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Early and long-term results of minimally invasive coronary artery bypass grafting in elderly patients

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Abstract

Background: Standard (conventional) coronary artery bypass grafting (CABG) is an invasive procedure which requires full median sternotomy and is performed with extracorporeal circulation (ECC), which can lead to serious complications.

Aim: To analyse the results of minimally invasive CABG (MIDCAB) in elderly patients.

Methods: Between 1999 and 2007, a total of 698 MIDCAB procedures were performed at our institution. We present the data on 235 elderly (≥ 70 years) patients (160 males, mean age 74.5 ± 3.2 years, range: 70–83 years) who were consecutively operated on in this period. Early mortality, post-operative complications, long-term survival, impact of multivessel disease (MVD) and hybrid coronary artery revascularisation on total mortality were analysed. Logistic EuroSCORE was 8.7%. The survival of 235 elderly patients was compared to the survival of the remaining 463 MIDCAB patients aged < 70 years (including risk factors for total mortality).

Results: The 30-day mortality was 2.5% (six patients). During follow-up, two patients underwent coronary reoperation and percutaneous coronary intervention (PCI) was performed in 16 patients. Kaplan-Meier analysis revealed a 1.5-year survival of 89.8% (95% CI 85.9–93.7%) and five-year survival of 79.7% (95% CI 74.3–85%). Compared to single vessel disease (SVD) patients, the MVD patients had significantly higher total mortality ($p = 0.0038$). Our study revealed MVD ($p = 0.0016$) and male sex ($p = 0.0091$) as important independent factors of total mortality in this group of elderly patients. The difference in total mortality between non-hybrid *vs* hybrid MIDCABs was not significant ($p = 0.63$). The younger MIDCAB patients (< 70 years) have a tendency to better survival, but the difference did not achieve statistical significance ($p = 0.088$). They had the same independent factors of total mortality as in the elderly group: MVD ($p = 0.0001$) and male sex ($p = 0.0059$).

Conclusions: The MIDCAB is a reasonable option for elderly patients with SVD, and in selected patients with MVD. The decision to perform MIDCAB rather than PCI in these high risk patients should always be very carefully considered in conjunction with the interventional cardiologist.

Key words: coronary artery disease, MIDCAB, elderly patients

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INTRODUCTION

Coronary artery bypass grafting (CABG) is the treatment of choice for selected patients with coronary artery disease (CAD) and its effectiveness has been confirmed by many randomised trials [1, 2]. Standard (conventional) CABG is an invasive procedure which requires full median sternotomy and is performed using extracorporeal circulation (ECC). Wide exposure through the sternum is necessary in the majority of pa-

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tients, but it is painful and in some patients can lead to serious complications e.g. osteomyelitis and mediastinitis. Contact between the blood and the tubing system and oxygenator in ECC activates blood cells, coagulation cascade, and other factors. Systemic inflammatory response syndrome can induce multiorgan failure. Activation of coagulation cascade increases the risk of bleeding, while aggregation of the blood platelets with subsequent thrombus formation can lead to cerebral and systemic microembolism. With off-pump coronary artery bypass (OPCAB), most of these complications can be reduced or avoided, and it is considered to be a less invasive procedure.

Another step in surgical coronary revascularisation toward a less invasive procedure is known as minimally invasive CABG (MIDCAB). Since its introduction in the mid-1990s, it has been widely used [3, 4]. The principle of this procedure is revascularisation of the left anterior descending coronary artery (LAD) using the left internal mammary artery (LIMA) on the beating heart via a left minithoracotomy. This technique combines the advantages of an off-pump procedure with reduced surgical trauma and wound complications. This minimally invasive procedure also provides the excellent long-term patency of a LIMA graft [5–7]. In some centres, MIDCAB is the preferred method of surgical revascularisation for isolated involvement of the LAD. In addition, MIDCAB is a valuable alternative to standard CABG in selected high-risk patients with multivessel disease (MVD) and extensive comorbidity, who are at a high risk for sternotomy and ECC-related complications.

