Original Article

Effects of Skeletonized versus Pedicled Radial Artery on Postoperative Graft Patency and Flow

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Abstract

Background: Radial artery (RA) was the second arterial graft introduced in clinical practice for myocardial revascularization. The skeletonization technique of the left internal thoracic artery (LITA) may actually change the graft's flow capacity with potential advantages. This leads to the assumption that the behavior of the RA, as a coronary graft, is similar to that of the LITA, when skeletonized.

Objective: This study evaluated 'free' aortic-coronary radial artery (RA) grafts, whether skeletonized or with adjacent tissues.

Methods: A prospective randomized study comparing 40 patients distributed into two groups was conducted. In group I, we used skeletonized radial arteries (20 patients), and in group II, we used radial arteries with adjacent tissues (20 patients). After the surgical procedure, patients underwent flow velocity measurements.

Results: The main surgical variables were: RA internal diameter, RA length, and free blood flow in the radial artery. The mean RA graft diameters as calculated using quantitative angiography in the immediate postoperative period were similar, as well as the flow velocity measurement variables. On the other hand, coronary cineangiography showed the presence of occlusion in one RA graft and stenosis in five RA grafts in GII, while GI presented stenosis in only one RA graft (p = 0.045).

Conclusion: These results show that the morphological and pathological features, as well as the hemodynamic performance of the free radial artery grafts, whether prepared in a skeletonized manner or with adjacent tissues, are similar. However, a larger number of non-obstructive lesions may be observed when RA is prepared with adjacent tissues. (Arq Bras Cardiol. 2014; 102(5):441-448)

Keywords: Coronary Diseases / surgery; Radial Artery / abnormalities; Radial Artery / surgery; Vascular Patency.

Introduction

Radial artery (RA) was the second arterial graft introduced in clinical practice for myocardial revascularization[1]. Initially, it presented unfavorable angiographic results. However, with changes in the surgical technique and the use of spasm-preventing vasodilators, RA started to be used safely and with good results in the treatment of coronary diseases[2].

RA skeletonized dissection was introduced by Taggart et al in 2001[3], based on the good results obtained with skeletonization of the left internal thoracic artery (LITA), which started with Cunningham et al in 1992[4]. There is no question about the effects of pedicled LITA for myocardial revascularization, and notwithstanding these excellent results, the skeletonization technique of LITA may actually change the graft's flow capacity with potential advantages[4-6]. This leads to the assumption that the behavior of the RA, as a coronary graft, is similar to that of the LITA, when skeletonized.

Therefore, the purpose of this study was to randomly compare the hemodynamic and functional performance of RA aorto-coronary grafts, prepared in a skeletonized manner or with adjacent tissues, by means of post-surgical angiography and flowmetry performed in the immediate postoperative period. Morphological and pathological features of these grafts were also compared.

Methods

Study population

This study was designed as a randomized clinical trial with distribution of twenty patients per group, according to RA dissection technique and preparation (Group I – skeletonized RA graft and Group II – RA graft with adjacent tissues). Patients diagnosed with stable angina, unstable angina, or a history of non-acute myocardial infarction (with or without ST-segment elevation) were included after free and clear discussion of risks, alternatives, and perceived benefits of the operations. The study protocol was approved by the institutional Research Ethics Committee

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and Scientific Review Board, and registered on the National Council of Research Ethics (CONEP). All patients gave written informed consent.

Patients with cineangiographic exams showing coronary stenoses above 70% and good distal anatomy[7] in at least two main branches including the circumflex territory, and negative classic and modified Allen test[8,9] in the forearm, which is intended for RA dissection, were selected. The following exclusion criteria were applied: (a) age over 70 years; (b) severe obesity; (c) positive Allen test[10,11]; (d) patients with arteriovenous fistula for hemodialysis, vasculitis, or Raynaud's disease; (e) RA presenting macroscopically visible calcifications or diffuse atherosclerotic disease; (f) redo operation; (g) additional procedure; (h) severely depressed left ventricular function; (i) contraindications for use of calcium-channel blockers; (j) contraindication for postoperative angiography; (j) acute myocardial infarct with or without ST-segment elevation; (k) patients with kidney failure, or peripheral arterial disease.

