Minimally invasive multivessel arterial revascularization—embrace innovation vigilantly!

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Keywords: Minimally invasive; arterial; coronary artery bypass grafting (CABG)

Submitted Sep 17, 2026. Accepted for publication Oct 28, 2026. Published online Nov 03, 2026.

doi: 10.21037/acs-2026-0330-cacb

View this article at: https://dx.doi.org/10.21037/acs-2026-0330-cacb

Introduction

Medicine is a fast evolving field. This obviously also applies to our discipline of cardiovascular surgery. Evolution and innovation are absolutely necessary, and we should embrace them but at the same time remain mindful of caveats that may compromise our results. After all, we deal with patients and the price one has to pay in cardiac surgery may be a very high one. The current editorial aims to embrace innovation as well as multivessel arterial revascularization but offers some reflections to stay vigilant and respectful toward historically well-established landmark results.

The evolution and status of arterial bypass grafting via the 'classical' approach

Coronary artery bypass grafting (CABG) was developed 1960s. Although initially some procedures were performed via thoracotomy, the classical sternotomy approach quickly gained widespread application.

As opposed to an initial strategy of 'all vein' bypass grafting, the landmark paper from Floyd Loop (1) established the superiority of the left internal mammary artery (LIMA) to the left anterior descending artery (LAD) as bypass conduit. Further clinical research has demonstrated extra advantage of multiple arterial bypass grafting (2). However, many of these studies are observational. Only very few randomized trials have been performed or are under way. The ART trial is the best known, and yet this trial failed to demonstrate superiority of bilateral internal thoracic artery (ITA) grafting as compared to single ITA bypass grafting in an 'intention-to-treat' analysis (3). However, the trial was characterized by a substantial cross-over percentage in the bilateral ITA group and additional radial artery use in the single ITA group. This made the investigators conclude that the multiple arterial graft hypothesis still requires testing in randomized trials. Despite its conclusions, greater use of arterial conduits in bypass grafting is currently still being advocated albeit depending on patient characteristics, conduit availability, coronary anatomy, and anticipated long-term benefit.

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The ROMA trial is expected to provide important randomized evidence regarding the clinical benefit of multiple arterial bypass grafting (4).

The search for improved long-term results in CABG is an important strategy in the competition against percutaneous coronary intervention (PCI) which is by definition the least invasive approach. Recently published randomized evidence comparing fractional flow reserve (FFR)-guided PCI and CABG in multivessel patients at 5 years was not significantly different for the composite of death, stroke and myocardial infarction [16% versus 14%; hazard ratio (HR) 1.16; P=0.27]. However myocardial infarction remained significantly more frequent after PCI (8% versus 5%), as did repeat revascularization (16% versus 8%) (5). In other words, CABG outperformed PCI for myocardial infarction and repeat revascularization at 5 years. It is also important to add that the use of bilateral ITA usage in this FAME-3 trial was only 25%.

Minimally invasive CABG

The evolution of any technical therapeutic action is toward minimally 'harming' patients. Primum non nocere ('first, do no harm') is a saying the Romans already advocated two millennia ago.

The quest for less invasive CABG approaches has urged surgeons to develop alternative techniques (alternative smaller incisions, direct vision, endoscopic, or robotic approaches) that were initially aimed at single vessel (mainly LAD) disease patients or multivessel cases but often in a hybrid setting with PCI for the non-LAD vessels. However, it is hopeful to observe that some centers systematically perform minimally invasive multivessel (multi-arterial) CABG for many years (6-10). The general adoption rate has unfortunately been low. Nevertheless, the efforts of several centers in minimally invasive CABG aim at reducing access-related surgical trauma without compromising completeness of revascularization, with appropriate use of arterial conduits, technical quality and graft durability. As a consequence, contemporary evidence in favor of minimally invasive CABG has expanded considerably. Sellin *et al.* (11) reported 392 consecutive non-emergency patients undergoing total coronary revascularization via left anterior thoracotomy. Complete anatomical revascularization was achieved in 95.1%, with a mean of 3.0 distal anastomoses per patient, and 70.4% of patients received at least two arterial grafts. Follow-up was complete in all patients at a mean of 15.2±10.7 months. At follow-up, all-cause mortality was 3.1%, myocardial infarction 1.5%, repeat revascularization 5.4%, stroke 0.7%, and overall major adverse cardiac and cerebrovascular events (MACCE) 8.7%. This experience demonstrates that avoidance of sternotomy does not necessarily require simplification of the revascularization strategy or abandonment of multiple arterial grafting.

