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Clinical outcome of arterial myocardial revascularization using bilateral internal thoracic arteries in diabetic patients: a single centre experience

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Abstract

OBJECTIVES: The use of bilateral internal thoracic arteries (BITAs) grafting has been documented to be advantageous over left internal thoracic artery (LITA) grafting. It has been shown to significantly improve clinical outcomes and increase long-term survival in patients with diabetes. However, harvesting BITAs may result in a greater risk of superficial wound infection (SWI) or deep sternal wound infection (DSWI) and cardiovascular complications (major adverse cardiac and cerebrovascular events; MACCE) in such a patient group. The objective of this study was to compare the incidence of SWI or DSWI and cardiovascular events in a series of isolated coronary artery bypass grafting (CABG) patients who underwent BITA grafting vs LITA grafting.

METHODS: A total of 147 patients with coronary artery disease and diabetes underwent isolated CABG at John Paul II Hospital. Of these, 38 procedures were performed using BITA grafting and 109 with LITA-saphenous vein grafting.

RESULTS: MACCE were similar in bilateral groups (7.9%—BITA group and 9.2%—LITA group). No significant difference was found in mortality and length of stay between bilateral groups. The MACCE risk factor was age. The incidence of SWI and DSWI and sternal re-fixation did not differ between the BITA or LITA groups (5.2 vs 9.1%, 5.2 vs 7.3% and 5.2 vs 6.4%). The risk factors for DSWI were age (odds ratio 3.47, $P = 0.032$ for every 10 years) and body mass index >30 kg/m^2.

CONCLUSIONS: Perioperative complications do not increase with the use of BITAs in this group of diabetic patients. There are no statistically significant differences in the number of superficial or deep wound infections or number of sternal resuturing between the BITA and LITA groups.

Keywords: Coronary artery bypass • thoracic arteries • Diabetes

INTRODUCTION

Surgical treatment of coronary artery disease requires harvesting of patients' arteries or veins for construction of coronary grafts. Superior arterial graft patency rates have been demonstrated in multiple studies. Ten years after operation, 60% of venous grafts are narrowed or occluded [1]. The left internal thoracic artery (LITA) rarely develops atherosclerosis, especially in patients under 65 years of age [1, 2]. Barner *et al*. [2] showed a higher 10-year patency rate of internal thoracic artery graft to left anterior descending artery (LAD) in comparison with venous grafts 82.6 vs 71%. In the Bypass Angioplasty Revascularization Investigation trial [3], the LITA to LAD bypass patency rate was 98% after 1 year and 91% after 4 years (venous bypass to LAD 87 and 83%, respectively). Based on the most recent angiographic findings, the patencies of internal thoracic artery bypass to LAD at 10 and 15 years after surgery were 95 and 88%, while the patencies of venous grafts were 61 and 32% over the same period of time [4].

Due to the superior patency of arterial grafts, many investigators use the right internal thoracic artery (RITA) more frequently. Buxton *et al*. [5] compared the results of operations using bilateral internal thoracic arteries (BITAs) and standard operations and showed a 15% improvement in the survival of patients after use of BITA in 10 years of follow-up. Lytle *et al*. [6] demonstrated improved survival and freedom from reoperation in patients revascularized with BITA in comparison with single internal thoracic artery and vein grafts over 20 years of follow-up. Most studies evaluating the results of coronary artery bypass grafting (CABG) in diabetic patients demonstrated an increased risk of in-hospital death, higher 30-day and follow-up mortality rates, as well as higher incidence of sternal wound infections (SWIs). Nevertheless, BITAs grafting has been shown to significantly improve clinical outcomes and increase long-term survival in patients with diabetes. In patients with diabetes, the usage of BITA was associated with lower mortality and better patency at follow-up. Therefore many authors (Calafiore, Toker) emphasize the importance of using total arterial revascularization in this patient group [7, 8]. However, harvesting BITAs may result in a greater risk of superficial or deep sternal wound infection (DSWI) and cardiovascular complications (major adverse cardiac and cerebrovascular events; MACCE). In addition, diabetes itself is an independent risk factor for infectious complications within the surgical wound.

We assessed the safety of harvesting BITAs in coronary artery bypass graft surgery in relation to a standard operation using the LITA and venous grafts in patients with diabetes and determined the frequency of infectious complications or cardiac events in diabetic patients after CABG surgery with the use of one or two internal thoracic arteries.

