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Does Off-Pump Bilateral Internal Thoracic Artery Grafting Increase Operative Risk in Dialysis Patients?

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ABSTRACT

Background: We compared short-term outcomes of patients with chronic dialysis receiving bilateral internal thoracic artery (BITA) grafting with single internal thoracic artery (SITA) grafting using propensity score analysis.

Methods: Between 2002 and 2008, 656 consecutive patients underwent isolated coronary artery bypass grafting (99.1% off-pump). Of these, 56 patients with chronic dialysis and multivessel disease were retrospectively compared according to surgical technique, BITA (n = 32) or SITA (n = 23) grafting. In an attempt to minimize the selection bias, propensity scores were created based on 13 preoperative factors (C statistics, 0.914).

Results: There was no significant difference in age, left ventricular ejection fraction, prevalence of diabetes mellitus, and logistic euroSCORE between the 2 groups. All patients underwent revascularization using the off-pump technique without conversion to cardiopulmonary bypass. All arterial conduits were harvested using skeletonization technique. Except for 1 patient, all ITAs were used as in situ graft. Complete revascularization was achieved in all patients. There was no significant difference in occurrence of mediastinitis, impaired wound healing, and stroke between the 2 groups. The 30-day mortality was 6.3% in the BITA group and 13.0% in the SITA group (P = .64). After adjusting for propensity score, BITA grafting was not associated with impaired wound healing (odds ratio, 0.63; 95% confidence interval, 0.04 to 8.79; P = .73) and 30-day mortality (odds ratio, 0.60; 95% confidence interval, 0.05 to 6.82; P = .68).

Conclusion: In situ skeletonized BITA grafting is safe and feasible in dialysis patients with multivessel disease.

INTRODUCTION

The safety of off-pump coronary artery bypass grafting (CABG) has been clearly established by several groups with short- and long-term results comparable to conventional CABG using cardiopulmonary bypass [Puskas 2004; Williams 2005; Hannan 2007]. Moreover, the 2004 ISMICS (International Society for Minimally Invasive Cardiothoracic Surgery) consensus conference has recommended that off-pump CABG should be considered particularly in high-risk patients to reduce perioperative mortality, morbidity, and resource utilization [Puskas 2005]. Although some investigators have reported short-term results of conventional CABG using bilateral internal thoracic artery (BITA) grafting in dialysis patients [Nakayama 2001; Kai 2007], limited information is available about perioperative outcomes in dialysis patients undergoing off-pump BITA grafting. The purpose of our study was to analyze perioperative outcomes and determine the risk and feasibility of off-pump BITA grafting for dialysis patients.

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MATERIALS AND METHODS

Study Population

Between January 2002 and December 2008, 656 consecutive patients underwent isolated CABG. We accepted those patients with no refusal policy, so this series included the overall patient encountered in everyday practice and covered low-risk to high-risk patients. Except for 1 reoperative case and 6 salvage cases in which percutaneous cardiopulmonary support was preoperatively introduced, all patients underwent myocardial revascularization using the off-pump technique without conversion to cardiopulmonary bypass during operation. Of this total, 55 patients with end-stage renal failure maintained on chronic hemodialysis and 2- or 3-vessel coronary disease were included for the present study. Patients were classified into 1 of the 2 groups depending on whether they underwent BITA grafting (n = 32, BITA group) or single internal thoracic artery (SITA) grafting (n = 23, SITA group). We analyzed patients' characteristics, operative data, complications, and 30-day mortality. These data were all prospectively collected and entered into our database as part of routine patient management at our institution. All of the patients had previously granted permission for use of their medical records for research purpose.

