Mid-term Outcomes of Total Arterial Revascularization Versus Conventional Coronary Surgery in Isolated Three-Vessel Coronary Disease

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INTRODUCTION

Although the internal thoracic artery (ITA) has been regarded as the graft of choice for left anterior descending artery (LAD) bypass during coronary artery bypass grafting (CABG) (1), there have been debates over which conduits are best fitted as second and third grafts for non-LAD bypass. Unlike several reports supporting the superior patency of arterial grafts over venous grafts (2-4), a recent prospective randomized study showed that the selection of arterial or venous graft for the second graft has not affected patency beyond 5 yr (5). In a clinical perspective that the purpose of CABG is to relieve ischemic symptoms and to improve survival, evidences are poor with regard to the selection of optimal second and third grafts for non-LAD bypass relating to clinical outcomes (6).

Therefore, the aim of the study was to investigate mid-term clinical outcomes after total arterial revascularization versus conventional coronary bypassing using both arterial and venous conduits in three-vessel coronary disease.

Whether arterial conduits are superior to venous grafts in coronary artery bypassing has been debated. The aim of this study was to investigate clinical outcomes after total arterial revascularization versus conventional coronary bypassing using both arterial and venous conduits in isolated three-vessel coronary disease. Between 2003 and 2005, 503 patients who underwent isolated coronary artery bypass grafting for three-vessel coronary disease were enrolled. A total of 117 patients underwent total arterial revascularization (Artery group) whereas 386 patients were treated with arterial and venous conduits (Vein group). Major adverse outcomes (death, myocardial infarction, stroke and repeat revascularization) were compared. Clinical follow-up was complete in all patients with a mean duration of 6.1 ± 0.9 yr. After adjustment for differences in baseline risk factors, risks of death (hazard ratio [HR] 0.96; 95% confidence interval [CI] 0.51-1.82, P = 0.90), myocardial infarction (HR 0.20, 95% CI 0.02-2.63, P = 0.22), stroke (HR 1.29, 95% CI 0.35-4.72, P = 0.70), repeat revascularization (HR 0.64, 95% CI 0.26-1.55, P = 0.32) and the composite outcomes (HR 0.83, 95% CI 0.50-1.36, P = 0.45) were similar between two groups. Since the use of veins does not increase the risks of adverse outcomes compared with total arterial revascularization, a selection of the conduit should be more liberal.

Key Words: Coronary Artery Bypass Grafting; Arteries; Veins

MATERIALS AND METHODS

Patients

All patients undergoing CABG are prospectively registered in the Asan Medical Center database (Seoul, Korea). This registry prospectively contains patient baseline characteristics, results of cardiac evaluations, detailed information on surgery, and perioperative complications. Between January 2003 and December 2005, 1,495 patients underwent CABG. Of them, 503 patients who underwent primary isolated CABG for three-vessel coronary disease were enrolled in the study. A total of 117 patients underwent total arterial revascularization strategy (Artery group) whereas 386 patients were treated with conventional strategy using both arterial and venous conduits (Vein group). The endpoints of the study were defined as death, myocardial infarction, stroke and repeat revascularization.

Surgery

All CABGs were performed by experienced cardiac surgeons, each of whom performs 100 CABGs annually. Off-pump or con-
Cox regression or multiple logistic regression models were used to compare time related outcomes (survival, freedom from reintervention, freedom from major cerebrovascular event) or binary outcomes (early complications), respectively, with the inclusion of the treatment option (total arterial revascularization versus conventional coronary bypass surgery) and the propensity score as potential predictors of outcomes.

All reported $P$ values were two-sided, and a value of $P < 0.05$ was considered statistically significant. SAS software, version 9.1 (SAS Institute, Cary, NC, USA) and SPSS version 12 were used for the statistical analysis.

**Ethics statement**

This study was approved by our institutional review board (No.:...
RESULTS

Baseline profiles
Baseline characteristics of the entire cohort are shown in Table 1. Patients in the Artery group were less likely to have hypertension and chronic renal failure, and were more likely to undergo off-pump surgery. Mean numbers of distal anastomoses were 3.4 ± 0.8 in the Artery group and 3.8 ± 1.0 in the Vein group (P < 0.001). In the Vein group, mean number of distal anastomoses using vein graft was 1.3 ± 0.6 (Median 1, range 1–4). The numbers of distal anastomoses using vein grafts were one in 289 (74.9%), three in 82 (21.2%), three in 9 (2.3%) and four in 5 (1.3%). The vein grafts were used for right coronary artery territory bypassing in 351, and for left circumflex or ramus intermedius territories in 53. Propensity score matching yielded 102 pairs of patients in which there were no significant differences in baseline characteristics between the two groups including the mean number of distal anastomoses (Table 2 and 3).

