One-stop hybrid coronary revascularization versus off-pump coronary artery bypass in patients with diabetes mellitus

Zhizhao Song, MD,^a Liuzhong Shen, MD,^a Zhe Zheng, MD,^a Bo Xu, MD,^b Hui Xiong, MD,^a Lihuan Li, MD,^c and Shengshou Hu, MD^a

ABSTRACT

Objectives: To compare in-hospital and midterm outcomes after one-stop hybrid coronary revascularization (HCR) and off-pump coronary artery bypass (OPCAB) in patients with diabetes mellitus (DM).

Methods: The series included 120 patients with DM who underwent one-stop HCR at Fuwai Hospital between June 2007 and September 2014. These patients were 1:2 matched with 240 patients who underwent OPCAB using propensity score matching. The primary endpoint was a major adverse cardiac or cerebrovascular event (MACCE) over midterm follow-up, and secondary endpoints were in-hospital outcomes. Accounting for matched-pairs design, the survival analysis was evaluated with a marginal Cox model, and the continuous and dichotomous variables of in-hospital outcomes were compared with the Wilcoxon signed-rank test and a logistic regression model using generalized estimating equations, respectively.

Results: Compared with OPCAB, one-stop HCR was associated with less chest tube drainage (median, 748 mL [interquartile range (IQR), 540-1080 mL] vs 990 mL [IQR, 730-1250 mL]; $P < .001$), a lower packed red blood cell transfusion rate (18.3% vs 29.6%; $P = .032$), shorter mechanical ventilation time (median, 13.7 hours [IQR, 10.3-16.9 hours] vs 16.8 hours [IQR, 13.0-19.6 hours]; $P < .001$), and shorter stay in intensive care unit (median 21.7 hours [IQR, 19.0-44.3 hours] vs 46.7 hours [IQR, 24.3-72.7 hours]; $P < .001$). Over 30 months of follow-up, one-stop HCR and OPCAB had a similar rate of MACCE (7.4% vs 8.0% at 3 years; hazard ratio, 0.807; 95% confidence limit, 0.352-1.849; $P = .612$), but one-stop HCR had a lower stroke rate (0% vs 3.6% at 3 years; $P = .046$).

Conclusions: For selected patients with DM, one-stop HCR provided safe and reproducible revascularization, with less perioperative invasiveness and similar and favorable midterm outcomes compared with OPCAB. (J Thorac Cardiovasc Surg 2016;151:1695-701)

MACCE Kaplan-Meier curves, with number of patients at risk and 95% confidence limits.

Central Message

For selected patients with DM, one-stop hybrid coronary revascularization provided a safe and reproducible revascularization option.

Perspective

Hybrid coronary revascularization (HCR) combines the advantage of both CABG and PCI to achieve complete revascularization. In selected patients with DM and multivessel CAD, the results of this study show that one-stop HCR decreased perioperative invasiveness and incurred similar and favorable midterm outcomes compared with OPCAB.

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From the Departments of ^aSurgery, ^bCardiology, and ^cAnesthesiology, State Key Laboratory of Cardiovascular Disease, Fuwai Hospital, National Center for Cardiovascular Disease, Chinese Academy of Medical Sciences and Peking Union Medical College, Beijing, China.

Z.S. and L.S. contributed equally to this work.

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Address for reprints: Shengshou Hu, MD, Department of Surgery, Fuwai Hospital, 167 Beilishi Rd, Xicheng District, Beijing 100037, China (E-mail: Shengshouhu@yahoo.com).

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One-quarter of coronary revascularization procedures are performed in patients with diabetes mellitus (DM). These patients present with accelerated atherosclerotic progression and increased platelet aggregation, which result in suboptimal outcomes compared with patients without

Scanning this QR code will take you to supplemental tables for this article.

