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Sequential Use of Internal Thoracic Artery in Myocardial Revascularization:
Mid- to Long-term Results of 430 Patients

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MYOKARDİYAL REVASKÜLARİZASYONDA İNTERNAL TORASİK ARTERİN SEQUENTİAL KULLANIMI: 430 Hastanın Orta ve Uzun Dönem Sonuçları

ÖZET

İnternal torasik arterin sequential kullanımının koroner arter bypass (KAB) operasyonlarının erken ve geç dönem sonuçlarına etkisi halen tartışmalıdır.

1986-1998 yılları arasında KAB operasyonu yapılan ve operasyonlarında en az bir sequential ITA grefti kullanılan 430 ardışık hasta çalışmaya alındı. Hastaların 379'u erkek, 51'i kadındı ve yaş ortalamaları 56,4 yıl (29-80 yıl arasında) idi. Hastaların 227'sinde (%52,8) her iki İTA grefti de kullanıldı. Hastalara total 1744 (hasta başına ortalama 4,05) distal koroner anastomoz yapıldı. Bunların 1172'si (ortalama 2,72) arteryel greftler kullanılarak oluşturuldu. Arteryel anastomozların içinde ise 980'i (ortalama 2,28) internal torasik arterin sequential olarak kullanılması ile yapıldı

Hastaların 8'i (%1,8) postoperatif erken dönemde kaybedildi. Oniki hastada (%2,8) perioperatif miyokard infarktüsü gelişti. Bunların 5'i (%1,2) İTA'in sequential olarak kullanıldığı bölge ile uyumluydu. Hastaların 372'si (%86,5) 1 ay ile 13 yıl arasında (ortalama 63 ± 37,7 ay) takip edildi. Takip süresi boyunca 9 hasta kaybedildi. Kaplan - Meier metoduna göre 5 ve 10 yıllık aktüel yaşam oranları, sırasıyla %95,6 ve %93,4 idi. Ortalama 33 ay sonra (10 gün - 10 yıl) 31' i anjinal semptomları nedeniyle olmak üzere, 64 hastaya (%17,2) koroner anjiyografi yapıldı. Sequential ITA anastomozlarının toplam açıklık oranı %91,7 (111/121) idi. Takip edilen hastaların 2'sine reoperasyon uygulandı.

Sonuç olarak KAB operasyonlarında İTA'in sequential kullanımı perioperatif mortalite ve morbiditeyi artırmamıştır. Sequential İTA anastomozlarının açıklık oranının çok iyi olması, bu prosedürün, KAB operasyonlarının geç dönem sonuçlarını düzeltici potansiyeli olduğunu düşündürmektedir. ***Türk Kardiyol Dern Arş 2001; 29: 747-755***

Anahtar kelimeler: *İnternal torasik arter, internal mammaryan arter, sequential anastomoz, miyokardiyal revaskülarizasyon*

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It has been generally accepted that the internal thoracic artery (ITA) graft is the best conduit for coronary artery bypass (CAB) surgery because of its superior long term patency rate [1-3]. Accelerated degenerative atherosclerosis is the main factor for late failure of venous grafts [4], but progressive atherosclerosis of the ITA has not been documented yet.

Although there is not much convincing clinical data about improved survival with the use of ITA grafts extensively, several authors showed recently that the extensive use of ITAs further decrease recurrence of angina and reoperations [5-8]. Although technically more demanding sequential use of the ITA for two or more coronary anastomoses have been an attractive method. Since the increased number of arterial anastomoses can be accomplished without an additional conduit and an additional incision, even in the high risk patients for bilateral ITA grafting.

There is still controversy about these questions: Can sequential use of ITA properly meet nutritional demands of the ischemic myocardium in early postoperative period; does the risk of the operation increase and what is the long-term success of the operation?

In this study, we report on a series of 430 consecutive patients who had undergone coronary bypass operation with the use of at least one sequential ITA graft.

The aim of this study is to describe the operative results as well as the mid and the long term angiographic results and clinical outcomes and to identify the risk factors that influence early and late results.

