Clinical outcome, pain perception and activities of daily life after minimally invasive coronary artery bypass grafting

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Abstract

Objective: Minimally invasive direct coronary artery bypass (MIDCAB) for revascularization of the left anterior descending artery has become a routine operation. We present our clinical experiences with beating heart MIDCAB surgery performed through partial lower sternotomy (PLS) and retrospectively compare the results of pain perception as well as activities of daily life (ADL) with the conventional full sternotomy.

Methods: From January 2009 to August 2012, 197 patients underwent MIDCAB using modified PLS at our hospital. Their mean age was 58.5±10.5 years. 54 (28%) had previous myocardial infarction, 38 (19%) had diabetes mellitus. The visual analog scale (VAS) for pain one, two and three, the ADL score for mobilization were obtained within four days after surgery. 98% of patients were followed-up with both direct visits and questionnaires to assess the major adverse cardiac events (MACE). We performed t-test for comperative data and Kaplan-Meier curves for survival analysis.

Results: There was one postoperative death (0.5%) and three conversions to full sternotomy (1.5%). Postoperative angiography was performed in 34 (17.2%) patients, who had some symptoms during the follow-up period of 45 months. The graft patency rate was 96.5% (190 of 197). At follow-up (24.1±11.7 months), survival free of MACE was 91.8±3.1% at 3.5 years. Both the Visual Analog Scale (VAS 35.1±9.6 vs. 57.1±7.8) and the ADL score (80.4±11.8 vs. 36.2±8.6) were significantly higher after the operation in comparison to the matched group of beating heart revascularizations with full sternotomy ($p<0.001$).

Conclusion: This study demonstrates that the MIDCAB using PLS can achieve an effective intermediate-term revascularization and an acceptable clinical outcome. Patients who undergo this procedure are free of major complications and enjoy good quality of life after surgery.

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Key words: minimally invasive coronary revascularization, partial lower sternotomy, LIMA, VAS, survival analysis

Introduction

Coronary artery bypass grafting (CABG) is performed to provide myocardial revascularization for the purpose of reducing cardiac symptoms and mortality as well as improvement in health related quality of life. Since Gruntzig (1) introduced percutaneous transluminal coronary angioplasty (PTCA) in 1977, interventional cardiologists have had a growing role in treatment of coronary artery stenosis. As a result, the relationship between cardiologist and cardiac surgeon has changed. The patients now referred for surgical revascularization procedures are substantially "older and sicker" than those on whom cardiothoracic surgeons had performed CABG a decade ago (2). At the same time, new surgical methods and anesthetic techniques, as well as development in the postoperative care have been adapted to improve the results of CABG.

Off-pump Coronary Artery Bypass Grafting (OPCAB) and Minimally Invasive Direct Coronary Bypass Grafting (MIDCAB) have been established to avoid the side effects of cardiopulmonary bypass (CPB) and to achieve better postoperative outcome and cosmetic results. The benefits of the avoidance of CPB have been proved and therefore OPCAB becomes a routine method in various centers (3-6). Most patients referred for bypass surgery with single-vessel disease involving the proximal LAD, are operated on using the MIDCAB technique as partial lower sternotomy (PLS) approach using left internal thoracic artery (LITA) in our institution.

The aims of new surgical methods are not only for reducing symptoms and mortality, but also for improving health-related

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activities of daily life and reducing pain (7-9). The term "key hole surgery" implies that patients will have less discomfort and less impairment of their daily activities. Therefore, the purpose of this study was to analyze our clinical results in MIDCAB patients and to determine the effects of small incision, in comparison with conventional full sternotomy, on postoperative pain and activities of daily life among patients after surgery.

Methods

Baseline

From January 2009 to August 2012, 1587 patients underwent elective primary CABG procedures at our institution. Of these, 1576 (99.3%) patients underwent beating heart surgery and full sternotomy, whereas 197 (12.4%) patients were selected to undergo MIDCAB using PLS (Table 1).

