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Original Article

Research on application value of minimally invasive direct coronary artery bypass combined with percutaneous coronary intervention in treatment of coronary heart disease

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Abstract: Objective: To investigate the clinical effect of minimally invasive direct coronary artery bypass (MIDCAB) in left chest with percutaneous coronary intervention (PCI) in the treatment of coronary heart disease. Methods: 100 cases of patients with coronary heart disease were randomly divided into observation group (50 cases) and control group (50 cases). The patients in observation group firstly underwent MIDCAB, and then underwent selective PCI to treat right coronary artery and vascular disease; the control group underwent traditional CABG. Indicators such as preoperative basic condition, postoperative drainage volume in 24 h, mechanical ventilation time, ICU monitoring time, hospital days, re-exploration for mediastinal bleeding, peri-operative myocardiac infarction and fatality rate etc. were compared between two groups. The occurrence of cardiovascular adverse events during follow-up period was also observed. Results: There were no significant differences of age, sex, history of diabetes and hypertension, the proportion of dyslipdemia, smoking, drinking, angina pectoris, and cardiac functional (NHYA classification) in the two groups of patients (P>0.05). Patients were followed-up for 3 months after operation; we found that the LVEF in observation group was obviously higher than that in control group and the difference had statistical significance (*P*<0.05). Compared with control group, the postoperative drainage volume in 24 h, mechanical ventilation time, CICU monitoring time, postoperative hospital stay, operative time and the length of incision were significantly less in observation group, which had statistical difference (*P*<0.05). There was no re-exploration for mediastinal bleeding or death in two groups. There was no significant difference in pleural effusion and infection between the two groups (*P*>0.05). The results of one-year follow-up showed that there were 2 cases of recurrence of myocardial infarction in the control group; however, there was no cardiac death or recurrence of myocardial infarction, or second CABG/PCI in observation group. Conclusion: For suitable patients with coronary heart disease, MIDCAB with PCI surgery is safe and reliable, and has a significant short-term clinical effect.

Keywords: Coronary heart disease, coronary artery bypass, percutaneous coronary intervention

Introduction

In recent years, the incidence of coronary heart disease is increasing year by year, and has become a common disease in the Department of Cardiology [1]. Coronary artery bypass grafting (CABG) is an effective method for the treatment of coronary heart disease, and the indications for GABG are left main artery lesion and multi vessel disease, which is suitable for patients who are not fit for interventional therapy or patient with higher interventional risk [2]. However, the surgical trauma of GABG is large, and patients are likely to have complications such as nonunion of chest bone, impairment of pulmonary function, renal inadequacy and edema of lower extremity, and most of the patients have the need of blood transfusion [3]. Percutaneous coronary intervention (PCI) is a non-medication treatment for coronary heart disease. The advantage of CABG is the application in the left internal mammary artery (LIMA); for the left anterior descending (LAD) lesions, the long-term patency rate of LIMA→ LAD

Table 1. Comparison of the general clinical data of two groups

Project	Observation group (n=50)	Control group (n=50)	*P*-values
Age (years old)	63.45±12.34	67.34±14.54	0.567
Gender (male)	36 (72%)	35 (70%)	0.784
Diabetes	30 (60%)	29 (58%)	0.645
Hypertension	31 (62%)	28 (56%)	0.664
Dyslipidemia	13 (26%)	11 (22%)	0.656
Smoke	16 (32%)	17 (34%)	0.745
Drinking	14 (28%)	15 (30%)	0.867
History of angina pectoris	38 (76%)	39 (78%)	0.125
Combined myocardial infarction	18 (36%)	16 (32%)	0.364
Cardiac function classification (NYHA classification)			
Class I	14	10	0.786
Class II	30	35	
Class III	6	5	

bypass is superior to PCI [4]. Studies have reported that the 10-year patency rate of LIMA graft can reach 90% [5]. For non-anterior descending artery disease, CABG surgery commonly use saphenous vein grafts, the short and long term patency rate is less than PCI. Minimally invasive direct coronary artery bypass (MIDCAB) provides a small trauma treatment for anterior descending artery occlusion and other serious diseases; if combined with PCI at the same time, MIDCAB can provide a new treatment for high-risk patients with multi-vessel vascular lesions [6]. We selected patients with anterior descending artery disease, who were unsuitable for interventional treatment, to participate in this study. MIDCAB was performed under assistance of internal mammary retractor of suspension type or chest mirror; internal mammary artery was freed, then anastomosis of internal mammary artery and anterior descending artery was performed, part of the patients were treated with intervention treatment on right coronary artery and circumflex branch of coronary artery; the aim of this study was to explore the effectiveness and safety of MIDCAB combined with PCI in primary hospitals.

