Does Myocardial Revascularization With Multiple Arterial Grafts Improve the Prognosis of Dialysis Patients?

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In the present study it was examined whether myocardial revascularization with multiple arterial grafts improves the prognosis of dialysis patients. The 20 subjects underwent coronary artery bypass grafting over 2 vessels (extra-corporeal circulation in 11 patients, off-pump bypass in 9 patients) and were divided into 2 groups according to the number of arterial grafts. Group A consisted of 9 patients in whom more than 2 arterial grafts were used and Group B, 11 patients requiring 1 internal thoracic artery and additional saphenous vein grafts. The surgical procedure was examined, as well as the short-term and long-term results of both groups. There were no differences in the profiles of the 2 groups. The mean arterial graft number in group A was 2.2 ± 0.6 and 1.0 ± 0.0 in group B. There was neither mediastinitis nor brain complication in either group. There were no operative deaths in group A and 1 in group B. The 55-month actuarial survival rate including all deaths, and estimated by cardiac deaths, was, respectively, 0.53 ± 0.21 and 0.80 ± 0.18 in group A and 0.42 ± 0.21 and 0.53 ± 0.23 in group B. The survival rate estimated by cardiac death in group A was better, but there was not a significant difference. Myocardial revascularization with multiple arterial grafts for dialysis patients had good short-term results without increased operative risk and may improve the long-term results related to cardiac death. However, there was no significant difference in survival including all deaths because of the numerous non-cardiac deaths. (*Circ J* 2003; 67: 871–875)

Key Words: Coronary artery bypass grafting; Dialysis patients; Multi-arterial graft; Off pump bypass

Patients with diabetes mellitus (DM) often require chronic dialysis and such patients have a high prevalence of coronary artery disease (CAD) and cardiovascular death¹. Although catheter intervention is used as a therapy, the restenosis rate is high². Therefore, patients are recommended to have coronary artery bypass grafting (CABG), but the long-term results are less than satisfactory. The benefits and good long-term results of multiple arterial grafts in non-dialysis patient have been reported^{3,4} so we studied the risks, benefits and long-term results of multiple arterial CABG for dialysis patients.

Methods

Patient Population

The subjects were 24 chronic dialysis patients who had undergone CABG from March 1995 to January 2003 and of these, 20 had had multiple grafting over 2 or more vessels. We divided these patients into 2 groups according to the number of the arterial grafts: Group A (9 patients) received 2 or more arterial grafts and Group B (11 patients) received 1 arterial graft and additional saphenous vein grafts (SVGs).

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Patient Selection Criteria

Patient selection was made according to whether access to the ascending aorta was safely possible, and whether multiple grafting of 4 or 5 branches was necessary; that is, a patient who had severe atherosclerosis of ascending aorta requiring the aortic no-touch technique would receive multiple in-situ arterial grafts and be classified as a group A patient. The left internal thoracic artery (LITA) and additional SVG grafts were often used for patients who required 4 or more multiple grafts, thus classifying them as group B. The selection of conventional CABG with cardiopulmonary bypass or off-pump bypass changed over time. At first, off-pump bypass was selected for the patients who had poor general condition, combined cancer and calcified ascending aorta. Conventional CABG was chosen for patients who had low cardiac function or poor run off of the distal coronary artery. From September 2001, most of the cases underwent off-pump bypass. In total, 11 patients had conventional CABG and 9 had off-pump bypass. Patient selection was not affected by the preoperative cardiac function or whether it was an emergency operation.

Operative Technique

The internal thoracic artery was harvested in a skeletonized fashion. Dilatation of the in situ artery was achieved by injection of papaverine, and in the case of a free graft, nitroglycerin was used.

When the operation was performed with cardiopulmonary bypass, body temperature was maintained at 33°C with natural cooling and tepid blood cardioplegia. Regarding the order of anastomosis, distal anastomosis of the vein

Table 1 Patient Characteristics

	Group A (n=9)	Group B (n=11)	p value
Age (years)	64±8	61±8	0.38
M/F	7/2	10/1	0.41
OMI	8 (89%)	5 (45%)	0.04
UAP	5 (56%)	5 (45%)	0.65
CHF	4 (44%)	3 (27%)	0.42
DM	6 (67%)	5 (45%)	0.34
ASO	1 (11%)	3 (27%)	0.36
TVD	8 (89%)	8 (73%)	0.36
LMT	3 (33%)	4 (36%)	0.88
Pre op IABP	2 (22%)	3 (27%)	0.79
LVEF (%)	45±11	49±20	0.62

OMI, old myocardial infarction; UAP, unstable angina pectoris; CHF, congestive heart failure; DM, diabetes mellitus; ASO, arteriosclerosis obliterans; TVD, triple vessel disease; LMT, left main trunk; IABP, intra-aortic balloon pumping; LVEF, left ventricular ejection fraction.

