IJC Heart & Vasculature 47 (2023) 101247

Contents lists available at ScienceDirect

IJC Heart & Vasculature

journal homepage: www.sciencedirect.com/journal/ijc-heart-and-vasculature

Editorial

Bilateral internal mammary arteries for coronary artery bypass grafting: One size does not fit all

As a result of the pioneering work by Drs. Arthur Vineburg, Robert H. Goetz, Vladimir P. Demikhov, Gordon Murray, and Vasilii I. Kolesov in the 1950–60s, coronary artery bypass grafting (CABG) has become an integral component of the coronary artery disease (CAD) treatment algorithm [1]. Various conduits for CABG have subsequently been the subject of extensive investigation. Despite experimentation with arterial grafts during the infancy of CABG, the prevailing strategy in coronary surgery continues to be mixed venous and arterial grafting, most commonly a single arterial graft via the gold-standard left internal mammary (LIMA) to left anterior descending (LAD) anastomosis supplemented by saphenous vein grafts (SVG). With anatomical and physiologic characteristics that promote excellent hemodynamics, the LIMA has demonstrated exceptional long-term patency and outcomes, cementing its role in CABG.

In light of contemporary evidence, multi- and total-arterial grafting is now gaining momentum. In a meta-analysis of 37 randomized controlled trials or propensity-matched retrospective studies, Saraiva et al. reported reduced rates of early mortality, late mortality, and major adverse cardiovascular and cerebrovascular events (MACCE) with increased rates of SWI when comparing multi- to single-arterial grafting [2]. As arterial conduit options, the radial artery and right internal mammary artery (RIMA) have both been investigated. Given its physiologic similarities to the LIMA, the RIMA has been the subject of particular interest. However, contrary to the extensive literature on the LIMA demonstrating a concrete benefit, there has been inconsistent randomized controlled and high-powered data on RIMA patency and late mortality.

The highly anticipated 10-year results of the Arterial Revascularization Trial (ART) demonstrated no difference in mortality or MACCE between the LIMA or bilateral internal mammary (BIMA) groups [3]. Notably, posthoc analyses of the ART trial have focused on specific patient populations, comparing single versus multi-arterial grafts to LIMA in diabetic patients [4] or LIMA to BIMA in patients 50–70 [5], and have identified lower rates of mortality and MACE for the BIMA or multi-arterial groups. The Randomization of Single vs Multiple Arterial Grafts (ROMA) trial that is currently underway will hopefully offer further insight into BIMA grafting and multi-arterial grafting overall [6,7].

Regarding patient populations of interest in BIMA grafting, a systematic review and meta-analysis comparing single IMA grafting to BIMA grafting in patients with diabetes or obesity was recently published by Stefil et al. in the International Journal of Cardiology: Heart and Vasculature [7]. Nineteen studies were included in the analysis of patients with diabetes and three studies in patients with obesity. The composite outcomes indicated a significant reduction in long-term mortality with BIMA grafting in patients with diabetes (risk ratio (RR) 0.79; 95% confidence interval (CI) 0.70–0.90; $p = 0.0003$) and a non-significant reduction in mortality in patients with obesity (RR 0.73; 95% CI 0.47–1.12; $p = 0.15$). Sternal wound complications were significantly greater with BIMA grafting in patients with diabetes (RR 1.53; 95% CI 1.23–1.90; $p = 0.0001$) and obesity (RR 2.24, 95% CI 1.63–3.07; $p < 0.00001$) [7].

