Does the Addition of a Gastroepiploic Artery to Bilateral Internal Thoracic Artery Improve Survival?

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It is unclear whether the additional conduit to supplement bilateral internal thoracic arteries (BITA) influences the patient outcome in coronary surgery. This retrospective study compared long-term survival of patients undergoing left-sided BITA grafting in which the third conduit to the right coronary system (RCA) was either vein graft (SVG) or gastroepiploic artery (GEA). From 1989 to 2014, 1432 consecutive patients underwent left-sided revascularization with BITA associated with SVG (n = 599) or GEA (n = 833) to RCA. Propensity score was calculated by logistic regression model and patients were matched 1 to 1 leading to 2 groups of 320 matched patients. The primary end point was the overall mortality from any cause. GEA was used in significantly lower risk patients. The 30-day mortality was 1.6% without influence of the graft configuration. Postoperative follow-up was 13.6 ± 6.6 years and was 94% complete. The significant difference in patients' survival observed at 20 years in favor of GEA in unmatched groups (48 ± 4% vs 33 ± 6%, $P < 0.001$) was not confirmed in matched groups (41 ± 7% vs 36 ± 7%, $P = 0.112$). In multivariable Cox model analysis, the conduit used to RCA did not influence the long-term survival in matched groups, like no other graft configuration or operative parameter. Only complete revascularization remained predictor of survival ($P = 0.016$), with age ($P < 0.0001$), diabetes status ($P = 0.007$), and left ventricle ejection fraction ($P < 0.0001$). Long-term survival in patients undergoing BITA grafting is not affected by using GEA as third arterial conduit in alternative to SVG. Further studies are necessary to assess its impact on long-term cardiac events.

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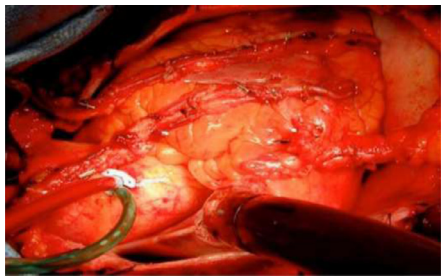
Keywords: Coronary artery bypass surgery, Internal thoracic artery, Gastroepiploic artery, Arterial revascularization



Gastroepiploic artery associated with in situ BITA for complete arterial revascularization

Central Message

In patients undergoing bilateral internal thoracic arteries on the left side, the use of the gastroepiploic artery to bypass the right side has no impact on the survival when compared to vein graft.

Perspective Statement

The impact of a third conduit associated to bilateral internal thoracic arteries is still controversial. This study shows that the use of the gastroepiploic artery to bypass the right side has no impact on the long-term survival when compared to vein graft. Its added value could be limited on the occurrence of cardiac events and it remains an adjunct to more complete arterial revascularization.

Abbreviation: CABG, coronary artery bypass grafting; ITA, internal thoracic artery; BITA, bilateral internal thoracic artery; SITA, single internal thoracic artery; GEA, gastroepiploic artery; SVG, saphenous vein graft; RCA, right coronary artery; LITA, left internal thoracic artery; RITA, right internal thoracic artery; LAD, left anterior descending artery; CX, circumflex artery; LV, left ventricle; NYHA, New York Heart Association; LVEF, left ventricular ejection fraction; PDA, posterior descending artery; PLA, postero-lateral artery; RA, radial artery; MACE, major adverse cardiac event

