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Comparison of the right internal thoracic artery and radial artery as a second arterial conduit in 'Y' composite fashion in patients undergoing coronary artery bypass grafting usingtotal arterial revascularization

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ABSTRACT

Introduction: The use of two arterial conduits for CABG is rapidly increasing. The second arterial conduit to LITA is usually RITA or radial artery. We sought to compare outcomes when either RITA or radial artery is exclusively used as a Y composite graft to LITA for total arterial revascularization.

Material and methods: We retrospectively analyzed 231 patients who underwent CABG in the period from 2010 to 2014. RITA was used in 178 patients (RITA group) and radial artery was used in 53 patients (radial group).

Results: Radial was used more frequently in female patients and in diabetic patients. Radial group had comparable number of distal anastomoses and lesser operative time to RTIA group. Early postoperative outcomes (low cardiac output syndrome, post-operative myocardial infarction, use of intra-aortic balloon pump, post-operative stroke, re-explorations, incidence of deep sternal wound infection and death) were all comparable in both the groups. Late deaths and need for repeat revascularization were also similar in both the groups for up to 4 years after surgery. Only the incidence of major acute cardiac and cerebrovascular events (MACCE) was more in the radial group.

Conclusion: Radial artery has comparable short- and mid-term outcomes to RITA when used as a second arterial conduit in CABG. Its use should be especially considered in diabetic patients when DSWI is a concern.

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Introduction

Total arterial revascularization (TAR) is emerging as a comparable grafting strategy to the conventional approach of the internal thoracic artery and saphenous vein grafts(SVG) in patients undergoing coronary artery bypass grafting (CABG)(1–3). The use of two arterial conduits for complete revascularization is rapidly increasing. The second conduit used in TAR is usually the right internal thoracic artery (RITA) or the radial artery (RA) (4). The grafting strategy can use the second conduit as a Y composite graft to the left internal thoracic artery (LITA) or as a free graft from aorta (4). The present study aimed to compare the patient

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outcomes in patients undergoing CABG using RA or RITA as the second arterial conduit in a Y composite fashion.

Materials and Methods

Data of patients who underwent CABG from 2010 to 2014 at LokmanyaTilak Municipal General Hospital, Sion, Mumbai, Indiawere retrospectively analyzed. All patients who underwent CABG using either the RITA or RAas a Y composite graft to LITA were included in the present study. The subjects were assigned into two groups of RITA and RA.

The exclusion criteria were: 1)proximal end of RITA or RA grafted to aorta,2) presence of SVG, 3) emergency surgery, redo surgery, and CABG combined with other heart surgeries (e.g., valvular,aortic root), 4) history of preoperative myocardial infarction(MI), 5)New York Heart Association classat the time of admission, 6) sign of hypertension, diabetesmellitus, andpreoperative renal dysfunction, 7) addiction to smoking, and 10) obesity.

The intra-operative variables that were compared in the present study included an average number of grafted target vessels, duration of surgery, and use of blood products. To avoid cardiopulmonary bypass (CPB) as a confounding factor, only surgeries that were performed by off-pump coronary artery bypass (OPCAB) without the use of CPB were included.

Early postoperative outcomes include low cardiac output syndrome (LCOS), postoperative myocardial infarction (MI), use of intra-aortic balloon pump (IABP), post-operative stroke, re-explorations, incidence of deep sternal wound infection (DSWI), and death.

Mortality after 1 year of surgery, major adverse cardiac and cerebrovascular event (MACCE), and the necessity to repeatrevascularization were among the long-term outcomes which were analyzed in the present study. Follow-up data were checked until 4 years after the surgery. In-patient registries, operative notes, discharge summaries, records of outdoor patient departments were obtained for the current study. Since the present research was a retrospective study, permission of the Ethics Committee and patient consents were waived off. Categorical variables were presented as frequencies and percentages and, were compared using the chi-square or Fisher's exact tests. Continuous variables were expressed as mean or medians with ranges and were compared by the Student's independent t-test.A confidence interval of 95 % was considered in the entire study. A p-value of less than 0.05 was considered statistically significant. Statistical analysis was done by using SPSS version 20.

Surgical technique

All surgeries were performed by surgeons with at least 5 years of experience inperforming the off-pumpCABG technique. The use of either RITA or RA was at the surgeon's discretion. The LITA and RITA were harvested in skeletonized fashion in all the patients. The RA was used only after confirmation of the patent deep palmar arch by 'Allen's test'. The RA was harvested by open technique in a pedicled fashion. The RITA or RA was anastomosed to LITA in an end to side fashion. The LITA was grafted to left anterior descending artery in all cases and the left circumflex and right coronary artery (RCA) territories were grafted with the other conduit in sequential manner.

