

Bilateral internal thoracic artery grafting in diabetic patients: Perioperative risk analysis

Diyabetik hastalarda bilateral internal torasik arter kullanımı: Perioperatif dönem risk değerlendirmesi

Murat Mert, MD, Cihat Bakay, MD, Ihsan Bakır, MD, Alev Arat Özkan, MD*, Barış Ökçün, MD*, Numan Ali Aydemir, MD

Department of Cardiovascular Surgery and *Department of Cardiology, Institute Of Cardiology, Istanbul University, Istanbul, Turkey

ABSTRACT

Objective: Diabetic patients have a higher risk to acquire coronary artery disease at younger ages and vein grafts used in these patients have a tendency to develop stenosis earlier. No significant differences have been reported between the patency of internal thoracic artery (ITA) grafts in diabetic and non-diabetic patients. However, bilateral ITA grafting in diabetic patients remains a controversial topic due to increased risks in the perioperative morbidity.

Methods: The effects of bilateral ITA grafting on perioperative morbidity for diabetic patients were studied in two different trials. The first study compared 25 diabetic patients with 25 non-diabetic patients with bilateral ITA grafts for the length of the intensive care unit and hospital stay periods, for superficial wound infection, sternal dehiscence, mediastinitis rates and readmissions following discharge. The second study compared 30 diabetic patients with bilateral ITA grafts to 30 diabetic patients with unilateral ITA grafts for the same criteria as in the first study.

Results: The first study showed no statistical difference between diabetic and non-diabetic patients for the criteria studied, but a slight increase was clinically observed in the readmission rate for diabetic patients due to superficial wound infection. The second study showed neither statistical, nor clinical differences between the two groups.

Conclusion: Full arterial revascularization is very important for the prognosis of diabetic patients. With a careful management, the slight increase in the perioperative morbidity could be reduced to acceptable levels enabling the diabetic patients to benefit from the long-term advantages of bilateral ITA grafting. (*Anadolu Kardiyol Derg 2004; 4: 290-5*)

Key words: Diabetes, coronary artery bypass graft, internal thoracic artery, superficial wound infection

ÖZET

Amaç: Diyabetik popülasyonun koroner arter hastalığına erken yaşlarda yakalanma riski yüksek olup bu hastalarda kullanılan safen ven greftleri daha erken dönemde tıkanma eğilimi göstermektedirler. Internal torasik arter (ITA) greftlerinin, diyabetik olmayan hastalarla karşılaştırıldığında, diyabetik hastalarda uzun dönem açık kalım oranlarında farklılıklar saptanmamıştır. Ancak, morbidite açısından bir risk oluşturduğu görüşü ile diyabetik hastalarda bilateral İTA grefti kullanılması tartışmalı bir konudur.

Yöntemler: Diyabetik hastalarda bilateral İTA kullanımının cerrahi dönem morbiditesi üzerine etkisi iki ayrı çalışmada incelendi. Birinci çalışmada, bilateral İTA kullanılan 25 diyabetik ve 25 diyabetik olmayan hasta, yoğun bakım ve hastane kalış süreleri, yüzeysel yara enfeksiyonu, sternum dehissensi, mediastinit oluşumu, çıkışı takiben yeniden hastaneye başvurma kriterleri açısından karşılaştırıldı. İkinci çalışmada aynı kriterler sadece bir İTA kullanılan 30 diyabetik hasta ile bilateral İTA kullanılan 30 diyabetik hastanın karşılaştırılmasında kullanıldı.

Bulgular: Birinci çalışma sonuçlarında diyabetik ve diyabetik olmayan hastalar arasında istatistik olarak anlamlı bir farklılık saptanmazken, klinik olarak diyabetik hastaların taburcu olmalarını takiben hastaneye daha sık başvurdıkları gözlemlendi. İkinci çalışmada ise incelenen gruplar arasında klinik ve istatistiksel açıdan farklılık saptanmadı.

