The Egyptian Cardiothoracic Surgeon

DOI: 10.35810/ects.v5i5.269

Vol. 5, No. 5, 85 - 90

Original Article

Multiple arterial grafts for total arterial coronary artery bypass grafting vs. the conventional approach

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Abstract

Background: Conduit choice for coronary artery bypass grafting (CABG) is a hot topic. The objectives of this study were to characterize the patients who received multiple arterial grafts vs. vein grafts; additionally, we compared the outcomes in those patients.

Methods: This retrospective study included 195 consecutive patients who underwent CABG. We grouped the patients into three groups according to the conduits used with the left internal mammary artery (LIMA). Group I had saphenous vein grafts (SVG) (n= 31), Group II had radial artery grafts (RA) (n= 86), and Group III had the bilateral internal mammary artery (BIMA) plus RA (n= 78).

Results: The patients with multiple arterial grafts were significantly younger (64.87±8.2 vs. 68.42±9.03 vs. 61.76±8.6 years, in the SVG, LIMA_RA, and BIMA+RA groups, respectively, P<0.001). Off-pump surgery was significantly more prevalent in patients with LIMA+RA (P= 0.01). Postoperative drainage was significantly higher in patients with BIMA+ RA compared to LIMA+RA (P= 0.006), with no significant difference between BIMA+ RA and LIMA+SVG (P= 0.081). Sternal wound infection was non-significantly higher with multiple arterial grafts (P=0.09). There was no difference in other hospital outcomes among groups. The median follow-up was 59 (47-66) months. The composite endpoint of recurrent angina, myocardial infarction, coronary revascularization, and heart failure occurred in 17 patients [4 (12.9%) vs. 8 (9.30%) vs. 5 (6.41%), in the vein graft, one arterial and two arterial grafts groups, respectively] (P=0.484). Mortality occurred in 7 patients, [1 (3.23%) vs. 4 (4.65%) vs. 2 (2.56%), in the vein graft, one arterial, and two arterial grafts groups, respectively] (P= 0.834).

Conclusions: Total arterial revascularization with multiple arterial grafts could increase postoperative drainage and sternal wound infection, with no difference in the short and long-term outcomes compared to single arterial and vein grafts. The choice of the conduit for coronary artery bypass grafting should be tailored according to the patient's characteristics.

KEYWORDS

Coronary artery bypass grafting; Total arterial revascularization; Radial artery; Internal mammary artery

Article History

Submitted: 28 Feb 2023

Revised: 30 Mar 2023

Accepted: 7 Apr 2023

Published: 1 Sep 2023

Introduction

Coronary artery bypass grafting (CABG) is still the main revascularization strategy for patients with multi-vessel disease [1]. The left internal mammary artery (LIMA) has been the standard graft for patients undergoing CABG with left

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anterior descending artery (LAD) disease [2]. The debate about the second conduit continues. Several studies have shown that using a second arterial conduit with LIMA could be associated with improved outcomes [3]. Possati and colleagues reported a good radial artery (RA) patency rate after ten years of follow-up [4]. In a meta-analysis, bilateral internal mammary arteries had superior survival benefits compared to LIMA alone [5]. The outcomes of CABG improved when the radial artery was used compared to the saphenous vein graft (SVG) [6]. This finding could be attributed to improved survival and decreased incidence of graft occlusion, recurrent angina, myocardial infarction, and revascularization associated with arterial grafts [4].

However, using RA was associated with harvesting site complications and arterial spasms [7]. Using the right internal mammary artery (RIMA) could improve long-term outcomes, although it could increase the risk of sternal wound infections [8,9]. Moreover, the benefits of using multiple arterial grafts have not been proven. Rocha and associates reported that CABG with three arterial grafts did not increase hospital complications. Although there was no difference in the long-term outcomes between 2 and 3 arterial grafts; however, multiple arterial grafts were superior to single arterial grafts regarding survival, myocardial infarction, and repeated revascularization [10]. Therefore, the objectives of this study were to characterize the patients who received one vs. two arterial grafts for total arterial revascularization plus LIMA. Additionally, we compared the outcomes of total arterial revascularization with one (LIMA+ RA) vs. two different arterial grafts (LIMA+RIMA+RA) vs. the conventional method (LIMA+ SVG).