Forty patients were selected for this study. All patients had angina class 2–4 according to the Canadian Cardiovascular Society. Previous myocardial infarction (MI), number of diseased vessels, age, gender, diabetes mellitus, hypertension and others characteristics were similar for both groups and are shown in Table 1. All patients were operated on electively.

Surgical technique and pharmacological protocol

All patients were operated on under cardiopulmonary bypass with mild hypothermia (32-34°C) and intermittent aortic cross-clamping. Soon after discontinuation of cardiopulmonary bypass, intravenous nitroglycerin was administered for 48 hours, and replaced by an oral calcium-channel antagonist after this period.

The RA was dissected and prepared concomitantly with LITA dissection. The RA dissection technique was that proposed by Reyes et al[12], and skeletonization, when applied, was performed out of the forearm with the use of scissors; collateral vessels were ligated using 4.0-cotton suture. Intraluminal filling of the RA grafts was performed using heparin-treated blood, and topical papaverine. LITA was used to graft the left anterior descending artery and all RA were used to graft the obtuse marginal artery, the intermediate branch or the first diagonal branch with lesions > 75%. RA grafts were anastomosed proximally in the aorta (retro-aortic), through the orifice performed with a scalpel, using continuous suture with 6.0 or 7.0 polypropylene, and distally to the coronary branches, using continuous end-to-side anastomosis with 7.0 polypropylene suture. The right coronary artery and its branches, as well as arteries with lesions > 75% received saphenous vein grafts.

The following intraoperative variables were analyzed: RA length and free RA flow. Pathological examination of RA endothelial behavior was also performed in both groups.

All patients received isosorbide mononitrate (0.8 mg/kg per min) and diltiazem (2 mg/kg per min) infused intraoperatively and up to 24 h after operation, followed by 20 mg and 180 mg/day orally, respectively, in addition to antiplatelet therapy for at least 6 months. The incidence of MI was monitored by electrocardiograms and serial analyses of serum CK-MB.

Angiography and flowmetry protocol

Patients underwent angiography and flowmetry between postoperative days 7 and 10. The test was performed via the femoral access. The grafts were analyzed by a senior cardiologist and classified according to presence or absence of: non-obstructive stenosis (< 50%), obstructive stenosis (> 50%) and total occlusion.

The average peak velocity and the RA graft flow were recorded in the initial portion (3 cm of the proximal anastomosis) of the RA in both groups. For these measurements, we used a 12-MHz Doppler guide of 0.014 inches (0.035 cm) in diameter, and 175 cm in length (Flowire; Cardiometrics Inc)[13]. The records were performed at rest and in hyperemia, which was induced by the injection of 30 μg of adenosine directly into the graft. Graft flow reserve consisted of the ratio between the peak velocities in hyperemia and at rest. The blood flow at the proximal portion of the grafts was calculated using the Doucette method[13], with the time average of peak velocity and the cross-sectional area of the graft. This area was obtained after determining the diameter by quantitative angiography for the analysis of the margin contour. Absolute dimensions were calculated, using the diagnostic catheter diameter as reference.

Statistical analysis

Data are expressed as mean ± standard deviation or as percentages, and were analyzed using Mann-Whitney non-parametric test, chi-square or Fisher's exact test, when appropriate. The sample size was projected for a 90% power to identify a 10% difference in graft patency, with the significance level set at 5%. P values lower than 0.05 were considered significant, as determined using the SPSS for Windows, version 13.0 (SPSS, Inc., Chicago, IL).