Definitions

Stroke was defined as the presence of any new focal neurological deficit that occurred any time after surgery until

Table 1. Preoperative Characteristics*

	BITA Group (n = 32)	SITA Group (n = 23)	*P*
Age, y (mean [SD])	64.1 (7.2)	68.6 (10.0)	.06
Female, n (%)	4 (13)	5 (22)	.47
Hemodialysis duration, y (mean [SD])	5.2 (3.3)	7.3 (7.1)	.15
Hemodialysis > 5 y, n (%)	14 (44)	14 (61)	.21
Body mass index, mean (SD)	22.6 (3.3)	20.6 (3.5)	.03
Body surface area, mean (SD)	1.65 (0.15)	1.59 (0.20)	.20
Hypertension, n (%)	22 (69)	14 (61)	.38
Hyperlipidemia, n (%)	12 (38)	2 (9)	.10
Diabetes mellitus, n (%)	21 (66)	10 (44)	.55
Insulin dependent diabetes, n (%)	13 (41)	8 (35)	.66
Chronic obstructive pulmonary disease, n (%)	5 (16)	4 (17)	.99
Peripheral arterial disease, n (%)	11 (34)	5 (22)	.31
NYHA function class, mean (SD)	2.2 (1.0)	2.6 (1.0)	.13
NYHA function class 3 or 4, n (%)	11 (34)	13 (57)	.10
History of percutaneous coronary intervention, n (%)	12 (38)	8 (35)	.84
History of myocardial infarction, n (%)	4 (13)	12 (52)	< .01
Congestive heart failure, n (%)	10 (31)	9 (39)	.54
Ejection fraction, % (mean [SD])	50.1 (11.3)	50.1 (13.0)	.99
Ejection fraction < 40%, n (%)	7 (22)	5 (22)	.99
Left main trunk disease > 50%, n (%)	12 (38)	9 (39)	.90
Diseased coronary arteries, n (mean [SD])	2.69 (0.4)	2.57 (0.5)	.36
Double vessel disease, n (%)	10 (31)	10 (44)	.35
Triple vessel disease, n (%)	22 (69)	13 (57)	.35
Intraaortic balloon pumping, n (%)	3 (9)	4 (17)	.44
Emergent, n (%)	7 (22)	6 (26)	.73
Logistic EuroSCORE, median (IQR)	5.9 (3.7-8.6)	6.0 (4.4-24.5)	.12

*BITA indicates bilateral internal thoracic artery; SITA, single internal thoracic artery; NYHA, New York Heart Association; IQR, interquartile range.

discharge and that was confirmed by a magnetic resonance imaging (MRI) scan of the brain. Perioperative myocardial infarction was defined as creatinine kinase-MB increase ≥10 times the upper limit of normal or ≥5 times the upper limit of normal with new 30-ms Q waves within 24 hours of surgery. Impaired wound healing was defined as wound erythema and a purulent discharge necessitating additional antibiotic agents and/or hospitalization. Completeness of revascularization was defined as bypassing all diseased major or primary coronary segmental vessels.

Operative Techniques

All arterial conduits, including internal thoracic artery (ITA) and gastroepiploic arteries, were harvested and skeletonized with an ultrasonic scalpel in all cases [Higami 2000; Higami 2001; Asai 2002; Asai 2006]. All procedures were performed through a median sternotomy. Several superficial sutures were placed at both the right and left edges of the pericardium to create a pericardial wall. Additionally, deep pericardial traction sutures were also placed to facilitate cardiac displacement. During anastomosis, a suction-type mechanical stabilizer (Octopus 4.3; Medtronic, Minneapolis, MN) was used to immobilize the target site of coronary artery. Distal myocardial perfusion was maintained using intracoronary shunt tube (Anastaflo; Edwards Lifescience, Irvine, CA). Epiaortic ultrasound was routinely performed to assess the safety of manipulation of the ascending aorta. Aortic anastomoses of vein graft were performed using a partial clamp occlusion or anastomotic device.

Graft Arrangement

A common combination for ITA graft placement was in situ grafting of the left ITA to the circumflex area and the right ITA to the left anterior descending artery by routing the right ITA through a right-sided pericardial incision, under the upper lobe of the right lung, in front of the ascending

Table 2. Operative Data*

	BITA Group (n = 32)	SITA Group (n = 23)	*P*
Distal anastomoses, n (mean [SD])	3.1 (1.1)	3.1 (1.0)	.37
Gastroepiploic artery, n (%)	9 (28)	5 (22)	.59
Saphenous vein, n (%)	10 (31)	20 (87)	< .01
Complete revascularization, n (%)	32 (100)	23 (100)	—
Total arterial revascularization, n (%)	22 (69)	3 (13)	< .01
Operation time, min (mean [SD])	283 (78)	269 (67)	.50
Aorta non-touch, n (%)	22 (69)	4 (17)	< .01