Most candidates for the PLS procedure were considered to be those patients with isolated LAD disease if: (I) a PTCA (with or without stent) was not considered feasible because of technical aspects such as proximal or complex lesions, or total LAD occlusion (74%); (II) a restenosis after a previous PTCA (with or without stent) had occurred (19%); (III) the cardiologist or the patient asked for the minimally invasive surgical procedure (6%); or (IV) multivessel patients that were non-graftable because of technical aspects (eg, distal stenoses with small coronary size, or heavy calcifications) and were selected for hybrid treatment (1%).

Study design and population

This study was designed to analyze our clinical results in MIDCAB patients (n=197) and to determine the effects of small incision, in comparison with a matched group of conventional full sternotomy patients, on postoperative pain and activities of daily life among patients after surgery.

Out of the 197, sixty-two patients that underwent MIDCAB using PLS (PLS group), were enrolled in the performance and pain analysis. Patients, who had postoperative morbidity (bleeding, prolonged ICU stay, etc.) were excluded. Then the patients were matched on preoperative prognostic variables (age, gender, left ventricular ejection fraction, Euro Score, body surface area, diabetes mellitus, and history of myocardial infarction) to 60 patients undergoing two-vessel bypass grafting using conventional full sternotomy and beating heart approach during this period (FS group) (Table 2).

Surgical technique

With a usual 4-5cm length of incision (Fig. 1), the chest was opened via partial lower mini sternotomy as midline cutting without L- or J shaping to left. It was necessary to carefully dissect the internal thoracic artery to the first intercostal space or left subclavian artery to avoid steal phenomena from the intercostal vessels. A classic Favaloro Retractor obtained exposure. For additional revascularization of the right coronary artery (n=3), a radial artery graft was dissected. After creating a pericardial cradle the target vessel was exposed with "four suture" stabilization technique (6). Anastomoses were performed with a running 8/0 polypropylene suture in standard beating heart bypass technique using proximal control of the target vessel and a blower mister to clear the anastomotic site.

Table 1. Demographic characteristics, comorbidities and previous cardiovascular events as well as postoperative data

	MIDCAB (PLS)
Total number of patients	197
Age, years	58.5±10.5
Female	57 (29%)
BSA, kg/m^2	1.93±0.2
Comorbidities	
Myocardial infarction	54 (28%)
Diabetes	38 (19%)
Hypertension	89 (45%)
Dyslipidemia	76 (38%)
Peripheral vascular disease	13 (7%)
CCS class	1.7±0.3
LVEF	57±8
Operative data	
Operative time, min	88±27
Conversion to full sternotomy	3 (1.5%)
Skin incision, cm	4.9±1.1
Double revascularization	20 (10.1%)
Postop course	
Postop hospital stay, day	4.5±1.2
ICU stay, hours	16.4±9
Chest tube, 24h/mL	320±110
Hospital mortality	1 (0.5%)
Follow up	
Mean follow up time, month	24.1±11.7
Greft occlusion	7 pts
Re-Operation	1 (0.5%)

Data are presented in mean ± standard deviation, *p<0.05 significant
BSA - body surface area; CCS - Canadian cardiovascular society angina classification; LVEF - left ventricular ejection fraction; MIDCAB - minimally invasive direct coronary revascularization; PLS - partial lower sternotomy

Clinical examinations and follow up

Functional status was estimated according to Activities of Daily Life (ADL) performance status (10) through interviews with the patient and a family member as well as medical care staff. The clinical ADL performance status was performed within the first three postoperative days and at discharge (Table 3).

In addition to clinical outcomes and performance status, visual analogue scale (VAS) pain score (with 0 reflecting no pain and 100 reflecting the worst imaginable pain), was recorded on

days one, two and three after surgery (11). We also documented the use of analgesic agents during postoperative period.

Follow-up information, that was available for 98% of the patients, was obtained by direct examination of the patient, postal questionnaires and telephone calls to the patient or the treating general physician. The date of the last inquiry was August 2012 and mean follow up time was 24.1±11.7 months. We measured the mid- to long-term Major Adverse Cardiac Events (MACE) that were defined as all-cause mortality, target vessel revascularization, myocardial infarction (MI), reoperation, and bypass dysfunction.

