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Comparison of MIDCAB Versus Conventional CABG Surgery Regarding Pain and Quality of Life

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ABSTRACT

Background: This prospective clinical trial focuses on pain and quality of life (QOL) after minimally invasive direct coronary artery bypass (MIDCAB) grafting versus conventional coronary artery bypass grafting (CABG).

Methods: Group A consisted of 65 consecutive MIDCAB patients using an anterolateral mini-thoracotomy and the "off-pump" technique. Group B consisted of 95 computer-matched patients who underwent conventional CABG with cardiopulmonary bypass (CPB). Pain was graduated using the visual analog scale (VAS), and the verbal rating scale (VRS) [Troidl 1990]. QOL was evaluated at the time of discharge and three months after surgery using modified Nottingham Health Questionnaires that separate physical, social, activity, emotional, pain, and sleeping conditions.

Results: Postoperative pain was higher after MIDCAB on postoperative day (POD) 1 ($p < 0.002$). From POD 4 onwards MIDCAB patients had less pain compared with the conventional group ($p < 0.04$). MIDCAB patients required less pain medication from POD 4 onwards ($p < 0.05$). QOL was significantly better in the MIDCAB group on POD 7 for physical ($p < 0.038$), activity ($p < 0.016$), pain ($p < 0.041$), and sleep ($p < 0.038$) conditions. The three-month questionnaire showed significantly better levels for MIDCAB patients regarding physical ($p < 0.03$) and pain ($p < 0.001$) conditions, and a trend for activity ($p < 0.08$) and emotional ($p < 0.08$) conditions.

Conclusions: Compared to patients undergoing conventional surgery, MIDCAB patients suffer more pain in the first three postoperative days, probably as a result of the lateral thoracotomy. From POD 4 onwards, MIDCAB patients are significantly better, experiencing less pain and showing better physical, activity, and sleeping conditions even three months after surgery. This can be attributed to the absence of median sternotomy and/or the avoidance of cardiopulmonary bypass.

INTRODUCTION

Minimally Invasive Direct Coronary Bypass (MIDCAB) is the first of a new generation of surgical approaches designed to reduce the trauma and invasiveness of traditional coronary artery bypass surgery [Robinson 1995, Subramanian 1995, Diegeler 1997]. Smaller incisions and the avoidance of cardiopulmonary bypass provide potential advantages to the patient in terms of reduced postoperative pain and an improvement in early mobility and functional recovery.

There are only few studies focusing on postoperative pain and quality of life (QOL) after conventional coronary artery bypass grafting (CABG) [Hunt 1980, Chocron 1996, Hlatky 1997, Klersy 1997, Sjöland 1997]. Until now, there are no studies indicating whether minimally invasive coronary surgery actually achieves a reduction in postoperative discomfort and impairment of the patient's daily activities. To test the hypothesis that MIDCAB provides advantages through a less invasive surgical approach, we investigated different scores for rating pain and QOL indicators to establish the benefits of MIDCAB grafting when compared to conventional CABG.

MATERIALS AND METHODS

A prospective non-randomized study was initiated to compare pain and QOL indicators in MIDCAB versus conventional CABG patients. MIDCAB was performed in 65 consecutive patients (Group A) and compared to a computer matched control population undergoing traditional

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Table 1. Preoperative Patient's Characteristics

	MIDCAB n = 65	Conventional CABG n = 95
Gender		
Male	66.2%	67.4%
Female	33.8%	32.6%
Age [years]	61.8 ±9.7	64.0 ±9.1
BSA [m^2]	1,78 ±0,2	1,84 ±0,2
EF [%]	69,9 ±8.8	59,7 ±15*
Diabetes mellitus	22/65 (33.8%)	38/95 (40.0%)
COPD	2/65 (3.0%)	7/95 (7.3%)
Hypertension	28/65 (43.0%)	56/95 (58.9%)
Obesity	22 (33.8%)	58/95 (61.0%)*

MIDCAB = minimally invasive direct coronary artery bypass; Conv = conventional approach; BSA = body surface area; EF = ejection fraction; COPD = chronic obstructive pulmonary disease

