ORIGINAL ARTICLE

Braz J Cardiovasc Surg 2007; 22(1): 60-67

Immediate results of right internal thoracic artery and radial artery as the second arterial graft in myocardial revascularization

Resultados imediatos da artéria torácica interna direita e artéria radial como segundo enxerto arterial em revascularização do miocárdio

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RBCCV 44205-869

Abstract

Objective: **We sought to compare early clinical outcomes in patients receiving a right internal thoracic artery or a radial artery as the second arterial graft in myocardial revascularization.**

Methods: **We retrospectively studied 58 consecutive patients who underwent coronary artery bypass surgery and received both a left internal thoracic artery graft and either a right internal thoracic artery (n=20) or a radial artery graft (n=38), between January 2004 and March 2006. Hospital mortality, pleural drainage, operative time and postoperative complications were analyzed.**

Results: **There were no significant preoperative differences between groups. There was only one (1.7%) in-hospital death which occurred in the Radial Group. Operative times was significantly higher in the Right Internal Thoracic Group (p-value = 0.0018), but were not associated with increased Intensive Care Unit stays, mechanical ventilation or other postoperative complications. We were able to perform significantly more distal anastomosis using the radial artery than the right internal thoracic artery (1.57 versus 1.05: p-value =0.003).**

Conclusion: **In our group of patients, the use of a right internal thoracic artery as a second arterial graft was associated with a prolonged operative time, but had no interference with the immediate clinical outcomes.**

Descriptors: **Myocardial revascularization. Mammary arteries. Radial artery. Evaluation of results of therapeutic interventions.**

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Article received in September 22nd , 2006
Article accepted in January 9th, 2007

Resumo

Objetivo: **Avaliar os resultados imediatos da cirurgia de revascularização miocárdica com o uso de um segundo enxerto arterial, comparando a artéria torácica interna direita e a artéria radial.**

Método: **No período de janeiro de 2004 a março de 2006, foram estudados 58 pacientes consecutivos submetidos à revascularização do miocárdio que receberam, além da artéria torácica interna esquerda, um segundo enxerto arterial. Vinte receberam a artéria torácica interna direita e 38, a artéria radial. Foram analisados mortalidade hospitalar, tempo de intubação, tempo de internação em UTI e hospitalar, tempo operatório, volume de sangramento, necessidade de transfusão e incidência de complicações pós-operatórias.**

Resultados: **Os grupos não diferiram entre si quanto às características pré-operatórias. Nos pacientes que receberam artéria torácica interna direita, houve incremento no tempo operatório, quando comparados àqueles que receberam radial, com média de 365 minutos contra 309 (p=0,0018). A média de anastomoses distais foi igual nos dois grupos, porém a média de artérias revascularizadas com o segundo enxerto arterial foi maior no grupo radial (1,57 x 1,05; p=0,003). Não houve diferença quanto às variáveis pós-operatórias analisadas. Houve um (1,7%) óbito hospitalar, que ocorreu no grupo revascularizado com artéria radial. Não ocorreu episódio de mediastinite nesta série de pacientes.**

Conclusão: **Os resultados imediatos não diferiram entre os dois grupos. Observou-se, no entanto, que o uso da artéria torácica interna direita relacionou-se com aumento do tempo operatório, nesta série de pacientes.**

Descritores: **Revascularização miocárdica. Artéria torácica interna. Artéria radial. Avaliação de resultado de intervenções terapêuticas.**

INTRODUCTION

The search for new arterial grafts for coronary artery bypass grafting (CABG) became crucial in the 1980s, when several authors demonstrated the superiority of the left internal thoracic artery (LITA) anastomosed to the anterior interventricular branch of the left coronary artery when compared to the aortocoronary saphenous vein graft [1-3]. Use of the right internal thoracic artery (RITA) seemed to be the most obvious alternative, but, despite of the description by Puig et al. [4] in 1984 of a technique to anastomose the pediculated RITA to the marginal branches of the left coronary artery through a retro-aortic passage, few groups routinely adopted this type of procedure at that time. The technical difficulty, associated with the necessity of long lengths of the RITA, increases in operative time and concern related to devitalizing the sternum were the probable reasons for not adopting this method. Other teams chose the RITA as a free graft and reported a patency of 89% over 5 years [5]. In 1999, due to a study performed in the Cleveland Clinic Foundation [6], the long-term clinical and angiographic benefits of utilizing the RITA as the second arterial graft were confirmed, later corroborated by a metaanalytical study published in 2001 [7].

