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Midterm follow-up with exclusive use of arterial grafts in complete myocardial revascularization of patients with triple vessel coronary artery disease

Seguimento clínico a médio prazo com uso exclusivo de enxertos arteriais na revascularização completa do miocárdio em pacientes com doença coronária triarterial

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Abstract

Objective: **To evaluate the midterm benefits of exclusive use of arterial grafts in patients with triple vessel coronary arteriosclerotic disease who underwent complete coronary artery bypass grafting.**

Method: **Between July 1995 and July 1997, 137 consecutive patients with triple vessel coronary atherosclerotic disease underwent complete coronary artery bypass grafting exclusively using arterial grafts. Of these patients, 112 (81.7%) were male, with ages ranging from 36 to 78 years old (mean 56.5 years). Three hundred and sixty-three arterial grafts were used to perform 442 coronary anastomoses, an average of 3.2 coronary anastomoses per patient. The arterial grafts used were left internal thoracic artery (99.3%), right internal thoracic artery (56.2%), radial artery (94.9%), right gastroepiploic artery (13.9%) and inferior epigastric artery (0.7%). In 80 (58.4%) patients, arterial composite "Y" grafts were constructed with the left internal thoracic artery and another arterial graft.**

Results: **No operative deaths occurred. Four (2.9%) deaths occurred in the postoperative period and only one (0.7%) patient needed reoperation in the immediate follow-up. The 7-year actuarial survival was 94.0% and the event free probability (myocardial infarction, angioplasty, reoperation or death) was 87.0%.**

Conclusions: **Good early and midterm clinical follow-ups can be achieved by exclusively using arterial grafts in the complete coronary artery bypass grafting of patients with triple vessel coronary arteriosclerotic disease. A long-term follow-up will be necessary to show the influence of exclusive use of arterial grafts in the surgical treatment of coronary insufficiency.**

Descriptors: **Miyocardial revascularization. Mammary arteries. Arteriosclerosis.**

Resumo

Objetivo: **Avaliar os benefícios a médio prazo do uso exclusivo de enxertos arteriais em pacientes com doença aterosclerótica coronária triarterial submetidos à revascularização completa do miocárdio.**

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Método: **Entre julho/95 e julho/97, 137 pacientes consecutivos foram submetidos à revascularização miocárdica com uso exclusivo de enxertos arteriais. Destes, 112 (81,7%) eram do sexo masculino e a idade variou de 36 a 78 anos (média de 56,5 anos). Foram utilizados 363 enxertos arteriais, sendo realizadas 442 anastomoses coronárias; média de 3,2 anastomoses coronárias por paciente. Os enxertos arteriais utilizados foram a artéria torácica interna esquerda (99,3%), artéria torácica interna direita (56,2%), artéria radial (94,9%), a artéria gastroepiplóica direita (13,9%) e a artéria epigástrica inferior (0,7%). Em 80 (58,4%) pacientes foram construídos enxertos arteriais compostos, com anastomose em "Y" da artéria torácica interna esquerda com outro enxerto arterial.**

Resultados: **Não houve mortalidade operatória. Ocorreram quatro (2,9%) óbitos durante o período de internação hospitalar e apenas um (0,7%) paciente necessitou ser reoperado no seguimento inicial. A probabilidade livre de eventos cardíacos (infarto do miocárdio, angioplastia, reoperação ou óbito) foi de 87,0% e a sobrevida foi de 94,0% com sete anos de seguimento clínico.**

Conclusões: **O uso exclusivo de enxertos arteriais na revascularização completa do miocárdio em pacientes com doença aterosclerótica coronária triarterial apresenta bons resultados imediatos e a médio prazo. O acompanhamento desses pacientes a longo prazo nos mostrará a influência do uso exclusivo de enxertos arteriais no tratamento cirúrgico da insuficiência coronária.**

Descritores: **Revascularização miocárdica. Artérias mamárias. Arteriosclerose.**

INTRODUCTION

The internal thoracic artery (ITA) has been recognized as the best graft for coronary artery bypass grafting (CABG) [1]. Its advantages increase with the passing of time, suggesting that the initial choice of this graft is a more important survival factor than the progression of arteriosclerotic disease in the coronary artery [2]. However, the main cause of recurrent angina and of reoperation is the progression of the arteriosclerosis in the saphenous vein (SV) graft [3,4]. The number of patients who require re-operations owing to the progression of the arteriosclerosis in the SV grafts and who present with the left internal thoracic artery (LITA) patent anastomised on the anterior descending coronary artery (AD) is increasing.

