Institutional review - Coronary

Skeletonized bilateral internal mammary artery grafting for patients with diabetes

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Abstract

To minimize sternal ischemia, skeletonized internal mammary artery (IMA) harvesting has been performed in the last few years. The benefits of skeletonization in high risk patients, such as diabetic patients undergoing bilateral IMA grafting, are unknown. A total of 99 patients underwent isolated coronary artery bypass grafting (CABG) using a pedicled bilateral IMA between 6/1/1997 and 5/31/2000 (group P), and 115 patients receiving a skeletonized IMA between 6/1/2001 and 3/31/2002 (group S). An ultrasonic scalpel was used for skeletonization. The perioperative and early angiographic results of CABG using these two techniques were collected prospectively and compared. There were two (1.7%) perioperative myocardial infarctions in group S and one (1.0%) in group P (P = NS), none of which were related to the IMA graft. The incidence of mediastinitis was one (0.9%) in group S and three (3.0%) in group P, P = NS, however, minor chest wound complications were observed in four (3.5%) in group S, which was significantly less frequent than the 12 (12.1%) in group P (P < 0.05). Angiographic control was obtained in 87 patients in group S and 36 in group P, revealing no IMA occlusions in either group. Bilateral skeletonized IMA grafting for diabetic patients is safe and may decrease wound complications.

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1. Introduction

The internal mammary arteries (IMAs) are most frequently used arterial conduits in coronary artery bypass grafting (CABG) [1,2]. Studies have shown that bilateral internal mammary artery (BIMA) grafting can provide better event-free survival than single IMA grafting in selected patients [1,3]. The greatest concern in the use of the BIMA is sternal wound complications, caused by devascularization of the sternum, especially in diabetic patients [4]. Studies showed that the skeletonized IMA harvesting technique maintained sternal blood flow [5] and may decrease sternal complications [5]. In this study, we focused on patients with diabetes who underwent BIMA grafting, and analyzed whether or not skeletonized BIMA grafting could reduce sternal complications for these high risk patients.

2. Methods

2.1. Patients

Between June 1, 1997 and March 31, 2002, a total of 1123 consecutive patients underwent isolated CABG at Shin-Tokyo Hospital Cardiovascular Group (Shin-Tokyo Hospital and Kobari General Hospital), including 467 (41.6%) with BIMA grafting. Among them, a total of 214 patients were found to be diabetic preoperatively, and their perioperative and follow-up data were prospectively collected. In the early study period, the IMAs were routinely harvested as a pedicle grafts, and in the late period as skeletonized grafts. Between June 1, 1997 and May 31, 2000, 99 diabetic patients underwent CABG using a pedicled BIMA (group P, 78 males and 21 females with
a mean age of 63.6 ± 9.1 years) and between June 1, 2000 and March 31, 2002, 115 received a skeletonized BIMA (group S; 77 males and 38 females with a mean age of 64.7 ± 8.3 years). The two groups were not significantly different in terms of cardiac profile, angiographic profile, coronary risk factors, or preoperative comorbidities as shown in Table 1.

Contraindication for BIMA harvest in our institution was in patients with severe osteoporosis, fragile sternum, or patients with uncontrolled diabetes (fasting blood sugar >280 mg/dl at admission).

2.2. Technique of IMA harvesting

The pedicle IMA was harvested as an en-bloc including the satellite veins and the surrounding adipose tissue, using metal clips and electrocautery. For prophylaxis of vasospasm, spraying of papaverine and intraluminal injection of milrinone were carried out.

Skeletonization of the IMA was performed using an ultrasonic scalpel. The removal of excessive tissue around the IMA and control of the side-branches were also carried out by the ultrasonic scalpel. Vasospasm prophylaxis protocols were same as pedicle graft.

2.3. CABG

After harvesting the appropriate grafts, CABG was performed under cardiopulmonary bypass with normothermia (36°C) or under off-pump beating-heart. The selection of off-pump CABG was individualized [6].

