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A 27-Year Comparative Analysis of Coronary Artery Surgery with Single and Multiple Arterial Grafting in Severe Left Ventricular Dysfunction

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Abstract: Background: Patients with severely reduced left ventricular ejection fraction (EF <30%) undergoing coronary artery bypass grafting represent a high-risk group. Although multiple arterial grafting has demonstrated survival advantages in broader populations, its effect in this subset remains insufficiently defined. Methods: A retrospective review of 489 patients with EF <30% undergoing surgery over 27 years was performed. Propensity matching (1:1 greedy technique) produced 121 pairs who received either single or multiple arterial conduits. Short-term outcomes, 30-day mortality, and long-term survival were evaluated. Survival analyses and Cox models were used to identify factors associated with mortality. Results: Matched groups showed no significant differences in early outcomes, including 30-day mortality (single 3.3% vs multiple 5.8%, P=0.36). In the unmatched cohort, multiple arterial grafting was linked to improved long-term survival (P=0.008), but this advantage was not statistically significant after matching (P=0.35). Ten-year survival was 71.9% for single versus 77.2% for multiple grafts; twenty-year survival was 49.3% versus 57.2%. In single arterial grafting group, preoperative atrial fibrillation was the only independent predictor of mortality (HR 3.216, 95% CI 1.080–9.575, P=0.04). In multiple arterial grafting group, age (HR 1.104, 95% CI 1.061–1.150, P<0.001), two prior myocardial infarctions (HR 4.242, 95% CI 1.749–10.338, P<0.001), and ex-smoking status (HR 3.069, 95% CI 1.401–6.721, P=0.01) were independently associated with higher mortality. Conclusion: These findings emphasise the need for careful patient selection and strategic conduit planning in severe ventricular dysfunction, and support further prospective work to determine which patients may derive durable benefit from more extensive arterial revascularisation.

Keywords: Arterial Grafting, Coronary Artery Bypass, Left Ventricular Dysfunction, Propensity Score Matching, Survival Analysis

INTRODUCTION

Coronary artery bypass grafting (CABG) remains the cornerstone of revascularization in patients with multivessel coronary artery disease, particularly those with impaired left ventricular (LV) function [1,2]. In this high-risk cohort, surgical strategy and conduit selection critically influence long-term outcomes. While left internal thoracic artery (LITA) grafting to the left anterior descending artery is universally accepted, the role of multiple arterial grafting (MAG)—particularly bilateral internal thoracic artery (BITA) or radial artery (RA) use—has been increasingly evaluated in contemporary studies for its potential to improve survival and reduce adverse cardiac events [3-5].

Despite these findings, MAG remains underutilized in patients with severely reduced left ventricular ejection fraction (EF <30%), often due to concerns regarding operative complexity, sternal wound complications, and perceived lack of benefit in the context of reduced myocardial viability. However, recent data from large registries and institutional cohorts suggest that these risks may be overstated, particularly when BITA is harvested using skeletonization techniques and RA is deployed selectively based on target vessel stenosis [4,5]. The present study aims to evaluate the impact of MAG versus single arterial grafting (SAG) on long-term survival in patients undergoing isolated CABG with EF <30%. By utilzing a large, contemporary cohort and applying rigorous propensity score methodology, we seek to clarify the prognostic implications of conduit strategy in this clinically vulnerable population.

METHODS

Data Source

This study represents a retrospective evaluation of prospectively collected data from a dedicated institutional cardiac surgery registry (Patient Analysis and Tracking System [PATS]; Dendrite Clinical Systems, Oxford, UK). The registry systematically records comprehensive clinical information across the perioperative continuum, including preoperative risk factors, intraoperative variables, postoperative complications, and long-term survival outcomes. The dataset undergoes routine external validation and contributes annually to the National Adult Cardiac Surgery Audit administered by the National Institute for Cardiovascular Outcomes Research. Mortality data were corroborated using both institutional records and the National Health Service Spine portal. Follow-up completeness was verified for all included patients. Ethical approval was obtained from the institutional audit committee, and the requirement for individual consent was waived in accordance with the retrospective nature of the study and the principles outlined in the Declaration of Helsinki (QS/SR 04/2024).