Results

Each group comprised 20 patients. There was no hospital mortality. The surgical variables are shown in Table 1. The postoperative complications were: atrial fibrillation (five cases), paroxysmal supraventricular tachycardia (one case), bronchial pneumonia (one case), re-operation due to bleeding in the immediate post-operative period (two cases), surgical wound infection (one case). The length of the RA grafts in the intraoperative period was 171 ± 22.5 mm, on average, in GI, and 163.5 ± 24.4 mm in GII (p = 0.414); and the free RA stroke volume, as calculated with a similar mean blood pressure, was 84.6 ± 53.1 ml/min in GI, and 95.5 ± 63.3 ml/min in GII (p = 0.627). There were no differences between the groups as regards pathological examinations.

Angiographic data

Thirty-nine patients underwent cardiac catheterization in the immediate postoperative period. At the moment of the procedure, there were no variations in blood pressure, heart rate, and hematocrit between the groups. The previous global patency between the groups was similar (p = NS), of 100% in GI (n = 19), and of 95% in GII (n = 20); however, perfect patency was different (p = 0.045) due to the fact

Table 1 – Clinical and surgical variables

	Group I (n = 20)	Group II (n = 20)	p-Value
Age (y)	52 ± 6.8	54 ± 5	0.221
Sex (M/F)	17/3	16/4	NS
High Blood Pressure (n)	17 (85%)	19 (95%)	0.605
Dislipidemia (n)	8 (40%)	9 (45%)	0.749
Diabetes (n)	6 (30%)	5 (25%)	0.723
Smoking habit (n)	11 (55%)	10 (50%)	0.752
Stable Angina (n)	17 (85%)	17 (85%)	NS
Previous AMI (n)	3 (15%)	3 (15%)	NS
CPB Time (min)	86 ± 23.76	89.1 ± 21.3	0.862
Anoxia Time (min)	60.5 ± 13.6	64.7 ± 16.9	0.429
Arterial Graft Revasc. (n)	2.2 ± 0.44	2.2 ± 0.4	NS
Total Revasc. Vessels (n)	3.25 ± 0.8	3.15 ± 0.8	NS
RITA (n)	2	4	NS
Saphenous veins(n)	17	15	NS

M: Male; F: Female; AMI: Acute myocardial infarction; CPB: Cardiopulmonary bypass; RITA: Right Internal Thoracic Artery.

that GI presented only one RA graft with non-obstructive stenosis (< 50%), while GII presented five RA grafts with stenosis (Figure 1), in addition to one occlusion (Figure 2).

Quantitative Angiography

The mean proximal diameter of the RA was 2.66 ± 0.11 mm in GI, and 2.53 ± 0.05 mm in GII, with 95% CI (Figure 3).

The average peak velocities in the initial portion of the RA at rest was 18.92 ± 1.75 cm/s in GI, and 18 ± 1.9 cm/s in GII. The RA graft flow reserve was 2.12 ± 0.11 in GI, and 2.01 ± 0.1 in GII (Figure 4). The blood flow in the initial portion of the RA was 54.92 ± 7.66 ml/min in GI, and 44.19 ± 5.13 in GII (Figure 5).

Discussion

The present study did not demonstrate differences between the surgical characteristics of RA grafts. Taggart et al[3] identified some advantages of the skeletonized RA, anticipating clearly its length, providing an option for the surgeon to choose the type of anastomosis (using it for more than one graft, sequentially, or also serving as an extension for other vessels)[3]. In this study, although we did not find any statistical differences between the groups regarding the RA length, skeletonization provided us with a better notion of the graft extension. Rukosujem observed the difference in the length of the skeletonized RA in relation to RAs with adjacent tissues, dissected with the use of scissors and clips[14].

There were no anatomical and pathological differences between the groups. This includes severe endothelial lesion due to electrocauterization and intimal thickening. Rukosujem observed a larger number of endothelial lesions in patients that had RA skeletonized with ultrasonic scalpels[14].

