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Original Article

Total Arterial Revascularization with Radial Artery and Internal Thoracic Artery T-Grafts Is Associated with Superior Long-Term Survival in Patients Undergoing Coronary Artery Bypass Grafting

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Aims: Compelling evidence encourages the use of the radial artery (RA) as the second arterial graft in coronary artery bypass grafting (CABG). However, its long-term benefits remain disputed. We sought to evaluate long-term outcome and survival by comparing patients receiving RAs with those receiving venous grafts to a single internal thoracic artery (ITA).

Methods: We analyzed 345 patients undergoing primary multivessel CABG and conducted a 13-year long follow-up. In all, 187 patients received the RA and the left ITA as T-graft; 158 patients received saphenous veins complementing a single ITA. We performed propensity-score matching on 81 pairs to balance treatment selection and confounders.

Results: Patients receiving RAs were younger and less likely to be female or to have pulmonary hypertension, impaired renal function, or left main coronary disease.

At 30 days, they showed significantly lower unadjusted mortality and renal impairment. Unadjusted long-term survival was superior in the RA group, even after propensity-score matching. We found that RA use protected from late mortality.

Conclusions: Using the RA and the left ITA as T-graft is associated with a significant long-term survival benefit in patients undergoing CABG. It may display a promising alternative to conventional use of a single ITA supplemented by saphenous veins.

Keywords: CABG, radial artery, T-graft

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Introduction

Coronary artery bypass grafting (CABG) has quickly advanced to one of the most frequently performed surgical procedures.[1] It is the most effective coronary revascularization method in severe coronary artery disease, which remains a leading cause of death in the Western countries.[2] Despite excellent short-term outcomes, long-term results of CABG remain dependent on the selection of graft conduits used. Although the recent long-term results from important trials showed significantly better survival rates after CABG than after percutaneous coronary intervention (PCI), CABG rates are declining over the past years, while PCI rates increase accordingly.[3,4] Nonetheless, CABG remains the gold standard for patients with coronary artery disease including those with diabetes and/or complex left main or three-vessel disease.[4]

The benefits of left internal thoracic artery (LITA) to left anterior descending coronary artery (LAD) grafting are well established and explain its common implementation in surgical practice. However, the choice of a second graft remains a considerable source of debate.[5,6]

There is robust evidence accumulating in favor of the radial artery (RA) as a second arterial graft, indicating superior patency rates and improved intermediate and long-term outcomes in comparison with venous grafts.[7,8] However, the use of the RA is still limited to <13% of all CABG operations.[9]

The purpose of this study is to assess long-term outcome of all-arterial CABG using the LITA and RA in T-Graft configuration and to evaluate survival benefit in a propensity-score matched comparison with combined venous and arterial bypass grafting using a single ITA and saphenous veins.

Methods

In this study, we selected patients who underwent their first non-emergent CABG for left-main or double- and triple-vessel coronary artery disease at our center from January 2002 to August 2004. Patients were study-eligible if they received either total arterial revascularization (TAR) with LITA and RA grafting in T-graft configuration or aortocoronary venous bypass (ACVB) in combination with arterial grafts using either the LITA or right internal thoracic artery (RITA) and saphenous vein grafts as complementing conduit.

For follow-up, patients were contacted to investigate subjective symptoms (New York Heart Association (NYHA), Canadian Cardiovascular Society [CCS]), survival, incidence of adverse events (stroke, myocardial infarction [MI]), and re-interventions (PCI, CABG) since the surgical procedure.

Pre-, peri-, and postoperative data were retrospectively acquired through the hospital's internal database or obtained by contacting the patient's cardiologist or general practitioner.

Mortality data were crosschecked with the respective Citizens Registration Office.

The follow-up time ranged from the date of the operation until the verified date of death or last date of contact.

All patients signed informed consent for data collection and processing at the time of consent for the surgical procedure.

Surgical Technique

For the ACVB group: The saphenous vein was harvested in parallel to the median sternotomy followed by the harvest of the ITA in a pedicled fashion and irrigation with papaverine. Subsequently, heparinization (300 U/kg) and cardiopulmonary bypass initiation followed in standard fashion. We used the thoracic internal artery as a bypass graft for the LAD (or, if necessary a diagonal branch) in situ. The saphenous vein was used for as many bypass grafts as necessary.