* = $p < 0.05$

CABG with cardiopulmonary bypass (Group B). The MIDCAB surgical technique used at our institution was previously reported [Diegeler 1997]. Briefly, the surgical technique consisted of: 1) an anterolateral mini-thoracotomy through the 4th intercostal space, 2) internal thoracic artery (ITA) harvesting under direct vision using specialized thoracic retractors, and 3) ITA to left descending coronary artery (LAD) anastomosis without CPB. Different devices for local mechanical immobilization of the target coronary artery were used during conduct of the study. Group A patients were selected for the MIDCAB operation based on the presence of stable angina pectoris with angiographically proven single vessel proximal LAD disease. Some patients in Group A were accepted for MIDCAB if other non-LAD vessels were diseased but not suitable for grafting.

Group B consisted of 95 patients selected as computer matched controls who underwent conventional on-pump CABG and participated in identical assessment of pain and QOL indicators. Group B patients were matched for the presence of stable angina pectoris along with angiographically proven two vessel coronary disease, at least one of which was a high-grade proximal LAD lesion along with another vessel suitable for a standard graft. Group B patients underwent conventional CABG at the same institution using a median sternotomy approach, CPB, moderate hypothermia (32-34° C), and cold cardioplegic arrest.

Patients taking chronic pain medications preoperatively were excluded from the study. The protocol allowed for subjects to be excluded from analysis if severe complications—cardiac low-output or pulmonary, renal, or neurological disorders—caused a prolonged postoperative course.

The intraoperative anesthetic and analgesic management (Disoprivan/Sufentanil) was identical for both groups. Extubation was planned for the earliest possible time after safe arrival in the ICU.

Postoperative pain medication included the intravenous application of Pethidin or Piritramid on POD 1 and 2, the oral administration of Tramadol between POD 2 and POD 4, and oral Paracetamol and Indomethacine from POD 4 onwards at the patient's request.

All patients were interviewed postoperatively on a daily basis up to the seventh day using a standard pain questionnaire. Two different scoring tests were used: the verbal rating scale (VRS), a five-step approach that allows differentiation between no pain, mild pain, moderate pain, severe pain, and unbearable pain, and the visual analog scale (VAS), which quantifies pain on a scale from 1 (no pain) to 10 (the worst pain the patient has ever experienced).

QOL was assessed using a modification of the Nottingham Health Questionnaire [Hunt 1980]. The modification consisted of the inclusion of one possible positive answer in each category. Different aspects of QOL were analyzed, namely mobilization, social status, level of activities, emotional state, pain, and sleeping disorders using a score that described a level of limitations in terms of percentages. The preoperative result served as a baseline. Changes in QOL were evaluated dimensionless in between preoperative and postoperative interviews, as well as in comparison to a three-month follow-up. All data were collected preoperatively and prior to discharge by direct interview and at a three-month follow-up by telephone interview. A total of 1,600 questionnaires were analyzed during the six-month period. Overall, patient compliance was very good, and follow-up was complete in 96.8% of patients.

Results are given as mean ± standard deviation. Statistical analysis was performed using the SPSS statistical package (SPSS Inc., Chicago, IL, USA). To assess for statistically significant differences in postoperative pain levels between the MIDCAB group and the conventional CABG group, a general linear model (GLM) was applied. A univariate analysis of variance for multiple measures was performed. Furthermore, results between the two groups were compared using the Student's T-test for independent samples.

RESULTS

Preoperative patient characteristics are shown in Table 1 (◎). Overall, 67 % of the patients were male (66.2% in Group A, 67.4% in Group B). Patients operated in the MIDCAB group were slightly, but not significantly, younger (61.8 ± 9.7 versus 64.0 ± 9.1 years). Group A patients had a statistically significant increased body surface area and obesity as compared to the conventional CABG group (61.0% versus 33.8%, $p < 0.05$). This was due to the selection criteria for MIDCAB surgery. Statistically significant differences were observed for ejection fraction in favor of the MIDCAB group; nevertheless left ventricular function was within normal ranges for both groups. There were no significant differences for preoperative cardiovascular risk factors.