Abbreviations and Acronyms

ACT	= activated clotting time
CABG	= coronary artery bypass grafting
CAD	= coronary artery disease
CL	= confidence limit
DES	= drug-eluting stent
DM	= diabetes mellitus
HCR	= hybrid coronary revascularization
HR	= hazard ratio
IQR	= interquartile range
LAD	= left anterior descending artery
LIMA	= left internal mammary artery
MACCE	= major adverse cardiac or cerebrovascular event
OPCAB	= off-pump coronary artery bypass
PCI	= percutaneous coronary intervention
SV	= saphenous vein

DM.^{1,2} A recent randomized clinical trial reported better survival with coronary artery bypass grafting (CABG) compared with percutaneous coronary intervention (PCI) for these patients.³ It is generally believed that the survival superiority of CABG is due mainly to the left internal mammary artery (LIMA) to left anterior descending artery (LAD) graft, based on its favorable long-term patency rate (>90% at 10 years).^{4,5} However, the patency rate of saphenous vein (SV) grafts decreases year by year, from approximately 80% at 1 year to an average of 70% at 5 years.^{6,7} In addition, the use of drug-eluting stents (DES) has a lower target lesion revascularization rate compared with bare metal stents (approximately 5% vs 20% at 1 year and 10% vs 25% at 5 years).^{8,9} Thus, PCI with DES is hypothesized to be a promising treatment for non-LAD lesions.¹⁰

Hybrid coronary revascularization (HCR), involving minimally invasive LIMA-LAD grafting and PCI for non-LAD lesions, combines the advantage of both strategies to achieve complete revascularization.¹¹ In initial experiences, HCR has produced favorable outcomes in selected patients with multivessel coronary artery disease (CAD).^{12,13} However, there are few published studies on the integrated revascularization strategy in patients with DM. In the present study, using propensity score matching, we compared in-hospital and midterm outcomes after one-stop HCR and off-pump coronary artery bypass (OPCAB) in patients with DM.

METHODS**Patient Selection**

Between June 2007 and September 2014, 120 patients with DM underwent one-stop HCR at Fuwai Hospital. During the same period, 1905 DM patients underwent OPCAB with LIMA-LAD grafting and SV to non-LAD grafting. After screening these patients with the exclusion criteria, the remaining patients (n = 1658) were subjected to propensity

score matching (original data presented in Table E1). The patients undergoing one-stop HCR were then 1:2 matched with those undergoing OPCAB (Figure 1). This study was approved by the institutional Ethical Committee of Fuwai Hospital.

The inclusion criteria for one-stop HCR were (1) multivessel CAD involving LAD lesion (eg, chronic total occlusion, excessive tortuosity, severely diffuse lesion) or left main coronary artery lesion (unprotected) not favorable for PCI, with non-LAD lesions suitable for PCI, and (2) multivessel CAD with traditional CABG contraindications (eg, heavily calcified ascending aorta, lack of available graft conduits, non-LAD lesions impracticable to anastomosis but feasible for PCI, high-risk status for traditional CABG, such as dysfunction of vital organs). The exclusion criteria for one-stop HCR were (1) minimally invasive LIMA-LAD grafting contraindications (eg, previous sternotomy; LIMA or left subclavian artery stenosis; distal LAD impracticable to anastomosis, such as intramyocardial LAD; significantly unstable hemodynamics, such as mechanical support) and (2) concurrent with other cardiac surgery, for example, valve replacement.

Since 2007, a heart team consisting of 2 experienced interventional cardiologists and 2 experienced cardiac surgeons, had been set up in a cardiology ward at Fuwai Hospital. If a patient met the foregoing criteria, decisions regarding the optimal revascularization strategy were made by the heart team considering the patient's clinical condition, coronary anatomy, and individual needs.

For the patients who underwent OPCAB, the criteria for entering propensity score matching were (1) multivessel CAD involving LAD lesion or left main coronary artery lesion and (2) completion of a LIMA-LAD graft and an SV to non-LAD graft. Exclusion criteria were (1) concurrent with other cardiac surgery, (2) previous sternotomy, and (3) significantly unstable hemodynamics.