Study Population

All patients with a documented LVEF below 30% who underwent isolated CABG between January 1996 and September 2023 at a single tertiary cardiac centre were eligible. A total of 489 patients met inclusion criteria. Participants were categorized into two groups based on intraoperative conduit strategy: SAG=359 and MAG=130. Surgical planning was conducted within a multidisciplinary heart team comprising cardiac surgeons, interventional cardiologists, and imaging specialists. Myocardial viability was systematically evaluated for all patients using contemporary imaging modalities to guide revascularization strategy and ensure appropriate selection for surgical intervention. Operative urgency was determined using a structured prioritization protocol.

Surgical Technique

CABG procedures were performed via median sternotomy. The use of cardiopulmonary bypass was determined by the operating surgeon based on anatomical and clinical considerations. Conduit selection reflected individual surgeon preference and coronary

anatomy. SAG was defined as the use of a single internal thoracic artery graft supplemented by saphenous vein grafts. MAG included the use of two or more arterial conduits, typically involving BITA and/or RA.

Postoperative Management

Postoperative care was delivered in a specialized cardiac intensive care unit under standardized protocols for ventilation, hemodynamic support, and fluid management. Pharmacologic therapy included antiplatelet agents, statins, beta-blockers, and renin-angiotensin system inhibitors, tailored to individual patient profiles. The use of dual antiplatelet therapy was not standardized and varied according to surgeon discretion and clinical context.

Statistical Analysis

Continuous variables were summarized as mean ± standard deviation or median with interquartile range, depending on distribution characteristics. Categorical variables were presented as frequencies and percentages. Normality was assessed using the Lilliefors-modified Kolmogorov–Smirnov test. Between-group comparisons employed Student's t-test or Mann–Whitney U-test for continuous data and Pearson's x^2 or Fisher's exact test for categorical data.

Survival outcomes were analyzed using Kaplan–Meier curves, with log-rank testing applied to compare survival distributions. Time-to-event data were reported with 95% confidence intervals at 5, 10, 15, and 20 years. Cox proportional hazards models were used to identify independent predictors of long-term mortality. Variables with p-values <0.20 in univariable analysis were considered for multivariable modeling using backward stepwise selection.

To mitigate baseline differences between SAG and MAG groups, propensity score matching (PSM) was performed. Propensity scores were derived from a logistic regression model incorporating all preoperative variables.

A 1:1 nearest-neighbour matching algorithm without replacement was applied using a caliper width of 0.05 standard deviations of the logit of the score. Standardized mean differences (SMDs) were used to assess covariate balance between groups before and after matching, with values <0.10 interpreted as indicating adequate balance. For categorical variables with more than two levels, balance was evaluated using Cohen's w, providing a single multinomial SMD for each variable. All statistical analyses were conducted using Stata/SE 18.0 (StataCorp LLC, College Station, TX, USA). Data preprocessing and initial calculations were performed using Microsoft Excel (Microsoft Corp., Redmond, WA, USA).

RESULTS

Baseline Characteristics

Among 489 patients with an ejection fraction <30% undergoing isolated CABG, 359 received SAG and 130 underwent MAG. Before matching, the most notable differences between groups were age (SMD 0.49), with MAG patients being younger on average, and smoking

status (SMD 0.20), with a higher proportion of current smokers in the MAG cohort. Cerebrovascular disease also showed measurable imbalance (SMD 0.20). All other preoperative characteristics—including sex, NYHA class, comorbidities, extent of coronary artery disease, and logistic EuroSCORE—demonstrated small standardized mean differences (SMD <0.15), indicating generally acceptable baseline comparability aside from the variables noted. Full baseline characteristics for the unmatched cohorts are presented in Table 1.