MATERIAL and METHODS

Patient Population:

Between 1986 and 1998, 430 consecutive patients had at least one sequential ITA graft in their CAB operations.

The patients were 379 men (88,1%) and 51 women (11,9%). Their ages ranged from 29 to 80 years (mean age, 56,4). Eighty-nine patients (20,7%) were older than 65 years. Criteria to make sequential ITA anastomoses except the surgeon's preference were appropriate ITA conduit and flow, coronary anatomy necessitating multiple anastomoses and absence of transmural myocardial infarction in the target area. Age had not been accepted as a criterion. Patient characteristics are presented in table 1. Angina pectoris was classified according to the Canadian Cardiovascular Society System. Complete arterial revascularization was performed in 103 patients (23,9%), while the others had additional saphenous vein grafts. Both ITA grafts were used in 227 patients (52,8%). In 5 of the cases a special method, "combined ITA" was employed in the early period of our experience [9]. Combined ITA graft was created by end-to-end anastomosis of left (insitu) and right (free) ITA's with the interposition of small piece of vein. A third arterial graft (right gastroepiploic artery in 13; Inferior epigastric artery in 4 and radial artery in 2) was used in 19 (4,4%) patients.

Operative Technique:

After standard median sternotomy, one or both ITA's were harvested from the chest wall, from the superficial epigastric branches to the level of the subclavian vein, with electrocautery and hemoclips on the arterial side. After systemic heparinization the ITA was transected distally and wrapped in a warm sponge irrigated with papaverine. Cardiopulmonary bypass (CPB) was conducted under moderate hypothermia (28° to 32°) with antegrade cristalloid cardioplegia in the former years and antegrade and/or retrograde blood cardioplegia recently. Two ml of a diluted solution of papaverine (0,05 g./ 2ml) were gently injected into the ITA at the onset of CPB by using 24 G intravenous cannula, mainly to dilate the ITA and to facilitate the making of side-to-side anastomoses. Distal anastomoses were performed during a single period of aortic occlusion with a running 7-0 and especially for diamond shaped anastomosis 8-0 polypropylene suture, generally starting from the posterior wall. Magnification of 3,5X and 4,5X was used. Proximal side-to-side anastomoses was performed firstly for anterior wall and right coronary artery anastomoses. Whereas for lateral wall revascularization distal end to side anastomoses were performed before proximal anastomoses to arrange the length of the ITA graft. We created longitudial or 45- to 90-degree diamond shaped side-to-side anastomoses, according to pedicle routing and coronary anatomy. The ITA pedicle was fixed to the epicardial surface with multiple sutures of 5/0 polypropylene suture to avoid traction or angulation. During the rewarming period the proximal anastomoses of additional vein grafts were made. At the end of CPB a piece of surgicel* irrigated with diluted papaverine was layed on ITA graft to avoid graft spasm. In 31 (7,2%) patients ITA grafts were used as a free graft and in 9 (2,1%) of the patients, right ITA was used through transvers sinus to revascularize the lateral wall. In 26 patients (6,0%) a left ventricular aneurysm was resected. Carotis endarterectomy was performed in 5 patients (1,2%). Aortic valve, mitral valve replacement and bilateral femoropopliteal bypass were made in 3 patients, respectively.

Surgicel: Ethicon 1903GB, manufacturer J & J Belgium

Table 1. Preoperative patients characteristics

	No	%
Diabetes mellitus	90	20,9
Hypertension	172	40
Smoking	284	66
Hypercholesterolemia	149	34,6
Previous MI	209	48,6
LV function:		
EF > 50 %	306	71
EF 50 % - 30 %	81	19
EF <.30 %	43	10
Single vessel disease	29	6,7
Two vessel disease	102	23,7
Three vessel disease	299	69,5
Prior CABG	5	1,2
CCS class III and IV	337	78,4
≥ 65 years	89	20,7

(MI: Myocardial infarction; LV: left ventricle; EF: Ejection fraction; CABG: Coronary artery bypass grafting; CCS: Canadian Cardiovascular Society)

A total of 1744 (mean 4,05 per patient) distal coronary anastomoses were performed. 1172 of which (mean 2,72 per patient) were arterial and 980 of which (mean 2,28 per patient) were sequential ITA anastomoses. Other 572 anastomoses (mean 1,33 per patient) were constructed with saphenous vein grafts. The number and types of arterial anastomoses are presented in table 2.