Procedures

One-stop HCR was performed in a hybrid operation room, involving minimally invasive LIMA-LAD grafting and consecutive PCI for non-LAD lesions. The procedure and the protocol for antiplatelet and anticoagulation therapy are outlined below.

Using a lift retractor, the LIMA pedicle was harvested under direct vision through reversed-L inferior sternotomy, and its distal end was anastomosed to LAD in situ with off-pump techniques. Transit time flow measurement was routinely performed when the anastomosis was completed. After the surgical operation, instant angiography to confirm the LIMA-LAD graft patency and PCI for non-LAD lesions was performed by an interventional cardiologist with a standardized technique through the femoral artery.

Before the procedure, clopidogrel was stopped for at least 7 days, whereas aspirin 100 mg/day was maintained. During the surgery, unfractionated heparin was administered intravenously before LIMA harvesting to achieve a kaolin-based activated clotting time (ACT) >300 seconds, and reversed with protamine sulfate when the LIMA-LAD anastomosis was successfully completed. For PCI, a loading dose of 300 mg clopidogrel was supplied through a nasogastric tube after confirming the LIMA-LAD graft patency with angiography, and additional unfractionated heparin was administered to achieve an ACT >250 seconds. After the procedure, clopidogrel 75 mg/day was administered for at least 12 months, and aspirin 300 mg/day for 1 month and 100 mg/day thereafter for life was prescribed.

OPCAB was performed through median sternotomy, and the graft conduits were obtained by conventional methods. The distal anastomoses were performed on a beating heart with the aid of a coronary stabilizer, and the proximal anastomoses were performed using partial aortic occlusion clamps. During the surgery, unfractionated heparin was administered intravenously before the LIMA harvest to maintain an ACT >300 seconds throughout the entire procedure, and protamine sulfate was used to reverse heparin when all anastomoses were completed. After the procedure, aspirin 100 mg/day for life was prescribed.

FIGURE 1. Flow chart of patient selection. *DM*, Diabetes mellitus; *HCR*, hybrid coronary revascularization; *OPCAB*, off-pump coronary artery bypass; *LIMA*, left internal mammary artery; *LAD*, left anterior descending artery; *SV*, saphenous vein.

Study Endpoints

The primary endpoint of this study was major adverse cardiac or cerebrovascular event (MACCE), a composite of all-cause death, myocardial infarction, stroke, and repeated revascularization, at the midterm follow-up. The second endpoints were postoperative in-hospital outcomes, including chest tube drainage, blood transfusion, mechanical ventilation time, length of intensive care unit stay, and length of hospital stay.

Follow-up

As part of institutional standard procedures, all postoperative patients were scheduled to return for an outpatient follow-up at 6 months after discharge and then once every year thereafter. The research staff would check the hospital database annually to complete any routine follow-up information by telephone or mail with standard forms.

Statistics

Propensity score matching. The propensity score was estimated by a logistic regression model in which one-stop HCR or OPCAB (1 or 0) was regressed on selected baseline variables. Referring to previous studies,^{12,14,15} the baseline variables that had an important impact on outcomes were included in the propensity score model. These variables included sex, age, body mass index, hypertension, hyperlipidemia, DM on insulin therapy, preoperative myocardial infarction, left main coronary artery disease, number of diseased vessels, left ventricular ejection fraction, renal dysfunction, and chronic lung disease (Table 1). The remaining baseline variables were also collected and compared between the 2 groups after propensity score matching (Table 2). A pre-designed SAS macro for 5→1 digit greedy matching without replacement was used to perform the 1:2 match. Balance in baseline variables was assessed using the standardized difference (SD), of which a value <10 is considered to indicate good balance between the 2 groups.¹⁶

Statistical methods for outcomes. Data are expressed as mean ± standard deviation, median (interquartile range [IQR]), or number (%). Accounting for the matched-pairs design, the survival analysis was evaluated with a marginal Cox model, and the continuous and dichotomous variables of the in-hospital outcomes were statistically compared using the

Wilcoxon signed-rank test and a logistic regression model using generalized estimating equations, respectively.^{17,18} A *P* value < .05 was considered statistically significant.

