

Robotic off-pump hybrid coronary revascularization - a niche area in need for objective data.

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Abstract

Hybrid coronary revascularization (HCR) consists of left internal thoracic artery (LITA) graft to the left anterior descending (LAD) artery and transcatheter revascularization of the non-LAD stenosis in specific settings to achieve complete coronary revascularization. Technique to perform the LITA to LAD graft has ranged from median sternotomy with cardiopulmonary bypass to robotically assisted totally endoscopic coronary bypass surgery using beating heart revascularization.

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Hybrid coronary revascularization (HCR) consists of left internal thoracic artery (LITA) graft to the left anterior descending (LAD) artery and transcatheter revascularization of the non-LAD stenosis in specific settings to achieve complete coronary revascularization. Technique to perform the LITA to LAD graft has ranged from median sternotomy with cardiopulmonary bypass to robotically assisted totally endoscopic coronary bypass surgery using beating heart revascularization. Torregrossa et al in this study on HCR, harvested the LITA robotically and performed the LITA to LAD anastomosis through a mini thoracotomy

without using cardiopulmonary bypass(1). They have also compared this technique of HCR with conventional on-pump coronary artery bypass grafting (CABG) and off-pump bypass grafting (OPCAB). The authors have shown excellent outcomes with all the three techniques. In this study, HCR led to reduced post-operative bleeding, need for blood transfusion and re-exploration for bleeding as well as reduced incidence of atrial fibrillation. This resulted in shorter lengths of intensive care unit (ICU) and hospital stays. The long-term survival was similar to conventional on-pump CABG and OPCAB. In order to balance the baseline differences that existed between the groups compared, the authors used Inverse probability of treatment weighting (IPTW) which is another strength of the paper and makes the conclusions drawn more reliable.

The reduction in post-operative blood loss along with reduced blood transfusion requirements is one of the most consistent advantages reported and has been confirmed in several meta-analyses.(2-6) Equally, most of the studies have also confirmed that compared with other techniques of revascularization, HCR is associated with similar 30-day mortality. (2-6) The evidence on reduction in rates of atrial fibrillation (AF) is not very strong with other studies and meta-analysis reporting no difference in AF rates between HCR and other techniques of revascularization.(4,7) The shorter ICU and overall hospital length of stay reported in this study is also supported by several other studies. (3-6) However, the definition of what constitutes operative time and hospital length of stay needs further discussion. HCR consists of two distinct procedures – CABG and PCI. In large number of patients HCR is carried out as a staged procedure during two separate admission and the hospital length of stay should include combined duration of stay for both the interventions. Similarly, the operative time of HCR, unless carried out as a single stage procedure, should include the time for both the surgical and transcatheter component. Regardless, most of the studies have shown that the operating time with HCR is significantly longer irrespective of whether they are robotically assisted or not. (7,8)

HCR constitutes a very wide range of approaches and the methodology of studies on HCR, need to provide more granularity. Whether the HCR was a single or two-staged procedure, whether PCI preceded CABG or vice-versa, the duration between the two procedures, any complications during waiting for the second intervention, and whether it was planned or unplanned must all be reported to make a more comprehensive and accurate comparison. The importance of this granularity cannot be over emphasized as, in the absence of data regarding both the components of HCR, it is difficult to draw reliable inferences both from scientific as well as resource utilization perspectives.

Robotically enhanced HCR is a niche area of coronary revascularization that requires the highest degree of technical expertise. Unlike PCI alone, it accomplishes revascularization of the LAD with the best graft, the LITA and thus provides the best of both worlds. The technique needs to be evaluated most importantly from a clinical outcome perspective but also from the economic perspective as well as the patient's perspective. From an economic perspective, studies attempting the cost-benefit assessment have shown considerable variations based on the surgical access or utilization of robotic assistance. Two studies with similar design where HCR was carried out as a single stage procedure using mini-thoracotomy for a LITA to LAD anastomosis reported a non-significant increase in costs associated with HCR when compared to conventional OPCAB. (9,10) However, it has to be noted that none of these studies utilized robotically assisted LITA harvesting. Another study which compared HCR without robotically assisted LITA harvest, but used mini-sternotomy rather than mini-thoracotomy reported a significantly increase in costs involved with HCR.(7) Studies reporting cost-comparison in studies similar to that of Torregrossa et al , where LITA was harvested with robotic assistance and the anastomosis performed through a mini-thoracotomy, have shown that irrespective of whether HCR was performed as a one-stage single day procedure or on two separate days during the same admission the costs were found to be significantly higher. (7,11) This is not surprising at all, as both the fixed and variable costs with the robotic systems are bound to be higher.

