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ORIGINAL RESEARCH

Hybrid Coronary Revascularization Versus Off-Pump Coronary Artery Bypass Grafting: Comparative Effectiveness Analysis With Long-Term Follow-up

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Background**—**Hybrid coronary revascularization (HCR) involves the integration of coronary artery bypass grafting (CABG) and percutaneous coronary intervention to treat multivessel coronary artery disease. Our objective was to perform a comparative analysis with long-term follow-up between HCR and conventional off-pump CABG.

Methods and Results**—**We compared all double off-pump CABG (n=216) and HCR (n=147; robotic-assisted minimally invasive direct CABG of the left internal thoracic artery to the left anterior descending artery and percutaneous coronary intervention to one of the non–left anterior descending vessels) performed at a single institution between March 2004 and November 2015. To adjust for the selection bias of receiving either off-pump CABG or HCR, we performed a propensity score analysis using inverse-probability weighting. Both groups had similar results in terms of re-exploration for bleeding, perioperative myocardial infarction, stroke, blood transfusion, in-hospital mortality, and intensive care unit length of stay. HCR was associated with a higher in-hospital reintervention rate (CABG 0% versus HCR 3.4%; P=0.03), lower prolonged mechanical ventilation (>24 hours) rate (4% versus 0.7%; P=0.02), and shorter hospital length of stay (8.1±5.8 versus 4.5±2.1 days; P<0.001). After a median follow-up of 81 (48–113) months for the off-pump CABG and 96 (53–115) months for HCR, the HCR group of patients had a trend toward improved survival (85% versus 96%; P=0.054). Freedom from any form of revascularization was similar between the 2 groups (92% versus 91%; P=0.80). Freedom from angina was better in the HCR group (73% versus 90%; P<0.001).

Conclusions**—**HCR seems to provide, in selected patients, a shorter postoperative recovery, with similar excellent short- and long-term outcomes when compared with standard off-pump CABG. **(*J Am Heart Assoc*. 2019;8:e014204. DOI: 10.1161/JAHA.119.014204.)**

Key Words: cardiac surgery • coronary artery bypass graft surgery • hybrid • percutaneous coronary intervention • robotic-assisted CABG

Hybrid coronary revascularization (HCR) most commonly combines a minimally invasive coronary artery bypass grafting (CABG) procedure (involving a left internal thoracic artery [LITA] to the left anterior descending coronary artery [LAD] anastomosis) with percutaneous coronary intervention (PCI) to non-LAD vessels. The rationale behind this hybrid strategy is that the combination of CABG and PCI to treat multivessel coronary artery disease (CAD) provides the patient with the simultaneous benefits of both the surgical and percutaneous revascularization strategies while avoiding some of the intrinsic complications associated with each individual procedure. HCR was first described by Angelini et al in 1996.[1] They used the classic minimally invasive direct coronary artery bypass procedure, in which the LITA is harvested by direct vision through a fourth interspace left minithoracotomy and then the LITA is anastomosed to the LAD on a beating heart. This enabled the surgeon to provide the survival benefit conferred by the LITA-to-LAD anastomosis[2,3] while minimizing the invasiveness of revascularization therapy and delivering a complete revascularization with PCI to the non-LAD vessels.

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Clinical Perspective

What Is New?

- Our study represents the first analysis of a comparison of 2-vessel disease (involving the left anterior descending artery [LAD] and one of the non-LAD vessels) treated with 2 different approaches, hybrid coronary revascularization (HCR) and conventional off-pump coronary artery bypass grafting, reporting on both mortality and freedom from reintervention.
- We compared the HCR group with patients who underwent a similar off-pump procedure, but performed conventionally, where the major difference between HCR and off-pump coronary artery bypass grafting was the technique used to revascularize the non-LAD vessels.

What Are the Clinical Implications?

- Our findings suggest that HCR can be safely performed in selected patients with multivessel coronary artery disease. The ideal patient is a patient with multivessel coronary artery disease with a complex proximal LAD lesion (SYNTAX [Synergy Between percutaneous coronary intervention (PCI) With Taxus and coronary artery bypass surgery (CABG)] score >34) suitable for left internal thoracic artery/LAD grafting, associated with significant, but not overly complex, non-LAD lesions (SYNTAX score <22) suitable for percutaneous coronary intervention and with no contraindications for dual antiplatelet therapy.
- HCR may be more appropriately considered an alternative to inappropriate multivessel percutaneous coronary intervention in patients with a low-intermediate SYNTAX score.

