

Total Arterial Off-pump Coronary Revascularization with a Bilateral Internal Mammary Artery Y Graft (208 cases)

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INTRODUCTION

A Y graft is a graft formed by the left internal mammary artery (LIMA) connected to the left anterior descending (LAD) artery and by a free right internal mammary artery (RIMA) connected to the LIMA and to a marginal artery of the left circumflex artery (LCx). Since the internal mammary artery (IMA) conduit for coronary artery bypass grafting (CABG) has better long-term results^[1] than saphenous vein grafts (SVGs), the LIMA graft is considered the best graft for bypassing the LAD coronary artery.^[2-4] The RIMA used under the same condition as the LIMA may offer the same results.^[5-7] Thus, Barn^[8], Tector^[9] and Barr^[10] proposed the Y or T graft procedure carried out by anastomosing the proximal end of the free RIMA to the side of the attached LIMA. This procedure provides an additional length to reach a distal coronary artery branch, such as the posterior descending branch of the right coronary artery, or the post branch of the left ventricle.

Kamathi^[11] and Chocron^[12] first reported their experiences with off-pump coronary artery bypass grafting (OPCABG) in the last century. Then this technique became more popular because it could

ABSTRACT

Objective: The aim was to evaluate the early outcome of off-pump coronary artery bypass grafting (OPCABG) with a bilateral internal mammary artery (BIMA) Y configuration graft to achieve total arterial myocardial revascularization. **Materials and Methods:** From October 2002 to December 2008, 208 patients (196 male and 12 female patients) underwent OPCABG by only using a BIMA Y configuration graft. The average age of the patients was 56.5 ± 11.3 years, with the age range being 33–78 years. A total of 167 (80.2%) cases had triple-vessel disease. Left main stem disease was found in 33 (15.9%) cases, and double-vessel disease was found in 8 (3.9%) cases. The semiskeletonization skill was used to harvest the two IMAs, and then the free right internal mammary artery was anastomosed end-to-side to the *in situ* left internal mammary artery to composite a Y configuration graft. Off-pump and sequential anastomosis methods were used to perform coronary artery bypass surgery for the patients. Graft patency was assessed by using the HT311 transit time flowmeter (USA Transonic Systems Inc.), intraoperatively. **Results:** We performed distal anastomoses of the grafts in 728 patients, the average being 3.5 ± 1.3 per person. No one died and got recurrent angina within 30 days after operation. **Conclusion:** OPCABG by using the BIMA Y graft was safe and effective to achieve total arterial revascularization, and avoid surgical operation on the ascending aorta, and other incisions.

Key words: Bilateral internal mammary arteries, coronary artery bypass grafting, internal mammary artery, LIMA – RIMA Y graft, off-pump

avoid more complications caused by cardiopulmonary bypass.

So, we used the bilateral internal mammary artery (BIMA) Y graft under OPCABG for the selected patients. We wanted to know whether it is the most appropriate selection for CABG. It may included four good effects as follow: total arterial revascularization being advantageous to long-term patent of bypass graft, no-touch to aortic avoiding cerebral apoplexy, beautify for wound, and less main organ complications.

In this paper, we have summarized our experience in recent years concerning the off-pump coronary artery bypass surgery using a BIMA Y graft to achieve total arterial revascularization. The report is as follows.

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MATERIALS AND METHODS

Clinical data

From October 2002 to December 2008, our department completed 208 (196 male and 12 female patients) cases of the CABG surgery using a BIMA Y configuration graft to achieve total arterial myocardial revascularization. The age range of the patients was 33–78 years, with the average age being 56.5 ± 11.3 years. Of the 208 patients, 15 (7.2%) patients were over 70 years of age. Triple-vessel lesions were present in 167 (80.2%) patients, left main trunk lesions in 33 (15.9%), and double-vessel diseases in 8 (3.9%) patients. The data and basic information are given in Table 1. At the same time, there were 3561 patients who finished CABG, including 3280 with OPCAB. The most of our patient were done CABG with the operation fashion LIMA + SVG. Patients treated with the BIMA Y graft were 5.84%. The patients were included in different operation groups. Since the results would be effected the different operation method selection preference and learning curve form individual surgeon, we did not compare the result from LIMA + SVG with the BIMA Y graft.