The long-term advantages of the use of both the ITAs in CABG were recently demonstrated [5]. However, in the majority of patients with indications of surgical treatment of coronary insufficiency presenting with triple artery disease, the use of both the ITAs is frequently insufficient for total CABG. Several authors have suggested the use of other arterial grafts such as the radial artery (RA) [6], the right gastroepiploic artery (RGEA) [7] and the lower epigastric artery (LEA) [8] to complete total CABG with multiple arterial grafts.

In this work we studied the initial and mid-term advantages of the exclusive use of arterial grafts in patients with coronary arteriosclerotic disease involving three arteries submitted to total CABG.

METHOD

Between July 1995 and July 1997, 137 consecutive patients submitted to total CABG exclusively utilized arterial grafts. All the patients presented with triple coronary artery arteriosclerotic disease and were submitted to surgical treatment in the Heart Insttute of the Hospital das Clínicas of the Medical School of the University of São Paulo.

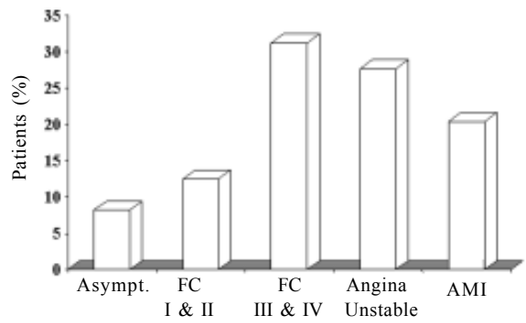
One hundred and twelve (81.7%) patients were male and the ages ranged from 36 to 78 years (mean of 56.5 years). Twenty-seven (19.7%) patients were diabetics, 40 (29.2%) had histories of myocardial infarction and 10 (7.3%) had been previously submitted to CABG (Table 1). Coronary insufficiency was manifested as acute myocardial infarction in 28 (20.4%) patients, unstable angina in 38 (27.7%), stable angina in 60 (43.8%) and 11 (8.0%) patients were asymptomatic (Figure 1).

Table 1. Pre-operative characteristics of the patients (N = 137)

Characteristics	Nº of patients (%)
Age > 70 years	18 (13.1)
Gender – male	112(81.7)
Systemic arterial hypertension	77 (56.2)
Smokers	69 (50.3)
Dyslipidemia	52 (38.0)
Family history	41 (29.9)
Prior myocardial infarction	40 (29.2)
Diabetes mellitus	27 (19.7)
Bilateral saphenectomy	11 (8.0)
CRI	8 (5.8)
COPD	5 (3.6)
Prior angioplasty	5 (3.6)
Reoperation	10 (7.3)

COPD = Chronic obstructive pulmonary disease, IRC = Non-diabetic chronic renal insufficiency

Pre-operative cineangiography demonstrated the involvement of the left coronary artery branch in 25 (18.2%) patients, normal function of the left ventricle in 83 (60.6%) patients, moderate dysfunction in 35 (25.5%) and significant dysfunction (ejection fraction = 35%) in 19 (13.9%) – Table 2.



Asympt. = Asymptomatic; FC = Angina functional class , AMI = Acute myocardial infarction

Fig. 1 - Distribution of patients according to clinical symptoms

Table 2: Pre-operative coronary cineangiography of the patients (N=137)

Characteristics	Nº of patients (%)
Triple coronary artery involvement	137 (100)
LCB involvement	25 (18.2)
EF = 55%	83 (60.6)
EF between 35% and 55%	35 (25.5)
EF =35%	19 (13.9)

EF = Left ventricle ejection fraction, LCB = Left coronary artery branch

Surgical technique

The approach employed was median sternotomy and CABG was performed with the help of cardiopulmonary bypass. Installation of cardiopulmonary bypass was achieved by the classic technique utilizing, after systemic heparinization of the patient (500 IU/kg), a Nº 22 or 24 cannula in the ascending aorta and a single two-part venous cannula to drain the inferior vena cava and right atrium. A Nº 14 catheter was positioned at the aortic root and connected to a aspirator of the heart-lung machine for continuous suction of blood, preventing hypertension, distension and consequent subendocardial ischemia of the left ventricle. Myocardial protection was achieved by intermittent clamping of the aorta or with an anterograde sanguineous cardioplegia solution.

