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Review of a 13-Year Single-Center Experience with Minimally Invasive Direct Coronary Artery Bypass as the Primary Surgical Treatment of Coronary Artery Disease

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ABSTRACT

Background and Aim of the Study: In this study, we review our experience with 1768 minimally invasive direct coronary artery bypass (MIDCAB) operations. The focus is on long-term outcome with more than 10 years of follow-up.

Methods: All patients undergoing standard MIDCAB between 1996 and 2009 were included. For all 1768 patients, pre-, intra-, and postoperative data could be completed. Long-term follow-up information about health status, major adverse cardiac and cerebrovascular events (MACCE), and freedom from angina was collected annually via questionnaire or personal contact. Five-year follow-up is available for 1313 patients, and 10-year-follow-up is available for 748 patients. A multivariate Cox regression analysis was performed to determine risk factors for long-term outcome.

Results: Mean age was 63.4 ± 10.8 years, mean ejection fraction was 60.0% ± 14.2%, and perioperative mortality risk calculated by logistic EuroSCORE was 3.8 ± 6.2%. In 31 patients (1.75%) intraoperative conversion to sternotomy was necessary. Early postoperative mortality was 0.8% (15 patients); 0.4% (7 patients) had a perioperative stroke. Seven hundred twelve patients received routine postoperative angiogram, showing 95.5% early graft patency. Short-term target vessel reintervention was needed in 59 patients (3.3%) (11 percutaneous transluminal coronary angioplasty (PTCA)/ stent, 48 re-operation). Kaplan–Meyer analysis revealed a 5-year survival rate of 88.3% (95% confidence interval [CI], 86.6% to 89.9%) and a 10-year-survival rate of 76.6% (95% CI, 73.5% to 78.7%). The freedom from MACCE and angina after 5 and 10 years was 85.3% (95% CI, 83.5% to 87.1%) and 70.9% (95% CI, 68.1% to 73.7%), respectively.

Conclusions: MIDCAB is a safe operation with low postoperative mortality and morbidity. With excellent short-term and long-term results, it is a very good alternative compared to both percutaneous coronary intervention (PCI) and conventional surgery.

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INTRODUCTION

Minimally invasive direct coronary artery bypass grafting (MIDCAB) has become the preferred method of surgical revascularization for isolated coronary artery disease of the anterior wall at many centers. In addition, MIDCAB is a good alternative in selected high-risk patients with multivessel disease who have extensive comorbidity or are at high risk for sternotomy [Jacobs 2007]. Furthermore, hybrid revascularization involving minimally invasive surgical bypass grafting of the left internal mammary artery (LIMA) to the left anterior descending coronary artery (LAD) plus percutaneous coronary intervention (PCI) has been a major topic of the last years [Friedrich 2007, Holzhey 2008].

The minimally invasive approach and the long-term benefits after LIMA to LAD grafting are the strongest arguments for the MIDCAB procedure. Yet the operation remains challenging, has a substantial learning curve [Holzhey 2007b], and has to prove its quality against alternatives such as PCI/stenting of the LAD or off-pump coronary artery bypass grafting (OPCAB) over and over again.

In this study, the perioperative data and the long-term follow-up of all standard MIDCAB patients were analyzed. The data are from a large single center with experience in MIDCAB over almost 15 years. This review is a follow-up and update of previously published data [Holzhey 2007a] with more patients included and a longer follow-up time.

PATIENTS AND METHODS

All 1768 patients who underwent standard MIDCAB from 1996 to 2009 were analyzed. During the same time period, 106 patients received a MIDCAB operation with telemanipulator-assisted LIMA harvest, and 119 patients had totally endoscopic bypass grafting (TECAB) to the LAD. Those patients were excluded from the analysis.

The policy at our institution is that whenever single bypass grafting to the LAD is required, a minimally invasive method is chosen. Therefore there is no "control group" of similar bypass patients operated on via sternotomy.

