Original Article

Radial Artery, Saphenous Vein versus Left Internal Thoracic Artery in Recurrent Ischemic Symptoms after Coronary Artery Bypass Graft Surgery

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Abstract

Background: The long-term results of coronary artery bypass surgery depend mostly on the type of the grafts. For a long time, it has been accepted that arterial grafts are superior to venous grafts. In this study, we evaluated the angiographic patency rates of arterial and venous grafts.

Methods: The study took place between 2003 and 2013 in the Departments of Cardiovascular Surgery in Baskent University. The study included 52 patients with recurrent ischemic symptoms (of total 2183 coronary artery bypass surgery patients) following coronary artery bypass surgery. The patients were evaluated by control angiography during over mid- and long-term postoperative period (mean, 75.25 ± 35.15 months). Based on the angiographic findings, the grafts were divided into 3 groups: severe stenosis, moderate stenosis, and patent.

Results: The preoperative demographics (age, gender, hypertension or diabetes mellitus) were similar in the three groups. The mean numbers of distal anastomoses were 3.27 ± 0.89 (range 2–5), the degree of native coronary artery stenosis for radial artery anastomosis was 79.65 ± 17.72, and the mean numbers of radial artery and saphenous vein grafts were 1.19 ± 0.44 and 1.10 ± 0.89, respectively. The patency rate was 80.77%for radial arteries, 63.2% for saphenous veins, and 82.4% for left internal thoracic arteries in the three groups.

Conclusion: The internal thoracic artery graft was confirmed to be the best option for aorta-coronary bypass surgery, as it has the highest patency rate compared to the other grafts. Radial artery and saphenous vein patency rate were also seen to be similar in the long-term.

Key words: Coronary artery bypass, grafts, recurrent ischemia

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Introduction

Coronary artery bypass graft (CABG) is a standard surgical procedure for advanced coronary artery disease. It is well known to decrease the symptoms and improve survival.[1–3] The long-term patency rate of grafts depends on the progression of atherosclerosis in native coronary arteries.

Grafts are divided into two groups; arterial and venous. As known well, the left internal thoracic artery (LITA) is the preferred graft in myocardial revascularization due to high patency, early and late survival rates. The radial and gastroepiploic arteries may also be considered as alternative arterial grafts. Saphenous vein (SV) grafts are the most commonly used venous grafts. Arterial grafts are superior to venous grafts due to their long-term patency rates. According to the literature, 90% of internal thoracic arteries remain patent 10 years after surgery, while only 50% of SV graft remain patent.[4]

In 1973, Carpentier, et al.,[5] described the first coronary artery surgery using a radial artery (RA). Subsequently, they recommended that RA should not be used due to the 35% incidence of narrowing or stenosis of the conduit.[6] In 1992, Acar, et al.,[7] reported promising mid-term and long-term patency rates for RA and argued that it had gained widespread acceptance as a conduit for CABG as a result of its suitable inner diameter, good length, minimal donor site discomfort, ease of handling, and excellent early clinical results. Improvements in the harvesting techniques and postoperative administration of calcium channel blockers were also expected to improve the results. Today, radial artery as an arterial graft is the second preferred graft after LITA for CABG. In our study, we compared the long term patency rates of arterial and venous grafts by angiography in patients with recurrent ischemic symptoms.

Materials and Methods

From 2003 to 2013, 2183 patients underwent coronary artery bypass surgery by the same team in Baskent University. During the follow-up period, 52 patients were admitted to our department with recurrent ischemic symptoms.

The exclusion criteria were emergency cases, patients in a state of cardiogenic shock (inotropic drugs or intra-aortic balloon pump), patients with ejection fraction below 30%, coronary endarterectomy, patients with left ventricular aneurysm, patients with mechanical complications of the coronary artery disease (like post-myocardial ventricular septal defect or ventricular free wall rupture), combined heart valve surgery and coronary artery bypass (like mitral valve replacement, aortic valve replacement or

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tricuspid valve repair), positive Allen test, Reynaud syndrome or vasculitis, redo CABG, porcelain aorta, off-pump surgery, and patients with bilateral lesions due to the stripping of varicose veins from the lower extremities.

The RA was always harvested from the non-dominant arm and removed as described by Reyes, et al.[8] LITA, RA and SV grafts were harvested simultaneously by the same surgical team. RA was soaked in 150 mL Ringer's lactate solution (containing 5 mg verapamil and 60 mg papaverine) until implanted. Aorta and two stage venous cannulation was performed for all patients. Antegrade crystalloid cardioplegia was administered in patients every 20 minutes in on-pump coronary artery bypass surgery via aortic root cannula. Except for one patient, LITA was used in all patients. The RA was used for the obtuse marginal artery, intermediate artery, or diagonal artery. Sequential anastomosis was not done in any patient.