Material and methods

General information

Patients with anterior descending artery disease, and patients with moderate/severe stenosis of the circumflex artery or right coronary artery who could be treated with combined PCI intervention treatment, all together 100 cases that treated in our hospital from March 2013 to April 2014, were selected in this study. The patients were, randomly divided into observation group (50 cases) and control group (50 cases). Patients in observation group first underwent minimally invasive off-pump coronary artery bypass in left chest (MIDCAB), and then underwent PCI to treat right coronary artery and the circumflex vascular lesions. Patients in control group were treated with the conventional CABG (median sternotomy incision with non-extracorporeal circulation). Preoperative data of the two groups of patients are shown in **Table 1**.

Operation method

MIDCAB method: Patients underwent double lumen endotracheal intubation after general anesthesia and took supine position, and the left chest was padded for 30 degrees. Automatic defibrillation electrode plates were placed on the right anterior chest and the left posterior chest of patients and connected with the automatic external defibrillator. A 6 cm incision was made on the fourth intercostal gap on left anterior chest wall, and then single lung ventilation was applied after getting access to chest. The LIMA was accessed under auxiliary thoracoscope or direct vision, the segment of LIMA to be freed was up to the edge of first rib and down to the fifth intercostal space. After freeing LIMA, we then cut pericardium, deter-

Table 2. Comparison of the indices of preoperative echocardiography in two groups

Project	Observation group (n=50)	Control group (n=50)	*P*-values
LA (cm)	3.34±0.34	3.36±0.35	0.751
LVEDD (cm)	5.74±0.64	5.63±0.34	0.641
LVESD (cm)	3.45±0.45	3.67±0.63	0.465
LVEDV (ml)	145.34±24.45	153.36±34.35	0.734
LVESV (ml)	65.14±11.64	71.53±10.35	0.345
LVEF	0.54±0.04	0.56±0.05	0.764

Table 3. Comparison of indices of postoperative echocardiography in two groups in 3-month follow-up

Project	Observation group (n=50)	Control group (n=50)	*P*-values
LA (cm)	3.51±0.31	3.48±0.27	0.807
LVEDD (cm)	5.34±0.11	5.63±0.34	0.141
LVESD (cm)	3.75±0.41	3.57±0.53	0.411
LVEDV (ml)	134.24±25.15	141.54±24.11	0.255
LVESV (ml)	64.34±11.45	70.34±16.45	0.465
LVEF	0.62±0.06*	0.58±0.01	0.237

Note: compared with the control group, *P<0.05.

mined the anastomosis location of anterior descending artery, estimated the sufficient free length of anterior descending artery, heparin (1 mg/kg), and dissected the distal LIMA. After withdrawing the suspension system, we placed rib retractor and suspended pericardium. And then the anterior descending branch was stabilized with a heart stabilizer, a shunt plug was placed after cutting coronary artery; anastomosis of the left internal mammary artery and anterior descending artery was finished by suturing with Prolene 8-0 line. Heparin was neutralized by Protamine at a ratio of 1:0.8; a thoracic drainage tube was placed before close chest. After the MIDCAB operation, the patients were scheduled for a selective PCI to treat right coronary artery and circumflex branch disease in the catheterization room by physicians from department of Cardiology.

PCI method: Within 24 h following MIDCAB surgery, patients started double resistance treatment by taking 0.1 g aspirin and 75 mg clopidogrel per day after the drainage significantly decreased; and then under stable condition, patients underwent PCI treatment after postoperative 6.45±1.62 days (on average) in the Department of Cardiology of our hospital. The PCI treatment refers to implantation of drug eluting stents (DES) in right coronary artery and/or circumflex artery; altogether 27 patients were implanted with 32 DESs, among which 14 stents were implanted in circumflex artery, and 18 stents were implanted in right coronary. LIMA angiography was performed during PCI process to confirm the patency of all LIMA→ LAD bridge.