For the TAR group: Upon full median sternotomy, the ITA was harvested in a pedicled fashion and was irrigated with papaverine solution. Duplex sonography was performed to assure palmar perfusion via the ulnar artery prior to harvesting the RA from the non-dominant arm. The performance of the T-anastomosis between the LITA and the RA occurred prior to initiating cardiopulmonary bypass with 8–0 prolene sutures. The T-anastomosis was carefully placed within the pericardium. Upon completion of the T-graft the heparinization (300 U/kg) and cardiopulmonary bypass initiation followed according to standard fashion. Intermittent antegrade cold-blood cardioplegia or crystalloid cardioplegia was used for myocardium protection. If heparin was given to keep the activated clotting time above 450 seconds, protamine was administered at the end of the surgical procedure. If possible, intravenous nitroglycerin infusions were administered for the first 24 hours. Six hours postoperatively, 300 mg of aspirin was given i.v. If not contraindicated, 100 mg of aspirin p.o., cholesterol-lowering agents, and β-blockers were administered daily.

Statistical Analysis and Propensity Score Matching

Normally distributed metric data were analyzed using the student's t Test and non-normally distributed metric or ordinal data were analyzed using the Mann–Whitney test. The Shapiro–Wilk test was used to test for normality. The Fisher-Exact Test was used for 2 × 2 contingency tables; other contingency tables were tested by chi-square test.

The association of covariates on overall survival was tested on the entire study population, while the effect of group (TAR vs. ACVB) on survival was tested among propensity-matched cohorts. Each confounder was tested using the Cox proportional hazard regression. Confounders with a *P* value of <0.1 were comprised in the multivariable model selected by forward selection (likelihood ratio) method. Hazard ratios (HR) were assessed for every variable.

Kaplan–Meier functions were used to plot postoperative survival. A log-rank test, stratified by the propensity-matched pairs, was used to assess the equality of survivor functions.

The TAR and ACVB groups showed significant risk factor and demographic differences. To balance the impact of treatment selection and confounders in this retrospective observational study, propensity-score matching was performed. It has shown to render unbiased assessment of treatment effects even in small study samples as long as accurate confounders are included in the matching.[10]

The following confounders turned out to be significant in the previous univariate survival analysis and were considered for matching: Gender, age, body mass index (BMI), hyperlipidemia, non-insulin-dependent diabetes mellitus (DM), peripheral arterial occlusive disease (PAOD), chronic obstructive pulmonary disease (COPD), pulmonary hypertension, glomerular filtration rate (GFR), NYHA class (Groups: I + II, III + IV), EuroSCORE (%), previous PCI, LAD stenosis, right coronary artery (RCA) stenosis, urgent operation, graft count and cross-clamp, and bypass times.

The propensity-score was derived by logistic regression with 1:1 matching using the nearest-neighbor method with a caliper width of 0.2 of the standard deviation (SD) of the logit of the propensity score.

To ensure proper balance among the groups, a comparison of SDs, means, and proportions of baseline demographic characteristics was performed. The Mann–Whitney test, the student's t-test and the χ^2 test validated statistical significance for continuous and categorical variables.

A *P* value of <0.05 was considered significant. Continuous variables were expressed as mean ± SD and categorical variables as total number (*n*) and percentages (%). The hazard rate and the 95% confidence range complemented confounders. IBM's SPSS Statistics Version 24 (SPSS Inc., Chicago, IL, USA) was used for all statistical analyses.

Results

Baseline and operative characteristics

We analyzed 345 patients who fulfilled the inclusion criteria. Both groups showed substantial differences in demographic and risk factors (**Table 1**). Reflecting a practice selection, patients receiving TAR were younger (62.1 ± 8.45 years vs. 68.6 ± 7.12 years, *P* <0.001), showed lower Euroscores (2.82 ± 3.11% vs. 4.74 ± 5.57%, *P* <0.001) and were less likely to have impaired renal function, pulmonary hypertension, and left main coronary disease. The TAR group had proportionally less females than the ACVB group (9.6% vs. 19.6%, *P* = 0.009). In patients receiving TAR, operative urgency was more likely to be non-urgent (86.6% vs. 61.4%, *P* <0.001) and NYHA classes I-II applied more frequently (47.6% vs. 11.4%, *P* <0.001). Left ventricular function showed no statistically significant difference between the two cohorts (58% vs. 57.3%, *P* = 0.673). Both groups were comparable for pre-treatment characteristics after matching of 81 patient pairs (**Table 2**).