Surgical technique

All patients received general anesthesia under a standardized protocol of the median sternotomy. The semiskeletonization method of the BIMA harvesting technique was employed.^[9] Internal mammary artery exposure was achieved with a sternal retractor, and was dissected from the chest wall along with a narrow pedicle of surrounding tissues with electrocautery and hemoclips. The LIMA was harvested first, and dissected from the origin to distal bifurcation. The RIMA was then dissected the same way as the LIMA. After heparinization, the RIMA was removed as a free graft. The LIMA was divided at the last bifurcation. The endothoracic fascia of the BIMAs was then resected with scissors or electrocautery. The IMA pedicle was left with accompanying veins and little fat. Both arteries were placed onto a thick pad of gauze. An oblique 1-cm incision was made in the LIMA, and the proximal end of the RIMA was anastomosed with a continuous 8-0 polypropylene suture. The anastomosis location was under the level of the pulmonary annulus. The BIMA composed a Y configuration graft, with the LIMA being as the short limb of the Y graft, and the RIMA the long one. The length of the RIMA made it possible to graft as far as the lateral circumflex or posterior descending arteries.

Off-pump technique

The off-pump coronary artery bypass surgery was

Table 1: Patients' general data

Variable	Number	Percentage
Gender	208	100
Male	196	94.2
Female	12	5.8
Age*	56.5±11.3	
Hypertension	73	35.1
DM	53	25.5
Hyperlipidemia	49	23.6
Smoke	87	41.8
OMI	80	38.5
COPD	11	5.3
CVD	44	21.2
PCI	36	17.3
Renal insufficiency (Cr>2.5 mg/dl)	7	3.4
Triple-vessel disease	167	80.2
Double-vessel disease	33	15.9
Left main disease	8	3.9
NYHA class*	2. 1±1.1 (1–4)	
CCSA class*	2. 3±1.3 (0–4)	
EF*		
Mean value of EF	0.51 ± 0.08 (0.30–0.76)	
EF<0.4	37	17.8

*Mean±SD (range). DM – Diabetes mellitus; OMI – Old myocardial infarction; COPD – Chronic obstructive pulmonary disease; CVD – Cerebrovascular disease; PCI – Percutaneous coronary intervention; NYHA – New York Heart Association; CCSA – Canadian Cardiovascular Society angina; EF – Ejection fraction

performed by the same surgeon. The patients were heparinized with an initial dose of 1.5 mg/kg of heparin, and periodically received supplemental doses to maintain an activated clotting time of ≥ 300 s. Anesthesia management, including volume loading and placing the patient in the Trendelenburg position, was controlled hemodynamic derangement during displacement or manipulation of the heart. To reduce the amplitude of ventricular wall movement, a compression-type mechanical stabilizer (Chase; Chase Medical Company) or suction-type mechanical stabilizer (Octopus; Medtronic, Minneapolis, MN, USA) was used. To obtain a bloodless operative field, the small bulldog clamp occluded the coronary flow with a temporary time, and a warm saline solution flush was used. The most critical vessel, the LAD branch in almost all patients, was revascularized first with the LIMA in an end -to-side fashion to provide a backup to the less critical area. Then the diagonal and circumflex branches' sequential anastomoses were performed in a side-to-side perpendicular (diamond) fashion using the RIMA. The posterior descending or distal right coronary artery graft was performed last using the distal end of the RIMA as an end-to-side anastomosis in parallel. All anastomoses were performed with a single continuous 7-0 polypropylene suture, under $\times 2.5$ magnification. After the anastomoses were completed, the flow of the Y graft was measured with the HT311 transit time flowmeter (USA Transonic Systems

Inc.). Graft patency was assessed using flow curves, mean flow, and pulsatility index (PI). A left extrapericardial fat pad was secured to anterior percardiotomy, and the sternum was closed with 8 wires.

Cardiac enzyme analyses and electrocardiogram were performed on all patients immediately postoperatively and at 1, 2, and 6 days. A surgical review was done at 1 month postoperatively and routine follow-up was undertaken by the cardiologists.

Statistical analysis

The variables are expressed were means $\pm$ standard deviations (SDs). The baseline characteristics and outcomes were compared using χ^2 analysis for categorical data and Student's *t*-test for continuous variables. Differences were considered significant only when the *P*-value was < 0.05 .

