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Hybrid Coronary Revascularization Using Limited Incisional Full Sternotomy Coronary Artery Bypass Surgery in Multivessel Disease: Early Results

Joonkyu Kang, M.D., Hyun Song, M.D., Ph.D., Seok In Lee, M.D., Mi Hyung Moon, M.D., Ph.D., Hwan Wook Kim, M.D., Ph.D., Gyun Hyun Jo, M.D., Ph.D.

Background: There are several modalities of coronary artery revascularization for multivessel coronary artery disease. Hybrid coronary revascularization (HCR) with minimally invasive direct coronary artery bypass grafting was introduced for high-risk patients, and recently, many centers have been using it. Limited incisional full sternotomy coronary artery bypass (LIFCAB) involves left internal thoracic artery (LITA)-to-left anterior descending coronary artery (LAD) anastomosis through a sternotomy with a minimal skin incision; it could be considered another technique for minimally invasive LITA-to-LAD anastomosis. Our center has performed HCR using LIFCAB, and in this paper, we report our short-term results, obtained in the past 3 years. ***Methods:*** The medical records of 38 patients from May 2010 to June 2013 were analyzed retrospectively. The observation period after HCR was 1 to 37 months (average, 18.3±10.3 months). The patency of revascularization was confirmed with postoperative coronary angio-computerized tomography or coronary angiography. ***Results:*** There were 3 superficial wound complications, but no mortalities. All the LITA-to-LAD anastomoses were patent in the immediate postoperative and follow-up studies, but stenosis was detected in 3 cases of percutaneous coronary intervention. ***Conclusion:*** HCR using LIFCAB is safe and yields satisfactory results from the viewpoint of revascularization for multivessel disease.

Key words: 1. Myocardial revascularization
2. Coronary artery bypass
3. Minimally invasive surgery

INTRODUCTION

Coronary artery revascularization for multivessel disease can be managed through various modalities, and the patency of left internal thoracic artery (LITA)-to-left anterior descending artery (LAD) anastomosis is the best among the options. Recent reports have noted a 10-year patency rate of 95% to 98% [1,2]. The patency of percutaneous coronary intervention (PCI) is enhanced by using drug-eluting stents (DESs). In the Randomized Comparison of a Sirolimus-Eluting Stent with a Standard Stent for Coronary Revascularization trial, PCI using DESs yielded free rates from target lesion revascularization at 1, 3, and 5 years of 99%, 93.8%, and 89.7%, respectively [3].

Hybrid coronary revascularization (HCR) for multivessel disease was introduced in the mid-1990s [4]. HCR is a combination method of grafting surgery using LITA of the LAD lesion with PCI of the remaining lesions. Because the procedure-related morbidity and mortality are lower than those

Department of Thoracic and Cardiovascular Surgery, Seoul St. Mary's Hospital, The Catholic University of Korea College of Medicine
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Corresponding author: Hyun Song, Department of Thoracic and Cardiovascular Surgery, Catholic Cancer Center, Seoul St. Mary's Hospital, The Catholic University of Korea College of Medicine, 222 Banpo-daero, Seocho-gu, Seoul 137-701, Korea
(Tel) 82-2-2258-2858 (Fax) 82-2-594-8644 (E-mail) hyunsong@catholic.ac.kr

Table 1. Demographic data of patients

Demographics	Value
Male	29.0 (76.3)
Female	9.0 (23.7)
Mean age (yr)	64.9±9.52
No. of diseased vessels	
Two-vessel disease	14.0 (36.8)
Three-vessel disease	24.0 (63.2)
Mean EuroSCORE	3.71±2.73
Mean left ventricular ejection fraction (%)	58.5±8.88
Good (>50)	30.0 (78.9)
Moderate (35–50)	7.0 (18.4)
Poor (<35)	1.0 (2.63)
Hypertension	28.0 (73.7)
Diabetes mellitus	21.0 (55.3)
Hyperlipidemia	8.0 (21.1)
Stable angina	18.0 (47.4)
Unstable angina	16.0 (42.1)
Myocardial infarction	4.0 (10.5)

Values are presented as mean±standard deviation or number (%).

with conventional coronary artery bypass grafting (CABG), interest in HCR has recently increased. Previous studies reported that the mortality rate associated with HCR was low. In particular, for high-risk patients, HCR was found to be safer and more effective [5,6].