The aim of our study was to analyse early and late post-operative results of the MIDCAB procedure in a group of elderly patients (≥ 70 years) and define the independent risk factors of mortality.

METHODS

Study population

Between 1999 and 2007, a total of 698 MIDCAB procedures were performed at our institution. We present the data on 235 elderly patients (aged ≥ 70 years) who were consecutively operated on in this period. The LAD was considered to be responsible for ischaemia or was an infarct-related artery. Conservative treatment or percutaneous coronary intervention (PCI) of the LAD was unacceptable, or more hazardous than surgical revascularisation in each patient scheduled for surgery. All data were prospectively collected in the National Registry of Cardiac Surgery and in both the Local and the National Interventional Registry. The closing date for follow-up (range: 18–120 months) for this report was 30 June, 2009. The mean age was 74.5 ± 3.2 years (range: 70–83 years), and 160 of the 235 were males. Preoperative data are summarised in Table 1. The predicted mortality calculated by logistic EuroSCORE was 8.7%.

Early mortality, post-operative complications, long-term survival, impact of MVD *vs* single vessel disease (SVD) and impact of hybrid *vs* non-hybrid coronary artery revascularisation on total mortality were analysed. The number of patients who underwent cardiac reoperation (completed in 100% of patients) and PCI (completed in 91.5% of patients) during follow-up were added. The survival of 235 elderly patients was compared to the survival of the remaining 463 MIDCAB patients aged < 70 years.

Table 1. Pre-operative data in the set of 235 patients

Diabetes mellitus	87 (37.0%)
Hypertension	193 (82.1%)
Smoking	119 (50.6%)
Atrial fibrillation	31 (13.2%)
Renal failure	0 (0%)
Previous cardiac operation:	
Coronary surgery	1 (0.4%)
Valve surgery	1 (0.4%)
Others	9 (3.8%)
Dyslipidaemia	152 (64.7%)
Peripheral arterial occlusive disease	87 (37.0%)
Previous myocardial infarction	158 (67.2%)
Cerebrovascular accident	26 (11.1%)
Chronic obstructive pulmonary disease	53 (22.6%)
Previous percutaneous coronary intervention	49 (20.9%)
1-vessel disease	74 (31.4%)
2-vessel disease	70 (29.8%)
3-vessel disease	91 (38.8%)
Left ventricular ejection fraction [%]	54.3 ± 13.7
Creatinine [mmol/L]	106 ± 32.8

The SVD with isolated involvement of LAD was present in 74 (31%) patients whereas 161 patients had MVD (70 [30%] patients had double-vessel disease and 91 [39%] patients had triple-vessel disease). Incomplete revascularisation was accepted in 144 MVD patients. The reasons for incomplete revascularisation were as follows: not significant stenosis of other coronary arteries; small vessel diseases (< 1 mm) where LAD was the only target artery eligible for revascularisation; and palliative incomplete revascularisation in high risk patients who were not candidates for ECC and/or sternotomy. Seventeen patients with MVD were scheduled for a hybrid procedure. The PCI of vessels other than the LAD was performed preoperatively in 15 patients and post-operatively in two patients. Data are summarised in Table 2. The decision to perform only palliative or hybrid MIDCAB procedure was made preoperatively by the heart team (cardiac surgeon and cardiologist).

Definitions

The criteria for periprocedural myocardial infarction (MI) were: a new onset of Q waves or elevation of cardiac enzymes (creatinine kinase [CK] peak-levels and MB fraction) accompa-

Table 2. Targets of percutaneous coronary intervention (PCI) — hybrid procedure

Target	PCI	
	Preoperative	Post-operative
Left main	0	0
Circumflex artery	7	1
Right coronary artery	8	1

nied by an elevation of ST segments in electrocardiographic examinations (ECG). A CK rise more than double above the normal upper range without a new Q wave on the ECG was considered a non-Q wave MI.