Postoperative Follow-up:

Clinical data were abstracted from patients' hospital records, and follow-up information was collected in two ye-

Table 2. Number and Types of Arterial Anastomoses:

	No	%
2 LITA	185	43
3 LITA	15	3,5
4 LITA	1	0,2
3 BITA	176	40,9
4 BITA	28	6,5
5 BITA	1	0,2
2 LITA + 2 TAC	1	0,2
3 BITA + 2 TAC	2	0,4
3 BITA + 1 TAC	9	2
4 BITA + 1 TAC	5	1,2
5 BITA + 1 TAC	1	0,2
6 BITA + 1 TAC	1	0,2
CITA	5	1,2
Total	**430**	

(LITA: Left internal thoracic artery; BITA: Bilateral internal thoracic artery; TAC: Third arterial conduit (right gastroepiploic artery, inferior epigastric artery or radial artery); CITA: Combined internal thoracic artery)

ars period. All patients were invited to the hospital to evaluate their clinical status. Data collection was also completed from the patients' most recent clinical visits, home visits, telephone interviews and the letters containing a comprehensive form to assess their functional capacity in patients who live outside of the city.

Postoperative stress tests were obtained in 283 (76%). Elective angiography was performed in 63 (16,9%) patients. In 31 of these patients angiography was performed due to the return of symptoms. The other patients were willing to undergo this procedure after giving informed consent. Patency failure was defined as anastomotic occlusion or stenosis of the recipient vessel or ITA of 50% or more.

Statistical Analysis:

The possible influence of the following factors on early and late mortality, perioperative myocardial infarction, mediastinitis and sternal morbidity (including mediastinitis, sternal dehiscence and sternal wound infection) were analyzed: Age, sex, diabetes mellitus, hypertension, smoking, hypercholesterolemia, left ventricular function, bilateral ITA usage, the number of arterial anastomoses, the number of coronary anastomoses, associated procedures, preoperative angina class and the number of diseased vessels preoperatively (Table 3). Chi-square test was used for statistical calculations. When the sample was not large and the expected values were less than 5, Fischer' s exact probability test was used. Survival curves were estimated with the Kaplan-Meier method. In all statistical tests, a p value less than 0,05 was considered to be statistically significant. All computations were performed using SPSS (Statistical Package for Social Science) version 7,5 for windows in IBM compatible computer.

RESULTS

In- Hospital Complications:

Of the 430 patients, 8 died before discharge or within 30 days of operation, corresponding to an early mortality rate of 1,8%. Two patients with preoperative severe left ventricular dysfunction, one of whom had preoperative intraaortic balloon pump support, died of low cardiac output. Another patient had a large left ventricular aneurysmectomy and mitral valve replacement. One patient died of extensive anterior myocardial infarction that developed at the 12th postoperative hour. Severe distal spasm of right internal thoracic artery to left anterior descending artery (LAD) bypass was observed in prompt reoperation. Although a saphenous vein bypass was performed to distal LAD, the patient couldn't wean from CPB. Three patients who had moderate to severe preoperative impairment of renal and/or pulmonary function died of multiorgan failure caused by long duration of intubation, renal failure and secondary sepsis. One patient who had bilateral ITA graft died of mediastinitis. The last patient suffered a stroke on the second postoperative day and died on 25th postoperative day.

Perioperative myocardial infarction was detected in 12 patients (2,8%) according to elevated levels of cardiac enzymes and new Q wave on electrocardiography. Eight infarctions (1,9%) were related to the arterial anastomoses area and 5 of them (1,2%) were related to the sequential ITA- grafted area. Other postoperative complications are presented in table 4.