Patients and Methods

This retrospective study included 195 consecutive patients who underwent CABG between 2010 and 2022. In this study, we grouped the patients into three groups according to the conduits used with LIMA. Group I had SVG (n= 31), Group II had radial artery (n= 86), and Group III had RIMA+RA (n= 78). We excluded patients with single graft (LIMA to LAD only), end-organ failure, concomitant cardiac procedure, and redo surgery. The choice of grafts was based on surgeons' preferences and experience. The Local Ethical Committee approved data collection for this study, and the need for patient consent was waived because of the retrospective design.

Data and outcomes:

Data collection for this study was from the paper and electronic charts and the electronic CABG registry. Preoperative data included age, gender, associated comorbidities, ejection fraction, left-main disease, and EuroSCORE. Study outcomes were hospital complications and mortality. The long-term outcomes were survival and the composite endpoint of recurrent angina, myocardial infarction, coronary revascularization, and congestive heart failure. The diagnosis of MI was established with ECG (new Q-wave- ST elevation), increased cardiac enzyme levels (CK-MB and troponin), and echocardiography (wall motion abnormalities). A stroke is a permanent neurological deficit lasting>24 hours. Renal impairment was defined as an increase of postoperative creatinine >1.5 than the preoperative value or the need for dialysis. Hospital outcomes occurred during the same hospital admission or within 30 days of the operation.

Techniques:

All patients had surgery through median sternotomy, and LIMA and RIMA were harvested in a skeletonized fashion. Harvesting of SVG and RA was performed via an open approach. In patients with RIMA graft, it was used as an in-situ graft in 64 patients (82%) and a free graft in 14 patients (18%). Patients who had RA received postoperative Ca-channel blockers. Our protocol was to stop antiplatelets for five days before surgery. All patients were discharged on dual antiplatelet therapy. Patients had regular follow-ups at the outpatient clinic after 1, 6, and 12 months then yearly.

Statistical analysis

One-way Analysis of Variance (ANOVA) was used to compare continuous data between the three groups in case of equal variance and Kruskal-Wallis in case of unequal variance. Post-hoc

Table 1: Comparison of the baseline data among the study groups. Data were presented as mean and SD, median (IQR), or numbers (%) when appropriate.

	LIMA+ SVG (n= 31)	LIMA+RA (n= 86)	BIMA+RA (n= 78)	P-value
Male	15 (48.39%) P1-2: 0.045	59 (68.60%) P2-3: 0.004	68 (87.18%) P1-3: <0.001	<0.001
Age (years)	64.87± 8.2 P1- 2: 0.161	68.42± 9.03 P2-3: 0.282	61.76± 8.6 P1- 3: <0.001	<0.001
Diabetes mellitus	12 (38.71%)	21 (24.42%)	23 (29.49%)	0.315
Peripheral arterial disease	6 (19.35%)	19 (22.09%)	11 (14.10%)	0.416
Cerebrovascular disease	1 (3.23%)	5 (5.81%)	0	0.076
Previous myocardial infarction	14 (45.16%)	44 (51.16%)	44 (56.41%)	0.547
Ejection fraction	56.03± 15.04	55.47± 12.38	59.74± 13.15	0.100
Stable angina	15 (48.39%)	45 (52.33%)	39 (50%)	0.918
Unstable angina	16 (51.61%)	41 (47.67%)	39 (50%)	0.918
Left main disease	11 (35.48%)	23 (26.74%)	21 (26.92%)	0.617
Logistic EuroSCORE	2.87 (2.24- 5.47) P1-2: 0.139	4.43 (2.1- 8.29) P2-3: <0.001	2.09 (1.51- 4.39) P1-3: 0.032	0.023

P1-2: p-value between group 1 (LIMA+ SVG) and 2 (LIMA+ RA), P2- 3 (BIMA+ RA): p-value between group 2 and 3

BIMA: bilateral internal mammary artery, LIMA: left internal mammary artery; RA: radial artery; SVG: saphenous vein graft

analysis was done for variables with significant differences between groups using Bonferroni or Dunn's test when appropriate. Description of continuous data was done as mean and standard deviation or median and interquartile range according to the Gaussian distribution. The Chi-squared and Fisher Exact tests were used for nominal data and were described as numbers and percentages. Time to events data were described using Kaplan and Meier curves and compared with the log-rank test. Cox regression was used for the multivariable analysis, adjusting for age, gender, and EuroSCORE. Stata 16 was used for analysis (Stata Corp- College Station- TX- USA). A P-value of less than 0.05 was considered significant.

