Effect of one-stop hybrid coronary revascularization on postoperative renal function and bleeding: A comparison study with off-pump coronary artery bypass grafting surgery

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Objectives: Although 1-stop hybrid coronary revascularization offers potential benefits for selected patients with multivessel coronary artery disease, the exposure to contrast dye and potent antiplatelet drugs could increase the risk of postoperative acute kidney injury and coagulopathy. The goal of the present study was to compare the measures of renal function, postoperative bleeding, and transfusion requirements in patients undergoing hybrid revascularization compared with off-pump coronary artery bypass grafting (CABG).

Methods: We retrospectively analyzed the data from 141 consecutive patients who had undergone 1-stop hybrid coronary revascularization from June 2007 to January 2011. Propensity score matching with 141 off-pump CABG patients from our surgical database was performed for comparison. The change in renal function, cumulative chest tube drainage, and clinical outcome parameters were compared between the 2 groups.

Results: Compared with off-pump CABG, patients undergoing hybrid revascularization had significantly less chest tube drainage at 12 hours after surgery ($P = .04$) and for the total amount during the postoperative period ($P < .001$) and required fewer blood transfusions ($P = .001$). The hybrid group had a higher incidence of acute kidney injury, but this did not reach statistical significance (25.2% vs 17.6%, $P = .13$). The hybrid group required less inotropic and vasoactive support, had fewer respiratory complications, required a shorter time of mechanical support, and had a decreased length of intensive care unit stay.

Conclusions: Compared with off-pump CABG, 1-stop hybrid coronary revascularization was associated with benefits such as less postoperative bleeding and blood transfusion requirements without significantly increasing the additional risk of acute kidney injury. (J Thorac Cardiovasc Surg 2014;147:1511-6)

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Hybrid coronary revascularization (HCR) has been defined as the combination of minimally invasive direct coronary artery bypass surgery and percutaneous coronary intervention (PCI) in selected patients with multivessel coronary artery disease.[1-4] The potential advantages of HCR include the superior long-term patency of the surgical left internal mammary artery (LIMA) to left anterior descending artery (LAD) bypass graft[5-7] and the benefits of PCI, especially with drug-eluting stents instead of saphenous vein grafts for non-LAD lesions.[8-10] The term ''1-stop HCR'' has been used when the 2 procedures have been performed consecutively in the same setting, typically referred to as a ''hybrid operating room.''[11,12] The suggested benefits of this new approach include improved efficiency and logistics, immediate angiographic confirmation of graft patency, and greater patient satisfaction.[2,13] The potential risks of 1-stop HCR have been associated with the administration of potent antiplatelet drugs and exposure to contrast dye, raising concerns about coagulopathy and increased transfusion requirements and renal insufficiency, respectively. The goal of the present study was to examine whether 1-stop HCR increases the risk of postoperative bleeding and renal insufficiency compared with off-pump coronary artery bypass grafting (OPCABG).

METHODS

Patient Selection

After institutional review board approval, we retrospectively collected data from 141 consecutive patients who had undergone 1-stop HCR at our institution from June 2007 to January 2011. Propensity score matching was used to select 141 patients from 3256 OPCABG patients with data recorded in our surgical database during the same period. The parameters used for matching were selected in accordance with the data readily

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Abbreviations and Acronyms

AKI = acute kidney injury
HCR = hybrid coronary revascularization
ICU = intensive care unit
LAD = left anterior descending coronary artery
LIMA = left internal mammary artery
OPCABG = off-pump coronary artery bypass grafting
PCI = percutaneous coronary intervention

available in our database: gender, age, body mass index, preoperative arterial hypertension, hyperlipidemia, diabetes mellitus, preoperative myocardial infarction, and left ventricular ejection fraction (Table 1). Additional parameters were collected and compared between the 2 groups after the primary matching process (Table 2).

The inclusion criteria for 1-stop HCR were the presence of multivessel coronary lesions demonstrated by coronary angiography, which involved a LAD lesion (or lesions) that was judged not suitable for PCI but was a suitable target for surgical grafting (eg, chronic total occlusion, severe calcification, ostial lesion, or proximal lesions) and non-LAD lesions that were suitable for PCI. Patients with previous sternotomy, LIMA stenosis, symptoms of congestive heart failure, or unstable hemodynamics (eg, preoperative pharmacologic or mechanical support), the need for concomitant cardiac surgery (eg, valve replacement or repair procedure), and patients with contradictions for PCI (eg, allergy to contrast dye) were excluded.

Procedure

A balanced general anesthesia technique with midazolam, etomidate or propofol, fentanyl or sufentanil, and vecuronium was used for induction, and a potent inhalational-based agent or propofol infusion were used for anesthesia maintenance.

