Evaluation of Coronary Revascularization for Ischemic Heart Disease: In the Consecutive 200 Cases

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The elective simple coronary revascularization in the last consecutive 200 patients were analyzed in this study. Despite of the increase in older patients who have more high risk factors, including low left ventricular ejection fraction (LVEF) and multiple vessel disease, there were no operative deaths in the second 100 patients. The use of calcium antagonist in patients with a history of spastic angina eliminated episodes of spastic angina in the perioperative period.

In the late postoperative period, there were no cardiac deaths during the 7-year follow-up period. Angina remained in two of three patients with the patent grafts, who had a history of spastic angina. Hyperlipidemia and diabetes mellitus influenced occlusion of the grafts and progression of atherosclerosis of native coronary arteries and then four of five reoperations. Exercise tolerance in patients, even those with preoperative low LVEF, has been improved although their was some increment of left ventricular end-diastolic pressure during exercise.

Patency rate in sequential grafting with saphenous vein grafts or internal mammary artery grafts were 92% in the average follow-up period of 11 months. The increase of flow rate with nitroglycerine and atrial pacing in internal mammary artery grafts (IMAG) were comparable with saphenous vein grafts.

THE number of patients who underwent coronary revascularization for ischemic heart disease increased recently even in Japan. Also surgical results for this treatment have been improved. However several factors limited the effectiveness of this procedure and surgical results. The purpose of this paper is to analyze these factors and to suggest some countermeasures on the basis of our recent findings.

Key words:

Coronary revascularization
Sequential grafting
Internal mammary artery graft
Graft flow
Spastic angina

MATERIALS

The last consecutive 200 patients who underwent elective coronary revascularization were analysed in this study (Table I). Patients who had coronary revascularization combined with other procedures were excluded from this study. The 200 patients were divided into two groups; the first 100 (Group I) and the second 100 patients (Group II). Average ages were 54.7 years and 57.4 in Groups I & II respectively. There was 1 patient over 70 years old in Group I and 7 in Group II. Four or more coronary branch anastomoses occurred in 5% of Group I

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TABLE I SUMMARY OF THE PATIENTS UNDERWENT CORONARY REVASCULARIZATION FOR ISCHEMIC HEART DISEASE

	Cases	Age	TVD & LMTD	No. of bypassed coronary branches per patient	No. of patients with four or more bypassed coronary art.	op. death
Group I	100	54.7	60	2.6	5	3
Group II	100	57.4	60	3.0	34	0

TVD: triple vessel disease

LMTD: left main trunk disease

Fig.1. Pre- and post-operative hemodynamic studies in patients with LVEF less than 0.40.

cases and 34% in Group II. Nine patients in Group I had left ventricular ejection fraction (LVEF) of less than 0.40 and 20 in Group II, including 6 who had less than 0.30.

Patients with significant organic stenoses in coronary arteries combined with a history of spastic angina were divided into two groups: Group I_{sp} with 20 patients who did not use calcium antagonist, diltiazem, and Group II_{sp} with 15 patients who used diltiazem, in cardioplegia and had 12–24 hour's continuous administration after operation.

RESULTS

There were three operative deaths (3%) in Group I and no operative deaths in Group II. The causes of death were low cardiac output syndrome in two patients and spastic angina in one who was included in Group I_{sp}. There were 3 episodes (15%) of spastic angina and one subsequent death in Group I_{sp}, described above, and no episodes in Group II_{sp}.

In patients with LVEF of less than 0.40, there was one operative death (11%) out of nine patients in Group I and no deaths in twenty patients in Group II. Patients in Group II included six patients with LVEF of less than 0.30 who also survived.

There were no late cardiac deaths in both groups during the 7 year follow-period.

The pre- and post-operative hemodynamic studies in nineteen patients with LVEF of less than 0.40 are shown in Fig. 1. LVEF at rest improved significantly in the late postoperative period. Left ventricular minute work (LVMW) increased significantly with exercise when compared with at rest. However, these increases in LVMW were obtained with significant increase of left ventricular end-diastolic pressure (LVEDP).

Five patients with a history of spastic angina were studied in the late postoperative period. Two of three patients who all had patent grafts still have angina at rest and not during exercise.

There were five reoperations. Reoperations in four of five patients were performed because of occlusion of the grafts to the left anterior descending artery (LAD). Two had hyperlipidemia and two had diabetes mellitus. One had reoperation because of progression of atherosclerosis of the native coronary arteries.