From the patient's perspective, assessments are generally done based on pain scores, quality of life and markers of functional recovery like the ability to return to work. While one study showed that the pain scores after robotically assisted HCR were surprisingly similar with OPCAB (8) the duration for pain to completely subside has been reported to be significantly shorter with HCR.(9) Overall satisfaction scores and the odds of returning to work within the first month were also significantly higher after HCR.(8,9,12).

The average time for returning to complete normal activity has been reported to be shorter by roughly three weeks after HCR. (8)

Clinical outcomes constitute the most important aspect of comparison for any intervention and is evaluated by feasibility and safety of the procedure in the short term as well as longer term outcomes. The safety and feasibility of HCR has now been well established through different studies and several meta-analyses. Two randomized controlled studies have been published comparing HCR with CABG. The 5-year report of the HYBRID (Hybrid Revascularization for Multivessel Coronary Artery Disease) trial has been published recently reported similar all-cause mortality, myocardial infarction(MI), repeat revascularization, stroke, and major adverse cardiac and cerebrovascular events(MACCE) between HCR and CABG.(13) Interestingly while the RCT confirmed clinical equipoise it also failed to show any differences in terms of reduced blood transfusion requirements, or length of stay between HCR and CABG. (14) Whether this represents a “true lack” of difference between the techniques or is an effect of “trial settings” which are often different from real life selection criteria remains unclear. Another RCT, the Hybrid coronary REvascularization Versus Stenting or Surgery (HREVS), that randomized patients to HCR, CABG and multivessel PCI also confirmed clinical equivalence among the three techniques with respect to all-cause mortality, rates of MI, stroke, MACCE rates and re-interventions at 3-year follow-up. However, once again, the trial showed no difference between HCR and CABG in terms of length of stay.(15)

Besides, both these RCTs have brought out an important issue, which is the conversion rate among patients designated to undergo HCR. In the HYBRID trial, only 93.9% patients in the HCR group received HCR. Six (6.1%) required a sternotomy and in 2(2.04%) had failed PCI.(14) Nearly 1 in 10(9.8%) patients randomized to the HCR arm of the HREVS trial were converted to CABG. (15)This is an important observation that further highlights that fact that while robotically assisted HCR may have good results in experienced hands it may have a long learning curve, that limits its uptake. Besides, it also suggests that in observational institutional studies the patients who got converted to alternative techniques may not have been included in the reported series.

The need for specialized operative infrastructure and specialized hybrid suites has been an important deterrent for robotically assisted HCR. Robotically assisted HCR is appealing as far as patient satisfaction are concerned, however, the reported advantage of reduced requirement for blood transfusion and shorter hospital length of stay are now being challenged by RCTs. This in turn negates the economic benefit argument with HCR even further. The conversion rates associated with HCR brings the issue of expertise into the discussion as well and may further deter uptake of robotically assisted HCR. In the absence of overwhelming superiority of HCR, it is unlikely that robotically assisted HCR will be practiced by surgeons widely and it is very likely to be confined to certain centers of excellence.