All patients received 1–10 mg/Kg/min of intravenous nitroglycerin and 1 μg/Kg/hr of diltiazem infusion for 24 hr. Thereafter, they received diltiazem oral therapy at a dosage of 90 mg/day for at least 6 months. All patients received 300 mg of aspirin daily. The patients were taking equal amounts of cardiovascular medication, including aspirin, lipid-lowering drugs, angiotensin-converting enzyme inhibitors, β blockers, and calcium channel blockers, as prescribed by their primary physician.

The patients were evaluated by control angiography at a mean of 75.25 ± 35.15 months. Based on the angiographic evaluations, the patients were divided into 3 groups according to the levels of stenosis; severe (≥ 70%), moderate (20–70%) and patent (< 20%). The study was conducted in accordance with the Declaration of Helsinki on Biomedical Research involving Human Subjects.

Statistical analysis

The results of the tests were expressed as the number of observations (n), mean ± standard deviation (SD), median and min-max values. The results of the homogeneity and normality tests were used to decide which statistical methods to apply in the comparison of the study groups. Levene's test was used to assess the homogeneity of variances in the different groups and the Shapiro-Wilk test was used to test normality in the different groups. Pearson's correlation coefficients were used to determine the relationship between two continuous variables. Normally distributed and with homogeneous variances groups were compared three or more independent groups by Analysis of Variance. According to those tests results parametric test assumptions were not available for some variables, so the comparisons of three or more independent groups by groups were performed by Kruskal Wallis test. Multiple comparison tests, the adjusted Bonferroni test was used. Categorical variables were statistically evaluated by Fisher's exact test and the χ^2 test. Variables found to be statistically significant in the univariate analysis were used in a multivariate logistic regression model with the backward stepwise method in order to determine the independent prognostic factors of radial and saphenous patency rate. In addition, a survival analysis using the Kaplan-Meier method was constructed for all grafts over time and the log-rank test was determined by the difference between the two groups. All statistical analyses were performed with the SPSS software (SPSS Ver. 10.0; SPSS Inc., Chicago IL, USA). A P value of <0.05 was considered statistically significant.

Results

Study Population

The study included 11 females (21.2%) and 41 males (78.8%) with a mean age of 61.15 ± 7.82 years. The most common preoperative co-morbidities were essential hypertension (HT) in 35 patients (67.3%), diabetes mellitus (DM) in 31 patients (59.6%), hyperlipidemia (HL) in 30 patients (57.7%), peripheral arterial disease in 5 patients (9.6%), cardiac failure in 4 patients (7.7%), and chronic obstructive pulmonary disease (COPD) in 4 patients (7.7%). Basic demographic information (age and sex) and medical history (smoking, diabetes, hypertension, hyperlipidemia, peripheral arterial disease, left ventricular ejection fraction (LVEF), and chronic renal failure) were obtained from the patients.

In 52 patients, 62 RA grafts, 57 SV grafts, and 51 left ITA were used. All distal anastomoses were considered independent grafts. The mean number of distal anastomoses was 3.27 ± 0.89 (range, 2–5) the mean number of radial artery grafts was 1.19 ± 0.44 and the mean number of saphenous grafts was 1.10 ± 0.89 (Table 1).

Patency rate for three grafts

The mean patency rate for RA was 80.77% (95% CI, 72.89%–87.96%). Angiography revealed that 49 grafts were patent, while showing moderate stenosis in 2 patients, and severe stenosis in 11 grafts. The patency rate was 63.2% (95% CI, 57.8–68.6%) for SV graft (36 patent and 21 severe stenosis grafts). Finally, for LITA, the patency rate was 82.4% (95% CI, 75.6%–89.2%) displayed by coronary angiography post surgery, with a mean follow-up time of 75 months. There was no significant difference in graft patency between LITA, RA, or SV grafts (P = 0.096). However, when the groups were evaluated as matched-pair groups, the patency rates were not significantly different between RA and SV graft, (RA-SV 0.97 ± 0.15, P = 0.092) or between RA and LITA (RA-LITA 0.21 ± 0.06, P = 0.150), while LITA patency was significantly higher than that of the SV graft (LITA-SV 0.11 ± 0.012, P = 0.001).

The radial artery and saphenous vein graft patency rates did not have any correlation with native coronary arteries (LAD/circumflex/right coronary artery) (95% CI, 76.62%–83.37%, P = 0.339, Pearson's Chi-square test) (Table 2). The radial artery patency rates were not associated with the stenosis of native distal coronary artery (95% CI, 32.26%–44.26%, P = 0.233, Kruskal-Wallis test).

