

One-year clinical and angiographic results of hybrid coronary revascularization

Ivy S. Modrau, MD, DMSc,^a Niels R. Holm, MD,^b Michael Mæng, MD, PhD,^b Hans E. Bøtker, MD, PhD, DMSc,^b Evald H. Christiansen, MD, PhD,^b Steen D. Kristensen, MD, DMSc,^b Jens F. Lassen, MD, PhD,^b Leif Thuesen, MD, DMSc,^b and Per H. Nielsen, MD,^a on behalf of the Hybrid Coronary Revascularization Study Group

ABSTRACT

Objective: To evaluate 1-year clinical and angiographic results after hybrid coronary revascularization (HCR) combining off-pump left internal mammary artery (LIMA) grafting through an inferior J-hemisternotomy with percutaneous coronary intervention (PCI).

Methods: Prospective, single-arm clinical feasibility study including 100 consecutive patients with multivessel disease undergoing staged HCR. The primary endpoint was the major adverse cardiac and cerebrovascular event rate at 1 year. Secondary endpoints included 1-year all-cause death, stroke, myocardial infarction, repeat revascularization, and angiographic graft and stent patency.

Results: One-year clinical follow-up data were available in all patients. The primary endpoint was met by 20 patients (20%). Individual endpoints were as follows: 1 death due to heart failure; 1 stroke, 2 procedure-related myocardial infarctions; and 1 spontaneous myocardial infarction during follow-up. A total of 16 patients underwent repeat revascularization: 5 surgical reinterventions during the index hospitalization for angiographically suspected internal mammary artery graft dysfunction, and 3 repeat PCIs. Only 1 patient had evidence of ischemia. After discharge, PCI was performed in 6 patients who had recurrent angina, and in 2 asymptomatic patients who had angiographic restenosis. At the 1-year angiographic follow-up, 87 of 89 (98%) patients had patent internal mammary artery grafts. Angiographic restenosis was present in 10 of 100 lesions treated by PCI.

Conclusions: Angiographically controlled HCR was associated with a high repeat revascularization rate. The 1-year 98% LIMA-graft patency rate, and low risk of death and stroke, seem promising for the long-term outcome. Non-left anterior descending coronary artery lesion revascularization remains a challenge. (*J Thorac Cardiovasc Surg* 2015;150:1181-6)

In patients with stable multivessel coronary artery disease involving the proximal left anterior descending coronary artery (LAD), current evidence indicates that coronary artery bypass grafting (CABG) should be advocated,

rather than percutaneous coronary intervention (PCI).^{1,2} Undergoing CABG is associated with superior long-term survival, and a lower incidence of repeat revascularization, but at the same time, a temporarily increased risk of stroke.³⁻⁶ Substantial evidence indicates that having a graft from the left internal mammary artery (LIMA) to the LAD is the main determinant of a favorable outcome of CABG.⁷⁻⁹ The benefit of other conduits to non-LAD vessels remains less clear, and surgical revascularization of non-LAD territories is challenged by PCI in which new generations of drug-eluting stents are used, with low rates of early and late major adverse cardiac events.^{10,11}

The rationale of hybrid coronary revascularization (HCR) is to achieve the survival benefits of the LIMA-to-LAD graft

From the Departments of ^aCardiothoracic Surgery and ^bCardiology, Aarhus University Hospital, Aarhus, Denmark.

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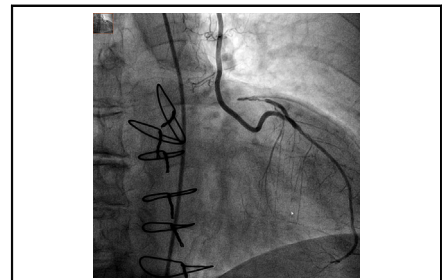
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Address for reprints: Ivy S. Modrau, MD, DMSc, Department of Cardiothoracic Surgery, Aarhus University Hospital, Palle Juul-Jensens Boulevard 99, 8200 Aarhus N, Denmark (E-mail: modrau@mail1.stofanet.dk).

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High left internal mammary artery graft patency seems promising for long-term survival after hybrid coronary revascularization.

Central Message

High 1-year LIMA graft patency, and low risk of death and stroke, seem promising for long-term outcome after HCR.

Perspective

Theoretically, HCR may increase survival and reduce the risk of stroke, compared with conventional revascularization. The high LIMA graft patency rate and low risk of death and stroke at 1 year seem promising for the long-term outcome of this revascularization strategy. Non-LAD revascularization remains a challenge.

See Editorial page 1028.