Surgical technique

The MIDCAB technique has been described in detail elsewhere. Briefly, all operations were performed under general anaesthesia with standard haemodynamic monitoring. A left anterior minithoracotomy was made in the fourth or fifth intercostal space (the length of the incision was 8–12 cm). The LIMA was harvested under direct vision as either a pedicled or skeletonised conduit. The patients were heparinised; the activated clotting time was kept at 300 s throughout the operation and was neutralised incompletely with a half dose of protamine after completion of the anastomosis. Once the suitable place for the anastomosis on the LAD had been identified, and its surrounding myocardium had been stabilised with a pressure stabiliser (CardioThoracic System, Inc, Cupertino, CA, USA), a mammarocoronary anastomosis followed with continuous 7–0 polyprolylene suture (Prolen, Visiblack, Ethicon). Good visibility was achieved with the carbon dioxide blower, silicon tourniquets and, in some instances, with intracoronary shunts. The open left pleural cavity was drained in all patients and the chest wall sutured in layers. To prevent chest pain after the operation, an intercostal nerve blockade was completed with 0.5% bupivacaine hydrochloride infiltration.

Statistical analysis

Statistical analysis was performed using the NCSS® 6 software at the 5% statistical significance level. The results are presented as mean ± SD or numbers and percentages. The cumulative survival rate was described using Kaplan-Meier estimate, and the comparison between groups using log-rank test. Multivariate Cox regression analysis served to examine baseline characteristics to identify independent risk factors for mortality among the patient populations (MVD and SVD). The model included age, sex, number of diseased vessels and involvement of the left main (LM).

Table 3. Percutaneous coronary reintervention (PCI) during follow-up

PCI*	SVD	MVD non-hybrid	MVD hybrid
No intervention	59	125	14
Direct/elective	0/7	2/5	1/2
RCA	3	3	0
RCx	3	1	1
LAD	0	4	1
LIMA	1	0	1

*Follow-up was completed in 215 (91.4%) patients; SVD — single vessel disease; MVD — multivessel disease; RCA — right coronary artery; RCx — circumflex artery; LAD — left anterior descending artery; LIMA — left internal mammary artery

RESULTS

Early mortality and complications

Six (2.55%) patients died within 30 days. Duration of intubation was 13.6 ± 39.5 hours and length of stay in intensive care unit — 41.5 ± 55.7 hours. Perioperative MI in LAD territory was diagnosed in four (1.7%) patients. Post-operative atrial fibrillation (AF) was observed in 50 (21%) patients. Seven (2.9%) patients developed renal failure with the need for dialysis. Post-operative pulmonary complications were found in 16 (6.8%) patients. Major or minor stroke occurred in six (2.5%) patients. All of them had complete recovery during the follow-up. Wound complications were documented in three (1.27%) patients.

Follow-up and long-term survival

Two patients had coronary reoperations and one patient had a non-coronary cardiac reoperation during follow-up. The PCI was performed in 16 patients; of these, five required reintervention on the target vessel (LAD). The PCI data are summarised in Table 3.

The Kaplan-Meier analysis revealed a 1.5-year survival of 89.8% (95% CI 85.9–93.7%) and a five-year survival of 79.7% (95% CI 74.3–85%). There was significantly higher total mortality in patients with MVD compared to SVD (Kaplan-Meier rates 27.3% [44 patients] *vs* 9.5% [7 patients]; Fig. 1). The difference in total mortality between non-hybrid *vs* hybrid MIDCABs was not significant (Kaplan-Meier rates 28.5% [41 patients] *vs* 17.6% [3 patients]; Fig. 2). A multivariate Cox regression analysis revealed MVD (RR = 3.1, 95% CI 1.4––6.89%, p = 0.0016) and male sex (RR = 2.4, 95% CI 1.17––4.94, p = 0.0091) as important independent factors of total mortality in this group of elderly patients.