Statistical analyses were performed with SAS version 9.4 (SAS Institute, Cary, NC).

RESULTS

Propensity Score Matching

Each of the 120 patients with DM who underwent one-stop HCR was successfully matched with 2 patients with DM who underwent OPCAB. Every baseline variable

TABLE 1. Baseline variables selected for the propensity score matching model

Variable	HCR (n = 120)	OPCAB (n = 240)	SD*
Female sex, n (%)	23 (19.2)	49 (20.4)	3.1
Age, year, mean ± SD	62.3 ± 9.4	62.8 ± 8.4	6.2
BMI, mean ± SD	25.6 ± 3.0	25.5 ± 2.9	3.2
Hypertension, n (%)	88 (73.3)	178 (74.2)	1.9
Hyperlipidemia, n (%)	96 (80.0)	193 (80.4)	1.1
Diabetes mellitus on insulin therapy, n (%)	57 (47.5)	116 (48.3)	1.7
Myocardial infarction, n (%)	39 (32.5)	75 (31.3)	2.7
LM, n (%)	41 (34.2)	87 (36.3)	4.4
Number of diseased vessels, mean ± SD	2.7 ± 0.5	2.7 ± 0.5	5.3
LVEF, mean ± SD	63.9 ± 7.3	64.2 ± 6.9	4.0
Renal dysfunction, n (%)	2 (1.7)	4 (1.7)	0
Chronic lung disease, n (%)	2 (1.7)	3 (1.3)	3.5

HCR, Hybrid coronary revascularization; *OPCAB*, off-pump coronary artery bypass grafting; *SD*, standardized difference; *BMI*, body mass index; *LM*, left main coronary artery ≥50% narrowing preoperatively; *LVEF*, left ventricular ejection fraction.

*A value <10 is considered to indicate good balance between the 2 groups.

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TABLE 2. Baseline variables not included in the propensity score matching model

Variable	HCR (n = 120)	OPCAB (n = 240)	SD*
Current smoker, n (%)	48 (40.0)	99 (41.3)	2.5
Cerebrovascular disease, n (%)	16 (13.3)	28 (11.7)	5.0
Extracardiac arteriopathy, n (%)	20 (16.7)	47 (19.6)	7.6
Serum creatinine, $\mu\text{mol/L}$, mean $\pm$ SD	81.4 $\pm$ 17.1	82.5 $\pm$ 23.8	5.3
RCA, n (%)	109 (90.8)	214 (89.2)	5.5
LAD, n (%)	120 (100)	240 (100)	NA
LCX, n (%)	95 (79.2)	198 (82.5)	8.5

HCR, Hybrid coronary revascularization; OPCAB, off-pump coronary artery bypass grafting; SD, standardized difference; RCA, right coronary artery system $\geq 50\%$ narrowing of any vessel preoperatively; LAD, left anterior descending artery $\geq 50\%$ narrowing preoperatively; LCX, left circumflex artery system $\geq 50\%$ narrowing of any vessel preoperatively; NA, not applicable. *A value < 10 is considered to indicate good balance between the 2 groups.

entered into the propensity score model had good balance between the 2 matched groups (Table 1). Baseline variables not included in the model were also balanced between the 2 groups (Table 2).

Procedure Characteristics

Each of 120 DM patients who underwent one-stop HCR underwent simultaneous minimally invasive LIMA-LAD grafting and PCI for non-LAD lesions. The mean number of stents implanted per patient was 1.6 ± 0.9 , and the mean length of implanted stents was 35.0 ± 21.4 mm (original data in Table E2).

Each of the 240 DM patients who underwent OPCAB underwent LIMA-LAD grafting and SV to non-LAD grafting. The mean number of non-LAD anastomoses per patient was 2.1 ± 0.6 (original data in Table E3).

