



ADULT CARDIAC SURGERY:

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Clinical and Angiographic Results After Hybrid Coronary Revascularization

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Background. With hybrid coronary revascularization (HCR), minimally invasive left internal mammary artery (LIMA) to left anterior descending coronary artery (LAD) grafting is combined with percutaneous coronary intervention (PCI) of non-LAD vessels. The purpose of this study was to examine the short-term clinical and angiographic results in one of the largest HCR series to date.

Methods. From 2003 to 2012, 300 consecutive patients (aged 64 ± 12 years, female 31.7%, predicted risk of mortality $1.6\% \pm 2.1\%$) underwent HCR on an intent-to-treat basis at a single institution. After robotic or thoracoscopic LIMA harvest, off-pump LIMA to LAD grafting was performed through a 3- to 4-cm sternal-sparing, non-rib-spreading thoracotomy. PCI was utilized to treat non-LAD lesions either before, after, or concomitant with the surgical procedure.

Results. Of the 300 patients undergoing HCR on an intent-to-treat basis, HCR was performed with surgery first in 192 patients (64.0%), PCI first in 56 (18.7%), and as

a concomitant procedure in 21 (7.0%). Of the 31 patients (10.1%) who did not undergo HCR, 24 patients (8.0%) did not have PCI and thus were incompletely revascularized. For all patients, 30-day mortality, stroke, and nonfatal myocardial infarction occurred in 4 (1.3%), 3 (1.0%), and 4 (1.3%), respectively. Angiographic LIMA evaluation was performed in 248 patients and revealed a FitzGibbon A LIMA patency rate of 97.6% (242 of 248 patients). Repeat revascularization was required in 13 of 300 patients (4.3%).

Conclusions. Hybrid coronary revascularization represents an alternative approach for patients with multivessel coronary disease with excellent short-term outcomes. It provides a minimally invasive alternative to traditional coronary artery bypass graft surgery and may prove more durable than multivessel PCI.

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With hybrid coronary revascularization (HCR), minimally invasive coronary artery bypass graft surgery (CABG) utilizing a left internal mammary artery (LIMA) graft to the left anterior descending coronary artery (LAD) is combined with percutaneous coronary intervention (PCI) to non-LAD targets. This approach capitalizes on the major strengths associated with CABG and PCI. It is well accepted that the benefits of CABG are largely attributable to the LIMA-LAD graft owing to its long-term patency and freedom from atherosclerosis [1, 2]. The failure rates of saphenous vein grafts [3, 4] and the lower restenosis rates with drug-eluting stents (DES) have made percutaneous treatment of non-LAD vessels ubiquitous and comparable to saphenous vein grafts.

Both approaches are currently used to treat selected patients with multivessel coronary disease, with both therapies demonstrating low morbidity and mortality and improvement in angina [5]. Therefore, HCR for the treatment of multivessel coronary disease must be compared with currently available therapy. With HCR, LIMA-LAD grafting is performed through a minimally invasive sternal-sparing approach, which often reduces the invasiveness of CABG and theoretically may reduce some of the morbidity associated with CABG, including stroke. This is combined with PCI to treat lesions in other coronary arteries, usually with DES.

Several single-institution series have been reported describing modern HCR [6–15]. They have documented

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Abbreviations and Acronyms

| | |
|------|--|
| CABG | = coronary artery bypass graft surgery |
| DES | = drug-eluting stent |
| HCR | = hybrid coronary revascularization |
| IMA | = internal mammary artery |
| LAD | = left anterior descending coronary artery |
| LIMA | = left internal mammary artery |
| OR | = operating room |
| PCI | = percutaneous coronary intervention |
| STS | = The Society of Thoracic Surgeons |

excellent early LIMA patency rates, low mortality rates, and a low incidence of target vessel revascularization. However, the majority of these series were relatively small. Therefore, the purpose of this study was to report short-term clinical and angiographic outcomes in a large cohort of patients undergoing HCR.

