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Off-Pump Coronary Artery Bypass Using Skeletonized Gastroepiploic Artery, a Pilot Study

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ABSTRACT

Background: The problem with using the gastroepiploic artery (GEA) for coronary artery bypass grafting (CABG) is vasospasm. To minimize vasospasm of the GEA, a skeletonized harvesting technique was used for GEA harvesting. We present the initial results of GEA grafting using this technique.

Methods: Between September 1, 2002, and December 31, 2002, a total of 25 patients (21 men and 4 women, mean age 65.4 ± 8.7 years) gave informed consent and underwent elective off-pump CABG using the skeletonized GEA. Skeletonization was completed using an ultrasonic scalpel (Harmonic scalpel, coagulating-scissors; Ethicon Endo-Surgery, Cincinnati, OH, USA). Follow-up data were available until August 31, 2003. Perioperative, early clinical, and follow-up results were analyzed.

Results: There were no hospital deaths, perioperative myocardial infarctions, congestive heart failure, strokes, or renal failure. There were no abdominal complications. Follow-up data were available from all patients, with a mean follow-up of 0.8 ± 0.1 years. There were no cardiac deaths or cardiac events.

Conclusion: During our limited follow-up period, the early results of skeletonized GEA grafting were excellent, and cardiac events have been well controlled. Mid-term follow-up study and angiographic study are necessary to confirm our initial clinical outcome data.

INTRODUCTION

The gastroepiploic artery (GEA) has been used for coronary artery bypass grafting (CABG). The late patency rate of the GEA was reported to be inferior to that of the internal mammary artery (IMA) but superior to that of the saphenous vein graft [Suma 2000, Hirose 2002a]. Major factors influencing the long-term patency of GEA grafting are vasospasm and flow competition [Suma 2000]. Flow competition of the GEA is appeared to be related to the graft diameter [Hashimoto 1996, Suma 2000]. Study of the IMA demonstrated that skeletonization successfully increased blood flow and graft diameter [Choi 1996, Wendler 1999]. The skeletonization technique has been used for radial artery harvesting, and it has decreased the incidence of graft stenosis [Amano 2002]. Because the GEA is classified as being in the same category as the radial artery, skeletonization of the GEA graft is considered and demonstrated successfully by Asai [2002]. However, the clinical outcomes of skeletonized GEA grafting have not been published. We present here early clinical results of skeletonized GEA grafting with approximately 1 year of follow-up.

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METHODS

Patients

The perioperative and remote data of patients who underwent isolated CABG at Juntendo University Hospital were prospectively entered into a structured database. Skeletonized GEA grafting was approved by the local committee and the patients gave informed consent prior to surgery. The inclusion criterion of the study was elective isolated CABG. Because more than 80% of the isolated CABG procedures are performed off-pump at our institute, the study patients were further limited to those undergoing off-pump CABG. The clinical results of skeletonized GEA grafting were scheduled for reevaluation after 25 cases. Between September 1, 2002, and December 31, 2002, a total of 51 consecutive elective isolated CABG were performed. Of these, 49 were off-pump CABG, and the GEA was used in 31 patients. Among them, 25 patients (21 men and 4 women; mean age, 65.4 ± 8.7 years) gave informed consent for skeletonized GEA grafting. Preoperative demographics of these patients are shown in Table 1.

Technique of Gastroepiploic Artery Harvesting

After median sternotomy, the IMAs were harvested in skeletonized fashion using an ultrasonic scalpel (Harmonic scalpel, dissection-hook type; Ethicon Endo-Surgery, Cincinnati, OH, USA). Simultaneously, the radial artery was harvested in skeletonized fashion as described previously [Amano 2002]. The midsternal incision was extended 5 to 6 cm caudally, and the peritoneal cavity was entered. The stomach was pulled up anteriorly and the GEA was evaluated by finger pal-

Table 1. Preoperative Patient Demographics (N = 25)

Clinical characteristics	
Age, y	65.4 ± 8.4 (50-75)
Age >75 y	2 (8%)
Female sex	4 (16%)
Cardiac profile	
Unstable angina	7 (28%)
Previous myocardial infarction	17 (68%)
Poor ejection function (<40%)	1 (4%)
Redo surgery	3 (12%)
Left main disease	2 (8%)
3-Vessel disease	23 (92%)
Coronary risk factors	
Hypertension	19 (76%)
Diabetes	16 (64%)
Hyperlipidemia	16 (64%)
Smoking	10 (40%)
Obesity	7 (28%)
Family history	8 (32%)
Peripheral vascular disease	4 (16%)
Cerebral vascular accident	7 (28%)
Chronic obstructive pulmonary disease	0 (0%)
Calcified ascending aorta	2 (8%)
Renal dysfunction	6 (24%)

pation. If there was extensive adhesion around the stomach or if there was a palpable mass in the stomach or liver, GEA harvest was abandoned and alternative conduits were harvested. Dissection of the GEA was carried out proximally to the pylorus ring and distally to the midportion of the greater curvature of the stomach, as described previously [Asai 2002].