Statistical analysis

Data were collected using FileMaker 11.0 software (FileMaker Inc., Santa Clara, CA) and the statistical analysis was performed using SPSS 14.0 software (SPSS, Chicago, IL). Categorical data were analyzed using the Wilcoxon-Mann-Whitney when appropriate. Independent samples t-test was used to compare other continuous variables. MACE free survival was calculated by Kaplan-Meier methods with 95% CI. All continuous variables are expressed as a mean±standard error of the mean. Statistical significance was assumed at a probability level of less than 0.05.

Results

Surgical Results

In 197 patients, the operation was conducted with the minimal access approach on a beating heart; in three patients (1.5%) the MIDCAB was converted to a median sternotomy due to insufficient length of the LITA and the lateralization of the coronary artery anatomy. Twenty patients (10.1%) had double vessel revascularization for a diagonal branch and right coronary artery as well as one young female patient that had triple vessel grafting.

One hundred and ninety (96.4%) patients were extubated during the first six postoperative hours and 194 (98.4%) patients had discharged from intensive care less than 24 hours after admission. Only one 78 year old female patient died in-hospital (0.5%), who had a mesenterial ischemia on the tenth postoperative day. Postoperative data of PLS patients are shown in Table 1.

Postoperative angiography was performed in 34 (17.2%) patients, who had some symptoms during follow up period of 45 months. Seven patients had occlusion of the LITA graft. One patient needed reoperation, and three patients had an angioplasty with stent implantation. The final three patients were not eligible for any revascularization methods, due to poor vessel conditions. There were two non-cardiac deaths and MACE free survival was 91.8% during follow up period (Fig. 2). At follow-up examination, CCS functional status was significantly improved from 1.7 to 1 (p<0.001), and no sternal complications or stroke occurred.

Performance and pain status

Patients experienced the most pain from coughing and in-bed mobilization. Maximal pain levels were observed on postoperative day two. Pain intensity according to the VAS in the matched "full sternotomy" group (n=60) at postoperative days two, three and four was significantly higher than in PLS group (n=62, p<0.001), (Fig. 3). In patients with PLS, early postoperative pain levels were relatively low as reflected by more patients expressing mild, or even no pain, and severe pain was rare. The use of analgesic agents during postoperative period in PLS group was significantly lower than in full sternotomy group (4.9±1.5 vs. 7.1±1.5, p<0.001). Result of lower pain perception, these patients were more active in daily life during early postoperative period (Fig. 4, p<0.001).

Table 2. Baseline clinical characteristics of patients undergoing partial lower sternotomy and full sternotomy surgery

	PLS	FS	*P*
Total number of patients	62	60	
Age	56.4±8.1	56.1±7.4	ns
Female	21 (34%)	18 (30%)	ns
BSA, kg/m^2	1.81±0.2	1.78±0.2	ns
Myocardial infarction	18 (30%)	22 (36%)	ns
Diabetes	13 (20%)	14 (23%)	ns
LVEF, %	58±7	55.6±9	ns
EuroSCORE	1.4±0.8	1.2±0.6	ns
Surgical results			
Operative time, min	94±21	102±28	ns
Skin incision, cm	5±1.1	28±2.2	<0.001
Postop hospital stay, day	4.5±1.2	4.2±1.1	ns
ICU stay, hours	14.8±8	16.2±9	ns
Chest tube, 24h/mL	340±100	410±132	ns

Data are presented in mean ± standard deviation, *p<0.05 significant
BSA - body surface area; FS - full sternotomy; LVEF - left ventricular ejection fraction; MIDCAB - minimally invasive direct coronary revascularization; PLS - partial lower sternotomy.

Table 3. Definition of activities of daily life and it's scoring

Activities of daily life	Score
Eating meal on his/her own	1 point
Wearing on his/her own	1 point
Going to toilet on his/her own	1 point
Taking medicine on his/her own	1 point
Walking around in the service on his/her own	1 point
Taking a bath on his/her own	1 point
Reading a newspaper/ book on his/her own	1 point
Communicating with other patients on his/her own	1 point
Not having a sleeping disorder	1 point
He/she can be discharged	1 point

Discussion

MIDCAB using PLS is an effective way to improve the quality of life and to provide angina relief for selected subgroups of

coronary patients. The midterm survival and event-free survival rates achievable with this surgical option are encouraging, even if longer follow-up times are needed for a more precise assessment of the results of this surgery.