Additionally, the increased use of telemanipulation surgical system in the past 15 years has further minimized surgical trauma. On the other hand, there has been a continuous improvement of drug-eluting stent (DES) performance, and PCI can now provide, in low-risk patients and in those with single non-LAD vessel disease, comparable short- and mid-term outcomes to CABG.[4,5] However, the safety and effectiveness of HCR has not yet been fully established. We present our experience with a long-term follow-up of HCR and a comparative analysis to conventional off-pump CABG.

Methods

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Study Population

All double off-pump CABG (n=216; bypass graft of LITA to LAD and a venous graft to one of the non-LAD vessels) and HCR (n=147; robotic-assisted minimally invasive CABG of the LITA to the LAD and PCI to one of the non-LAD vessels) performed at our institution between March 2004 and November 2015 were included in the analysis. All the robotic-assisted minimally invasive CABG procedures were performed by 1 surgeon, whereas the standard CABG procedures were performed by 2 different surgeons. To ensure a homogenous HCR group, we only included patients who underwent robotic minimally invasive coronary artery bypass (RACABG); thus, the HCR group did not have any patients with total endoscopic coronary artery bypass. Hence, in this article, RACABG infers that the patient underwent robotic-assisted CABG. This study was approved by the institutional research ethics board at Western University (London, Ontario, Canada), which waived the need for individual patient consent.

Risk profile and demographic features of the 2 groups of patients are described in Table 1. Patients were included in the HCR group if they had double-vessel CAD with an LAD lesion that was not amenable for percutaneous intervention, but was suitable for bypass grafting with the LITA, and in whom the non-LAD lesions were anatomically suitable to be treated percutaneously. Exclusion criteria consisted of patients with contraindications to robotic-assisted coronary surgery, off-pump CABG, or PCI.

Statistical Analysis

The 3 primary outcomes of this study were in-hospital mortality, major perioperative complications, and intensive care unit and hospital length of stay. Secondary outcomes consisted of long-term survival, freedom from any form of revascularization, and freedom from angina. We used descriptive statistics to compare baseline patients' characteristics. Given the observational nature of our data set and the intrinsic bias of receiving either the off-pump CABG or the hybrid approach, we sought to address confounding by performing a propensity score (PS) analysis with inverse-probability weighting. PS was calculated with an a priori logistic regression model that was built using covariates that were judged to strongly influence the surgical approach selected by the surgeons or impact the above-listed outcomes of this study. These covariates included patients' age, sex, body mass index, hypertension, diabetes mellitus, peripheral vascular disease, chronic obstructive pulmonary disease, congestive heart failure, previous stroke, recent myocardial infarction (MI), serum creatinine, hemoglobin level, left ventricular grade, presence of left main coronary artery disease, and Canadian Cardiovascular Society score. Based on these variables, our model was found to have a good reliability (as shown by the Hosmer–Lemeshow goodness of fit; P=0.98), and it also had a good level of discrimination (c-statistic=0.84). We subsequently trimmed 19 observations (15 in the off-pump CABG group; 4 in the HCR

Table 1. Baseline Demographics

Variable	Original Sample			Weighted Sample
	Off-Pump (n=201)	Hybrid (n=143)	Standardized Differences	Standardized Differences
Age, y, mean (SD)	68.8 (10.5)	61.7 (10.7)	−0.669	−0.017
Female, n (%)	49 (24)	33 (23)	−0.030	0.043
Body mass index, kg/m^2, mean (SD)	29.0 (5.9)	30.3 (5.7)	0.221	−0.020
Hypertension, n (%)	171 (85)	115 (80)	−0.123	0.038
Smoker, n (%)	28 (14)	26 (18)	0.116	−0.022
Diabetes mellitus type 2, n (%)	56 (28)	31 (22)	−0.143	0.112
Previous stroke, n (%)	31 (15)	9 (6)	−0.296	0.306
Baseline creatinine, μmol/L, mean (SD)	103 (68)	91 (44)	−0.207	−0.118
Chronic obstructive pulmonary disease, n (%)	27 (13)	7 (5)	−0.298	0.266
Peripheral vascular disease, n (%)	40 (20)	6 (4)	−0.496	0.174
Left ventricular grade, n (%)				
1	115 (57)	102 (71)		
2	61 (30)	31 (22)	−0.198	0.160
3	22 (11)	9 (6)	−0.166	−0.174
4	3 (1)	1 (1)	−0.076	−0.071
Congestive heart failure, n (%)	14 (7)	1 (1)	−0.330	−0.101
Preoperative hemoglobin, mean (SD)	134 (18)	140 (16)	0.391	−0.111
Recent myocardial infarction, n (%)	58 (29)	26 (18)	−0.253	0.184
CCS score, n (%)				
0	2 (1)	2 (1)		
1	2 (1)	2 (1)	0.037	0.030
2	17 (8)	15 (10)	0.069	−0.030
3	55 (27)	85 (59)	0.682	0.229
4	125 (62)	39 (27)	−0.748	−0.223
Urgency, n (%)				
Elective	69 (34)	108 (76)		
Urgent	110 (55)	35 (24)		
Emergency or salvage	22 (11)	0		
Left main coronary artery disease, n (%)	64 (32)	4 (3)	−0.829	−0.043