Table 1: Preoperative demographics of the unmatched cohort

Variable	SAG (n = 359)	MAG (n = 130)	P value	SMD
Age (years)	66.3 ± 9.4	61.6 ± 10.0	<0.001	0.49
Female	37 (10.3%)	14 (10.8%)	0.88	0.02
NYHA Classification			0.12	0.17
Class I	60 (16.7%)	28 (21.5%)		
Class II	126 (35.1%)	52 (40.0%)		
Class III	132 (36.8%)	33 (25.4%)		
Class IV	41 (11.4%)	17 (13.1%)		
CHF			0.10	0.15
Never	216 (60.2)	92 (70.8%)		
Past	56 (15.6%)	15 (11.5%)		
Now	87 (24.2%)	23 (17.7%)		
Previous MI			0.90	0.05
None	77 (21.4%)	32 (24.6%)		
One MI	214 (59.6%)	74 (56.9%)		
Two MI	34 (9.5%)	12 (9.2%)		
Three or more MI	34 (9.5%)	12 (9.2%)		
Previous Cardiac Surgery	7 (1.9%)	4 (3.1%)	0.46	0.08
Diabetes	154 (42.9%)	49 (37.7%)	0.30	0.11
Hypercholesterolemia	254 (70.8%)	98 (75.4%)	0.31	0.10
Hypertension	234 (65.2%)	82 (63.1%)	0.67	0.04
Smoking Status			0.03	0.20
Never	105 (29.2%)	24 (18.5%)		
Ex-smoker	200 (55.7%)	78 (60.0%)		
Current smoker	54 (15.0%)	28 (21.5%)		
Renal Disease	23 (6.4%)	4 (3.1%)	0.15	0.15
Respiratory Disease	54 (15.0%)	13 (10.0%)	0.15	0.14
Cerebrovascular Disease	29 (8.1%)	4 (3.1%)	0.05	0.20
Preoperative AF	24 (6.7%)	6 (4.6%)	0.40	0.09
Extent of CAD			0.27	0.09
1 vessel	15 (4.2%)	5 (3.9%)		
2 vessels	42 (11.7%)	10 (7.7%)		
3 vessels	302 (84.1%)	115 (88.5%)		
Left Main Stem Disease	99 (27.6%)	32 (24.6%)	0.51	0.07
Logistic EuroSCORE	5.8 ± 8.8	4.8 ± 6.5	0.85	0.12

Data n (%), median ± standard deviation, AF = atrial fibrillation; CAD = coronary artery disease; CHF = congestive heart failure; MAG = multiple arterial grafting; MI = myocardial infarction; NYHA = New York Heart Association; SAG = single arterial grafting; SMD = standardized mean difference

Following PSM, baseline characteristics were well balanced between the SAG and MAG groups. All standardized mean differences were <0.10, and no clinically meaningful imbalances remained across demographic, clinical, or angiographic variables. The matched cohorts therefore demonstrated excellent covariate balance, as detailed in Table 2.