RESULTS

A total of 728 distal anastomoses were made in all patients, with an average of 3.5 ± 1.3 bypasses performed for each patient. No one received supplemental vein graft. The flow of the Y graft was measured intraoperatively, which showed that all of the anastomoses were patent. The mean flow in the main stem of the LIMA was 62.8 ± 14.3 ml/min, with the PI being 2.9 ± 1.8 . The mean flow of the distal LIMA graft was 32.3 ± 11.1 ml/min, with the PI being 3.2 ± 1.7 . The mean flow of the proximal RIMA was 31.8 ± 8.5 ml/min, with the PI being 2.7 ± 1.5 . At the same time, 29 (13.9%) cases underwent off-pump ventricular aneurysm plasty; 21 (10.1%) cases underwent coronary artery endarterectomy. There were no perioperative deaths.

A total of 35 (16.8%) patients did not undergo blood transfusion; 4 (1.9%) patients had myocardial infarction perioperatively and 2 (1.0%) cases IABP (aortic balloon pump). Two (1.0%) patients received CRRT (continuous renal dialysis). Three (1.4%) cases needed reentry for bleeding. Six (2.9%) patients developed wound problems (including 2 diabetic patients), with superficial wound infection in 2 (1.0%) patients, sternal dehiscence due to wire loosening in 2 (1.0%), and sternal wound infection in 2 (1.0%) patients (including 1 diabetic patient). One (0.5%) case had a cerebral vascular accident. All patients were successfully discharged from the hospital.

All patients were free of angina at the 1-month visit. Cardiology angiography was not performed because of the economic reason and worry about iatrogenic injury of the LIMA. Only one patient died of CVD at 3 months postoperatively during the follow-up. Others were still alive

after a mean follow-up of 20.4 ± 4.3 months (6–69 months) and no patient had newborn myocardial infarction and severe angina. Postoperatively at 6 months, the mean left ventricular ejection fraction was 0.52 ± 0.11 , compared with that preoperatively, 0.51 ± 0.08 ($P=0.13$). Patients' NYHA score was 2.0 ± 1.2 versus 2.1 ± 1.1 ($P=0.24$). But patients' CCSA score were 1.6 ± 1.1 versus 2.3 ± 1.3 preoperatively ($P=0.00001$).

DISCUSSION

In 1967, Kolessov^[1] first reported internal mammary artery to coronary artery anastomosis; Green,^[2] Tector,^[3] Mills,^[4] Loop,^[5] Dion,^[6] and their associates increased the versatility of the IMA in CABG. The lower patency of SVGs compared with IMA grafts awoke more surgeons to apply arterial conduit for coronary bypass, especially using BIMAs.^[7,8] Tector,^[9] Barra,^[10] Kamath,^[11] and Chocron^[12] described sequential anastomoses, BIMA anastomoses, the free graft technique, and reimplantation of the RIMA as a free graft into the LIMA *in situ* to compose a Y or T graft. Good late clinical results were reported by Tector,^[9] Tatoulis^[13] and Lytle.^[14]

Among the various strategies regarding the selection of the ideal arterial graft, the IMA, we used a single Y configuration graft with a free RIMA attached to the side of the LIMA *in situ*. Through this graft strategy, the LIMA could be anastomosed to the LAD, which was fundamental to CABG because of the graft's superior long-term patency. The other important reason for us to use this graft strategy was to maximize the use of ideal arterial grafts, namely, BIMAs. Patients who had undergone CABG with BIMAs were well known to have long-term results that were superior to those found with only the LIMA.^[14,15] The RIMA was histologically identical to the LIMA, and might show similar long-term patency rates. The length of the semiskeletonized RIMA in the Asian population is approximately 15–20 cm if harvested from the first rib to the bifurcation. In most patients, the RIMA could reach the RCA system without difficulty. Consequently, all of the triple-vessel diseases could be revascularized with the two ideal arterial grafts – the BIMAs. This technique used previously also showed good early clinical and angiographic results when performed without a cardiopulmonary bypass.^[16,17] The total arterial OPCABG using BIMA was with a very low incidence of in-hospital death, complication, and late outcomes compared to the on-pump technique. In our study, the off-pump coronary artery bypass graft with the BIMA Y graft was safe and feasible for all patients. No one was obliged to change off-pump to on-pump intraoperation, especially including

moderate or severe heart function (LVEF<30%). There was no death within 30 days postoperatively.

