Long-term Results and its Managements After Coronary Bypass Surgery

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Between 1970 and 1985, 221 patients with coronary artery occlusive disease underwent aorto-coronary bypass (A-C bypass) and other procedures. Among these patients, 187 had A-C bypass alone and A-C bypass in addition to correction of valvular lesions or arterialization of the coronary vein, myocardial puncture by laser. The remaining 34 had surgical corrections for myocardial infarction and its complications.

Subjects were 100 patients who underwent A-C bypass alone over 6 months ago and whose follow-up study could be performed. Subsequently, 94% of the patients have met the criteria for grade I of NYHA functional capacity and have returned to normal work at a mean of 4 years and 2 months after surgery. Improved left ventricular function has been maintained postoperatively in the patients with complete revascularization. Improved operative technique, in addition to intraoperative balloon angioplasty and onlay patch grafting, have increased the patency rate (78% in 1 mm, 94% in 2 mm of coronary diameter) of the grafts with postoperative anticoagulant therapy.

On the basis of our long-term observations, coronary bypass surgery, particular in complete revascularization, provides for significant improvement in both the quality and life expectancy of patients with severe coronary heart disease. Treadmill exercise test and magnetic resonance image (MRI) were useful, non-invasive and acceptable examinations in long-term follow up.

With the recent developments in coronary bypass surgery, the number of operations for coronary artery occlusive disease has increased remarkably in Japan. As of August 1985, according to a questionnaire of coronary surgery, aortocoronary bypass (A-C bypass) had been performed in 10,456 patients with angina pectoris and surgical repairs had been carried out in 1,800 patients with acute myocardial infarction and its complications in Japan. Good operative results, especially in A-C bypass group, have been consistently obtained and these procedures have now been accepted by most cardiologists as the appropriate treatment for ischemic heart disease.4-4

The purpose of this study is to describe the long-term follow-up results after A-C bypass.

MATERIALS AND METHOD

In 1970, we performed an A-C bypass on our first patient with severe angina pectoris whose postoperative course was uneventful. Since then, 221 patients with coronary artery occlusive disease have been operated on in our hospital. Of these, myocardial revascularizations such as A-C bypass and arterialization of the coronary venous system were performed in 187 cases with angina pectoris, and surgical corrections except for A-C

Key Words:
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Graft patency
Long-term result

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bypass for myocardial infarction and its complications were carried out in the remaining 34 cases (Table I). In addition, intraaortic balloon pumping (IABP) had been initiated in 44 patients with cardiogenic shock following acute myocardial infarction, in which 48% of them could be weaned from shock conditions.

1) Indications for coronary bypass surgery

In our series, indications for operation are as follows: a) presence of angina pectoris in spite of intensive medical therapy, b) existence of organic proximal stenosis of more than 75% of internal diameter of the coronary arteries, c) adequate distal run-off and good left ventricular function, d) presence of high left lesion where stenosis exists at the proximal portion of the left coronary artery, and jeopardized collaterals.

2) Operative technique

Operations were performed under cardiopulmonary bypass with cold cardioplegia. St. Thomas Hospital solution, which has been utilized as a cardioplegia since 1979, was injected into the ascending aorta through an aortic root cannula after distal aortic cross clamping. And then the heart was arrested and topically cooled with ice slush.

The great saphenous vein was carefully removed and all branches were ligated in a usual fashion not to compromise the main lumen. Thereafter, coronary anastomoses were performed with continuous sutures using 6-0 monofilament polypropylene by reversing the saphenous vein and attaching it to the distal coronary arteries beyond the last area of stenosis and occlusion. In most of the cases with multiple coronary stenoses and small coronary arteries, intraoperative balloon angioplasty and onlay patch grafting were routinely utilized (Fig. 1). Proximal anastomoses were carried out with 5-0 sutures after release of the aortic cross clamp and application of a partial clamp of the aorta. After completion of A-C bypass, blood flow in the bypass graft was measured by an electromagnetic flowmeter.