The younger MIDCAB patients (< 70 years) had a tendency to better survival, however the difference did not achie-

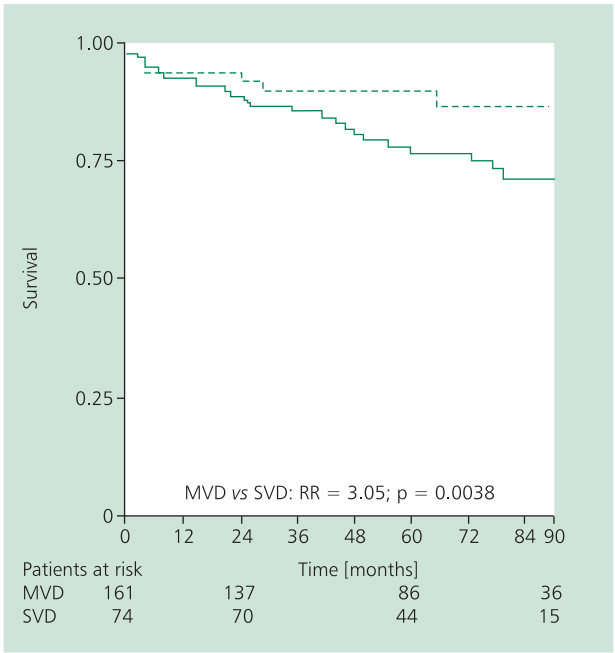

Figure 1. Cumulative survival of patients ≥ 70 years after minimally invasive direct coronary artery bypass according to the presence or absence of multivessel disease (MVD). Solid line represents MVD patients and dotted line represents single vessel disease (SVD) patients; RR — relative risk

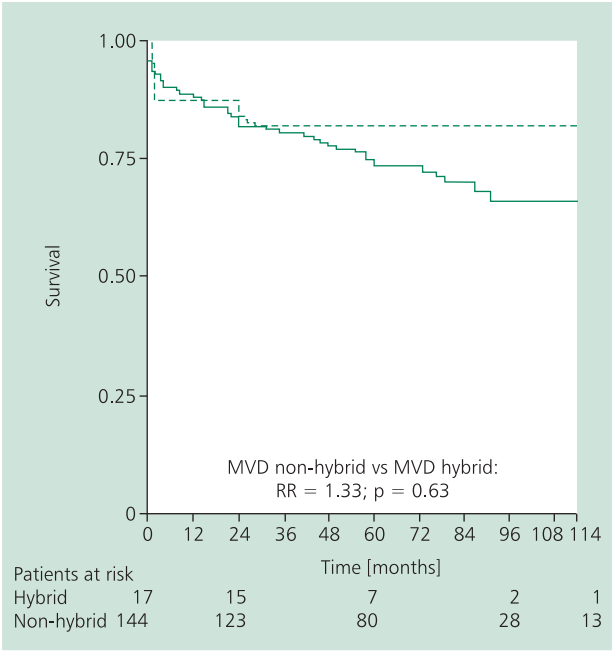

Figure 2. Cumulative survival of multivessel disease (MVD) patients after hybrid *vs* non-hybrid minimally invasive direct coronary artery bypass. Solid line represents non-hybrid patients and dotted line represents hybrid patients; RR — relative risk

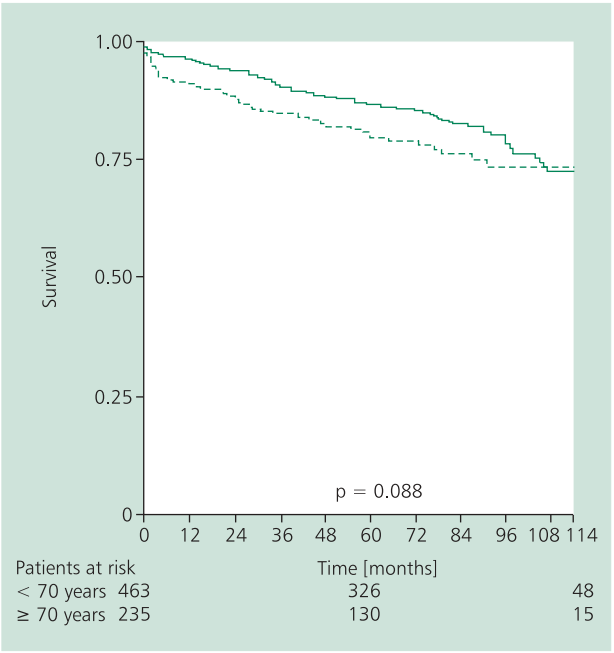

Figure 3. Cumulative survival of patients < 70 years (solid line) and ≥ 70 years (dotted line)

ve significance (Fig. 3). There were the same independent factors of total mortality as in the elderly group: MVD (RR = 2.1, 95% CI 1.5–3.0, p = 0.0001) and male sex (RR = 1.9, 95% CI 1.2–3.1, p = 0.0059).