Sonuç: Tam arteriyel revaskülarizasyonun sağlanması, diyabetik hastaların uzun dönem prognozu açısından büyük önem taşımaktadır. Dikkatli bir izlem ile, erken dönemdeki morbidite artışı çok düşük seviyelere indirilerek, diyabetik hastaların da bilateral İTA greftlerinin uzun dönem avantajlarından yararlanabilmesi mümkün olmaktadır. (*Anadolu Kardiyol Derg 2004; 290-5*)

Anahtar kelimeler: Diyabet, koroner arter baypas grefti, internal torasik arter, yüzeysel yara enfeksiyonu.

Introduction

The most popular graft used in coronary artery surgery, which is intensively becoming an arterial graft surgery, is still the internal thoracic artery (ITA) with its perfect long-term pa-

tency rates (1,2). The abilities of ITA to possess a functional endothelium (3,4) and to regulate the blood flow according to the myocardial oxygen demand (5) are now considered by every cardiologist and cardiac surgeon. It also has a more compatible diameter with that of the coronary artery, which

prevents turbulent flow at the anastomosis line (6). Following the reports on the long-term benefits of a single ITA usage in coronary artery disease patients (7), interests have been directed towards bilateral usage of ITA at the beginning of last decade. During the first attempts, it was claimed that this procedure resulted in an increased rate of postoperative bleeding and sternal infections; in a prolonged hospital stay (8) and that, it did not contribute positively to the long-term survival when compared to unilateral ITA usage (9). However, bilateral ITA usage and full arterial revascularization by using additional arterial grafts regained popularity in the last years, especially in young patients. Schmidt (10) and Pick (11) reported bilateral ITA grafts and especially left ventricular revascularization with bilateral ITA grafts to be significantly superior in terms of recurrence of angina, new myocardial infarction rate and long-term survival during 10 years follow-up period as compared to unilateral ITA grafting.

Diabetic patients have a tendency to acquire coronary artery disease at younger ages than non-diabetic population (12) and the saphenous vein grafts used in these patients may develop stenosis earlier (2). However, we did not meet any study concerning the early stenosis or occlusion of the ITA grafts rate in diabetic patients when compared to non-diabetic patients. For these reasons, bilateral ITA usage in diabetic patients is of great importance for the long-term prognosis of these patients. Although there are some reports stating that bilateral ITA usage in diabetics results in an increased rate of superficial wound and sternal infections, mediastinitis and prolonged hospital stay (13-15) thus, suggesting avoidance of bilateral ITA usage in these patients (16,17), there are also a lot of surgical teams using bilateral ITA grafts in diabetic patients (18-21). Discussions on this topic are going on.

The effects of bilateral internal thoracic artery grafting on the postoperative morbidity of diabetic patients were studied by two different trials in this manuscript.

Material and Methods

In our institution, since 1990, we have been using bilateral ITA grafts in all diabetic patients under 65 years old with a preoperatively regulated blood glucose level and without any additional risk factor (poor left ventricular function, chronic obstructive pulmonary disease, obesity etc.). Since 1994, we have preferred to revascularize the left ventricle with bilateral ITA grafts in all appropriate cases. Our operational strategy is to revascularize the left anterior descending coronary artery with the right ITA, while the left ITA is grafted to the major obtuse branch of the circumflex coronary artery. Till now, we have used bilateral ITA grafts in approximately 400 diabetic patients in our clinic and we initiated two studies in January 2000 to contribute to the discussions on this topic.

In this study, a patient with a history of regular anti-diabetic medication or with a recorded fasting blood glucose level above 140 mg/dl was considered as a diabetic.