*BITA indicates bilateral internal thoracic artery; SITA, single internal thoracic artery; SD, standard deviation.

aorta. Alternatively, when the left ITA was grafted to the left anterior descending artery, the right ITA was grafted to the diagonal or high obtuse marginal branch. Later, the right ITA was covered with loosely approximated mediastinal tissue before the sternum was reapproximated with wires. We used the skeletonized gastroepiploic artery to reconstruct the posterior descending artery or posterior lateral artery. Routine use of composite grafts was avoided as much as possible because composite arterial grafting has been shown to be associated with an increase in morbidity when compared with conventional artery bypass grafting [Légaré 2004].

Avoidance of Wound Infection

In the operating room, hair around the surgical site was removed with clippers, and a surgical scrub was performed on the body wall and legs with a povidone-iodine solution. An antimicrobacterial drape (Ioban; 3M, Brookings, SD) was applied to the surgical site. Before skin incision, cefazolin (1 g) was given initially; additional cefazolin was given every 4 hours during surgery. After completion of the anastomoses, the surgical site was washed with 1 L of warm saline. The presternal space was closed with one layer of nonabsorbable monofilament single sutures, followed by a continuous absorbable skin suture. No prophylactic intravenous antibiotics were administered postoperatively.

Control of Blood Glucose

In the intensive care unit, glucose levels were obtained from arterial blood gas samples every 2 to 4 hours. The continuous insulin infusion was initiated for blood glucose more than 200 mg/dL and adjusted to target intraoperative blood glucose between 100 and 200 mg/dL. Once patients were transferred to the floor, blood glucose values were obtained every 4 to 6 hours via finger stick blood samples and maintained according to the sliding scale with subcutaneous insulin in addition to their preoperative subcutaneous regimens. Patients with newly diagnosed or poorly controlled diabetes also received endocrinology consultation for better control in the postoperative period.

Statistical Analysis

In the data description, categorical variables are summarized as frequencies and the comparisons were made by the Pearson chi-square test. Continuous variables are summarized as mean and standard deviation or median and interquartile range. Those comparisons were made by *t* test for the normal data and the Mann-Whitney test for skewed data. The logistic regression analysis was performed to determine the influence of BITA grafting on impaired wound healing and 30-day mortality. In an attempt to minimize selection bias, a propensity score was created using logistic regression based on the following patient characteristics that would affect the surgeon's decision about operative strategy: age, sex, body mass index, body surface area, diabetes mellitus, peripheral arterial disease, New York Heart Association (NYHA) functional class, history of myocardial infarction, left ventricular ejection fraction, number of systems with > 75% stenosis, left main trunk stenosis > 50%, emergent operation, and preoperative intraaortic balloon pumping. The C statistic for this model was 0.914. Because the number of patients and events was small, we used the propensity score for regression adjustment. In regression adjustment based on propensity score, both the comparison variable of interest (in this case, BITA grafting) and the propensity score were included in the model. The significant level of *P* value was set at 5%. All statistical analyses were performed with the SPSS statistical package version 11.0 (SPSS Inc, Chicago, IL).

RESULTS

Preoperative Characteristics

Patients in the BITA group had significantly higher body mass index and a higher rate of history of myocardial infarction than patients in the SITA group. There was no significant difference in other characteristics between the 2 groups (Table 1).

Operative Data and ITA Arrangement

In both groups, all patients underwent myocardial revascularization using the off-pump technique without conversion to cardiopulmonary bypass during surgery, and all arterial conduits were harvested with skeletonization technique. Patients in the BITA group had a higher rate of total arterial revascularization, aorta non-touch technique, and less use of saphenous vein than the SITA group. There was no significant

Table 3. Combinations for ITA Graft Placement*

BITA group (n = 32)	n
in situ LITA-LAD, in situ RITA-CX	4
in situ RITA-LAD, in situ LITA-CX	26
in situ ITA-LAD, in situ ITA-RCA	2
SITA group (n = 23)	n
in situ LITA-LAD	21
in situ RITA-LAD	1
composite LITA-LAD	1

