Hybrid Coronary Revascularization
The Future of Coronary Artery Bypass Surgery or an Unfulfilled Promise?

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Advancement in technique and technology over the past 2 decades has helped improve clinical outcomes in both surgical and interventional percutaneous coronary revascularization. Hybrid coronary revascularization (HCR) procedures introduced in 2011 by the American Heart Association/American College of Cardiology Foundation updated guidelines for coronary artery bypass grafting (CABG) surgery, by means of drug-eluting stents (DES) for non-LAD vessels. Various minimally invasive surgical approaches are used to perform the LIMA to LAD graft. These approaches and techniques include off-pump coronary revascularization, robotically assisted procedures, small left thoracotomy, and partial sternotomy.

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In the current issue of Circulation, Harskamp and colleagues describe contemporary practice patterns and clinical outcomes after hybrid coronary artery revascularization in the United States. Isolated CABG in patients who underwent HCR in the Society of Thoracic Surgeons Adult Database between July 2011 and March 2013 were the subject of the study. The authors found only 0.48% (n=950) of 198,622 CABG patients had HCR with 809 of 950 patients (85%) having a staged procedure, whereas a small number of patients (141 of 950; 15%) had HCR done concurrently. Only one third of the centers performing CABG procedures participated in the HCR cohort.

Patients with HCR had higher cardiovascular risk profiles than CABG patients, whereas CABG patients had more complex coronary anatomy. HCR patients had more off-pump procedures performed and more nonsternotomy approaches. HCR patients also had a higher incidence of robotic assistance. Overall, outcomes were similar between the groups for the composite of in-hospital mortality and major morbidity.

The concept of HCR was introduced by Angelini and colleagues in 1996 by performing a minimally invasive thoracotomy LIMA-LAD anastomosis and balloon angioplasty of the non-LAD vessels. Since then, implementation of this procedure has been limited because of the complexity and learning curve of the surgical techniques and suboptimal results of bare-metal stenting compared with surgical revascularization. With the introduction of DES and the decreased rate of stent restenosis, HCR has reemerged as an alternative to conventional surgical revascularization in high-risk patients. In recent years, several institutional series have confirmed that HCR can be accomplished safely with low operative mortality (<2%) and low morbidity.

Thus, is HCR the future in coronary revascularization? The results from the practice patterns in the United States described by Harskamp et al warrant caution. The learning curve, the financial and time commitment, and the need for a hybrid operating room create stringent requirements that many programs will not be able to support. In addition, the clinical benefit of HCR over CABG has not been evaluated by a randomized trial.

When to Perform HCR
The most common indications for HCR are ungraftable non-LAD vessels, lack of conduit, reoperations, severe aortic atherosclerosis, severe calcification of the mitral annulus, and prior chest radiation. Other indications include high-risk patients (recent myocardial infarction, prior stroke, frailty, end-stage renal disease on dialysis) in whom a less invasive approach may reduce the operative time and ischemic time. In a retrospective study that compared the outcomes of HCR versus CABG surgery according to preoperative clinical risk stratification (euroSCORE [European System for Cardiac Operative Risk Evaluation] <5 or ≥5), there were no differences in 30-day composite index outcome for CABG surgery versus HCR; however, in patients with complex coronary anatomy (SYNTAX [Synergy Between Percutaneous Coronary Intervention With Taxus and Cardiac Surgery] score ≤32 versus ≥33) and with higher preoperative clinical risk (euroSCORE >5), results were worse for HCR than for conventional CABG. Although use of DES has shown lower rates of repeat revascularization and thrombosis in several trials, in reality, DES are often used in more complex patients, such as those with bifurcating lesions, type C lesions, multiple stents, or occluded vessels, than those included in the trials.

How and Where to Perform HCR
Several minimally invasive techniques have been used to perform HCR despite the common theme being the steep learning curve for the surgeon and the need for specialized training in these techniques. Thus, the use of HCR depends significantly on the availability of surgeons trained in minimally invasive procedures.
The question of where to perform HCR and the best sequence, concurrent versus staged, remains unresolved. The most compelling approach is the concurrent approach (1 stage), in which during the same session, PCI and CABG are performed in the same area. However, this approach is limited by hybrid operating room availability, the need for cross-training of personnel, the potential risk of bleeding after administration of antiplatelet agents, and the risk of contrast-induced nephrotoxicity. The most common approach (staged) reported by Harskamp et al1 (85% of all HCR procedures) poses several challenges, including the need for 2 procedures and 2 hand-offs among teams. In the staged approach, the optimal sequence (PCI first and then CABG versus CABG first and then PCI) depends on the coronary anatomy of the patient and the patient’s clinical presentation. On one end of the spectrum, there is the risk of performing multivessel stenting in an unprotected LAD territory versus the need for reintervention in the presence of anastomotic problems.

**The True Value of HCR**

Some studies report reduced length of stay and shorter hospital stay9 with HCR versus CABG depending on the timing of PCI and CABG and the modality. A recent report by Bachinsky and colleagues10 compared same-setting robotic-assisted hybrid CABG to off-pump coronary artery bypass. Patients after HCR had improved quality-of-life measures and a shorter time to return to work than those treated with off-pump coronary artery revascularization. Because of the higher procedural costs, however, HCR was more expensive than off-pump coronary revascularization.

Another financial analysis of hospital costs and reimbursements showed that HCR results in not only higher procedural costs but also a higher reimbursement rate, with improved resource utilization because of less blood transfusion, shorter ventilation time, and shorter length of stay than with off-pump coronary revascularization.11 Thus, compared with off-pump coronary artery bypass, HCR results in a greater contribution margin for the hospital.11

With new DES and lower reintervention rates, it is possible that the patency of saphenous vein grafts is no better than the newer generation of DES. There are no randomized trials comparing HCR versus CABG; thus, the clinical significance must be validated by large, pooled meta-analyses and data from single large institutions. The overall assessment of the clinical value of HCR is that HCR has lower in-hospital morbidity than CABG surgery but the same rates of in-hospital mortality and 1-year major adverse cardiovascular or cerebrovascular events; however, there is a higher reintervention rate attributable to stent restenosis.12 Thus, the question of the true value of HCR remains undetermined. HCR, albeit with higher initial procedural costs but lower in-hospital costs related to lower morbidity, may have the same or better initial value than regular CABG surgery, which is probably offset by future coronary reintervention related to stent restenosis. Therefore, the wide application of HCR is limited by the uncertainty of the long-term effectiveness of DES and the higher cost.

**Conclusions**

Unless the overall patient experience, outcomes, and financial implications of HCR are significantly better than for standard CABG alone in the long-term, HCR will continue to play a limited role in coronary revascularization. Harskamp and colleagues5 delineate the current practice of HCR in the United States. HCR remains a valuable alternative to conventional CABG surgery in the hands of expert centers where there is integration between cardiac surgery and cardiologists and where cardiac surgeons are trained in minimally invasive procedures. Patients with complex lesions in the LAD (high SYNTAX score derived from LAD lesions) are most amenable to LIMA-to-LAD bypass and PCI to noncomplex, non-LAD lesions. The ideal subset of patients in whom the medical and financial risks of a minimally invasive procedure are acceptable is still to be determined.

**Disclosures**

None.

**References**


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