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Minimally Invasive Direct Coronary Artery Bypass: Current Experience

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Hitoshi Hirose, MD, FICS,[1] Atsushi Amano, MD,[2] Akihito Takahashi, MD[3]

[1]Department of Cardiovascular Surgery, Shin-Tokyo Hospital, Chiba; [2]Department of Cardiovascular Surgery, Juntendo University Hospital, Tokyo; [3]Department of Cardiovascular Surgery, Cardiovascular Institute Hospital, Tokyo, Japan

Dr. Hirose

ABSTRACT

Background: Minimally invasive direct coronary artery bypass (MIDCAB) via a small incision has been performed for revascularization of the left anterior descending artery with the left internal mammary artery. In this study, we analyzed outcome in patients who underwent MIDCAB.

Methods: Between June 1997 and July 2002, a total of 125 patients (96 men and 29 women; mean age, 65.1 ± 9.6 years) underwent MIDCAB. Perioperative and follow-up data were entered into a structured database.

Results: Coronary anastomosis time was 17.0 ± 5.0 minutes. Mean intubation period, intensive care unit stay, and postoperative hospital stay were 4.0 ± 2.8 hours, 1.3 ± 0.8 days, and 9.7 ± 4.6 days, respectively. There were no hospital deaths or cases of postoperative heart failure, myocardial infarction, renal failure, prolonged ventilation (>2 days), or stroke. During the follow-up period of 3.3 ± 1.5 years, 12 patients developed angina, and there were 10 deaths. The actuarial 3-year survival rate was 92.6%, and the event-free rate was 87.1%.

Conclusion: MIDCAB can be performed with early recovery with minimum mortality and morbidity. The long-term results after MIDCAB are acceptable.

INTRODUCTION

Minimally invasive direct coronary artery bypass (MIDCAB) via a small anterior thoracotomy incision has been performed for revascularization of the left anterior descending artery (LAD) using the left internal mammary artery (LIMA). The approach is via a small anterior thoracotomy incision [Subramanian 1997]. The aim of MIDCAB is elimination of cardiopulmonary bypass, avoidance of manipulation of the aorta, revascularization of the LAD with the most reliable arterial conduit, and cosmetic effect as the result of the small skin incision. A previous study demonstrated early recovery of patients who underwent MIDCAB [Subramanian 1997]. However, critics of MIDCAB mention the questionable quality of anastomosis owing to the small and limited operative field and unknown long-term results. We review our current MIDCAB experience focusing on postoperative and remote results.

METHODS

Patients

Perioperative and remote data on patients who underwent MIDCAB at the Shin-Tokyo Hospital Group were prospectively entered into a structured database. Patients who underwent combined general or major vascular surgery were excluded from this study. Between June 1997 and July 2002, a total of 125 consecutive MIDCABs were performed in our group. The study patients consisted of 96 men and 29 women with a mean age of 65.1 ± 9.6 years. Their preoperative demographics are shown in Table 1. The reasons for referral to MIDCAB were a single LAD lesion failed or expected to fail with catheter intervention (68 patients [54.4%]), LAD-dominant 2- or 3-vessel disease (31 patients [24.8%]), hybrid coronary intervention (3 patients [2.4%]), patient's preference (10 patients [8%]), and medical comorbidity, such as malignancy, stroke, or renal failure (23 patients [18.4%]). All patients with multivessel disease had culprit lesions in the LAD.

Minimally Invasive Direct Coronary Artery Bypass

After establishment of general anesthesia and separate lung ventilation, a small left thoracotomy (8-cm skin incision) was made at the left 5th intercostal space. The LIMA was harvested under the surface of the sternum under direct vision with a chest wall retractor (Thoralift; Cardio Thoracic Systems, Cupertino, CA, USA). The pericardium was opened, and the LAD was investigated. Proximal and distal control of the target vessel was performed with silicon snares. In case of a high-flow coronary artery or electrocardiographic change during the local coronary clamp, an intracoronary shunt tube was placed to maintain distal perfusion. LIMA-LAD anastomosis was performed with 8-0 propylene sutures under a coronary stabilizer (Ring system stabilizer [US Surgical, Norwalk, CT, USA] or Octopus stabilizer [Medtronic, Minneapolis, MN, USA]). A carbon oxide gas blower was used to facilitate anastomosis by providing a blood-free operating field. If the LIMA was not long enough to reach the LAD or if the diagonal artery needed to be revascularized, the inferior epigastric artery (IEA) was harvested to elongate the graft or to make a Y graft.