Logistic regression analyses and estimated grafts survival

The results of the univariate and multivariate logistic regression analyses for the RA and SV graft can be seen in Tables 3–4. On univariate analysis, sex and hyperlipidemia for radial artery patency rate and DM and COPD for SV graft were the most prognostic factors. In the multivariate logistic regression model, male sex (odds ratio, 3.013; 95% CI, 0.634–14.316; P < 0.05) and hyperlipidemia (odds ratio, 3.197; 95% CI, 0,674–15,165; P < 0.05), remained independently associated with lower RA graft patency rate (Table 3). Also, DM (odds ratio, 5.0; 95% CI, 0.471–53.040; P < 0.05) remained independently associated with lower SV graft patency rate (Table 4).

Estimated survival with RA at 75 months, calculated using the Kaplan-Meier graft stenosis curve, showed no significant improvement (77.6% for RA patients versus 63.2% for SV graft patients at 75.25 ± 35.15 years; log-rank test, P = 0.264) (Figure 1). Kaplan-Meier survival at 43, 60, and 96 months was 94.2%,

Table 1. Descriptive statistics between graft and target coronary artery.

Descriptive statistics	Minimum	Maximum	Mean	Std. Deviation	First Quartile	Median	Third Quartile
CABG-number	2.00	5.00	3.27	0.89	3	3	4
Radial artery- number	1.00	3.00	1.19	0.44	0	1	2,5
Saphenous vein - number	0.00	3.00	1.10	0.89	0	1	2
LITA- number	0.00	1.00	0.98	0.14	1	1	1
Average radial artery-Cx anastomosis	0.00	2.00	0.93	0.41	0,75	1	1,75
Average radial artery-diagonal anastomosis	0.00	1.00	0.64	0.50	0,25	0,5	0,75
Average radial artery-RCA anastomosis	0.00	1.00	0.83	0.41	0,35	0,65	0,85
Average saphenous vein –Cx anastomosis	0.00	1.00	0.55	0.52	0,25	0,5	0,75
Average saphenous vein –diagonal anastomosis	0.00	1.00	0.73	0.46	0,30	0,60	0,80
Average saphenous vein –RCA anastomosis	0.00	1.00	0.61	0.50	0,25	0,5	0,75

LITA = left internal thoracic artery, CABG = cardiopulmonary bypass, Cx = circumflex coronary artery, RCA = right coronary artery.

Table 2. Analysis between radial artery and saphenous vein patency for target-coronary artery.

Distal coronary artery	Radial artery	Saphenous vein	Total	*P*
Cx				0.06
Severe stenosis (≥70%)	5(11.9%)	5(45.5%)	10(%18.9)	
Moderate stenosis (20–70%)	2(4.8%)	0(0%)	2(%3.8)	
Patent (< 20%)	35(83.3%)	6(54.5%)	41(%77.4)	
Total	42(100%)	11(100%)	53(%100)	
D				0.6
Severe stenosis (≥70%)	5(35.7%)	4(26.7%)	9(%31.1)	
Moderate stenosis (20–70%)	0	0	0	
Patent (< 20%)	9(64.3%)	11(73.3%)	20(%68.9)	
Total	14(100%)	15(100%)	29(%100)	
RCA				0.301
Severe stenosis (≥70%)	1(16.7%)	12(38.7%)	13(35.1%)	
Moderate stenosis (20–70%)	0	0	0	
Patent (< 20%)	5(83.3%)	19(61.3%)	24(64.9%)	
Total	6(100%)	31(100%)	37(100%)	

*Correlation is significant at the $P < 0.05$ level (2-tailed). Cx = circumflex coronary artery, RCA = right coronary artery, D = diagonal artery

Table 3. Univariate and multivariate analysis for predicting radial artery patency.

	Univariate			Multivariate		
Variable	***P***	**OR**	**(95%CI)**	***P***	**OR**	**(95%CI)**
Sex (Males)	<0.05*	1.027	0.921 – 1.146	< 0.05	3.013	0.634 – 14.316
Hyperlipidemia	<0.05*	2.241	0.381 – 13.176	<0 .05	3.197	0.674 – 15.165
Hypertension	0.802	1.326	0.146 – 12.008	0,073	-0,486	0,020 – 18,722
DM	0.833	1.259	0.149 – 10.663	0,189	1,716	0,429 – 72,081
Cardiac failure	0.537	2.473	0.183 – 1.436	0,376	1,472	0,540 – 2,465
COPD	0.203	0.513	0.854 – 0.960	0,519	-1,301	0,471 – 16,496
CRF	0.742	1.663	0.081 – 34.313	0,988	-20,298	-15,745 – -27,685
PAD	0.900	0.345	1.007 – 1.081	0,844	0,348	0,348 – 2,326

*Odds ratio is significant at the $P < 0.05$ level (2-tailed). COPD = chronic obstructive pulmonary disease, CRF = chronic renal failure, DM = diabetes mellitus, PAD = peripheral arterial disease, OR = odds ratio

Table 4. Univariate and multivariate analysis for predicting saphenous vein patency.

