Hybrid Coronary Revascularization Versus Off-Pump Coronary Artery Bypass for the Treatment of Left Main Coronary Stenosis

Michael E. Halkos, MD, S. Tanveer Rab, MD, Thomas A. Vassiliades, MD, MBA, Douglas C. Morris, MD, John S. Douglas, MD, Patrick D. Kilgo, MS, Henry A. Liberman, MD, Robert A. Guyton, MD, Vinod H. Thourani, MD, and John D. Puskas, MD

Clinical Research Unit, Divisions of Cardiothoracic Surgery and Cardiology, Emory University School of Medicine, Atlanta, Georgia; and Medtronic Corporation, Minneapolis, Minnesota

Background. **Coronary artery bypass grafting is standard of care for left main (LM) coronary artery stenosis. Hybrid coronary revascularization (HCR) is an alternative therapy, combining a minimally invasive, sternal-sparing, off-pump left internal mammary artery to left anterior descending coronary anastomosis with percutaneous coronary stent placement through the LM into the circumflex coronary artery.**

Methods. **From October 8, 2003, to April 23, 2010, 27 patients with LM coronary disease had HCR at a US academic center. These patients were matched 3:1 to 81 contemporaneous patients treated with off-pump coronary artery bypass grafting through a sternotomy by an optimal matching algorithm using seven preoperative variables. In-hospital major adverse cardiac and cerebrovascular events and repeat revascularization during the study period were compared between groups. All-cause mortality was compared using the National Social Security Death Index.**

Results. **Patency of the left internal mammary artery to left anterior descending coronary anastomosis was confirmed in all cases before LM stenting, which was successful in all patients. There was no perioperative death, stroke, or myocardial infarction among the HCR patients. Major adverse cardiac and cerebrovascular events were similar between groups. During a median of 3.2 years of follow-up, patients treated with HCR had a higher incidence of repeat revascularization than those treated with off-pump coronary artery bypass grafting (2 of 27, 7.4% versus 1 of 81, 1.2%; $p = 0.09$), but this was not statistically significant. The incidence of blood transfusion was higher with off-pump coronary artery bypass grafting (50 of 81, 61.7% versus 9 of 27 33.3%; $p = 0.01$).**

Conclusions. **Hybrid revascularization is a safe, feasible, and minimally invasive alternative to off-pump coronary artery bypass grafting for the treatment of LM coronary disease. Further investigation into the comparative effectiveness of this alternative strategy is warranted to identify optimal candidates for HCR.**

(Ann Thorac Surg 2011;92:2155–60)

Trials comparing coronary artery bypass surgery (CABG) with percutaneous coronary intervention (PCI) for left main (LM) coronary stenosis have been mostly observational in nature with only one randomized trial comparing these two treatment strategies [1]. Therefore, CABG has remained the gold standard for the treatment of significant LM stenosis in patients suitable for CABG [2, 3]. Nonetheless, PCI has emerged as an alternative therapy for selected patients with LM disease and has recently been upgraded to a IIb recommendation [4]. Several observational analyses have demonstrated comparable short- and mid-term survival between CABG and PCI for LM stenosis despite a higher incidence of repeat revascularization in patients treated with PCI [5–11].

The major survival advantage with CABG is attributable to the left internal mammary artery (LIMA) to left anterior descending coronary artery (LAD) bypass [12]. Hybrid coronary revascularization (HCR) represents a minimally invasive alternative strategy that combines the durability and survival advantage of the LIMA-LAD graft with less-invasive PCI using drug-eluting stents to treat non-LAD vessels. Therefore, the purpose of this observational study was to compare patients undergoing HCR with patients undergoing off-pump coronary artery bypass grafting (OPCAB) for the treatment of LM disease.

Accepted for publication Aug 2, 2011.

Presented at the Poster Session of the Forty-seventh Annual Meeting of The Society of Thoracic Surgeons, San Diego, CA, Jan 31–Feb 2, 2011.

Address correspondence to Dr Halkos, Division of Cardiothoracic Surgery, Emory University School of Medicine, Emory University Hospital Midtown, 550 Peachtree St NE, 6th Flr, Medical Office Tower, Atlanta, GA 30308; e-mail: mhalkos@emory.edu.

Dr Vassiliades discloses that he has a financial relationship with Medtronic; and Dr Halkos with Intuitive Surgical.