Sef *et al.* conducted a systematic review of 26 studies, including 7,556 patients undergoing minimally invasive CABG for multivessel coronary disease. Average early mortality and stroke rates were 0.6% and 0.4%, respectively (10).

These data demonstrate the cumulative safety experience in the field of minimally invasive CABG. On top of that the recently published MIST trial adds randomized data (12). MIST randomized 170 patients with multivessel coronary artery disease to minimally invasive CABG or sternotomy CABG. The primary endpoint was not mortality but patient-reported physical recovery at one month, MACCE, graft patency, or long-term clinical durability. Physical recovery was significantly better after

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minimally invasive CABG, while no deaths nor strokes occurred in either group through 12 months. These data demonstrate that, in appropriately selected patients and when performed by experienced teams, minimally invasive multivessel CABG improves early physical recovery without safety penalty at 12 months. However, long-term clinical and graft-related outcomes remain to be established. It also remains to be demonstrated whether these results can be transferred to lower-volume programs and broader patient profiles. In addition, longer-term graft-patency data remain limited.

How to implement minimally invasive CABG?

There is an increasing demand for minimally invasive techniques within the surgical field. This is partly driven by the competition with PCI, some economic considerations such as faster functional recovery and not least by patient preference.

I also strongly believe we need to further embark on this road but not at any price for any starting center. Indeed, in cardiac surgery, the difference between success and failure can be very close. I believe a stepwise implementation strategy is a good way to move forward but with controlled risk for undesirable side effects. Changing multiple aspects of the procedure at the same time reduces the control one can have over the entire procedure. This induces an increased risk of errors or complications one should avoid. We should aim at obtaining the same excellent 'standard' results at all times and with whatever technique we use. Preparing these cases thoroughly, informing the team, and going over the various steps is of paramount importance. This includes patient selection, appropriate preoperative imaging, team-based training, defined cannulation and perfusion strategies when cardiopulmonary bypass is used, intraoperative quality control, systematic outcome collection, assessment of the learning curve, clearly defined criteria for conversion or modification of the operative strategy, etc. A structured implementation is crucial to be successful. It is therefore important to standardize minimally invasive CABG to enable teaching and reproducibility across centers without deterioration of the established CABG quality benchmarks.

Know your results and don't hide from them

'Bad luck happens' is an irritating sentence I keep hearing whenever something goes wrong intra- or postoperatively. I strongly believe this attitude does not help us forward.

Whenever in such a situation, we should have the intellectual honesty to re-analyze the case and try to understand why something went wrong and what can be changed to avoid a similar situation in the future. Did we prepare the case well enough? Was the team well enough informed? Was the exposure adequate? Did we perform an adequate anastomosis and checked it? Did any hemostasis issues arise? Was the revascularization complete?

Equally, we should also check results over a longer term. Operative results are not just reflected by operative mortality and morbidity but equally by longer-term patency rates. This is an area where we can still improve as a community as systematic long-term graft imaging is scarce. Ideally we should know our anastomotic patency rates beyond hospital discharge. I realize this is difficult to do and represents an enormous and costly amount of work. However, analyzing our operative short- and longer-term outcomes

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can teach us a great deal and may also contribute to further stimulating surgeons to apply e.g. (full) arterial revascularization more aggressively.

We should not perform minimally invasive approaches just for the sake of 'minimally invasive'. We should not switch to a single IMA and venous CABG approach because it may be easier through minimally invasive approaches as opposed to an extended (full) arterial CABG. We should check our work the same way we do in 'open' procedures. We should check our own and our centers' results in minimally invasive CABG and compare them to published and our own 'open' results. We should also publish our results as much as possible. We should never be afraid to adapt, change, or discontinue a certain technique if results are disappointing. After all, our surgical community is best served by new techniques being open to all surgeons and not just to a happy few technically outstanding individuals. Believers in progress are absolutely needed, and the demonstration that what they do is better than what they did is also needed to convince more reluctant persons to embark on the same minimally invasive path. Only then will we be able as a community to further expand the application of minimally invasive multivessel arterial revascularization.