In-Hospital Outcomes

Compared with OPCAB, one-stop HCR had less chest tube drainage within 24 hours (median, 573 mL [IQR, 320-835 mL] vs 700 mL [IQR, 530-950 mL]; $P < .001$) and total chest tube drainage (median, 748 mL [IQR, 540-1080 mL] vs 990 mL [IQR, 730-1250 mL]; $P < .001$). Correspondingly, the packed red blood cell transfusion rate was significantly lower in the one-stop HCR group (18.3% vs 29.6%; $P = .032$). However, there were no statistically significant between-group differences in the rates of plasma transfusion (19.2% for one-stop HCR vs 22.1% for OPCAB; $P = .523$), any blood product transfusion (29.2% vs 39.6%; $P = .076$), and reoperation for controlling bleeding (0.8% vs 2.5%; $P = .307$). One-stop HCR was associated with a shorter mechanical ventilation time (median, 13.7 hours [IQR, 10.3-16.9 hours] vs 16.8 hours [IQR, 13.0-19.6 hours]; $P < .001$) and a shorter length of intensive care unit stay (median, 21.7 hours [IQR, 19.0-44.3 hours] vs 46.5 hours [IQR, 24.3-72.7 hours]; $P < .001$), but a similar length of hospital

TABLE 3. Postoperative in-hospital outcomes

Variable	HCR (n = 120)	OPCAB (n = 240)	P value
Chest tube drainage within 24 hours, mL, median (IQR)	573 (320-835)	700 (530-950)	$< .001$
Total chest tube drainage, mL, median (IQR)	748 (540-1080)	990 (730-1250)	$< .001$
Transfusion of packed RBCs, n (%)	22 (18.3)	71 (29.6)	.032
Transfusion of plasma, n (%)	23 (19.2)	53 (22.1)	.523
Transfusion of any blood products, n (%)	35 (29.2)	95 (39.6)	.076
Reoperation for controlling bleeding, n (%)	1 (0.8)	6 (2.5)	.307
Mechanical ventilation time, hour, median (IQR)	13.7 (10.3-16.9)	16.8 (13.0-19.6)	$< .001$
Length of ICU stay, hour, median (IQR)	21.7 (19.0-44.3)	46.5 (24.3-72.7)	$< .001$
Length of hospital stay, day, median (IQR)	7 (7-9)	7 (7-9)	.627

HCR, Hybrid coronary revascularization; OPCAB, off-pump coronary artery bypass grafting; IQR, interquartile range; RBC, red blood cell; ICU, intensive care unit.

stay (median, 7 days [IQR, 7-9 days] vs 7 days [IQR, 7-9 days]; $P = .627$) (Table 3).

Midterm Outcomes

By March 15, 2015, follow-up data were obtained from 120 patients (100%) of the one-stop HCR group and 237 patients (98.8%) of the OPCAB group. Over a median follow-up of more than 30 months (30.7 months [IQR, 22.4-52.6 months] vs 34.1 months [IQR, 20.0-43.5 months]; $P = .826$), the cumulative MACCE rates were similar in the one-stop HCR and OPCAB groups (7.4% vs 8.0% at 3 years; hazard ratio [HR], 0.807; 95% confidence limit [CL], 0.352-1.849; $P = .612$) (Figure 2). Mortality (2.7% vs 2.8% at 3 years; HR, 1.000; 95% CL, 0.249-4.020; $P = 1.00$), the rate of myocardial infarction (0% vs 0.4% at 3 years; $P = .252$), and the rate of repeat revascularization (4.7% vs 2.3% at 3 years; HR, 1.545; 95% CL, 0.452-5.286; $P = .488$) were not statistically significantly different between the 2 groups; however, the stroke rate was significantly lower in the one-stop HCR group (0% vs 3.6% at 3 years; $P = .046$) (Table 4).