Demographics of the patients in the sample after trimming of the propensity score to ensure common support (overlap) of the propensity scores within each group. Nineteen observations (15 from the OPCAB group; 4 from the hybrid group) were eliminated from further analysis. Urgency excluded from logistic regression model predicting treatment given that it perfectly predicted treatment. Percentages may not sum to 100% because of rounding. CCS indicates Canadian Cardiovascular Society; IQR, interquartile range; OPCAB, off-pump coronary artery bypass.

group) from the lower and upper tails of the PS because of a lack of common support. Patient characteristics before and after inverse-probability weighting adjustment were compared using standardized differences with an absolute value above 10% indicating significance. We used the *teffects ipw* package in Stata software (version 14; StataCorp LP, College Station, TX) and the average treatment effect to perform the inverse-probability weighting–adjusted analysis of our outcomes. $P<0.05$ was considered statistically significant.

Results

Short- and long-term outcomes are illustrated in Table 2. In the 2 groups, there was no statistically significant difference in the rate of re-exploration for bleeding (CABG 1.7% versus HCR 2.8%; P=0.36), postoperative atrial fibrillation (CABG 19% versus HCR 12%; P=0.13), perioperative MI (CABG 0.5% versus HCR 1.4%; P=0.36), stroke (CABG 1% versus HCR 2.1%; P=0.88), need of hemodialysis (CABG 0.5% versus HCR 0%;

Table 2. In-Hospital and Follow-up Outcomes

Outcome	Off-Pump (n=201)	Hybrid (n=143)	Propensity-Score–Adjusted Risk Difference (95% CI)	*P* Value
In-hospital outcomes				
Conversion to sternotomy, n (%)	n/a	7* (5)	n/a	n/a
Reopening for bleeding, n (%)	3 (1.5)	5 (3.5)	2.2% (−2.6 to 7.1)	0.36
Reintervention (PCI/CABG), n (%)	0	5 (3.4)	2.8% (0.3–5.3)	0.029
Postoperative atrial fibrillation, n (%)	38 (19)	17 (12)	−7.1% (−16.0 to 2.1)	0.13
Myocardial infarction, n (%)	1 (0.5)	2 (1.4)	0.7% (−0.8 to 2.2)	0.36
Stroke, n (%)	2 (1)	3 (2.1)	−0.2% (−1.9 to 2.2)	0.88
Mechanical ventilation >24 h, n (%)	8 (4)	1 (0.7)	−3.3% (−5.9 to −0.6)	0.017
Hemodialysis, n (%)	1 (0.5)	0	−0.3% (−0.9 to 0.3)	0.31
Any transfusion of packed red blood cells, n (%)	56 (28)	21 (15)	5.6% (−15 to 26)	0.60
Death, n (%)	2 (1.0)	0	−0.8% (−1.9 to 0.3)	0.15
			Propensity-Score–Adjusted Difference in Means (95% CI)	
ICU length of stay, d, mean (SD)	1.8 (1.3)	1.0 (0.8)	−0.42 (−0.93 to 0.09)	0.10
Hospital length of stay, d, mean (SD)	8.1 (5.8)	4.5 (2.1)	−2.5 (−3.2 to −1.8)	<0.001
Follow-up to-date outcomes				
Follow-up time, mo, median (IQR)	81 (48–113)	96 (53–115)		
Alive, n (%)	146/172 (85)	129/134 (96)	5.7% (−0.09 to 11.6)	0.054
Freedom from angina (among survivors), n (%)	107/146 (73)	116/129 (90)	20.8 (12–30)	<0.001
Freedom from any revascularization (among survivors), n (%)	133/145 (92)	117/129 (91)	−1.0% (−8.7 to 6.8)	0.80