Surgical Technique

The operation was performed through a 5 to 6 cm anterolateral muscle-sparing minithoracotomy with LIMA takedown under direct vision. The activated clotting time was kept at a level above 300 seconds throughout the operation and was usually neutralized incompletely with half-dose protamine after completion of the anastomosis. A reusable pressure stabilizer without suction was used. Proximal LAD occlusion was performed using a 4-0 felt-pledgeted suture. Preconditioning was not applied. Distal occlusion was avoided whenever possible. A mister-blower was used in all cases. The use of intracoronary shunts was rare. Antiplatelet therapy using 100 mg of aspirin was continued or started with the day of hospital admission and was given lifelong.

Data Collection

All patients gave their written consent to anonymous data storage and analysis, and the conduction of this study was approved by the local ethics committee. Intraoperative data, perioperative complications, and angiographic findings were collected from written and electronic files of all patients in a prospective database.

Seven hundred twelve patients received elective coronary angiogram postoperatively to evaluate graft patency, and 372 patients were re-studied at 6 months. When MIDCAB had become a routine procedure, a postoperative angiogram was only performed when graft problems were suspected by clinical symptoms, electrocardiogram (ECG) findings, or elevated enzymes or when the patient participated in a clinical trial.

Follow-Up

Follow-up information from all patients was gathered routinely by annual postal questionnaires and telephone calls to the patient and/or the treating general physician. Data on survival, general condition, occurrence of major adverse cardiac and cerebrovascular events (MACCE; myocardial infarction, target vessel reintervention, cardiac death, and stroke), and recurrence of angina were collected. The closing interval for follow-up for this publication was January 2011. Five-year follow-up was completed for 89% and 10-year-follow-up for 77% of all possible patients.

Statistical Analysis

Categorical variables are expressed as proportions, and continuous variables are expressed as mean ± standard deviations throughout this study. For long-term survival and MACCE-free survival, Kaplan–Meier analysis was performed. To asses the role of risk factors for long-term outcome, uni- and multivariant Cox regression analyses were performed using the following potential risk factors: age, female sex, body mass index (BMI), smoking, arterial hypertension, diabetes mellitus, hyperlipoproteinaemia, chronic obstructive lung disease (COLD), peripheral artery occlusive disease (PAOD), renal insufficiency, impaired ejection fraction, recent myocardial infarction (MI), previous cardiac surgery, chronic total occlusion (CTO) of LAD, and previous PCI of LAD. Moreover, the influence of multivessel coronary artery disease and the revascularization strategy (hybrid approach, deliberate incomplete revascularization) was included into the analysis.

RESULTS

Mean age was 63.4 ± 10.8 years (range 25 to 92 years); 84 patients were older than 80 years. Seventy-two percent of the patients were men. The majority of patients (1665, 94.2%) were scheduled for elective revascularization, but urgent (82 patients, 4.6%) and emergency (21 patients, 1.2%) cases were not excluded. The mean ejection fraction was 60.0% ± 14.2%, and the preoperatively calculated additive euroSCORE ranged from 0 to 17 points (mean 2.5 points) with corresponding expected perioperative mortality from 0.9% to 72.8% (mean 3.8%). The complete risk profile is given in Table 1.

Table 1. Preoperative Patient Characteristics and Risk Factors*

Number of patients	1768
Mean age, y	63.4 ± 10.8
Men	1273 (72%)
Mean body mass index	27.3 ± 3.9
Long-term smokers	573 (32.4%)
Arterial hypertension	1416 (80.1%)
Diabetes	
Type I	9 (0.5%)
Type II without insulin	307 (17.4%)
Type II with insulin	171 (9.7%)
Hyperlipoproteinaemia	1154 (65.3%)
Chronic obstructive pulmonary disease	130 (7.4%)
Peripheral arterial occlusive disease	258 (14.6%)
Neurological disorder	65 (3.7%)
Renal failure	44 (2.4%)
Critical preopertive state	28 (1.6%)
Unstable angina pectoris	146 (8.3%)
Pulmonary hypertension	14 (0.8%)
Implanted pacemaker	52 (2.9%)
Implantable cardioverter defibrillator	8 (0.5%)
Previous cardiac operation	57 (3.2%)
previous stent implantation in target vessel	322 (18.2%)
Chronic total occlusion of target vessel	407 (23.0%)
Previous stent implantation in other vessels	232 (13.1%)
Mean EuroSCORE, points	2.5 ± 2.5
Mean logistic EuroSCORE	3.8% ± 6.2%

*Data are presented as n (%) or mean ± standard deviation.