The increased risk of sternal wound infection (SWI) has long been a major barrier to the more widespread adoption of BIMA grafting. Prior to this study of over 25,000 patients by Stefil and colleagues, there was a paucity of evidence for a long-term mortality benefit with BIMA grafting [7]. Given these results, the value of these respective outcomes must be weighed carefully. Although the increased rate of SWI is well-established, especially in those with diabetes, the benefit of reduced long-term mortality and MACE with BIMA grafting may outweigh this risk. Additionally, strategies exist to mitigate the risk of SWI including skeletonized IMA harvesting, negative pressure wound therapy, and the application of antibiotic solutions to the sternum prior to sternal closure for high-risk patients [8–10]. In contrast, strategies for reduction in mortality are valuable and cannot be overlooked. Additionally, there is insufficient evidence to suggest that the risk of SWI portends inferior long-term outcomes, with at minimum equivalent mortality rates reported with BIMA grafting in high-powered studies [3,5,7].

Furthermore, while the focus of the CABG literature has largely been optimal graft selection, there has been relatively limited analysis and discussion of target selection. The LIMA, both in clinical practice and clinical trials, is near-universally considered the first-line graft for the LAD anastomosis. Consequently, the RIMA is most commonly grafted to either the right coronary artery (RCA) or the left circumflex system. Even more so with arterial grafting than venous grafting, target quality plays a significant role in the predicted graft durability. Therefore, the reservation of the LAD for the LIMA graft may contribute to worse or inconsistent outcomes for RIMA grafts irrespective of graft quality. This may explain the discrepancies in RIMA patency rates and subsequent patient outcomes identified in the previous literature. Some studies have demonstrated excellent patency rates while others, most notably a posthoc analysis of the Cardiovascular Outcomes for People Using Anticoagulation Strategies (COMPASS) CABG study, have reported inferior patency rates to alternative arterial and venous conduits [11]. Alboom et al identified rates of graft failure at one year to be 6.4% for the LIMA, 9.9% for the radial artery, 10.4% for saphenous vein grafts, and 26.8% for the RIMA. Additionally, they found rates of RIMA failure to be greatest when anastomosed to the circumflex system (42%), which was two-fold greater than that with a LAD anastomosis (19%), and almost four-fold greater than that with an RCA anastomosis (11.8%). Of note, in

https://doi.org/10.1016/j.ijcha.2023.101247
Received 13 July 2023; Accepted 15 July 2023
Available online 23 July 2023

the ART trial, the RIMA was only grafted to the left coronary system as a RIMA-RCA anastomosis was not permitted secondary to concerns over long-term patency [3]. RIMA failure rates also vary by proximal site. In situ RIMA to the left circumflex artery exhibited a 63% failure rate as compared to 24% for an indirect anastomosis, although this difference was not statistically significant. Furthermore, similar to the literature on the utilization of the RA as a CABG conduit, RIMA patency is influenced by target vessel stenosis [11–14]. A higher RIMA failure rate with anastomoses to target vessels with <90% stenosis as compared to ≥90%, although not statistically significant, has been observed (33% vs. 17%) [11].

While discrepancies between studies have clouded the evidence for graft selection for CABG, the *meta*-analysis by Stefil and colleagues has demonstrated a long-term mortality benefit with BIMA grafting in patients with diabetes at the expense of an increase in perioperative SWI. While the mortality outcomes are promising, these differences must be considered in the context of the previous literature when applied to clinical practice. The addition of a RIMA graft during CABG requires careful consideration of patient anatomy and comorbidities. An individualized approach to conduit selection is critical. Younger patients and those with diabetes may benefit from an additional RIMA graft and the improved durability it may potentially provide. The patient's coronary anatomy is of the utmost importance. Target location and stenosis, as well as harvesting technique and proximal location influence graft patency and its potential application. Finally, intraoperative and perioperative strategies should be utilized to mitigate SWI risk to minimize postoperative morbidity following BIMA grafting in suitable patients.

Given the complexity of CABG conduit selection, future investigation is certainly warranted in an attempt to discern positive and negative prognostic factors of graft function. A detailed understanding of conduit performance in variable coronary locations and patients with various preoperative comorbidities will permit optimal conduit selection and a tailored surgical approach to CABG.

Acknowledgments

None.

Author Contributions

RE, NMF, SJB, JN: Conception, writing/revisions, approval of final manuscript.