RESULTS

All cases were divided into three groups according to the date of the operations such as Group I (1970–1975), Group II (1976–1980) and Group III (1981–1985) (Table II). Of the 182 patients with A-C bypass alone, number of bypass grafts and hospital- and late mortality were analyzed, and in addition the NYHA, graft patencies were analyzed in 96 cases that could be confirmed in the long-term follow up study.

1) Analysis of death cases

There were totally six deaths among 100 cases during past 15 year. Four patients died of low cardiac output syndrome in hospital and another two died of congestive heart failure, or refractory arrhythmia at the time of 6 years after surgery. Recently, a marked decrease of operative mortality was recognized in our series (1.8% during past 5 years).

2) Analysis of long-term survivors

a) Changes in NYHA functional capacity and rate of social return

Postoperative clinical findings were analyzed in all cases according to the classification of NYHA. Forty six (84%) out of 55 cases whose preoperative clinical conditions were grade III or IV of NYHA improved to NYHA I postoperative-
TABLE II LONG-TERM RESULTS AFTER A-C BYPASS

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<tbody>
<tr>
<td>No. of Case</td>
<td>18 (10%)</td>
<td>27 (15%)</td>
<td>137 (75%)</td>
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<tr>
<td>Age</td>
<td>41~64Y (mean 52)</td>
<td>31~68Y (51)</td>
<td>26~74Y (56)</td>
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<tr>
<td>No. of Bypass</td>
<td>Single 13, double 5</td>
<td>Single 8, double 18</td>
<td>Single 41, double 67</td>
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<tr>
<td></td>
<td>(1.2 grafts/pt)</td>
<td>Triple 1</td>
<td>Triple 27, Quadruple 2</td>
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<tr>
<td>*Hospital death</td>
<td>3/18 (16.7)</td>
<td>0/27 (0)</td>
<td>1/55 (1.8)</td>
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<td>Late death</td>
<td>1/15 (6.7)</td>
<td>1/27 (3.7)</td>
<td>0/54 (0)</td>
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<tr>
<td>*Graft patency (%)</td>
<td>13/18 (72.2)</td>
<td>37/43 (86)</td>
<td>107/117 (91)</td>
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*Long-term results in 100 cases

Fig.1. A-C bypass procedure for small coronary artery.

ly. Only 10 cases remained in NYHA II. At an average of 4 years and 2 months after surgery, 94% of all cases were in NYHA I and returned to normal work (Fig. 2). That is, the rate of social return to the same work before operation was 94%, the remaining 6% altered to light work. There were no patients who were unable to work. Thus, both the high rate of social return and excellent quality of life were clearly observed after A-C bypass.

b) Correlations between coronary diameter, graft flow and graft patency

The inner diameter of the longitudinally incised coronary artery was measured by a Parsonnet probe; blood flow in the bypass graft after completion of A-C bypass was estimated by an electromagnetic flowmeter. And graft patency was angiographically confirmed prior to patient discharge from hospital. Subsequently, mean graft flow was 43.1 ± 13.3 ml/min and its

<table>
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<tr>
<th>Survival cases</th>
<th>Return to normal</th>
<th>light work</th>
<th>no work</th>
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<tr>
<td>96</td>
<td>90 (94%)</td>
<td>6 (6%)</td>
<td>0</td>
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Fig. 2. Clinical findings in NYHA classification before and after surgery (Survival case over 6 months, 96 cases)

graft patency was 71% in coronary diameter of 1 mm, 63.2 ± 25.5 ml/min, 86% in 1.5 mm, 68.6 ± 25.2 ml/min, 92% in 2.0 mm, 73.3 ± 32 ml/min, 96% in 2.5 mm diameter of the coronary artery (Fig. 3).