*ITA indicates internal thoracic artery; BITA, bilateral ITA; LITA, left ITA; LAD, left anterior descending coronary artery; RITA, right ITA; CX, circumflex artery; RCA, right coronary artery; SITA, single ITA.

difference in the number of distal anastomosis, the use of gastroepiploic artery, and operation time between the 2 groups (Table 2). In the BITA group, 2 patients were revascularized with in situ ITA grafting to the right coronary artery. In 1 urgent case in which harvested left ITA flow was weak probably because of left subclavian artery stenosis, a Y graft was constructed by attaching the free left ITA proximally saphenous vein, which was anastomosed to the major branches of the circumflex artery. In all other cases, ITAs were used as in situ grafts (Table 3).

Complications

The incidences of ventilation > 24 hours and atrial fibrillation were similar in the 2 groups. Stroke occurred in 1 patient in the SITA groups 4 days after operation. This patient was a 69-year-old woman who underwent am emergency operation with intraaortic balloon pumping, and the saphenous vein was placed on the ascending aorta using partial clamping. Impaired chest wound healing occurred in 3 patients in the BITA group and 2 patients in the SITA group, with no significant difference (P = .99). Two patients in the SITA group had impaired leg wound healing. No mediastinitis occurred. BITA grafting was not associated with impaired chest wound healing (propensity score adjusted odds ratio, 0.63; 95% confidence interval, 0.04 to 8.79; P = .73). These results are summarized in Table 4.

Mortality

The 30-day mortality was 9.1% (5/55 patients) in all patients, 6.3% (2/32 patients, numbers 1 and 2) in the BITA group, and 13.0% (3/23 patients, numbers 3, 4, and 5) in the SITA group (P = .64). Table 5 shows the details of 30-day mortality. Four patients underwent emergency operations (numbers 2 to 5). Causes of death were acute respiratory distress syndrome (numbers 1 and 2), low cardiac output syndrome (number 3), liver dysfunction (number 4), and superior mesenteric artery thrombosis (number 5). After adjusting for the propensity score, BITA grafting was not associated with 30-day mortality (propensity score adjusted odds ratio, 0.60; 95% confidence interval, 0.05 to 6.82; P = .68).

DISCUSSION

The present study provides perioperative outcomes on a series of consecutive dialysis patients among whom the off-pump technique was unexceptionally applied without conversion to cardiopulmonary bypass; all arterial conduits were routinely harvested with skeletonization technique; all arterial conduits was used as in situ graft except for 1 patient; and a high rate of complete revascularization was achieved. The major findings of the present study were that the rate of impaired wound healing, mediastinitis, stroke, and 30-day mortality were not different between the BITA group and the SITA group; the BITA grafting was not associated with increased rate of impaired wound healing and 30-day mortality after propensity score.

Kai and colleagues investigated early and late results in 76 dialysis patients undergoing BITA grafting in comparison with 25 undergoing SITA grafting. In this study, skeletonization and off-pump technique were used in 82.9% of patients in the BITA group. They reported that the rate of mediastinitis was 7.9% in the BITA group and 8.0% in the SITA group (P > .99); 30-day mortality was 1.3% in the BITA group and 4.0% in the SITA group (P = .44) [Kai 2007]. Nakayama and coworkers compared early outcomes in 25 dialysis patients undergoing BITA grafting and 52 undergoing SITA grafting. In this study, cardiopulmonary bypass and pedicle ITA were used in all cases. They reported that wound healing problems occurred in 0% of patients in the BITA group and 3.8% in the SITA group; hospital mortality was 4% in the BITA group and 7.7% in the SITA group (P = .49) [Nakayama 2001]. The 30-day mortality in our study was higher than these studies probably because the rates of emergency and preoperative intraaortic balloon pumping were higher.

Reduction of wound infections has been demonstrated in some reports when BITA was harvested in a skeletonization technique [Peterson 2003; De Paulis 2005]. Meanwhile, Nakano and associates have demonstrated that the use of BITA, even when harvested in a skeletonization technique, was a risk factor for wound infection in diabetic patients [Nakano 2008]. In our study, all arterial conduits were harvested with skeletonization technique. No mediastinitis occurred. There was no statistical difference in occurrence of impaired wound healing between the 2 groups; however, the SITA group had a higher rate of impaired leg wound healing probably because the SITA group had a greater use of saphenous vein graft (SVG) for achievement of complete revascularization than the BITA group.