MATERIALS AND METHODS

Clinical data of 147 consecutive patients with stable coronary heart disease and diabetes who underwent CABG from January 2006 to July 2008 in the Department of Cardiovascular Surgery and Transplantology Institute of Cardiology John Paul II Hospital, Krakow, Poland were retrospectively analysed.

Patients were divided into two groups: the BITA group (BITAs), and LITA group (only LITA). Other grafts were performed using either the radial artery or saphenous vein.

Patients undergoing urgent surgery, with instable ischaemic heart disease, after previous cardiac surgery and patients who had concomitant procedures (such as valve replacement or repair, carotid surgery) were excluded from the study.

The BITA group consisted of 38 patients, while the control group (LITA) consisted of 109 patients.

Surgical technique

Internal thoracic arteries were harvested as a pedicle with the surrounding tissues and accompanying veins. Arteries were taken with diathermy and the use of clips. The internal thoracic arteries (ITAs) were divided 3 min after systemic heparinization and left in a sponge soaked with papaverine, while the distal end was clamped with a small bulldog clamp. The pleural spaces were always opened, and the pericardium was incised to avoid any tension on the arterial conduits.

The final decision on operative strategy: on-pump vs off-pump and choice of grafts, was made by surgeons performing the operation, based on their own experience. If the RITA was taken as a 'free graft', in 95% of cases it was implanted into the LITA (anastomosis type T or Y) and in 5%, directly into the aorta.

Chest drains were positioned in one or bilateral pleural spaces and in the mediastinum. The sternum was reaproximated with a steel wire, and subcutaneous tissues were closed with two layers of continuous absorbable sutures and skin with continuous intracutaneous absorbable suture.

Perioperative management

As a standard before skin incision, patients received cefazolin (1 g), which was continued in repeated doses (three times a day) until chest tubes removal. In case of infection, a swab was taken from the wound and following the outcome of cultures, targeted antibiotics were administered.

Glicemic control during operation and intensive care unit (ICU) stay was achieved by insulin infusion and in the following days, intensive insulin therapy (four infusion).

Definitions for deep and superficial sternal wound infection followed the guidelines of the Centers for Disease Control and Prevention [9]. DSWI was recognized if infection involved sternal or mediastinal tissues and at least one of the following: isolation of an organism from culture of the mediastinal tissue or fluid, visual evidence of mediastinitis, chest instability or fever associated with the presence of purulent drainage. SWI was defined when purulent discharge was not associated with involvement of sternal or mediastinal tissues.

The presence of superficial or deep sternal infection was diagnosed at the time of hospitalization. The incidence of sternal resuturing was stated at the time of hospitalization and during the first 3 months after discharge.

Statistical analysis

Continuous data are displayed as means with standard deviation. Categorical data are expressed as proportions. Categorical variables were analysed using the chi-squared test or Fisher's exact test when appropriate.

In all studies, P-values <0.05 were considered statistically significant. Calculations were performed using STATA 8.0 package.

Due to the small number of cases, the Blackstone convention (≤0.1 probably significant and ≤0.2 possibly significant) was used in the assessment of risk factors.

RESULTS

Preoperative and operative data

Table 1 shows baseline characteristics of the two groups.

The average age in the BITA group was 62 ± 8 and 66 ± 7 years in the LITA group (Table 1). Sixty percents of the BITA group and 50% of the LITA group took insulin.

The number of grafts performed (LITA = 2.57 vs BITA = 2.6) and percentage of operations without cardiopulmonary bypass in bilateral groups were similar (LITA = 46% vs BITA = 45%) (Table 2). Postoperative drainage, measured in the first 24-h postoperative in the ICU was greater (P = 0.004) in the BITA group (mean 1059 ml SD 499 vs 794 ml SD 383), as well as the rethoracotomy rates (7.9% in the BITA group vs 4.6% in the LITA group).

Four patients in the LITA group died within 30 days after surgery, resulting in an early mortality of 3.6%. Causes of death were postoperative myocardial infarction in one patient and organ failure and sepsis in three patients.

In the BITA group, early mortality was 2.6% (P = 1.00) (Table 2). This patient died with heart failure after myocardial infarction in the perioperative period.

