Simultaneous Hybrid Revascularization Versus Off-Pump Coronary Artery Bypass for Multivessel Coronary Artery Disease

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Background. **This study sought to compare early and midterm clinical outcomes of a simultaneous hybrid coronary revascularization procedure with those in a propensity-matched subset of patients undergoing conventional off-pump coronary artery bypass grafting.**

Methods. **From June 2007 through December 2009, 104 consecutive patients (mean age 61.8 ± 10.2 years) with multivessel coronary artery disease underwent elective simultaneous coronary revascularization at Fuwai Hospital. Using propensity score methodology, these patients were matched with 104 patients who had undergone off-pump coronary artery bypass grafting through median sternotomy during the same period. We compared these groups' in-hospital clinical outcomes and freedom from major adverse cardiac or cerebrovascular events at a mean follow-up of 18 ± 7.9 months.**

Results. **The hybrid procedure required longer operative time and incurred higher in-hospital costs, but had shorter median intubation time (11.6 ± 6.3 vs 13.8 ± 6.8 hours, $p = 0.02$), intensive care unit length of stay (34.5 ± 35.6 vs 55.3 ± 46.4 hours, $p < 0.001$), and postoperative in-hospital length of stay (8.2 ± 2.6 vs 9.5 ± 4.5 days, $p = 0.01$). The hybrid group had significantly less chest tube drainage (789 ± 389 vs 834 ± 285 mL, $p = 0.005$) and need for blood transfusion (28.8% vs 51.9%, $p > 0.001$). At a mean follow-up of 18 months, the freedom from major adverse cardiac or cerebrovascular events is in favor of the hybrid group (99.0% vs 90.4%; $p = 0.03$).**

Conclusions. **Compared with conventional off-pump coronary artery bypass grafting, simultaneous hybrid coronary revascularization shortens recovery time and has superior outcomes at a mean follow-up of 18 months. Simultaneous hybrid coronary revascularization provides a safe and reproducible alternative for selected patients with multivessel coronary artery diseases.**

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With the development of specialized devices and increased experiences, off-pump coronary artery bypass grafting (OPCAB) has become a well-established procedure for coronary revascularization. Off-pump coronary artery bypass grafting is associated with lower rates of atrial fibrillation and requirements for blood transfusion and ventilation time greater than 24 hours [1], shorter length of intensive care unit (ICU) and hospital stays, and fewer perioperative complications, especially in elderly patients with severe comorbidities [2–4]. However, OPCAB is technically demanding, especially when marginal branches need to be revascularized [5], which related to the less complete revascularization and lower graft patency compared with conventional CABG [6]. As conventional CABG, the OPCAB needs to be performed through median sternotomy; the large incision makes patients fear choosing this procedure. In addition, sufficient studies have shown that vein grafts have no different outcome compared with stents in the long-term prognosis.

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A novel "hybrid" approach to coronary revascularization, which combines minimally invasive CABG (MIDCAB) and percutaneous coronary intervention (PCI), has recently emerged as a safe and feasible alternative to conventional CABG in selected patients with multivessel coronary artery disease [7]. Moreover, introduction of the simultaneous hybrid operating suite, equipped with radiographic capability, allows surgical and percutaneous procedures to be performed consecutively in the same setting [8]. In initial clinical experience the hybrid procedure has proven to be a safe and feasible option with acceptable clinical outcomes [9–13]. However, few studies are available on the outcomes of coronary revascularization after conventional OPCAB versus this new hybrid strategy. The purpose of this study was to compare early and midterm clinical outcomes after these two procedures in a propensity-matched subset of patients.

Patients and Methods

Patient Selection

From June 2007 to December 2009, the simultaneous hybrid coronary revascularization procedure was performed in 104

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Abbreviations and Acronyms

ACT	= activated clotting time
BMI	= body mass index
CAD	= coronary artery disease
cCABG	= conventional coronary artery bypass grafting
ICU	= intensive care unit
LAD	= left anterior descending coronary artery
LCx	= left circumflex branch
LITA	= left internal thoracic artery
LVB	= left ventricular branch
LVEF	= left ventricular ejection fraction
MACCE	= major adverse cardiac or cerebrovascular events
MIDCAB	= minimally invasive CABG
OM	= obtuse marginal
OPCAB	= off-pump coronary artery bypass grafting
PCI	= percutaneous coronary intervention
PDA	= posterior descending artery
PTCA	= percutaneous transluminal coronary angioplasty
RCA	= right coronary artery
RITA	= right internal thoracic artery
SVG	= saphenous vein grafts

consecutive patients at Fuwai hospital. Using propensity score matching, a group of 104 patients who had received a left internal thoracic artery (LITA) and saphenous vein grafts were selected as a control group from a cohort of 967 patients who had undergone elective OPCAB through median sternotomy during the same period.