Most of the patients were referred for single vessel coronary artery disease of the LAD (1098 patients); 444 patients had formal 2-vessel disease, and 226 patients had formal 3-vessel disease. Those patients were scheduled for MIDCAB when the stenoses of the other vessels were insignificant, when the coronary arteries were graded too small (< 1 mm) for surgical revascularization and/or severely calcified distally, or when the corresponding myocardial territories were scarred, non-vital, or aneurysmatic as diagnosed by magnetic resonance imaging (MRI). However, 191 patients had multivessel disease with an indication for additional therapy of other coronary vessels. Thus, a hybrid procedure was completed performing pre- (54 patients), intra- (3 patients), or postoperative (62 patients) non-LAD stenting. In the other 72 patients, incomplete revascularization was accepted because of high risk for sternotomy and/or extensive comorbidity [Jacobs 2007].

Intraoperative Course

Mean operation time was 111 ± 14 minutes, and 60 patients received a second bypass graft to the diagonal or intermediate branch using an additional venous graft, the left radial artery, or the LIMA sequentially. Target vessel occlusion caused temporary ST elevation or depression in 74 patients (4.2%) and reversed immediately upon reperfusion in all cases. Ventricular fibrillation and severe drop of blood pressure occurred with 12 and 6 patients, respectively. In most of the cases, these complications were overcome by external defibrillation and temporary inotropic support. In a total of 40 cases (2.3%), the operation could not be completed as planned. Median sternotomy became necessary in 31 cases (1.75%), and 17 patients (0.96%) needed cardiopulmonary bypass. Details of all conversions are summarized in Table 2.

Postoperative Angiography and Reintervention

During the first years, when MIDCAB was still a new procedure under investigation, 712 patients (40.3%) received an elective routine pre-discharge angiogram showing a patency rate of 96.8% with 23 grafts (3.2%) occluded. Later, routine control angiography was stopped and a coronary angiogram was performed solely based on the presence of postoperative ST elevations or increased cardiac enzymes indicating myocardial ischemia. Symptom based angiography was performed in an additional 85 patients (4.8%). Out of these patients, 69 (81.2%) had patent grafts (Fitzgibbon A: 53 patients = 62.3%) and 16 grafts (18.8%) were occluded. In a total of 59 patients (3.3%), short-term reintervention of the target vessel was performed. In most cases, because of stenosis of the anastomosis, stenosis of the LAD distal to the anastomosis or narrowing or kinking of the LIMA. These problems were managed by PCI/stent implantation (11 patients) or reoperation (48 patients). In detail re-anastomosis through the primary minithoracotomy (18 patients) or by beating-heart re-anastomosis through median sternotomy (12 patients) was performed. In 15 patients, reoperation by conventional bypass grafting with median sternotomy and cardiopulmonary bypass became necessary, most often because of severe calcification of the LAD (5 patients), severe circulatory depression on occlusion of the LAD (3 patients), or emergency reoperation (2 patients). One patient suffered from left main dissection during angiogram and thus needed bypass grafting to the circumflex artery (LIMA–LAD bypass patent), and 1 patient with posterior MI due to acute stent thrombosis required urgent revascularization of the right coronary artery. Three patients who were originally planned as hybrid cases and had occlusion of the LAD bypass received secondary conventional multivessel bypass grafting.