Adjusted risk differences and differences in means obtained from inverse probability of treatment-weighted analysis. Differences in risk or means are for the hybrid group relative to the off-pump group. Therefore, for adverse events like death, a negative number is in favor of the hybrid group. “Freedom from angina” is defined as Canadian Cardiovascular Society class 0. When denominators do not equal sample size, this is either attributable to missing data or because the patient could not experience the event because of death. CABG indicates coronary artery bypass grafting; ICU, intensive care unit; IQR, interquartile range; n/a, not applicable; PCI, percutaneous coronary intervention.
*The 7 patients in the hybrid coronary revascularization (HCR) group that required conversion to sternotomy were counted in the HCR analysis.

P=0.31), blood transfusion (CABG 28% versus HCR 15%; *P*=0.60), in-hospital mortality (CABG 1.0% versus HCR 0%; *P*=0.15), and intensive care unit length of stay (CABG 1.8±1.3 versus HCR 1.0±0.8 days; *P*=0.10). In the HCR group, 7 patients (5%) required conversion to sternotomy and conventional on-pump CABG because of hemodynamic instability (3 patients) or bleeding (4 patients). The majority of the patients (n=114; 77.5%) underwent single-stage HCR where RACABG and PCI were performed in the same session, 9.4% of patients (n=19) underwent PCI before RACABG, and 18.7% of patients (n=38) underwent PCI after RACABG. A total of 90.5% of patients (n=133) in the HCR group were treated with DESs, whereas 9.5% of patients (n=14) were treated with bare metal stents. HCR was associated with a higher in-hospital reintervention rate, either repeated PCI or surgical revision of the LITA-LAD anastomosis (CABG 0% versus HCR 3.4%; *P*=0.029), lower prolonged mechanical ventilation (>24 hours) rate (CABG 4% versus HCR 0.7%; *P*=0.017), and shorter hospital length of stay (CABG 8.1±5.8 versus HCR 4.5±2.1 days; *P*<0.001). After a median follow-up period of 81 (48–113) months for the CABG group and 96 (53–115) months for the HCR group, there was a nonsignificant trend in survival in favor of HCR (CABG 85% versus HCR 96%; *P*=0.054) and no difference in freedom from any form of revascularization (CABG 92% versus HCR 91%; *P*=0.80). However, freedom from angina was better in the HCR group (CABG 73% versus HCR 90%; *P*<0.001).

Discussion

Our experience suggests that a hybrid coronary revascularization strategy is safe and efficacious with similar excellent short- and long-term results, but with some advantages over standard off-pump CABG. We observed that in the HCR group, there was a higher in-hospital reintervention rate compared with the CABG group; however, HCR resulted in a lower incidence of postoperative prolonged ventilation and a shorter hospital length of stay. HCR was associated with a trend toward improved survival and a significant better freedom from angina at the long-term follow-up. In our opinion, the higher rate of in-hospital reintervention rate that was observed in the HCR group is attributable to the fact that the patients who underwent standard off-pump CABG did not have any routine postoperative angiographic evaluation of the grafts; therefore, the rate of graft failure in this group was not detected and could have been underestimated. Hence, no patient in this group underwent reintervention. In contrast, all the patients in the HCR group had postoperative angiography, and any patient who was discovered to have any significant anastomotic abnormality underwent a reintervention for revision of the LITA-LAD anastomosis. All the reinterventions in the HCR group were in-hospital, and no new patients needed reintervention for the LITA graft in long-term outcomes (in fact, the 5 patients in the HCR group that had a revision for their LITA graft were also included in the long-term outcomes). The stroke rate in the HCR group was 2.1% despite no cannulation or aortic manipulation. We attributed the stroke rate in the HCR group to the wire manipulation during the PCI. The wire manipulation possibly resulted in an embolic event resulting in the neurological event. These events were all self-limiting and minor, with all patients making a full recovery. In addition, another element that might have also contributed is that patients in the HCR group who developed postoperative atrial fibrillation were not treated with full anticoagulation because of the fact that they were on dual antiplatelet therapy.