Carpentier et al. [8] in 1973 described the use of the radial artery (RA) as a graft in CABG surgery, but the lack of vasodilators at that time may have permitted vasospasms of this graft in a series of patients, which resulted in abandoning the technique soon after. Future angiographic studies performed in these patients demonstrated RA graft patency 15 years after the surgery, including in patients in whom it was thought that early occlusion of this graft had occurred. This fact led to the re-emergence of this option [9] and since then, some groups have demonstrated promising short- and long-terms results utilizing the RA [10-13].

Some retrospective studies suggested better immediate results using the RA as the second arterial graft [14,15] but other studies demonstrate the better patency of the RITA compared to the RA [16,17]. However we are far from reaching a consensus on this issue.

The current study aims at comparing the immediate results utilizing these two grafts in our service with an initial series of patients.

METHOD

Selection of patients

Between January 2004 and March 2006, 351 patients were submitted to CABG in our service. Of these, 78 (22%) received two or more arterial grafts. Fifty-eight consecutive patients were selected for the study in whom the LITA was used as the principal arterial graft, and either the RITA or RA were associated as a second arterial grafts. Additional saphenous grafts were employed according to the necessity of each case. The option to utilize any specific conduct was made by the head surgeon with generally a second arterial graft being chosen for young patients (<65 years) and when the target coronary artery presented critical injury (>70 %) with a good distal bed. Patients who received more than two arterial grafts were not included in this study.

Thirty-eight patients received RA as the second arterial graft (Radial Group) and twenty patients received RITA (Mammary Group). The RA was only dissected from the non-dominant arm and only after the Allen's test was proven to be negative. In both groups insulin-dependent diabetic patients were excluded.

Preoperative characteristics were similar between the groups (Table 1).

The present study was approved by Ethics Commissions of the hospitals where the procedures were performed.

Table 1. Preoperative variable

Preoperative variable	Radial Group	Mammary Group	p-value
Age in years	Nº (%)	n (%)	NS
(Mean ± SD)	56 ± 7	57±8	NS
Women	9 (23.7%)	4 (20%)	NS
BMI > 30	9 (23.7)	7 (35%)	NS
SAH	20 (52.6%)	11 (55%)	NS
Smokers	15 (44.7%)	9 (45%)	NS
Prior AMI	14 (36.8%)	7 (35%)	NS
LV dysfunction	7 (18.4%)	3 (15%)	NS
Familiar history	8 (21%)	7 (35%)	NS
Diabetes Mellitus	8 (21%)	3 (15%)	NS
Dyslipidemia	12 (31.5%)	10 (50%)	NS
CRF (Cs>2)	0	1 (5%)	NS
Reoperation	1 (2.6%)	2 (10%)	NS
LCT injury	6 (15.7%)	6 (30%)	NS
Single artery	1 (2.6%)	0	NS
Two arteries	13 (47.4%)	10 (50%)	NS
Three arteries	14 (50%)	10 (50%)	NS

BMI = Body Mass Index, SAH = Systemic Arterial Hypertension, CRF - Chronic Renal Failure, Sc = Creatinine Serum level, LCT = Left Coronary Trunk, NS = non-significant.

Operative procedure

The patients were submitted to longitudinal median sternotomy, followed by opening of the pericardium. The coronary arteries and aorta were checked and the grafts dissected. When the two thoracic arteries were employed, the head surgeon dissected both. Opening of the pleural spaces was performed to improve accessibility to both the LITA and RITA. In cases in which the RA was utilized, the first surgical assistant dissected the artery, which was then prepared in a solution containing papaverine and diltiazem. All patients received intravenous diltiazem for the induction of anesthesia, followed by a continuous venous infusion of nitroglycerin which was continued for at least the first 24 hours of the postoperative period [18].

For most cases during our initial experience using the RITA, we preferred to utilize cardiopulmonary bypasses (CPB) with single venous cannulation using a double-stage cannula and cannulation of the ascending aorta avoiding parietal plaques. Perfusion was performed at moderate hypothermia (32ºC), longitudinal clamping of the aorta and myocardial protection using an intermittent anterograde blood cardioplegia. When the surgery is performed off-pump we utilize the Octopus III (Medtronic, Inc) suction stabilizer and intracoronary artery shunt (Bard MCJ) for all distal anastomoses and avoided ligating the coronary arteries [19]. The proximal anastomoses, when performed in the aorta, were made by side clamping. The use of antifibrinolytics in on-pump surgeries was the responsibility of the anesthesiology team and did not vary between groups. In our service, the antifibrinolytic agent routinely utilized is tranexamic acid, but it is not used in off-pump surgeries.

