



doi: 10.21037/acs-2023-rcabg-0195

**Cite this article as:** Kitahara H, Balkhy HH. The value of bilateral internal thoracic artery grafting in incomplete revascularization and advanced hybrid revascularization. *Ann Cardiothorac Surg* 2024. doi: 10.21037/acs-2023-rcabg-0195

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# The value of bilateral internal thoracic artery grafting in incomplete revascularization and advanced hybrid revascularization

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**Keywords:** Bilateral internal thoracic artery (BITA); complete revascularization (CR); hybrid revascularization

Submitted Nov 22, 2023. Accepted for publication Feb 21, 2024. Published online Mar 13, 2024.

doi: 10.21037/acs-2023-rcabg-0195

View this article at: <https://dx.doi.org/10.21037/acs-2023-rcabg-0195>

Obtaining complete revascularization (CR) is deemed a mandatory objective in coronary artery bypass grafting (CABG), as previous studies in the literature have suggested its association with improved long-term outcomes (1,2). While minimally invasive coronary bypass surgery has gained widespread adoption due to the benefits of early functional recovery and fewer short-term complications, concerns persist regarding its ability to provide CR for patients with multi-vessel coronary artery disease. Moreover, achieving multi-arterial grafting, which is also an independent factor associated with better long-term outcomes (3), is considered challenging in the minimally invasive setting, where many surgeons express reservations.

We posit that minimally invasive coronary surgery should not limit the feasibility of both multi-arterial grafting and CR. Our practice has yielded favorable results with totally endoscopic coronary artery bypass (TECAB) utilizing two internal thoracic arteries (ITA) and hybrid percutaneous coronary intervention (PCI), referred to as advanced hybrid coronary revascularization (AHCR) (4). Multi-vessel AHCR, initially described by Bonaros *et al.* in 2014, demonstrated comparable short-term outcomes to single-vessel hybrid revascularization (5). The rationale behind AHCR is to provide multi-arterial grafting using bilateral ITAs (BITAs) for the first and second most crucial left coronary targets and add hybrid PCI to less important targets to achieve CR. To assess the completeness of revascularization, we calculated the residual SYNTAX scores after AHCR for a cohort of patients undergoing BITA grafting with PCI (6). The mean preoperative

SYNTAX score was 33.1, and the mean residual SYNTAX score (calculated on the postoperative angiogram during PCI) was 4.6. Eighty-six percent of patients achieved complete or near-CR (residual SYNTAX score less than eight), with this group exhibiting higher two-year survival and freedom from major adverse cardiovascular events compared to the incomplete revascularization (ICR) group. In a subsequent publication of outcomes in 156 AHCR patients, we reported a mean number of arterial grafts of 2.16 and mean number of targets treated by PCI of 1.23 for a total of 3.39 vessels revascularized (7).

Although there is no direct comparison between the outcomes of vein grafting and PCI, considering the unsatisfactory long-term patency of vein grafts, hybrid PCI may offer similar or even superior long-term outcomes. In conventional CABG, vein grafts are primarily used for the third or fourth target vessels, irrespective of stenosis grade, due to their ready availability and robust blood flow. Arterial conduits on the other hand may pose challenges in cases of non-severe stenosis with competitive flow. Given these considerations, if the third target vessel is insufficiently tight or lacks an available arterial conduit, hybrid PCI can be an ideal option over surgical grafting with veins, especially as it avoids leg incisions and aortic manipulation. According to previous meta-analytic findings, it has been demonstrated that CABG performed without manipulation of the ascending aorta (referred to as anaortic off-pump CABG) can significantly decrease the incidence of postoperative stroke, particularly among patients with a history of prior stroke (8). Therefore, we believe that

AHCR, involving off-pump multi-arterial TECAB with two ITAs combined with hybrid PCI, is beneficial not only for patients seeking minimally invasive options but also for those without a tightly stenotic third target vessel or those with a history of cerebrovascular accident. In addition, it can be offered equally to patients traditionally excluded from the benefits of BITA grafting via sternotomy (e.g., insulin dependent diabetic and obese patients). It is crucial to note that any PCI target lesions require assessment by a heart team. In a previous report, we found that 8% of patients did not complete the intended AHCR and staged PCI due to its difficulty. If PCI is challenging or expected to yield unfavorable outcomes, reconsideration of conventional CABG with a focus on multi-arterial grafting and CR is warranted.

It is important to note the recent evidence showing that the use of more than one arterial graft even in the setting of ICR may be more important than achieving CR. Bakaeen *et al.* highlighted this in a recent publication where they reported that the use of two arterial grafts to the two most important left coronary arteries was independently associated with better long-term outcomes, irrespective of CR or ICR (9). In this report, an important coronary target was defined as an artery with a terminal reach towards the apex of more than 75%. This study implies that the third target vessel can be treated using either arterial grafts, vein grafts, stents or even disregarded without compromising long-term outcomes when employing BITAs for the first and second most important targets. Other evidence suggests that multiple arterial grafting compensates for the potentially worse outcomes seen with ICR. Kieser *et al.* proposed that ICR is not associated with decreased survival and midterm outcomes in younger patients undergoing CABG with multi-arterial grafting (10). In addition, multi-arterial grafting has been demonstrated to be associated with improved patient survival compared with single-arterial CABG, regardless of the completeness of revascularization (3).

Finally, it must be recognized that there are multiple current definitions of CR, that take into consideration various aspects including anatomical involvement of all diseased vessels, viable territories, main-branch vessels and functional revascularization. Using the SYNTAX score as a basis for assessing CR has also been proposed, where complete or near CR is considered to be achieved when the residual SYNTAX score is less than eight (11). Given, the absence of a standardized definition of CR, careful consideration should be given to the many different revascularization strategies available. This emphasizes the

importance of multidisciplinary heart team discussions around the treatment of coronary artery disease and conduit selection on a case-by-case basis, considering the patient's specific situation and profile.

### Acknowledgments

*Funding:* None.

### Footnote

*Conflicts of Interest:* The authors declare no conflicts of interest.

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