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Aortic Nontouch Off-Pump Complete Revascularization Using 3 In Situ Arterial Conduits: Bilateral Internal Mammary Arteries and Gastroepiploic Artery

Dr. Hirose

Hitoshi Hirose, MD, FICS, Atsushi Amano, MD, Akihito Takahashi, MD

Department of Cardiovascular Surgery, Juntendo University Hospital, Tokyo, Japan

ABSTRACT

Background: Arterial grafts have been used frequently in recent coronary artery bypass grafting (CABG). Off-pump CABG can facilitate early patient recovery. A combination of in situ graft and off-pump technique results in complete aortic nontouch surgery; however, outcome has not been well established.

Methods: Between May 1998 and December 2001, 1035 consecutive isolated CABG operations were performed at Juntendo–Shin-Tokyo Hospital Group. Of these, off-pump CABG using in situ bilateral internal mammary arteries and in situ gastroepiploic artery was performed in 48 patients (41 men and 7 women; mean age, 74.5 ± 9.9 years). Perioperative and follow-up data were studied.

Results: The average number of distal anastomoses was 3.4 ± 0.7, and complete revascularization was achieved in all patients. There were no hospital deaths. Perioperative myocardial infarction was observed in 1 patient, congestive heart failure in 1, stroke in 2, and mediastinitis in 1. Postoperative catheterization was performed in 30 patients and revealed no graft occlusions. During the follow-up period of 2.3 ± 1.2 years, no remote deaths, angina recurrence, or coronary interventions were observed.

Conclusion: Off-pump CABG using an all in situ arterial graft can be performed safely, and follow-up results are excellent.

INTRODUCTION

To avoid remote cardiac events associated with graft occlusions, which are known to occur more frequently in patients who undergo bypass with saphenous vein grafts [Reardon 1997], the use of arterial conduits has been increasing in recent coronary artery bypass grafting (CABG) [Reardon 1997, Barner 1998]. The internal mammary arteries (IMAs) are the most frequently used, and their patency rates have been reported to be 90% or higher even 10 years after surgery [Reardon 1997, Barner 1998]. Bilateral IMAs (BIMA) have been reported to provide better event-free rates than a single IMA in selected patients [Lytle 1999]. The gastroepiploic artery (GEA) has been found to have an acceptable long-term patency rate [Hirose 2002c]. One of the advantages of GEA compared with other arterial conduits, such as radial artery, is that the GEA can be used as an in situ graft. Off-pump CABG is known to facilitate early patient recovery [Hirose 2002b], and recent developments in instruments have made complete off-pump revascularization feasible [Hirose 2002a]. A combination of in situ grafts and off-pump technique allows complete aortic nontouch surgery. We report our experience and the outcome of off-pump CABG using only in situ arterial grafts for complete coronary revascularization.

METHODS

Between May 1998 and December 2001, 1035 consecutive patients underwent isolated CABG at Juntendo–Shin-Tokyo Hospital Cardiovascular Group (Shin-Tokyo Hospital and Kobari General Hospital). Of these, 691 (66.8%) of the patients underwent off-pump CABG; 48 of these patients underwent total in situ arterial bypass with BIMA and GEA.

Patients with uncontrolled diabetes and patients with severe osteoporosis, who were considered to be at high risk of sternal complications, were not candidates for BIMA harvesting. The contraindications to GEA harvesting were a history of upper abdominal surgery or active peptic ulcer or the presence of a gastroduodenal mass. In the early study period, between 1998 and 1999, IMA harvesting was performed in a pedicle; however, the procedure was switched to skeletonized harvesting after January 2000, as described elsewhere [Higami 2000]. The GEA was harvested as a thin pedicle (Figure). Skeletonization was facilitated by an ultrasonic scalpel (Harmonic Scalpel; Ethicon Endo-Surgery, Cincinnati, OH, USA). Off-pump CABG using BIMA and GEA grafts was not performed in emergency cases owing to the relatively long graft harvesting time. The indications for off-pump in situ grafting using BIMA and GEA were individualized, although relatively young patients without previous contraindications and patients at high risk of stroke were preferably selected for this procedure.