The percentage use of CPB was not different between the two groups, nor was the mean number of distal anastomoses. However, the mean number of distal anastomoses with the second arterial graft was 1.57 ± 0.74 for the Radial Group and 1.05 ± 0.2 (p-value = 0.0032) in the Mammary Group, as the RA is more commonly utilized in sequential anastomoses and, occasionally, it is long enough for two different grafts. Proximal anastomosis of the RA was performed in the aorta in 26 (68.5%) cases, as a Y-shaped graft with the LITA in 7 (18.5%) cases and the graft was split in two and proximally anastomosed to the aorta to revascularize the right coronary artery and its branches and also in the LITA to revascularize the branches of the left coronary artery in 5 (13%) cases. Distal anastomoses using this graft were to the marginal branches in 57% of cases, to the diagonal or diagonalis branches in 25% and to right coronary artery branches in 18%. The RITA was utilized "*in situ*" in almost all cases. In just one case, there was a necessity of using this artery as a free graft. The percentage of territories irrigated using this graft was similar to those for the RA, with the exception of one case in which the RITA was used to revascularize the anterior interventricular branch and the LITA to revascularize the side of the heart. Detailed data of the perioperative variables are shown in Table 2.

Data collection

A search of the department database was used for data collection with omitted data being obtained by consulting the hospital records of patients.

The main aim was to calculate hospital mortality and secondary goals were to investigate immediate postoperative complications, intubation duration, the

Table 2. Perioperative variables

Variable	Radial Group (n = 38)	Mammary Group (n = 20)	p-value
Use of CPB	30 (78.9%)	17 (85%)	NS
Use of antifibrinolytics	12 (31.5%)	7 (35%)	NS
Number of distal anastomoses	2,8 ± 1.1	2.95 ± 0.8	NS
Number of distal anastomoses with second arterial graft	1.57 ± 0.74	1.05 ± 0.2	0.0032
Anastomoses of second arterial graft in the RCA/PD	11 (18%)	4 (20%)	NS
Anastomoses of second arterial graft in the marginal branches	34 (57%)	12 (60%)	NS
Anastomoses of second arterial graft in diagonal branches	15 (25%)	3 (15%)	NS
Anastomoses of second arterial graft in anterior descending	0	1 (5%)	NS
LITA -AD	34 (89.5%)	19 (95%)	NS
LITA - Dg	2 (5.5%)	0	NS
LITA - RCA	1 (2.5%)	0	NS
LITA - Mg	1 (2.5%)	1 (5%)	NS

CPB = Cardiopulmonary bypass; RCA = Right Coronary Artery; PD = posterior descending branch posterior of the right coronary artery; DA = anterior descending artery; Dg = diagonal branch; Mg= marginal branch; NS = non-significant

intensive care unit (ICU) and hospital durations, volume of bleeding, the necessity of re-exploration and quantity of blood derivative products required. All the preparation times of grafts were calculated (the time elapsed from when the patient arrived in the operating room to the start of CPB or of the anastomoses), CPB duration and total surgery duration (time from the arrival of the patient in the operating room until their arrival in the ICU). The volume of bleeding was measured in the first 6, 12 and 24 postoperative hours, as was the quantity of blood derivative products transfused during the hospital stay.

The criteria to define acute myocardial infarction (AMI) in the perioperative period of CABG were those classically accepted in the literature: a new and persistent Q-wave, left branch block or total atrioventricular block on the electrocardiogram (ECG) during rest associated with a serum CK-MB level greater than 30 UI/L or serum CK-MB level greater than 80 UI/L in isolation. Enzymatic measurements were made at 0, 6, 12, 24 and 48 postoperative hours. ECGs were performed at 0, 24 and 48 postoperative hours [20].

Statistical analysis

Statistical analysis was performed using the GraphPad Prism version 4.0. The Student t-test was used to analyze continuous variables and the Fisher's exact and Chi-Squared tests were used for categorical variables. The data of continuous variables are expressed as means ± standard deviation and of the categorical variables as total number and/or percentages. Significance was established with p-values < 0.05.

RESULTS

Although the CPB times were similar in the two groups (98.7 ± 33.7 minutes vs. 103.8 ± 24.0 minutes), total operating time in the Mammary Group was 365.2 ± 69.3 minutes, whilst in the Radial Group it was 309 ± 57.8 minutes (p-value = 0.0018). This is explained by the longer time spent preparing the grafts that, in the first group, was 185.8 minutes ± 40.6 and in the second 142.3 ± 44.8 (p-value = 0.0006) – Figure 1.