Table 2 Surgical Procedure

	Group A (n=9)	Group B (n=11)	p value
Emergency	5 (56%)	5 (45%)	0.65
Off-pump bypass	5 (56%)	4 (36%)	0.39
Graft number	2.7±0.9	3.4±0.9	0.10
Arterial graft number	2.2±0.7*	1.0±0.0	0.0001
Blood transfusion (U)	6.3±3.0	4.8±2.5	0.23
Operation time (min)	402±71	424±84	0.54
Complete revascularization	6 (67%)	10 (91%)	0.17

*LITA&RITA&RGEA: 1; LITA&RITA: 4; LITA&RGEA: 4. LITA, left internal thoracic artery; RITA, right internal thoracic artery; RGEA, right gastro-epiploic artery.

graft was performed first and the sequential grafting technique with a 7-0 monofilament suture was used as much as possible. Next, the arterial grafts were anastomosed, and finally, proximal anastomosis of the vein grafts was performed using the single-clamp method.

In the off-pump bypass procedure, a deep pericardial suture and a suction type heart stabilizer were used. In general, the artery was used in situ, but when it did not reach the target coronary arteries, y-shaped composite grafting was used. Regarding the order of anastomosis, when an additional vein graft was used the proximal anastomosis was performed with a side-biting clamp and 6-0 suture. Next, the LITA—left anterior descending coronary artery anastomosis was performed with 7-0 or 8-0 suture, then the heart was lifted and rotated, and the distal anastomosis of the circumflex system or right coronary system was performed.

Continuous hemofiltration, which does not affect the patient's hemodynamics, was used immediately following the operation and after the hemodynamics had stabilized, hemofiltration was changed to the usual intermittent hemodialysis.

Statistical Analysis

Patient characteristics (diagnosis, concomitant disease, CAD, cardiac function, circulatory support), surgical procedure (the timing of operation, the ratio of off-pump bypass, the number of anastomoses, the amount of blood transfusion), postoperative condition (maximum creatine kinase MB level (CK-MB), the catecholamine dosage, period of intubation, time from continuous hemofiltration

Table 3 Postoperative Short-Term Results

	Group A (n=9)	Group B (n=11)	p value
max CK-MB (U/L)	35±20	49±47	0.43
max DOA ($\mu\text{g}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$)	4±2	6±5	0.27
post op IABP	0	1	0.35
Respirator (days)	1.4±0.7	1.9±2.2	0.54
Cont. hemofiltration (days)	1.4±0.4	3.0±1.0	0.20
Operative death	0	1	0.35
Re-sternotomy for bleeding	1	1	0.88
Graft patency	22/22	32/32	—

DOA, dopamine; Cont.hemofiltration, continuous hemofiltration.

to usual dialysis, operative results, postoperative complications, patency rate), and long-term results (actuarial survival rates, survival rates estimated by cardiac death) were studied in both groups.

The chi-squared test was used for the nonparametric variables and the unpaired t test for continuous variables. A p-value <0.05 was regarded as statistically significant. Long-term survival rates were calculated using the Kaplan-Meier method, and statistical significance was analyzed using the Cox-Mantel test. Hospital deaths were included as events in this analysis. All data are presented as mean ± SD unless stated otherwise.

Results

Patient Characteristics (Table 1)

Age, sex, and concomitant diseases, such as DM and arteriosclerosis obliterans (ASO), were not significantly different between the 2 groups. The causes of chronic renal failure in group A and group B, were DM in 6 (67%) and 5 (45%), respectively, and other reasons in the remaining 33% and 55% of each group. In terms of cardiac function, both groups had the same ratio of congestive heart failure (CHF) and unstable angina pectoris (UAP). Old myocardial infarction (OMI) occurred significantly often in group A. The preoperative mean ejection fraction (EF), the number of patients who had an EF of less than 35% and who had triple vessel disease (TVD) and left main trunk stenosis (LMT) were not significantly different between the 2 groups. Preoperative intra-aortic balloon pumping (IABP) was necessary in 2 of 9 patients (22%) in group A and in 3 of 11 (27%) in group B. Thus, most of the parameters, including preoperative comorbidities and cardiac profiles, showed no significant differences between the 2 groups.

Surgical Procedure (Table 2)

Each group had 5 emergency cases. The mean graft number in group A was 2.7±0.9 and 3.4±0.9 in group B. The mean arterial graft number in group A was 2.2±0.6 and 1.0±0.0 in group B. Except for the number of arterial grafts, none of the parameters, including the ratio of emergency operations, off-pump bypass and amount of blood transfusion, showed any significant differences between the 2 groups. Table 2 shows the combinations of graft used. In group A, 3 arterial grafts were used in 1 case, and 2 arterial grafts in 8 cases. Complete revascularization was achieved in 16 of 20 cases.