Table 2: Preoperative demographics of the propensity-matched cohort

Variable	SAG (n = 121)	MAG (n = 121)	P value	SMD
Age (years)	60.8 ± 9.7	62.3 ± 9.8	.22	.09
Female	13 (10.7%)	14 (11.6%)	.84	.03
NYHA Classification			.90	.09
Class I	17 (25.3%)	24 (19.8%)		
Class II	58 (44.8%)	48 (39.7%)		
Class III	37 (25.9%)	32 (26.4%)		
Class IV	9 (4.0%)	17 (14.0%)		
CHF			.34	.08
Never	92 (76.0%)	83 (68.6%)		
Past	9 (7.4%)	15 (12.4%)		
Now	20 (16.5%)	23 (19.0%)		
Previous MI			.91	.04
None	28 (23.1%)	29 (24.0%)		
One MI	71 (58.7%)	68 (56.2%)		
Two MI	13 (10.7%)	12 (9.9%)		
Three or more MI	9 (7.4%)	12 (9.9%)		
Previous Cardiac Surgery	2 (1.7%)	2 (1.7%)	1.00	.00
Diabetes	40 (33.1%)	47 (38.8%)	.35	.08
Hypercholesterolemia	92 (76.0)	91 (75.2%)	.88	.02
Hypertension	82 (67.8%)	79 (65.3%)	.68	.05
Smoking Status			.24	.09
Never	20 (16.5%)	23 (19.0%)		
Ex-smoker	68 (56.2%)	76 (62.8%)		
Current smoker	33 (27.3%)	22 (18.2%)		
Renal Disease	2 (1.7%)	4 (3.3%)	.41	.09
Respiratory Disease	6 (5.0%)	13 (10.7%)	.09	.07
Cerebrovascular Disease	3 (2.5%)	4 (3.3%)	.70	.05
Preoperative AF	6 (5.0%)	6 (5.0%)	1.00	.00
Extent of CAD			.83	.05
1 vessel	1 (0.8%)	3 (2.5%)		
2 vessels	14 (11.6)	10 (8.3%)		
3 vessels	106 (87.6%)	108 (89.3%)		
Left Main Stem Disease	30 (24.8%)	30 (24.8%)	1.00	.00
Logistic EuroSCORE	4.7 ± 7.4	4.8 ± 6.6	.45	.01

Data are n (%) or mean ± standard deviation. AF = atrial fibrillation; CAD = coronary artery disease; CHF = congestive heart failure; MAG = multiple arterial grafting; MI = myocardial infarction; NYHA = New York Heart Association; SAG = single arterial grafting; SMD = standardized mean difference.

Perioperative Outcomes

Short-term outcomes were comparable between the SAG and MAG groups in both unmatched and propensity-matched analyses. In the unmatched cohort (Table 3), rates of reoperation for bleeding (SAG: 4.5% vs. MAG: 3.1%, P=0.45), tracheostomy (5.3% vs. 2.3%, P=0.16), cerebrovascular events (2.8% vs. 1.5%, P=0.43), and renal replacement therapy (7.8% vs. 6.2%, P=0.54) did not differ significantly between groups. Thirty-day mortality was numerically lower in the MAG group (5.4% vs. 6.7%), though this difference was not statistically significant (p=0.60).

Table 3: Short-term outcomes of the unmatched cohort

Variable	SAG (n = 359)	MAG (n = 130)	P value
Reoperation	16 (4.5%)	4 (3.1%)	0.45
Tracheostomy	19 (5.3%)	3 (2.3%)	0.16
CVA/TIA	10 (2.8%)	2 (1.5%)	0.43
RRT	28 (7.8%)	8 (6.2%)	0.54
Death at 30 Days	24 (6.7%)	7 (5.4%)	0.60

Data n (%), median ± standard deviation, CVA = cerebrovascular accident; MAG = multiple arterial grafting; RRT = renal replacement therapy; SAG = single arterial grafting; TIA = transient ischemic attack

In the matched analysis, short-term perioperative outcomes were broadly comparable between SAG and MAG groups, with no significant differences across major postoperative complications or early mortality (Table 4).

Table 4: Short-term outcomes of the propensity-matched cohort

Variable	SAG (n = 121)	MAG (n = 121)	P value
Reoperation	4 (3.3%)	4 (3.3%)	1.00
Tracheostomy	7 (5.8%)	3 (2.5%)	.20
CVA/TIA	3 (2.5%)	2 (1.7%)	.65
RRT	7 (5.8%)	8 (6.6%)	.79
Death at 30 Days	4 (3.3%)	7 (5.8%)	.36

Data are n (%). CVA = cerebrovascular accident; MAG = multiple arterial grafting; RRT = renal replacement therapy; SAG = single arterial grafting; TIA = transient ischemic attack.