Table 2. Intraoperative Conversion

Converstion to	Number of Patients	Reasons for Conversion (n)
Sternotomy(off-pump coronary artery bypass)	21	Injury of left internal mammary artery (LIMA) (7)
		LIMA too short (3)
		Left anterior descending coronary artery (LAD) intramural or extremely calcified (5)
		Problems with anastomosis (3)
		Low cardiac output (LCO) (1)
		Injury of right ventricle (1)
		Intolerance of single lung ventilation (1)
Sternotomy + cardiopulmonary bypass (CBP)	10	LCO (2)
		LAD intramural (4)
		Problems with anastomosis (3)
		Injury of right ventricle (1)
CPB (femoral cannulation)	7	LCO (6)
		LAD intramural (1)
Venous graft through minimally invasive direct coronary artery bypass incision	1	Distal dissection of LIMA
Abortion of operation	1	LAD was only a fibrous band

Perioperative Mortality and Complications

Early postoperative mortality was 0.8% (15 patients with a mean predicted mortality of 19.8%) and compared favorably to the preoperatively calculated logistic euroSCORE of 3.8%.

Seven patients (0.4%) suffered permanent stroke, and 54 patients (3.0%) underwent re-thoracotomy due to hematothorax or excessive bleeding. In all of these cases, the source could be identified and fixed, in 50 cases through the original minithoracotomy. Four patients needed a sternotomy. Other severe complications, which impaired recovery and prolonged hospital stay, were perioperative MI (8 patients = 0.5%), necessity for use of intraaortic balloon pump (IABP)/extracorporeal membrane oxygenation (ECMO) (12 patients = 0.7%), acute renal failure (17 patients = 0.9%), respiratory failure/pneumonia with prolonged artificial respiration (32 patients = 1.8%), and sepsis (3 patients = 0.2%). A summary of the postoperative complications is given in Table 3.

Table 3. Postoperative Complications

Early postoperative death	15 (0.8%)
Stroke	7 (0.4%)
Cerebral hemorrhage	1 (0.1%)
Transient ischemic attack/prolonged reversible ischemic neurologic deficit (TIA/PRIND)	6 (0.3%)
Symptomatic transitory psychotic syndrome	19 (1.1%)
Rethoracotomy (sternotomy) for bleeding	4 (0.2%)
Rethoracotomy (lateral minithoracotomy) for bleeding	50 (2.8%)
Bleeding >1000 mL without reoperation	85 (4.8%)
Low cardiac output (LCO): prolonged catecholamines	14 (0.8%)
LCO: intraaortic balloon pump necessary	12 (0.7%)
LCO: extracorporeal membrane oxygenation necessary	2 (0.1%)
Postoperative myocardial infarction	8 (0.5%)
Unstable angina	2 (0.1%)
Reoperation for pericardial effusion	2 (0.1%)
Postoperative new atrial fibrillation	145 (8.2%)
Bradycardia with necessity for pacemaker implantation	10 (0.6%)
Prolonged articifial ventilation (>24 h)	32 (1.8%)
Reintubation	11 (0.6%)
Pneumonia	14 (0.8%)
Pneumothorax	43 (2.4%)
Extrapleural thoracal hematoma	6 (0.3%)
Pleural effusion	145 (8.2%)
Tracheotomy	2 (0.1%)
Left sided paralysis of diaphragm	5 (0.3%)
Acute renal dysfunction, necessity of temporary dialysis	12 (0.7%)
Pulmonary embolism	3 (0.2%)
Sepsis	3 (0.2%)
Intestinal ischemia	1 (0.1%)
Wound infection	27 (1.5%)
Delayed mobilization >14 d	6 (0.3%)

Follow-Up and Long-Term Survival

Follow-up coronary angiogram at 6 months was available from 372 patients (21%), of whom 53 had suspected ischemia. In these 372 patients, a patency rate of 93.3% (347 patients) was found. Three hundred twenty-eight patients (88.2%) were graded Fitzgibbon A, 19 patients (5.1%) Fitzgibbon B, and 10 patients (2.7%) had total occlusion of the graft.

