolize distally.^{1,3-7,9-12)} During the time of cardiac dissection, stenotic grafts were never touched prior to aortic cross-clamping. Gentle handling and early ligation of the atherosclerotic vein after aortic cross-clamping may reduce risks.

Cardiac dissection

We preferred to dissect all sides of the heart including the posterior and inferior walls when possible, even when only grafting to the left anterior descending artery or diagonal branch was planned, to obtain a good operative field and to prepare for any cardiac accident. In addition, a counter shock was easily adapted intraoperatively.

Arterial grafts

We tried to use more arterial grafts and aimed for as complete a revascularization as possible at the reoperation.

Perioperative hemorrhage

Aprotinin at a dose of 2,000,000 units is useful for reducing perioperative bleeding¹³⁾ and has little or no unfavorable effects on graft patency.¹⁴⁾ There were no patients requiring reoperation for bleeding, and blood transfusion was not necessary for 12 patients. Aprotinin is a useful drug for cardiac reoperation, however, it sometimes causes anaphylaxis. Therefore, at the initial CABG, using this drug should be avoided.

Conclusions

IA-DSA, appropriate preparation for follow-up surgery at the primary operation, and complete revascularization using arterial grafts at reoperation appear to contribute to the satisfactory outcome of coronary reoperation.

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