Early postoperative mortality was higher in patients with 3 vessel disease ($p<0,05$). Occurrence of perioperative myocardial infarction were not statistically correlated any of the parameters. Sternal morbidity was higher in diabetic patients than nondiabetics ($p<0,05$). Bilateral ITA usage in diabetic patients also increased sternal morbidity significantly ($p<0,05$). Mediastinitis was higher in patients with bilateral ITA graft (3/227 versus 0/200; p= not significant) and diabetes (2/88 versus 1/339; p= not significant), but bilateral ITA usage in diabetic patients was significantly corraleted with the occurrence of mediastinitis (2/25 versus 1/402 ; p= 0.001).

Follow-up:

Follow-up ranged from 1 month to 13 years (mean 63 ± 37,7 months) for 372 patients (86,5%). Nine patients died during follow-up. Two of whom died of ventricular fibrillation secondary to myocardial infarction, 2nd and 6th postoperative years, respectively. The first one who had normal right coronary artery at the time of the operation suffered from inferior and right ventricle myocardial infarction and the other one had ventricular fibrillation at admission to emergency service. This patient did not respond to resuscitative efforts and died. Three patients suffered from sudden death in the 6th postoperative month, and the 9th and 12th years, respectively. All of them were men and had bilateral ITA grafts. Two patients died of malignancy on the 3th and 5th postoperative years, respectively. The last two patients died of stroke and gastrointestinal bleeding in the second postoperative month and the 4th year, respectively. Statistical analysis demonstrated that none of the variables corralated with late mortality (Table 3).

Table 3. Preoperative and intraoperative variables for statistical analysis:

Variable	No. of patients	Early mortality (n)	Perioperative MI (n)	Sternal morbidity (n)	Mediastinitis (n)	No. of followed patients	Late mortality (n)
Age							
≥ 65	89	2	4	5	1	71	4
< 65	341	6	8	12	2	301	5
LV function							
≥ 50	292	5	7	13	3	260	7
0.30 - 0.49	91	1	5	3	0	75	2
< 30	47	2	0	1	0	37	0
BITA							
Yes	230	3	7	9	3	195	7
No	200	5	5	8	0	177	2
No. of arterial anastomoses							
2	186	4	5	7	0	174	2
3	191	4	5	8	3	154	5
4	42	0	2	2	0	36	2
≥ 5	11	0	0	0	0	8	0
Coronary artery disease							
One vessel	29	0	2	2	0	22	0
Two vessel	102	0	3	3	0	99	3
Three vessel	299	8*	7	12	3	251	6
Sex							
Male	379	14	10	14	3	329	7
Female	51	3	2	3	0	43	2
Diabetes							
Yes	90	4	2	8*	2	75	2
No	340	4	10	9	1	297	7
Hypertension							
Yes	172	5	5	10	2	153	6
No	258	3	7	7	1	219	3
Smoking							
Yes	284	7	8	11	3	230	4
No	146	1	4	6	0	142	5
Hyperlipidemia							
Yes	149	3	6	4	1	123	3
No	281	5	6	13	2	249	6
Associated procedure							
Yes	33	1	0	1	0	23	0
No	397	7	12	16	3	349	9
BITA and Diabetes							
Yes	27	1	1	4*	2*	18	0
No	403	7	11	13	1	354	9

*(BITA: Bilateral ITA; MI: myocardial infarction; LV: left ventricle; *: p< 0.05)*

According to Kaplan Meier method 5 and 10 year actuarial survival (including in-hospital death) was 95,6% and 93,4% respectively (Fig 1).

Of the 372 survivors followed-up, 325 (87,4%) were free of angina, 31 (8,3%) were complaining of exertional angina (class I). Five patients (1,3%) were complaining of angina with ordinary activities (class II) and 2 patients (0,5%) were complaining of angina at rest (class III).