In recent years, there has been an increasing trend toward HCR procedures because of a continuous improvement of the DES performance and because of a broader use of minimally invasive techniques, especially with robotic assistance. As compared with conventional CABG, HCR allowed the surgeon to provide the patient with the survival benefit of the LITA-LAD anastomosis, while at the same time avoiding the risks of cardiopulmonary bypass, aortic clamping, and sternotomy,[2,3] and, with the use of PCI for non-LAD lesions, it allowed for the complete revascularization of all diseased coronary arteries. However, despite these numerous advantages, the indications for HCR have not been yet fully established, and, consequently, HCR has failed to be widely adopted by the surgical community. For instance, when we look at the Society of Thoracic Surgeons adult cardiac surgery database, we see that between July 2011 and March 2013, HCR represented only a small 0.48% of the total CABG procedures.[6] Several reasons could be behind the sparse use of HCR. First of all, as opposed to conventional CABG, the minimally invasive LITA-LAD anastomosis construction is technically more demanding. Second of all, to be able to simultaneously perform the 2 procedures (RACABG and PCI), a hybrid operating room must be available, which subsequently increases the cost of the operation. Also, the 2 procedures (RACABG and PCI) have different periprocedural management protocols. In addition to these logistic barriers, there is also the lack of high-level clinical evidence to support the use of HCR, with a lack of randomized clinical trials. In fact, the majority of the evidence supporting the use of HCR comes from observational, mostly retrospective studies. The first meta-analysis that addressed the safety and efficacy of HCR was done by Harskamp et al, who combined 6 observational cohort studies looking at more than 1100 patients who underwent HCR.[7] In this study, the risk of the composite of death, MI, stroke, and repeat revascularization was similar in the HCR group as compared with patients treated with CABG at 30 days and in follow-up at 1 year (4.1% of patients after HCR and 9.1% of patients with CABG). Death, MI, and stroke rates were numerically lower and in favor of HCR, but did not reach statistical significance. The rate of repeat revascularization at 3 years was higher in HCR (8.3% of patients after HCR and 3.4% of patients after CABG; $P<0.001$). In addition, regardless of whether HCR was performed using a single-stage or a 2-stage approach, the findings remained similar. Improved patient quality of life was also a major finding of this study, where HCR performed minimally invasively resulted in shorter length of hospital stay and quicker return to work and functional life.

The results of the new-generation DESs are playing an important role in coronary revascularization, and these could contribute to a wider diffusion of HCR. Newer DESs, in fact, show favorable outcomes[8–10] especially if compared with results of first-generation stents as well as venous grafts, which are more prone to atherosclerotic degeneration and progressive narrowing with high early and long-term failure rates as shown in the PREVENT (Project of Ex-vivo Vein Graft Engineering via Transfection) IV study.[11]

Similar to the findings by Harskamp et al,[7] Zhu et al also combined the data from 10 observational cohort studies, yielding a total of 6176 patients.[12] Looking at major adverse cardiac or cerebrovascular events, there was no significant difference between HCR and CABG groups during in-hospital stay and at 1-year follow-up. The researchers found that as compared with conventional CABG, patients undergoing HCR had less blood product transfusion and a shorter intensive care unit and hospital length of stay.[12]

Harskamp et al compared HCR versus standard CABG using a PS matching algorithm.[13] They looked at 306 patients who had undergone HCR, and they matched them 1:3 to 918 patients who underwent standard CABG. The 30-day composite of death, MI, or stroke after HCR and CABG was 3.3% and 3.1%, respectively (odds ratio, 1.07; 95% CI, 0.52–2.21; P=0.85). Moreover, there were lower rates of in-hospital major morbidity (8.5% versus 15.5%; P=0.005), lower blood transfusion use (21.6% versus 46.6%; $P<0.001$), lower chest tube drainage (690 mL; 25th–75th percentile: 485–1050 versus 920 mL, 25th–75th percentile: 710–1230 mL; $P<0.001$), and shorter postoperative length of stay (<5-day stay: 52.6% versus 38.1%; P=0.001) in the HCR group compared with the CABG group. During the 3-year follow-up period, mortality was similar after HCR and CABG (8.8% versus 10.2%; hazard ratio=0.91; 95% CI, 0.55–1.52; P=0.72).

The results of our analysis are concordant with the above-mentioned studies. In fact, we found that when comparing the HCR and off-pump CABG groups, there was not any significant difference in terms of major peri- and postoperative complications. Hospital length of stay was shorter in the HCR group (CABG 8.1±5.8 versus HCR 4.5±2.1 days; $P<0.001$). There was a greater freedom from angina (CABG 73% versus HCR 90%; $P<0.001$) in HCR patients at the end of the long-term follow-up.