Inclusion criteria were multivessel coronary artery disease in which the left anterior descending coronary artery (LAD) was judged as a suitable target for grafting but not catheter-based intervention, and non-LAD lesions were technically suitable for both OPCAB and PCI. Exclusion criteria included left subclavian artery and LITA stenosis, buried intramyocardial LAD, need for a concomitant operation (eg, valve repair or replacement), overt congestive heart failure, hemodynamic instability, other conditions rendering PCI unsuitable (eg, fresh thrombus, coronary vessel diameter <1.5 mm), and situations in which complete revascularization was not possible. Matching criteria included demographics, comorbidities, and coronary anatomy variables known to be risk factors for surgical revascularization. This study has been approved by the Institutional Review Board of Fuwai Hospital.

Surgical Procedure

SIMULTANEOUS HYBRID PROCEDURE. The MIDCAB was first performed through a lower partial ministernotomy without cardiopulmonary bypass. Briefly, a reversed-J lower partial sternotomy was performed up to the left second intercostal space. With the assistance of a lift retractor, the LITA conduit was harvested as a pedicle under direct vision. The distal anastomosis of in situ LITA-to-LAD grafts was completed with the aid of a stabilizing device (Pilling Weck Surgical Co, Research Triangle Park, NC). The PCI was performed immediately after closure of the thorax. Access was achieved through the femoral artery by using 6-French guiding catheters. Angiography was performed to confirm patency of the LITA graft and then PCI was performed on the non-LAD lesions. Guidewire and stent selection, along with predilatation and postdilatation, were left to the discretion of the clinician. Stents were implanted if necessary.

Low-dose aspirin (100 mg/day) was continued perioperatively, while clopidogrel was discontinued 7 days or more before operation. A 300-mg loading dose of clopidogrel was administered through a nasogastric tube after confirmation of LITA graft patency. Unfractionated heparin was then administered again to obtain an activated clotting time of greater than 250 seconds. Aspirin dosage was 300 mg/day for 1 month and 100 mg/day thereafter, while clopidogrel was administered as a maintenance dose of 75 mg/day for 12 months. Low-molecular heparin and glycoprotein IIb/IIIa antagonists were not used perioperatively.

OPCAB. The OPCAB control group underwent revascularization through median sternotomy. Conduits included a LITA, a saphenous vein, and a radial artery, which were obtained using a conventional open technique. The distal anastomoses were first performed on the beating heart using an Octopus stabilizer (Medtronic Inc, Minneapolis, MN) for target coronary artery stabilization. Proximal anastomoses were then completed under partial aortic occlusion clamp.

Unfractionated heparin (100 to 120 IU/kg body weight) was administrated intravenously to obtain a kaolin-based activated clotting time of greater than 300 seconds before harvest of the LITA. After completion of the graft procedure, heparin was antagonized by protamine sulfate with the recommended dose. Intraoperative transonic flow measurement (Medi-Stim Butterfly system BF2004; Medi-Stim AS, Oslo, Norway) was performed routinely to verify the graft quality. A cell-saving device was available, with a perfusionist on standby in all cases.

Study Endpoints and Follow-Up

The primary endpoint was freedom from major adverse cardiac or cerebrovascular events (MACCE), a composite of death, myocardial infarction (classical symptoms, electrocardiogram and serum cardiac biomarkers changes), neurologic event (stroke or transient ischemic attack), and target lesion or vessel repeat revascularization. Secondary endpoints were in-hospital outcomes, including ICU and hospital lengths of stay, intubation time, blood transfusion requirements, complications, and costs.

Hospital records, including demographics, preoperative risk factors (Table 1), and perioperative data (Table 2), were reviewed. Follow-up by mail, telephone, or hospital record review was 100% complete.