Briefly, the anterior layer of the greater omentum was opened by electrocautery, and the GEA was identified. Then the GEA was encircled with vessel loops and gently retracted superiorly to identify the branches. The branches of the GEA were transected using an ultrasonic scalpel (Harmonic scalpel, coagulation scissors type). The satellite veins running along the GEA were also separated by applying the ultrasonic scalpel in the space between the GEA and satellite veins. No clips or electrocautery was used for skeletonization of the GEA. After heparin was administered by an anesthesiologist, the distal GEA was transected. Diluted phosphodiesterase inhibitor (olprinone, 0.5 mg/mL) was injected from the distal end of the GEA. Then the distal end of the conduit was closed with a metallic clip, and the conduit was wrapped in a warm papaverine-soaked sponge. The GEA pedicle was pulled up to the pericardial cavity via a small hole made in the middle of the diaphragm, passing the pedicle in front of the stomach and liver. The omentum was closed using absorbable sutures without leaving any drains. Gastric decompression using a nasogastric tube was continued while the patient remained intubated.

Coronary Artery Bypass Graft

After harvesting of appropriate grafts, CABG was performed under off-pump beating-heart as described previously [Hirose 2002b]. For exposure of the coronary artery, the retropericardial sutures and a suction type of coronary stabilizer were used. High-flow native coronary artery anastomosis or electrocardiogram (EKG) change during anastomosis was an indication for intracoronary shunt.

All GEAs were primarily used as in situ grafts. The main targets of the GEA were distal right coronary artery (RCA) or distal circumflex artery (Figure). Revascularization of the left anterior descending artery (LAD) was performed with one of the IMAs. The radial artery was used for revascularization of the circumflex artery. If the ascending aorta was severely calcified, the proximal end of the radial artery was anastomosed with the IMA instead of the aorta.

Intraoperative antispasm care included administration of a systemic intravenous infusion of diltiazem (1 μg/kg per minute) or nicorandil (0.5 μg/kg per minute). These calcium channel blockers were continued postoperatively for at least 1 year using oral maintenance doses. Intravenous milrinone was not routinely administered.

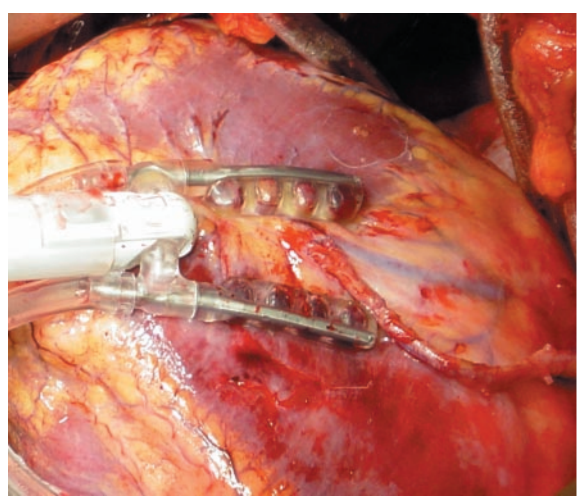
Data Collection

Perioperative data were prospectively collected. EKGs of all studied patients were continuously monitored and 12-lead EKG was performed daily by postoperative day 3 and then twice a week until discharge to rule out myocardial infarction. Any EKG changes were to be further evaluated by angiography. Outpatient follow-up data until August 31, 2003, were available for analysis. Remote myocardial infarction, angina, arrhythmia requiring hospitalization, congestive heart failure requiring hospitalization, coronary reintervention (percutaneous transluminal coronary angioplasty or redo-CABG), and sudden death were defined as cardiac events. Results are expressed as mean ± standard deviation.

RESULTS

Operative Results

Operative data are shown in Table 2. Skeletonized harvest of the GEA was successfully performed in all study patients.



Off-pump anastomosis of the gastroepiploic artery harvested using the skeletonization technique.

Table 2. Surgical Results (N = 25)

No. of distal anastomoses	4.1 ± 1.2 (2-6)
Off-pump coronary artery bypass graft	25 (100%)
Complete revascularization	25 (100%)
Bilateral internal mammary artery	4 (16%)
Total arterial revascularization	24 (96%)
Aorta nontouch surgery	12 (48%)
Operation time, min	358 ± 86 (235-590)
Left internal mammary artery	24 (96%)
Right internal mammary artery	4 (16%)
Radial artery	19 (76%)
Gastroepiploic artery	25 (100%)
Saphenous vein	1 (4%)

The time required for skeletonized GEA harvesting was roughly 25 minutes. One patient had a relatively small diameter of the distal GEA compared to that of the proximal GEA. The distal part of the GEA of this patient was discarded and then the GEA was extended with a radial artery and bypassed to the distal RCA. In another patient with subclavian stenoses and calcified aorta, the LAD was revascularized with a skeletonized in situ GEA graft. Off-pump CABG was successfully performed in all study patients. The mean number of distal anastomoses performed was 4.1 ± 1.0, and all patients were completely revascularized. Bypass was performed with arterial grafts alone in all patients except for 1 patient with multiple coronary lesions. Sequential anastomosis using the skeletonized GEA was performed in 6 patients (24%).