Material and Methods

Hybrid coronary revascularization procedures were defined as those in which a minimally invasive LIMA-LAD bypass was planned in combination with PCI to at least one major non-LAD coronary artery. From 2003 to 2012, 300 hybrid cases were identified querying the Emory University institutional Society of Thoracic Surgeons (STS) Adult Cardiac Database for all eligible cases during the entire period in which HCR has been performed. At Emory, a custom data field was created within the STS database that defined hybrid patients on an intent-to-treat basis to capture patients who either were converted to sternotomy for multivessel CABG, or to identify those who underwent only PCI or LIMA-LAD grafting without the second portion of the hybrid procedure. For patients who underwent both procedures during the index hospitalization, clinical outcomes were limited to 30-day follow-up available through the STS database. For patients who underwent PCI after surgery during a separate hospitalization, follow-up was complete for 30 days after surgery or until discharge after PCI, whichever was longer. Patients who had PCI performed first during a separate admission had clinical outcomes followed from PCI date until 30 days after surgery. Patients who underwent emergent PCI or angioplasty for an acute coronary syndrome, then traditional multivessel CABG through sternotomy, were not defined as hybrid patients for this study, even though those are currently coded as HCR procedures in the STS database. Patients were classified as having HCR procedures if either surgical or percutaneous intervention was planned within 3 months of the initial procedure, and if the lesion treated was not previously treated with either technique.

This study was conducted in accordance with Institutional Review Board approval and the Health Insurance Portability and Accountability Act. The Institutional Review Board approved the study and waived the need for individual patient consent.

Indications and Contraindications for HCR

The relative indications for a hybrid approach include the presence of proximal LAD stenosis amenable to minimally invasive LIMA-LAD bypass and the presence of non-LAD lesions that are amenable to PCI. The decision to proceed with HCR was made only after careful discussion between the heart team and the patient. Examples of angiograms are shown in [Figures 1 and 2](#).

Relative contraindications for HCR included a poor LAD target vessel, hemodynamic instability, previous sternotomy or left thoracotomy, severe lung disease with inability to tolerate single-lung ventilation, body mass index greater than 40, or non-LAD disease not amenable to PCI. In general, the goal for all hybrid procedures was to achieve complete revascularization with both LIMA-LAD grafting and PCI.

Procedures

Before 2009, the surgical component of the hybrid procedure was performed with the EndoACAB procedure, which has been described in detail [13]. Since 2009, the majority of LIMA-LAD grafts have been performed with robotic assistance. The Da Vinci Robotic surgical system (Intuitive Surgical, Sunnyvale, CA) is utilized to harvest the LIMA, open the pericardium, and identify the optimal target site on the LAD. A spinal needle is then passed through the chest wall while evacuating carbon dioxide to allow the heart to return to its normal anatomic position. This allows for a precise 3 cm to 4 cm mini-thoracotomy incision to be made directly over the planned site of LAD anastomosis. This is accomplished without rib spreading and provides excellent exposure for an off-pump LIMA-LAD anastomosis. A minimally invasive stabilizer is used to stabilize the target vessel (Nuvo; Medtronic, Minneapolis, MN). Intracoronary shunts are used liberally.

For HCR procedures, the order and timing of the surgical and percutaneous interventional procedures are determined by the patient's coronary anatomy and are joint decisions between the surgeon and interventional cardiologist. In general, the LIMA-LAD bypass is performed first to minimize complications associated with antiplatelet and anticoagulation medication, and to allow LIMA-LAD patency to be confirmed before PCI. However, it is our policy to treat the culprit lesion first. Thus, patients with critical non-LAD anatomy will typically undergo PCI before LIMA-LAD bypass. Similarly, most patients undergo both procedures during the index hospitalization to ensure complete revascularization. However, there are important exceptions, including patients who present with a non-LAD culprit lesion who undergo PCI at an outside or referring hospital.

Antiplatelet and Anticoagulation Management

For patients undergoing PCI first, LIMA-LAD grafting was performed without discontinuing clopidogrel. For patients who underwent the surgical portion of the procedure first, 150 mg clopidogrel was administered after

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