DISCUSSION

HCR aims to accomplish complete revascularization with minimally invasive LIMA to LAD grafting and PCI for non-LAD lesions.¹⁹ One-stop HCR is performed in a state-of-the-art operation room, in which the coronary surgery and intervention are performed consecutively.²⁰ Compared with staged HCR, in which the procedures are performed in different operative suites staged over days or even weeks, the simultaneous HCR eliminates logistic

FIGURE 2. The MACCE Kaplan–Meier curves with number of patients at risk and 95% confidence limits. The HR was evaluated over a median follow-up of more than 30 months using a marginal Cox model. *OPCAB*, Off-pump coronary artery bypass; *HCR*, hybrid coronary revascularization; *HR*, hazard ratio; *CL*, confidence limit.

concerns about the timing and sequencing of separate procedures, and also minimizes the exposure to anesthesia and the inconvenience of transferring patients among different disciplines. In addition, the patency of the LIMA-LAD graft can be routinely assessed by instant angiography, and PCI is accomplished under the protection of the LIMA-LAD graft and in the presence of cardiac surgeons, and thus aggressive stenting is allowed.²⁰ To our knowledge, this is by far the largest cohort of patients with DM undergoing one-stop HCR reported to date.

Patients with DM have more diffuse atherosclerosis and aggressive pathological progression, leading to a greater risk of restenosis and new stenosis after coronary revascularization.¹ A recent randomized clinical trial found

lower mortality and myocardial infarction rates for CABG compared with PCI in these patients.³ The LIMA-LAD graft is presumably essential to the survival superiority of CABG.⁴ One-stop HCR preserves LIMA-LAD grafting by means of minimally invasive strategies, and also routinely provides instant angiography to confirm graft patency.²⁰ Among patients undergoing one-stop HCR, 2 major defects (1.7%), distal LIMA conduit stenosis and stenosis at the LIMA-LAD anastomosis, were detected in the LIMA-LAD grafts after intraoperative angiography. Both defects were corrected by immediate reoperation.

In this study, the similar midterm survival rate in the OPCAB and one-stop HCR groups (2.7% vs 2.8% at 3 years; HR, 1.000; 95% CL, 0.249-4.020; *P* = 1.00)

TABLE 4. MACCE in the one-stop HCR and OPCAB groups

Variable	HCR (n = 120)	OPCAB (n = 237)	HR (95% CL)	Cumulative event rate at 3 years		P value
				HCR, %	OPCAB, %	
Any MACCE, n	8	19	0.807 (0.352-1.849)	7.4	8.0	.612
All-cause death, n	3	6	1.000 (0.249-4.020)	2.7	2.8	1.000
Stroke, n	0	8	NA	0	3.6	.046*
Myocardial infarction, n	0	2	NA	0	0.4	.252*
Repeated revascularization, n	5	6	1.545 (0.452-5.286)	4.7	2.3	.488
Target lesion revascularization, n	2	5	0.719 (0.132-3.924)	2.1	1.9	.703
Follow-up time, months, median (IQR)	30.7 (22.4-52.6)	34.1 (20.0-43.5)	NA	NA	NA	.826

HCR, Hybrid coronary revascularization; *OPCAB*, off-pump coronary artery bypass grafting; *HR*, hazard ratio; *CL*, confidence limits; *MACCE*, major adverse cardiac and cerebrovascular events; *NA*, not applicable; *IQR*, interquartile range. *Log-rank test.

may be attributed mainly to the high-quality LIMA-LAD graft. In addition, the rate of target lesion revascularization for PCI with DES has gradually decreased with improvements in stent materials and processes,^{21,22} and the rate is similar to the failure rate of saphenous grafts.¹⁰ Theoretically, by combining LIMA-LAD grafting and PCI with DES for non-LAD lesions, HCR may have a similar rate of repeat revascularization as conventional surgical revascularization in select patients. Our 30-month follow-up results showed similar rates of revascularization (4.7% for the one-stop HCR group vs 2.3% for the OPCAB group at 3 years; HR, 1.545; 95% CL, 0.452-5.286; $P = .488$) and target lesion revascularization (2.1% vs 1.9% at 3 years; HR, 0.719; 95% CL, 0.132-3.924; $P = .703$).