Short-Term Results (Table 4)

Cardiac Complications There were no cases of perioperative myocardial infarction (PMI) in either group. Post-

Table 4 Causes of Early and Late Deaths

Case of death	Group A	Group B
Cardiac	1 (22 mo: CHF, MNMS)	4 (3 w: VF, 8 mo: sudden death, 51 mo: CHF, amputation, 60 mo: CHF)
Cerebrovascular disease	1 (24 mo: hemorrhage)	1 (35 mo: infarction)
ASO	(22 mo: MNMS)	(51 mo: amputation)
Pulmonary	1 (3 mo: ARDS)	
Sepsis		1 (64 mo)

mo, month; w, weeks; CHF, congestive heart failure; MNMS, myonephrotic metabolic syndrome; VF, ventricular fibrillation; ARDS, acute respiratory distress syndrome.

operative new IABP was needed in 1 patient in group B. Postoperative max CK-MB was 35.2 ± 19.6 U/ml in group A and 48.6 ± 47.0 U/ml in group B. Postoperative maximum catecholamine dosage was $4.0 \pm 2.1 \mu\text{g} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$ in group A and $6.0 \pm 4.9 \mu\text{g} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$ in group B. There was no significant difference between the 2 groups.

Postoperative Bleeding Each group had 1 case of re-sternotomy for bleeding. Intra-operative blood transfusion (BTF) was 6.3 ± 3.0 U in group A and 4.8 ± 2.5 U in group B. Although the amount of BTF for group A was larger, the difference was not significant.

Infection There was neither mediastinitis nor minor wound complications in either group.

Respiratory Complications The mean duration of continuous hemofiltration was 1.9 ± 1.2 days in group A and 4.1 ± 3.2 days in group B. The mean respirator duration was 1.4 ± 1.9 days in group A and 1.9 ± 2.2 days in group B. There was a longer time interval before the start of usual hemodialysis and a longer period of respirator support in group B, but the difference was not significant.

Other Complications There was no cases of new peri-operative cerebrovascular disease in either group. There was no ileus accompanying the harvest of the right gastroepiploic artery (GEA).

Hospital Mortality

There were no operative deaths in group A and in group B there was 1 case of early sudden death (3 weeks after surgery) because of ventricular fibrillation (Table 4).

Angiographic Data

All grafts, except in the case of early death, showed 100% patency (Table 3).

Long-Term Results

The mean follow-up time was 25.1 ± 20.2 months and 29.4 ± 23.8 months in groups A and B, respectively. Table 4 shows the causes of death in each group: 2 cardiac deaths were related to ASO (myonephrotic metabolic syndrome and leg amputation) and there were 4 non-cardiac causes of death (2 cerebrovascular diseases, 1 pulmonary disease and 1 sepsis). In group A, actuarial survival rates at 12 months and 55 months, including all deaths, were 0.89 ± 0.11 and 0.53 ± 0.21 , respectively, and in group B, they were 0.80 ± 0.13 and 0.42 ± 0.21 (Fig 1). Survival rates at 12 months and 55 months (estimated cardiac deaths) were 0.80 ± 0.18 and 0.80 ± 0.18 in group A, and 0.80 ± 0.13 and 0.53 ± 0.23 in group B (Fig 2). There were fewer cardiac deaths in group A at 55 months, but there was no significant difference ($p=0.54$).

Fig 1. Comparison of actuarial survival rates including all death (Upper) and estimated by cardiac deaths (Lower) between the multi-arterial group (group A) and single-artery group (group B).

Discussion

Chronic dialysis patients often have other accompanying diseases, such as DM, hypertension and hyperlipidemia. These patients frequently develop severe atherosclerosis because of the dialysis, and the incidence of cardiovascular disease is high. The annual mortality rate of dialysis patients is approximately 25% and half of the deaths are related to cardiovascular disease¹. The 1-year survival rate of dialysis patients after myocardial infarction is reported to be 46.1%⁵.

Because of progressive calcification of the coronary artery, intervention therapy has a low initial success rate and a high rate of restenosis² and surgical revascularization is often required. However, considering the results from non-dialysis patients, CABG also does not achieve good result in the short and long term. The reported surgical mortality ranges from 11.4% to 20 %⁶⁻⁸ and the high morbidity and mortality of the surgical procedure are related to difficulties with water and electrolyte control immediately after the operation, unstable hemodynamics, and the high rate of infection because of immune suppression⁹ and anemia¹⁰, as well as a tendency of bleeding because of abnormalities of platelets and coagulation factor¹¹ and concomitant respiratory disease.