Control exercise test were performed in 283 patients (76%) after an average of 24 months (range 1 month to 12 years). Myocardial ischemia was detected in

Table 4. Postoperative Complications:

	No	%
Perioperative myocardial infarction	12	2,8
Use of IABP	11	2,6
Sternal Morbidity :	17	3,9
Mediastinitis	3	0,7
Dehiscence	5	1,2
Sternal wound infection	9	2,0
Bleeding requiring exploration	8	1,8
Pleural effusion	9	2,0
Stroke	3	0,7
Peritoneal dialysis	8	33
Gastro intestinal bleeding	4	0.9
Diaphragm paralizis	31	7.2
Atrial fibrillation	42	9.7
Ventricular arrhythmias (requiring medical therapy)	21	4.8

(IABP: Intra aortic balloon pump)

21 patients (7,4%). Sixteen of whom had undergone coronary angiography. The other 5 patients received medical therapy at the completion of the study.

Coronary angiography was performed in 64 patients (17,2%) after a mean of 33 months (range 10 days to 10 years) (Fig 2 and 3). In 31 of these patients, angiography was performed due to return of symptoms or positive exercise test but in the other group for study reasons only. Except combined ITA anastomoses, overall patency rate of sequential ITA anastomoses was 91,7% (111/121). Overall patency rate of other arterial grafts (non-sequential ITA, rGEA and IEA) was 94,7% (18/19). Nine patients had failure of sequential ITA anastomoses. Of the 5 patients who had left ITA to diagonal and LAD bypasses, diagonal artery anastomosis was occluded in 2. Both diagonal coronary arteries had a small diameter (1,00 and 1,25) and had some atherosclerotic changes at the anastomosis area. These failures at a side-to-side anastomosis did not impede the flow of the conduit to the distal anastomoses. LAD anastomosis was occluded in 2 patients and both diagonal and LAD anastomoses were occluded in 1 patient. The quality of the vessels was poor in these patients and two of them had diabetes. Inadequate filling in LAD anastomosis was detected in 1 patient because of competition (native LAD stenosis 50%). Occluded obtuse marginal (OM) anastomosis was detected in one patient who had left ITA to diagonal and OM anastomoses. Occlusion of distal OM anastomosis was seen in a male patient with diabetes and poor vessel quality. Filling in distal OM anastomosis was poor in one patient because of competition (native OM2 stenosis 50%). In the last patient who had free ITA to anterolateral (AL) and OM artery, occlusion was detected at the level of proximal aortic anastomosis. Retrograde filling of both anastomoses from AL anastomosis was observed (native AL stenosis 50%). Patency rate and types of anastomoses are presented in table 5.

One patient with occluded diagonal and LAD anastomoses underwent repeat coronary artery bypass