In the last decade, efforts in all areas of surgery have focused on minimally invasive surgical techniques. In cardiac surgery, there are two important aspects of this concept: (a) minimal access to limit surgical trauma, and (b) avoidance of cardiopulmonary bypass. MIDCAB performed with smaller incisions and without cardiopulmonary bypass is becoming more and more popular. The reasons for the success of these procedures are shorter hospital stay, rapid recovery, faster return to activity, reduced patient morbidity, and less postoperative pain than with standard procedures (7-9). However, the complete median sternotomy is still gold standard for CABG, it allows full access to the LITA and better exposition of LAD, as well as full safety during OPCAB surgery.

PLS provides several advantages over left anterior small thoracotomy approach (LAST), which is preferred among cardiac surgeons. The advantages to use PLS technique are the ITA dissection is similar to full sternotomy but is easier than LAST; LAD is visible in full length; a conversion to full sternotomy is easier than LAST (12, 13). Compared to patients undergoing conventional surgery, patients operated using LAST technique suffer more pain in the first three postoperative days, probably as a result of the lateral thoracotomy (14-16).

Our early postoperative results were comparable with the other working groups (7-9). There has been considerable concern among surgeons and cardiologists that the greater technical difficulty of off-pump coronary revascularization via small access might translate into less precise anastomoses and subsequently lead to diminished graft patency. Focusing on the ratio of graft occlusion and MACE (death, MI, second revascularization), the present study showed a 1% graft occlusion and a 2.60% MACE rate at six months after surgery in MIDCAB patients. However, another study, showed a graft occlusion ratio of 8% and a MACE ratio of 15% during six month period after MIDCAB using LAST technique (15). Over a 3.5-year period, we found that seven patients of 197 had graft occlusion and MACE was 4.6% in our MIDCAB patients using PLS, which is comparable with the results of experienced centers (7-9, 12, 15).

Post-operative pain levels and activities of daily life are significant indicators for evaluating the changes in physical and psychological well-being. We determined that patients, who underwent MIDCAB using PLS, had significantly lower postoperative pain levels in comparison with the conventional full sternotomy. According to the literature, significantly higher pain levels have been reported for MIDCAB using LAST technique on the first postoperative days when compared to conventional CABG procedures (14, 16).

Consequently, the pain leads to inadequate and shallow breathing as well as reduced mobilization. With our patient group, faster mobilization was obtained due to lower levels of

Figure 1. Cosmetic result of MIDCAB using partial lower sternotomy (PLS)

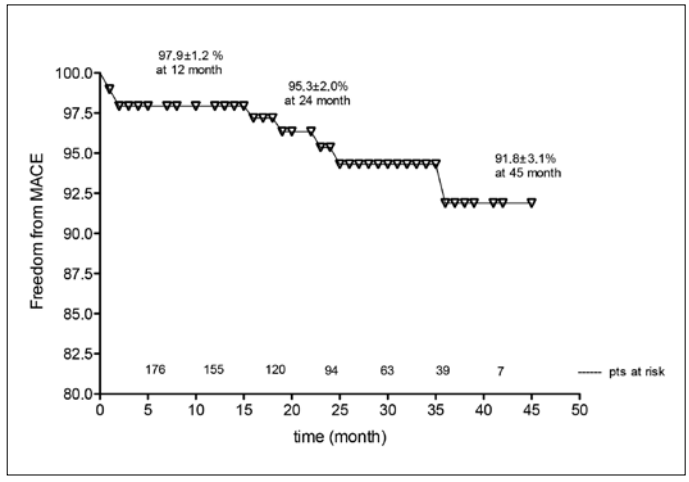

Figure 2. Kaplan-Meier curve for freedom from MACE following MIDCAB using PLS

post-operative pain. Chest stabilization was protected and inspiration was better, so that faster recovery was achieved after PLS. Similar results were described using the same technique by other authors (12).