One major disadvantage of CABG is a higher stroke incidence than that associated with PCI, especially in the early term,^{3,23} which is generally considered to be associated with cardiopulmonary bypass (CPB) and surgical procedures on the ascending aorta.²⁴ By avoiding the need for CPB, OPCAB has the potential to reduce the incidence of stroke; however, the use of a partial aortic occlusion clamp may still increase the risk of stroke.²⁵ Compared with OPCAB, HCR is totally absent from the aortic operation and may minimize the relevant risk of stroke. In addition, macroembolization and microembolization have been identified as major sources of stroke after cardiac surgeries.²⁶ Therefore, dual antiplatelet strategy after one-stop HCR might play a potential role in the prevention of postoperative stroke.²⁷ In this study, one-stop HCR was associated with a significantly lower stroke rate compared with OPCAB (0% vs 3.6% at 3 years; $P = .046$). Considering the more advanced and diffuse atherosclerotic plaque in the aorta and arteries of patients with DM, one-stop HCR is a promising alternative approach to revascularization for these patients.

Another major disadvantage of conventional surgical revascularization is the significant trauma, which is associated with an increased need for blood products and longer recovery time.²⁸ Patients with DM experience more frequent complications with incision healing compared with patients without DM.²⁹ One-stop HCR not only involves minor surgical trauma with minimally invasive LIMA-LAD grafting and less-invasive PCI for non-LAD lesions, but also diminishes the risk of perioperative bleeding through the use of a modified antiplatelet and anticoagulation protocol.³⁰ In this study, one-stop HCR was associated with less chest tube drainage, a lower packed red blood cell transfusion rate, and faster recovery compared with OPCAB. Thus, one-stop HCR provides an attractive revascularization option for patients unfavorable for median sternotomy, extensive skin incision, or CPB, including selected patients with DM.

This study has several limitations. First, this was a retrospective study from a single center. The relatively small sample size and short follow-up time may weaken the force of our statistical analyses. Randomized clinical trials with long-term follow-up comparing one-stop HCR and OPCAB are expected. Second, there might be a bias in terms of unknown confounding factors, although our use of propensity score matching simulated randomized progress with regard to the important prognostic impactors. Third, the dual antiplatelet therapy in the one-stop HCR group might have played a role in the prevention of postoperative stroke; nevertheless, there remains no evidence of the efficacy of widespread use of long-term aspirin with clopidogrel for the secondary prevention of ischemic stroke.

CONCLUSIONS

In selected patients with DM and multivessel CAD, one-stop HCR decreased perioperative invasiveness and was associated with similar and favorable midterm outcomes compared with OPCAB. One-stop HCR may be a safe and reproducible alternative for this cohort of patients.

Conflict of Interest Statement

Authors have nothing to disclose with regard to commercial support.

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Key Words: one-stop hybrid coronary revascularization, off-pump coronary artery bypass, diabetes mellitus

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TABLE E1. Preoperative variables before matching

Variable	HCR (n = 120)	OPCAB (n = 1658)	SD
Female sex, n (%)	23 (19.2)	445 (26.8)	18.3
Age, year, mean $\pm$ SD	62.3 $\pm$ 9.4	61.6 $\pm$ 8.4	7.1
BMI, mean $\pm$ SD	25.6 $\pm$ 3.0	25.6 $\pm$ 3.0	0.5
Hypertension, n (%)	88 (73.3)	1314 (79.3)	14.0
Hyperlipidemia, n (%)	96 (80.0)	1210 (73.0)	16.6
Diabetes mellitus on insulin, n (%)	57 (47.5)	626 (37.8)	19.8
Myocardial infarction, n (%)	39 (32.5)	526 (31.7)	1.7
LM, n (%)	41 (34.2)	430 (25.9)	18.0
Number of diseased vessels, mean $\pm$ SD	2.7 $\pm$ 0.5	2.8 $\pm$ 0.4	23.0
LVEF, mean $\pm$ SD	63.9 $\pm$ 7.3	60.0 $\pm$ 8.6	48.9
Renal dysfunction, n (%)	2 (1.7)	22 (1.3)	2.8
Chronic lung disease, n (%)	2 (1.7)	12 (0.7)	8.8
Current smoker, n (%)	48 (40.0)	812 (49.0)	18.1
Cerebrovascular disease, n (%)	16 (13.3)	166 (10.0)	10.4
Extracardiac arteriopathy, n (%)	20 (16.7)	248 (15.0)	4.8
Serum creatinine, mean $\pm$ SD	81.4 $\pm$ 17.1	80.6 $\pm$ 21.8	4.2
RCA, n (%)	109 (90.8)	1455 (87.8)	9.9
LAD, n (%)	120 (100)	1644 (99.2)	13.0
LCX, n (%)	95 (79.2)	1449 (87.4)	22.2