Dr. Hirose is currently at the Department of Thoracic and Cardiovascular Surgery, Cleveland Clinic Foundation, Cleveland, Ohio, USA.

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Address correspondence and reprint requests to: Hitoshi Hirose, MD, FICS, 2300 Overlook Rd #312, Cleveland, OH 44106, USA; 1-216-707-9445; fax: 1-216-707-9446 (e-mail: genex@ nifty.com).

Table 1. Preoperative Patient Demographics (n = 125)

Clinical characteristics	
Age (mean ± SD), y	65.1 ± 9.6
Age over 75 y, n	27 (21.6%)
Female, n	29 (23.2%)
Cardiac profile, n	
Unstable angina	13 (10.4%)
Acute myocardial infarction	4 (3.2%)
Previous myocardial infarction	65 (52.0%)
Left main disease	20 (16.0%)
Left anterior descending single disease	68 (54.4%)
Three-vessel disease	17 (13.6%)
History of congestive heart failure	13 (10.4%)
Poor ejection function (<40%)	2 (1.6%)
Atrial fibrillation	6 (4.8%)
Redo surgery	1 (0.8%)
Coronary risk factors, n	
Hypertension	72 (57.6%)
Diabetes	48 (38.4%)
Insulin user	11 (8.8%)
Hyperlipidemia	58 (46.4%)
Smoking	54 (43.2%)
Obesity	8 (6.4%)
Family history	14 (11.2%)
Comorbidity, n	
Active malignancy	5 (4.0%)
Peripheral vascular disease	2 (1.6%)
Cerebral vascular accident	13 (10.4%)
Chronic pulmonary obstructive disease	3 (2.4%)
Renal dysfunction	13 (10.4%)
Hemodialysis	5 (4.0%)
Euro score (mean ± SD)	2.8 ± 2.2

Postoperative Angiography

Postoperative angiography was performed before discharge from the hospital if the patient agreed to the procedure. If the patient remained angina free, a repeated coronary angiogram was not routinely obtained.

Data Collection

Postoperative data were collected prospectively. Outpatient follow-up was completed by the end of January 31, 2003. Remote myocardial infarction, angina, arrhythmia necessitating hospitalization, congestive heart failure necessitating hospitalization, coronary reintervention, and sudden death were counted as cardiac events. Results were expressed as mean ± SD. Long-term survival and event-free rate were calculated by the Kaplan-Meier method.

RESULTS

Operative and Postoperative Results

Operative results are shown in Table 2. During the period of study, 2 of the 127 patients (1.6%) experienced failed MIDCAB. The approach was converted to median sternotomy owing to dissection of the LIMA in 1 patient and failed separate lung ventilation in 1 patient. Both the LAD and the diagonal artery were revascularized via a MIDCAB approach in 4 (3.2%) of the patients. The IEA was harvested to elongate the LIMA or to make a Y graft with the LIMA in 10 patients (8.0%). All patients were hemodynamically stable during the procedure. The coronary anastomosis time was 17.0 ± 5.0 minutes. Blood transfusion was required by only 4 (3.2%) of the patients.

Postoperative recovery also is shown in Table 2. Thirteen (10.4%) of the patients were extubated in the operating room, and all of the other patients were extubated on the day after surgery. No patients developed postoperative respiratory failure or pneumonia. Seven (5.6%) of the patients were sent out of the intensive care unit on the day of surgery, and 82 (65.6%) of the patients, the next day. Fifty-three (42.4%) of the patients went home within 1 week of surgery, and 86 (68.8%) of the patients, within 10 days. The most frequent reason for delayed discharge was postoperative angiography.