As per our institution's protocol, arterial grafts to vessels other than LAD were constructed only if the target vessel had more than 80% stenosis. Expect for LAD, other vessels with 70-80% stenosis which received venous grafts were excluded from the current study. All the selected cases were performed without the use of CPB. Standard treatment to prevent spasm of the arterial grafts consisted of soakage of the free grafts in a solution containing verapamil, **nitroglycerin**, and heparin. In addition, nicorandil is administrated both orally and intravenously to prevent arterial spasm in the post-operative period.

Definitions

1. The RITA anastomosed to LITA in a 'Y' composite fashion is denoted as 'LITA-RITA Y'. Similarly, Radial LITA anastomoses are referred to as 'LITA-RAD Y'.
2. Obesity was defined as body mass index>30 kg/m^2.

Post-operative low cardiac output syndrome (LCOS) was defined as a requirement of

either dopamine, dobutamine, adrenalineor IABP to maintain a systolic blood pressure higher than 90 mmHg and cardiac output greater than 2.2 L/min/m−2 for at least 30 min in the intensive care unit(4).

3.Post-operative/(MI) was defined as the appearance of new pathological Q-waves, new left bundle branch block and/or **c**reatinekinase**-**MB values above 5 times the 99th percentile of the normal reference range during the initial 72 h following CABG(5).

4.Deep sternal wound infection (DSWI) was defined as positive culture results of surgical sites or drainage from the mediastinal area or evidence of infection during surgical re-exploration or fever, sternal instability, and positive blood culture results(6).

5.Major adverse cardiac and cerebrovascular event (MACCE) was defined as the composite of death, MI, cerebrovascular accident or stroke(7).

Results

A total of 603 patients underwent CABG in the study period. About 231 patients had undergone either LITA-RITAY (RITA group) or LITA-RAD Y(RA group). Out of these 231patients, 178(77%) underwent LITA-RITA Y and 53(23%) underwent LITA RAD Y.

The mean age scores were comparable in both groups, as they were measured at 58.19±14.8 and60.47±17.4 in the RITA and RA groups, respectively (P=0.0628). More females received RA (19/53) than RITA (29/178) (P=0.0035). History of previous MI was present similarly in the RITA (110, 61.7%) and (28, 52%) RA group (P=0.2662). Diabetes was observed more frequently in the RA group (24, 45%) than the RITA group (52, 29%) (P=0.0288). Hypertension, history of smoking, obesity, and preoperative renal failure were not significantly different in both groups. The pre-operative ejection fraction (EF) was also comparable in both groups, as it was estimated at 40.73±10.82 and41.60±10.82in the RITAandRA groups, respectively (95% CI=-4.21 to 2.46; P=0.6067). The pre-operative data is presented in Table 1

Table 1. Comparison of pr-operative variables between RITA and RA groups

	RITA	RA	P-value
Number (231)	178(77%)	53(23%)	
Age(in years in mean +/- SD)	58.19±14.8	60.47±17.4	0.0628[1]
Male/Female	149/29	34/19	0.0035[2]
Previous MI	110(61.7%)	28(52%)	0.2662[2]
Diabetes Mellitus	52(29%)	24(45%)	0.0288[2]
Hypertension	95(53.3%)	26(49.05%)	0.3236[2]
Smoking	119(66.8%)	32(60.3%)	0.384[2]
Obesity	77(43.2%)	27(50.9%)	0.406[2]
Renal Impairment	21(11.7%)	5(9.4%)	0.632[2]
NYHA 2	147 (63.7 %)	48 (20.8%)	0.228[2]
NYHA 3	21 (9.1%)	2 (0.9%)	
NYHA 4	10`(4.3%)	3 (1.3%)	
Pre-Op EF(% in Mean± SD)	50.7±10.82	51.6±10.8	0.606[1]

RITA: Right Internal Thoracic Artery, MI: myocardial infarction, NYHA: New York Heart Association classificationPre-Op EF: pre-operative ejection fraction**,** 1: student's independent t test, 2: Chi square test

Intra-operative data

On average 3.69target vessels were grafted. The RAgroup had a similar number of distal anastomoses (3.86±2), comparedto the RITA group (3.63±1.71). Operative time was significantly higher in the RITA group (107.76±15.1 vs. 102.22±16.36).