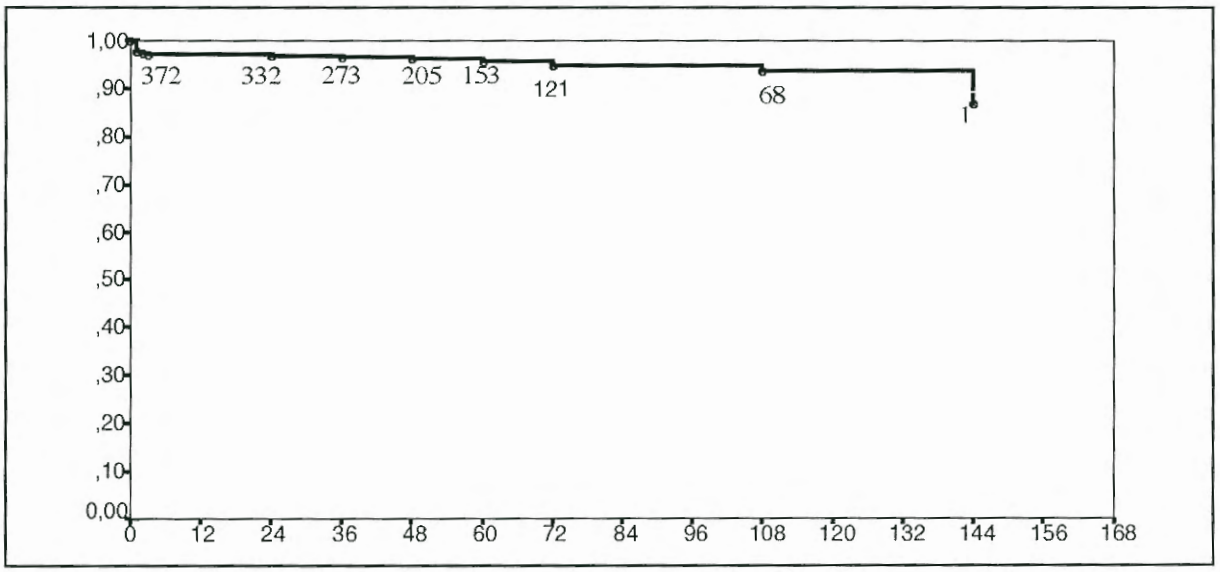

Figure 1. Actuarial survival curve of the patients:

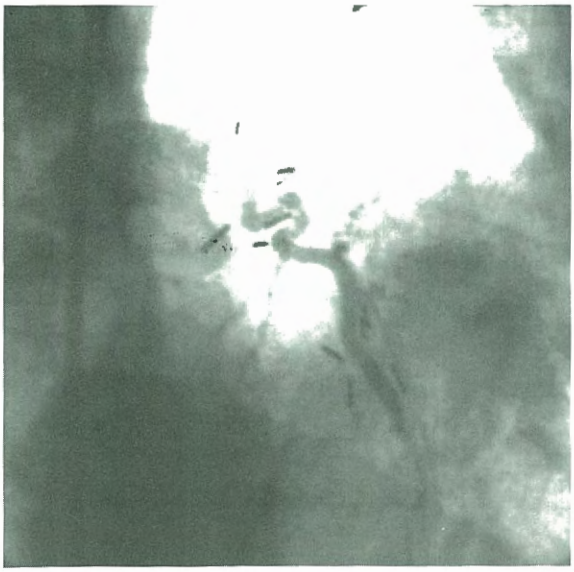

Figure 2. Diagonal and LAD sequential left ITA anastomoses in 10th year after the operation.

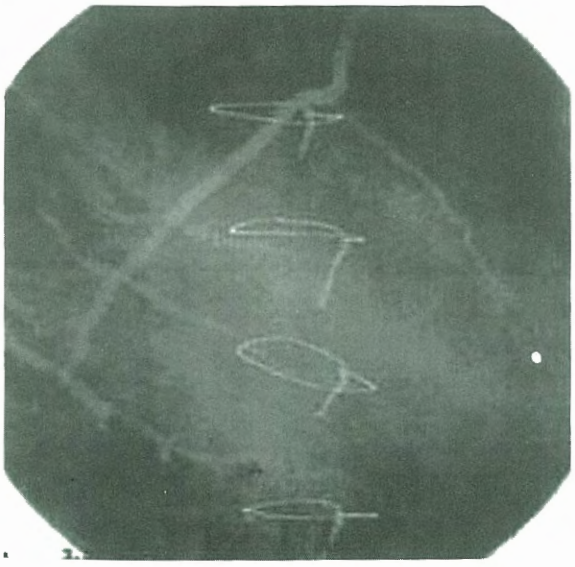

Figure 3. Diagonal - Obtuse marginal 1 - Obtuse marginal 2 - Posterolateral circumflex artery sequential left ITA anastomoses in 10th day after the operation

grafting in the second postoperative year. Seven patients underwent percutaneous transluminal coronary angioplasty because of progression of native vessel stenosis or occlusion of saphenous vein grafts. The other patients with angina or angiographic problems were receiving medical therapy at the completion of this study.