There was no difference in respect to the volume of bleeding in both groups or in the quantity of blood products administered. A patient from the Radial Group needed to be submitted to a re-exploration surgery due to bleeding. During the re-intervention active bleeding was identified in the right atrium that was immediately repaired and the patient evolved well (Table 3).

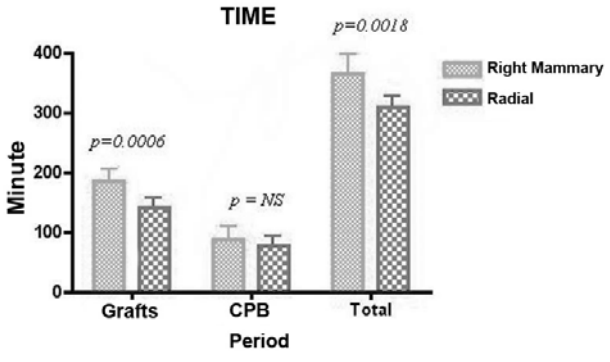

Fig 1 – CPB – Cardiopulmonary bypass; NS – Non-significant

In the Radial Group, only one patient had perioperative AMI with total atrioventricular block – (TAVB) and high enzymatic levels accompanied by low heart output. After a slow improvement of the ventricular dysfunction the patient suffered from a pulmonary infection which evolved with sepsis and death on the 28th postoperative day, which was the only death in this series. In the Mammary Group there were no cases of perioperative AMI. Approximately the same percentage of patients required inotropic drugs in the immediate postoperative period.

In respect to intubation, ICU and hospitalization durations, there were no statistically significant differences between the two groups. Only one patient presented atrial fibrillation in the postoperative period. This patient belonged to the Radial Group, and the complication was chemically reverted using intravenous amiodarone. Three patients presented with neurological complications. In the Radial Group, one patient had a transitory ischemic stroke and another patient had an episode of convulsions; both were discharged from hospital without sequels. In the Mammary Group, one patient had an episode of mental confusion. Additionally, one patient in the Mammary Group evolved with an episode of bronchopneumonia and was treated with broad-spectrum intravenous antibiotics and was discharged from hospital in good clinical conditions. In the Radial Group, apart from the patient who died, two others suffered from bronchopneumonia but they evolved well. Mediastinitis was not seen in this series of patients (Table 4).

Table 3. Bleeding volume

Event	Radial Group (n = 38)	RITA Group (n = 20)	p-value
Bleeding in 6 hours (mL)	311.3 ± 238.2	389 ± 222.5	NS
Bleeding in 12 hours (mL)	501 ± 346.9	573.5 ± 273.8	NS
Bleeding in 24 hours (mL)	826.3 ± 481.3	943.5 ± 474.4	NS
Re-operation for bleeding	1 (2.6%)	0	NS
RBCC transfusion (mL/patient)	605.2 ± 560.8	543.3 ± 238.2	NS
FFP transfusion (mL/patient)	68.4 ± 167.1	30 ± 95.3	NS
Platelets transfusion (mL/patient)	36.3 ± 75.9	12 ± 36	NS

CH – red blood cell concentrates; FFP – Frozen fresh plasma; NS – Non-significant

Table 4. Results

Events	Radial Group (n = 38)	RITA Group (n = 20)	p-value
AMI perioperative period	1 (2.6%)	0	NS
Inotropic in the IPO	25 (65.7%)	14 (70%)	NS
Extubation time (hours)	12.5 ± 8.6	15.1 ± 11.2	NS
ICU time (hours)	70.6 ± 41.2	75.8 ± 47.1	NS
Pulmonary infection	3 (7.8%)	1 (5%)	NS
Mediastinitis	0	0	NS
Atrial fibrillation	1 (2.6%)	0	NS
Neurological disorder	2 (5.2%)	1 (5%)	NS
ARF	0	0	NS
Low heart outflow	1 (2.6%)	0	NS
Hospital release time (day)	17.8 ± 10.6	14.4 ± 8.3	NS
Hospital mortality	1 (2.6%)	0	NS

AMI = Acute Myocardial Infarction in the perioperative period; IPO = Immediate postoperative period; ICU = Intensive Care Unit; ARF = Acute Renal Failure; NS = non-significant.

DISCUSSION

There is currently much interest in medical research related to the use of arterial grafts in CABG [21-25]. In particular, the comparison between RA and RITA grafts is being widely discussed [14-17]. In spite of this, there are very few prospective randomized studies and studies from different services show conflicting outcomes; hence there is no consensus about the best second arterial graft.