Abbreviations and Acronyms

CABG	= coronary artery bypass grafting
EuroSCORE	= European System for Cardiac Operative Risk Evaluation
HCR	= hybrid coronary revascularization
LAD	= left anterior descending coronary artery
LIMA	= left internal mammary artery
MACCE	= major adverse cardiac and cerebrovascular events
PCI	= percutaneous coronary intervention
SYNTAX	= synergy between PCI with Taxus and cardiac surgery

with reduced invasiveness to minimize postprocedural discomfort and morbidity, particularly the risk of stroke. Although the incidence of stroke has decreased over the past few decades, it is still more frequent in the year immediately after CABG than after PCI.^{6,12}

During the past 2 decades, the concept of HCR has been assessed in numerous case series and registry studies, mainly retrospective and including selected patients.¹³ Most studies on HCR applied minimally invasive direct CABG, performing the LIMA-to-LAD graft off-pump through an anterolateral mini-thoracotomy. Most of the initial series harvested the LIMA under direct vision, whereas recent series used thoracoscopic or robotic techniques. Few studies used totally endoscopic CABG, a closed-chest robotic approach, either off or on pump. Alternatively, the LIMA-to-LAD graft may be performed as an off-pump procedure through an inferior reversed J-hemisternotomy. We chose this technique because of its excellent exposure of the heart, technical ease, low risk of complicating chronic pain, and applicability in virtually all patients.¹⁴ Consecutive series of elective HCR with well-defined criteria of inclusion, and systematic clinical and angiographic follow-up, are scarce.

METHODS**Study Design**

We performed a prospective, single-arm, single-center clinical feasibility study on elective, staged HCR, combining LIMA-to-LAD grafting, performed as an off-pump procedure through an inferior reversed J-hemisternotomy, with PCI. This prespecified analysis presents the 1-year clinical and angiographic outcomes of 100 patients with multivessel disease.

The local heart team, consisting of interventional cardiologists and cardiac surgeons, evaluated all patients referred to Aarhus University Hospital in Denmark for coronary revascularization. Inclusion criteria were as follows: significant stenosis (>75% by visual assessment, or fractional flow reserve <80%) or occlusion of the proximal LAD; a LAD amenable to surgical revascularization; and ≤ 3 non-LAD lesions suitable for PCI. Per protocol, we limited the number of non-LAD lesions as a means to minimize the complexity of the PCI procedure. In

asymptomatic patients, documentation of myocardial ischemia was required. Exclusion criteria were as follows: need of complex stenting (defined as stenting of a bifurcation lesion or excessive tortuosity of proximal segment; extremely angulated segments [$>90^\circ$], and severely tortuous and/or calcified coronary lesion); ST-elevation myocardial infarction within 24 hours; expected survival of <1 year; history of CABG or PCI with use of drug-eluting stents; and contraindication to double antiplatelet treatment or drug-eluting stents.

Surgery was scheduled to precede PCI by 2 to 5 days. In the case of chronically occluded non-LAD vessels, PCI was performed 2 days prior to surgery to avoid surgical reintervention in case of PCI failure. Written informed consent was obtained from all participants. The study conformed to the principles outlined in the Declaration of Helsinki and was approved by the Central Denmark Region Committees on Biomedical Research Ethics.

Surgical Technique and Perioperative Management

A CABG procedure was performed as an off-pump LIMA-to-LAD anastomosis through an inferior reversed J-hemisternotomy up to the left third or fourth intercostal space. The LIMA was harvested up to the sternal transection under direct vision, using a modified mammary retractor. Unfractionated heparin 300 IU/kg was administered during harvest of the LIMA, and additional boluses were given as required to maintain an activated clotting time of >400 seconds. Following a C-formed incision of the pericardium, left-sided pericardial stay sutures were placed to expose the LAD. Standard off-pump revascularization of the anterior wall was performed as described elsewhere.¹⁵ Briefly, the LAD was snared proximal to the anastomosis site, while an intracoronary shunt was inserted. Anastomosis between LIMA and LAD was performed with a running monophilic suture under direct vision using a suction stabilizer and a small sternal retractor. At the end of the procedure, the anticoagulation effect of heparin was antagonized with protamine at a ratio of 1:1 to the initial dose of heparin. Patients who had stopped acetylsalicylic acid therapy prior to surgery resumed the treatment with a bolus of 300 mg orally, 6 to 9 hours postoperatively.

From day 1 after surgery, all patients received a lifelong daily maintenance dose of 75 mg of acetylsalicylic acid. In patients who had surgery prior to PCI, subcutaneous dalteparin 5000 IE was given twice daily until the day before PCI, to prevent deep venous thrombosis. Patients on dual antiplatelet therapy after PCI and before the off-pump CABG with inferior reversed J-hemisternotomy did not receive low molecular heparin therapy postoperatively. After hemisternotomy, no physical restrictions were imposed other than to respect the individual's pain threshold.

Percutaneous Coronary Intervention

All patients received a loading dose of clopidogrel (300 mg) on the evening immediately preceding PCI. For those who underwent off-pump CABG with inferior reversed J-hemisternotomy prior to PCI, angiographic assessment of the LIMA graft was conducted. Before stenting, the patients received unfractionated heparin (70-100 IU/kg body weight) intravenously, to achieve an activated clotting time of >250 seconds. Borderline stenoses were assessed by fractional flow reserve measurement. Standard best practices were used to perform PCI with second- and third-generation drug-eluting stents. After PCI, all patients received a daily maintenance dose of 75 mg of clopidogrel for 1 year, in addition to acetylsalicylic acid.

Definitions and Follow-up

The primary endpoint was the rate of major adverse cardiac or cerebrovascular events (MACCE), the composite of all-cause death, stroke, myocardial infarction, and repeat revascularization by PCI or CABG at 1 year. Secondary endpoints included the individual components and angiographic graft and stent patency.

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