Follow-up sums up to 11,467 patient years. We recorded 321 deaths, 43 for cardiac, 52 for non-cardiac, and 226 for unknown reasons. Furthermore, 62 (3.5%) patients sustained MI, 19 needed re-intervention of the target vessel (LAD), and 6 patients underwent other redo cardiac surgery. A total of 127 patients complained of recurrent angina at the time of the last follow-up. Seven patients were admitted back to our institution for pleural hernia of the mini-thoracotomy, and 5 others were readmitted for purulent wound infection. The first were treated with reoperation, and the latter with intravenous antibiotics and secondary wound healing without further problems.

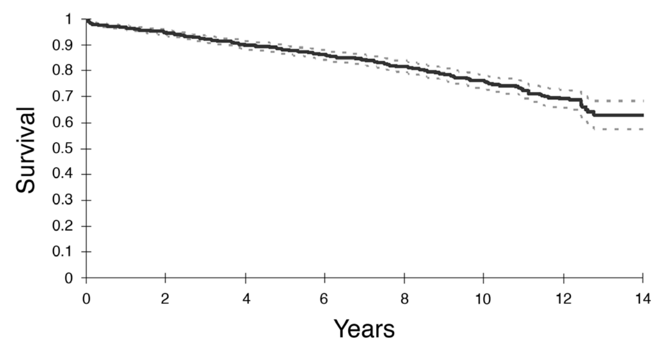

Figure 1. Postoperative long-term survival (Kaplan–Meier curves and 95% confidence interval).

Altogether, the 5-year-survival as calculated with Kaplan–Meier analysis (Figure 1) was 88.3% (95% confidence interval [CI], 86.6% to 89.9%), and the 10-year survival was 76.6% (95% CI, 73.5% to 78.7%). The survival free from any MACCE and angina after 5 and 10 years was 85.3% (95% CI, 83.5% to 87.1%) and 70.9% (95% CI, 68.1% to 73.7%), respectively (Figure 2).

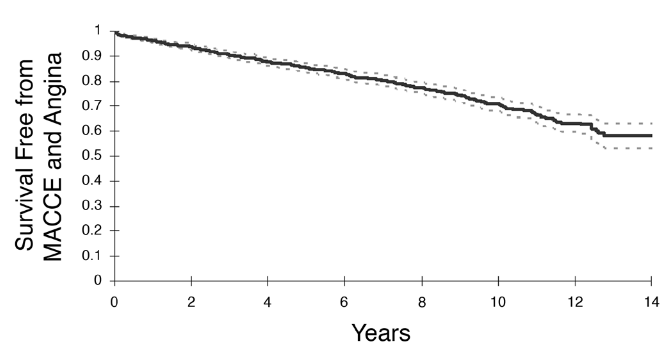

Figure 2. Freedom from major adverse cardiac and cerebrovascular events (MACCE) and angina (Kaplan–Meier curves and 95% confidence interval).

Multivariate Risk Factor Analysis

The results of univariate Cox regression analysis calculating the influence of patient risk factors on long-term outcome are depicted in Figure 3 (survival) and Figure 4 (MACCE).

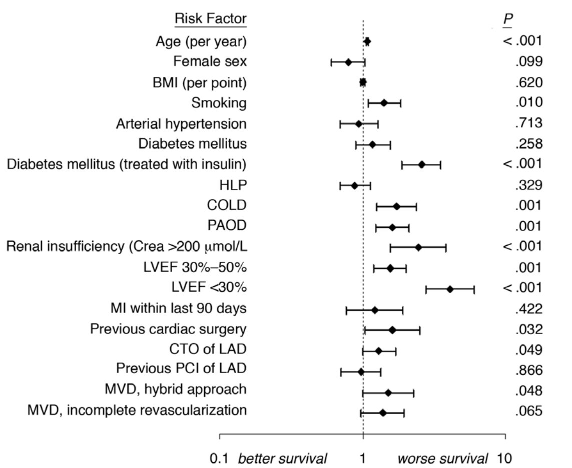

Figure 3. Results of the univariate risk factor analysis for long-term survival. BMI indicates body mass index; HLP, hyperlipoproteinaemia; COLD, chronic obstructive lung disease; PAOD, peripheral artery occlusive disease; Crea, serum creatinine level; LVEF, left ventricular ejection fraction; MI, myocardial infarction; CTO, chronic total occlusion; LAD, left anterior descending coronary artery; PCI, percutaneous coronary intervention; MVD, multivessel coronary disease.