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INTRODUCTION

Long-term advantages of multiple arterial grafting in patients undergoing coronary artery bypass surgery (CABG) has been controversial for decades despite mounting of evidence supporting the use of this technique for myocardial revascularization.[1,2] There was a huge expectation from the 10-year multicenter randomized arterial revascularization trial[3] which finally reported comparable 10-year outcomes of bilateral internal thoracic artery (BITA) grafting relative to single internal thoracic artery grafting (SITA). However, large observational series and multiple meta-analyses have demonstrated the clinical benefits of BITA over SITA. Nowadays, the optimal configuration of BITA is to use them to bypass the left coronary network in patients who do not have a high risk of sternal wound infection.[4,5] There is little evidence to guide surgeons regarding the optimal conduit choice for the right coronary system and the benefits related to a third arterial conduit are much more controversial.[6,7] It is unclear whether the addition of a gastroepioic artery (GEA) in patients already receiving BITA provides any additional survival benefit over that of a saphenous vein (SVG). In this retrospective study based on our 25-year experience in arterial grafting, we reviewed our series and compared both strategies to answer the following question: Is there an incremental survival benefit for GEA as a third arterial graft over revascularization BITA?

MATERIALS AND METHODS

All patients who underwent isolated CABG procedure using BITA in our department that was performed by the same surgeon from January 1989 to August 2014 were selected for the study. We retrospectively analyzed prospectively collected the data from the surgical registry of the department. This was approved by the local ethical committee and after receiving prior consent from the patient. The inclusion criteria were BITA on the left side regardless if sequential ITA was used, associated with either vein graft or GEA graft on the right side regardless the target vessel: right coronary artery (RCA) or its branches. The exclusion criteria were emergency, reoperation, associated procedure, and unstable situation with acute myocardial infarction or intra-aortic balloon pump.

Surgical Technique

Our surgical techniques in CABG were previously reported in studies focused on early postoperative outcome.[8] All arterial grafts were used as in situ grafts with thin pedicle; skeletonization was not systematic and was done to increase the length of the graft when necessary. Patients received both left and right internal thoracic artery (LITA and RITA) to the most important coronary arteries on the left side: RITA crossing in front the aorta to the left anterior descending artery (LAD) and LITA to the circumflex artery (CX) system; sequential ITA grafts were performed according to the coronary lesions and the technical possibilities, mainly sequential LITA to diagonal and marginal branches. A supplemental vein graft or an additional GEA arterial graft was used to bypass the right coronary artery system, as needed. The choice was individually decided according to the state of the patient and the availability of GEA. As arterial grafting is technically more demanding, the main concern was no increase in mortality or morbidity and a vein graft was often preferred in patients with left ventricular (LV) dysfunction or obesity. The use of the GEA was conditioned to a good adequacy between the size of the GEA and the size of the target coronary vessel; a vein graft was preferred also when the GEA diameter was less than 1.5 mm. Diabetes status or severe dyslipidemia was never a limitation. CABG was done on-pump with antegrade and retrograde crystalloid cardioplegia. Complete myocardial revascularization was defined as a bypass of all vessels with a diameter more than 1 mm and a significant lesion defined as more than 70% stenosis. All patients received aspirin antiplatelet therapy postoperatively. Postoperative statin and beta-blockers became common practice over the years.

Definitions and End Point

Early mortality was defined as any death within 30 days of CABG. Late death was defined as death occurring after 30 days from surgery. All causes of mortality were used to assess the long-term outcome. The latest survival status of the patients was obtained in 2019 from the National Institute of Statistics and Economic studies (INSEE) and a genealogy agency in the case of lack of information; the common closing date for follow-up was December 1, 2019. The primary end point was overall mortality from any cause and was analyzed according to the potential risk factors and the surgical configuration.

Statistical Analysis

Descriptive statistics for categorical variables are reported as number and percentage. Normality of continuous variables was tested and they are reported as median (Q1-Q3); they were compared using non-parametric U test of Mann-Whitney; they were also reported as mean ± standard deviation to be consistent with standardized mean difference calculated to assess the degree of variable balance. Categorical variables were compared using χ^2 or Fisher's exact test. Overall survival was estimated using the Kaplan-Meier method and the stratified log rank test was applied to compare the equality of the survival; actuarial survival was reported on tables and curves. Univariable analyses of predictors of all-cause death were done with binary logistic regression. Propensity-score matching was performed to correct for the bias associated with the use of the GEA. A propensity score for each patient was calculated by logistic regression model with the graft strategy as the dependent variable and age, gender, NYHA status, left main stenosis, diabetes, left ventricular ejection fraction (LVEF), sequential ITA, complete revascularization, the target vessel of the RCA system, the number of distal anastomoses, the operative times (clamp time and cardiopulmonary time) and the year of surgery as independent variables. Patients were matched 1 to 1 on their propensity score using the greedy matching method without replacement and a fixed caliper width of 0.005. All