Within the TAR group, 187 (100%) patients received a RA grafted to the 187 LITAs (100%) in T-graft configuration. The 158 patients in the ACVB group received either a single (5.7%) or two and more (94.3%) venous grafts to supplement 156 LITAs (98.7%) and 2 RITAs (1.3%). In total, a mean of 3.29 ± 0.7 RA and 3.63 ± 0.82 ACVB distal anastomoses was performed. Further operative characteristics are displayed in **Table 3**.

More importantly, patients receiving TAR experienced significantly shorter operation times (183 ± 29.2 min vs. 200 ± 61.8 min, *P* = 0.002), cardiopulmonary bypass times (20.5 ± 86.6 h vs. 23.9 ± 37.1 h, *P* <0.001), aortic cross-clamp times (40.5 ± 12 min vs. 50.9 ± 17.7 min, *P* <0.001), and ventilation times (67.3 ± 17.6 min vs. 97.1 ± 45 min, *P* <0.001). Also, hospital and intensive care unit stays were significantly shorter in the TAR group.

Outcomes

Early postoperative incidence of adverse events such as MIs, neurological complications (stroke, transient ischemic attack [TIA]), deep sternal wound infections, respective harvesting site infections, and prolonged ventilation (>48h) was not statistically different in both groups. However, renal impairment and death (within 30 days) occurred less frequently in patients receiving TAR (1.1 % vs. 9.2%, *P* <0.001 and 0% vs. 4.5%, *P* = 0.004, respectively) (**Table 3**).

Table 1 Baseline characteristics in unmatched cohorts

	TAR (n = 187)		ACVB (n = 158)		
	Mean	SD	Mean	SD	*P* value
Age (years)	62.1	8.45	68.6	7.12	<0.001
GFR (mL/min)	98	30.5	78.7	30.3	<0.001
Euroscore (%)	2.82	3.11	4.74	5.57	<0.001
Left main disease (%)	14.2	24.3	27.8	35.1	<0.001
BMI	27.6	3.98	26.9	3.29	0.077
Left ventricular ejection fraction (%)	58	13.0	57.3	14.5	0.673
	n	(%)	n	(%)	*P* value
Gender					
Female	18	9.6	31	19.6	0.009
Male	169	90.4	127	80.4	
Arterial hypertension	152	81.3	115	72.8	0.071
Hyperlipidemia	135	72.2	110	69.6	0.635
DM					
Non-insulin-dependent	52	27.8	44	27.8	1.000
Insulin-dependent	20	10.7	20	12.7	0.615
PAOD	37	19.8	27	17.1	0.579
COPD	26	13.9	15	9.5	0.244
Pulmonary hypertension	13	7	2	1.3	0.014
Extent of coronary vessel disease					
Two-vessel disease	21	11.2	16	10.1	0.862
Three-vessel disease	166	88.8	138	87.3	0.740
Left ventricular ejection fraction					
Mild (45–54%)	31	22.3	25	18.5	0.307
Moderate (30–44%)	12	8.6	20	14.8	
Severe (<30%)	2	1.4	4	3.0	
Previous MI <90 days	36	19.3	24	15.2	0.393
Previous PCI	32	17.1	28	17.9	0.887
Previous cardiac surgery	8	4.3	12	7.6	0.248
NYHA status					
I-II	89	47.6	18	11.4	<0.001
III-IV	98	82.4	140	88.6	
CCS class of angina					
No angina	12	6.4	4	2.5	0.083
I-II	63	33.7	44	27.8	
III-IV	112	59.9	110	69.6	
Operative urgency					
Non-urgent	161	86.6	97	61.4	<0.001
Urgent	25	13.4	61	38.6	

ACVB: combined arterial and venous bypass; BMI: body mass index; CCS: Canadian Cardiovascular Society; COPD: chronic obstructive pulmonary disease; DM: diabetes mellitus; GFR: glomerular filtration rate; MI: myocardial infarction; NYHA: New York Heart Association; PAOD: peripheral arterial occlusive disease; PCI: previous coronary intervention; SD: standard deviation; TAR: total arterial revascularization