DISCUSSION

Elderly patients with CAD have a higher operative risk and, therefore, may benefit from a less invasive procedure. We have presumed that this is also valid for MIDCAB [8]. Because we have experience of more than 900 MIDCAB procedures, we decided to analyse our prospectively collected data for MIDCAB patients. The aim was to examine the early and long-term mortality of elderly patients with MIDCAB and to identify the risk factors of adverse cardiac events and mortality. Although many authors presented MIDCAB results, none of these studies have primarily focused on elderly patients.

Holzhey et al. [9] found very low early mortality (0.8%) in a group of 1,347 patients. The mean age was 63 years and predicted mortality was 3.6%. Similar results with virtually zero early mortality have been published by Diegeler et al. [10], but the mean age in their series was even lower than that in the Holzhey et al. [9] report. Doty et al. [11] published the results of 162 MIDCAB patients. The mean age and early mortality was 64 years and 4.9%. Interestingly, in that study, all early deaths were restricted to patients older than 70 years. In the other published MIDCAB series, early mortality ranged from 0 to 4.9% [12].

Early mortality in our cohort was 2.5%. In comparison with the predicted mortality calculated by EuroSCORE (8.7%),

this result seems satisfactory. Although the mean age of 74.5 ± ± 3.2 years in our patients is much higher than in other published series, the early mortality is comparable.

Early morbidity in our elderly patients was similar to reported complications rate from other series. Perioperative MI was diagnosed in four patients. All these patients were ≥ 76 years of age. Older patients have generally more advanced coronary atherosclerosis and therefore a higher risk of MI. The incidence of perioperative MI in other published MIDCAB cohorts ranged from 0 to 3.9% [12, 13], but the mean age in these series was lower.

The occurrence of post-operative AF is another important issue. Nabuchi et al. [14] reported the incidence of AF as being 16% after MIDCAB (mean age 67 years). Nakamura et al. [15] reported the rate of AF after OPCAB as being up to 40% in patients older than 75 years, but only 20% in younger patients (mean age 63 years). Compared with other studies, the rate of post-operative AF in our group of elderly patients (21%) was relatively low. The rate of other complications in our cohort (wound complications, pulmonary complications, post-operative stroke and so on) was similar to reported results of other groups.

Our results partially confirmed that the MIDCAB procedure in patients with MVD is associated with poorer intermediate or long-term outcomes, compared to SVD patients [16]. The MVD patients had significantly higher total mortality compared to SVD patients. The proportion of MVD patients in our study population was much higher (nearly 69%) than in other studies. For example, in the MIDCAB series published by Lichtenberg et al. [16] only 36% of the patients had MVD, but this MVD proportion is still higher when compared to other MIDCAB studies. The explanation for the unusual proportion of MVD *vs* SVD in our cohort is the advanced age which is associated with more advanced and diffuse coronary atherosclerosis. In most of our patients, the indications for MIDCAB were considered as a palliative treatment in high risk patients with MVD rather than complete revascularisation in patients with SVD. Despite that, overall long-term mortality in our study population was favourable. Holzhey et al. [9] published the long-term results of 1,347 patients after MIDCAB. This study from Leipzig, Germany, is the biggest published MIDCAB series in the world. Five-year survival was 91%, but again predicted mortality was much lower than in our study, and mean age of the patients was 62 years. It is logical that younger patients have better long-term outcomes than elderly patients. This further demonstrates that the MIDCAB procedure is a valuable solution for elderly and high-risk patients.