Combined ITA grafting procedure was performed in only 5 patients in 1989 with no mortality and morbidity. Postoperative coronary angiography performed to all patients 2 days before discharge (mean 10 days postoperatively) revealed that all 20 sequential anastomoses with combined ITA grafts were patent (Table 6). Late follow-up was obtained in 4 patients. In one patient all 4 anastomoses were patent in 7th postoperative year control angiography. In one patient who had 6 anastomoses, there was an occlusion before the first anastomosis on the combined ITA graft in 6th postoperative year angiography. Retrograde filling of all anastomosis from right coronary artery was observed. In the other patient who refused coronary angiography, there was no ischemia on thallium scintigraphy in the 7th postoperative year. The last patient who lives outside the city, said that he had no anginal symptoms on telephone interview in 7th postoperative year. The patient with occluded combined ITA graft was reoperated. Free IEA graft bypass was employed from the aorta to the combined ITA graft on the distal to the occlusion. Control angiography two years after reoperation revealed the patency of all anastomoses.

DISCUSSION

The superior performance of the ITA is due to its relative resistance to atherosclerosis [10], considered to be related to its high capacity for prostacyclin synthesis [11], and the integrity of its elastic lamina [12]. Also, the enhanced production of nitric oxide from the ITA endothelium may account for improved patency of the ITA graft [13]. Besides, ITAs have other advantages including ideal coronary-to-conduit size match, the capacity for flow regulation in response to varying myocardial demand [14] and no need for additional incision for harvesting.

The first reports on the use of ITA as a sequential graft appeared in 1983 because of insufficiency of venous grafts and aortic wall disease [15]. Additional reports described the technique and excellent results obtained [16].

In our clinic, we have used sequential ITA grafting since 1986 in increasing number of CAB operations. Sequential use of ITA grafting which was 15,3% before 1995, increased to 40,8% afterwards, in our practice. This series is one of the largest series in the world literature. The surgical mortality of this series (1,8%) includes only 3 (0,7%) cardiac related death and among those only one (0,2%) died as a result of

Table 5. Patency and Types of Sequential ITA Anastomoses on coronary angiographies

Conduit	Type of anastomosis	No. of patients	No. of anastomosis	Site of occlusion (n=)		Patency (%)
LITA	D - LAD	33	66	3	3	90,9
LITA	D - OM	7	14	-	1	92,8
LITA	OM_1-OM_2	9	18	-	1	94,4
LITA	LADp-d	3	6	-	-	100
LITA	D_1-D_2-LAD	1	3	-	-	100
LITA	D-OM_1-OM_2-Plcx	1	4	-	-	100
RITA	LADp-d	4	8	-	-	100
RITA (free)	AL-OM	1	2	1	1	0
Total		**59**	**121**	**4**	**6**	**91,7**

(AL: Anterolateral artery; d: distal; D: diagonal artery; LAD: left anterior descending artery; LITA: left internal thoracic artery; OM: obtuse marginal artery; p: proximal; Plcx: Posterolateral circumflex artery; RITA: Right internal thoracic artery)

Table 6. Types of combined ITA anastomoses:

Distribution	No. of patients
LAD-D1-D2-OM-PLRCA-RCA	1
LAD-Dx-OM-PLCX	2
LAD-Dx-PLCX-RDP	1
LAD-PLCX	1

(LAD: Left anterior descending artery; D1-2, Dx: Diagonal artery 1 or 2) PLRCA: Posterolateral right coronary artery; RCA: Right coronary artery; OM: Obtuse marginal branche. RDP: Right descending posterior artery; RCA: Right coronary artery; PLCX: Posterolateral circumflex artery)

failure of the arterial anastomosis. This mortality rate is comparable with mortalities reported for CAB either with sequential or nonsequential ITA grafts [5-7,17].

Incidence of perioperative myocardial infarction varies from 0,7% to 3,4% in similar series [8,17]. In our series, in 5 of the 12 patients who had perioperative myocardial infarction (2,8%), infarction was confined to the sequential ITA grafted area (1,2%). Statistical analysis showed no correlation between number of arterial anastomoses and occurrence of perioperative myocardial infarction and early mortality. These results suggest that sequential ITA grafts can properly nourish ischemic myocardium in early postoperative period. Except for these indirect findings, we also saw a dramatically substantial increase in ITA graft size (up to 5 mm.) in all patients with combined ITA grafts in the angiographic studies done 10 days postoperatively. In one of the patients with combined ITA graft who underwent reoperation for bleeding at the night of the operation, the graft was already seen to be more than 4 mm. in diameter. This demonstrates that the known physiologic adaptation of the ITA graft to increased myocardial demand [14] may occur in such an early period.