Minimally invasive direct coronary artery bypass grafting (MIDCAB) is usually performed through a 5- to 10-cm left anterolateral thoracotomy. There are advantages of this procedure compared with conventional CABG, which are better cosmetic outcomes, no morbidity of cannulation or cardiopulmonary bypass, and faster recovery [7,8]. However, in the cases wherein patients were hemodynamically unstable during the operation, switching to conventional CABG was difficult. The conversion rate to conventional sternotomy during MIDCAB was 1.8%, and the risk of morbidity and mortality increased with the conversion [9]. Therefore, we began with the safer minimally invasive coronary artery bypass surgery of limited incisional full sternotomy coronary artery bypass surgery (LIFCAB). LIFCAB involved LITA-to-LAD anastomosis through a sternotomy with a minimal skin incision. The surgeon could create a classic view through the sternotomy, and it was easy to convert to conventional CABG when the patient was hemodynamically unstable. We have used LIFCAB since 2010 and performed HCR using LIFCAB. Therefore, in this paper, we report the short-term results of HCR using LIFCAB.

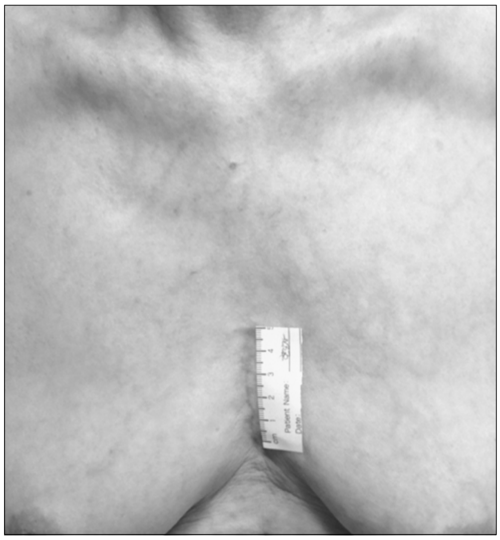

Fig. 1. Skin incision for limited incisional full sternotomy coronary artery bypass surgery.

METHODS

From May 2010 to June 2013, 78 patients were treated with LIFCAB, whereas 38 multivessel disease patients underwent treatment with HCR. The medical records of these 38 patients were analyzed retrospectively. They included 29 males and 9 females. The mean values of the EuroSCORE and left ventricular ejection fraction were 3.71%±2.73% and 58.50%±8.88%, respectively. The demographic data are summarized in Table 1.

HCR was defined as LITA-to-LAD grafting and PCI to a non-LAD lesion during the same hospitalization period. We included patients with high risk for PCI of LAD lesions because of diffuse stenosis or severe calcification. PCI was possible in lesions other than LAD.

LIFCAB involved off-pump CABG surgery through a full sternotomy and small skin incision (range, 5 to 7 cm) (Fig. 1). A long sternal blade was used for performing full sternotomy under the small incision (Fig. 2).