After establishing the cardiopulmonary bypass and inducing cardiac arrest, the CABG itself was initiated. All the coronary arteries responsible for the perfusion of the great myocardial areas and which presented with significant obstructive lesions (= 70%) were treated. The end-to-side distal anastomosis of the graft with the coronary artery was preformed first. The proximal anastomosis of the graft with the aorta was made with the patient still under cardiopulmonary bypass and with total aortic clamping. The Y-shaped anastomosis of the compound grafts was preformed at the end of the cardiopulmonary bypass, with the heart beating.

Surgical Procedure

A total of 363 arterial grafts were used, making a total of 442 coronary anastomoses, an average of 3.2 per patient. The LITA was utilized in 136 (99.3%) patients and the right internal thoracic artery (RITA) in 77 (56.2%). Both ITAs were utilized in 76 (55.5%) patients, with the RITA freely used as a Y-shaped compound graft with the LITA in 32 (42.1%) of the cases. The RA was utilized in 130 (94.9%) patients, where in 48 (36.9%) cases it was anastomosed in a Y-shape to the LITA. The RGEA was utilized in 19 (13.9%) patients and the LEA in 1 (0.7%) patient.

CABG of the branches of the left coronary artery were normally performed with both ITAs. The LITA, in situ and retro-aortic, was used in grafting to the left marginal arteries. In the cases where the RITA, "in situ", was not long enough to reach the circumflex coronary artery branches, this was used as a free graft, anastomosed in a Y-shape on the LITA (Figure 2).

The RA was preferred in situations of sequential anastomosis in which more than one branch of the left coronary artery (diagonal, left marginal or posterior ventricular (PV) arteries) required revascularization (Figure 3). The free graft was anastomised to the aorta or as a compound Y-shape graft with the LITA. In patients with pneumopathies, obesity or diabetes, the RA was also preferred in relation to the RITA.

The RGEA, "in situ", was utilized in critical lesions or occlusion of the right coronary artery (RC) to revascularize the posterior descending (PD) branches or the PV (Figure 4).

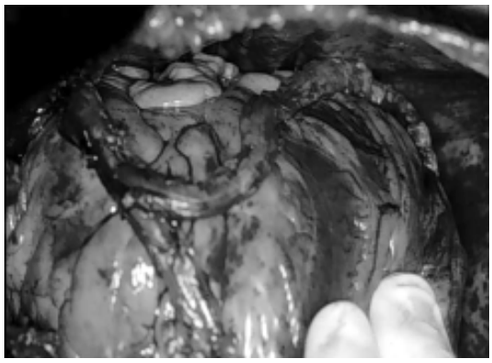


Fig. 2 - Intra-operative view. Y-shape anastomosis of the right internal thoracic artery (RITA) to the left internal thoracic artery (LITA) for the revascularization of the left coronary artery branches

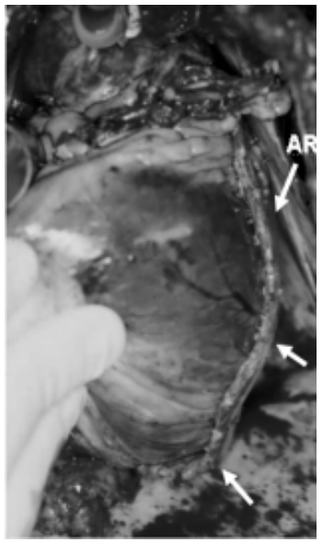


Fig. 3 - Intra-operative view. Sequential anastomoses of the radial artery (RA) with two marginal coronary arteries and the posterior ventricular branch of the circumflex artery

The arterial grafts utilized, as well as the respective anastomoses with the coronary arteries are described in Table 3.