Study-1: This was a prospective study performed between January 2000 and May 2001. In this study, 25 diabetic patients (9 with type 1 and 16 with type 2 diabetes mellitus) (Gro-

up-1), operated in elective conditions with bilateral ITA were compared to 25 non-diabetic patients (Group-2) operated during the same period with bilateral ITA, for the length of intensive care unit and hospital stay, the rate of superficial wound infection, sternal dehiscence, mediastinitis and readmission rates to the hospital for these problems following the hospital discharge. In accordance to the general policy of our clinic on the bilateral ITA usage in diabetics, patients older than 65 years, obese patients, those with a history of chronic obstructive pulmonary disease or previous myocardial infarction and with poor left ventricular ejection fraction (<35 %) were excluded from the study. The mean age of the Group -1 patients was 56.76 ± 8.63 years and 18 of them were male and 7-female. The Group -2 consisted of 5 female and 20 male patients with a mean age of 52.33 ± 10.58 years. As the number of the non-diabetic patients operated during this period was much higher than the diabetic patients with bilateral ITA grafts, the control group was randomized by choosing every first patient operated after the diabetic patient. The same antibiotic agent (2nd generation cephalosporine) was administered to all patients for perioperative prophylaxis. In Group-1 patients, sternum was closed by wires through the intercostal spaces and the subcutaneous tissues were sutured with interrupted simple sutures. In Group-2, the sternum was proximated by wires through the sternum and the subcutaneous tissues were sutured with continuous sutures according with our routine protocol. The skin was closed with continuous subcutaneous sutures in both groups.

Study-2: This was a retrospective study started in accordance to the first study that covered the diabetic and non-diabetic patients in whom bilateral ITA were used. The aim of this second study was to compare diabetic patients in whom bilateral ITA grafts were used with diabetic patients in whom only left ITA was used. Patients were chosen retrospectively, from December 1999 through November 1998, among the first 30 diabetic patients fulfilling the study criteria for each group, without previous history of myocardial infarction and whose ejection fractions were above 35%. Group-1 consisted of 30 diabetic patients (11 with type 1 and 19 with type 2 diabetes mellitus) whose bilateral ITA were used and these patients were compared to Group-2 consisted of 30 diabetic patients (9-type 1 and 21-type 2) whose only left ITA was used, for the length of the intensive care unit and hospital stay, superficial wound infection, sternal dehiscence, mediastinitis and re-admission to the hospital for these problems following discharge. The mean age of the Group 1 patients was 57.13 ± 8.51 years (4 female and 26 male patients), while Group 2 consisted of 8 female and 22 male patients with a mean age of 62.00 ± 8.31 years. The same antibiotic agent (second generation cephalosporine) was administered to the patients in both groups for perioperative prophylaxis. The sternum and the skin were closed according to our routine protocol in patients with single ITA, while sternal wires through the intercostal spaces and simple sutures for subcutaneous tissues were used for patients with bilateral ITA grafts.

The term “superficial wound infection” used in the report means delayed healing of the cutaneous and subcutaneous tissues, dehiscence at the incision line and growth of pathogen microorganisms in the samples taken. The conditions, which made re-fixation of the sternum necessary without any macroscopic and bacteriologic evidence of infection, were referred to as dehiscence while growth of pathogen microorganisms in samples taken from the sternum and the mediastinum was accepted as mediastinitis.

The statistical analysis was done using two-tailed Student’s t test and two-sided Fisher’s exact test and any *p value <0.05 was accepted statistically significant.

Results

The results of both studies are summarized in the Tables 1 and 2.

Study 1 (Diabetic patients with bilateral ITA (Group-1) vs. non-diabetic patients with bilateral ITA (Group-2)): No mortality was observed during the postoperative period and none of the patients required intraaortic balloon pump assistance. The duration of the hospital stay and duration of the intensive care unit stay (Table 1) did not differ significantly between Group 1 and Group 2 (p>0.05). During the postoperative period, 3 patients in Group-1 (12%) had superficial wound infection without sternal involvement (Table 2). Among these patients, one had the infection during his hospital stay while the other two

were readmitted to the hospital within the first month following the discharge (8%). Superficial wound infection was encountered in 2 patients in Group-2 (8%) (p <0.45) . One patient from each group had sternal dehiscence without any evidence of infection). These patients were taken to the operating room for sternum refixation and the samples taken from the mediastinum at the time of the procedure remained sterile. Mediastinitis was not present in any group. As it already was mentioned, 2 patients from Group-1 were readmitted to the hospital within the first month following the discharge for superficial wound infection. One of these patients had a course of antibiotic therapy and surgical debridement of the wound while antibiotic therapy and local wound care were adequate for the other patient. The mean duration of the hospital stay in the readmission period was 3.2 ± 0.85 days. None of the patients in Group 2 were readmitted to the hospital for wound healing problems (p <0.49)

