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Using the Bilateral Internal Mammary Artery in the Left or Right Coronary Artery System: 5-Year Comparison of Operation Techniques and Angiographic Results

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ABSTRACT

Objective. Using the bilateral internal mammary artery (IMA) in coronary artery bypass grafting (CABG) surgery has prolonged survival, improved functional capacity, and reduced the rate of reintervention without increasing postoperative early morbidity and mortality.

Methods. Between January 1996 and December 1997, 94 CABG operations were performed using the bilateral IMA. In Group A (n = 45), the right IMA was anastomosed to the left coronary artery system; in Group B (n = 49), the right IMA was anastomosed to the right coronary artery system. The left IMA was always anastomosed to the left coronary artery system in both groups.

Results. There was 1 death (Group A) (1.06%), and 1 late death (Group B) (1.07%). One patient in Group A underwent balloon angioplasty, and 1 patient in Group B underwent reoperation after the follow-up. Pre- and postoperative data were similar between both groups, except for off-pump CABG, which was higher in Group B (2.2% versus 36.7%; P <.001). Twenty-three randomized patients in each group underwent control angiography until May 2002. Angiographic results showed that the patency of the right IMA to the right or left coronary artery system was similar (78.26% versus 82.6%; P = .7). But the left IMA had a better patency rate than the right IMA (95.65% versus 80.43%; P = .02). The patency rates of the left and right IMA anastomosis on the beating heart in Group B were not significantly different (92.3% versus 76.9%; P = .27). The patency of right IMA anastomosis with or without off-pump technique in Group B was similar (76.9% versus 80%; P = .84).

Conclusions. Bilateral IMA can be used with low morbidity and mortality. The angiographic and clinical results of off-pump CABG show that bilateral IMA can also be used in off-pump surgery with similar results.

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INTRODUCTION

The purposes of myocardial revascularization are to prolong survival, to improve the quality of life, to eliminate or ameliorate angina, to reduce the need for a subsequent intervention, and to decrease the frequency of repetitive ischemic events such as myocardial infarction. The success of myocardial revascularization mainly depends on long-term graft patency and the number of bypassed coronary arteries. Recently, it has been stated that the use of the bilateral internal mammary artery (BIMA) in coronary artery bypass grafting (CABG) operations has improved functional capacity, reduced the rate of reintervention, prolonged survival, and decreased the rate of reoperation without increasing morbidity and postoperative early mortality when compared to the use of the left internal mammary artery (LIMA) [Pick 1997; Tatoulis 1999; Lytle 1999; Endo 2001; Dewar 1995; Jones 1997; Berreklouw 2001; He 1994; Ashraf 1994; Ioannidis 2001; Toker 2000]. Fiore and associates [1990] concluded that the right internal mammary artery (RIMA) to right coronary artery (RCA) anastomosis in BIMA-operated patients had good effects, reduced the long-term angina and myocardial infarction frequency, and decreased reintervention rate. In contrast, some authors emphasized that heart failure accompanied the RIMA to RCA anastomosis [Dietl 1995; Chow 1995; Buxton 2000]. Many other comparative and noncomparative studies using the RIMA to the left coronary artery (LCA) system have been published in recent years and found that the patency was superior to those anastomosed to the RCA [Buxton 2000; Ura 2000; Schmidt 1997; Gerola 1996; Buche 1995]. Off-pump CABG techniques have been used for the last decade and are becoming popular because of their advantages over the conventional technique and their better angiographic results [Kirali 1999; Omeroglu 2000; Kirali 2002]. Long-term patency of the RIMA using the conventional technique is as good as the LIMA, but we do not know the mid-term patency rate of BIMA anastomosis performed with off-pump techniques.

The purpose of this study was to investigate mid-term outcome and angiographic results using the BIMA and to compare using the RIMA to the left or right coronary artery system. Secondly, off-pump technique was investigated to determine whether or not this strategy might worsen the patency of the BIMA.