HCR, Hybrid coronary revascularization; OPCAB, off-pump coronary artery bypass grafting; SD, standardized difference; BMI, body mass index; LM, left main coronary artery $\geq 50\%$ narrowing preoperatively; LVEF, left ventricular ejection fraction; RCA, right coronary artery system $\geq 50\%$ narrowing of any vessel preoperatively; LAD, left anterior descending artery $\geq 50\%$ narrowing preoperatively; LCX, left circumflex artery system $\geq 50\%$ narrowing of any vessel preoperatively.

TABLE E2. Procedural characteristics in the one-stop HCR group (n = 120)

Characteristic	Value
LIMA-LAD grafting, n (%)	120 (100)
PCI for non-LAD, n (%)	120 (100)
Drug-eluting stents, n (%)	119 (99.2)
Bare metal stents, n (%)	1 (0.8)
Stented lesions, n	165
LM, n (%)	27 (16.4)
LAD system, n (%)	3 (1.8)
DA	3
LCX system, n (%)	59 (35.6)
LCX	50
OM	9
RCA system, n (%)	76 (46.1)
RCA, n	67
PDA, n	6
LVB, n	3
Stents, n	196
Drug-eluting stents, n (%)	195 (99.5)
Paclitaxel-eluting stents, n (%)	7 (3.6)
Sirolimus-eluting stents, n (%)	131 (67.2)
Zotarolimus-eluting stents, n (%)	33 (16.9)
Everolimus-eluting stents, n (%)	24 (12.3)
Bare metal stents, n (%)	1 (0.5)
Stents per patient, mean $\pm$ SD	1.6 $\pm$ 0.9
Total stents length per patient, mm, mean $\pm$ SD	35.0 $\pm$ 21.4

LIMA, Left internal mammary artery; LAD, left anterior descending artery; PCI, percutaneous coronary intervention; LM, left main coronary artery; DA, diagonal artery; LCX, left circumflex artery; OM, obtuse marginal branch; RCA, right coronary artery; PDA, posterior descending artery; LVB, left ventricular branch; SD, standard deviation.

TABLE E3. Procedural characteristics in the OPCAB group

Characteristic	OPCAB (n = 240)
LIMA-LAD grafting, n (%)	240 (100)
Non-LAD grafting, n (%)	240 (100)
AA-SV-non-LAD grafting, n (%)	240 (100)
Distal anastomoses of non-LAD grafting, n	512
LAD system, n (%)	137 (26.8)
DA, n	112
IM, n	25
LCX system, n (%)	190 (37.1)
LCX, n	17
OM, n	173
RCA system, n (%)	185 (36.1)
RCA, n	33
PDA, n	120
LVB, n	32
Anastomoses of non-LAD per patient, mean $\pm$ SD	2.1 $\pm$ 0.6

OPCAB, Off-pump coronary artery bypass grafting; LIMA, left internal mammary artery; LAD, left anterior descending artery; AA, ascending aorta; SV, saphenous vein; non-LAD, coronary arteries other than left anterior descending artery; DA, diagonal artery; IM, intermediate artery; LCX, left circumflex artery; OM, obtuse marginal branch; RCA, right coronary artery; PDA, posterior descending artery; LVB, left ventricular branch.