Results

Baseline comparison:

BIMA plus radial artery was significantly higher in males (P<0.001). Patients with BIMA plus RA were significantly younger than other groups (P<0.001). There was no difference in the comorbidities between groups, and the Euro SCORE was significantly lower in patients who had one RA+BIMA compared to LIMA+ SVG (P= 0.032) and LIMA+RA (P<0.001). (Table 1)

Operative and postoperative outcomes:

Off-pump surgery was significantly more prevalent in patients with LIMA+RA (P= 0.01). Postoperative drainage was significantly higher in patients with BIMA+ RA compared to LIMA+RA (P= 0.006), with no significant difference between BIMA+ RA and LIMA+SVG (P= 0.081). There was no difference in mechanical ventilation duration, ICU stay, early angiography, reoperation, perioperative MI, neurological complications, renal impairment, hospital stay, and hospital mortality. Sternal wound infection was non-significantly higher in the BIMA+ RA group. (Table 2)

Follow-up data:

The median follow-up was 59 (47- 66) months. The composite endpoint of recurrent angina, MI, coronary revascularization, and CHF occurred in 17 patients [4 (12.9%) vs. 8 (9.30%) vs. 5 (6.41%), in the LIMA+SVG, LIMA+ RA, and BIMA+RA groups, respectively] (Log-rank P= 0.484). (Figure 1) Recurrent angina occurred in 15 patients [4 (12.9%) vs. 8 (9.30%) vs. 3 (3.85%) in the LIMA +SVG, LIMA+RA, and BIMA+RA groups,

Table 2: Operative and postoperative outcomes. Data were presented as mean and SD, median (IQR), or numbers (%) when appropriate.

	LIMA+ SVG (n= 31)	LIMA+RA (n= 86)	BIMA+RA (n= 78)	P-value
Emergency surgery	5 (16.13%)	5 (5.81%)	9 (11.54%)	0.199
Off-pump surgery	17 (54.84%) P1- 2: 0.021	66 (76.74%) P2-3: 0.002	44 (56.41%) P 1- 3: 0.881	0.01
Drainage (ml/12 h)	375 (240- 530) P1-2: 0.330	342 (260- 470) P2-3: 0.006	447 (325- 600) P1-3: 0.081	0.040
MV duration (h)	7.5 (6- 13)	8.5 (6- 16)	8.5 (7- 14)	0.548
ICU stay (h)	24 (19.5- 48)	25 (20- 46)	24 (21- 46)	0.816
Early angiography	2 (6.45%)	2 (2.33%)	1 (1.28%)	0.309
Reoperation				
Bleeding	0	4 (4.65%)	2 (2.56%)	0.476
Graft dysfunction	1 (3.23%)	0	0	
Non-cardiac cause	1 (3.23%)	2 (2.33%)	2 (2.56%)	
Perioperative myocardial infarction	1 (3.23%)	2 (2.33%)	1 (1.28%)	0.812
Neurological complications	0	1 (1.16%)	1 (1.28%)	>0.99
Renal impairment	2 (6.45%)	13 (15.12%)	7 (8.97%)	0.301
Pulmonary complications	2 (6.45%)	6 (6.98%)	4 (5.13%)	0.923
Sternal infection	1 (3.23%)	0	4 (5.13%)	0.090
Hospital mortality	1 (3.23%)	2 (2.33%)	0	0.383
Hospital stay (days)	9 (8- 11)	9.5 (8- 13)	8 (7- 11)	0.78

BIMA: bilateral internal mammary artery, LIMA: left internal mammary artery; RA: radial artery; SVG: saphenous vein graft

respectively]. MI occurred in 3 patients, one in each group. Coronary interventions occurred in 6 patients; 3 patients were in the SVG+LIMA group, and 3 were in the LIMA+ RA group. All coronary reinterventions were PCI. In the SVG group, PCI was performed on LIMA (n= 1), native coronary vessel (n= 1), and a vein graft (n=1). All PCIs were to the RA in the LIMA+RA group. CHF occurred in one patient with BIMA. After adjusting for age, gender, and EuroSCORE, groups did not differ in the composite endpoint (HR: 0.69 (95% CI: 0.35- 1.38); P= 0.297).

Mortality occurred in 7 patients, [1 (3.23%) vs. 4 (4.65%) vs. 2 (2.56%), in the LIMA+SVG, LIMA+ RA, and BIMA+RA groups, respectively] (Log-rank P= 0.834). After adjusting for age, gender, and EuroSCORE, there was no difference in survival among groups (HR: 1.19 (95% CI: 0.32- 4.43); P= 0.796).