Table 1. Preoperative Patient Characteristics*

	Group A RIMA to Left, n = 45	Group B RIMA to Right, n = 49	*P*
Age, y	44.37 ± 5.8	45.53 ± 6.1	.7
Female sex	1 (2.2%)	0	.3
Diabetes mellitus	2 (4.4%)	4 (8.1%)	.4
Obesity	2 (4.4%)	5 (10.2%)	.4
Hyperlipidemia	16 (35.5%)	23 (46.9%)	.1
Hypertension	12 (26.6%)	13 (26.5%)	.6
Smoking	34 (75.5%)	39 (79.5%)	.3
Familial history	25 (55.5%)	21 (42.8%)	.2
COPD	22 (48.8%)	19 (38.7%)	.2
NYHA class	2.6 ± 0.8	2.8 ± 0.8	.2
Previous MI	26 (57.7%)	24 (48.9%)	.1
Unstable angina	8 (17.7%)	12 (24.4%)	.4
Severe LVD	3 (6.6%)	5 (10.2%)	.5
2 vessels	15 (33.3%)	19 (38.7%)	.5
3 vessels	27 (60%)	29 (59.1%)	.9
Left main	3 (6.6%)	1 (2%)	.2

*RIMA indicates right internal mammary artery; COPD, chronic obstructive pulmonary disease; NYHA, New York Heart Association; MI, myocardial infarction; LVD, left ventricular dysfunction.

Table 2. Surgical Procedures*

Group A RIMA to Left, n = 45		Group B RIMA to Right, n = 49	
CPB	n	CPB	n
LIMA-LAD + RIMA-Cx	26†	LIMA-LAD, RIMA-RCA	27
LIMA-LAD, free RIMA-Cx	5	LIMA-LAD, free RIMA-RCA	1
LIMA-LAD, RIMA-D_1	1†	LIMA-D_1, RIMA-RCA	2
LIMA-D_1, RIMA-LAD	2	OPCAB	n
Free LIMA-Cx, RIMA-LAD	1	LIMA-LAD, RIMA-RCA	17
RIMA-LAD, LIMA-Cx	9	LIMA-LAD, free RIMA-RCA	1
OPCAB	n	MIDCAB	n
LIMA-D_1, RIMA-LAD	1	LIMA-LAD, RIMA-RCA	1

*RIMA indicates right internal mammary artery; CPB, cardiopulmonary bypass; LIMA, left internal mammary artery; LAD, left anterior descending artery; RCA, right coronary artery; D_1, first diagonal; Cx, circumflex; OPCAB, off-pump coronary artery bypass; MIDCAB, minimally invasive direct coronary artery bypass.

†RIMA passed through transverse sinus.

PATIENTS AND METHODS

A retrospective study was conducted to compare the short- and mid-term performance of the BIMA combined with a randomized control angiographic evaluation to investigate the patency rate of the BIMA. Between January 1996 and December 1997, 94 isolated CABG operations were performed using the BIMA. The total CABG operations performed during the same period of time in our institution was 1559. Combined surgical procedures such as CABG associated with valve repair or replacement, aneurysmectomy, CABG operations using a third arterial graft (such as the BIMA plus the radial or gastroepiploic artery), reoperations, and urgent operation after acute myocardial infarction were excluded from the study. Our selection of patients for the BIMA graft was not random, and younger male patients were selected for BIMA revascularization. We tried not to select patients with diabetes mellitus (DM) and/or severe obesity. Patients were randomly divided into 2 groups and group selection was dependent on the length of the RIMA. In Group A (n = 45), both the LIMA and RIMA were anastomosed to the LCA system, and in Group B (n = 49) the LIMA was anastomosed to the LCA system and the RIMA was anastomosed to the RCA system. The major target vessel for the LIMA was the left anterior descending artery (LAD). The decision of which internal thoracic artery would be anastomosed to which vessel was intraoperatively determined according to the length of the conduit and the lesion region of the coronary artery. Preoperative characteristics of patients in both groups were similar (Table 1).

Surgical Procedures

All patients underwent a uniform operative technique in which the internal mammary arteries (IMAs) were singly anastomosed to the coronary arteries. Median sternotomy was performed in all cases, except for 1 patient who underwent minimally invasive CABG procedure. Both IMAs were harvested with a pedicle containing the pleura, the transversus thoracic muscle and fascia, and the internal thoracic veins. All branches of both IMAs were ligated with small clips adjacent to the IMA. The pedicle was sprayed with a solution containing 60 mg/100 mL papaverine and Ringer lactate solution. Eighty-seven patients received the BIMA as in situ grafts, and the RIMA was used as a free graft in 7 patients (Table 2). The RIMA was passed through the transverse sinus in 27 patients in Group A to be anastomosed to the major branches of the circumflex artery (n = 26) or to the diagonal branch of the LAD.