Study 2 (Diabetic patients with bilateral ITA (Group-1) vs. diabetic patients with left ITA only (Group-2). Because the patients involved in the study were chosen according to the date of the operation , two patients in Group-2 who died (one patient died as a result of sepsis and multiorgan failure in the second postoperative month and the other died because of low cardiac output on the 8th postoperative day) were excluded from the study and the following two were included. When the files of the patients operated between 1998 and 2000 were reviewed, the duration of hospital stay for Group 1 and Group 2

Table 1. Hospital and intensive care unit stay periods of patients

	Age, years	Male/Female	ICU stay, days	Hospital stay, days
Study 1				
Diabetics with bilateral ITA	56.76±8.63	18 / 7	2.17 ±0.49	7.42±1.77
Non-diabetics with bilateral ITA	52.33±10.58	20 / 5	2.40±0.74	8.29±3.67
P	NS	NS	NS	NS
Study 2				
Diabetics with bilateral ITA	57.13±8.51	26 / 4	3.04±1.73	10.37±3.68
Diabetics with single ITA	62.0±8.31	22 / 8	3.87±5.84	10.34±6.67
P	NS	NS	NS	NS
p> 0.05 ICU : Intensive care unit, ITA : Internal thoracic artery, NS : Statistically non-significant				

Table 2. Comparison of the perioperative morbidity

	Superficial wound infection, n (%)	Readmission, n (%)	Dehiscence, n (%)	Mediastinitis, n (%)
Study 1				
Diabetics with bilateral ITA	3 (12)	2 (8)	1 (4)	0
Non-diabetics with bilateral ITA	2 (8)	0 (0)	1 (4)	0
P	0.45	0.49	1	1
Study 2				
Diabetics with bilateral ITA	3 (10)	1 (3.3)	1 (3.3)	1 (3.3)
Diabetics with single ITA	2 (6.6)	1 (3.3)	0	0
P	0.4	1	0.2	0.2
ITA : Internal thoracic artery				

were 10.37 ± 3.68 days and 10.34 ± 6.67 days respectively ($p < 0.98$). There was no significant difference in the duration of intensive unit care stay between the two groups ($p < 0.46$) (Table 1). Superficial wound infection was encountered in 3 patients (10%) in Group-1 (Table 2). Two of them had the infection during the early postoperative course while one was readmitted to the hospital within 1 month following discharge. One of the two patients who had the wound infection during the early postoperative course received antibiotic therapy and local wound care while the other patient required surgical debridement of the wound in the operation room. Local wound care and antibiotic therapy were adequate for the patient who was readmitted to the hospital. Superficial wound infection during the early postoperative course was encountered in 2 patients (6.66%) in Group 2. Healing was accomplished by local wound care and antibiotic administration. One patient from this group was readmitted to the hospital for superficial wound infection following discharge (postoperative 22nd day) and was taken to the operation room for surgical debridement of the wound. One patient (3.33%) in Group 1 had sternal dehiscence that required re-fixation while no dehiscence was observed in Group 2. One patient in Group-1 had high fever, dehiscence and coagulase negative *Staphylococcus aureus* isolated from samples taken from drainage tubes on the 8th postoperative day. He was taken to the operation room with the diagnosis of mediastinitis (3.33%). He had subcutaneous, sternal and mediastinal tissue resection. The thorax was irrigated with povidone iodine solution for three days. The patient received antibiotic therapy with vancomycin and netromycin for 3 weeks and was discharged from the hospital on the 34th postoperative day. No evidence of mediastinitis was observed in Group 2 patients.