Long-term Survival

Survival analysis was conducted over a 20-year follow-up period. In the unmatched cohort, mean follow-up duration was significantly longer in the MAG cohort (12.0 ± 8.2 vs. 9.7 ± 6.6 years, P=0.001). Patients who received MAG demonstrated significantly improved long-term survival compared with those who underwent SAG (log-rank=7.13, P=0.008). Survival estimates at 5, 10, 15, and 20 years favored MAG, with a 17.3% absolute difference at 20 years (MAG: 59.8% vs. SAG: 42.5%; Table 5); the corresponding survival curves are shown in Figure 1.

Table 5: Kaplan-Meier survival estimates for the unmatched cohort

Time (years)	Survival (%)	95% CI	Log-rank P value
SAG			.008
5	82.7%	.77 – .85	
10	66.9%	.61 – .72	
15	55.2%	.49 – .61	
20	42.5%	.17 – .40	
MAG			
5	82.9%	.75 – .89	
10	78.1%	.70 – .85	
15	66.2%	.56 – .75	
20	59.8%	.49 – .69	

CI = confidence interval; MAG = multiple arterial grafting; SAG = single arterial grafting.

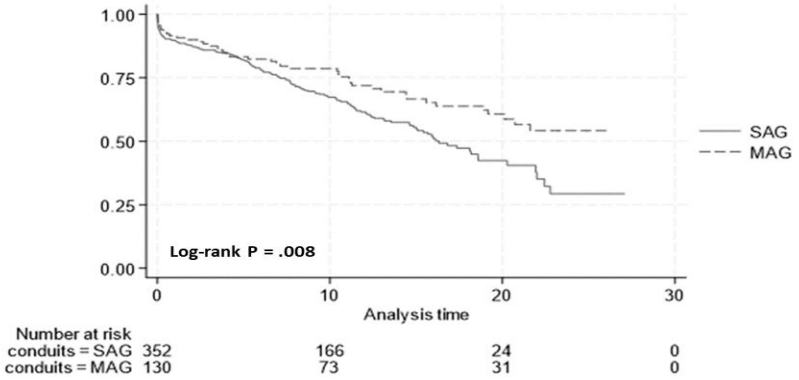

Figure 1: Kaplan-Meier survival curves for the unmatched cohort

In contrast, in the matched cohort, mean follow-up was similar (SAG 11.2 ± 7.6 vs. MAG 11.7 ± 8.1 years, P=0.64), with no statistically significant difference in survival between MAG and SAG groups (log-rank=0.87, P=0.35). Although MAG was associated with numerically higher survival at each time point, the differences did not reach statistical significance. At 20 years, survival was 57.2% in the MAG group and 49.3% in the SAG group (Table 6); the corresponding survival curves are shown in Figure 2.

Table 6: Kaplan-Meier survival estimates for the propensity-matched cohort

Time (years)	Survival (%)	95% CI	Log-rank P value
SAG			.35
5	85.1%	.74 – .88	
10	71.9%	.62 – .80	
15	64.0%	.53 – .73	
20	49.3%	.37 – .61	
MAG	82.5%	.74 – .88	
5			
10	77.2%	.68 – .84	
15	64.1%	.53 – .73	
20	57.2%	.46 – .67	

CI = confidence interval; MAG = multiple arterial grafting; SAG = single arterial grafting.