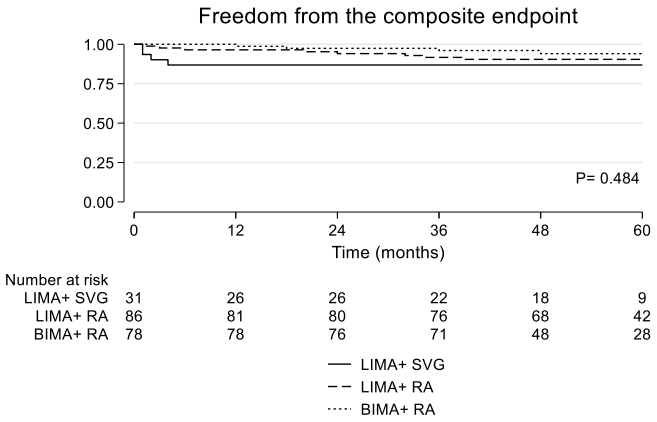

Figure 1: Kaplan Meier survival curve for freedom from the composite endpoint. BIMA: bilateral internal mammary artery, LIMA: left internal mammary artery; RA: radial artery; SVG: saphenous vein graft

Discussion

The debate about coronary artery conduits is still continuous. This study compared the hospital and long-term outcomes, including the composite endpoint of recurrent angina, MI, repeated revascularization, and CHF among patients who had conventional CABG (LIMA+SVG) vs. total arterial revascularization using one or two arterial

grafts plus LIMA. Patients who received multiple arterial conduits were most commonly males, younger, and with lower EuroSCORE. These findings reflect the rationale for choosing patients suitable for total arterial revascularization. Rocha and associates found that patients with total arterial revascularization had better freedom from major cardiovascular events and myocardial infarction; however, they did not report differences in stroke and survival between conventional CABG and total arterial revascularization [11]. Therefore, most surgeons advocate total arterial revascularization in young and low-risk patients for better long-term outcomes.

Most hospital outcomes, including hospital complications, ICU and hospital stay, and hospital mortality, did not differ significantly among groups. However, BIMA was associated with increased postoperative drainage and sternal wound infections. These results are similar to other series. In a meta-analysis of 20 studies, Oswald and associates found that BIMA use was significantly associated with sternal wound infections [12]. Several strategies have been proposed to decrease the incidence of sternal wound infections after BIMA. These strategies include preoperative antibiotic prophylaxis, tight glycemic control, and using skeletonized grafts to preserve the vascularity of the sternum [13]. However, other studies reported no effect of harvesting techniques on postoperative sternal wound infection [14,15]. In addition to the sternal infection, the raw surface after BIMA harvest increases the drainage postoperatively compared to other techniques.

We did not report a difference in long-term mortality and the composite endpoint of recurrent angina, MI, CHF, and repeat coronary revascularization between groups. However, the composite endpoint was not significantly higher with the vein graft, followed by the single arterial+LIMA conduit. The multiple arterial conduits had a lower composite endpoint incidence and mortality incidence. Several studies reported improved long-term outcomes after total arterial revascularization. Bisleri and coworkers reported superior survival ten years after total arterial revascularization (77% vs. 72%) [16]. Shi and associates compared the outcomes of BIMA plus RA vs. BIMA plus SVG [17]. Survival at ten years was 90% vs. 81%, and at 15 years was 82% vs. 72% in total arterial vs. vein groups. On the other hand, Mohammadi and associates found that using RA with BIMA did not have survival benefits over 15 years of follow-up compared to BIMA plus SVG [18]. Muneretto and associates reported a significant decrease in cardiac-related events in patients with total arterial revascularization [19]. Garratti and colleagues reported a non-significantly higher MI over long-term follow-up on patients who received SVG compared to total arterial revascularization [20].

Study limitations

Several limitations should be considered before interpreting the results of this study. The study is retrospective, and patients' selection was based on surgeons' preferences and experiences. Some of the patients' characteristics affected the selection process. These biases could have affected the occurrence of the study outcomes. Moreover, the study is limited by the small patients' number. Most of the non-significance between several variables could be related to the small patients' number.

Conclusion

Total arterial revascularization with multiple arterial grafts could increase postoperative drainage and sternal wound infection, with no difference in the short and long-term outcomes compared to single arterial and vein grafts. The choice of the conduit for coronary artery bypass grafting should be tailored according to the patient's characteristics.

Conflict of interest: Authors declare no conflict of interest.

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