Cardioplumonary bypass (CPB) was performed subsequently at 32°C and continuous retrograde isothermic blood cardioplegia was used for myocardial protection in patients undergoing CPB operation. A single cross clamp for all distal and proximal anastomoses was preferred. One patient in Group A and 18 patients in Group B underwent beating heart surgery. For the operations with a beating heart, heparin was administered to hold activated clotting time over 200 seconds. Beta-blocker agents were used for slowing the heart rate to less than 80 beats per minute. We occluded only the proximal part of the coronary artery using a bulldog-clamp. We never occluded the distal segment of the coronary artery. An oxygen blowing system was used to improve the visualization of the anastomotic region. Distal anastomosis was sutured using 7-0 polypropylene material in a continuous technique. The rest of the operation was performed in the usual manner. Operative data are shown in Table 3. Only 1 patient underwent a minimally invasive procedure, and anterior thoracotomy was performed at both sides of the thorax.

Late Follow-up

Information on patients was provided by the patients, supported by telephone interviews with family physicians or patients, and hospital records between February and May 2002. If patients had suffered late ischemic-related events,

Table 3. Intraoperative Data*

	Group A RIMA to Left, n = 45	Group B RIMA to Right, n = 49	*P*
ACC time, min	66.2 ± 3	71.94 ± 12	.4
CPB time, min	94.74 ± 3.6	100.48 ± 14	.45
Off-pump	1 (2.2%)	18 (36.7%)	<.001
Complete revascularization	32 (71.1%)	40 (81.6%)	.4
Bypassed vessel	2.84 ± 0.8	2.89 ± 0.8	.8

*RIMA indicates right internal mammary artery; ACC, aortic cross clamp; CPB, cardiopulmonary bypass.

meticulous inquiry into angiographic data and hospital records was carried out to gain detailed information. Follow-up was 100% completed with 94 cases. Total follow-up was 489.7 patient-years, with a mean of 5.21 ± 0.98 years (range, 0-6.6 years).

Statistical Analysis

Statistical analyses were performed using SPSS version 10.0 software (SPSS, Inc., Chicago, IL, USA). Mean ± standard deviation and range were calculated for descriptive variables. Differences between categorical variables were tested using a χ^2 and a Fisher exact test. Differences between continuous variables were tested using a Student *t* test. Univariate and forward stepwise logistic regression analysis was used to assess risk factors for early mortality, mediastinitis, and reoperation for bleeding. Long-term event-free curves were estimated by the Kaplan-Meier method, and differences between groups were compared with a log-rank test. Results are presented as mean ± standard error. Univariate and multivariate Cox proportional hazard regression analysis was used to assess risk factors as independent predictors of late mortality and reintervention. A *P* value less than or equal to .05 was considered statistically significant for all comparisons.

RESULTS

Early Results

Perioperative and early postoperative results were similar in both groups (Table 4). Postoperative low cardiac output syndrome developed in 10 patients (10.6%), and 4 patients (4.2%) required postoperative intra-aortic balloon pump support.

Table 4. Morbidity and Mortality Rates*

	Group A RIMA to Left, n = 45	Group B RIMA to Right, n = 49	*P*
Perioperative MI	2 (4.4%)	2 (4%)	.6
Inotropic support	5 (11.1%)	5 (10.2%)	.6
IABP	1 (2.2%)	3 (6.1%)	.3
Revision	1 (2.2%)	1 (2%)	.7
Respiratory complications	1 (2.2%)	1 (2%)	.5
Mediastinitis	0	3 (6%)	.1
Neurologic events	0	0	—
Hospital mortality	1 (2.2%)	0	.5

*RIMA indicates right internal mammary artery; MI, myocardial infarction; IABP, intra-aortic balloon pump.