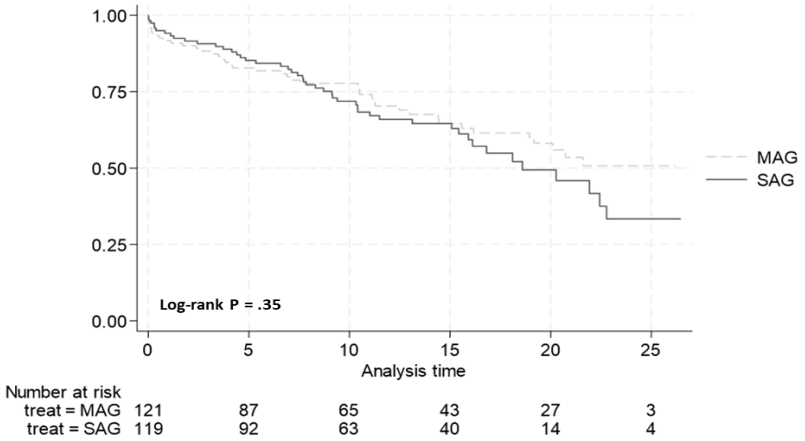

Figure 2: Kaplan-Meier survival curves for the propensity-matched cohort

Predictors of Long-Term Mortality

In the SAG cohort, few variables demonstrated independent associations with long-term mortality after adjustment. Preoperative atrial fibrillation emerged as the only statistically significant predictor in the multivariable model (HR 3.216, 95% CI 1.080–9.575, P = 0.04). Although previous cardiac surgery showed a trend toward increased mortality (HR 2.902, 95% CI 0.677–12.44, P = 0.15), this did not reach statistical significance. Full univariable and multivariable results are presented in Table 7.

Table 7: Univariable and multivariable Cox regression for long-term mortality in the SAG cohort

Univariable Cox regression					Multivariable Cox regression			
Variable	**HR**	**95% CI Lower**	**95% CI Upper**	**P value**	**HR**	**95% CI Lower**	**95% CI Upper**	**P value**
Age	.987	.960	1.016	.38				
Gender	.620	.222	1.735	.36				
NYHA I (ref)	1							
NYHA II	.580	.275	1.223	.15				
NYHA III	.685	.314	1.493	.34				
NYHA IV	.434	.096	1.964	.28				
No previous Mis (ref)	1							
1 previous MI	1.106	.559	2.188	.77				
2 previous Mis	1.003	.370	2.719	1.00				
3 or more previous MIs	.545	.122	2.440	.43				
Previous cardiac surgery	2.620	.627	10.940	.19	2.902	.677	12.44	.15
Diabetes	1.567	.853	2.877	.15				
Hypercholesterolaemia	.611	.336	1.110	.11	.631	.342	1.164	.14
Hypertension	.837	.466	1.502	.55				
CHF	.925	.609	1.405	.72				
Cerebrovascular disease	1.373	.188	10.024	.75				
Never smoker (ref)	1							
Ex-smoker	1.180	.539	2.585	.68				
Current smoker	2.585	.325	2.191	.73				
Pulmonary disease	1.196	.288	4.966	.81				
Preoperative AF	3.952	1.367	11.428	.01	3.216	1.080	9.575	.04
LMS disease	.502	.212	1.184	.12	.565	.236	1.348	.20

Backward stepwise selection included clinically important variables and variables with univariable P<0.20. AF = atrial fibrillation; CI = confidence interval; CHF = congestive heart failure; HR = hazard ratio; LMS = left main stem; MI = myocardial infarction; NYHA = New York Heart Association; SAG = single arterial grafting.

In the MAG cohort, age remained a strong and independent predictor of long-term mortality (HR 1.104, 95% CI 1.061–1.150, P < 0.001). A history of two previous myocardial infarctions was independently associated with increased mortality (HR 4.242, 95% CI 1.749–10.338, P < 0.001). Ex-smoker status was also a significant predictor of higher mortality (HR 3.069, 95% CI 1.401–6.721, P = 0.01). Full results are shown in Table 8.