Borger et al. [15] demonstrated a lower risk of death or cardiovascular events over five years for patients submitted to CABG using two arterial grafts compared to those who receive only the LITA as an arterial graft. In the same article, they reported a higher rate of mediastinitis using the RITA compared to a group that received the RA. However, there was no difference in hospital or five-year mortality rates between the groups. Caputo et al. [14] reported their experience in which they found the RA was far superior to the RITA over the short- and medium-terms with less postoperative arrhythmia and perioperative infarction, lower transfusional requirements and less time in the ICU, as well as a better 18-month event-free survival. But, they did not demonstrate differences in the mortality rates.

Buxton et al. [17] did not believe that the RA presented better outcomes than the RITA as a second arterial graft and demonstrated similar clinical results between the groups and better patency over the medium-term employing the RITA (94.4% vs. 90.6%). Calafiore et al. [26] compared the

two grafts over short- and medium-terms and did not find clinical or angiographical differences between them with both showing excellent results.

Nevertheless, none of the studies were efficacious in showing better survival rates of patients when using multiple arterial grafts until, in 1999, Lytle et al. [6] published an article demonstrating, after exhaustive statistical analysis of a cohort of 10124 patients, significantly better survival over 5, 10 and 15 years of follow-up using both internal thoracic arteries (ITAs) compared to the use of one ITA. In 2004, the 20-year follow-up of these patients still showed better advantages using both the ITAs; even indicating that these outcomes also applied to high risk patients, such as diabetic patients and those with left ventricular dysfunction.

As long-term clinical results using the RITA seem to be well established, our attention returned to the immediate outcomes, where the greatest controversy is to be found. CABG surgery using both ITAs is more work due to the time spent in harvesting the grafts, which was confirmed by us in the current study, but also due to the technical refinements necessary to create the retro-aortic passage of the graft and anastomosis to the marginal branches without harming the flow. The greater occurrence of mediastinitis in patients submitted to CABG using both ITAs, specifically in diabetic patients, was reported by several authors [6,15,28,29]. However, skeletonized dissection of the ITA decreases the devitalization of the sternum and has contributed to a reduction in this rate, even in diabetic and elderly patients [26,30-32]. An exception is insulin-dependent diabetic patients, who have even higher risk and present with mediastinitis in as many as 6.3% of cases [33]. In our limited sample, we did not use the RITA in insulin-dependent diabetic patients and, although we did not dissect the ITAs from all patients using skeletonization, no episodes of mediastinitis were reported.

Studies show worse results for the RITA when it is used as a free graft, in coronary arteries with non-critical stenosis and for revascularizing of the right coronary artery [34-36]. Comparing the RITA "*in situ*" and in Y-shape grafts with the LITA, Calafiore et al. [37] found similar results between the groups over the medium-term, even stressing the possibility of performing more sequential anastomoses with this free graft. Indeed, a disadvantage of the RITA "*in situ*" is the difficulty to make more than one distal anastomosis, on the contrary to the RA that seems to be more suitable for sequential anastomoses. In our study, we observed that the RA was utilized for, on average, 1.57 distal anastomoses, while the RITA was used for just one. Although some authors suggest the utilization of the RITA as a free graft in sequential anastomoses giving good results [37-39], we prefer to adopt the first strategy because we believe it is important to maintain the graft alive maintaining the possibility of remodeling [40]. A similar controversy exists about the best place for the proximal anastomosis of the radial artery. Although most studies did not find clinical or angiographic differences between the two techniques [41-43], Italian researchers suggested that there is a better behavior of the graft anastomosed to the aorta when the degree of coronary artery obstruction is between 70 and 90% [43].

There are great differences of opinion in the literature in relation to the patency over the medium- and long-terms of these two grafts, principally because some studies perform arteriographies only in symptomatic patients, while other studies perform examinations at times pre-determined by protocols, independently of symptoms. However, the patency in the medium-term of the RITA varies between 91-100% and, over 15 years it can be as much as 88% [26,35,44]. Two recent review studies failed to obtain angiographic results in the long-term follow-up after the use of the RA [45, 46]. The results of patency over five years of this graft varied from 82 to 99% [10, 26], while the short-term results are still more controversial. Some authors demonstrate 100% patency in one year [9], other authors report worse results than using the saphenous vein, with 51% over less than two years [47]. Recently, a metanalysis comparing the radial artery with the saphenous vein graft was not able to find differences between the grafts [48].

CONCLUSION

There were no differences in the immediate results between the two groups. A greater operative time was observed for the Mammary Group, but without reflecting on the rate of complications.

ACKNOWLEDGMENTS

The authors wish to thank Professor Dr. Luiz Felipe Pinho Moreira for his help in the statistical analysis and for his ideas and constant stimulation during the research.

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