Thus far, there is only 1 small, randomized controlled trial comparing HCR with CABG[14]; 200 patients with multivessel CAD involving the LAD and at least 1 major non-LAD coronary artery that were amenable to both PCI and CABG were enrolled. Patients were randomly assigned to undergo HCR or CABG in a 1:1 ratio. The primary end point of this study was evaluation of the safety of HCR. Feasibility was defined by percentage of patients who had a successful HCR procedure and percentage of patients who required conversion to standard CABG. Occurrence of major adverse cardiac or cerebrovascular events, such as death, MI, stroke, repeated revascularization, and major bleeding, and cerebrovascular events within a 12-month follow-up was also assessed. Of the patients in the HCR group, 93.9% had complete HCR and 6.1% of patients were converted to standard CABG. At 12 months, rates of death (2.0% versus 2.9%; *P*=not significant), MI (6.1% versus 3.9%; *P*=not significant), major bleeding (2% versus 2%; *P*=not significant), and repeat revascularization (2% versus 0%; *P*=not significant) were similar in the 2 groups. No cerebrovascular accident was observed in either group.

Our group has previously reported on patients who underwent HCR with angiographic follow-up. The first study[15] included a total of 58 patients who underwent HCR, with a mean follow-up of 20.2 months. LITA-LAD patency rate was 91% of 54 patients who had repeat catheterization. Later in 2014,[16] another study including 94 patients who underwent HCR with angiographic follow-up at 6 months demonstrated a 94% anastomotic patency rate of LITA-LAD.

Unfortunately, in the later study, it was not possible to compare this anastomosis patency rate between the HCR group and the off-pump CABG group because of the fact that patients who had standard off-pump CABG did not undergo angiographic follow-up. However, a recent study by Patel et al[17] comparing HCR with CABG showed similar short and intermediate patency rates for both revascularization strategies. The study by Patel et al compared mortality rates.[17] Instead, our study represents the first analysis of a comparison of patients with 2-vessel disease treated with either HCR or conventional off-pump CABG, looking at both mortality and freedom from reintervention. The strength of our study is that we compared the HCR group with patients who underwent a similar off-pump procedure, but performed conventionally and bypassing 2 coronary arteries.

This study demonstrates that HCR can be safely and reproducibly performed in selected patients with multivessel CAD. The ideal patient is a patient with multivessel CAD with a complex proximal LAD lesion (SYNTAX [Synergy Between percutaneous coronary intervention (PCI) With Taxus and coronary artery bypass surgery (CABG)] score >34) suitable for LITA-LAD grafting, associated with significant, but not overly complex, non-LAD lesions (SYNTAX score <22) suitable for PCI and with no contraindications for dual antiplatelet therapy. The results of this comparison should not be interpreted as HCR being an alternative to off-pump CABG for patients with a high SYNTAX score. Instead, HCR may be more appropriately considered an alternative to multivessel PCI in patients with low-intermediate SYNTAX scores.

We acknowledge some limitations to our study. First, we used a retrospective, observational data set that has the risk of selection bias, which was only partially controlled for in our PS-adjusted analyses using inverse-probability weighting. Our data set came from a single institution. Furthermore, we were not able to provide detailed angiographic information, such as SYNTAX score of the coronary lesions in each group, because of the limitations of our database.

Conclusions

HCR appears to be safe and efficacious, with faster postoperative recovery and similar outcomes when compared with standard off-pump CABG. It represents a truly minimally invasive complete coronary artery revascularization approach for patients with multivessel CAD and provides excellent short- and long-term outcomes. However, randomized, prospective control trials comparing HCR with conventional CABG or multivessel PCI will be necessary to further evaluate the effectiveness of this alternative technique of coronary artery revascularization.

Disclosures

Dr Michael Chu reports speaker's honorarium from Medtronic, Boston Scientific, Terumo Aortic, and Abbott Vascular. Dr Patrick Teefy reports honoraria from Medtronic for Peer-to-Peer lecturing and patient demonstrations of the PCI Arm of Hybrid procedures. Dr Bob Kiaii reports consultant and speaker fees from Medtronic, Edwards Life Sciences, Boston Scientific, and Johnson & Johnson. The remaining authors have no disclosures to report.

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