Achouh and Acar[15] discussed the follow-up results of 629 radial artery grafts performed over 20 years. Focal stenosis occurred in 3% of RAs, while string signs were observed in 0.9%. Overall graft patency was 83%. Graft patency decreased exponentially during the first postoperative year, but patency declined at a linear rate with low attrition afterwards, suggesting a lack of radial graft disease[15].

In the present study, the postoperative angiography showed evidences of a similar global patency between the groups, but a difference in perfect patency, due to the larger number of non-obstructive stenosis (<50%) and to an occlusion in the RA grafts with adjacent tissues. Skeletonization allows, thorough more faithful visual inspection, the identification of spasms or areas with lesions, which may not be visible in the grafts with adjacent tissues, thus improving the angiographic quality of the graft.

The difference between the global and perfect patency of the RA with adjacent tissues has been demonstrated since the 1990's by several authors. Parolari et al[16] published a literature review presenting an early global average patency of 98.1%, and perfect patency of 90.8% of RA grafts with adjacent tissues[17]. The authors also reported average global and perfect patency rates of 93.3% and 78.8%, respectively, between 6 and 36 months after surgery. Similar differences were also observed by other authors[18,19].

Corroborating the results of our angiographic investigation, Amano et al, in a non-random series of cases, found RA total patency of 98.6% and 98.8%, respectively, for skeletonized RA and with adjacent tissues; while perfect patency was of 96.5% and 84.9%, respectively[20]. Hirose et al showed early angiographic results of skeletonized RA with ultrasonic scalpels of 96% for perfect patency (free of stenosis), with no differences in comparison to the patency of other arterial grafts[21]. In 2004, Hirose et al also published angiographic outcomes of a one-year follow-up, showing that 20 patients who received skeletonized RA presented a perfect patency rate of 95.2%[22].