RESULTS

There were no operative mortalities. Myocardial protection was performed using intermittent clamping of the ascending aorta in 83 (60.5%) patients and in 54 (39.5%) patients a sanguineous cardioplegia solution was used. The CPB time ranged from 51 to 228 minutes (mean 103.5 minutes). Three (2.1%) patients presented with significant hemodynamic instability after removal of the CPB and required the use of an intra-aortic balloon. Transfusions of concentrated red blood cells during the operation were necessary in 69 (50.3%) patients.

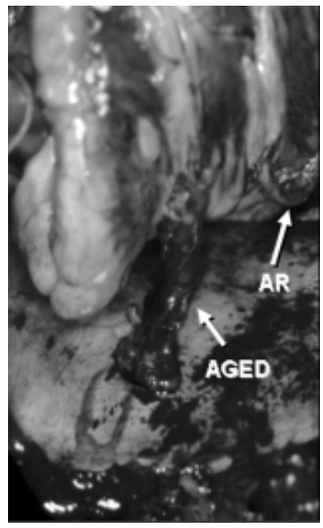


Fig. 4 - Right gastroepiploic artery (RGEA) "in situ" anastomosed to the posterior descending coronary artery and the radial artery (RA) anastomosed to the posterior ventricular coronary artery

Table 3: Arterial grafts utilized and respective anastomoses to the coronary arteries

	LITA	RITA	RA	RGEA	AEI	TOTAL
AD	135	1	-	-	-	136
DI / LM	12	60	155	1	1	229
RC	-	2	-	-	-	2
PD / PV	-	19	38	18	-	75
TOTAL	147	82	193	19	1	442

LITA = Left internal thoracic artery, RITA = right internal thoracic artery, RA = Radial artery, RGEA = right gastroepiploic artery, IEA = inferior epigastric artery, RC = right coronary artery, AD = anterior descending, DI = diagonal, PD = posterior descending, PV= posterior ventricular, LM = left marginal

Three (2.2%) patients required reoperations to review of the hemostasis. Five (3.6%) patients presented with elevated enzyme levels suggestive of acute myocardial infarction (AMI), however only in three (2.2%) patients this was

associated to electrocardiographic alterations characterizing AMI. One (0.7%) patient who coursed with AMI of the anterior wall of the left ventricle required reoperation. In the surgery, the anastomosis of the LITA with the AD developed thrombi and was re-made. Three (2.2%) patients presented with strokes in the postoperative period, although only one (0.7%) evolved with sequelae. Mediastinitis was diagnosed in three (2.2%) patients, however all had a good clinical evolution. The main complaints presented in the postoperative period are listed in Table 4.

Four (2.9%) deaths occurred during hospitalization. One of the patients who passed away had undergone the second CABG reoperation and another presented with an acute phase of AMI. The causes of the hospital morbidities are listed in Table 5.

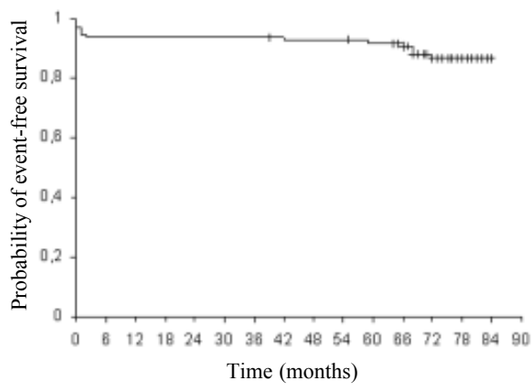
Table 4: Complications in the immediate postoperative period (Nº = 29 / 137 – 21.0%)

Complication	**Nº of patients (%)**
Pulmonary infection	13 (9.5)
Atrial fibrillation	12 (8.8)
Renal insufficiency	4 (2.9)
Acute myocardial infarction	3 (2.2)
Stroke	3 (2.2)
Mediastinitis	3 (2.2)
Bleeding	3 (2.2)

Table 5. Causes of hospital mortality (Nº = 4 / 137 – 2.9%)

Cause	**Nº of patients (%)**
Upper digestive tract hemorrhage/Sepsis	1 (0.7)
Acute myocardial infarction/cardiogenic shock	1 (0.7)
Peripheral arterial insufficiency/Sepsis	1 (0.7)
Ischemic stroke/Sepsis	1 (0.7)

The late clinical follow up of the patients varied from 5 to 7 years, with a mean of 5.7 ± 1.6 years. In this period four (2.9%) deaths occurred and 6 (4.5%) patients presented with relapse of the angina; five clinically controlled and one re-operated. The cardiac event-free probability (myocardial infarction, angioplasty, re-operation or death) was 87.0% ± 4.0% and the survival rate was 94.0% ± 2.0% with up to 7 years of follow up (Figures 5 and 6).