In-Hospital Results

There were no hospital deaths, postoperative myocardial infarctions, congestive heart failure, renal failure, or stroke. One patient was brought back to the operating room for exploration of the chest because of a large amount of chest tube drainage, and bleeding from the chest wall was found but the GEA graft was intact. Another patient who underwent bilateral IMA grafting developed mediastinitis. Another patient developed respiratory failure requiring reintubation. There were no abdominal complications such as bowel obstruction, incisional hernia, delay of feeding, or gastroduodenal bleeding. Mean intubation time, ICU stay, and postoperative stay were 6.6 ± 3.5 hours, 2.3 ± 1.0 days, and 19.0 ± 22.1 days, respectively.

Remote Results

All studied patients were followed up by the outpatient clinic for a mean of 0.9 ± 0.2 years. During follow-up, there were no deaths or cardiac events. All patients remained symptom free. Because none of the studied patients developed chest pain or EKG change, none of the patient underwent postoperative angiography.

DISCUSSION

The skeletonization of the GEA could be performed with electrocautery and metal clips [Gagliardotto 1998]. However, the use of an ultrasonic scalpel makes skeletonization much easier. Heat injury by electrocautery and hematoma due to inadequate hemostasis are major causes of vasospasm in the GEA. The use of an ultrasonic scalpel makes transection of the side branches of the GEA and achievement of hemostasis possible without heat injury to the main trunk. The coagulating shears type of ultrasonic scalpel provides more complete hemostasis than the dissection hook type, especially hemostasis of vessels located in deep fat tissue like the GEA, because coagulating shears can deliver ultrasonic energy more effectively between the shears [Asai 2002]. Dissection between the GEA and satellite vein was easily achieved using cavitation ability of the ultrasonic scalpel without cutting the vessels. We did not experience any graft injuries with the current harvest technique. Despite meticulous handling of the GEA, vasospasm often occurs during the skeletonization process. However, due to the lack of the adventitia, the vasospasm can be easily reversed by an intraluminal injection of a vasodilator. In addition, a study of the skeletonized arterial graft demonstrated that the skeletonization itself will not affect the biofunctional integrity of the arterial graft [Ueda 2003].

The disadvantages of GEA grafting before the introduction of the skeletonized technique included vasospasm and flow competition due to a relatively low graft flow [Uchida 1996, Suma 2000]. If the site of coronary stenosis is further proximal and the degree of native coronary stenosis is less severe, native coronary artery blood flow may overcome the GEA graft flow [Uchida 1996]. If relatively low graft flow compared to high native coronary artery flow persists, the GEA may become atrophic and eventually occluded, due to the flow competition mechanism [Uchida 1996]. Thus, the indication for GEA grafting used to be limited to patients with tight stenosis, more distal lesions, or total proximal occlusion [Suma 2000, Hirose 2002a]. Revascularization of a mildly stenosed large caliber coronary artery used to be achieved using a saphenous vein, which can provide a high flow and remain free from vasospasm, rather than the GEA. However, the long-term patency rate of the saphenous vein graft is known to be less than 50% at 10 years.

Since the development of the skeletonization technique, the revascularization strategy for a mildly stenosed high-flow coronary artery has been remarkably changed from the use of the saphenous vein to the use of a skeletonized arterial graft, because skeletonization can provide a large-caliber high-flow conduit [Choi 1996, Wendler 1999]. The saphenous vein graft, used to bypass a mildly stenosed high-flow coronary artery, has been completely replaced by a skeletonized arterial conduit in our institute. In patient selection for GEA grafting, limitations related to the graft flow are no longer applicable. There were no occurrences of hypoperfusion or perioperative myocardial infarction in our series.

The conduits of choice for revascularization of the distal RCA now include a skeletonized radial artery or a skeletonized GEA, because the in situ IMA is not long enough to reach the distal RCA. The advantage of using the GEA compared to the radial artery is that the GEA can be used for an in situ graft whereas the radial artery requires proximal anastomosis to the ascending aorta unless a composite Y-graft is made with an IMA. Using the off-pump technique and in situ conduits such as the IMA and GEA, complete arterial revascularization can be carried out without touching the aorta. This technique will be most beneficial for patients with a calcified or severely atherosclerotic aorta. In our series, aorta nontouch surgery was performed in 48% of the patients. Furthermore, skeletonization of the GEA can provide sufficient length of graft to facilitate sequential anastomoses or further anastomoses beyond the circumflex artery. The well-skeletonized GEA may even reach the LAD.

Summary

The early results of skeletonized GEA grafting using an ultrasonic scalpel and appropriate antivasospastic maneuvers were excellent. The potential benefits of skeletonization include: easy reversal of vasospasm, large caliber conduit, sufficient length to reach any of the coronary arteries without anastomosis to the ascending aorta, ease of handling due to the absence of the adventitia, and its nature as an arterial graft.

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