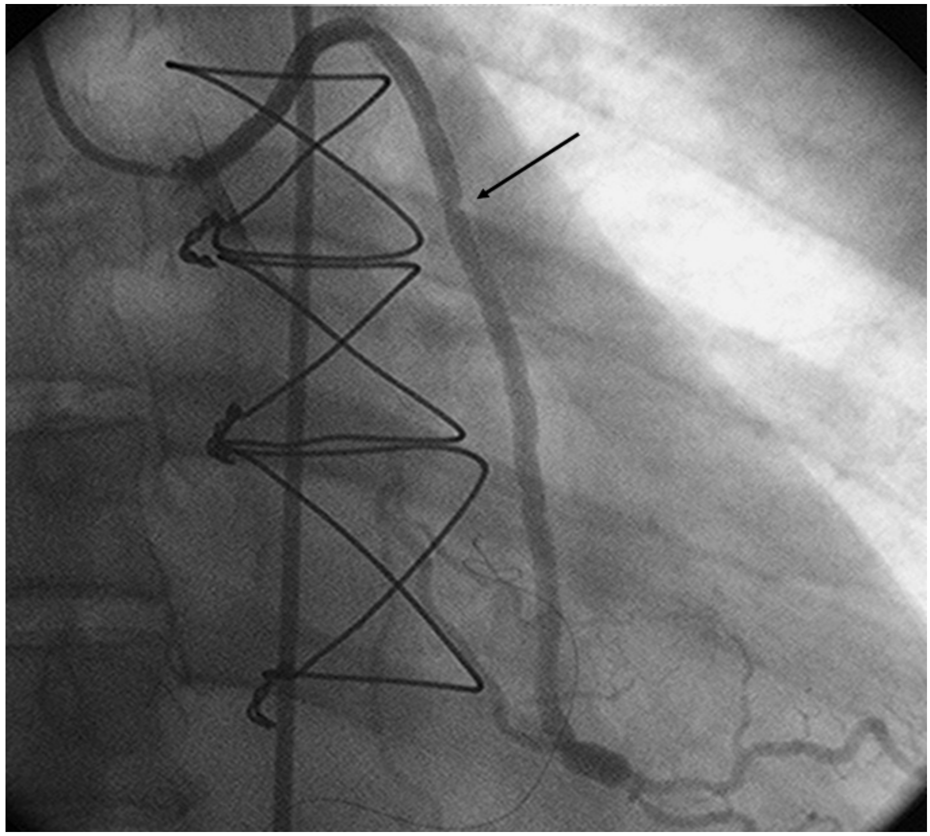

Figure 1 – *Pedicled radial artery with non-obstructive lesion in the proximal third.*

Ali et al concluded that skeletonization of the RA provides valuable patency results. Therefore, if the RA is to be used as a conduit in Coronary Artery Bypass Graft surgery, it may be harvested in either a skeletonized or pedicled fashion, however, their study suggested that skeletonitazion may offer the radial conduit some patency benefit when compared to the pedicled technique[23]. Tokuda et al[24] found that for grafts to the left coronary system, a mean flow < 15 ml/min, and for grafts to the right coronary system, a mean flow < 20 ml/min were predictive of graft failure.

The proximal internal diameters of the RA grafts, as calculated using the quantitative angiographic method were similar in this study. There is no previous information comparing the internal proximal diameter of RAs. However, when this parameter was analyzed in the skeletonized and pediculated LITA using quantitative angiography, a significant increase in the proximal internal diameter with skeletonization was described[5].

Webb et al reported a radial artery diameter by quantitative coronary angiography of approximately 2.7 mm in 15 cases after a 5-year follow-up[25].

In the analysis of the flow variables (intravascular blood flow, average peak velocity, RA graft flow reserve) using intravascular Doppler flowmetry in the immediate postoperative period, we did not observe any statistical difference between the two study groups. The intravascular Doppler methodology employed in this study for the collection of data (blood flow velocity) is highly reliable[13]. The behavior of blood flow of the LITA graft to the left anterior descending artery had already been studied by Akasaka et al using Doppler flowmetry in 1995[26]. They showed that the blood flow was of 62±17 ml/min at rest and the coronary flow reserve, of 1.8 ± 0.3. Similar results were also observed by Gurné et al[27]. Takami and Ina[5] compared two strategies for the dissection of LITA – skeletonized and pediculated, and, using intraoperative flowmetry, they found a superior flow (42.6 ± 29.1 ml/min) of skeletonized LITA in relation to pediculated LITA (26.4 ± 16.1 ml/min)[21]. On the other hand, Rukosujew et al[15] calculated the perivascular free blood flow in 40 patients who received either skeletonized RA or with adjacent tissues, and found no statistical differences between the groups, similar to the results observed in the current study.

Webb et al[25] calculated a mean coronary graft volume blood flow baseline of 35 ml/min in graft radial artery. The coronary flow reserve has also been a variable increasingly used for the assessment of coronary lesions and outcomes of percutaneous interventions. Similarly to average peak velocity, this parameter may display large variations in patients with angiographically normal arteries. Based on the experience with the analysis of coronary flow reserve in LITA, and reported by Webb et al[25], the mean coronary flow reserve in radial graft was 2.3 with the use of velocity measurements.