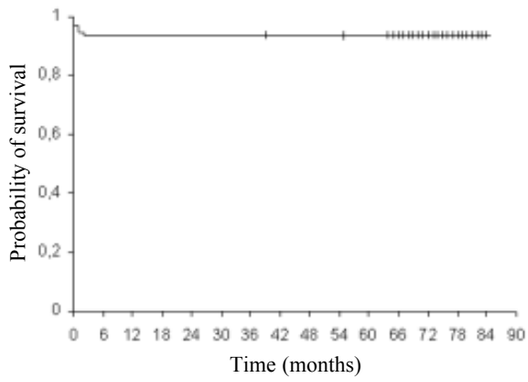


Time (months)	probability of survival	Standard error	Nº at risk
0	1.00	0.00	97
6	0.94	0.02	91
12	0.94	0.02	91
24	0.94	0.02	91
36	0.94	0.02	91
48	0.93	0.03	89
60	0.92	0.03	87
72	0.87	0.04	58
84	0.87	0.04	0

Fig. 5 - Probability of survival free of cardiac events (acute myocardial infarction, angioplasty, reoperation and death) with up to 7 years of clinical follow up (Kaplan-Meier method). The table illustrates the number of at-risk patients in the different follow-up periods

COMMENTS

The evolution of coronary arteriosclerotic disease has been positively influenced by the improvements in its surgical treatment. The immediate and long-term benefits of CABG are well known particularly when the LITA is used for the graft [9,10]. The importance of anastomosis of the LITA and the AD has been understood since the end of the 1970s, but only recently the long-term advantages with the use of both the ITAs in CABG have been demonstrated [5].



Time (months)	probability of survival	Standard error	Nº at risk
0	1.00	0.00	97
6	0.94	0.02	91
12	0.94	0.02	91
24	0.94	0.02	91
36	0.94	0.02	91
48	0.94	0.02	90
60	0.94	0.02	89
72	0.94	0.02	62
84	0.94	0.02	0

Fig. 6 - Probability of survival with up to 7 years of clinical follow up (Kaplan-Meier method). The table illustrates the number of at-risk patients in the different follow-up periods

On the other hand, the choice of grafts for CABG has become complicated as, with the development of interventionalist cardiology, the majority of the patients with single or double arterial coronary disease have been submitted to percutaneous revascularization, with surgical CABG mainly reserved for patients with multiple artery coronary disease.

Currently, the majority of the patients with multiple artery coronary disease are submitted to CABG using the LITA, or less frequently both ITAs, in combination with SV grafts. However, the SV, utilized as a graft, suffers from endothelial proliferation when connected to the arterial circulation and, after some years, it can develop obstructive disease. The main cause of obstructive disease is thrombosis, between the 5th and 10th postoperative year, with the consequence of relapse of the angina and the necessity of re-operation [3,4].

Aiming at expanding the use of both ITAs, some authors started to use compound grafts, such as the RITA anastomosed in a Y- or T-shape with the LITA, to revascularize all the branches of the left coronary artery with arterial grafts [13,14]. Nevertheless, with this technique the right coronary artery is not approached and revascularization of its branches becomes difficult. The use of the RA or RGEA to compliment revascularization, specifically of the right coronary artery and its branches becomes more attractive [15,16]. In our series, compound grafts with Y-shape anastomosis were utilized in 80 (58.4%) patients.

The number of patients operated on using this technique has increased in the majority of heart surgery centers and surgeons are becoming more familiar with the procedure. They have increased their knowledge of the different arterial grafts and, despite the rapid evolution in the use of these grafts that has taken place over the last years, the influence of the use of multiple arterial grafts in CABG has been controversial.