Table 5. Univariate Analysis for Early Mortality, Mediastinitis, and Re-exploration for Severe Bleeding

Variable	Early Mortality, *P*	Mediastinitis, *P*	Revision, *P*
Group	.314	.092	.951
Age	.648	.923	.638
Hypertension	.544	.788	.018
Diabetes mellitus	.788	.056	.709
Chronic obstructive pulmonary disease	.358	.05	.854
Hyperlipidemia	.39	.747	
Obesity	.77	.613	.682
Smoking	.044		
Previous myocardial infarction	.304		
Graft number	.156		
Complete revascularization	.64	.414	.517
Off-pump	.615	.541	.487
Inotropic support	.004	.539	.072
Perioperative myocardial infarction	<.001	.642	.012
Respiratory complication	.915	.855	.882
Revision	.879	.795	
Mediastinitis	.852		.793

There was 1 (1.06%) early mortality (<30 days) and the reason was perioperative myocardial infarction (MI). The patient underwent surgery and CPB was performed, but the patient died because of low cardiac output syndrome. On univariate analysis, perioperative myocardial infarction (*P* <.001), inotropic support (*P* = .004), and smoking (*P* = .044) were found to be statistically significant predictors of hospital mortality. Forward stepwise logistic regression analysis evaluated no predictors for hospital mortality (Table 5).

Despite the relatively smaller frequency of DM and obesity in all patients, there were only 3 cases of mediastinitis in Group B. One of the patients had DM, but the other 2 patients had chronic obstructive pulmonary disease (COPD), and none were obese. On univariable analysis, COPD (*P* = .05) and DM (*P* = .056) were found to be statistically significant predictors of mediastinitis. Forward stepwise logistic regression analysis evaluated no predictors for mediastinitis (Table 5).

Re-exploration for serious bleeding was necessary in 1 patient. We did not find any surgical bleeding. Another patient underwent re-exploration for perioperative MI and CPB-support was performed, but the patient died. On univariable analysis, perioperative MI (*P* = .012) and hypertension (*P* = .015) were found to be statistically significant predictors of serious bleeding (Table 5). Forward stepwise logistic regression analysis evaluated no predictors for massive bleeding, but perioperative MI (*P* = .077; odds ratio 22) was a serious risk factor for re-exploration.

Late Results

One patient from Group B died 1 year after operation. This patient postoperatively received inotropic support for

Table 6. Univariate Analysis for Late Mortality and Reintervention

Variable	Late Mortality, *P*	Reintervention, *P*
Group	.323	1
Age	.906	
Hypertension	.1	.38
Diabetes mellitus	.788	.7
Chronic obstructive pulmonary disease	.279	.19
Hyperlipidemia	.247	.22
Obesity	.77	.68
Smoking	.627	.47
Previous myocardial infarction	.334	
Graft number	.151	.53
Complete revascularization	.64	
Off-pump	.615	.28
Inotropic support	.003	
Perioperative myocardial infarction	<.001	.013
Respiratory complication	.915	
Revision	<.001	
Mediastinitis	.852	
Functional capacity	.355	
Postoperative angina	.75	.039
Late myocardial infarction	.88	.83

low cardiac output syndrome. Late mortality rate was 1.1% for all patients. Univariate analysis showed that perioperative myocardial infarction (*P* <.001), re-exploration (*P* <.001), and inotropic support (*P* = .003) were found to be statistically significant predictors of late mortality (Table 6). Cox proportional hazard analysis showed no determinate for late mortality. Actuarial survival for all patients was 97.8% ± 1.5% at 6.5 years (6.5 ± 0.1 years, 95% CI 6.3-6.6 years). Actuarial freedom from death was similar in both groups (97.8% ± 0.22% versus 97.9% ± 0.21%; *P* = .97).

Late postoperative results were similar in both groups (Table 7). One patient in Group A underwent postoperative percutaneous transluminal coronary angioplasty (PTCA) for severe stenosis in the LIMA to LAD anastomotic area. One patient in Group B underwent a late reoperation. On univariable analysis, perioperative MI (*P* = .013) and postoperative angina (*P* = .039) were found to be statistically significant predictors for reintervention (Table 6). Forward stepwise logistic regression analysis evaluated no predictors for reintervention, but perioperative MI (*P* = .059; odds ratio 16.6) was a serious risk factor for reintervention. Another patient in Group B had a new MI. Treadmill exercise test results were positive in 1 of 11 patients in Group A and in 1 of 10 patients in Group B.

Table 7. Late Postoperative Results*

	Group A RIMA to Left, n = 45	Group B RIMA to Right, n = 49	*P*
Follow-up, y	5.1 ± 0.9	5.3 ± 1	.3
Inotropic support	2 (4.4%)	6 (12.2%)	.1
PTCA ± stent	0	1 (2%)	.5
New myocardial infarction	0	1 (2%)	.5
Positive exercise test	1 (2.2%)	2 (4%)	.6
Negative exercise test	10 (22.2%)	8 (16.3%)	.4
Late mortality	0	1 (2%)	.7
Total ischemic events	1 (2.2%)	3 (6%)	.4

*RIMA indicates right internal mammary artery; PTCA, percutaneous transluminal coronary angioplasty.