	Univariate			Multivariate		
Variable	***P***	**OR**	**(95% CI)**	***P***	**OR**	**(95%CI)**
Sex (Males)	0.814	0.734	0.056 – 9.632	0,841	0,756	0,102 – 4,368
Hyperlipidemia	0.253	3.076	0.448 – 21.098	0,372	2,241	1,145 – 6,144
Hypertension	0.641	0.577	0.057 – 5.814	0,802	1,259	0,562 – 4,245
DM	$P < 0.05$*	2.918	0.352 – 24.167	$P < 0.05$*	5.0	0.471 – 53.040
Cardiac failure	0.210	0.981	0.856 – 7.364	0,537	2,474	1,542 – 6,328
COPD	$P < 0.05$*	2.697	1.027 – 22.364	0,742	0,276	0,089 – 1,325
CRF	0.110	0.154	0.014 – 1.258	0,203	1,663	0,967 – 4,332
PAD	0.912	0.856	0.053 – 13.729	0,999	0,513	0,124 – 1,964

*Odds ratio is significant at the $P < 0.05$ level (2-tailed). COPD = chronic obstructive pulmonary disease CRF = chronic renal failure, DM = diabetes mellitus, PAD = peripheral arterial disease, OR = odds ratio.

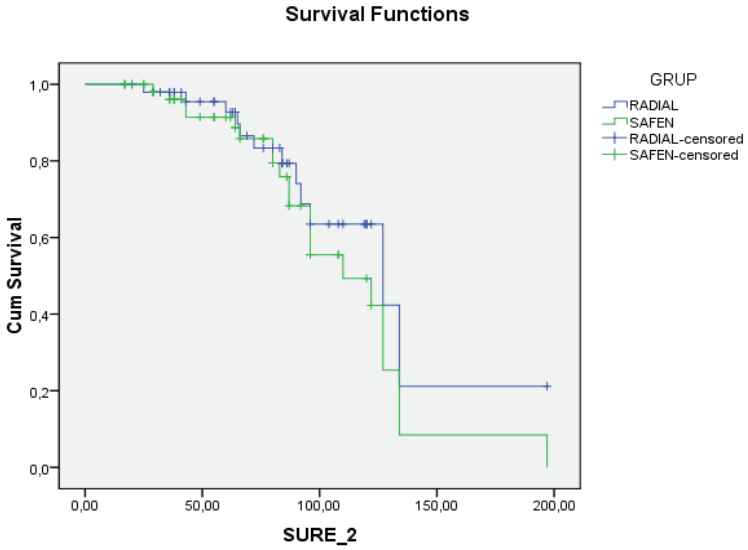

Figure 1. Kaplan-Meier survival curves for radial artery and saphenous vein grafts after coronary artery bypass surgery.

91.7%, and 64.6% for the RA group versus 91.4%, 88.7%, and 55.5% for the SV graft group, respectively (log-rank test, $P = 0.264$). Percutaneous intervention (balloon angioplasty and/or stent implantation) was necessary in 11 patients while reoperation was necessary in only 3 patients at a mean time interval of 75.25 ± 35.15 months after the first surgery.

Discussion

Much attention has been directed towards male sex and hyperlipidemia as independent risk factors for RA graft patency rate versus DM for SV graft. Another significant finding was that RA and SV graft patencies were similar in the long-term. LITA grafts must be the first choice due to their superior patency rates. However, the second best conduit for CABG is still debated. Buxton, et al.,[9] reported that in patients younger than 70 years of age, RA grafts may not be superior to SV grafts. Recently, a prospective, randomized RAPS study was reported by Desai, et al.,[10] and RA was found to be superior to SV graft in terms of one-year patency rates (stenosis rate of 8.2% for RA vs. 13.6% for SV graft). Various arterial grafts have been adopted over the past 30 years. Usage of the RA was abandoned due to early angiographic results until Acar, et al., during a 2-year follow-up period, detected that the patency rate was 93% with administration with Ca antagonists and aspirin.[7] The advantages for RA graft are the adaptation of arterial blood pressure in diabetic and obese patients, as well as being harvested more easily and carrying a lower risk of infection compared to the SV graft.