Total revascularization with the use of only arterial grafts presents some limitations, such as: prolonged operative time, increased bleeding, graft spasms with peri-operative myocardial hypoperfusion and a greater risk of infection.

The increase in the operative time is more related to the preparation of the arterial grafts, as only the RA can be dissected concomitant to the sternotomy. The dissection of the RITA and principally the RGEA, increase the operative time. However, the CPB time was not influenced by the greater number of anastomoses with arterial grafts. In our study, the average time of CPB of 103 minutes was not significantly greater than the mean time used to perform this type of operation using venous grafts. The bleeding was also not important as approximately 50% of the patients did not require intra-operative transfusions.

Infectious problems are more related to the use of both ITAs, owing to the greater incidence of mediastinitis when utilizing this technique. This complication is more common in insulin-dependent diabetic patients and thus this technique is contraindicated in respect to this group. In our series, three (2.2%) patients presented with mediastinitis in the postoperative period. In two, both ITAs had been used, one of whom was also diabetic. All had a good clinical evolution. In obese patients, with pneumopathies or diabetes we tried to avoid the use of both ITAs and preferred to use the RA instead.

Spasms of arterial grafts can be prevented by the topical administration of heated papaverine solution, careful dissection of the grafts, maintenance of an adequate perfusion pressure both during and after CPB, and the administration of vasodilators such as nitroglycerine and sodium nitroprusside in the intraoperative and immediate postoperative periods. Calcium channel blockers, when necessary, can also be

useful. Among our patients, 3 (2.2%) presented with low postoperative cardiac outputs and required intra-aortic balloons, which may have been related to spasms of the arterial grafts.

Postoperative myocardial hypoperfusion might be caused by a series of factors, such as: problems with the arterial grafts (inadequate length, spasms or curving) or technical problems of the anastomoses. Among our 137 patients, one (0.7%) presented with postoperative acute myocardial infarction with significant hemodynamic repercussions and requiring reoperation. In the reoperation, the presence of thrombi in the anastomosis of the LITA graft to the anterior interventricular branch was evidenced and the anastomosis was remade and the patient evolved satisfactorily.

The occurrence of myocardial infarction during CABG surgeries with the exclusive use of arterial grafts is a subject frequently reported in the literature. Some authors affirm that the incidence of complications is low and the use of arterial grafts, especially of the LITA anastomosed on the AD, reduces the incidence of low cardiac output syndrome, peri-operative infarction and operative mortality and improves survival [18,19]. In our cohort, we observed 3 (2.2%) cases of peri-operative infarction related to patients operated on in the acute phase of AMI or with unstable angina. The presence of a lesion in the branch of the left coronary artery did not influence the occurrence of postoperative infarction. The mortality of 2.9% (4 patients) was also more related to the prior clinical conditions of the patients than with the use of arterial grafts. In one patient it was the second reoperation, a second was operated on in the acute phase of AMI which evolved with complications owing to the use of the inter-aortic balloon and another an aged patient with calcification of the aorta evolved with postoperative stroke and death.

The probability of cardiac event-free (myocardial infarction, reoperation, angioplasty or death) in a 7-year follow-up period was 8.7%. Only one patient required reoperation in this period for occlusion of the RA sequentially anastomosed to two left marginal arteries. The overall survival rate was 94.0% in the same period. Other studies, with mid-term follow ups, also demonstrated good results with CABG with the exclusive use of arterial grafts [20].

This work aimed at evaluating the immediate and mid-term clinical results of CABG with the exclusive use of arterial grafts, showing good results in terms of survival and event-free rates. However, there is a limitation by not using cineangiographic studies to demonstrate the patency of the grafts. Protocols with late cineangiographic studies and comparisons with a group of patients submitted to CABG surgery with the LITA associated with SV grafts are necessary for a better assessment of the influence of the exclusive use of arterial grafts in total CABG.

CONCLUSION

In conclusion, the exclusive use of arterial grafts in total CABG in patients with multiple coronary artery atherosclerotic disease gives good immediate and mid-term results. The adequate selection of the patients to be submitted to this technique may improve even further the results.

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