CONCLUSIONS

The MIDCAB is a reasonable option for elderly patients with SVD, and selected patients with MVD. The decision to perform MIDCAB rather than PCI in these high risk patients should always be very carefully considered and consulted with interventional cardiologist.

Conflict of interest: *none declared*

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Wczesne i odległe wyniki małoinwazyjnego pomostowania tętnic wieńcowych u osób starszych

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Streszczenie

Wstęp: Pomostowanie tętnic wieńcowych (CABG) jest leczeniem z wyboru w wybranych grupach osób z chorobą wieńcową. Standardowe CABG jest inwazyjną procedurą wymagającą sternotomii i krążenia pozaustrojowego, co wiąże się z ryzykiem wystąpienia powikłań. Małoinwazyjne CABG (MIDCAB) polegające na rewaskularyzacji gałęzi przedniej zstępującej lewej tętnicy wieńcowej z użyciem lewej tętnicy piersiowej wewnętrznej, poprzez lewostronną minitorakotomię i bez użycia krążenia pozaustrojowego, jest procedurą pozwalającą na ograniczenie powikłań CABG.

Cel: Celem pracy była ocena wyników MIDCAB u osób starszych (≥ 70 lat).

Metody: W latach 1999–2007 w ośrodku autorów pracy przeprowadzono 698 procedur MIDCAB. Badaniem objęto grupę kolejnych 235 chorych w wieku ≥ 70 lat (160 mężczyzn, średnia wieku 74,5 ± 3,2 roku, zakres 70–83) operowanych w tym okresie. Analizowano wczesną śmiertelność, powikłania pooperacyjne, przeżycie długoterminowe i wpływ wielonaczyniowej choroby wieńcowej (MVD) oraz hybrydowej rewaskularyzacji na przeżycie odległe w grupie 235 chorych w wieku ≥ 70 lat i u 463 pozostałych osób. Przewidywana wczesna śmiertelność według EuroSCORE wynosiła 8,7%.

Wyniki: Śmiertelność 30-dniowa w badanej grupie starszych chorych wyniosła 2,55% (zmarło 6 osób). W okresie obserwacji odległej 2 pacjentów przebyło reoperację w zakresie tętnic wieńcowych, a u 16 wykonano przezskórną interwencję wieńcową (PCI). Analiza za pomocą krzywych Kaplana-Meiera ujawniła 1,5-roczną i 5-letnią przeżywalność wynoszącą odpowiednio 89,8% (95% CI 85,9–93,7%) i 79,7% (95% CI 74,3–85%). W porównaniu z osobami z jednonaczyniową chorobą wieńcową (SVD) w grupie pacjentów z MVD zanotowano wyższą całkowitą śmiertelność ($p = 0,0038$). Wykazano, że MVD ($p = 0,0016$) i płeć męska ($p = 0,0091$) są niezależnymi czynnikami ryzyka zgonu w badanej populacji osób starszych. Różnica w śmiertelności w grupie chorych poddanych niehybrydowemu i hybrydowemu MIDCAB była nieistotna statystycznie ($p = 0,63$). W grupie chorych < 70. roku życia poddanych MIDCAB zaobserwowano nieistotną statystycznie ($p = 0,088$) tendencję do mniejszej śmiertelności. U tych pacjentów stwierdzono, podobnie jak w grupie chorych starszych, że niezależnymi czynnikami ryzyka zgonu są MVD ($p = 0,0001$) i płeć męska ($p = 0,0059$).

Wnioski: Na podstawie uzyskanych wyników można stwierdzić, że MIDCAB jest odpowiednim wyborem w przypadku osób starszych z SVD i wybranych chorych z MVD. Decyzja co do rodzaju zabiegu rewaskularyzacyjnego (MIDCAB czy PCI) w tej obarczonej dużym ryzykiem grupie pacjentów powinna być podjęta wspólnie przez kardiochirurga i kardiologa inwazyjnego.

Słowa kluczowe: choroba wieńcowa, MIDCAB, chorzy starsi

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