References:

1. Torregrossa G, Sa MP, Eynde JV den, Malin J, Sicouri S, Wertan M, et al. Hybrid Robotic Off-pump Versus Conventional On-Pump and Off-Pump Coronary Artery Bypass Graft Surgery in Women. *J Card Surg*.
2. Wang C, Li P, Zhang F, Li J, Kong Q. Is hybrid coronary revascularization really beneficial in the long term? *Eur J Cardiothorac Surg*. 2021 Nov 2;60(5):1158–66.
3. Sardar P, Kundu A, Bischoff M, Chatterjee S, Owan T, Nairooz R, et al. Hybrid coronary revascularization versus coronary artery bypass grafting in patients with multivessel coronary artery disease: A meta-analysis. *Catheter Cardiovasc Interv*. 2018 Feb 1;91(2):203–12.
4. Nolan S, Filion KB, Atallah R, Moss E, Reynier P, Eisenberg MJ. Hybrid Coronary Revascularization vs Complete Coronary Artery Bypass Grafting for Multivessel Coronary Artery Disease: A Systematic Review and Meta-Analysis. *J Invasive Cardiol*. 2018 Dec;30(12):E131–49.
5. Harskamp RE, Bagai A, Halkos ME, Rao SV, Bachinsky WB, Patel MR, et al. Clinical outcomes after hybrid coronary revascularization versus coronary artery bypass surgery: a meta-analysis of 1,190 patients.

Am Heart J. 2014 Apr;167(4):585–92.

6. Guan Z, Zhang Z, Gu K, Wang H, Lin J, Zhou W, et al. Minimally Invasive CABG or Hybrid Coronary Revascularization for Multivessel Coronary Diseases: Which Is Best? A Systematic Review and Metaanalysis. *Heart Surg Forum*. 2019 Dec 20;22(6):E493–502.

7. Hu S, Li Q, Gao P, Xiong H, Zheng Z, Li L, et al. Simultaneous hybrid revascularization versus off-pump coronary artery bypass for multivessel coronary artery disease. *Ann Thorac Surg*. 2011 Feb;91(2):432–8.

8. Bachinsky WB, Abdelsalam M, Boga G, Kiljanek L, Mumtaz M, McCarty C. Comparative study of same sitting hybrid coronary artery revascularization versus off-pump coronary artery bypass in multivessel coronary artery disease. *J Interv Cardiol*. 2012 Oct;25(5):460–8.

9. Kon ZN, Brown EN, Tran R, Joshi A, Reicher B, Grant MC, et al. Simultaneous hybrid coronary revascularization reduces postoperative morbidity compared with results from conventional off-pump coronary artery bypass. *J Thorac Cardiovasc Surg*. 2008 Feb;135(2):367–75.

10. Reicher B, Poston RS, Mehra MR, Joshi A, Odonkor P, Kon Z, et al. Simultaneous “hybrid” percutaneous coronary intervention and minimally invasive surgical bypass grafting: feasibility, safety, and clinical outcomes. *Am Heart J*. 2008 Apr;155(4):661–7.

11. Halkos ME, Ford L, Peterson D, Bluestein SM, Liberman HA, Kilgo P, et al. The impact of hybrid coronary revascularization on hospital costs and reimbursements. *Ann Thorac Surg*. 2014 May;97(5):1610–5; discussion 1615–1616.

12. Hage A, Giambruno V, Jones P, Chu MW, Fox S, Teefy P, et al. Hybrid Coronary Revascularization Versus Off-Pump Coronary Artery Bypass Grafting: Comparative Effectiveness Analysis With Long-Term Follow-up. *Journal of the American Heart Association*. 2019 Dec 1;8(24):e014204.

13. Tajstra M, Hrapkowicz T, Hawranek M, Filipiak K, Gierlotka M, Zembala M, et al. Hybrid Coronary Revascularization in Selected Patients With Multivessel Disease: 5-Year Clinical Outcomes of the Prospective Randomized Pilot Study. *JACC Cardiovasc Interv*. 2018 May 14;11(9):847–52.

14. Gąsior M, Zembala MO, Tajstra M, Filipiak K, Gierlotka M, Hrapkowicz T, et al. Hybrid Revascularization for Multivessel Coronary Artery Disease. *JACC: Cardiovascular Interventions*. 2014 Nov 1;7(11):1277–83.

15. Ganyukov VI, Kochergin NA, Shilov AA, Tarasov RS, Skupien J, Kozyrin KA, et al. Randomized Clinical Trial of Surgical Versus Percutaneous Versus Hybrid Multivessel Coronary Revascularization: 3 Years’ Follow-Up. *JACC Cardiovasc Interv*. 2021 May 24;14(10):1163–5.