Discussion

Following the more favorable long-term results of the ITA grafts (1,2), the interest in full arterial revascularization with bilateral ITA and other arterial grafts has increased (10, 11). However, the need for identifying the ideal patient profile for bilateral ITA usage has emerged when claims that bilateral ITA usage significantly increased the postoperative morbidity in some patient groups had been raised (19). A consensus has been constituted that patients under 60 years of age, non-obese, non-diabetic patients without chronic obstructive pulmonary disease and patients who do not have a limited physical activity prior to the operation are suitable for bilateral ITA grafting (13). However, these criteria have been modified by time with the increasing importance of arterial grafts and with a tendency to grant the advantages of bilateral ITA grafts to as much patients as possible. Chronic obstructive pulmonary disease and morbid obesity still constitute contraindications to bilateral ITA usage but the age limit is already reset to seventies and even more (22). On the other hand, diabetic patients are still a matter of discussion. General opinion is that bilateral ITA usage in diabetic patients significantly increases the

morbidity and thus, it should be avoided (15). However, there are also some groups having the opinion that the diabetic patients should also benefit from the favorable long-term advantages of bilateral ITA usage (20,21).

It is known that diabetic patients have more problems with postoperative wound healing compared to the normal population and they are more susceptible to infections due to the defects in their cellular and humoral immune systems (16). Diabetic patients and the patients whose bilateral ITA were used as a coronary artery bypass graft constitute the highest risk groups for problems confined to the surgical incision line, generally named as sternal infection (16). Diminished sternal blood supply caused by bilateral ITA usage prepares appropriate conditions for sternal infection in diabetic patients who already have deficiencies in wound healing process. According to different series, sternal infection is seen in 9.3% to 14% of diabetic patients whose bilateral ITA were used (13,16) and this is almost twice the amount seen in diabetics whose only the left ITA was used (23). Majority of the clinics claim bilateral ITA usage in diabetic patients (16) for the prolonged intensive care unit and hospital stay periods and related increase in morbidity (11) due to the problems confined to the incision line. However, as we mentioned early the point that the diabetic patients acquire coronary artery disease earlier than the non-diabetic population makes extensive arterial graft usage very important when the long-term prognosis of these patients is concerned. For these reasons, some clinics, while accepting a prominent increase in postoperative superficial wound infections compared to the non-diabetic population, defend that the diabetic patients should also benefit from the long-term advantages of bilateral ITA usage if there are no any additional risk factors (25,26).

In our clinic where bilateral ITA are used in diabetic patients, maximum care is taken to use low-voltage cautery and to clip the side branches as proximal as possible to avoid impairment of blood supply to the thorax when harvesting the internal thoracic artery graft. We think that this harvest technique also called skeletonized ITA harvesting (27,28) plays a major role in the uneventful postoperative period of the diabetic patients. Meticulous hemostasis should be carried out and the sternum should be closed with wires through the intercostal spaces in order not to damage the sternal integrity and blood supply. We prefer to close the subcutaneous tissues with interrupted simple sutures to avoid tissue necrosis and special attention should be paid to wound care to minimize the possible complications that can be encountered in diabetic patients (13,29).

We have been using bilateral ITA grafts for several years in diabetic patients if there is no other coexisting risk factor and if the patient's blood glucose could be regulated before the operation. We believe that close monitoring and aggressive regulation of the blood glucose levels, even with continuous insulin infusion, is of paramount importance to minimize the complications during the perioperative period. With the application of these measures mentioned above, the differen-