In univariate analysis, age, DM, PAOD, COPD, GFR, NYHA class, pulmonary hypertension, EuroSCORE, RCA stenosis, urgency of operation, graft count and cross-clamp, and bypass times were significant negative factors for survival. In contrast, male gender, BMI (cut-off value = 25), hyperlipidemia, previous PCI, and LAD stenosis seemed to be protective from mortality. Multivariate analysis using Cox proportional hazard regression with forward selection (likelihood ratio) method demonstrated that only previous PCI and cross-clamp time as independent factors negatively impacted survival.

Follow-up was slightly shorter in the TAR group (13.1 ± 0.86 years vs. 13.6 ± 0.15 years, P <0.001). The occurrence of stroke or TIA, MIs, and coronary re-interventions (CABG or PCI) in the long-term follow-up of the unmatched cohorts was comparable (**Table 4**). Cardiovascular disease, the leading cause of death in both groups, was proportionally more frequent in the ACVB

Table 2 Baseline characteristics in propensity-score-matched cohorts

	TAR (n = 81)		ACVB (n = 81)		
	Mean	SD	Mean	SD	*P* value
Age (years)	66.1	6.97	66.3	6.87	0.847
BMI	27.1	3.85	26.9	2.79	0.760
GFR (mL/min)	87.9	22.2	88.2	25.5	0.932
Euroscore (%)	2.89	2.33	2.91	1.96	0.351
LAD stenosis (%)	76.1	24.9	75.9	25	0.970
RCA stenosis (%)	24	36.1	26.3	39	0.761
PLA1 stenosis (%)	68	33.5	71.4	32.2	0.470
	n	(%)	n	(%)	*P* value
Gender					
Female	11	13.6	9	11.1	0.812
Male	70	86.4	72	88.9	
Hyperlipidemia	58	71.6	56	69.1	0.864
DM (non-insulin-dependent)	21	25.9	23	28.4	0.860
PAOD	12	14.8	14	17.3	0.831
COPD	8	9.9	6	7.4	0.781
Pulmonary hypertension	0	0	0	0	
Three-vessel disease	71	87.7	74	91.4	0.609
Previous PCI	17	21	14	17.3	0.690
Previous cardiac surgery	3	3.7	2	2.5	1.000
NYHA status					
I-II	18	22.2	17	21	1.000
III-IV	63	77.8	64	79	
Operative urgency					
Non-urgent	61	75.3	58	71.6	0.722
Urgent	20	24.7	23	28.4	

ACVB: combined arterial and venous revascularization; BMI: body mass index; COPD: chronic obstructive pulmonary disease; DM: diabetes mellitus; GFR: glomerular filtration rate; LAD: left anterior descending; NYHA: New York Heart Association; PAOD: peripheral arterial occlusive disease; PCI: previous coronary intervention; PLA: posterior lateral branch; RCA: right coronary artery; SD: standard deviation; TAR: total arterial revascularization

group (22.8% vs. 12.3%). Patients receiving TAR showed distinctly superior long-term survival (12.5 ± 0.32 years vs. 10.2 ± 0.42 years, P <0.001) (**Table 4**). Most notably, group affiliation did not alter this observation among propensity-score matched patients (**Fig. 1**): Patients receiving TAR exhibited improved survival (12.7 ± 0.41 years vs. 11.3 ± 0.45 years, $P = 0.017$) among the matched pairs. Additionally, Cox regression confirmed that TAR group affiliation protected from late mortality (HR 0.541, 95% CI: 0.324–0.904, $P = 0.017$).

Discussion

In our study, we were able to show that TAR is superior to the combined venous and arterial approach. During the early days of TAR, this approach was reserved for healthier patients and performed by more skilled surgeons. Over the time, this policy has changed, and TAR is now a standard operation, taught to our surgeons from the beginning of their career. Primarily, we aim to choose TAR and only resort to using venous grafts as an alternative if respective contraindications exist.