The long-term prognosis of dialysis patients is also poor. The 5-year survival rate in dialysis patients after myocardial infarction is reported to be 10%⁵, but Nakayama et al reported a superior survival rate (93% at 8 years) after

multi-arterial revascularization.¹² The reported 5-year survival rate of surgically revascularized dialysis patients ranges from 32%⁶ to 55.8%⁷, but if there are associated diseases, such as DM or ASO, the rate drops to between 22.9%¹³ and 42.2%⁷. The poor long-term results are considered to be related the combination of other diseases, such as cerebrovascular disease¹⁴ and ASO, and also due to the difficulty of complete revascularization¹⁵ because of calcified arteries and the rapid progress of new coronary lesions.

Generally, the long-term result of using the interval thoracic artery (ITA) is much better than for a vein graft,¹⁶ and there are reports of the advantage of multi-arterial grafts compared with the single ITA and additional SVGs.^{3,4} With those multi-arterial grafts, the radial artery (RA) is reported to be superior to the right ITA (RITA) or right GEA (RGEA) in terms of practicality.⁴ Because the harvesting of the RITA and RGEA requires a longer time, increased bleeding and postoperative complications, such as mediastinitis,¹⁷ pulmonary complications and intestinal complications, can occur. Further, there is hesitation to use multi-arterial grafts in chronic dialysis patients in whom the RA can not be used. Even so, the good results of multi-arterial grafting in the non-dialysis patient raises the expectation that similar good long-term results could be obtained in dialysis patients,¹² although it is thought there might be increased operative risk and complications.

In the present study, the short-term and long-term results of the multi-arterial bypass group were compared with those of the single-artery bypass group. Differences in the patient profiles and surgical procedure were not noticeable between the 2 groups despite different patient selection criteria. In the multi-arterial group, the damaging effect from the graft harvest was equal to or even less than the single arterial group, from the viewpoint of postoperative CK-MB value, dopamine dosage and IABP usage. The surgical mortality was 0% in group A and 9% in group B. Considering that half of the cases were emergencies, the operative results were good in both groups. This study of the postoperative complications following multi-arterial bypass graft harvesting showed no difference between the 2 groups. There was no mediastinitis accompanying the ITA harvest. Each group had 1 case of re-sternotomy for postoperative bleeding. The skeletonized method for ITA harvest seemed to be useful for the preservation of blood supply of the tissue surrounding the sternum. There was no difference in ventilator time between the 2 groups and no pulmonary complications. Using the off-pump bypass procedure, which did not require extracorporeal circulation, and extra-pleural harvesting of ITA might protect the postoperative pulmonary function. Further, there were no cerebrovascular complications either peri- or post-operatively. It should be emphasized that off-pump bypass without touching the ascending aorta in severe atherosclerosis prevents cerebral complications. The ileus and pulmonary complications that can accompany right GEA harvest did not occur. The advantage of the off-pump bypass procedure in dialysis patients is clear: there is easy control of water and potassium without using cardiopulmonary bypass and high potassium cardioplegia.¹⁸ Although there was concern about the quality of the anastomoses, especially to the calcified coronary artery, which necessitated volume loading for stable perioperative hemodynamics with the off-pump bypass procedure, the operative results were good in view of the patency rate.

Both groups showed poor long-term results, the reason

for which is that dialysis patients suffer from higher than average mortality from non-cardiac causes such as cerebrovascular disease, infection, ASO and pulmonary disease. Examining the cardiac deaths, the multi-arterial group had fewer deaths than the single-artery group. Though we could not show a significant difference, there were possibly fewer cardiac deaths related to vein graft deterioration in the multi-arterial group.

Study Limitations

The present study suffers from the limitations common to all nonrandomized, retrospective analyses. The decision for multi-arterial bypass was made according to each patient's aortic sclerosis, the number of grafts, and concomitant disease. However, the preoperative and operative parameters were similar between multi-arterial group and single artery with SVGs. The small sample size was also a major study limitation; a larger study should be performed.

Conclusion

Multi-arterial grafts during CABG in dialysis patients did not increase the surgical risk. Skeletonized arterial harvesting, off-pump CABG and the aortic no-touch technique were effective procedures. Though we could not prove the effectiveness of multi-arterial grafts with regard to the long-term result, there is the possibility of improving the incidence of cardiac deaths. Because of the high frequency of other diseases in dialysis patients, the non-cardiac diseases, such as cerebrovascular disease, peripheral vascular disease and infection, must be controlled in order to improve the long-term results of multi-arterial CABG.

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