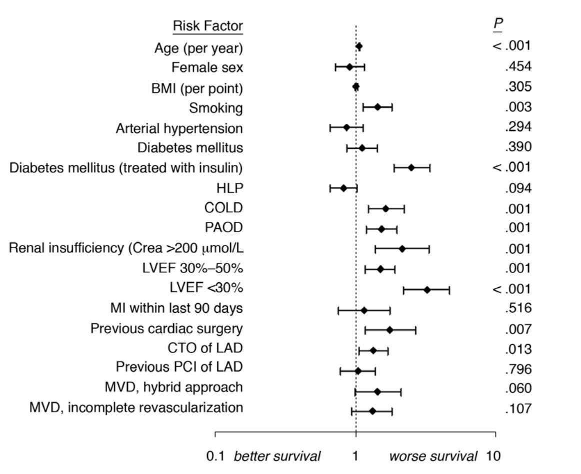

Figure 4. Results of the univariate risk factor analysis for occurrence of major adverse cardiac and cerebrovascular events (MACCE) during follow-up. BMI indicates body mass index; HLP, hyperlipoproteinaemia; COLD, chronic obstructive lung disease; PAOD, peripheral artery occlusive disease; Crea, serum creatinine level; LVEF, left ventricular ejection fraction; MI, myocardial infarction; CTO, chronic total occlusion; LAD, left anterior descending coronary artery; PCI, percutaneous coronary intervention; MVD, multivessel coronary disease.

After multivariate testing, the following factors were revealed to have a significant influence on survival: age (odds ratio [OR], 1.081/year; 95% CI, 1.067 to 1.096/year; $P < .001$), smoking (OR, 1.463; 95% CI, 1.126 to 1.902; $P = .004$), insulin-treated diabetes mellitus (OR, 2.468; 95% CI, 1.821 to 3.344; $P < .001$), COLD (OR, 1.756; 95% CI, 1.283 to 2.403; $P < .001$), PAOD (OR, 1.664; 95% CI, 1.268 to 2.183; $P < .001$), renal insufficiency indicated by a preoperative serum creatinine level > 200 μmol/L (OR, 2.374; 95% CI, 1.547 to 3.642; $P < .001$), left ventricular ejection fraction (LVEF) between 30% and 50% (OR, 1.652; 95% CI, 1.274 to 2.142; $P < .001$), LVEF lower than 30% (OR, 4.648; 95% CI, 3.166 to 6.822; $P < .001$), and previous cardiac operation (OR, 1.723; 95% CI, 1.127 to 2.633; $P = .012$).

Almost the same risk factors were a predictor for higher occurrence of MACCE after surgery: age (OR, 1.067/year; 95% CI, 1.055 to 1.080/year; $P < .001$), smoking (OR, 1.434; 95% CI, 1.133 to 1.816; $P = .003$), insulin-treated diabetes mellitus (OR, 2.485; 95% CI, 1.876 to 3.292; $P < .001$), COLD (OR, 1.640; 95% CI, 1.222 to 2.201; $P = .001$), PAOD (OR, 1.533; 95% CI, 1.191 to 1.971; $P = .001$), renal insufficiency (OR, 2.247; 95% CI, 1.469 to 3.438; $P < .001$), LVEF between 30% and 50% (OR, 1.553; 95% CI, 1.225 to 1.967; $P < .001$), LVEF lower than 30% (OR, 3.313; 95% CI, 2.281 to 4.812; $P < .001$), and previous cardiac operation (OR, 1.785; 95% CI, 1.197 to 2.662; $P = .004$). Additionally, preoperative chronic total occlusion of the LAD turned out to be a significant risk factor for MACCE in the follow-up period (OR, 1.362; 95% CI, 1.078 to 1.721; $P = .009$).