Published by Elsevier Inc

0003-4975/$36.00
doi:10.1016/j.athoracsur.2011.08.012

Abbreviations and Acronyms

CABG = coronary artery bypass grafting
CAD = coronary artery disease
HCR = hybrid coronary revascularization
LAD = left anterior descending coronary artery
LIMA = left internal mammary artery
LM = left main coronary artery
OPCAB = off-pump coronary artery bypass grafting
PCI = percutaneous coronary intervention
STS = The Society of Thoracic Surgeons

Material and Methods

From October 8, 2003, to April 23, 2010, 27 consecutive patients underwent HCR for the treatment of LM coronary artery disease (CAD) at Emory University Hospitals. In this study, HCR patients were matched 3:1 with contemporaneous patients undergoing OPCAB for LM CAD using an optimal matching algorithm [13]. Data for all patients were queried from the Emory University institutional Society of Thoracic Surgeons Adult Cardiac Database (STS) for preoperative, intraoperative, and postoperative data. Procedural data and the need for repeat revascularization were determined by individual patient chart review as well as a medical records query within Emory University Hospitals. This study was approved by the Institutional Review Board of Emory University.

The algorithm sequentially matched each HCR patient record with potential OPCAB control patients by calculating the multivariable distance between the patients based on seven preoperative variables. The algorithm chooses the set of matches that minimizes the sum of the multivariate distances across all possible sets of matches. The matching variables were chosen to include important risk factors for adverse outcomes including the STS predicted risk of mortality, patient age, sex, ejection fraction, diabetes, myocardial infarction within 7 days, and number of diseased vessels. The STS predicted risk of mortality, which is a function of more than 30 preoperative variables, was weighted twice as high as any other matching factor because it is a conglomerate of each patient's entire risk profile. All preoperative variables were collected and compared between groups to assess comorbidity imbalances across the surgical groups.

Indications for Hybrid Coronary Revascularization

For patients with LM CAD, HCR was considered for patients with favorable LAD anatomy for a minimally invasive LIMA-LAD bypass and LM lesions amenable to PCI. Patients with more complex coronary anatomy (calcified LM, severe multivessel CAD) were referred for CABG. Relative contraindications included a nongraftable LAD, hemodynamic instability or ongoing chest pain, coronary lesions not amenable to PCI, previous CABG or left thoracotomy, severe lung disease precluding single-lung ventilation, morbid obesity, or contraindications to clopidogrel therapy. The ultimate decision regarding an HCR approach was reached only after careful discussion among the surgeon, cardiologist, and patient. Our preference for all patients was to proceed with complete revascularization. If complete revascularization cannot be achieved with an HCR approach, then patients are referred for CABG. Currently, HCR patients are two-tiered: those at low risk but interested in minimally invasive options, and higher-risk patients who may not tolerate the invasiveness of traditional CABG through sternotomy.

Hybrid Coronary Revascularization Technique

Hybrid coronary revascularization was defined as a sternal-sparing, off-pump, minimally invasive, hand-sewn LIMA-LAD bypass graft through a 3- to 4-cm anterolateral minithoracotomy. All procedures were performed with either thoracoscopic or robotic assistance [14]. After LIMA harvest, a pericardiotomy was performed to expose the LAD. The precise location for the anterolateral thoracotomy incision was made by passing a spinal needle through the chest wall and visualizing the needle endoscopically after the carbon dioxide was evacuated from the left chest. This allowed for a tailored 3- to 4-cm skin incision to be made precisely over the LAD to facilitate the manual off-pump anastomosis. A soft tissue retractor was used without rib spreading to facilitate exposure. The LAD was stabilized with a reusable, custom-made off-pump stabilizer, which provided transient coronary occlusion with proximal and distal vessel loops.

In all HCR cases, the LIMA-LAD anastomosis was performed first as part of a staged procedure on separate days (Fig 1). Postoperatively, PCI for the LM coronary

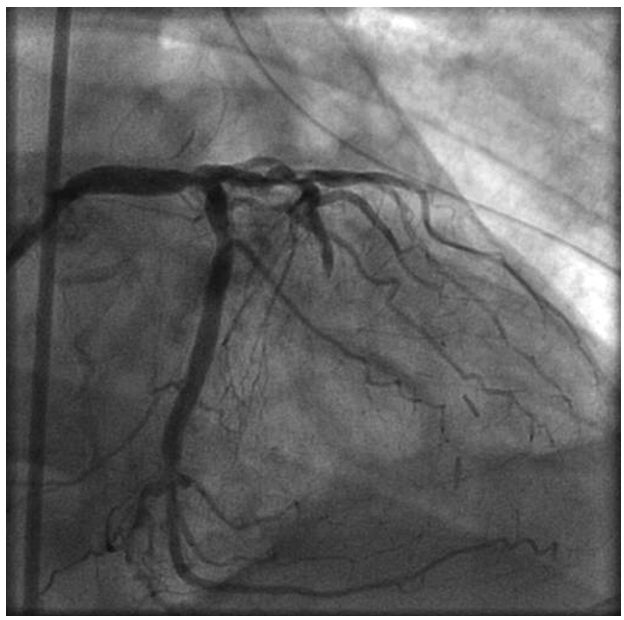

Fig 1. Cardiac catheterization showing significant left main and left anterior descending coronary artery stenosis.