ce in morbidity between the diabetic and non-diabetic patients has decreased prominently in our clinic and these results are in accordance with recent reports on use of bilateral ITA grafts in diabetic patients (26-28). We think that meticulous hemostasis as well as putting the sternum wires through the intercostal spaces are very important tools to protect the sternal integrity which already has an impaired blood supply after both ITA were harvested. We also think that continuous sutures in subcutaneous tissue, with its stretching effect, will lead to a predisposition for tissue necrosis, and thus to wound infection in diabetic patients. We therefore use interrupted simple sutures for the subcutaneous tissue in diabetic patients who have bilateral ITA grafts. Incision care has a special importance in these patients. Wound dressings are changed twice a day and samples are taken from any abnormal discharge in the incision line in order to administer the appropriate antibiotics as early as possible. We did not observe any difference in the length of intensive care unit and hospital stays, dehiscence and mediastinitis rates between diabetic and non-diabetic patients in whom bilateral ITA were used. Though not statistically significant, it was clinically observed that diabetic patients with bilateral ITA grafts carried a slightly higher risk of superficial wound infection in the early-term following discharge compared to non-diabetic patients, which required a short re-hospitalization period. We also think that the interpretation of the results obtained from the second study is much more interesting. It can be interpreted that the risk for increased wound infection in diabetic patients is already taken with a single ITA usage alone and addition of a second one did not carry any additional risk. It is open to discussion whether the number of patients in our series is adequate for a healthy interpretation of the results or not, but one must appreciate the difficulty to obtain large series of bilateral ITA usage in diabetics, because there are often co existing risk factors precluding bilateral ITA harvesting in these patients, like obesity, limited physical activity, pulmonary insufficiency, renal failure and poor coronary quality.

As a result, full arterial revascularization has a great importance for the long-term prognosis of diabetic patients because they may acquire coronary artery disease at younger ages than non-diabetic patients and saphenous vein grafts may develop stenosis earlier compared to normal population. Bilateral ITA usage in diabetic patients is still opened to discussion problem and we believe that these two studies will contribute to the discussions on this topic. Depending on the results of our study, there is not a significant difference in morbidity between the diabetic patients, whose unilateral and bilateral ITA were used and there was no any statistically significant difference between diabetic and non-diabetic patients, whose bilateral ITA were used. We, therefore, believe that diabetic patients should benefit from favorable long-term advantages of bilateral ITA usage with some special measures taken perioperatively, because some problems on the incision line may occur in the early-term following discharge.

References

1. Loop FD, Lytle BW, Cosgrove DM, et al. Influence of the internal mammary artery graft on 10-year survival and other cardiac events. *N Engl J Med* 1986;314:1-6.
2. Lytle BW, Loop FD, Cosgrove DM, Ratliff NB, Easley K, Taylor PC. Long-term (5 to 12 years) serial studies of internal mammary artery and saphenous vein coronary artery bypass grafts. *J Thorac Cardiovasc Surg* 1985;89:248-58.
3. Luscher TF, Diederich D, Siebenmann R, et al. Difference between endothelium-dependent relaxation in arterial and in venous coronary bypass grafts. *N Engl J Med* 1988;319:462-7.
4. Furchgott RF, Cherry PD, Zawadzki JY, Jothianandan D. Endothelial cells as mediators of vasodilation of arteries. *J Cardiovasc Pharmacol* 1984;6(Suppl): S336-43.
5. Pearson PJ, Evora PRB, Schaff HV. Bioassay of EDRF of the internal mammary arteries: implications for early and late bypass graft patency. *Ann Thorac Surg* 1992;54:1078-82.
6. Drexler H, Zeiher AM, Wollschlager H, Meinertz T, Just H. Flow-dependent coronary artery dilation in humans. *Circulation* 1989;80:466-74.
7. Loop FD, Lytle BW, Cosgrove DM. New arteries for old. *Circulation* 1989;79(Suppl):40-5.
8. Cosgrove DM, Lytle BW, Loop FD, et al. Does bilateral mammary artery grafting increase surgical risk? *J Thorac Cardiovasc Surg* 1988;95:850-6.
9. Lytle BW, Blackstone EH, Floyd D, et al. Two internal thoracic artery grafts are better than one graft. *J Thorac Cardiovasc Surg* 1999; 117: 855-72.
10. Schmidt SE, Jones JY, Thornby JI, Miller CC, Beall AC. Improved survival with multiple left-sided bilateral internal thoracic artery grafts. *Ann Thorac Surg* 1997;64:9-15.
11. Pick AW, Orszulak TA, Anderson BJ, Schaff HY. Single versus bilateral internal mammary artery grafts: 10-year outcome analysis. *Ann Thorac Surg* 1997;64:599-605.
12. Schumacher MC, Hunt SC, Williams RR. Interactions between diabetes and family history of coronary artery disease and other risk factors for coronary heart disease among adults with diabetes in Utah. *Epidemiology* 1990;4:298-304.
13. Accola KD, Jones EL, Craver JM, Weintraub WS, Guyton RA. Bilateral mammary artery grafting avoidance of complications with extended use. *Ann Thorac Surg* 1993;56:872-9.
14. Hazelrig SD, Wellons HA, Schneider JA, Kolm P. Wound complications after median sternotomy, relationship to internal mammary artery grafting. *J Thorac Cardiovasc Surg* 1989;98:1096-9.
15. Tavalacci MP, Merle V, Josset V, et al. Mediastinitis after coronary artery bypass graft surgery. Influence of the mammary grafting for diabetic patients. *J Hosp Infect* 2003;55:21-5.
16. Borger MA, Rao V, Weisel RD, et al. Deep sternal wound infection: Factors and outcomes. *Ann Thorac Surg* 1998;65:1050-6.
17. Suma H, Amano A, Fukuda S, et al. Gastroepiploic artery graft for anterior descending coronary artery bypass. *Ann Thorac Surg* 1994;57:925-7.
18. Gerola LR, Puig LB, Moreira LF, et al. Right internal thoracic artery through the transverse sinus in myocardial revascularization. *Ann Thorac Surg* 1996;61:1708-13.
19. Lytle BW, Cosgrove DM, Loop FD, Borsh J, Goormastic M, Taylor PC. Perioperative risk of bilateral internal mammary artery grafting: analysis of 500 cases from 1971 to 1984. *Circulation* 1986;74(Suppl):37-41.