Unadjusted clinical outcomes
Clinical follow-up was complete in all patients (100%) with a mean follow-up duration of 6.1 ± 0.9 yr, during which there were 60 deaths, 25 reinterventions, 3 non-fatal myocardial infarctions, 18 strokes. Ninety patients experienced at least one of the major adverse events during follow-up (Table 4). There were no significant differences in the rates of death, reintervention, myocardial infarction, stroke and the composite outcomes between the Artery and the Vein groups in crude and propensity score matched population.

Table 2. Baseline characteristics of propensity score matched population

| Parameters | Artery group | Vein group | P value |
|-----------|-------------|------------|--------|
| Number of patients | 102 | 102 | |
| Age (yr) | 62.2 ± 8.9 | 61.7 ± 7.9 | 0.71 |
| Female gender, No. (%) | 26 | 22 | 0.51 |
| Body mass index (kg/m²) | 24.8 ± 3.1 | 24.5 ± 2.7 | 0.51 |
| Diabetes mellitus, No. (%) | 47 | 43 | 0.57 |
| Hypertension, No. (%) | 55 | 60 | 0.48 |
| Dyslipidemia, No. (%) | 55 | 56 | 0.89 |
| Current smoker, No. (%) | 25 | 32 | 0.275 |
| History of MI, No. (%) | 25 | 21 | 0.50 |
| Chronic renal failure, No. (%) | 2 | 1 | > 0.99 |
| Peripheral arteriopathy, No. (%) | 1 | 2 | > 0.99 |
| History of CVA or TIA, No. (%) | 5 | 3 | 0.47 |
| Acute MI < 7 days | 1 | 1 | > 0.99 |
| Unstable angina | 25 | 25 | > 0.99 |
| LV ejection fraction (%) | 55.7 ± 10.9 | 56.5 ± 12.3 | 0.62 |
| Coronary lesion category | |
| Left main disease, No. (%) | 35 | 33 | 0.67 |
| Chronic total occlusion ≥ 1, No. (%) | 54 | 51 | |
| Off pump/on pump, No. | 34/68 | 29/73 | 0.45 |
| Grafting strategy | |
| Number of distal anastomoses using each graft conduit | |
| ITA to LAD | 115 | |
| ITA to other territory | 47 | |
| RA | 246 | 528 | 0.53 |
| GEA | 0 | |
| SVG | 0 | 498 | |
| Total | 398 | 1,448 | |

Table 3. Number of distal anastomoses using each graft conduit

| Sites of anastomoses | No. of anastomoses |
|----------------------|---------------------|
| Artery group (n = 117) | Vein group (n = 386) | Total (n = 503) |
| ITA | 139 (1.2) | 422 (1.1) | 561 (1.1) |
| ITA to LAD | 115 | 375 | 490 |
| ITA to other territory | 24 | 47 | 71 |
| RA | 246 (2.1) | 528 (1.4) | 774 (1.5) |
| GEA | 13 (0.1) | 0 | 13 |
| SVG | 0 | 498 (1.3) | 498 |
| Total | 398 (3.4) | 1,448 (3.8) | 1,846 (3.7) |

Table 4. Complications and mortality

| Complications | Entire cohort | Propensity score matched cohort |
|---------------|--------------|---------------------------------|
|                | Artery group | Vein group | P value | Artery group | Vein group | P value |
| Death | 14 (12.0) | 46 (11.9) | 0.99 | 12 (11.8) | 11 (10.8) | 0.83 |
| Non-fatal MI | 2 (1.7) | 1 (0.3) | 0.074 | 2 (2.0) | 0 | 0.16 |
| Stroke | 3 (2.6) | 15 (3.9) | 0.50 | 2 (2.0) | 3 (2.9) | 0.65 |
| Reintervention | 9 (7.7) | 16 (4.1) | 0.12 | 9 (8.8) | 5 (4.9) | 0.27 |
| Composite outcomes | 24 (20.5) | 66 (17.1) | 0.40 | 21 (20.6) | 17 (16.7) | 0.47 |

MV, myocardial infarction. 