Postoperatively, there was a trend towards prolonged mechanical ventilation in the CABG group (14 ± 3.8 hours versus 8 ± 4.2 hours in the MIDCAB group ($p = 0,16$)). In Group B, 13/95 patients (13.6%) received a transfusion

Table 2. Duration of Intensive Care and Hospital Stay

	MIDCAB	Conventional CABG	p < 0.05
Number of grafts	1.05	2.21	p < 0.05
Ventilation [h]	8	14	n.s.
ICU [h]	22	30	n.s.
Blood loss [ml]	568 ± 114 ml	623 ± 136	n.s.
Blood units [patients]	1/65 (1,5%)	13/95 (13,7%)	p < 0.05
Complications	0	3	n.s.
Renal	0	1	n.s.
Pulmonal	0	1	n.s.
Cardial	0	1	n.s.

ICU = Intensive Care Unit

during their hospital stay versus only 1/65 patients (0.15%) in Group A ($p < 0.05$). The chest tubes for wound drainage were in place for an average of 39 to 55 hours, with no difference between groups. Perioperative data are depicted in Table 2 (◎).

When asked about postoperative pain medication, all patients stated that it was sufficient. However, pain medication usage during postoperative day (POD) 1 showed a statistically higher total dosage of Dolantin in the MIDCAB group at 52.7 ± 33.4mg/24h versus 10.9 ± 0.8mg/24h in the CABG group ($p < 0.05$). From POD 4 onwards, more patients in the conventional CABG group received pain medication, consisting of either Tramal, Paracetamol, or Indomethacin. These differences in pain medication usage became statistically significant on POD 7 with respect to the application of Indomethacin; 15/95 patients (15.7%) in the CABG group versus 2/65 patients (3.0%) in the MIDCAB group ($p < 0.05$). Pain medication usage is listed in Table 3 (◎).

Maximum pain levels were observed on the first and second POD, respectively. As soon as the chest tubes were removed, most patients started to regain their preoperative activity levels. Pain intensities according to the VRS and the VAS were significantly higher on POD 1 in the MIDCAB group and appeared as only a trend in the MIDCAB group versus the conventional group by postoperative days 2 and 3. From POD 4 onwards, the VRS and VAS showed a reversed trend towards a higher level of pain in the CABG group (see Figure 1a and 1b ◎). This trend was statistically significant on POD 7 when using the VAS (see Figure 1b ◎). By the time of discharge, pain levels had decreased in almost all patients.

During the first postoperative week, QOL aspects—activities, mobility, and pain, social, sleep, and emotional conditions—were limited. Patients in Group A, however, showed significantly fewer limitations in activities compared with Group B ($p < 0.05$). At three-months' follow-up, all patients were improved compared to preoperative and the limitations in QOL had decreased for all measured parameters. Nevertheless, when compared with the CABG group, MIDCAB patients showed a statistically improved outcome regarding QOL aspects like mobility and pain and a trend toward less limitations in terms of activities and sleep. No differences between both surgical groups could be evaluated regarding emotional and social aspects, as expected (see Figures 2a through 2f ◎).

Only one patient in each group was dropped from the study due to prolonged postoperative recovery.

DISCUSSION

Post-surgical pain and QOL are important endpoints to evaluate the perioperative trauma and invasiveness of sur-

Table 3. Postoperative Pain Medication

MIDCAB	n = 65	Pethidin	Piritramid	Tramadol	Paracetamol	Indomethacin
POD 1	n-patients (%)	46/65 (70.7%)	41/65 (63.0%)			
	mg/d (mean ± SD)	52.7± 33.4*	9.39 ± 7.3			
POD 2	n-patients (%)		35/65 (53.8%)			
	mg/d (mean ± SD)		7.3 ± 5.2			
POD 3	n-patients (%)			37/65 (56.9%)	49/65 (75.3%)	
POD 4	n-patients (%)			18/65 (27.7%)*	36/65 (55.4%)	10/65 (15.3%)
POD 7	n-patients (%)				2/65 (3.0%)	2/65 (3.0%)*
CABG	n = 95	Pethidin	Piritramid	Tramadol	Paracetamol	Indomethacin
POD 1	n-patients (%)	32/95 (33.6%)	64/95 (67.3%)			
	mg/d (mean ± SD)	10.9 ± 0.8*	8.4± 6.69			
POD 2	n-patients (%)		50/95 (52.6%)			
	mg/d (mean ± SD)		5.8 ± 3.2			
POD 3	n-patients (%)			49/95 (51.2%)	58/95 (61,1%)	
POD 4	n-patients (%)			39/95 (41.1%)	53/95 (55.8%)	18/95 (18,9%)
POD 7	n-patients (%)					15/95 (15.7%)*