The left internal mammary artery (LIMA) was used as an in-situ graft in all cases and preferably bypassed to the left anterior descending artery (LAD). The target of the right internal mammary artery (RIMA) was individualized; however, in most cases, in-situ RIMA was used for bypass to the LAD. In that case, the in-situ LIMA was anastomosed to the diagonal or the circumflex artery. The in-situ RIMA also used for revascularization of the proximal right coronary artery. The free RIMA graft were used as a composite ‘Y’ graft with the LIMA, if the ascending aorta was calcified and if the patient required revascularization of both the LAD and circumflex arteries.
2.4. Angiographic control

Postoperative angiographic control was obtained prior to discharge from the hospital if the patients agreed to the procedure. For quality assurance of the new technique, the patients who underwent skeletonized IMA grafting were strongly recommended for angiographic study.

2.5. Data collection

The institutional ethics committee approved the skeletonized IMA grafting, and all the patients signed an informed consent prior to surgery. The following parameters were collected prospectively: patient’s age, gender, cardiac profile, preoperative risk factors, graft materials, surgical data, postoperative complications and mortality. Minor chest wound complications included excess drainage, minor superficial wound separation, and superficial wound infection. Mediastinitis was defined as deep sternal infection involving the presternal fascia.

Outpatient follow-up data entry were complied by April 30, 2002. Myocardial infarction, recurrence of angina, arrhythmia requiring hospitalization, congestive heart failure requiring hospitalization, coronary re-intervention (percutaneous transluminal coronary angioplasty (PTCA) with or without stent placement or redo-CABG), and sudden death were counted as cardiac events.

2.6. Statistical analysis

The results were expressed as mean ± standard deviation. Statistical analysis was performed using the Student’s t-tests for continuous variables or Chi-square tests (Fisher’s exact tests if \( n < 5 \)) for categorical variables. A \( P \)-value less than 0.05 was considered significant. All statistical analyses were performed using Statview version 5.0 (SAS Institute, Cary, NC).

3. Results

3.1. Operative results

The mean number of distal anastomoses was 4.1 ± 1.1 in group S and 3.6 ± 1.1 in group P (\( P < 0.05 \)). An additional saphenous vein graft was less often required in group S (13.9%) than in group P (25.3%), \( P < 0.05 \). The total operation time (338.8 ± 71.9 min in group S versus 348.5 ± 83.5 min in group P, \( P = \text{NS} \)) was not significantly different between the two groups. No IMA injuries during harvest were noted in either group. Composite Y-grafts were performed in 21 cases (18.3%) in group S and 18 (18.2%) in group P (\( P = \text{NS} \)).

3.2. In-hospital results

The postoperative course is displayed in Table 2. Postoperative intubation time and postoperative stay were not significantly different between the two groups. ICU stay was shorter in group S than group P, reflecting the recent frequent use of off-pump CABG. There were three deaths: two were due to stroke (one in group S and one in group P), and another was due to mediastinitis in group P. Perioperative myocardial infarction was observed in two (1.7%) in group S versus 348.5 ± 83.5 min in group P, \( P = \text{NS} \) was not significantly different between the two groups. No IMA injuries during harvest were noted in either group. Composite Y-grafts were performed in 21 cases (18.3%) in group S and 18 (18.2%) in group P (\( P = \text{NS} \)).

Since many patients underwent off-pump CABG (81.7% in group S versus 35.4% in group P), the incidence of chest complications were separately analyzed, and were observed...
in 14/129 (10.9%) in the off-pump patients and 6/85 (7.5%) in the on-pump, \( P = \text{NS} \).

### 3.3. Remote results

Among the survivors, postoperative follow-up was completed as shown in Table 3. The follow-up period was significantly shorter in group S (0.4 ± 0.3 years) than in group P (2.4 ± 0.9 years). During the follow-up period, cardiac events occurred in four patients (3.5%) in group S and 13 patients (13.4%) in group P. The two incidences of PTCA were not directly linked to the IMA graft or its target vessels. During the same follow-up period, there were no deaths in group S and two in group P. No late sternal complications were encountered in either group.

### 3.4. Angiographic study

Angiographic control was obtained in 87 patients (75.7%) in group S and 36 patients in group P. This allowed us to evaluate 100 anastomoses of the LIMA and 95 anastomoses of the RIMA in group S, and 39 anastomoses of the LIMA and 38 anastomoses of the RIMA in group P. There were no IMA occlusions in either group. A string sign (diffuse narrowing of the graft) was observed in two in group P, but none in group S.