For the 1-stop hybrid procedure, the patients first underwent minimally invasive direct coronary artery bypass surgery using a midline ministernotomy approach, followed by PCI for non-LAD lesions. Technically, a reversed-J inferior sternotomy was performed up to the left second intercostal space, and the LIMA was harvested with the assistance of a lift retractor under direct vision. Unfractionated heparin (100-120 IU/kg body weight) was administered before harvesting the LIMA. Surgical anastomosis of the LIMA to LAD graft was performed using a stabilizer (Octopus, Medtronic Inc, Minneapolis, Minn) on the beating heart. Patients who did not tolerate OPCABG because of unstable hemodynamics were converted to on-pump surgery. After surgical LIMA to LAD anastomosis and chest closure, angiography was performed to confirm the patency of the LIMA-LAD graft. If any angiographic defects were identified, surgical revision was immediately performed. For the PCI procedure, access was established through the femoral artery using a previously described standard technique.[14]

For the OPCABG procedure, a median sternotomy was performed in all patients. The LIMA and saphenous vein conduits were harvested under direct vision. The distal anastomoses of the LIMA to LAD and saphenous conduits to non-LAD target grafts were performed on the beating heart using a stabilizer (Octopus). The proximal anastomoses were accomplished with a partial occluding aortic clamp. Transonic flow measurements (Medi-Stim Butterfly System BF2004; Medi-Stim AS, Oslo, Norway) were performed in all patients to confirm graft patency after revascularization.

Anticoagulation Protocol

Details about the anticoagulation and, specifically, the antiplatelet regimen for hybrid procedures practiced in our institution have been previously published.[15] Aspirin 100 mg once daily was continued until the morning of surgery, and clopidogrel was discontinued ≥5 to 7 days before surgery. Unfractionated heparin (100-120 IU/kg body weight) was administered intraoperatively to achieve an activated clotting time >300 seconds during the surgical procedure. After completion of the LIMA to LAD anastomosis, heparin was reversed with protamine sulfate in accordance with the results from a heparin-protamine titration assay. A loading dose of 300 mg clopidogrel was administered through a nasogastric tube before the PCI procedure. Additional heparin (100 IU/kg body weight) was administered if the activated clotting time was <200 seconds during the PCI procedure. The maintenance antiplatelet regimen after the procedure consisted of 75 mg clopidogrel once daily for ≥12 months, and aspirin 300 mg once daily for the first 30 days, followed by 100 mg aspirin once daily for life.

For the OPCABG procedure, aspirin and clopidogrel were discontinued ≥5 days before surgery. Also, 200 IU/kg body weight of unfractionated heparin was administered before harvesting the LIMA. Additional heparin was administered to maintain the activated clotting time >300 seconds throughout the whole procedure. After completion of all anastomoses, heparin was fully reversed with protamine sulfate.

Data Collection

The primary endpoints of the present study were to compare the incidence of postoperative bleeding and transfusion requirements and renal function between the 2 groups. Postoperative chest tube drainage was measured at 6 and 12 hours after the procedure, and the total cumulative chest tube drainage was recorded for the whole postoperative period. Serum creatinine was compared between the 2 groups for the first 3 postoperative days. If more than 1 serum creatinine value was available each day, the highest value was chosen for analysis. Acute kidney injury (AKI) was defined according to the Acute Kidney Injury Network criteria: serum creatinine increase ≥26.5 μmol/L or an increase to 1.5-fold from baseline within 48 hours.[16]

The secondary endpoints were defined as the following postoperative clinical outcomes: mortality during the hospital stay, hemodynamic instability requiring the use of an intra-aortic balloon pump, hemodialysis, myocardial damage (defined as an increase in serum creatinine kinase to >5 times the upper normal limit[17]), new-onset atrial fibrillation, mechanical ventilation duration, respiratory insufficiency requiring endotracheal reintubation, abnormal postoperative chest radiographic findings such as atelectasis and pleural effusion, neurologic complications (eg, stroke or transient ischemia attack), emergency reoperation and resternotomy, length of stay in the intensive care unit (ICU), and postoperative hospital length of stay. Hemodynamic stability was assessed using the following 3 categories: hemodynamically stable (no vasoactive or inotropic drug administration), moderate hemodynamic instability (1-2 drugs), and unstable when >3 drugs were required intraoperatively or during the postoperative period in the ICU.

Statistical Analysis

Propensity score matching was performed using Statistical Analysis Systems software for Windows, version 9.2 (SAS Institute Inc, Cary, NC). A predesigned SAS macro program was used for the propensity score algorithm, using an interval score <0.01 between the 2 groups to define a qualified match. If more than 1 OPCABG case was matched to a hybrid case, random selection was performed using the macro program.

The data are expressed as the mean ± standard deviation, median, or percentage. For continuous variables, the Student *t* test was used to measure the differences with a normal distribution and the Wilcoxon rank sum test was used for variables not normally distributed. Categorical variables were compared using the chi-square statistic or Fisher's exact test. Analysis of variance for repeated measures was used to measure differences between the measurement points (original data presented in Table E1). *P* values < .05 were considered statistically significant. All statistical