Dr. Hirose is currently at the Department of Thoracic and Cardiovascular Surgery, Cleveland Clinic Foundation, Cleveland, Ohio, USA. Dr. Amano is currently at the Department of Cardiovascular Surgery, Juntendo University Hospital, Tokyo, Japan. Dr. Takahashi is currently at the Department of Cardiovascular Surgery, Cardiovascular Institute Hospital, Tokyo, Japan.

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Address correspondence and reprint requests to: Hitoshi Hirose, MD, FICS, Dept of Thoracic and Cardiovascular Surgery, The Cleveland Clinic Foundation, 9500 Euclid Ave/F25, Cleveland, OH 44195, USA; 1-216-445-6816; 1-216-707-9446 (e-mail: genex@nifty.com).

Harvested in situ internal mammary arteries and gastroepiploic arteries.

Perioperative and follow-up data were prospectively entered into a structured database, and perioperative data were extracted from it. Outpatient follow-up information was collected by direct patient contact, by responses to mailed questionnaires, or by contact with private cardiologists. Any cardiac events after hospital discharge, including myocardial infarction, angina, arrhythmia requiring hospitalization, congestive heart failure requiring hospitalization, native coronary artery or graft stenosis requiring any type of coronary intervention, and sudden death were counted as cardiac events. These follow-up data were compiled up to December 31, 2002. The end points were patient death or the occurrence of one of the above cardiac events.

For quality control, early angiography within 3 months of surgery was strongly recommended for all patients. Remote angiography was recommended for all patients if symptoms of angina developed. The quality of anastomosis was graded according to FitzGibbon's classification [FitzGibbon 1996]. Grafts were considered to be patent at grade A or B. Perfect anastomotic patency was counted only grade A anastomoses.

Results were expressed as mean ± standard deviation. Statistical analysis was performed using Student *t* test or Mann-Whitney *U* test as appropriate for continuous variables or by chi-square test (Fisher exact tests if n < 5) for categorical variables. A *P* value less than .05 was considered significant. All statistical analyses were performed using JMP version 5.0 (SAS Institute, Cary, NC, USA).

RESULTS

Patient Demographics

The study patients were 48 patients (41 men and 7 women; mean age, 64.5 ± 9.9 years). The demographic details of the patients are given in Table 1. A history of cerebral vascular accident was noted in 11 (22.9%) of the patients and calcified ascending aorta in 13 (27.1%) of the patients. The average Euro score was 3.6 ± 2.0.

Operative Results

The operative data are shown in Table 2. The mean number of distal anastomoses was 3.4 ± 0.7. The LAD was always revascularized with one of the IMAs. The other IMA was used for bypass to the circumflex artery. The common combinations of IMA bypass targets were as follows: left IMA (LIMA)–LAD and right IMA (RIMA)–circumflex artery or LIMA–circumflex artery and RIMA-LAD. In addition to these, the diagonal artery and/or obtuse marginal artery was bypassed in a sequential manner if necessary. The distal right coronary artery always was revascularized with the GEA. The GEA also was used for bypass to the circumflex artery.

In-Hospital Results

The postoperative course is displayed in Table 2. There were no hospital deaths. Postoperative complications included postoperative myocardial infarction in 1 patient, congestive heart failure in 1 patient, stroke in 2 patients, and mediastinitis in 1 patient. The 1 case of perioperative myocardial infarction was related to vasospasm of the native coronary artery, whereas all in situ grafts were patent, as confirmed by angiography.