Coronary artery graft stenosis is usually multifactorial. It may be associated with graft selection, graft contest with native vessels,[11,12] the distal vascular bed,[11] surgical technical errors in the proximal or distal anastomoses, or in the preparation technique. The RA is more prone to vasoconstriction than other arterial grafts due to its intensely muscular medial layer. Vasoconstriction is the most important reason for early graft stenosis and various vasodilator agents (verapamil, nitroglycerin, and papaverine) are used to prevent this complication. It is recommended that oral calcium channel blockers are used for at least one year for vasodilation.[13] After the first year, Ca channel blockers are not important in terms of the clinical outcome of the patency rate of the RA.[14]

A complete RA string sign was defined as diffuse narrowing along the full length of the graft. Risks were perioperative alpha-adrenergic agonist drugs usage and anastomosing in native coronary artery stenosis less than 90%. In this way, the coronary target locations play a role in RA patency rate. We did not detect any string sign in our patients. We anastomosed the RA in demanding situations by stipulating that the proximal target-vessel stenosis exceed 70% (average, 79.65% ± 17.72%).

In the literature, RA patency rate was higher for the diagonal artery (93.1% [95/102]) compared with the circumflex (82.5% [274/332, $P < 0.01$]) or the right coronary artery (77.6% [146/188, $P < 0.001$]).[15] Moran, et al., detected that it was similar to the rate of RA patency rate in different regions.[16] We generally used the RA on the circumflex or diagonal artery system, and found that the radial artery and saphenous vein patency rate was similar between the different coronary arteries.

Proximal anastomoses can be performed on the aorta or other vascular grafts (proximal RA anastomoses were performed on the aorta in all patients except for one). There are different studies exploring graft patency in the literature. Some authors have shown good results with RA, using the proximal anastomosis onto the aorta, by always considering the short-term studies.[17] However, several reports concluded that the proximal anastomotic site did not influence the patency rate of RA.[18,19]

Female sex was shown to be a risk factor after CABG in several studies.[20,21] In the literature, the patency rate of RA grafts was correlated to DM (detrimental), sex (women had higher stenosis rates), and use of angiotensin converting inhibitors (beneficial).[22] In our study, we also found that females carried a higher risk of RA patency rate in the long-term. However, patency rates of SV grafts did not differ between the sexes in our study.

In the literature, several authors have reported the impact of hyperlipidemia on the SV graft. For example, lowering low density lipoprotein cholesterol (LDL-C) to below 100 mg/dL has been shown to be effective for slowing the progression of SV graft atherosclerosis.[23] Statin therapy initiated in the early months after hospital discharge independently reduces all-cause mortality and major adverse cardiovascular events after CABG.[24] Although

there has been limited research on the outcomes of RA patency rate with hyperlipidemia, in our study, male sex and hyperlipidemia emerged as independent predictors of long-term RA patency rate outcomes following CABG.

Diabetes is a known risk factor for long-term survival. Singh, et al.,[25] indicated in their article that CABG stenosis was more common among diabetics than nondiabetics on the first year angiography, mainly due to a higher frequency of SV graft stenosis in diabetics. Additionally, the patency rate in diabetic patients was seen to occur more frequently in RA grafts than SV grafts in the first year after coronary artery bypass.[25] In our study, we also confirmed that DM was a risk factor for SV graft patency rate.

In conclusion, RA and SV grafts and LITA patency rates are comparable. Male sex and hyperlipidemia negatively affected RA patency rate, whereas DM negatively impacted SV grafts. As such, in cases involving diabetic patients, we believe that the RA should be the second choice graft after ITA, in contrast to the literature.[25] However, the SV graft may be preferred for male patients as suggested by previous studies.[26] The RA graft patency rate has been reported to be sensitive to both target location and proximal target stenosis, but we did not observe this. We believe that patient selection, harvesting, and operative techniques play a more definitive role. During long-term follow-up, non-surgical factors including hypercholesterolemia, risk factor modification (such as diet and smoking cessation), and discharge therapies (including antiplatelet and lipid-lowering agents) affects the grafts patency rate. Further studies including larger sample sizes are needed to support these findings.

Study Limitations

This was an inherently retrospective observational study that included only a small number of patients. There may be one more limitation about graft patency. Graft patency rates seen in the normal population may not be observed in our study, because patients with recurrent symptoms were included.

Declaration of conflicting interests

The authors declare no conflicts of interest with respect to the authorship and/or publication of this article.

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