Table 8. Control Angiographic Results

Group A: n = 45, RIMA-Left 23/45, Mean Time 2.5 ± 1.4 years

Type of graft	LAD	Diagonal	Circumflex	Total
LIMA	21/22	1/1	—	22/23 (95.65%)
RIMA	1/1	1/1	15/19	17/21 (80.95%)
Free RIMA	—	—	2/2	2/2 (100%)
Total RIMA				19/23 (82.6%)

Group B: n = 49, RIMA-Right 23/49, Mean Time 2.5 ± 1.6 years

Type of Graft	LAD	RCA	Total
LIMA	22/23	—	22/23 (95.65%)
On-pump	10/10		100%
Off-pump	11/12		91.7%
MICABG	1/1		100%
RIMA	—	18/23	18/23 (78.26%)
On-pump		8/10	80%
Off-pump		9/12	75%
MICABG		1/1	100%

*RIMA indicates right internal mammary artery; LAD, left anterior descending artery; LIMA, left internal mammary artery; RCA, right coronary artery; MICABG, minimally invasive coronary artery bypass graft.

Graft Patency

Forty-six postoperative angiographic studies were done at a mean interval of 2.5 ± 1.5 years (Table 8). Among these patients, there were 9 patients with a dysfunctional LIMA (n = 1), RIMA (n = 7), or BIMA (n = 1). The patency rate of the LIMA was 95.65% (44/46) and it was significantly higher (*P* = .02) than those of the RIMA (80.43%; 37/46). When we compared using the RIMA to the left or right coronary artery system, there was no difference (82.6% versus 78.26%; *P* = .7). Thirteen of 18 patients (72.2%) who underwent beating heart operation in Group B underwent control angiography and the patency rate of RIMA to RCA anastomosis with off-pump technique was 76.9%. The patency rate of RIMA anastomosis with or without off-pump technique was similar (76.9% versus 80%; *P* = s.633). The patency rate of LIMA to LAD anastomosis in Group B was 92.3% and it was higher than those of RIMA, but was not significant (*P* = .27).

Univariate analysis showed that RIMA anastomosis on the left or right coronary artery system (*P* = .94), DM (*P* = .6), hypertension (*P* = .54), hyperlipidemia (*P* = .97), obesity (*P* = .77), incomplete revascularization (*P* = .78), off-pump technique (*P* = .71), perioperative myocardial infarction (*P* = .31), and mediastinitis (*P* = .6) were not statistical predictors of late patency of the RIMA. Only late MI was dependent on the

occluded RIMA anastomosis (P = .052), but it was not significant according to multivariate analysis.

Univariate analysis showed that LIMA anastomosis on the left or right coronary artery system (P = .97), DM (P = .83), hypertension (P = .32), hyperlipidemia (P = .23), obesity (P = .58), incomplete revascularization (P = 0.2), off-pump technique (P = 0.42), perioperative myocardial infarction (P = .76), mediastinitis (P = .83), and late MI (P = .83) were not statistical predictors of late patency of LIMA.

DISCUSSION

The BIMA is becoming increasingly popular because it provides satisfying early and late results [Lytle 2001]. It has been demonstrated in recent studies that the use of the BIMA has better long-term survival and decreased rates of reintervention without increasing the postoperative morbidity and mortality ratios when compared to using only the LIMA [Pick 1997; Endo 2001; Jones 1997; Berreklouw 2001; He 1994; Ioannidis 2001]. Knapic and colleagues [1996] emphasized that although the hospitalization period did not differ, the entubation time was longer for BIMA-operated patients. Taggart [2000] found that the blood gases parameters were similar in patients using the single or bilateral IMA.