Transit-time flowmetry was widely accepted for use in intraoperative graft assessment because it is noninvasive, technically simple, reproducible, fast, and inexpensive.^[18-20] It provided important and accurate intraoperative information on the status and patency of each individual graft. The ideal PI value should be between 1 and 5 after bypass grafts finished. Sometimes the technical error in the anastomosis may increase higher PI values.^[18] A problem was thought to be present when the mean flow of the graft was less than 15 ml/min. In our study, the mean flow of all the Y grafts was measured intraoperatively at the main stem, distal LIMA graft, and proximal RIMA. The ideal patent was confirmed, indicating that all the Y grafts were patent following the anastomosis.

Numerous studies had shown that the use of both internal mammary arteries improved long-term survival relative to the use of the left internal thoracic artery and SVGs. However, the concern that diabetes may lead to an increased risk of deep sternal wound infection had limited the use of both internal mammary arteries in nondiabetic patients.^[14,15,21] Although use of BIMA is considered a risk factor for sternal infection,^[22] this risk appears to be attenuated by skeletonized IMA mobilization.^[23] Tarrío and colleagues reported the largest group of patients (743 cases) who underwent OPCABG with the BIMA Y or T graft.^[24] They used the skeletonization technique to reduce the sternal complication. The rate of mediastinitis was 0.9% (7/743), similar to that in our study (1%, 2/208). In our series, we dissected the BIMA using the narrow pedicle IMA first, and then resected the endothoracic fascia by the semiskeletonization technique.^[25,26] Therefore, more muscle was left attached to the chest wall, thus minimizing sternal devascularization and possibly reducing the risk of deep sternal wound infection as well. In this group, there were six patients who suffered from a wound event, including two diabetic patients. There were two infected, with one diabetic patient. We did not find any difference with the other CABG patients without the BIMA Y graft in our department. If the blood glucose was controlled ideally before operation, and the sternum fracture was avoided, and the sternum was fixed stably in operation, diabetic patients could get same result as no diabetic patients. So we feel that diabetes is not a contraindication to the BIMA Y graft. For a mature team, this technique could be easily performed in daily practice. It was not a time-consuming procedure and was the same technique as the conventional pedicle technique in our department. In fact, a long learning curve is needed for a fresh team. We think freshers should

finish 100 conventional CABGs before taking up a BIMA Y graft.

However, total arterial revascularization with two arterial grafts can cause the life-threatening hypoperfusion syndrome^[27] because reperfusion of the entire myocardium depends on the proximal source of the left IMA. This scenario had led to the concern whether the flow reserve in the LIMA was sufficient to supply more than one coronary anastomosis. Several reports had concluded that the IMA T graft allowed complete myocardial revascularization with good perioperative results and that the flow reserve of the proximal LIMA was adequate for multiple coronary anastomoses.^[28] Clinically, we did not observe any hypoperfusion syndrome in our study, which was consistent with other surgeons who preferred this graft strategy.^[29,30] We performed CABG without CPB to reduce the occurrence of unstable hemodynamics, and avoided using the distal IMA for anastomoses. Adding to that, we did pay more attention to treat first the intercostal artery and removing the unstable hypertension patient. There were evidences that the coronary flow reserve could be improved several months after operation,^[31,32] and that the IMA could adapt to the myocardial blood demand by compensatory dilatation.^[33,34]

OPCABG combined with the aorta no-touch technique has been accepted as an effective procedure to avoid neurologic and aortic complications, and to reduce operative risks.^[35] In our study, the incidence of stroke was 0.4% (1 of 208), similar to Tarrío's (0.4%, 3 of 743) and Kim's (0.8%, 4 of 512) results.

In conclusion, the total arterial off-pump coronary bypass grafting using a BIMA Y graft could be safely performed with low in-hospital mortality and complication rates. Surgical tricks and the new technology in coronary stabilizers allow surgeons to perform a complete myocardial coronary revascularization using the best available arterial conduit (BIMA).

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