Incidence of stroke was not statistically different between groups (2.63 vs 2.75%, P = 1.00).

The incidence of MACCE, such as myocardial infarction, death or stroke, were not statistically significant (P = 1.00) (Table 2). The risk factor for MACCE was age [odds ratio (OR) 2.79 (1.05–7.36), P = 0.038]. A probable risk factor for MACCE was a history of

Table 1: Preoperative patient characteristics

Variable	LITA group (*n* = 109)	BITA group (*n* = 38)	*P*-value
Age (years)	66 ± 7.5	62 ± 8.3	0.010*
BMI (kg/m^2)	29 ± 4.0	28 ± 3.6	0.39
Ejection fraction (%)	51.1 ± 10	51.6 ± 8	0.92
Male sex	65 (60)	25 (66)	0.50
Hypertension	96 (88)	36 (95)	0.24
Prior myocardial infarction	71 (65)	28 (74)	0.33
Prior	18 (16)	5 (18)	1.00
Chronic kidney disease	11 (10)	2 (5.2)	0.52
Chronic lung disease	7 (6.4)	3 (7.8)	0.72
Hypercholesterolemia	65 (59.6)	26 (72.2)	0.23
History of stroke	6 (5.5)	1 (2.6)	0.68
History of peripheral vascular disease	13 (11.9)	14 (36.8)	0.001*
Diabetes–Insulin	54 (49.5)	23 (60.5)	0.24
Diabetes–oral therapy	55 (50.5)	15 (39.5)	0.26
BMI >30 (kg/m^2)	44 (40)	12 (32)	0.34

BITA: bilateral internal thoracic arteries; LITA: left internal thoracic artery.
Values are expressed as *n* (%) or mean ± SD.
**P*-values <0.05–statistically significant.

Table 2: Coronary artery bypass grafting data

	LITA group (*n* = 109)	BITA group (*n* = 38)	*P*-value
Operation time (min)	165 ± 30.6	201 ± 33	<0.0001*
Aortic cross-clamp time (min)	32.5 ± 8.6	34 ± 13	1.00
Blood loss (ml)	794 ± 383	1059 ± 499	0.0040*
Number of grafts	2.57 ± 0.61	2.60 ± 0.59	0.89
Off-pump	50 (46)	17 (45)	0.90
Reoperation due to bleeding	5 (4.6)	3 (7.9)	0.43
Radial artery graft	16 (14)	11 (29)	0.048*
Hospital stay (days)	13 ± 4.7	15 ± 6.5	0.15***
Perioperative myocardial infarction	4 (3.7)	2 (5.2)	0.65
30-day–mortality	4 (3.67)	1 (2.63)	1.00
30-day–stroke	3 (2.75)	1 (2.6)	1.00
30-day–MACCE	10 (9.2)	3 (7.9)	1.00
Saphenous vein graft	93 (86)	11 (29)	<0.001*

BITA: bilateral internal thoracic arteries; LITA: left internal thoracic artery; MACCE: major adverse cardiac and cerebrovascular events.
Values are expressed as *n* (%) or mean ± SD.
**P*-values <0.05-statistically significant.
***Possible effect (*P* ≤ 0.2).

peripheral atherosclerosis [OR 4.14 (0.84–20.36), *P* = 0.08] and a possible risk factor for MACCE was low ejection fraction (EF) before surgery [OR 0.94 (0.87–1.01), *P* = 0.11] (Table 3).

In the case of death, probable risk factors estimated using multivariate logistic regression were high body mass index (BMI) and low ejection fraction preoperatively (Table 4). Peripheral artery disease (6.55 times, *P* = 0.13), age (3.91 times per 10 years, *P* = 0.115) or history of myocardial infarction (*P* = 0.15) were possible risk factors.

Table 3: Multivariate analysis for risk factors for MACCE

Variable	Odds ratio	95% CI	*P*-value
Age (unit = 10 years)	2.79	(1.05–7.36)	0.038*
Female gender	2.37	(0.53–10.6)	0.26
BITA vs LITA	0.66	(0.09–4.67)	0.68
BMI	1.02	(0.87–1.2)	0.76
Myocardial infarction before surgery	1.06	(0.22–4.93)	0.94
Peripheral atherosclerosis	4.14	(0.84–20.36)	0.08**
EF (%) before surgery	0.94	(0.87–1.01)	0.11***

BITA: bilateral internal thoracic arteries; LITA: left internal thoracic artery.
**P*-values <0.05-statistically significant.
**Probable effect (*P* ≤ 0.1).
***Possible effect (*P* ≤ 0.2).