DISCUSSION

MIDCAB is one of several alternatives for revascularization of the anterior wall. It is a challenging surgical alternative and has a substantial learning curve [Holzhey 2007b]. On the other hand, it is minimally invasive and is therefore oftentimes compared directly to PCI of the LAD. In this context, it is important to have solid short- and long-term data to show its significance for the treatment of coronary artery disease.

Our study shows that MIDCAB is a safe and efficient procedure for patients with single vessel disease and selected patients with multivessel disease. It is associated with an acceptable conversion rate, a low complication rate, and good long-term results. These findings are consistent with previous studies [Calafiore 1998; Diegeler 1999; Biglioli 2000; Mehran 2000; Kettering 2004]. The perioperative mortality of 0.8% compares favorably to the 2.6% mortality for both off-pump and on-pump single bypass grafting as reported in the registry of the German Society for Thoracic and Cardiovascular Surgery in 2009 [Gummert 2010]. A comparison with the results of single vessel on- or off-pump revascularization of the LAD within our center is not useful, because hardly any such operations have been performed since the introduction of MIDCAB. Historic data of single vessel LIMA to LAD grafting performed on-pump reveal a mortality of 0.0% to 1.8% [Goy 1994; O'Keefe 1999].

In a comprehensive metaanalysis of the perioperative outcome and midterm results of MIDCAB grafting, Kettering et al have summarized the results of 17 studies [Kettering 2004]. The results of our study are in line with the reported results of other groups reporting complication rates of early mortality (1.3%), perioperative infarction rates (0,8%), conversion rate to sternotomy/CPB (1.8%), short-term reintervention on target vessel (up to 8.9%), and overall perioperative complication rate (1.6% to 40%). Postoperative angiographic patency rates between 94% and 99% are also concordant with our results.

Several recent publications focus on mid-term and long-term results. Al-Ruzzeh et al reported excellent mid-term general health perception and quality of life even compared to an age-matched group of healthy British people and great satisfaction with the procedure [Al-Ruzzeh 2004]. In a comparison of MIDCAB to OPCAB LIMA–LAD bypass grafting, Vicol found a slightly lower rate of mid-term adverse cardiac events in the OPCAB group and concluded that MIDCAB should only be performed by experienced surgeons [Vicol 2003]. Further long-term surveillances of MIDCAB patients come to similar conclusions and results as our study: Zimarino describes a 5-year adverse event rate of 12% [Zimarino 2004], and Fraund found a long-term mortality of 6.8% and a MACCE rate of 9.7% in an average follow-up period of 3.4 ± 0.7 years [Fraund 2005].

Jegaden et al compared 3 minimally invasive techniques for single LAD grafting: port-access surgery, minimally invasive direct CABG (MIDCAB), and off-pump TECAB. They concluded that MIDCAB is associated with a lower rate of early bypass failure and re-intervention and is more cost effective [Jegaden 2011].

The MIDCAB operation remains more challenging than conventional CABG and is more costly than bare metal stenting. Despite the long-term availability of bare metal stents, long-term data are sparse [Zimarino 2004; Sellke 2005] and rarely exceed the first post-interventional year. Besides low peri-procedural mortality, infarction, and complication rate, most of the current studies outline the problem of early stent stenosis and a high re-intervention rate during the first 6 months. This eventually equals the initial cost savings of the procedure [Thiele 2005]. Patency rates at 6 months are reported at 71% with only few further stenoses of the target vessel after that time. In a 5-year follow-up of a prospective trial, Goy reports a higher rate of myocardial infarction (15% versus 4%; P = .0001), additional revascularization (38% versus 9%; P = .0001), and lower freedom from events (62% versus 91%; P = .0001) in the PTCA group as compared to conventional on-pump LIMA–LAD bypass surgery [Goy 1999]. In a 5-year follow-up of a randomized trial with stenting versus bypass operation for multivessel disease, Serruys reported a significantly lower re-intervention rate in the bypass group with no significant differences in mortality or other MACCE [Aoki 2005; Serruys 2005].