In some centers, concerns over its vasospastic tendencies, its technical challenge, and the necessity of bypassing severe stenosis (>70%) to avoid a reduction in conduit patency have limited the adoption of RA grafting.[11,12)]

However, apart from its recognized superior patency rates over venous grafts,[7,13–15)] numerous anatomo-pathological characteristics have been reported that qualify the RA as a suitable conduit for CABG: its resistance to atherosclerosis, adaption to high arterial pressure, its convenient site allowing parallel LITA harvesting, caliber size and length, and the considerable muscular wall enabling easy handling.[16)] These promising qualities are in sharp contrast to the persistent reluctance of surgeons towards its extended use in TAR.

The main finding of our study is that multiple arterial grafting using a LITA and RA as a composite T-graft was

Table 3 Operative characteristics and early outcomes in unmatched cohorts

	TAR (n = 187)		ACVB (n = 158)		
	Mean	SD	Mean	SD	*P* value
Operation time (min)	183	29.2	200	61.8	0.002
Bypass time (min)	67.3	17.6	97.1	45	<0.001
Cross-clamp time	40.5	12	50.9	17.7	<0.001
Peripheral anastomoses (count)	3.29	0.7	3.62	0.75	<0.001
Ventilation time (h)	20.5	86.8	23.9	37.1	<0.001
Stay on ICU (days)	1.73	4.11	2.16	2.46	<0.001
Total hospital stay (days)	13.5	7.39	15.1	7.48	0.044
Follow-up time (years)	13.1	0.86	13.6	0.15	<0.001
	n	(%)	n	(%)	*P* value
Conduits used					
Venous					
1	0	0	9	5.7	<0.001
2	0	0	128	81	<0.001
3	0	0	21	13.3	<0.001
Arterial					
1	0	0	158	100	<0.001
2	187	100	0	0	<0.001
Harvested grafts					
LITA	187	100	156	93.7	<0.001
RITA	0	0	2	1.3	<0.001
RA	187	100	0	0	<0.001
SV	0	0	158	100	<0.001
Conduits to					
LAD	185	98.9	154	97.5	0.419
Diagonal	86	46	84	53.2	0.196
RCx	4	2.1	2	1.3	0.691
PLA1	128	68.4	124	78.5	0.039
PLA2	41	21.9	33	20.9	0.895
PLA3	3	1.6	8	5.1	0.121
RIM	20	10.7	23	14.6	0.327
RCA	5	2.7	19	12	<0.001
RPLA	27	14.4	21	13.3	0.876
RIVP	113	60.4	97	61.4	0.912
SAE					
Cardiopulmonary resuscitation	5	2.7	4	2.5	1.000
Myocardial infarction	3	1.6	3	1.9	1.000
Low cardiac output	3	1.6	9	5.7	0.073
Neurological complications	8	4.3	4	2.5	0.557
Renal failure					
GFR (ml/min) <60	16	8.6	40	26.3	<0.001
GFR (mL/min) <30	2	1.1	14	9.2	<0.001
Deep sternal infection	1	0.5	5	3.2	0.097
Harvesting site infection	2	1.1	7	4.4	0.086
Prolonged ventilation (>48 h)	5	2.7	6	3.8	0.557
Post-OP death within 30 days	0	0	7	4.5	0.004

ACVB: combined arterial and venous revascularization; GFR: glomerular filtration rate; ICU: intensive care unit; LAD: left anterior descending; LITA: left internal thoracic artery; PLA: posterior lateral branch; RA: radial artery; RCA: right coronary artery; RCx: left circumflex; RIM: ramus intermedius; RITA: right internal thoracic artery; RIVP: right posterior descending; RPLA: right posterior lateral branch; SAE: serious adverse event; SD: standard deviation; SV: saphenous vein; TAR: total arterial revascularization

associated with superior long-term survival compared to a combination of ITA and venous grafting. Despite the smaller likelihood of death due to cardiac-related causes, use of TAR did not derive a positive impact on long-term complications and events such as MI, stroke, TIA, and re-interventions.