Table 4: Multivariate analysis of risk factors for in-hospital death

Variable	Odds ratio	95% CI	*P*-value
Age (unit = 10 years)	3.91	(0.71–21.33)	0.115***
BITA vs LITA	2.17	(0.09–47.88)	0.62
BMI	1.27	(0.96–1.68)	0.083**
Prior myocardial infarction	0.16	(0.01–1.88)	0.15***
Peripheral atherosclerosis	6.55	(0.57–75.41)	0.13**
EF (%) before surgery	0.86	(0.75–1.0)	0.056**

BITA: bilateral internal thoracic arteries; LITA: left internal thoracic artery; BMI: body mass index.
**P*-values <0.05–statistically significant.
**Probable effect (*P* ≤ 0.1).
***Possible effect (*P* ≤ 0.2).

Patients who died were older (70.3 ± 6.8 vs 65.3 ± 7.9, *P* = 0.15), had higher BMI (31.1 ± 3.8 vs 28.9 ± 3.9, *P* = 0.20) and lower ejection fraction before surgery (43.6 ± 13.7 vs 51.5 ± 9.6, *P* = 0.16) (Table 5).

Wound complications

In the postoperative period, bilateral the incidence of SWI (9.1 vs 5.2%) and the incidence of DSWI (7.3 vs 5.2%) and sternal refixation due to infection (6.4 vs 5.4%) were greater in patients after bypass surgery using only the LITA (Table 6). These differences, however, did not reach statistical significance.

The total number of DSWIs in the whole group was 10 cases (6.8%).

In the BITA group, all patients with DSWI after sternal refixation left the hospital in good general condition.

In the LITA group, seven of eight patients with DSWI had sternal refixation and were discharged from hospital in good general condition.

One patient with DSWI, but without sternal instability, did not require refixation, only antibiotic therapy. The patient left the hospital in good general condition without signs of infection.

Table 5: In-hospital mortality

Variable	Died (n = 5)	Survived (n = 142)	P-value
Age	70.3 ± 6.8	65.3 ± 7.9	0.15***
LITA	4 (80)	105 (74)	1.00
BMI	31.1 ± 3.8	28.9 ± 3.9	0.20***
Prior myocardial infarction	3 (60)	96 (68)	0.66
Peripheral atherosclerosis	2 (40)	25 (18)	0.23
EF (%) before surgery	43.6 ± 13.7	51.5 ± 9.6	0.16***

BMI: body mass index; LITA: left internal thoracic artery.
***Possible effect ($P \le 0.2$).

Table 6: In hospital wound infection

Variable	LITA group (n = 109)	BITA group (n = 38)	P-value
Superficial wound infection	10 (9.1)	2 (5.2)	0.73
Deep sternal infection	8 (7.3)	2 (5.2)	1.00
Sternal refixation			
All causes	9 (8.2)	2 (5.2)	0.47
Infection	7 (6.4)	2 (5.2)	1.00

BITA: bilateral internal thoracic arteries; LITA: left internal thoracic artery.
Values are expressed as n (%).

In 3 months of follow-up, three patients in the LITA group and one patient in the BITA group required sternal resuturing because of DSWI and sternal instability.

Additionally, two patients from the BITA group and three patients from the LITA group required refixation because of sternal instability without evidence of infection.

Risk factors for DSWI were age and high BMI (>30). Every 10 years increased the risk 3.47 times (P = 0.032). BMI >30 increased the risk 6.80 times (P = 0.015) (Table 7).

Table 7: Multivariate analysis of risk factors for DSWI

Variable	Odds ratio	95% CI	P-value
Age (unit = 10 years)	3.47	(1.11–10.83)	0.032*
Female gender	2.64	(0.52–13.58)	0.24
BITA vs LITA	1.18	(0.18–7.65)	0.86
BMI >30	6.80	(1.45–31.84)	0.015*
Diabetes—insulin	0.90	(0.22–3.64)	0.88

BMI: body mass index; BITA: bilateral internal thoracic arteries; LITA: left internal thoracic artery.
*P-values <0.05—statistically significant.