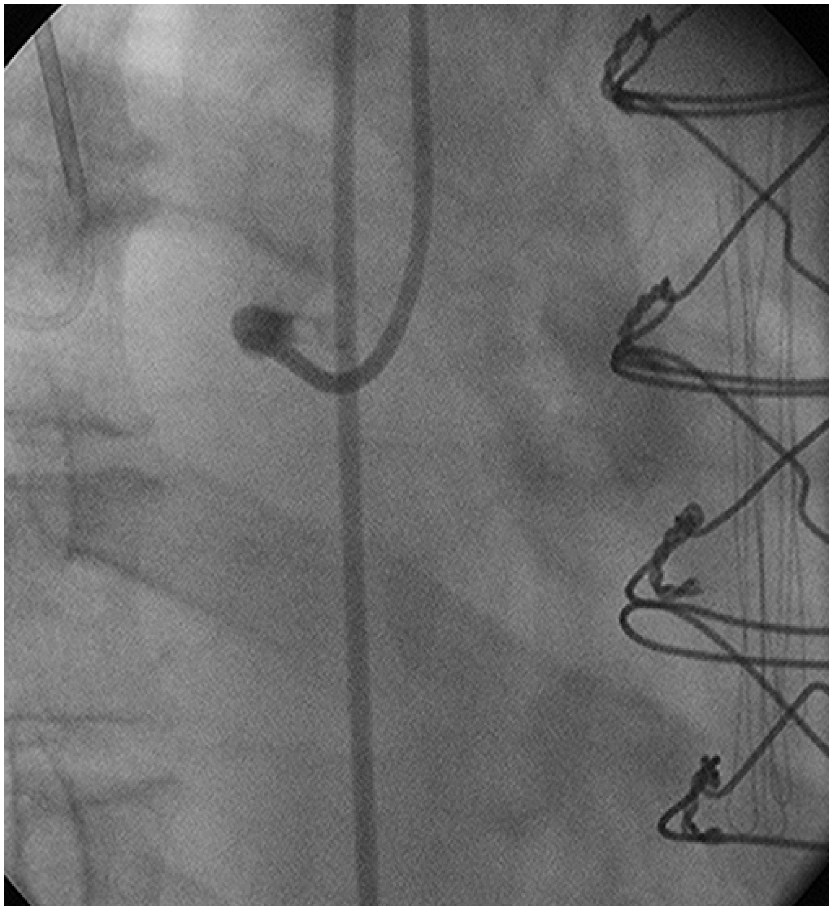

Figure 2 – *Pedicled radial artery proximally occluded.*

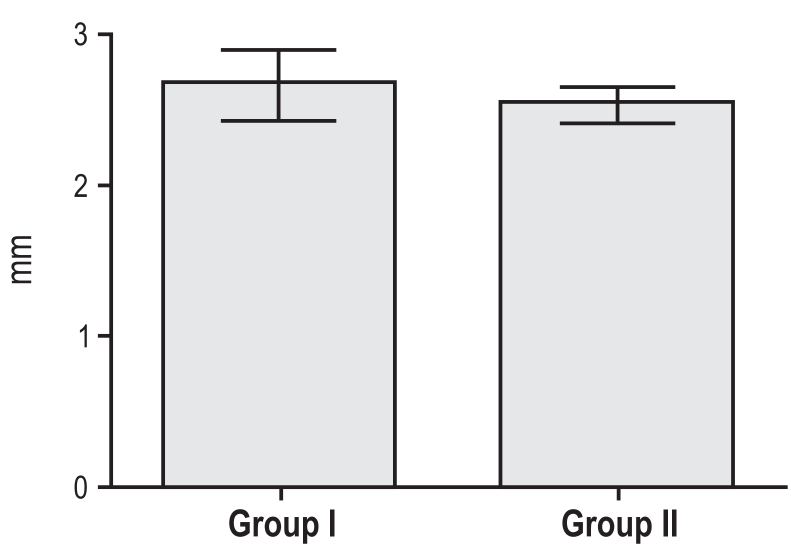

Figure 3 – *Mean proximal internal angiographic diameter of the radial artery (p = 0.492). Mean ± 95% CI.*