Funding

None.

References

[1] I.E. Konstantinov, H. Robert, Goetz: The surgeon who performed the first successful clinical coronary artery bypass operation, Ann. Thorac. Surg. 69 (6) (2000) 1966–1972.

[2] F.A. Saraiva, J.P. Leite-Moreira, A.S. Barros, et al., Multiple versus single arterial grafting in coronary artery bypass grafting: a meta-analysis of randomized controlled trials and propensity score studies, Int. J. Cardiol. 320 (2020) 55–63.

[3] D.P. Taggart, U. Benedetto, S. Gerry, et al., Bilateral versus single internal-thoracic-artery grafts at 10 years, N Eng J Med. 380 (5) (2019) 437–446.

[4] D.P. Taggart, K. Audisio, S. Gerry, et al., Single versus multiple arterial grafting in diabetic patients at 10 years: the Arterial Revascularization Trial, Eur. Heart J. 43 (44) (2022) 4644–4652.

[5] M. Gaudino, A. Di Franco, M. Flather, et al., Association of age with 10-year outcomes after coronary surgery in the arterial revascularization trial, J. Am. Coll. Cardiol. 77 (1) (2021) 18–26.

[6] M. Gaudino, J.H. Alexander, F.G. Bakaeen, et al., Randomized comparison of the clinical outcome of single versus multiple arterial grafts: the ROMA trial-rationale and study protocol, Eur J Cardio-thorac Surg. 52 (6) (2017) 1031–1040.

[7] M. Stefil, M. Dixon, U. Benedetto, et al., Coronary artery bypass grafting using bilateral internal thoracic arteries in patients with diabetes and obesity: a systematic review and meta-analysis, Int. J. Cardiol. Heart Vasc. 2023 (Published online ahead of print).

[8] U. Benedetto, D.G. Altman, S. Gerry, et al., Pedicled and skeletonized single and bilateral internal thoracic artery grafts and the incidence of sternal wound complications: insights from the Arterial Revascularization Trial, J. Thorac. Cardiovasc. Surg. 152 (1) (2016) 270–276, https://doi.org/10.1016/j.jtcvs.2016.03.056.

[9] C. Dai, Z. Lu, H. Zhu, S. Xue, F. Lian, Bilateral internal mammary artery grafting and risk of sternal wound infection: evidence from observational studies, Ann. Thorac. Surg. 95 (6) (2013) 1938–1945.

[10] T.J. Donovan, S. Sino, A. Paraforos, J. Leick, I. Friedrich, Topical vancomycin reduces the incidence of deep sternal wound complications after sternotomy, Ann. Thorac. Surg. 114 (2) (2022) 511–518.

[11] M. Alboom, A. Browne, T. Sheth, et al., Conduit selection and early graft failure in coronary artery bypass surgery: a post hoc analysis of the Cardiovascular Outcomes for People Using Anticoagulation Strategies (COMPASS) coronary artery bypass grafting study, J. Thorac. Cardiovasc. Surg. 165 (3) (2023) 1080–1089.e1.

[12] G. Nasso, R. Coppola, R. Bonifazi, et al., Arterial revascularization in primary coronary artery bypass grafting: direct comparison of 4 strategies-results of the Stand-in-Y Mammary Study, J. Thorac. Cardiovasc. Surg. 137 (5) (2009) 1093–1100.

[13] S. Deb, E.A. Cohen, S.K. Singh, et al., Radial artery and saphenous vein patency more than 5 years after coronary artery bypass surgery: results from RAPS (Radial Artery Patency Study), J. Am. Coll. Cardiol. 60 (1) (2012) 28–35.

[14] O.K. Jawitz, M.L. Cox, D. Ranney, et al., Outcomes following revascularization with radial artery bypass grafts: insights from the PREVENT-IV trial, Am. Heart J. 228 (1) (2020) 91–97.

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