potentially important variables were first individually tested by a log-rank test of the corresponding Kaplan-Meir survival curves and then they were included in a multivariable Cox regression analysis to identify independent predictors of survival in matched groups. Statistical analyses were based on variables documented and complete in all patients. A 2-tailed P value < 0.05 was always considered to indicate statistical significance. All statistical analyses were performed using IBM-SPSS Statistics software version 25.0 (IBM-SPSS Inv, Armonk, NY).

RESULTS

Finally, 1432 patients with 3-vessel disease and BITA grafting on the left side were included in the study: 599 patients had an associated vein graft, and 833 patients had an associated gastroepiploic graft to bypass the RCA network (Fig. 1). Time of surgery was analyzed as a continuous variable and then patients were distributed in 5 class of 5 years each (Table 1, E1). Time of surgery was not instrumental in the selection of surgical strategy and both additional grafts on the right side were used concomitantly; however, GEA graft was less frequently used in the most recent years.

In unmatched population, a vein graft was used in older patients and in females. It was also used in patients with diabetes, in patients with left main stenosis, in patients with significant heart failure defined as NYHA class ≥ 2, and in patients with left ventricular dysfunction and impairment of ejection fraction (Table 1, E1). Finally, GEA seems to have been used in lower risk patients. Complete revascularization and sequential ITA uses were the same in the vein or GEA groups. However, GEA was more frequently used to bypass the RCA branches, posterior descending artery (PDA) or posterolateral artery (PLA) and vein graft was more frequently used to bypass the RCA itself (Table 1). Interestingly in the vein group, the GEA graft was assessed and finally not used because of an insufficient diameter, flow or length in 58% of patients; in other cases, a vein graft was used because GEA graft was not available easily due to previous abdominal surgery (18%) or because of the high risk profile of the patients (24%). In this series, the early mortality was 1.6% and it was not significantly influenced by the surgical technique and the third conduit used. The mean postoperative follow-up was 13.6 ± 7.2 years, and 94% complete: 734 late deaths occurred (mean delay 12 ± 6.6 years), 590 patients were alive (mean follow-up 17.3 ± 5.8 years), and 85 patients were lost of follow-up (37 patients during the first postoperative year, and 48 patients after 6.2 ± 2.6 years). The long-term survival after BITA grafting was significantly influenced by the third conduit used to bypass the RCA system with a 15% difference at 20 years in favor of GEA use (Fig. 2). Several preoperative and intraoperative variables were identified as significant predictors of all causes mortality by univariable analysis: age, heart failure, LV ejection fraction, number of distal anastomoses, complete revascularization, sequential ITA graft and GEA graft. Gender, diabetes status, right coronary target (RCA vs PDA or PLA) and operative times were not significant prognosis factors of mortality (Table 2).