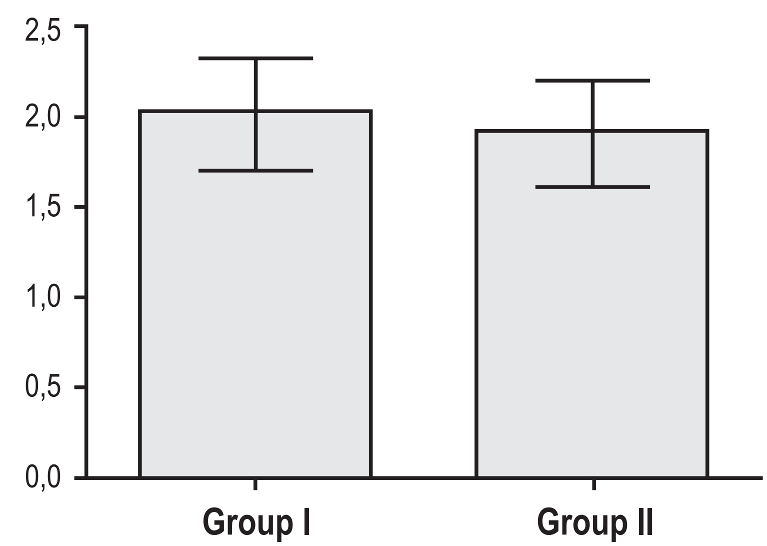

Figure 4 – *Coronary Flow Reserve of the radial artery (p = 0.624). Mean ± 95%CI.*

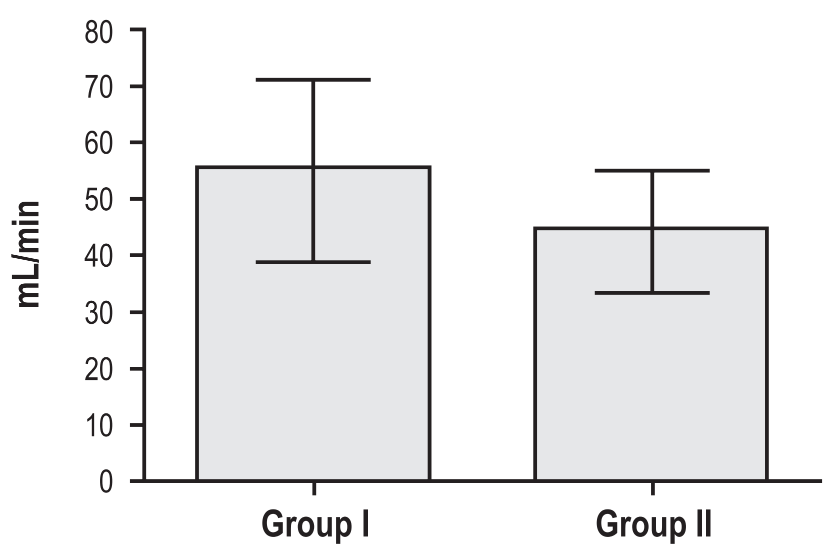

Figure 5 – *Blood flow of the radial artery at rest (p = 0.435). Mean ± 95% CI.*

In this study the RA graft flow reserve was 2.12±0.11 in GI, and of 2.01±0.1 in GII. We can conclude that it was satisfactory in this study, thus demonstrating a significant perspective of RA adaptability to different coronary territories.

In conclusion, the results of the present study, with a selected group of patients, allow us to state that the morphologic, functional and hemodynamic performances of RA aorto-coronary grafts to left coronary branches are similar, whether it is prepared in a skeletonized or pedicled manner. However, the higher frequency of obstruction and stenosis occurring in pedicled grafts may pose a limitation to their long-term performance.

Author contributions

Conception and design of the research and Statistical analysis: Bonini RCA, Moreira, LFP; Acquisition of data and Analysis and interpretation of the data: Bonini RCA, Staico R; Obtaining funding and Writing of the manuscript: Bonini RCA; Critical revision of the manuscript for intellectual content: Bonini RCA, Dinkhuysen JJ, Moreira, LFP; Performed surgery: Issa M, Arnoni AS, Chaccur P, Abdulmassih Neto C, Dinkhuysen JJ, Paulista PP, Souza LCB.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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Study Association

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