Observation index

Echocardiography was used to measure and calculate the left atrial diameter (LA), left ventricular end diastolic diameter (LVEDD), left ventricular end systolic diameter (LVESD), Left ventricular end diastolic volume (LVEDV), left ventricular end systolic volume (LVESV), and Left ventricular ejection fraction (LVEF) of patients on admission and during the 3-months follow-up. The postoperative drainage volume, mechanical ventilation time, CICU monitoring time, hospital days, re-exploration for mediastinal bleeding, and infection etc. were observed and recorded. All enrolled patients returned to visit at the Department of Cardiology in our hospital for follow-up for one year after discharge; the major adverse cardiovascular events (MACE), including death, recurrent myocardial infarction, revascularization, were recorded, echocardiography was re-examined and cardiac function of patients was also re-assessed.

Statistical methods

All the data were statistically analyzed by SPSS 17.0 software. Measurement data were expressed as $\bar{x}\pm S$. Comparison between groups was examined using t test; count data was expressed as percentage, comparison between groups was examined using χ^2 test. Difference was considered statistically significant when $P<0.05$.

Results

Comparison of basic data between two groups of patients

There was no significant difference in age, gender, history of diabetes, hypertension, angina pectoris and myocardial infarction, dyslipidemia proportion, smoking history, drinking history, and cardiac function (NYHA classification) between the two groups of patients (P>0.05),

Table 4. Comparison of various postoperative observation indices in two groupsof patients

Project	Observation group (50)	Control group (50)	*P*-values
Postoperative drainage volume in 24 h (ml)	71.6±11.8	174±24.5	0.017
Mechanical ventilation time (h)	5.34±1.65	15.55±2.54	0.005
CICU monitoring time (h)	34.35±11.65	38.67±12.45	0.035
Hospital days (d)	20.34±4.67	38.45±5.75	0.011
Incision length (cm)	7.6±2.4	29.5±3.5	0.009
Operation time (h)	3.7±0.7	4.6±0.8	0.023

Table 5. Comparison of the indices of the two groups of patients during the follow-up period

Project	Observation group (50)	Control group (50)	*P*-values
Re-exploration for mediastinal bleeding	0	0	>0.05
Pleural effusion	3	2	>0.05
Infection	0	1	>0.05
Death	0	0	>0.05

Table 6. Comparison of adverse cardiovascular events in two groups of patients

Project	Observation group (50)	Control group (50)
Cardiac death	0	0
Recurrent myocardial infarction	0	2
Second CABG	0	0
Second PCI	0	0

see **Table 1**. Two groups of patients were comparable.

Comparison of the results of preoperative echocardiography in two groups

The results of preoperative echocardiographic indices, including the diameter of left atrium (LA), left ventricular end diastolic diameter (LVEDD), left ventricular systolic end diastolic diameter (LVESD), left ventricular diastolic end diastolic volume (LVEDV), left ventricular end systolic volume (LVESV), and left ventricular ejection ejection fraction (LVEF), were shown in **Table 2**; by t-test statistical analysis, the results showed that there was no significant difference between the two groups (P>0.05).

Comparison of the results of echocardiography between two groups in 3 months after operation

All patients were followed up for 3 months and echocardiography was re-examinaed after discharge; although the value of LA, LVEDD, LVESD, LVEDV and LVESV was different between two groups, there was no statistical significance (P>0.05). However, the difference of LVEF between the two groups was statistically significant, see **Table 3**.

Comparison of postoperative observation indices of two groups of patients

The differences in operation time, drainage volume in postoperative 24 h, incision length, ventilator assisted time and hospital days between observation group and control group had statistical significance, see **Table 4**.

Comparison of the indices of the two groups of patients during the follow-up period after discharge

There was no re-exploration of mediastinal bleeding and death in both observation group and control group; 3 cases of postoperative pleural effusion occurred in observation group, compared with 2 cases in control group, there was no significant difference between the two groups (P>0.05). There was only 1 case of postoperative infection in control group, but it didn't happen to observation group, the difference was not statistical significant (P>0.05). See **Table 5**.

Comparison of adverse cardiovascular events between two groups of patients during hospitalization and 1 year postoperative follow-up

The results of follow-up showed that there were no major cardiovascular adverse events, such as cardiac death, coronary artery bypass regrafting and second PCI, occurred in both groups, but 2 patients in control group had myocardial infarction again. See **Table 6**.