DISCUSSION

The most frequent coronary operation is the LITA graft on LAD and venous grafts. In recent years, more surgeons have begun to use BITAs and perform total arterial revascularization using the left radial artery.

Magee *et al*. [10] showed dysfunction of <25% of venous grafts in follow-up after the control angiographic study. Compared with the artery, the vein shows a 2.6 times greater tendency to dysfunction. After a few years, the right internal thoracic artery demonstrates a high percentage of patency (96% at 5 years, 81% after 10 years), comparable with the left internal thoracic artery (98 and 95%) [4]. Also, Rankin *et al*. [11] demonstrated a statistically significant reduction in mortality, myocardial infarction or need for percutaneous coronary intervention after using BITAs when compared with LITA, after 20 years of observation.

Kurlansky *et al*. [12] have shown that BITA grafting offers a long-term survival advantage over SIMA grafting in propensity-matched groups.

CABG in patients with diabetes is associated with higher perioperative mortality [13], and insulin therapy is an independent risk factor for increased mortality [14]. Annual and 10-year survival rate after CABG was lower in patients with diabetes mellitus (DM) [15] .

In diabetic patients with BITAs harvested, many authors emphasized the higher patency of grafts and an increased 10-year survival rate, especially with preserved ventricular function [16] and a lower perioperative mortality compared with a group of one internal thoracic artery [17]. Stevens *et al*. [18] assessed the impact of diabetes on the operative complications with BITAs used. The BITA group with diabetes had lower mortality rates and total hospital mortality (0 vs 0.5%, 0.9 vs 2.6%).

Zhang *et al*. [19], in 2001, published the results from a systematic review and meta-analysis of studies of diabetic patients undergoing coronary artery bypass surgery compared with non-diabetics. In the conclusions, the authors emphasize that the patients with DM who are undergoing CABG are at increased risk of mortality (1, 3, 5 and 10 years), stroke, renal failure, sternal infection and blood transfusion when compared with those without DM.

Gansera *et al*. [20] assessed the number of perioperative complications after LITA or BITA harvesting (pedicle). Thirty-day mortality in patients with diabetes was lower in the BITA group (3.1 vs 4.7%) than in the LITA group.

In our study, deaths occurred more frequently in the LITA group than in the BITA group (3.67 vs 2.63%).

The numbers of MACCE and mortality were comparable with the results published by Tarantini *et al*. [21] and Daemen *et al*. [22] and were slightly higher than in the paper by Stevens *et al*. [19].

Our results reveal higher mortality in older patients, with lower ejection fraction and history of myocardial infarction. A higher BMI has a possible effect on mortality.

It should be noted that the harvesting of the internal thoracic artery can reduce blood flow within the sternum. A significant decrease in perfusion in the sternum after collection of ITA in the postoperative period has been proved [23]. This fact may contribute to the difficult healing of the sternum.

In addition, many researchers point out that diabetes is an independent risk factor for sternal wound infection in the perioperative period [24]. Savage *et al*. [18] showed that risk factors for sternal infection in patients with diabetes include harvesting BITAs (2.8 vs 1.7%, compared with harvesting one internal thoracic artery), insulin-dependent diabetes, BMI >35 and peripheral atherosclerosis.

In a single institution study of consecutive patients undergoing cardiac surgery, multivariate analysis revealed diabetes (OR = 1.7) and obesity (OR = 2.2 11) as a predictors of DSWI [25].

DSWIs occurred in our group (all patients with diabetes) significantly more frequently in older patients with high BMI. BITA harvesting was not an independent risk factor for DSWI in patients with diabetes.

The study has several limitations. First, the study is a retrospective analysis. The second limitation is the low number of cases. Finally, an estimation of glucose control (glycosylated haemoglobin) before surgery and its impact on postoperative infection rate would be interesting.

The use of BITAs in diabetic patients, is associated in our study with an acceptable perioperative risk and similar hospital mortality. Infectious complications, occurring usually more frequently in patients with diabetes, were comparable in bilateral groups. Harvesting BITAs in the group of patients with diabetes did not significantly affect the number of wound infections or the need for sternal refixation, as compared with patients who have taken only one internal thoracic artery.

Conflict of interest: none declared.

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