20. Yamamoto T, Hosoda Y, Takazawa K, Hayashi I, Miyagawa H, Sasa S. Is diabetes mellitus a major risk factor in coronary artery bypass grafting? The influence of internal thoracic artery grafting on late survival in diabetic patients. *Jpn J Thorac Cardiovasc Surg* 2000;48:344-52.
21. Hirofani T, Nakamichi T, Munakata M, Takeuchi S. Risks and benefits of bilateral internal thoracic artery grafting in diabetic patients. *Ann Thorac Surg* 2003;76:2017-22.
22. Barner HB, Standeven JW, Reese J. Twelve-year experience with internal mammary artery for coronary artery bypass. *J Thorac Cardiovasc Surg* 1985;90:668-75.
23. Kalush SI, Cherukuri RB, Teller D, Watson C, Murphy B, Shaheen S. Bilateral mammary artery bypass and sternal dehiscence. A favorable outcome. *Am Surg* 1990;56:487-93.
24. Galbut DL, Traad EA, Dorman MJ, et al. Coronary artery bypass grafting in the elderly, single versus bilateral internal mammary artery grafts. *J Thorac Cardiovasc Surg* 1993;106:128-36.
25. He GW, Acuff TE, Ryan WH, Bowman RT, Douthit MB, Mack MJ. Determinants of operative mortality in elderly patients undergoing coronary artery bypass grafting. Emphasis on the influence of internal mammary artery grafting on mortality and morbidity. *J Thorac Cardiovasc Surg* 1994;108:73-81.
26. Lev-Ran O, Mohr R, Pevni D, et al. Bilateral internal thoracic artery grafting in diabetic patients. Short-term and long-term results of a 515-patient series. *J Thorac Cardiovasc Surg* 2004;127:1145-50.
27. Matsa M, Paz Y, Gurevitch J, et al. Bilateral skeletonized internal thoracic artery grafts in patients with diabetes mellitus. *J Thorac Cardiovasc Surg* 2001;121:668-74.
28. Lev-Ran O, Mohr R, Amir K, et al. Bilateral internal thoracic artery grafting in insulin-treated diabetics: should it be avoided. *Ann Thorac Surg* 2003;75:1872-7.
29. Tatoulis J, Buxton B, Fuller JA. Results of 1454 free right internal thoracic artery-to-coronary artery grafts. *Ann Thorac Surg* 1997;64:1263-9.