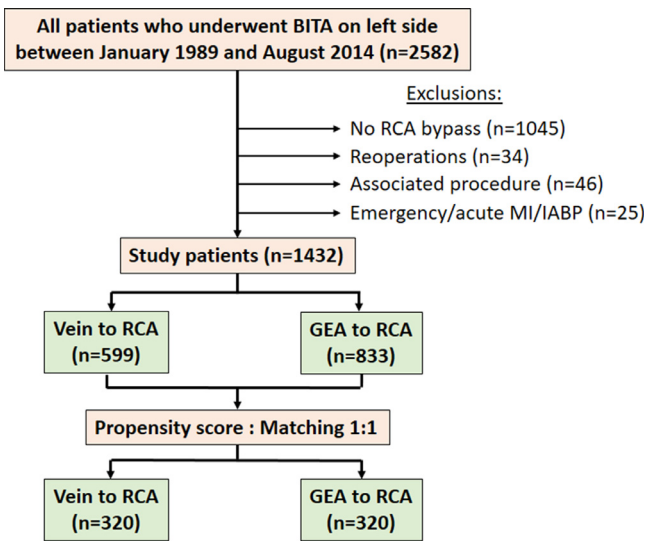

Figure 1. CONSORT diagram of patients included in the study. BITA, bilateral internal thoracic artery; GEA, gastroepiploic artery; IABP, intra-aortic balloon pump; MI, myocardial infarction; RCA, right coronary artery.

In matched groups, there was no more difference in preoperative characteristics between both groups, confirming an optimal matching model according to propensity score distributions (Fig. 3) and standardized median differences (Table 1). Obviously, the 2 groups were not matched according to the number of arterial anastomoses. The early postoperative outcome was similar in both groups (Table E2). The late survival was significantly influenced by age, heart failure, diabetes status, LV ejection fraction, and complete revascularization (Table E3); however the late survival was not significantly different among matched groups (Mantel-Cox chi-square: 2.56, $P = 0.112$; Fig. 2). In multivariable analysis with Cox regression model (Chi-square: 147.769; df: 14; $P < 0.0001$), age, diabetes status, LV ejection and complete revascularization were significant independent prognosis factor of long-term survival; while GEA graft, sequential ITA, RCA target vessel and operative times had no impact on late outcome (Table 3). Finally, there was no benefit effect of GEA as additional arterial graft to bypass the RCA network, in comparison with vein graft and independently of the target vessel bypassed with (Fig. 4).

DISCUSSION

Historically the literature strongly supports the use of BITA to revascularize the left coronary branches that supply the majority of the left ventricle.[9,10] Despite the benefits of left-sided ITA grafting, there is still no consensus on the complementary graft of choice for the right coronary system; rather than using a SVG, arterial conduits, such as the radial artery (RA) or gastroeiploic artery, can be used.[6,7] The GEA was introduced in the early 90s and it was recognized as an adjunct to

Table 1. Comparison of Preoperative Clinical Variables and Postoperative Outcomes by Patients Groups

Variable	Unmatched Groups				Matched Groups			
	BITA+Vein N = 599	BITA+GEA N = 833	SMD	*P* Value	BITA+Vein N = 320	BITA+GEA N = 320	SMD	*P* Value
Propensity score	0.38 ± 0.25	0.73 ± 0.21	-1.207	<0.001	0.54 ± 0.22	0.54 ± 0.22	0.007	0.983
Age—year	66 ± 9	61 ± 9	0.548	<0.001	64 ± 9	64 ± 8	-0.051	0.441
Male gender	472 (79%)	793 (95%)	-0.489	<0.001	291 (91%)	286 (89%)	0.066	0.507
Heart failure NYHA ≥2	77 (13%)	57 (7%)	0.246	<0.001	29 (9%)	29 (9%)	0	1
Left main lesion	110 (19%)	98 (12%)	0.187	0.002	53 (17%)	50 (16%)	0.027	0.747
LV ejection fraction—%	59 ± 13	61 ± 12	-0.182	0.03	59 ± 13	59 ± 12	0.025	0.461
Diabetes	89 (15%)	69 (8%)	0.210	0.001	38 (12%)	35 (11%)	0.031	0.709
Date of surgery								
01/1989–01/1994	20 (3%)	254 (30%)	-0.782	<0.001	18 (6%)	25 (8%)	-0.080	0.525
01/1994–01/1999	147 (25%)	349 (42%)	-0.366		120 (38%)	128 (40%)	-0.041	
01/1999–01/2004	260 (43%)	154 (19%)	0.538		110 (34%)	99 (31%)	0.065	
01/2004–04/2009	97 (16%)	62 (7%)	0.285		62 (19%)	54 (17%)	0.052	
01/2009–08/2014	75 (13%)	14 (2%)	0.428		10 (3%)	14 (4%)	0.053	
Distal anastomoses	3.6 ± 0.6	3.4 ± 0.6	0.215	<0.001	3.5 ± 0.6	3.5 ± 0.6	0.010	0.897
Arterial anastomoses	2.5 ± 0.6	3.4 ± 0.6	-1.274	<0.001	2.4 ± 0.5	3.5 ± 0.6	-1.332	<0.001
Complete revascularization	505 (84%)	694 (83%)	0.027	0.615	264 (83%)	262 (82%)	0.026	0.836
Clamp time—min.	53 ± 14	59 ± 13	-0.444	<0.001	55 ± 13	56 ± 12	-0.029	0.725
CPB time—min.	74 ± 15	76 ± 27	-0.091	0.334	74 ± 14	75 ± 16	-0.070	0.290
Sequential ITA	260 (43%)	320 (38%)	0.101	0.058	130 (40%)	131 (41%)	-0.020	0.936
RCA branches bypassed	318 (53%)	541 (65%)	-0.245	0.001	188 (59%)	203 (63%)	0.082	0.223
1-mo mortality	12 (2%)	11 (1.3%)	0.054	0.240	6 (1.8%)	3 (0.9%)	0.079	0.310
Mean follow-up—year	11.5 ± 6.2	15.1 ± 7.5	-0.502	0.001	13 ± 6	13 ± 6	-0.091	0.155