POD = postoperative day; mg/d = milligram/day; SD = standard deviation

* = $p < 0.05$

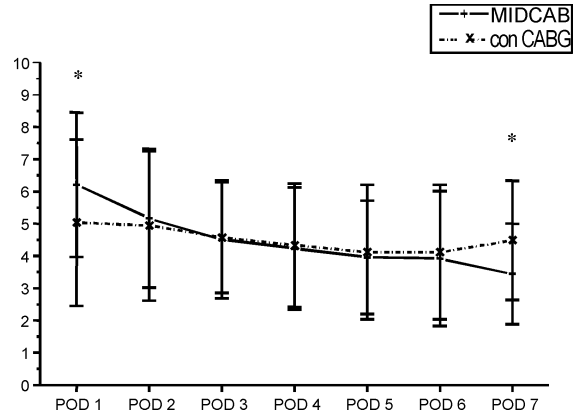

Figure 1a. Pain according to visial analoge scale (VAS).

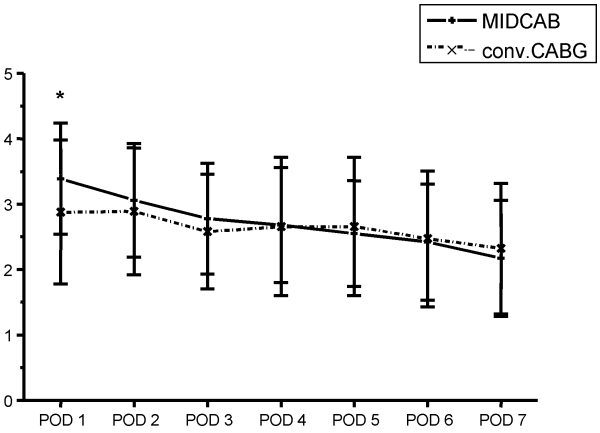

Figure 1b. Pain according to verbal rating scale (VRS)

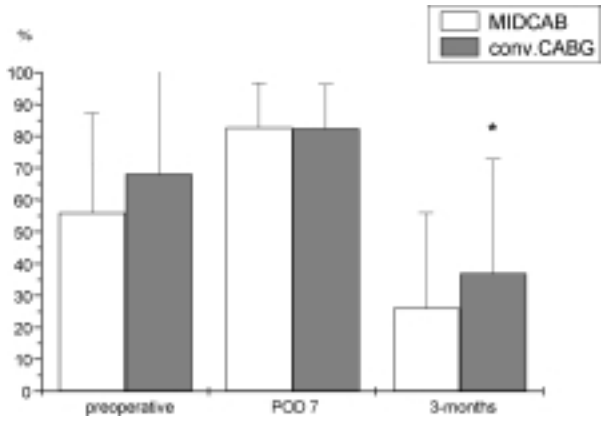

Figure 2a. Quality of life; degree of limitation of mobility (in percent)

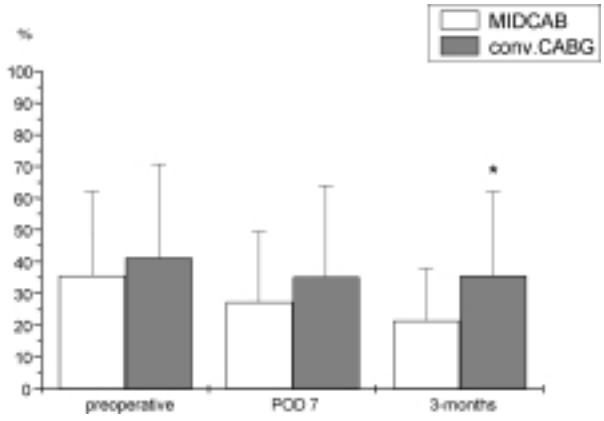

Figure 2b. Quality of life; degree of limitation by pain (in percent)