CVA, cerebrovascular accident; ITA, Internal thoracic artery; LV, left ventricle; MI, myocardial infarction; TIA, transient ischemic attack.
matched comparisons (Table 4).
Twenty-five repeat-revascularizations included one case of redo-CABG (saphenous vein graft revision immediately after the operation) and 24 cases of percutaneous coronary intervention. When the myocardial ischemic events (reintervention and myocardial infarction, n = 26; two patients had both events) were analyzed according to the conduits used for bypassing, they were left ITA problem in 6 (out of 561 left ITA grafts, 1.1%), radial artery problems in 11 (out of 774 radial arteries, 1.4%), saphenous vein grafts problems in 5 (out of 498, 1.0%) and non-target territory problems in 4 (right coronary artery in 3, obtuse marginal artery in 1).

**Adjusted hazard**
Kaplan-Meier curves for overall survival, freedom from reintervention and event-free survival in propensity score matched patients are shown in Fig. 1, and there were no significant differences in the rates of events between the two groups.

After adjustment, risks of death (hazard ratio [HR] 0.96; 95% confidence interval [CI] 0.51-1.82, \( P = 0.90 \)), myocardial infarction (HR 0.20, 95% CI 0.02-2.63, \( P = 0.22 \)), stroke (HR 1.29, 95% CI 0.35-4.72, \( P = 0.70 \)), repeat revascularization (HR 0.64, 95% CI 0.26-1.55, \( P = 0.32 \)) and the combined risk of death, myocardial infarction, stroke or repeat revascularization (HR 0.83, 95% CI 0.50-1.36, \( P = 0.45 \)) were similar between the Artery group and the Vein group. For the 102 propensity score-matched pairs, similar results were obtained for all clinical endpoints (Table 5).

**DISCUSSION**
The present study showed that conventional coronary artery
surgery in three-vessel coronary disease, compared with total arterial revascularization, demonstrated similar risks of death, myocardial infarction, stroke, reintervention and composite outcomes. In this study, we included three-vessel disease only because the importance of second and third grafts can be magnified in this subset of coronary diseases. In order to obtain midterm clinical outcomes over 5 yr, patients enrollments were confined to those who underwent surgery before the end of 2005.

The goals of coronary artery bypass graft surgery are relief of ischemic symptoms, prevention of myocardial pumping failure and prolongation of the patient’s survival. For decades, arterial grafts have been reported to have better patency rate and superior clinical results compared to venous conduits (8-10). Since the long-term survival depends on the patency of graft vessel after CABG, the excellent long-term patency and survival of left ITA (11) arguably encouraged the use of arterial graft such as radial artery, gastroepiploic artery and right ITA rather than vein graft and led to the enthusiasm to achieve total arterial revascularization. Radial artery graft shows more than 90% patency rate at 1 yr and 5 yr compared to about 85% of vein graft for left circumflex coronary artery (2, 3). It also demonstrated about 85% of patency rate at 5 yr for left circumflex coronary artery and right coronary artery (8-10). On the other hand, Hayward et al. showed that there was no difference in 5 yr patency rates between radial artery graft and saphenous vein graft (90.0% vs 87.0%) (3). Khot and co-workers reported that radial artery graft revealed lower patency rate than saphenous vein graft for left circumflex coronary artery and right coronary artery (12). Furthermore, in a study evaluating post-CABG symptomatic patients with conventional angiography, about 75% patency rate of radial artery graft was reported at mean follow-up of 27.1 months (4). Another study also demonstrated that the patency rate of radial artery graft in symptomatic patient was as low as 60% (13).

The use of bilateral ITA showed superior patency rate and survival rate than the use of radial artery graft and saphenous vein graft in triple vessel disease (14, 15). However, harvesting of bilateral ITA is technically demanding, time consuming and may cause sternal wound infection. And recent multi-center randomized trial revealed that the use of veins does not increase the risks of adverse outcomes on mid-term follow-up between two groups. Since procedural factors such as less manipulation, no pressure dilatation of vein graft or no tough technique also improved a quality of vein graft, which may result in similar clinical outcomes compared with artery graft in this study.

This study is subject to the limitations inherent in retrospective work with observational data. The non-randomized design may have affected the results because of unmeasured confounders, procedure bias or detection bias, even with the use of propensity score matching. This study is not an ‘intention-to-treat’ based comparison and graft patency was not considered.

The concept of total arterial revascularization has been based on superior graft patency rate of arterial graft rather than venous graft on angiographic data ground. However, in clinical perspective, our results showed similar risks of death and major adverse outcomes on mid-term follow-up between two groups. Since the use of veins does not increase the risks of adverse outcomes compared with total arterial revascularization, a selection of the conduit should be more liberal.

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