A Swan-Ganz catheter was inserted via the right internal jugular vein, and the cardiac output was monitored continuously. In the supine position, a midline incision was made

Fig. 2. Long sternal blade.

from the point of 1 to 1.5 cm above the internipple line to about 6 cm lower, around the xyphoid process. The subcutaneous tissue was softly separated from the muscle layer with electrocautery until the sternal notch, thus making it easier to perform a full sternotomy. The sternal notch was dissected easily with a right-angled clamp without the fear of bleeding. After the entire sternum was exposed, sternotomy was performed as the second step. First, after marking the median line of the sternum with electrocautery, usual sternotomy was performed from the xyphoid process to the upper end of the skin incision. A small separation of the sternum was retracted with an Army-Navy retractor, and upper sternotomy was performed with an oscillating saw (Fig. 2). The fibrous band in the sternal notch was incised for achieving full separation of the sternum. A full pericardiotomy was performed to evaluate the gross state of the heart. With the help of an ordinary retractor, the LITA was harvested as pedicled graft by using a harmonic scalpel, and in some cases, the proximal LITA was harvested using a 5-mm thoracoscope. After harvesting the LITA, off-pump coronary artery bypass grafting to the LAD was performed in the usual manner. A small (24Fr) chest tube and a hemovac drain were sufficient for the postoperative drainage. Five or six sternal wires (one or two on the manubrium) were placed for stabilizing the sternum. The subcutaneous tissue was fixed to the pectoralis muscle with one or two interrupted sutures, while not allowing for the stagnation of tissue fluid or blood, which could lead to tissue swelling. The wound was closed considering cosmesis (Fig. 1).

Table 2. Target of percutaneous coronary intervention

Target	Percutaneous coronary intervention		
	Preoperative	Postoperative	Simultaneous
LCx	17	1	0
RCA	11	3	0
RCA+LCx	6	0	0

LCx, left circumflex artery; RCA, right coronary artery.

PCI was performed before the operation for 34 patients and after the operation for 4 patients. The patency of the revascularization procedure was confirmed with postoperative coronary angio-computerized tomography (CT) or coronary angiography before discharge. The short-term outcomes with respect to patency were determined in the outpatient department at 6 or 12 months after HCR or when new onset symptoms developed. In addition, occurrences of mortality and perioperative morbidities were surveyed. All data were collected retrospectively, and this study was approved by the institutional review bard of Seoul St. Mary's Hospital.

RESULTS

All cases except one were performed electively. In one emergency case, PCI was performed on the right coronary artery before the operation due to acute myocardial infarction. In all cases, HCR was completed without major complications or mortality, but there were two superficial wound infections and one case of wound dehiscence. The target vessels for PCI are listed in Table 2. The mean number of DESs used for PCI was 1.34±0.71, and the diameter and the length of the lesion were 3.08±0.65 mm and 21.66±8.13 mm, respectively.

The conversion to CABG using CPB was unnecessary. The mean operation time was 135.66±33.44 minutes. Antiplatelet agents aspirin (100 mg) and clopidogrel (75 mg) were continued before the operation for patients who underwent PCI first. The medication was stopped only on the operative day and was restarted immediately after extubation. Most patients could be weaned from mechanical ventilation within 6 hours postoperatively. There were no mortalities or complications such as bleeding, arrhythmia, acute kidney injury, and media-

Table 3. Operative and postoperative data

Variable	Value
Mean operation time (min)	135.66±33.44
Mean extubation time (hr)	4.87±2.71
Morbidity	
Wound infection	2 (5.26)
Wound dehiscence	1 (2.63)
Mortality	0

Values are presented as mean±standard deviation or number (%).

Table 4. Patency of graft and PCI (no. of patents/total)

Variable	Period after HCR (mo)			
	Initial[a)]	6	12	≥12
Graft (LITA-to-LAD) (n=38)	33/33	24/24	11/11	5/5
PCI				
Left circumflex artery (n=24)	23/23	21/21	10/12	1/1
Right coronary artery (n=20)	16/16	9/9	7/8	4/4

PCI, percutaneous coronary intervention; HCR, hybrid coronary revascularization; LITA-to-LAD, left internal thoracic artery-to-left anterior descending artery.
[a)]Initial: first coronary angio-computed tomography or coronary angiography after HCR.

stinitis, but there were occurrences of superficial wound infection and dehiscence (Table 3).