Table 4 Follow-up in unmatched cohorts

	TAR (n = 128)		ACVB (n = 105)		
	Mean	SD	Mean	SD	*P* value
Follow-up time (years)	13.1	0.86	13.6	0.15	<0.001
Long-term survival (years)	12.5	0.32	10.2	0.42	<0.001
	n	(%)	n	(%)	*P* value
Apoplex	17	13.3	8	7.6	0.204
Myocardial infarction	14	10.9	15	14.3	0.550
PCI	24	18.8	18	17.1	0.864
Coronary bypass operation	3	2.3	2	1.9	1.000
NYHA status					
I-II	95	74.2	76	63.8	0.058
III-IV	33	25.8	38	36.2	
CCS class of angina					
No angina	2	1.6	26	24.8	<0.001
I-II	119	93	64	61	
III-IV	7	5.5	15	14.3	

	TAR (n = 57)		ACVB (n = 93)	
	n	(%)	n	(%)
Cause of death				
Cardiovascular diseases	7	12.3	21	22.8
Cancer	5	8.5	5	5.4
Sepsis/Inflammation	5	8.8	2	2.2
Stroke	3	5.3	2	2.2
Acute renal failure	2	3.5	1	1.1
Multiorgan dysfunction	0	0	3	3.3
Trauma	2	3.5	1	1.1
Hemorrhage	0	0	1	1.1
Other causes	0	0	1	1.1
Unknown cause	33	57.9	55	59.8

ACVB: combined arterial and venous revascularization; CCS: Canadian Cardiovascular Society; NYHA: New York Heart Association; PCI: previous coronary intervention; SD: standard deviation; TAR: total arterial revascularization

Our results are consistent with other studies that have alluded to improved survival when using the RA in multiple arterial grafting.[17–19]

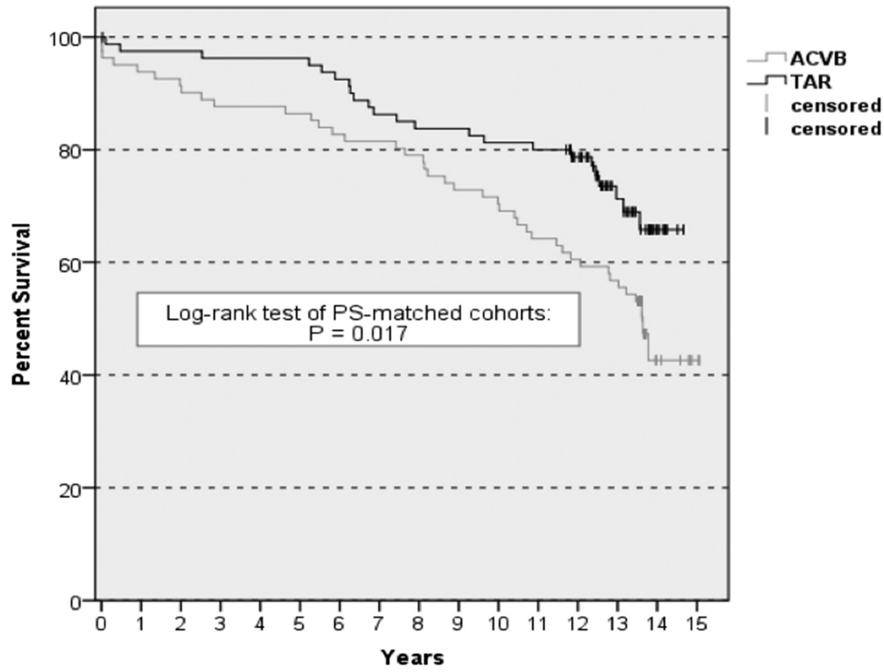
Buxton and colleagues validated the association of TAR using the LITA and RA with improved long-term survival benefit compared to ACVB in a propensity-matched cohort study after 15 years of follow-up (54% ± 3.3% vs. 41% ± 3.0%, $P = 0.0004$).[20]

Another large cohort study conducted by Schwann et al. investigated propensity-matched patients undergoing non-salvage primary CABG at two institutions. The authors found ITA and RA grafting to be associated with significantly better cumulative mortality rates compared to ITA and saphenous vein grafting.