There were no deaths or cases of respiratory failure, pneumonia, postoperative myocardial infarction, congestive heart failure, or stroke. There were no false anastomoses other than the LAD. Other complications are listed in Table 2.

Angiographic Results

Angiography was performed for 82 (65.6%) of the patients before discharge. A total of 88 distal anastomoses were examined. All the anastomoses were patent and stenosis free, except for 1 occlusion and 1 case of anastomotic stenosis. The patient with an occluded LIMA-LAD graft underwent successful percutaneous transluminal coronary angioplasty (PTCA) to the LAD and remained symptom free. The patient with 50% anastomotic stenosis did not demonstrate ischemic signs by the stress test and was symptom free for

Table 2. Operative Results (n = 125)

Number of distal anastomoses	1.0 ± 1.2
Number of blood transfusions	4 (3.2%)
Coronary anastomosis time/vessel, min	17.0 ± 5.0
Operation time, min (mean ± SD)	183.4 ± 34.6
Intubation, h (mean ± SD)	4.0 ± 2.8
Intensive care unit stay, d (mean ± SD)	1.3 ± 0.8
Postoperative stay, d (mean ± SD)	9.7 ± 4.6
Postoperative complications, n	
Congestive heart failure	0
Postoperative myocardial infarction	0
Ventilator support >2 d	0
Pneumonia	0
Postoperative stroke	0
Reexploration for bleeding	1 (0.8%)
Postoperative hemodialysis	0
Wound infection	1 (0.8%)
Pericardial effusion	1 (0.8%)
Atrial fibrillation	16 (12.6%)
In-hospital death	0

Table 3. Follow-up Results

Number of patients followed	125/125 (100%)
Follow-up period, y (mean ± SD)	3.3 ± 1.5
Remote cardiac events, n	
Angina	12 (9.6%)
Coronary catheter intervention	10 (8.0%)
Congestive heart failure	0
Arrhythmia	1 (0.8%)
Sudden death	0
Distant death	
Cardiac death	1 (0.8%)
Noncardiac death	9 (7.2%)

2.5 years after surgery. The perfect patency rate in the early period after surgery was 97.7% (86/88). An additional 28 patients underwent angiography more than 3 months after surgery. Late angiography revealed 4 occlusions, 1 string sign of the LIMA graft, and 1 case of anastomotic stenosis. All patients with graft occlusions and string sign had experienced angina and were treated with PTCA.

Follow-up Results

Collection of long-term data was completed for all patients with a mean follow-up period of 3.3 ± 1.5 years (Table 3). Angina recurred in 12 (9.6%) of the patients: LIMA-LAD graft-related angina in 5 (4 occlusions and 1 string sign), progression of native coronary artery disease in 3 (1 diagonal artery, 1 right coronary artery, and 1 circumflex artery), and unknown (refused catheterization) in 2. All patients with postoperative angina and angiographically documented coronary lesions were treated with PTCA. An additional 2 PTCA procedures were performed on asymptomatic patients as therapy for the native coronary artery disease.

There were 10 remote deaths, including 1 cardiac death due to acute myocardial infarction. The patient was a 49-year-old man with renal dysfunction, diabetes, and calcified aorta who had a dominant left coronary artery and significant stenoses on the LAD and right coronary artery. The patient underwent successful MIDCAB, and postoperative recovery was uneventful. However, the patient experienced massive acute myocardial infarction 2.7 years after surgery and died. No angiographic examinations were available for this patient because of renal dysfunction.

The actuarial 3- and 4-year survival rates were 92.6% and 90.9%, respectively. The actuarial 3- and 4-year event-free rates were 87.1% and 85.0%.