Table 8: Univariable and multivariable Cox regression for long-term mortality in the MAG cohort

Univariable Cox regression					Multivariable Cox regression			
Variable	**HR**	**95% CI Lower**	**95% CI Upper**	**P value**	**HR**	**95% CI Lower**	**95% CI Upper**	**P value**
Age	1.076	1.038	1.115	<.001	1.104	1.061	1.150	<.001
Gender	.940	.335	2.639	.91				
NYHA I (ref)	1							
NYHA II	.596	.286	1.240	.17	.463	.230	.933	.03
NYHA III	.533	.220	1.292	.16	.417	.178	.977	.04
NYHA IV	.812	.287	2.300	.70				
No previous Mis (ref)	1							
1 previous MI	.569	.287	1.127	.11				
2 previous MIs	1.466	.589	3.648	.41	4.242	1.749	10.338	<.001
3 or more previous MIs	.127	.017	.968	.05	.158	.021	1.163	.07
Previous cardiac surgery	1.152	.158	8.404	.89				
Diabetes	1.150	.616	2.146	.66				
Hypercholesterolaemia	1.593	.737	3.444	.24				
Hypertension	1.164	.617	2.194	.64				
CHF	1.053	.707	1.567	.80				
Cerebrovascular diseas	1.209	.164	8.892	.85				
Never smoker (ref)	1							
Ex-smoker	2.143	.838	5.483	.11	3.069	1.401	6.721	.01
Current smoker	0.660	.158	2.770	.57				
CKD	1.103	.150	8.09	.92				
Pulmonary disease	0.734	.226	2.381	.61				
Preoperative AF	0.765	.185	3.169	.71				
LMS disease	1.309	.619	2.772	.48				

Backward stepwise selection included clinically important variables and variables with univariable P<0.20. AF = atrial fibrillation; CI = confidence interval; CKD = chronic kidney disease; CHF = congestive heart failure; HR = hazard ratio; LMS = left main stem; MAG = multiple arterial grafting; MI = myocardial infarction; NYHA = New York Heart Association.

DISCUSSION

This study provides a comprehensive 27-year evaluation of single versus multiple arterial grafting in patients with severely impaired left ventricular function (EF <30%) undergoing isolated CABG. In the unmatched cohort, MAG was associated with a clear long-term survival advantage; however, this benefit was no longer evident following PSM, indicating that the apparent superiority of MAG was largely driven by baseline differences—most notably younger age and more favourable risk profiles among MAG recipients. After adjustment, predictors of long-term mortality differed between grafting strategies. In the SAG cohort, preoperative atrial fibrillation was the only independent risk factor for mortality, whereas in the MAG cohort, age remained a strong adverse predictor. A history of two previous myocardial infarctions and ex-smoker status were also independently associated with increased mortality in the MAG group.

Our findings both align with and diverge from previously published literature evaluating MAG in patients with varying degrees of ventricular dysfunction. Ren et al. [6], in a binational registry analysis of over 59,000 patients, reported a consistent survival

benefit of MAG across all strata of ejection fraction, including those with EF <30% (HR 0.82, 95% CI 0.71–0.96, P=0.01). However, when the analysis was restricted to total arterial grafting, the survival benefit in the EF <30% subgroup was attenuated and no longer statistically significant (HR 0.87, 95% CI 0.67–1.13, P=0.30). This nuanced finding mirrors our matched cohort results, where the survival advantage of MAG was not preserved after controlling for baseline characteristics. The attenuation of benefit may reflect differences in conduit configuration, completeness of revascularization, or the influence of selection bias inherent in observational datasets.

Zhang et al. [7] examined patients with mild to moderate LV dysfunction undergoing multi-vessel CABG and found that MAG was associated with reduced mid-term rates of major adverse events (HR 0.64), myocardial infarction (HR 0.39), and repeat revascularization (HR 0.42), without differences in mortality or stroke. While their findings support the use of MAG in patients with preserved or moderately reduced EF, they do not address outcomes in those with severe dysfunction. The discrepancy between their results and ours may be attributable to differences in LV function severity, as patients with EF >30% are more likely to experience myocardial recovery post-CABG. Additionally, Zhang's study had a shorter follow-up duration (mean 3.3 years), potentially missing late mortality events unrelated to graft choice.

