Impact of Total Arterial Reconstruction on Long-Term Mortality and Morbidity: Off-Pump Total Arterial Reconstruction Versus Non-Total Arterial Reconstruction

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Background. We were interested in how favorable an influence total arterial reconstruction has on the clinical outcome of patients undergoing off-pump coronary artery bypass graft surgery.

Methods. From January 2002 to December 2013, a total of 1,064 patients underwent isolated off-pump coronary artery bypass graft surgery at our institution. Of these 1,064 patients, 763 underwent total arterial revascularization (AR) and 301 underwent a combination of artery and vein revascularization (AVR). We compared the clinical results between the two groups using the propensity score matching technique.

Results. In all, 260 cases from the AVR group and 520 from the AR group were successfully matched. All procedures were performed using the off-pump technique without conversion to on-pump. Eight patients in the AVR group (3.1%) and 5 in the AR group (1.0%) died in hospital. Multivariate analysis revealed that chronic kidney disease (odds ratio 6.9, $p < 0.001$), urgency (odds ratio 7.3, $p < 0.001$), and body mass index (odds ratio 1.3, $p = 0.02$) were independent risk factors for hospital death. Follow-up was complete for 97.6% of the patients to a maximum of 13 years. According to the Kaplan-Meier method, the rate of 12-year freedom from all causes of death was 69.7% for the AVR group and 72.6% for the AR group ($p = 0.002$), and the corresponding rates for major adverse cardiac events were 83.9% and 87.7% ($p = 0.009$). By multivariate Cox regression analysis, total arterial reconstruction was identified as a preventive factor for late cardiac events.

Conclusions. Total arterial revascularization has some degree of favorable effect on the long-term clinical outcome of patients undergoing off-pump coronary artery bypass graft surgery.

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A number of studies have demonstrated the advantage of off-pump coronary artery bypass graft surgery (CABG) over conventional on-pump CABG for high-risk patients [1–3]. After the development of the off-pump CABG technique, the current trend in revascularization strategy is toward in-situ all-arterial grafting because of the benefits of the aorta nontouch technique and better long-term clinical outcomes. As is generally known, the use of the internal thoracic artery (ITA) is associated with low rates of mortality and reintervention. Furthermore, a number of important reports demonstrate that bilateral ITA (BITA) grafting to the left anterior descending artery (LAD) and circumflex coronary artery offers the best rates of long-term survival and the lowest rates of reintervention [4–10]. In the decade since Buxton and coworkers [7] and Lytle and coworkers [6] demonstrated the long-term efficacy of BITA grafting, it has been gaining acceptance among surgeons, and there is no doubt that it affords the best long-term outcome. We now have three reliable in-situ arterial grafts, including both ITAs and the gastroepiploic artery (GEA). CABG with grafting of the BITAs to the left coronary system and, in addition, of the GEA to the distal right coronary artery (RCA) has been reported to provide good long-term outcome [11–13]. Using the GEA combined with the BITAs can achieve complete avoidance of aorta manipulation.

The aim of the present study was to investigate whether patients undergoing off-pump total arterial grafting have better clinical outcome than patients treated with a combination of artery and vein grafting.

Patients and Methods

The Institutional Review Board approved the study. All patients had previously granted permission for use of their medical records for research purposes. Between January 2002 and December 2013, 1,064 consecutive patients underwent isolated off-pump CABG at Shiga

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Abbreviations and Acronyms

AR = arterial revascularization
AVR = artery and vein revascularization
BITA = bilateral internal thoracic arteries
CABG = coronary artery bypass graft surgery
CI = confidence interval
GEA = gastroepiploic artery
HR = hazard ratio
ITA = internal thoracic artery
LAD = left anterior descending artery
LITA = left internal thoracic artery
OR = odds ratio
RCA = right coronary artery
RITA = right internal thoracic artery
SVG = saphenous vein graft

Medical University Hospital. Of these 1,064 patients, 763 underwent total arterial revascularization (AR group) and 301 underwent a combination of artery and vein grafting (AVR group). The propensity score, which was the probability that a patient had total arterial revascularization, was calculated to achieve one-to-two matching sets with similar clinical characteristics for fair comparison. Logistic regression with backward selection was performed to calculate the propensity score, based on the following 17 patient characteristics (Table 1) that might affect total arterial grafting: age, sex, smoking history, hypertension, dyslipidemia, chronic pulmonary disease, peripheral arterial disease, diabetes mellitus, previous stroke, chronic renal failure, congestive heart failure, previous myocardial infarction, left main disease, left ventricular ejection fraction less than 40%, previous percutaneous coronary intervention, urgency, and body mass index. The early and long-term clinical outcomes were compared between the two matched groups.