Continuous variables are reported as mean ± standard deviation with *P* value of non-parametric U test of Mann-Whitney. BITA, bilateral internal thoracic artery; CPB, cardiopulmonary bypass; GEA, gastroepiploic artery; LV, left ventricular; min, minutes; NYHA, New York Heart Association; RCA, right coronary artery; SMD, standardized mean difference.

more complete arterial revascularization in ITA grafting.[11] It has potential advantages over the use of radial artery or composite BITA Y-graft strategy because it is a third in situ graft, independent of the ITA configuration and we adopted it very

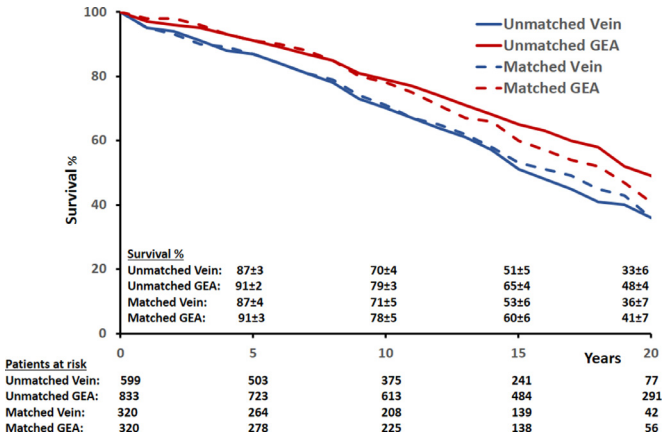

Figure 2. Survival curves of bilateral ITA grafting on the left side according to the third graft on the right side: GEA or SVG, in unmatched groups (Mentel-Cox, chi-square = 30.659, $P < 0.0001$) and in matched groups (Mentel-Cox chi-square = 2.523, $P = 0.112$). GEA, gastroepiploic artery; ITA, internal thoracic artery.

Table 2. Univariable Binary Logistic Regression Analysis of Variables Influencing the Mortality in the Unmatched Cohort of Patients