DISCUSSION

Patient selection for MIDCAB is controversial. A single LAD lesion after failed PTCA is the most common referral for MIDCAB. Patients in whom catheter intervention is difficult owing to small reference size (<1.5 mm), coronary artery kinking, or dye allergy have been treated with MIDCAB. However, most patients with single LAD lesions have been treated with PTCA with and without stenting. A randomized study of patient outcome after stenting versus MIDCAB for a single proximal LAD lesion demonstrated that procedure-related mortality and morbidity were higher in the MIDCAB group, but the long-term event-free rate was lower, than in the stenting group [Diegeler 2002]. In that study, MIDCAB failure and conversion to midsternotomy were observed in 4.5% (5/110), postoperative myocardial infarction in 3.8% (4/105), stroke in 1.0% (1/105), and death within 30 days after surgery in 1.9% (2/105) of the patients. The authors suggested that MIDCAB might need further improvement of technique to reduce periprocedural morbidity, although the long-term results of MIDCAB were superior to those of stenting. Our MIDCAB patients showed no mortality, postoperative myocardial infarction, or stroke. Our results suggest that MIDCAB is a more favorable procedure for single LAD lesions than stenting.

Patients with LAD-dominant multivessel disease can be MIDCAB candidates. However, these patients carry risk of perioperative infarction at the nonrevascularized coronary artery, although no perioperative infarction was observed in our series. Hybrid PTCA should be considered for these patients [Riess 2002]. The risk of PTCA against the non-LAD coronary arteries after successful LIMA-LAD bypass is minimal. High-risk patients with 3-vessel coronary disease and symptomatic angina may be offered palliative LIMA-LAD bypass using MIDCAB [Izzart 1998]. These high-risk patients are, for example, those with diabetic nephropathy and peripheral vascular disease who are undergoing dialysis (high risk of mediastinitis and lack of conduits), recent stroke with a fragile sternum (high risk of stroke and sternal nonunion), or malignant tumor with unstable angina due to an LAD lesion (high risk of possible tumor spread and limited activity owing to angina).

Patients undergoing MIDCAB are expected to show early recovery and have minimal postoperative complications, as we report. This small number of complications most likely was due to avoidance of cardiopulmonary bypass and avoidance of median sternotomy. Fluid retention and volume overload after MIDCAB are rare, and the rarity may contribute to the low incidence of postoperative congestive heart failure, prolonged ventilator support, and postoperative dialysis. Because of early recovery, minimal complications, and reliable LIMA-LAD bypass, some patients requested MIDCAB rather than conventional coronary artery bypass grafting (CABG) or PTCA. The cosmetic advantage of MIDCAB over median sternotomy is obvious.

The postoperative coronary events were clearly related to incomplete revascularization or suboptimal LIMA-LAD anastomosis. Patients with stenosis or occlusion of an LIMA-LAD bypass after MIDCAB will develop angina because of the nature of single-vessel revascularization. All patients who develop chest pain after MIDCAB should be evaluated with angiography if the graft fails or if de novo native coronary artery disease is developing. Patients with graft failure should undergo repeated PTCA or redo CABG via median sternotomy. If the LIMA-LAD graft is patent, the patient can undergo PTCA with minimal risk. The reported LIMA-LAD

patency rate after MIDCAB is between 92% and 98% [Subramanian 1997, Cremer 1999, Doty 1999]. Another follow-up study after MIDCAB demonstrated a 2-year survival rate of 92% and a reintervention-free rate of 92% [Subramanian 1997]. We believe that our angiographic and remote results were within the range of these previous reports or somewhat superior to them.

SUMMARY

This study was based on nonrandomized, longitudinal clinical experience at a single institution. Single LAD lesions after failed PTCA can be managed by MIDCAB with minimum risk. Once proper revascularization to the LAD is performed by MIDCAB, long-term cardiac events can be avoided adequately. The indications for MIDCAB for patients with multivessel disease should be carefully selected. The cases of patients at high risk of coronary disease should be followed closely for development of de novo disease in nonrevascularized coronary arteries.

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