Remote Results

Follow-up was completed for all patients. The mean follow-up period was 2.3 ± 1.0 years. During the follow-up period, no

Table 1. Preoperative Patient Demographics (N = 48)

Clinical characteristics	
Age, y	64.5 ± 9.9 (range, 44-88)
Age over 75 y, n	8 (16.7%)
Female sex, n	7 (14.6%)
Cardiac profile, n	
Unstable angina	6 (12.5%)
Previous myocardial infarction	37 (77.1%)
History of congestive heart failure	7 (14.6%)
Poor ejection function (<40%)	8 (16.7%)
Angiographic profile, n	
Left main disease	11 (22.9%)
Three-vessel disease	42 (87.5%)
Coronary risk factors, n	
Hypertension	31 (64.6%)
Diabetes	27 (56.3%)
Insulin user	8 (16.7%)
Hyperlipidemia	25 (52.1%)
Obesity	21 (43.8%)
Smoking	5 (10.4%)
Family history	6 (12.5%)
Comorbidity, n	
Peripheral vascular disease	6 (12.5%)
Cerebral vascular accident	11 (22.9%)
Chronic obstructive pulmonary disease	2 (4.2%)
Calcified ascending aorta	13 (27.1%)
Renal dysfunction (serum creatinine >1.5 mg/dL)	18 (37.5%)
Hemodialysis	5 (10.4%)
Euro Score	3.5 ± 2.0 (range, 0-8)

Table 2. Surgical Results (N = 48)

Number of distal anastomoses	3.4 ± 0.7 (range, 3-6)
Operation time, min	337.1 ± 71.4 (range, 250-705)
Blood transfusion, n	12 (25.0%)
Intubation, h	8.5 ± 8.3 (range, 2-47)
Intensive care unit stay, d	2.4 ± 1.1 (range, 1-7)
Postoperative stay, d	14.3 ± 6.8 (range, 6-42)
Postoperative complications, n	
Congestive heart failure	1 (2.1%)
Postoperative myocardial infarction	1 (2.1%)
Respiratory failure	0
Pneumonia	0
Severe arrhythmia	2 (4.2%)
Cerebral vascular accident	2 (4.2%)
Reexploration for bleeding	0
Postoperative hemodialysis	0
Mediastinitis	1 (2.1%)
In-hospital death	0

deaths, angina recurrence, or coronary reintervention was observed (Table 3). There were 2 instances of remote congestive heart failure, which required hospital admission.

Angiographic Study

Control angiography before discharge or within 3 months of surgery was performed on 30 (62.3%) of the patients. No graft occlusions were found. There were 3 distal anastomotic stenoses (grade B anastomoses): in the LIMA in 1 patient, the RIMA in 1 patient, and the GEA in 1 patient. The perfect anastomosis patency rate was 97.3% (36/37) in LIMA grafts, 97.2% (35/36) in RIMA grafts, and 96.9% (31/32) in GEA grafts.

DISCUSSION

BIMA grafting has been used relatively frequently in our practice, because of its superior long-term results compared with single IMA grafting [Schmidt 1997, Lytle 1999]. The patency rates of in situ LIMA and in situ RIMA are similar, and their graft patency rates are reported to be better than 90% at 10 years [Reardon 1997, Barner 1998]. The graft patency rate of the GEA is reported to be inferior to that of the IMA. The reported 5-year patency rate for the GEA is 84% [Suma 2000]. However, GEA has all the characteristics of arterial grafts, such as endothelial function, smooth muscle receptors, and low incidence of atherosclerosis [He 1995]. One of the advantages of IMA and GEA compared with saphenous vein or radial artery is its availability for use as an in situ graft. In a study of IMA grafting, in situ grafting has found to have a better long-term patency rate than free grafting [Verhelst 1996]. The inferior graft patency of free grafts has been explained by denervation and graft size mismatch at the proximal anastomosis [Verhelst 1996]. Flow regulation of the GEA has been well observed. Graft narrowing or occlusion can occur if the native coronary artery has high flow. Graft recanalization also can occur if the native coronary artery stenosis progresses [Hirose 2002c]. Our early angiographic patency rates with in situ IMA and GEA were excellent. No patients developed angina or needed coronary intervention during the follow-up period. This excellent angina-free rate reflects the good graft patency rates.