Predictor	Unmatched Groups	
	HR (95 % CI)	*P* Value
Preoperative		
Age	1.086 (1.071–1.100)	<0.001
Male gender	0.910 (0.630–1.315)	0.617
Heart failure NYHA≥2	1.260 (1.041–1.527)	0.018
Diabetes	1.318 (0.915–1.898)	0.138
Left main	1.044 (0.875–1.244)	0.634
LV ejection fraction	0.983 (0.973–0.993)	0.001
Intraoperative		
Number distal anastomoses	0.779 (0.661–0.918)	0.003
Complete revascularization	0.618 (0.449–0.852)	0.003
Gastroepiploic artery	1.873 (1.460–2.401)	<0.001
Sequential ITA	0.732 (0.579–0.926)	0.009
PDA/PLA bypassed	1.035 (0.915–1.170)	0.587
Clamp time	0.999 (0.991–1.008)	0.896
CPB time	0.998 (0.989–1.008)	0.701

CI, confidence interval; CPB, cardiopulmonary bypass; HR, hazard ratio; ITA, internal thoracic artery; LV, left ventricular; NYHA, New York Heart Association; PDA, posterior descending artery; PLA, postero-lateral artery.

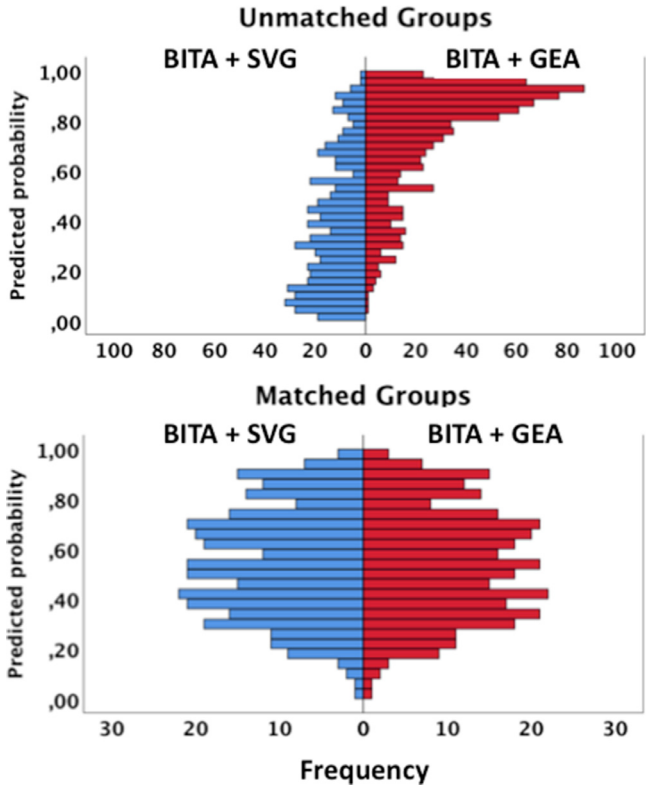

Figure 3. Propensity score-matched study of BITA grafting on the left side according to the third graft on the right side: GEA or SVG. Mirrored histograms of propensity score in unmatched and matched groups. BITA, bilateral internal thoracic artery; GEA, gastroepiploic artery; SVG, saphenous vein graft.

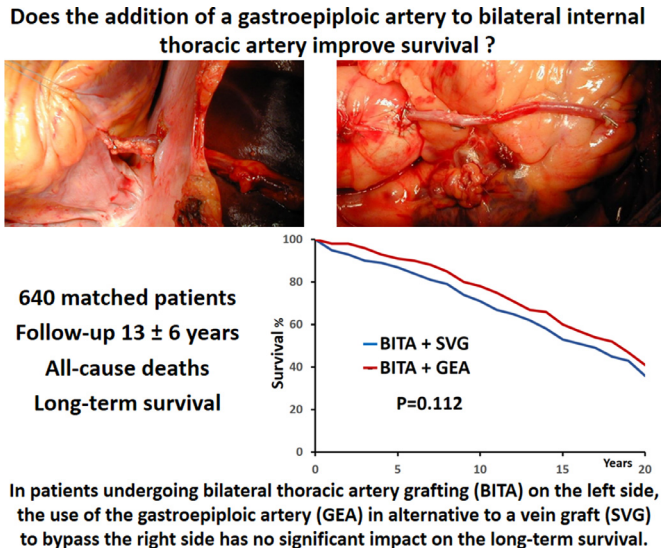

Figure 4. Comparison of survival probabilities in matched patients who underwent bilateral internal thoracic grafting on the left side with either a gastroepiploic artery or a saphenous vein graft on the right side showing no significant difference with a follow-up up to 20 years.