Therefore, and lastly, we should also participate in trial design, trial execution and publication of its results. This allows a given surgeon/center to compare results with peers. Only then will we know whether we do 'a good job' or not. In that regard I applaud initiatives as the multicenter randomized MIST trial (12). Collaboration in trial design and participation in it proves a constant interest in moving the field forward in a well-established, scientifically rigorous, and controlled way. We have come a long way, and it is a slow process, but progress is being made!

Conclusions

I believe it is absolutely crucial to further evolve cardiac surgery as a whole, and more particularly also CABG surgery, into a more widely adopted minimally invasive procedure. This requires techniques to be standardized, applicable by many surgeons and centers, and not just by a few technically very gifted individuals. We should continuously monitor our results along this journey in order not to decrease the existing excellent quality of our work established in standard operative settings and more recently progressively reiterated in minimally invasive CABG. Only then we will be able to scale up the incidence of minimally invasively performed multivessel arterial revascularization. Let's further embrace innovation but remain vigilant!

Acknowledgments

None.

Footnote

Funding: None.

Conflicts of Interest: The author has no conflicts of interest to declare.

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References

1. Loop FD, Lytle BW, Cosgrove DM, et al. Influence of the internal-mammary-artery graft on 10-year survival and other cardiac events. N Engl J Med 1986;314:1-6.
2. Lytle BW, Blackstone EH, Sabik JF, et al. The effect of bilateral internal thoracic artery grafting on survival during 20 postoperative years. Ann Thorac Surg 2004;78:2005-12; discussion 2012-4.
3. Taggart DP, Altman DG, Gray AM, et al. Randomized Trial of Bilateral versus Single Internal-Thoracic-Artery Grafts. N Engl J Med 2016;375:2540-9.
4. Gaudino MFL, Taggart DP, Fremes SE. The ROMA trial: why it is needed. Curr Opin Cardiol 2018;33:622-6.
5. Fearon WF, Zimmermann FM, Ding VY, et al. Outcomes after fractional flow reserve-guided percutaneous coronary intervention versus coronary artery bypass grafting (FAME 3): 5-year follow-up of a multicentre, open-label, randomised trial. Lancet 2526;405:1481-90.
6. Nisivaco S, Bhasin R, Kitahara H, et al. Bilateral internal thoracic artery grafting in robotic beating-heart totally endoscopic coronary artery bypass: 10-year outcomes. Ann Cardiothorac Surg 2024;13:354-63.
7. Bonatti J, Wallner S, Crailsheim I, et al. Minimally invasive and robotic coronary artery bypass grafting-a 25-year review. J Thorac Dis 2021;13:1922-44.
8. Babliak O, Demianenko V, Melnyk Y, et al. Multivessel Arterial Revascularization via Left Anterior Thoracotomy. Semin Thorac Cardiovasc Surg 2020;32:655-62.
9. Davierwala PM, Verevkin A, Bergien L, et al. Twenty-year outcomes of minimally invasive direct coronary artery bypass surgery: The Leipzig experience. J Thorac Cardiovasc Surg 2023;165:115-127.e4.
10. Sef D, Thet MS, Hashim SA, et al. Minimally Invasive Coronary Artery Bypass Grafting for Multivessel Coronary Artery Disease: A Systematic Review. Innovations (Phila) 2024;19:351-9.
11. Sellin C, Belmenai A, Niethammer M, et al. Sternum-sparing multivessel coronary surgery as a routine procedure: Midterm results of total coronary revascularization via left anterior thoracotomy. JTCVS Tech 2024;26:52-60.

12. Ruel M, Nambala S, Guo MH, et al. Multivessel coronary artery bypass grafting via small thoracotomy versus sternotomy (MIST): an investigator-initiated, international, open-label, randomised controlled trial. Lancet 2026;408:711-20.

Cite this article as: Casselman F. Minimally invasive multivessel arterial revascularization—embrace innovation vigilantly! Ann Cardiothorac Surg 2026. doi: 10.21037/acs-2026-0330-cacb

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