All patients were successfully followed up for 18.3±10.3 months (range, 1 to 37 months) after HCR. All of the LITAs were patent in the follow-up coronary angio-CT or angiography. However, for three patients who suffered from newly developed chest pain during the follow-up, one in the left circumflex artery and two in the right coronary artery, restenosis was confirmed within a year. These patients were retreated with PCI as soon as possible (Table 4).

DISCUSSION

In patients with multivessel disease, conventional CABG was one of the standard treatments [10]. The 5-year patency rates of the LITA-LAD were between 92% and 99%, and the 10-year patency rates were between 95% and 98% [2,14,15]. The recent PREVENT IV (project of ex-vivo vein graft engineering via transfection IV) and PRAGUE-4 (primary angioplasty in patients transferred from general community hospitals to specialized PTCA units with or without emergency thrombolysis-4) trials reported vein graft patency rates of 50% to 75% after 1 year [16-18]. Despite the improvement in various aspects of conventional CABG, it carries the risk of peri- and postoperative complications and mortality concerning cannulation and CPB [11-13]. Elderly patients with comorbidities were at greater risk, so HCR was introduced as an alternative treatment.

Angelini et al. [4] reported the first HCR of 6 cases of MIDCAB to LITA-LAD combined with PCI to non-LAD vessels. Many centers now perform HCR for multivessel disease, and the American College of Cardiology Foundation and the American Heart Association have recommended HCR for selected patients on level of evidence B for limitation to traditional CABG, lack of suitable graft conduits, or unfavorable LAD artery for PCI [19].

MIDCAB offers the advantage of not needing a greater amount of anticoagulant than conventional CABG with CPB [11], but the surgeon has to work within limited fields, and it is difficult to convert MIDCAB to conventional CABG when the patient is hemodynamically unstable [20]. In a previous study, the conversion rate to sternotomy was approximately 2% in MIDCAB [9]. In contrast, the conversion to conventional CABG in LIFCAB is easier than in MIDCAB through just extending a wound. In fact, one case of LIFCAB converted to on-pump beating CABG, but we simply extended the skin incision and then performed the procedure without any problems. Because the operative field of LIFCAB is similar to that of conventional CABG, the learning curve for beginners is shorter and they can properly perform a classical view for the anastomosis. In addition, mobilizing the LITA is convenient in LIFCAB, so the time required for harvesting the LITA is reduced. We have performed HCR using LIFCAB since 2010. Our short-term mortality and morbidity outcomes have been satisfactory. The patency of the LITA-to-LAD anastomosis was confirmed, and our results did not differ from those of MIDCAB, which are reported to be 93% to 100% [1]. We performed this operation with a 7-cm skin incision in the first few cases and were able to gradually reduce the length of the skin incision with experience. We now operate with a 5- to 6-cm skin incision without difficulty. Sternotomy is associated with a greater risk of bleeding and mediastinitis than thoracotomy, but in this study, complications such as bleeding or mediastinitis did not occur.

The operation time was not too long, and all patients could be weaned from mechanical ventilation within 6 hours postoperatively. Despite sternotomy, we believe that LIFAB is a minimally invasive surgery procedure and is suitable for HCR.

Due to the small size of our sample, we cannot compare the results with those of conventional CABG. In this paper, we reported the short-term results of HCR using LIFCAB. In future, we intend to report long-term results and conduct a study comparing it with conventional CABG for multivessel disease. In conclusion, HCR using LIFCAB is a safe and feasible new technique.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