Table 3. Multivariable Cox Regression Analysis of Variables Influencing the Survival in Matched Cohort of Patients

Predictor	HR (95 % CI)	*P* Value
Preoperative		
Age	1.088 (1.068−1.108)	<0.0001
Male gender	0.856 (0.533−1.375)	0.520
Heart failure NYHA≥2	1.202 (0.984−1.468)	0.071
Diabetes	1.968 (1.331−2.910)	0.001
Left main	1.133 (0.787−1.632)	0.502
LV ejection fraction	0.975 (0.963−0.988)	<0.0001
Date of surgery	0.990 (0827−1.184)	0.910
Intraoperative		
Number distal anastomoses	0.803 (0.456−1.414)	0.448
Complete revascularization	0.754 (0.584−0.973)	0.030
Gastroepiploic artery	1.009 (0.822−1.237)	0.935
Sequential ITA	0.888 (0.718−1.096)	0.269
PDA/PLA bypassed	1.053 (0.803−1.374)	0.705
Clamp time	1.003 (0.990−1.016)	0.658
CPB time	1.102 (0.890−1.121)	0.324

CI, confidence interval; CPB, cardiopulmonary bypass; HR, hazard ratio; ITA, internal thoracic artery; LV, left ventricular; NYHA, New York Heart Association; PDA, posterior descending artery; PLA, postero-lateral artery.
Chi-square 147.769, df 14, $P < 0.0001$.

early with exceptional related complications as previously reported.[12] In multiple arterial grafting, our strategy was to tailor the operation to the patient according to the coronary network and the estimated operative risk to avoid an increase of early mortality. Our preference has been pedicled ITA grafts to bypass the left coronary artery system with a wide use of sequential ITA graft, and a pedicled GEA graft to the RCA system. A vein graft was used as an alternative when the GEA was not accessible or inappropriate, and also in high-risk patients. The present study confirmed that the use of GEA graft has no impact on early outcome in BITA grafting.[8] The primary endpoint of this retrospective observational study was focused on the overall mortality with a mean postoperative follow-up of 13.6 years. The main finding is that in patients undergoing BITA grafting, the addition of the GEA as a third arterial conduit was not associated with improved long-term survival relative to a matched group of patient undergoing BITA grafting with additional SVG graft.

The impact of a third arterial graft in addition to the bilateral mammary arteries has not been clearly defined and remained controversial. Pevni et al[13] showed in a retrospective study that early and midterm results in patients undergoing left-sided BITA grafting were not affected by the conduit used for RCA grafting: RITA, SVG, GEA, and no-graft. Esaki et al[14] performed a similar comparison and found no superiority of the RGEA over the SVG at 7 years postoperatively. Di Mauro et al[15] in a propensity score-matched study showed that in patients with 3-vessel disease undergoing BITA grafting, supplementary venous grafts on the right side seemed to provide more stability than GEA. Glineur et al[16] in a randomized study showed that there

was no significant difference in patency and adverse event between vein graft and GEA to bypass the RCA system; they pointed out the careful selection of the coronary target to obtain good results in GEA grafting. Suzuki et al[17] in a similar study found that a skeletonized GEA associated to BITA gave better outcome at the 5-year follow-up compared with the SVG. Recently, 2 meta-analyses[18,19] showed that the use of a third arterial conduit in CABG is associated with superior long-term survival rates; however, the positive impact seemed to be more related to the RA than to the GEA. Our series, the largest reported in this field, has confirmed the absence of a clear benefit on survival of GEA associated with BITA grafting; that could be related to a lower than expected long-term patency of the GEA in comparison with SVG, or that the long-term survival of patients undergoing BITA grafting is definitively not affected by the revascularization of the RCA.