Skeletonized harvesting of the IMA has been known to preserve the local circulation and to reduce the incidence of sternal wound complications [Higami 2000]. Skeletonized IMA provides extra length and delivers higher graft flow compared with pedicled grafts [Choi 1996]. Skeletonized LIMA always has enough length to reach the posterolateral branch of the circumflex artery, and skeletonized RIMA easily reaches the LAD and often the circumflex artery. We use an ultrasonic scalpel for skeletonization to facilitate dissection and hemostasis. Skeletonization-related complications did not occur in our series. Skeletonization of the GEA is more challenging than that of the IMA because of the muscular arterial characteristics of the GEA, especially frequent occurrence of vasospasm. However, successful skeletonization of a GEA graft recently was reported [Asai 2002], and this technique has been under evaluation at our institution.

Use of off-pump surgery and in situ grafts allowed us to avoid aortic manipulation completely. Avoidance of aortic manipulation has decreased the incidence of postoperative stroke [Grega 2003], and fewer neurological events after off-pump CABG have been reported than with on-pump CABG [Stamou 2002, Zamvar 2002]. Furthermore, multivessel off-pump CABG has been associated with a decrease in early mortality [Cleveland 2001, Magee 2002]. Theoretically, off-pump CABG using in situ grafts minimizes the risk of postoperative neurological events and mortality, and optimizes patient recovery. In our series, 2 patients developed postoperative stroke related to postoperative atrial fibrillation. Postoperative atrial fibrillation occurred in 12 (25.0%) of the patients in our series. To minimize the risk of postoperative stroke, we started using low molecular weight heparin or warfarin in patients who had more than 2 episodes of recurrent atrial fibrillation. Because most patients prefer to undergo angiography prior to discharge rather than come back to the hospital for postoperative angiography, the postoperative stay in our study was relatively long.

The number of patients undergoing off-pump BIMA and GEA grafting is growing, supported by current results. In the early period of the study, between May 1998 and December 1999, only 9 patients (5.7 patients

Table 3. Remote Results

Number of patients followed	48/48 (100%)
Follow-up period, y	2.3 ± 1.2
Patients with outpatient cardiac events, n	2 (4.2%)
Angina	0
Congestive heart failure	2
Catheter intervention	0
Arrhythmia	0
Sudden death	0
Distant deaths, n	0

per year) underwent off-pump all–in situ BIMA and GEA grafting; however, during the late period of the study, between January 2000 and December 2001, 39 patients (19.5 patients per year) underwent off-pump all–in situ BIMA and GEA grafting. This increase most likely was due to good early results, advances in harvesting technique (skeletonization), and development of new devices for off-pump surgery.

SUMMARY

Off-pump arterial bypass using in situ BIMA and GEA has provided good short-term and midterm outcomes. The excellent graft patency rates of these in situ conduits has most likely contributed to excellent relief from cardiac events.

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REVIEW AND COMMENTARY

Invited Commentary by Donald E. Ross, FRACS, The Royal North Shore Hospital, Sydney, Australia:

This small, highly selected series of OPCAB cases was performed with in situ arterial grafts and, therefore, no aortic manipulation. Of 1035 coronary operations, 691 were off pump and only 48, that is, only 4.6%, were performed with the designated technique. Nevertheless, the patient demographics show a reasonably high-risk group.

The theoretical benefits of avoiding all aortic manipulation are profound, and many surgeons are exploring various methods to achieve this end. The authors are to be complemented for adding to this experience, even if their numbers are too small to draw many conclusions.

Having found that it can be done, the authors next need to determine how applicable the procedure is to all their coronary referrals. I would humbly suggest that use of T and composite grafting with the radial artery would considerably increase this number.

Of the complications, 2 strokes from atrial fibrillation were especially unfortunate. Such strokes usually are rare occurrences. It would be interesting to know whether this complication was particular to the study group.