Thus, blood flow in the graft has apparently depended on the inner diameter of the coronary arteries. In the recent cases, high patency rate of the graft has been obtained by means of intraoperative transluminal balloon angioplasty, onlay patch grafting, and postoperative anticoagulant.
therapy. That is, patency rate increased from 71% to 78% in 1 mm diameter, and from 92% to 94% in 2 mm. It could be considered that these procedures were necessary for those patients whose coronary diameters indicated within 1.5 mm.

c) Hemodynamic changes before and after A-C bypass

Left ventricular function (CI, LVedp, EF, LVEDVI) at rest before and after A-C bypass was analyzed in both complete-and incomplete revascularization groups. In the complete revascularization group where bypasses were made to all stenotic coronary arteries and its grafts were patent postoperatively, the cardiac index (CI) increased from 2.82 ± 0.42 l/min preoperatively to 3.35 ± 0.6 l/min postoperatively. Left ventricular end-diastolic pressure (LVedp) decreased from 14.6 ± 5.2 mmHg preoperatively to 9.7 ± 3.6 mmHg postoperatively and ejection fraction (EF) improved from 0.53 ± 0.12 preoperatively to 0.67 ± 0.12 postoperatively (Fig. 4).

Thus, these left ventricular functions improved significantly in the complete revascularization group and especially in the cases whose bypasses were anastomosed to the left anterior descending artery (LAD), or the circumflex artery (Cx) and their grafts were patent postoperatively. However, there were no significant differences in the incomplete revascularization group among these parameters. On the basis of these findings, we have done our best to perform complete revascularization when possible. By means of intraoperative coronary balloon angioplasty and thromboendarterectomy, the number of complete revascularizations have increased gradually to 82% of all cases.

d) Parameters in long-term follow up study

To determine clinical conditions of the patients over a long-term period after A-C bypass, it is important to check left ventricular function and graft patency.

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For the purpose of this study, we evaluated patients by periodic treadmill exercise tests, myocardial scintigraphy and magnetic resonance image \(^8\) (Fig. 5). These non-invasive methods are very convenient for outpatient and provide much information.

**DISCUSSION**

Increased surgical experience and improved techniques, particularly the use of cold cardioplegia for topical cardiac cooling, have reduced operative mortality after a decade of our experience. Hospital mortality has clearly improved, even though our indications for A-C bypass have been broadened to include those patients who have anginal attack with poor ventricular function \(^8\)–\(^11\).

In general, it has been reported that women have early mortality when compared with men and a reduction in early mortality has been seen in males but not in female patients. But, we found no differences in both of our series. The importance of complete revascularization of all stenotic coronary arteries was observed left ventricular function and lower late mortality in those patients in long-term follow up study. However, the risk of the more prolonged surgical
procedure for multiple bypass grafts must be kept in mind. For this reason, intraoperative balloon angioplasty and onlay patch grafting were often utilized particularly for patients with multiple luminal stenoses of less than 50%. Balloon angioplasty is a leading method in reducing the need for additional multiple revascularization procedures. To increase patency rate laser was employed to make vascular anastomosis for small caliber vessels such as coronary arteries. A-C bypass was successfully done under beating heart experimentally. In near future, A-C bypass by laser will be performed clinically, of which long-term patency can be surely expected.12

Subsequently, better long-term symptomatic relief as well as improved left ventricular function were clearly observed with the increased number of complete revascularization13–16 procedures. These improvements are due to the fact that a greater amount of arterial blood can be brought into an ischemic area of the myocardium.

Thus, coronary bypass surgery provides significant advances in both the quality and length of life in patients with coronary artery occlusive disease.

CONCLUSIONS

1) Better symptomatic relief and improvement of left ventricular function were clearly recognized in the complete revascularization group. Bypasses to the LAD and the Cx were especially effective as evidenced in the long-term follow up study.

2) Left ventricular function at rest and on exercise must be evaluated periodically to estimate long-term results,

3) Treadmill exercise test, myocardial scintigraphy and magnetic resonance image were noninvasive and useful examinations to check the clinical conditions of outpatients in the long-term period after surgery.

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