23 patients had heterozygous hyperlipidemia two of whom had reoperation. Two patients who had homozygous hyperlipidemia, were on plas-

TABLE II GRAFT FLOW IN IMAGs AND SVGs TO THE LAD DURING OPERATION AND IN THE LATE POSTOPERATIVE PERIOD WITH INTERVENTION; WITH INJECTION OF NITROGLYCERINE DURING OPERATION AND WITH ATRIAL PACING IN THE LATEPOSTOPERATIVE PERIOD

	IMAG	SVG
Rate of increase in graft flow after administration of NTG	1.58 ± 0.38 (n = 10)	1.61 ± 0.51 (n = 10)
Rate of increase in graft flow during atrial pacing	1.60 ± 0.44 (n = 6)	1.76 ± 0.36 (n = 8)

IMAG: internal mammary artery graft

SVG: saphenous vein graft

NTG: nitroglycerine

LAD: left anterior descending artery

mapheresis and remained without angina 1–4 years post-operatively.

Internal mammary artery grafts (IMAG) in a single coronary anastomosis were used in 43 patients. Sequential grafting with saphenous vein grafts (SVG) or IMAG were performed in 51 patients. Maximum anastomoses to coronary arteries with a graft were four in a patient, in whom a cephalic vein was used because of varices of the saphenous vein. There were no operative deaths in these patients in whom were used IMAGs and sequential grafts.

Using SVGs, the graft patency rate with sequential grafting of 22 coronary anastomoses with nine SVGs and four anastomoses with two IMAGs were studied in ten patients 1 to 24 months (average 11 months) after surgery. Seven of the eight patients who underwent sequential grafting with SVGs had revascularization of four or more coronary arteries. Occlusion occurred in an anastomosis at the aorta using an SVG in the first case, although two anastomoses in coronary arteries were patent. Accordingly, 26 of 28 coronary anastomoses (92%) were patent.

Graft flows in SVGs and IMAGs to the LAD (Table II) were compared during operation and in the late postoperative period with interventions; with injection of nitroglycerine 100 gamma into the graft during operation and with atrial pacing in the late postoperative period. Flows through IMAGs increased 1.59 times with nitroglycerine (NTG) as much as those before injection of NTG and those through SVGs 1.61 times.

Fig.2. Graft flow in a IMAG before and after anastomosis during operation and in the late postoperative period.

Flows through IMAGs increased 1.60 times with atrial pacing 1.5 times as many as pacing rate at rest and those through SVGs 1.78 times.

In one patient with an IMAG, graft flow (Fig. 2) was measured before anastomosis through its free end, after anastomosis during operation with the electromagnetic flow meter before and after NTG administration into the graft, and at one month after operation with cinedensitometry method¹ at rest and with atrial pacing. Flows were 95, 25, 34, 55 and 98 ml/min respectively.

DISCUSSIN

Although indications have been widened to older patients and to those with the more risk factors including multiple vessel disease and low LVEF, the improvement in operative results of surgical treatment for ischemic heart disease was obtained mainly by improvement of post-operative management and cardioplegia^{2,3}

Improvement of operative results is also due to decrease in the episodes of spastic angina in the perioperative period by administration of calcium-antagonist, diltiazem, with cardioplegia during surgery and in the early postoperative period to patients with a history of spastic

angina. One of three operative deaths in Group I was due to spastic angina which generally occurred during or soon after surgery and was one of the most severe and stormy complications. Since application of diltiazem, there have been no episodes of spastic angina in the perioperative period so far in our institute.

Benefits from coronary revascularization include prevention of cardiac deaths, relief from angina and improvement of cardiac function. There were no late cardiac deaths in this series. These are better results than those reported in USA and Europe.⁴⁻⁶

Occlusion of the grafts, especially the graft to LAD, or progression in atherosclerosis of their native coronary arteries, caused recurrence of the angina in the late postoperative period. Five patients required reoperation; four had hyperlipidemia or diabetes mellitus. These factors influence prognosis after coronary revascularization.

To improve patency rate in the late postoperative period, IMAGs have been used for the last 2 years. The IMAG has been reported to have better patency rate in the late postoperative period than the SVG.⁷ Our results are still too early to comment the late patency with the IMAG. Another way to improve the late patency rate is to use sequential grafts because the flow per graft increases due to multiple anastomoses of coronary branches per graft.^{8,9} Sequential grafting was performed with SVG and IMAG. As the number of grafts studied were few in our series, significance of the findings of this procedure were uncertain. Although most of the patients, in whom the graft patency were studied, had four or more coronaries anastomosed, patency rate was comparable with patency rate in single distal anastomosis per graft. The first case had occlusion of the proximal anastomosis, which killed the effects of patent distal plural anastomoses. This was one of the problems in this procedure.

When IMAGs were used, there was controversy whether IMAGs could carry enough blood flow to the myocardium.¹⁰ Our results showed IMAGs could carry the same degree of increases with SVGs in flow rate with the decrease of coronary vascular resistance due to NTG or increase of oxygen consumption with increase

of heart rate by atrial pacing.

Spastic angina is one of the serious perioperative problems in coronary revascularization in patients with significant organic stenoses in coronary arteries combined with spastic angina. In addition, spastic angina was one of the causes of residual angina in the late postoperative period; some patients with a history of spastic angina had residual angina in spite of their patent grafts with no residual coronary artery organic stenosis.

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