REFERENCES

1. DeRose JJ. *Current state of integrated "hybrid" coronary revascularization.* Semin Thorac Cardiovasc Surg 2009;21: 229-36.
2. Tatoulis J, Buxton BF, Fuller JA. *Patencies of 2127 arterial to coronary conduits over 15 years.* Ann Thorac Surg 2004; 77:93-101.
3. Narasimhan S, Srinivas VS, DeRose JJ Jr. *Hybrid coronary revascularization: a review.* Cardiol Rev 2011;19:101-7.
4. Angelini GD, Wilde P, Salerno TA, Bosco G, Calafiore AM. *Integrated left small thoracotomy and angioplasty for multivessel coronary artery revascularisation.* Lancet 1996;347: 757-8.
5. Friedrich GJ, Bonatti J. *Hybrid coronary artery revascularization: review and update 2007.* Heart Surg Forum 2007;10: E292-6.
6. Popma JJ, Nathan S, Hagberg RC, Khabbaz KR. *Hybrid myocardial revascularization: an integrated approach to coronary revascularization.* Catheter Cardiovasc Interv 2010;75 Suppl 1:S28-34.
7. Bonchek LI, Ullyot DJ. *Minimally invasive coronary bypass: a dissenting opinion.* Circulation 1998;98:495-7.
8. Calafiore AM, Di Giammarco G, Teodori G, et al. *Midterm results after minimally invasive coronary surgery (LAST operation).* J Thorac Cardiovasc Surg 1998;115:763-71.
9. Kettering K. *Minimally invasive direct coronary artery bypass grafting: a meta-analysis.* J Cardiovasc Surg (Torino) 2008;49:793-800.
10. Cameron A, Davis KB, Green G, Schaff HV. *Coronary bypass surgery with internal-thoracic-artery grafts: effects on survival over a 15-year period.* N Engl J Med 1996;334: 216-9.
11. Kirklin JK, Westaby S, Blackstone EH, Kirklin JW, Chenoweth DE, Pacifico AD. *Complement and the damaging effects of cardiopulmonary bypass.* J Thorac Cardiovasc Surg 1983;86:845-57.
12. Salasidis GC, Latter DA, Steinmetz OK, Blair JF, Graham AM. *Carotid artery duplex scanning in preoperative assessment for coronary artery revascularization: the association between peripheral vascular disease, carotid artery stenosis, and stroke.* J Vasc Surg 1995;21:154-60.
13. Regragui I, Birdi I, Izzat MB, et al. *The effects of cardiopulmonary bypass temperature on neuropsychologic outcome after coronary artery operations: a prospective randomized trial.* J Thorac Cardiovasc Surg 1996;112:1036-45.
14. Kim KB, Cho KR, Jeong DS. *Midterm angiographic follow-up after off-pump coronary artery bypass: serial comparison using early, 1-year, and 5-year postoperative angiograms.* J Thorac Cardiovasc Surg 2008;135:300-7.
15. Hayward PA, Buxton BF. *Contemporary coronary graft patency: 5-year observational data from a randomized trial of conduits.* Ann Thorac Surg 2007;84:795-9.
16. Alexander JH, Hafley G, Harrington RA, et al. *Efficacy and safety of edifoligide, an E2F transcription factor decoy, for prevention of vein graft failure following coronary artery bypass graft surgery: PREVENT IV: a randomized controlled trial.* JAMA 2005;294:2446-54.
17. Magee MJ, Alexander JH, Hafley G, et al. *Coronary artery bypass graft failure after on-pump and off-pump coronary artery bypass: findings from PREVENT IV.* Ann Thorac Surg 2008;85:494-9.
18. Widimsky P, Straka Z, Stros P, et al. *One-year coronary bypass graft patency: a randomized comparison between off-pump and on-pump surgery angiographic results of the PRAGUE-4 trial.* Circulation 2004;110:3418-23.
19. Hillis LD, Smith PK, Anderson JL, et al. *2011 ACCF/AHA Guideline for Coronary Artery Bypass Graft Surgery: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines: developed in collaboration with the American Association for Thoracic Surgery, Society of Cardiovascular Anesthesiologists, and Society of Thoracic Surgeons.* J Am Coll Cardiol 2011;58:e123-210.
20. Borst C, Grundeman PF. *Minimally invasive coronary artery bypass grafting: an experimental perspective.* Circulation 1999;99:1400-3.