Patients with acute myocardial infarction were included, but patients who had undergone a salvage procedure and patients with single-vessel disease were excluded from the study. Off-pump surgery was performed in all CABG cases with no exclusion criteria. Follow-up was achieved by direct communication with the patient, the patient's family, or the attending physician.

Patients with diabetes were identified as those previously diagnosed by a physician and requiring treatment with nutritional modification, oral medication, or insulin at the time of surgery. Patients with no preoperative diagnosis in whom diabetes was discovered and treated during or after hospitalization were defined as non-diabetes. Hospital mortality was defined as death during the same hospital admission period regardless of cause. Postoperative renal failure was defined as the requirement for new temporary hemodialysis. Postoperative stroke was defined as a new neurologic deficit persisting for more than 24 hours after onset and was confirmed by computed tomography. Perioperative myocardial infarction was defined as a new Q wave after surgery on an electrocardiogram or a significant elevation in postoperative cardiac enzyme.

Surgical Details

Our surgical technique has been described previously [14]. All procedures were performed through a median sternotomy. All conduits (one or both ITAs and the right GEA) were harvested and skeletonized using an ultrasonic scalpel (Harmonic Scalpel; Ethicon Endosurgery, Cincinnati, OH). We used bilateral ITAs routinely for two-vessel or three-vessel disease patients who required grafting to the LAD and circumflex artery. We also used the skeletonized GEA proactively to reconstruct the distal RCA as an in-situ graft. Saphenous vein grafts (SVG) were mainly used for reconstruction of the distal RCA. An intracoronary shunt tube and CO_2 blower were used routinely.

Statistical Analysis

Data are presented as the mean ± SD. Categoric variables were analyzed using the χ^2 or Fisher's exact test. Continuous variables were examined using the *t* test or the Mann-Whitney *U* test. Univariate and multivariate Cox proportional hazards regression analyses were performed for the analysis of late mortality and cardiac events. The multivariate analyses were performed with a stepwise forward regression model into which was entered each variable with a probability value of less than 0.25 in the univariate analysis. Actuarial survival and event-free survival curves were estimated using the Kaplan-Meier method, comparing differences between

Table 1. Preoperative Patient Characteristics

Preoperative Characteristics	AR Group (n = 250)	AVR Group (n = 260)	*p* Value
Age, mean ± SD	69.0 ± 10.0	70.8 ± 9.6	<0.001
Female	90 (17.4)	56 (21.5)	0.15
Smoking history	311 (59.8)	121 (46.5)	<0.001
Hypertension	376 (72.3)	170 (65.4)	0.04
Dyslipidemia	273 (56.3)	118 (45.4)	0.06
Diabetes mellitus	281 (54.0)	107 (41.2)	<0.001
COPD	103 (19.8)	55 (21.2)	0.66
Peripheral arterial disease	51 (9.8)	24 (9.2)	0.80
Previous stroke	51 (9.8)	29 (11.1)	0.56
Chronic renal failure[a]	86 (16.5)	59 (22.7)	0.04
Congestive heart failure	150 (28.8)	87 (33.5)	0.19
Previous myocardial infarction	164 (31.5)	113 (43.5)	0.001
Left main disease	216 (41.5)	121 (46.5)	0.18
LVEF <40%	54 (10.4)	42 (16.2)	0.02
Previous PCI	163 (31.3)	72 (27.7)	0.29
Emergency	101 (19.4)	93 (36.1)	<0.001
Body mass index, kg/m^2, mean	23.6	22.7	0.12

[a] Serum creatinin greater than 1.5.

Values are n (%) unless otherwise indicated.

AR = artery revascularization; AVR = artery and vein revascularization; COPD = chronic obstructive pulmonary disease; LVEF = left ventricular ejection fraction; PCI = percutaneous coronary intervention; SD = standard deviation.