Moreover,the use of blood products was similar in both groups. The intra-operative data is presented in Table 2.

Table 2. Intraoperative variables between RITA and RA groups

	RITA (178)	RA (53)	P-Value
No. of distal anastomoses	3.63±1.71	3.867±2.0	0.105
Operative time (in minutes)	107.76±15.1	102.22±16.36	0.0001
Use of blood products (1 or more Blood Transfusion/No BloodTransfusion)	32/146	10/43	0.842

RITA: right internal thoracic artery

Early postoperative outcomes

Post-operative LCOS was detected in 21(11.7%) of casesin the RA group and in 7(13.2%) of cases in the RITA group (P=0.811). Moreover, the IABP was more frequently used in the RA group (n=10, 5.6%), compared to the RITA group (n=4, 7.5%)(P=0.53). Out of five patients who had MI in the postoperative period, four patients had received RA and only one had received RITA (P=0.132). Furthermore, re-exploration for bleeding was performed on three patients in the RITA group. No patient underwent re-exploration in the RA group. In addition, the incidence rate of stroke was low. Only one patient from the RITA group in the entire cohort had a stroke. Overall DSWI was observed in 7(3%) patients, all had a history of diabetes. The DSWI was more frequent in the RITA group, six patients in the RITA group versus one patient from the RA group (P=0.68).

Sternal re-wiring was required in three patientsin RIMA group. Four patients died in the early postoperative period, two from each group. Three patients had MI, two from the RA group and one from the RITA group. The other cause of death in the RITA group was due to septic shock. Out of five patients suffering from MI in the postoperative period, three died before undergoing any intervention. The remaining two patients underwent angioplasty of the culprit's vessel on post-operative 4th and 5th days. All postoperative outcomes were comparable in both groups and no statistical difference. There were no ischemic complications of the upper limb in the RA group. The early postoperative results are shown in Table 3.

Table 3. Early postoperative results between RITA and RA group

	RITA(178)	Radial(53)	P-value
LCOS	21(11.7%)	7(13.2%)	0.811
IABP use	10(5.6%)	4(7.5%)	0.53
MI	1(0.5%)	2(3%)	0.132
Re-exploration	3(1.6%)	0	1.0
DSWI	6(3.3%)	1(1.8%)	0.68
Early death	2(1.1%)	2(3.7%)	0.2303

LCOS: Low Cardiac Output Syndrome
IABP: Intra-Aortic Balloon Pump
MI: Myocardial Infarction
DSWI: Deep Sternal Wound Infection

Late outcomes

The patients' follow-up data were recorded for up to 4 years after the surgery. Late death occurred in five patients, two from the RA group and three from the RITA group. The MACCE occurred in six patients (including three deaths) form the cohort. Five were from the RA group and one from the RITA group. In addition, three patients from the RA group had late MI. Another patient from the RITA group had stroke. Overall six patients required repeat revascularization. Four patients from the RA group required percutaneous transluminal coronary angioplasty within 4 years. Another two patients from the RITA group required revascularization. One underwent PTCA and the other repeated the CABG. Only the incidence of MACCE was found to be statistically significant in the late outcomes. The late outcomes are presented in Table 4.

Table 4. Late events between RITA and RA groups

	RITA(178)	Radial(53)	P-value
Late death	3(1.6%)	2(3%)	0.32
MACCE	1(0.4%)	5(9%)	0.027
Repeat revascularisation	2(1%)	4(7%)	0.226

MACCE: Major Adverse Cardiac and Cerebrovascular Event

Discussion

The TAR is recently considered a superior strategy for CABG (1,2). Several studies have shown good long-term patency of arterial grafts, compared to venous grafts (8,9).The second arterial conduit can be either RA, RITA or the less frequently used gastroepiploic artery (9).

The RITA is an excellent second arterial conduit after LITA. It was first used as an in situ graft to RCA by Kolessov in 1964 (10). Since then it has been extensively used as a free graft from the aorta or in situ graft in CABG. However, the major utility of RITA was proved by Sauvage in 1986 when he demonstrated the LITARITAT or Y composite grafting technique (11). The RITA as a composite graft to LITA is emerging as the strategy of choice in total arterial revascularization. The patency rates of RITA have been shown to be comparable to LITA in randomized studies(12–14). The excellent performance of RITA can be attributed to its histological similarity to its left counterpart and inherent resistance to arteriosclerosis (15,16). However, the concern for sternal dehiscence with the use of bilateral internal thoracic arteries, especially in diabetic patients is a valid concern. There are a few studies suggesting that the use of skeletonized bilateral internal thoracic arteries in CABG does not increase the odds of sternal complications. However, most of the large studies and randomized trials have shown that bilateral internal thoracic artery(BITA) harvest is associated with sternal wound complications (3,17–19). Even in the present study, there was a 3.3% incidence of DSWI in the RITA group against 1.8% in the RA group. However, the results in this regard were not statistically significant.