Operative mortality of conventional CABG with cardiopulmonary bypass has been reported to range from 11.4% to 14.6% in patients with chronic dialysis [Labrousse 1999; Franga 2000; Khaitan 2000; Liu 2000; Dacey 2002]. Operative mortality of off-pump CABG has been recently reported to range from 0% to 6.7% in patients with chronic dialysis [Hirose 2001; Tashiro 2002; Papadimitriou 2003]. In our study, all patients underwent off-pump CABG. The rate of 30-day mortality was 9.1% (5/55 patients).

Several studies have shown that the off-pump technique itself could be one of the reasons for incomplete revascularization, which is associated with poor prognosis [Caputo

Table 4. Complications*

	BITA Group (n = 32)	SITA Group (n = 23)	*P*
Ventilation > 24 h, n (%)	13 (41)	7 (30)	.96
Atrial fibrillation, n (%)	6 (19)	5 (22)	.79
Stroke, n (%)	0	1 (4)	.42
Re-exploration for bleeding, n (%)	0	0	—
Perioperative myocardial infarction, n (%)	0	0	—
Impaired chest wound healing, n (%)	3 (9)	2 (9)	.99
Impaired leg wound healing, n (%)	0	2 (9)	.17
Mediastinitis, n (%)	0	0	—
30-day mortality, n (%)	2 (6)	3 (13)	.64

*BITA indicates bilateral internal thoracic artery; SITA, single internal thoracic artery.

Table 5. Details of Mortality*

Patient Number	Age, y	Sex	Urgency	Mechanical Support	Comorbidity	Logistic EuroSCORE	Cause of Death
1	62	male	elective	—	DM	11.4	ARDS
2	76	female	emergent	IABP	DM, PAD	26.9	ARDS
3	67	male	emergent	IABP	DM	18.2	LOS
4	70	female	emergent	IABP	DM, PAD	46.4	Liver failure
5	73	female	emergent	—	DM, PAD	29.3	SMA thrombosis

*DM indicates diabetes mellitus; ARDS, acute respiratory distress syndrome; IABP, intraaortic balloon pumping; PAD, peripheral artery disease; LOS, low output syndrome; SMA, superior mesenteric artery.

2005; Kleisli 2005]. In this study, the rate of complete revascularization was 100% in both groups, and the mean number of distal anastomosis was 3.3 in the BITA group and 3.1 in the SITA group.

Although we cannot make a definitive conclusion from our results due to the small sample size and lack of remote outcomes, our results indicate that in situ skeletonized off-pump BITA grafting did not increase operative risk among dialysis patients.

Limitations

There are several important limitations in the present study. First, even with propensity score adjustment, we cannot truly evaluate the effect of BITA grafting as we could in a prospective randomized trial. Although the propensity score can adjust for confounding by indication and selection bias, we cannot eliminate residual confounding due to unobserved factors. Second, our study population was small, resulting in insufficient statistical power. The limited number of postoperative complications did not allow the construction of a statistical model to assess the impact of BITA grafting on other complications including stroke, perioperative myocardial infarction, and mediastinitis. Third, this was a single institution study, so the conclusions may not be applicable in general. Forth, the lack of available coronary angiographic data did not allow us to evaluate the graft patency. Finally, our database did not have enough length of follow-up and sample size to analyze remote outcomes.

Strengths

In this series, the off-pump technique was unexceptionally applied to all patients without conversion to cardiopulmonary bypass, and a high rate of complete revascularization was achieved. Moreover, all arterial conduits were harvested using the skeletonization technique in all cases. There is thus no selection bias for the use of cardiopulmonary bypass and the skeletonization technique, and all of the patients were consecutive.

CONCLUSION

Among dialysis patients with multi-vessel coronary artery disease, in situ skeletonized bilateral internal thoracic artery grafting without cardiopulmonary bypass is safe and feasible without increasing rates of impaired wound healing, mediastinitis, stroke, and 30-day mortality. Further studies are necessary to confirm the short- and long-term efficacy and safety of off-pump bilateral internal thoracic artery grafting in dialysis patients.

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