The target vessels of the RIMA remain uncertain, whereas the LIMA is generally considered to be the graft of choice for the LAD system. When the RIMA is used in situ, the RCA or circumflex system are the easiest to reach. The long-term results of BIMA-operated patients with the RIMA to the LCA system [He 1994; Ura 2000; Gerola 1996; Buche 1995] or with the RIMA to the RCA system [Fiore 1990] anastomosis have better results than the LIMA-only patients for repetitive angina, MI, PTCA, and reoperation. But the RIMA to the RCA system anastomosis can result in graft failure. Buxton and colleagues [2000] stated that the anastomosis of the RIMA to coronary arteries except the LAD could result in graft failure. Eight-year survival rates of saphenous vein graft for RIMA to RCA anastomosis were found to be similar in patients with double vessels disease (LAD and RCA) when LIMA to LAD anastomosis was standard protocol [Schmidt 199]. Presently, RIMA to the LCA system anastomosis is preferred by most cardiac surgeons because of the better outcome and patency rate [Lytle; 1999; Buxton 2000; Schmidt 1997].

In the present study, early- and mid-term results (total cardiac ischemic events such as relapsing angina, MI, PTCA, reoperation, and death) were comparable with the literature, which was collected and published by Ascione and colleagues [2001]. We performed control angiography for the randomly selected 23 patients (≅50%) in each group 2.3 years after operation. Angiographic results showed that the patency of the RIMA to the right or left coronary artery system was similar (78.26% versus 82.6%; P = .7). But the LIMA had a better patency rate than the RIMA (95.65% versus 80.43%; P = .02). The patency rates of LIMA and RIMA anastomosis on the beating heart were not significantly different, but were better for LIMA (91.7% versus 75%; P = .27); whereas the patency of RIMA anastomosis with or without off-pump technique in the Group B was similar (76.9% versus 80%; P = .84). The patency rate of the RIMA in this study was lower that those published in the literature. We could not identify any risk factor for late occlusion of the RIMA. We can only say that technical problems during harvesting the RIMA and the surgical anatomy of target vessels could affect the patency of the RIMA, because most of these operations were our first experience using the RIMA.

Interestingly, the importance of this study is to show that off-pump techniques does not worsen the quality of RIMA to RCA anastomosis despite not using a stabilizer. The early patency rate (mean, 33 days) of arterial grafts anastomosed with off-pump technique was reported as 99% [Calafiore 1999]. But late patency rate of RIMA to RCA anastomosis on the beating heart has not been evaluated yet. The study demonstrated that 2.5-year patency rate of RIMA to RCA anastomosis on the beating heart was not worse than the conventional technique. The 2.5-year patency rate of RIMA on the beating heart was evaluated in 72% of all patients who underwent off-pump surgery, and it was higher (80%) than those of the conventional technique and lower than those who had the RIMA anastomosed to the LCA system. Also, RIMA to the left side anastomosis had a better 2.5-year patency rate than RIMA to the right side with the conventional technique (82.6% versus 76.9%; P = .66). As we reported previously, the 3-year patency rate for LIMA to LAD anastomosis on the beating heart in patients receiving single IMA was similar to the results of this study [Omeroglu 2000], and it is comparable to those of conventional techniques as reported in the literature [Ascione 2001].

In conclusion, we demonstrated by carefully administered angiographic studies that RIMA to the RCA system anastomosis without use of CPB results are similar to those obtained with CPB. It seems that BIMA to the LCA system anastomosis has better benefits, although the difference is not statistically significant.

REFERENCES

Ascione R, Underwood MJ, Lloyd CT, Jeremy JY, Bryan AJ, Angelini GD. 2001. Clinical and angiographic outcome of different surgical strategies of bilateral internal mammary artery grafting. Ann Thorac Surg 72:959-65.

Ashraf SS, Shaukat N, Akhtar K, et al. 1994. A comparison of early mortality and morbidity after single versus bilateral internal mammary artery grafting with the free right internal mammary artery. Br Heart J 72:321-6.

Berreklouw E, Rademakers PPC, Koster JM, van Leur L, van der Wielen BJW, Westers P. 2001. Better ischemic event-free survival after two internal thoracic artery grafts: 13 years of follow-up. Ann Thorac Surg 72:1535-41.

Buche M, Schroeder E, Chenu P, et al. 1995. Revascularization of the circumflex artery with the pedicled right internal thoracic artery: clinical functional and angiographic midterm results. J Thorac Cardiovasc Surg 110:1338-43.

Buxton BF, Reungsakulrach P, Fuller J, Rosalion A, Reid CM, Tatoulis J. 2000. The right internal thoracic artery graft–benefits of grafting the left coronary system and native vessels with a high grade stenosis. Eur J Cardiothorac Surg 18:255-61.