Better patency of GEA graft over vein graft has been emphasized in several studies; it has been reported correlated to a large inner diameter of GEA, a severely stenosed RCA and possibly a skeletonized graft.[13-16] In our experience, the use of the GEA graft was the first choice in 1180 patients; it was carefully selected according to its diameter and the adequacy with the target vessel and it was discarded in 29 % of cases because of anatomic limits. We paid less attention to the severity of the RCA stenosis as it is recommended in currently guidelines (11) but GEA was mainly used to bypass the RCA branches with a lower risk of competitive flow. We can speculate that despite the superiority in patency of the GEA relative to SVG, the lack of survival benefit by using the GEA as a third graft might be partially explained by the determinant role of the both ITA, which were likely used to graft the most important myocardial territories with the GEA left to graft the third territory in order of clinical significance, thus eliminating any potential survival benefit.[20]

In a younger population, Tavilla et al[21] have reported a 20-year survival probability of 63.5% with a 7% rate of repeat revascularization, suggesting that the impact of GEA as third arterial graft could be more on freedom of long-term cardiac events.

The alternative of a radial artery conduit (RA) could have provided better results possibly; according to the Radial Project report,[22] as compared with the use of SVG, the use of RA for CABG resulted in a lower rate of adverse cardiac events. There are strong data to support a potential survival benefit when it is used as third arterial conduit.[23–25] However we have no experience with of it and it was never used in this series. The GEA graft has not gained worldwide acceptance among cardiac surgeons, mainly because of concerns regarding flow capacity and the reluctance to enter the abdominal cavity. Our matched groups analysis has demonstrated that despite a large experience and a careful selection of the graft, the use of the GEA as a third arterial graft associated to BITA was not an added value on long-term survival in comparison with a vein graft. Nowadays, there are no criteria to support a systematic or frequent use of the GEA graft as we did. In the most recent years, we have turned to the alternative of a composite Y-graft configuration using free right ITA graft connected proximally to the left ITA; it is another attractive possibility to perform extensive arterial revascularization,[26,27] without the anatomic limitations of the GEA, although the Y-graft patency has been reported lower especially to distal CX and RCA, but still better than the known patency of SV grafts.[28,29] Nowadays, we continue to use GEA in sporadic cases when SVG or ITA access is an issue. Nevertheless, GEA graft remains an adjunct to more complete arterial revascularization in ITA grafting.

Limitations

The present study has several limitations, inherent to its design and objectives. This is a retrospective observational nonrandomized study based on a 25-year single center, single surgeon and single technical configuration operative experience. Only solid preoperative characteristic and documented for all patients were integrated in the risk factors analysis: for example Euroscore or STS score were missing before 2000, obesity status was not defined properly according to BMI, and they were not included. Nevertheless, the preoperative characteristic included are recognized as the main risk factors of CABG, defining well our CABG population and discriminant in comparisons between the multiple arterial grafting strategies performed in patients. The operative parameters were more exhaustive, more precise, allowing a robust analysis of the operative configuration and its impact. Only long-term survival and all-cause mortality were defined as primary end-point of the study. It was not the intent of the study to report on other MACE as myocardial infarction, repeat revascularization, cause of death, or on graft patency, and the collection of such information was not realistic in this study of over 30 years. Propensity-score matching was performed to correct for the bias associated with the use of the GEA graft. The possible residual bias related to factors not accounted for in the match regression as obesity or renal dysfunction would be in favor of GEA graft as a persistent lower risk group of patients probably.

CONCLUSIONS

According to our results, the use of the GEA graft in alternative to a vein graft to bypass the RCA system has no impact on the long-term survival in patients undergoing BITA grafting on the left side. However, GEA remains a possible adjunct to more complete arterial revascularization in ITA grafting strategy; its potential benefit on long-term cardiac events has to be confirmed in further studies.

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SUPPLEMENTARY MATERIAL

Scanning this QR code will take you to the article title page to access supplementary information.

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