### 4. Discussion

Skeletonization of artery is defined as immobilization of the arterial trunk from the satellite veins and surrounding tissue. For safe and complete skeletonization, the application of an ultrasonic scalpel is essential. Dissection of the tissue planes and hemostasis of the branches are easily achieved with an ultrasonic scalpel without causing graft injury or vasoconstriction. Transection of the branches of the IMA is safely performed with an ultrasonic scalpel, when the branches are transected at least 1mm from the main trunk [7]. Unlike electrocautery, heat injury to the main trunk of the IMA does not occur as long as the ultrasonic scalpel is used properly. When transecting the branches of the artery, the tip must be perpendicular to it and the operator must wait a few seconds until complete protein coagulum is made and the branch transects itself. Since the coagulation effect of the ultrasonic scalpel depends on protein denaturing, vein hemostasis using the ultrasonic scalpel is always difficult. If the satellite vein is injured during the IMA harvest, it should be ligated with metal clips. The dense adhesion around the IMA can be safely dissected using the cavitation fragmentation mechanism of the ultrasonic scalpel [7].

No skeletonized harvesting-related complications were observed. No postoperative myocardial infarction occurred in the territory of the IMA graft in our study. The hemostasis of the ultrasonic scalpel was adequate and no patients developed postoperative bleeding from the skeletonized conduits. Choi reported that the skeletonized IMA can deliver a higher blood flow than the pedicled IMA [8]. The response to the intraluminally injected vasodilators was reported to be greater in skeletonized grafts than pedicle grafts [9]. We felt the skeletonized graft more easily expanded with intra-luminal injection of milrinone. The increased length of the IMA graft allows us more flexible options for anastomoses. The skeletonized LIMA can easily reach the circumflex artery, and the RIMA can reach the LAD. Since the caliber size is increased by the skeletonization, the flow competition between a graft and the native coronary artery is minimized, which allows us to anastomose the IMAs to high flow coronary arteries with mild stenosis.

The incidence of sternal complications was reported to be higher in patients with a BIMA than in patients with a single IMA [10]. Other risk factors for sternal complications include obesity, chronic obstructive pulmonary disease, advanced age, peripheral vascular disease, redo surgery, postoperative low-output syndrome, and reoperation for bleeding [11]. Larger study of CABG by Bourger reported a baseline deep sternal wound infection rate of 0.83%. In their study, both BIMA grafting and diabetes were isolated predictors for deep sternal wound infection: 0.8% without BIMA and 2.6% with BIMA, 0.8% without diabetes and 2.6% with diabetes, and 14.3% with combination of BIMA and diabetes [11]. Our baseline incidence of mediastinitis and minor chest wound complication rates among patients who underwent isolated CABG in this study period were 1.0 and 4.6%, respectively. Our study showed that the incidence of mediastinitis was not significantly different with or without the skeletonized technique for IMA harvesting. However, minor chest wound complications were decreased by the use of the skeletonized technique. The preservation of collateral flow to the sternum by the skeletonized technique most likely contributes to this decrease of chest complications, which already mentioned by others [12,13].
The postoperative angiography confirmed the quality of IMA. The angiographic results of IMA harvested by two different techniques were not significantly different, although the long-term results remains unknown at this point. Since no string signs were observed in the skeletonized group, we believe that postoperative vasospasm has been adequately controlled with our current protocols.

Because of the preferable results of skeletonized grafting, the frequency of BIMA grafting in our institution increased dramatically after the introduction of the skeletonized technique (Fig. 1). Bilateral IMA harvesting rate for diabetic patients was 23–34% during the early phase of study when we harvest the IMA or a pedicle, but it increased to 57–61% during the late phase of study when we started harvesting the IMA as a skeletonized fashion.

This study was performed in a non-randomized prospective manner. Alternation of the operative modality during the study period may influence the surgical results. One of the major surgical modifications during the study period was the more frequent use of off-pump CABG. However, our results showed that off-pump CABG had little effect on chest wound complications in this particular patient group.

4.1. Summary

Skeletonized BIMA grafting for diabetic patients is safe and have potential contribution for the reduction of chest wound complications. Skeletonized grafting-related adverse effects were not observed in our limited early angiographic results. To confirm the remote results of skeletonized IMA grafting, further follow-up is necessary.

References