Calafiore AM, Teodori G, Giammarca GD, et al. 1999. Multiple arterial conduits without cardiopulmonary bypass: early angiographic results. Ann Thorac Surg 67:450-6.

Chow MST, Sim E, Orszulak TA, Schaff HV. 1994. Patency of internal thoracic artery grafts: comparison of right versus left and importance of vessel grafted. Circulation 90(part 2):129-32.

Dewar LRS, Jamieson WRE, Janusz MT, et al. 1995. Unilateral versus bilateral internal mammary revascularization, survival and event-free performance. Circulation 92(Suppl II);8-13.

Dietl CA, Benoit LH, Gilbert CL, et al. 1995. Which is the graft of choice for the right coronary and posterior descending arteries? Comparison of the right internal mammary artery and the right gastroepiploic artery. Circulation 92(Suppl II):92-7.

Endo M, Nishida H, Tomizawa Y, Kasanuki H. 2001. Benefit of bilateral over single internal mammary artery grafts for multiple coronary artery bypass grafting. Circulation 104:2164-70.

Fiore AC, Naunheim KS, Dean P, et al. 1990. Results of internal thoracic artery grafting over 15 years: single versus double grafts. Ann Thorac Surg 49:202-9.

Gerola LR, Puig LB, Moreira LFP, et al. 1996. Right internal thoracic artery through the transverse sinus in myocardial revascularization. Ann Thorac Surg 61:1708-13.

He GW, Ryan WH, Acuff TE, et al. 1994. Risk factors for operative mortality and sternal wound infection in bilateral internal mammary artery grafting. J Thorac Cardiovasc Surg 107:196-202.

Ioannidis JP, Galanos O, Katritsis D, et al. 2001. Early mortality and morbidity of bilateral versus single internal thoracic artery revascularization: propensity and risk modeling. J Am Coll Cardiol 37:521-8.

Jones JW, Schmidt SE, Miller R, Nahas C, Beall AC Jr. 1997. Suitability and durability of multiple internal thoracic artery coronary artery bypasses. Ann Surg 225:785-92.

Kirali K, Daglar B, Güler M, et al. 1999. Experiences of Kosuyolu in minimally invasive coronary artery surgery. Turkish J Thorac Cardiovasc Surg 7:25-9.

Kirali K, Rabus MB, Yakut N, et al. 2002. Early- and long-term comparison of the on- and off-pump bypass surgery in patients with left ventricular dysfunction. Heart Surg Forum 5:177-81.

Knapik P, Spyt TJ, Richardson JB, McLennan I. 1996. Bilateral and unilateral use of internal thoracic artery for myocardial revascularization. Comparison of extubation outcome and duration of hospital stay. Chest 109:1231-3.

Lytle BW, Blackstone EH, Loop FD, et al. 1999. Two internal thoracic artery grafts are better than one. J Thorac Cardiovasc Surg 117:855-72.

Lytle BW, Loop FD. 2001. Superiority of bilateral internal thoracic artery grafting. Circulation 104:2152-4.

Omeroglu SN, Kirali K, Güler M, et al. 2000. Mid-term angiographic assessment of coronary artery bypass grafting without cardiopulmonary bypass. Ann Thorac Surg 70:844-9.

Pick AW, Orszulak TA, Anderson BJ, Schaff HV. 1997. Single versus bilateral internal mammary artery grafts: 10-year outcome analysis. Ann Thorac Surg 64:599-605.

Schmidt SE, Jones JW, Thornby JI, Miller III CC, Beall AC Jr. 1997. Improved survival with multiple left-sided bilateral internal thoracic artery grafts. Ann Thorac Surg 64:9-15.

Taggart DP. 2000. Respiratory dysfunction after cardiac surgery: effects of avoiding cardiopulmonary bypass and the use of bilateral internal mammary arteries. Eur J Cardiothorac Surg 18:31-7.

Tatoulis J, Buxton BF, Fuller JA, Royse AG. 1999. Total arterial coronary revascularization: techniques and results in 3,220 patients. Ann Thorac Surg 68:2093-9.

Toker ME, Kirali K, Guler M, et al. 2000. The use of bilateral internal mammarian artery for coronary artery revascularization: mid-term results. T Klin J Cardiovasc Surg 1:13-8.

Ura M, Sakata R, Nakayama Y, Arai Y, Saito T. 2000. Long-term results of bilateral internal thoracic artery grafting. Ann Thorac Surg 70:1991-6.