Aziz and colleagues reported in another metaanalysis of 12 studies with a total of 1952 patients [Aziz 2007] that MIDCAB for isolated lesions of the left anterior descending artery was associated with fewer mid-term complications than PCI. Focusing on the randomized trials in this analysis, a higher rate of recurrence of angina (OR, 2.62; 95% CI, 1.32 to 5.21), incidence of major adverse coronary and cerebral events (OR, 2.86; 95% CI, 1.62 to 5.08), and need for repeat revascularisation (OR, 4.63; 95% CI, 2.52 to 8.51) with percutaneous stenting was shown. No significant difference was found in myocardial infarction, stroke, or mortality at maximum follow-up between interventions.

In another analysis comparing 9 randomized controlled trials including 1210 patients undergoing MIDCAB or PCI (one trial using drug-eluting stents), Kapoor and colleagues found no differences in survival at 30 days, 1 year, or 5 years, nor were there differences in the rates of procedural strokes or myocardial infarctions, whereas the rate of repeat revascularization was significantly less after CABG than after PCI (at 1 year, 7.3% versus 19.5%; at 5 years, 7.3% versus 33.5%). Freedom from recurrent angina was significantly greater after CABG than after PCI (at 1 year, 95.5% versus 84.6%; at 5 years, 84.2% versus 75.6%) [Kapoor 2008].

Hueb and colleagues compared the 10-year follow-up after PCI, CABG, and medical treatment in patients with multivessel coronary artery disease, stable angina, and preserved ventricular function. Compared with CABG, medical treatment was associated with a significantly higher incidence of subsequent MI, a higher rate of additional revascularization, a higher incidence of cardiac death, and consequently a 2.29-fold increased risk of combined events. PCI was associated with an increased need for further revascularization, a higher incidence of MI, and a 1.46-fold increased risk of combined events compared with CABG. Additionally, CABG was better than medical treatment at eliminating anginal symptoms [Hueb 2010].

The described benefits are most likely less prominent with the extended use of drug-eluting stents while the perioperative risks of the surgical procedure remain [Hravnak 2001; Brambilla 2005]. In one randomized controlled trial, PCI with sirolimus-eluting stents in isolated proximal LAD disease was non-inferior to MIDCAB surgery at 12-month follow-up with respect to MACCE at a similar relief in clinical symptoms [Thiele 2009]. However, the long-term superiority of these stents remains still to be proven, and they, as opposed to surgical revascularization, will be lesion dependent.

In the light of these considerations, it is has to be stressed that the quality of the MIDCAB procedure can only remain high when performed in centers with case loads adequate to allow surgeons to continuously sustain their skill level [Okawa 2000; Vicol 2003; Holzhey 2007b]. Under these circumstances, MIDCAB is a true alternative to conventional surgery. Even if the equivalence of stenting in the long-term outcome will turn out to be true, there are still a number of indications, such as repeated in-stent stenosis, chronic occlusion of the LAD [Holzhey 2010], or lesions not suitable for stenting for anatomic reasons (complex type C stenosis or small vessels), where the MIDCAB operation will remain a good alternative.

CONCLUSION

MIDCAB is a safe operation with low postoperative mortality and morbidity. With excellent short- and long-term results, it is a very good alternative compared to both PCI and conventional surgery.

LIMITATIONS OF THE STUDY

The study is retrospective in nature and is therefore subject to the inherent weaknesses of a retrospective analysis. The analysis describes the experience of a single center. Therefore the results cannot be generalized without caution. On the other hand, patient selection, surgical technique, and postoperative care have been basically the same for all these patients, which yields homogeneous conditions for the study. The loss to follow-up of a number of patients is a further drawback and is explained in part by a lack of cooperation and by the fact that many patients were external referrals from remote centers.

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