Pu et al. [8] conducted a population-based study in British Columbia involving over 20,000 patients with multivessel or left main disease. MAG was associated with reduced long-term mortality (HR 0.79), myocardial infarction (HR 0.63), heart failure (HR 0.79), and repeat revascularization (HR 0.74), with benefits persisting across subgroups including those with moderately impaired EF. Importantly, MAG did not increase 30-day morbidity or mortality, reinforcing its safety profile. Our findings corroborate this safety signal, with in-hospital mortality rates low and comparable between MAG and SAG (1.6% vs. 2.2%, P=0.78), even in patients with EF <30%. However, Pu et al.'s cohort did not isolate patients with severe dysfunction, limiting direct comparability to our study.

Beyond conduit strategy, our analysis identified several patient-level factors that shaped long-term mortality and offer insight into the biological and clinical determinants of survival after CABG in patients with severe ventricular dysfunction. In the SAG cohort, preoperative atrial fibrillation emerged as the only independent predictor of mortality, consistent with the adverse hemodynamic and thromboembolic consequences of atrial fibrillation in the setting of impaired ventricular function [9,10]. In contrast, the MAG cohort demonstrated a broader set of prognostic markers. Age remained a strong and consistent risk factor, reflecting the cumulative effects of vascular aging, endothelial dysfunction, and reduced myocardial reserve that diminish tolerance to ischemic and surgical stress [11,12]. A history of two previous myocardial infarctions markedly increased mortality risk, highlighting the detrimental impact of cumulative myocardial injury, scar burden, and reduced viable myocardium on long-term outcomes [13.14]. Additionally, ex-smoker status was independently associated with increased mortality, likely reflecting persistent vascular and pulmonary sequelae of smoking that remain clinically relevant long after cessation [15,16]. Collectively, these findings demonstrate that long-term outcomes after CABG in patients with severe LV dysfunction are shaped not only by grafting strategy but also by underlying patient-level characteristics, underscoring the need to integrate biological resilience, ischemic burden, and comorbidity profiles into surgical decision-making.

Rocha et al. [17] previously reported that while MAG (≥2 arterial grafts) was superior to SAG, there was no incremental survival benefit with three arterial grafts compared to two. Our study did not stratify MAG by number or type of arterial conduits, which may have diluted the observed effect. The heterogeneity in MAG definition—whether BITA, RA combinations, or total arterial revascularization—remains a key limitation. Institutional practice variation, surgeon experience, and target vessel anatomy likely influenced conduit selection and outcomes, underscoring the need for more granular data in future studies.

This study benefits from a long follow-up duration, complete survival data, and robust statistical methodology including propensity score matching and multivariable modeling. The focus on patients with EF <30% addresses a clinically vulnerable population often underrepresented in conduit trials. Limitations include the retrospective design, potential for residual confounding, and lack of granularity on conduit type (e.g., total arterial vs. mixed MAG) and target vessel characteristics. Additionally, the relatively small size of the MAG cohort may limit power for subgroup analyses.

These findings suggest that while MAG may confer a survival advantage in broader clinical practice, this benefit is attenuated when baseline characteristics are rigorously balanced. The divergence in survival curves in the unmatched cohort highlights the potential influence of selection bias and underscores the importance of individualized conduit strategy in patients with severe left ventricular dysfunction. Risk stratification incorporating functional status, comorbidity burden, and conduit anatomy may aid in optimizing graft selection.

Prospective studies focusing on conduit strategy in patients with impaired ventricular function are needed to validate these findings and explore underlying mechanisms. Integration of imaging biomarkers, frailty indices, and surgeon-level variables may enhance risk prediction and guide personalized surgical planning. Multicenter data harmonization and standardized reporting frameworks will be essential to advance conduit research and enable more definitive comparisons across patient populations and surgical strategies.

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