Sternal morbidity and mediastinitis related to diabetes and bilateral ITA usage in our cohort of patients is similar with the other series [18]. In diabetic patients an another arterial conduit (radial artery e.g.) may be used to increase the number of arterial anastomoses without increasing the risk of mediastinitis. However, infection rate may increase due to an additional incision according to the graft harvested. Sequential use of ITA has the potential advantage to increase the number of arterial anastomoses without an additional incision and related morbidity.

To date, the use of the third arterial graft has increased in CAB operations [19]. But according to our experience all or most of the viable myocardial areas can be grafted with the use of bilateral and sequential ITA techniques in most patients. Thus, indication of using any third arterial graft may be limited to routine use of sequential ITA techniques in CAB operations.

Investigation of survival advantage with the use of sequential and/or bilateral ITA is very difficult due to limitations in patient matching. A recent report from Schmidt and colleagues showed improved sur-

vival with the use of multiple left sided bilateral ITA grafts [8]. Other studies, the longest with a 17 year follow-up by Galbut and colleagues [6], show excellent survival in patients with bilateral ITA grafts [7,20]. The 5 year survival rate in these populations ranges consistently between 88% and 97,2% and at 10 years between 80% to 90,2%. Long-term studies that grouped the total consecutive patient population based upon whether one or both ITAs were grafted, demonstrated superior clinical outcomes in the bilateral ITA graft groups [21]. Naunheim and associates [22] and Fiore and colleagues [5] followed-up the same computer-matched cohorts of 100 patients having bilateral ITA operations and 100 patients receiving single ITA grafts for 15 years and found no significant difference in survival. Five and 10 years survival rates in our patient group were 95,6% and 93,4%, respectively; in accordance with the other series. In this report many different types of procedures and additional procedures have been included to the study. So, to find a proper group of patients to match survival rates was impossible. Moreover according to the survival analysis, any decreasing effect of bilateral ITA usage and the number of the arterial anastomoses on the late mortality could not be demonstrated.

However we think that the most important parameter which affects the long-term clinical outcome in CAB patients is the graft patency. For that reason angiographic results of the sequential ITA anastomoses has a crucial clinical importance. Among 63 patients who underwent an angiographic study in a mean of 33 months, patency rate of overall sequential ITA anastomoses was 91,7%. Despite the fact that the reason for the postoperative angiographic study was angina in half of these patients, this patency rate is clearly superior to saphenous vein grafts and similar to the nonsequential ITA grafts.

Failure of the sequential ITA anastomoses in some of the patients may be attributed to several factors, such as the luminal diameter and quality of the coronary artery and angulation. In two of these patients it could be explained by competitive flow caused by a low-grade stenosis in the native coronary artery. But some suggest that graft failure caused by competition is a reversible phenomenon and graft may reopen after the native vessel stenosis increase by time [23].

In most of the patients we used right ITA for the revascularization of the LAD artery, through crossing the aorta anteriorly and left ITA for sequential anastomoses of the lateral wall. In our opinion this type of arrangement is the most easy and effective way for bilateral sequential ITA anastomoses. But right ITA has a risk of injury during reopening of the sternum in reoperations. To avoid this problem we cover right ITA graft with pericardial fat tissue and we think that reoperation rate of these patients is not high.

We performed combined ITA procedures in only 5 patients at the beginning of our experience. Then we gained experience for extensive sequential ITA anastomoses with the use of two separate ITA grafts. They were an important experience for the safety of sequential ITA anastomoses and these procedures encouraged us to perform sequential ITA techniques in increased number of patients.

In conclusion, sequential use of ITA grafts was not associated with an increased perioperative mortality and morbidity and has the potential to improve the long-term results of CAB surgery because of excellent patency rates.

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