The RA was the most commonly used second arterial graft in previous decades. It was initially used in CABG by Carpentier (10).Although its use had decreased due to the concern of vasospasm, its usage has increased again due to the use of antispasmodic drugs(20). There is a general consensus that the RA should be used only if the target coronary artery has more than 70-80% stenosis (1–3). The proximal end of RA can be a variable. The present study included only patients in whom the proximal end was constructed on the LITA. More commonly it is constructed on the aorta either directly or with a vein cuff. Less frequently the proximal end can be anastomosed to the in situ RITA. Evidence suggests that the site of proximal anastomoses does not affect the patency of the RA (21–23).

In terms of operative time, the use of RA has a natural advantage over RITA, as it can be harvested simultaneously with LITA. In the present study, the operative time was significantly lower in the RA group. Based on the findings of the current study, it was found that the number of distal anastomoses in the RA group was similar to the RITA

group. In a long-term study performed by Ruttmann et al., on comparing the BITA against LITA+RA, similar mean grafts were measured at 3.2±0.87 and 3.2±0.90in the BITA±SVG and LITA+RA±SVG groups, respectively (P=0.14)(24). However, their inclusion of SV Gin both groups could have altered the total number of grafts in each group. In another propensity analysis, Tranurgh et al. demonstrated significantly higher number of arterial grafts per patient in the RITA group against the RA group. However, more sequential grafting of LITA in the RITA group (43%) was performed against the RA group (3.8%) in their study(25). Caputo et al. demonstrated higher number of arterial grafts on the left side (LAD and LCx territory) in the RA group than in the RITA group(26).

The superiority of RA over venous grafts has been well established. In a patient-level meta-combined-analysis of randomized controlled trials, Guadino et al. proved that the use of RA grafts in CABG instead of the SVG resulted in a lower rate of adverse cardiac events and a higher patency rate at 5-year follow-up (27). The Radial Artery Patency Study also showed that RAs are associated with reduced rates of functional and complete graft occlusion, compared to SVGs>5 years post-surgery (28).

Few studies compared the clinical outcomes of the RA with RITA. Based on the current findings, it was found that the postoperative LCOS, MI, and early deaths were similar in both groups. In the case of late outcomes, late deaths and the need for repeating the revascularization were similar; however, the incidence of MACCE was higher in the RA group. Caputo et al. in a non-randomized prospective trial reported that RA is superior to RITA in terms of cardiac-related event or death (26).Ruttmann et al. in a retrospective analysis showed that the use of RITA was associated with better outcomes than RA when perioperative MI, stroke, and MACCE were taken into account. However, they had included SVGs in both groups and matched groups showed higher incidences of COPD and lower EF in the RA group (24).

In another retrospective analysis conducted by Navia et al., it was revealed that the usage of RITA has a lesser re-intervention rate than the RA (29). Tranbaugh et al. compared the RITA and RA which were grafted to the circumflex territory after LITA was anastomosed to the LAD. Their study showed a similarity between RA to RITA in terms of long-term survival. They found better survival rates in COPD patients and lesser major adverse events in the RA group (25). In the mid-term results of the Radial Artery Patency and Clinical Outcomes randomized trial, Haward et al. showed comparable outcomes in younger patients receiving either RA or RITA (30). In a recent large meta-analysis carried out by Guadino et al., it was concluded that use of the RITA or RA was associated with a similar late and operative mortality and postoperative complications. They also mentioned that after the use of BITA, DSWI is a matter of concern (31).

Limitations

The present study was a retrospective single centre study with a small cohort of patients. Postoperative angiography to determine graft patency was performed only in symptomatic patients and was not performed routinely as a part of the study.

Conclusion

Based on the obtained findings, the RA was an effective second arterial conduit in comparison with LITA in patients undergoing CABG. In addition, the RA had comparable short- and mid-term outcomes, compared to RITA. Consequently, the use of RA should be highlighted especially in diabetic patients with DSWI.

Conflicts of Interest:

The authors declare that there is no conflict of interest.

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