Discussion

Coronary artery bypass grafting (CABG) and percutaneous coronary intervention (PCI) are effective methods for treatment of coronary heart disease [7]. LIMA→ LAD bypass is regarded as the "gold standard" for coronary revascularization. A large number of evidence-based medical studies have showed that the 10-year patency rate of LIMA→ LAD bypass is over 95%, which has absolute advantage over DES used in PCI [8-11]. As a result, so far, LIMA→ LAD bypass for the treatment of coronary heart disease and combined with PCI for other coronary artery lesions has become a hotspot in the field of treatment for coronary heart disease.

Some scholars use the mode of median thoracotomy for LIMA→ LAD bypass and following with PCI [12, 13], while some scholars use the mode of small incision under the breastbone for LIMA→ LAD bypass and following with PCI [14, 15]. With deep exploration in the concepts and methods of minimally invasive surgery, MIDCAB technology has been gradually matured, and more widely used in clinic application [16, 17]. MIDCAB technology, integrating two concepts of extracorporeal circulation and small incision, can not only avoid the internal milieu disorder caused by extracorporeal circulation but also reduce the trauma caused by traditional CABG, therefore, by using of MIDCAB to complete LIMA→ LAD bypass, and following with selective PCI, we can further reduce the trauma and improve prognosis [18, 19]. Internal Mammary retract system of suspension type was used in this study to lift the ribs and fully expose the thoracic cavity, and then LIMA was obtained with a special extended mammary artery retractor under direct vision; there was no breast arterial injury nor transferring to conventional thoracotomy occurred in the surgery.

The study results showed that there was significant difference in postoperative drainage volume in 24 h (71.6±11.8 ml *vs.* 24.5 ml ±174 ml), mechanical ventilation time (5.34±1.65 h *vs.* 15.55±2.54 h), CICU monitoring time (34.35±11.65 h *vs.* 38.67±12.45 h), hospital stay (20.34±4.67 d *vs.* 38.45±5.75 d), and operation time (3.7±0.7 h *vs.* 4.6±0.8 h) between observation group and control group ($P<0.05$), indicating that compared with the conventional CABG, MIDCAB combined with PCI can significantly reduce the postoperative drainage, operation time, mechanical ventilation time and ICU monitoring time, postoperative hospitalization time and incision length, thus MIDCAB combined with PCI has remarkable advantage over conventional CABG for its small incision and short recovery time. The results of this study also showed that there was no re-exploration for mediastinal bleeding nor death in both observation group and control group; only 3 patients in the observation group (n=50) had postoperative pleural effusion, compared with two cases in control group, the difference had no statistical significance ($P > 0.05$); there was 1 patient had postoperative infection in control group, but it did not occur in observation group, no significant difference was observed between the two groups ($P > 0.05$). This indicates that compared with the traditional CABG, MIDCAB combined with PCI wouldn't significantly increase the pleural effusion or infectious complications, it also wouldn't lead to re-exploration for mediastinal bleeding or death, suggesting MIDCAB combined with PCI has the similar therapeutic effect with conventional CABG, both of them are safe treatment for the purpose of treating coronary heart disease without reducing the vascular patency rate; however, by comprehensively comparing of operating time, incision length, hospitalization, postoperative recovery and follow-up, MIDCAB combined with PCI has significant advantage over conventional CABG surgery.

Animal experiments and clinical studies have showed that large part of myocardial infarction would lead to ventricular remodeling and ventricular hypertrophy, and further affect the cardiac function and long-term prognosis [20]. Clinical studies have reported that MIDCAB combined with PCI can improve ventricular remodeling in patients with coronary heart disease, reduce left ventricular mass index, and increase left ventricular ejection fraction [21, 22]. In this study, comparing with control group, LVEF of patients in observation group was significantly increased (0.62±0.06 *vs.* 0.58±0.01, $P<0.05$), indicating MIDCAB combined with PCI can significantly improve ventricular remodeling and enhance cardiac function.

In summary, MIDCAB combined with PCI has the advantages of smaller incision, shorter

operative time, fewer complications and quicker recovery. For severe coronary heart disease, especially associated with organ dysfunction, MIDCAB can greatly reduce the risk of surgery, especially for the left anterior descending complicated with other coronary lesions that could be solved by PCI. MIDCAB combined with PCI is a safe and effective surgery to treat coronary heart disease that can significantly improve the cardiac function of patients.

Disclosure of conflict of interest

None.

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