Similarly, Goldstone et al. reported a significantly lower mortality rate in patients receiving arterial grafts in multivessel CABG compared to venous grafts. Additionally, the authors showed that the RITA led to an increase in sternal wound infections and that it offered no benefit over the use of the RA.[21]

Our results are at odds with studies that have investigated the impact of RA use on survival in distinct subgroups of patients. Hayward and colleagues reported similar survival rates between propensity-matched RA and venous groups after 7 years of follow-up in high-risk patients (RA: 75 ± 2.6% vs. Veins: 74 ± 2.9%, $P = 0.65$).[22]

Another study has alluded to a limited use of the RA as a second arterial conduit since a gradual decline of



Number at risk (%); deaths in PS-matched cohorts

Years	1	3	5	7	10	13
ACVB	76 (93,8); 5	71 (87,7); 10	70 (86,4); 11	66 (81,5); 15	57 (70,4); 24	46 (56,8); 35
TAR	78 (97,5); 2	77 (96,3); 3	77 (96,3); 3	69 (86,3); 11	65 (81,3); 15	31 (71,2); 21

Fig. 1 Overall survival in the propensity-matched cohort by type of conduit. ACVB: combined arterial and venous revascularization; TAR: total arterial revascularization

survival benefit was observed with increasing age. Patients older than 70 years no longer presented with improved survival (adjusted HR 0.90, 95% CI: 0.63–1.28, $P = 0.57$).[23]

The use of the RA as a T-graft remains under discussion. The RA can be used either as a free graft (directly to the aorta) or as a Y- or T-graft (anastomosed to the LITA or RITA) as a composite graft. Whereas long-term outcomes between these two techniques seem to be comparable, some surgeons are hesitant when it comes to the use of a single composite T-graft due to concerns regarding inferior long-term patency rates in comparison with multiple singular grafts. We do, however, believe that the use of the RA as a T-graft results in several advantages. It may be beneficial in preventing neurological events in patients with severe calcification of the ascending aorta since additional aortic side-clamping is unnecessary. Also, the use of the RA as a T-graft provides sufficient conduit length which usually enables the performance of up to four sequential anastomoses. Therefore, even in complex cases, a complete revascularization may be performed with only two bypass grafts. Also, RA anastomeses made to the ascending aorta can be prone to develop fibrous intimal hyperplasia due to the enormous aortic wall stress.[7] Besides, the limited use of two grafts during the initial surgical revascularization allows the harvest of further grafts in the case of a necessary surgical re-intervention.

A possible drawback that remains with the concept of composite grafts is the dependency of distal anastomoses perfusion on a single inflow (LITA or RITA). Even though Affleck et al. showed sufficient flow reserve of the T-graft to meet cardiac demand,[24] Jung et al. showed better patency rates for the direct aortic anastomosis when comparing direct aortic anastomosis of the RA and anastomosis to the LITA.[25] However, these results were questioned by other groups that found no difference between these surgical techniques.[26,27] Jung et al. argued that direct RA–aortic anastomosis might lead to an ameliorated RA flow due to higher aortic driving pressure compared to the composite graft.

Additionally, RA patency rates have shown to be greatly impacted by target vessel characteristics such as anastomosis site as well as level of stenosis within the bypassed artery.[28] Whereas the use of RA grafts to the LAD or the circumflex has shown to yield encouraging results, Nakajima et al. have shown higher risk rates for anastomotic failure in RCA anastomosis targets, especially in branch locations that have shown to be moderately stenosed.[29] Given overall higher patency rates, we do believe in strategic implication of the RA in RCA targets that show high stenosis. With respect to flow dynamic in the bypassed moderately stenosed RCA targets, other conduits may show superior performance.

There are certain questions raised by our data that need to be addressed in future studies. As mentioned, MI, stroke, TIA, and re-interventions did not differ between the groups. Also, the relatively high incidence of stroke during follow-up needs to be addressed further. Especially in relation to the occurrence of atrial fibrillation, the resection of the left atrial appendage as a standard in operative revascularization should be discussed.

Study limitations

Our findings are based on a retrospective analysis of observational single-center data, which could restrict their transferability. We have implemented propensity score matching to estimate causal treatment effects in a comparatively small study cohort; therefore, effects of unmeasured covariates cannot be ruled out.

Conclusions

In view of our results, the RA should be considered more frequently as a composite to the LITA in all-arterial revascularization. Our analysis supports the hypothesis that it could project better long-term survival onto the greater population undergoing CABG.

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Disclosure Statement

No conflict of interest declared.

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