In the group of PLS patients, there was less need for analgesic in comparison with the group of full sternotomy patients. As a result, analgesic dependent side-effects were reduced. Nonsteroidal anti-inflammatory drugs (NSAIDs), which are used to manage postoperative pain act by inhibiting the production of prostaglandins, have significant side-effects on various systems. Most common side-effects of NSAIDs are on the lower bowel and stomach. These are dyspepsia, constipation and straining. Moreover, another considerable side-effect is hepatotoxicity. İt may occur that transaminases arise 1.2 or 1.3 times the normal rate, causing temporary renal injury (17).

Study limitations

The main limitation of this study in comparing ADL and VAS scoring, was that the full sternotomy group had always two-vessel disease and longer operative times, while the other group

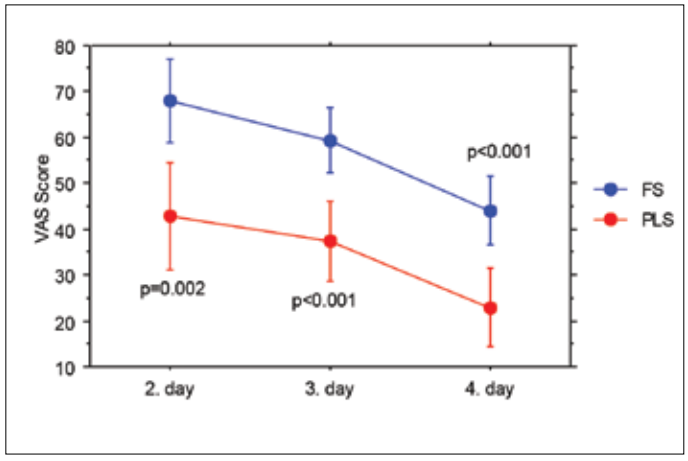

Figure 3. Assesment of postoperative pain perception using VAS in two groups

PLS: minimally invasive direct coronary revascularization using partial lower sternotomy, FS - full sternotomy; Data are presented in mean±standard deviation, *p<0.05 significant

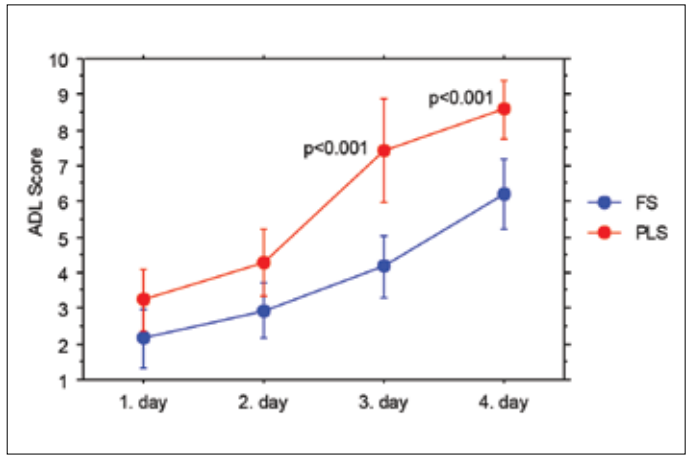

Figure 4. Comparison of ADL (Activities of Daily Life) in both groups of patients

FS - full sternotomy; PLS - minimally invasive direct coronary revascularization using partial lower sternotomy, Data are presented in mean±standard deviation, *p<0.05 significant

had only single-vessel revascularization. Because we routinely use the minimal access for LAD revascularization, it was not possible to create a patient group for full sternotomy with only single bypass. Since most of patients had no cardiac symptoms during the follow-up period, we performed a control angiography only on a small number of patients (17.2%), which is also a possible limitation of this study.

Conclusion

This study demonstrates that the MIDCAB using PLS can achieve an effective intermediate-term revascularization and an acceptable clinical outcome. Patients who undergo this procedure are free of major complications and enjoy good quality of life after surgery.

Conflict of interest: None declared.

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