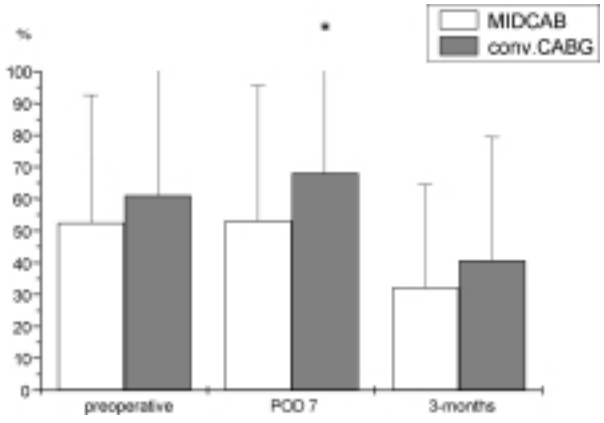

Figure 2c. Quality of life; degree of limitation of activity (in percent)

gical procedures and, furthermore, to reflect the success of the treatment itself. In this prospective study, we examined whether or not there were differences for patients operated using a minimally invasive versus conventional approach for CABG.

Pain perception is rather individualized. Nevertheless, the use of scoring systems provides partial quantification of these otherwise subjective symptoms [Westin, 1997]. Thus, some conclusions may be drawn by the results of those scoring tests, but in the end, individual aspects remain.

Overall, pain—found in both groups of this study—was low and sufficiently treated in most patients. As anticipated, thoracic pain is of tolerable intensity if the sternum and the ribs are stable postoperatively. Since the parietal pleura is very sensitive to mechanical irritation, chest tubes inside the pleural space are one major source of postoperative pain in cardiac patients. Thus, most of the pain related to this fact is relieved when the chest tubes are removed.

As this study discovered, even a small anterolateral thoracotomy is painful. Thus, adequate medication is mandatory in MIDCAB patients to achieve optimal patient comfort. However, from the third POD onwards, patients in the MIDCAB group suffered less pain as compared to the conventional trans-sternal group, which was close to reaching statistical significance until POD 7. This is an important result that may explain the finding of a significantly reduced limitation of activities in MIDCAB patients soon after surgery. The sternotomy approach caused some pain and muscular tension in the back over a prolonged postoperative period. Due to this, a number of sternotomy

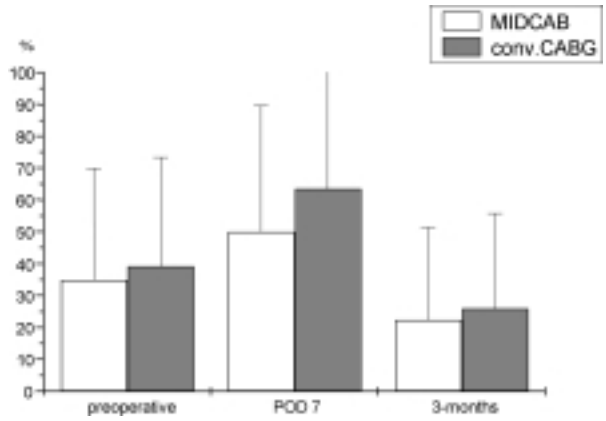

Figure 2d. Quality of life; degree of limitation problems with sleeping (in percent)

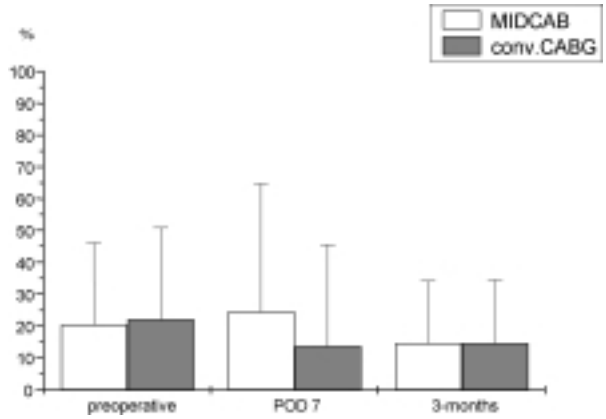

Figure 2e. Quality of life; degree of limitation by social problems (in percent)

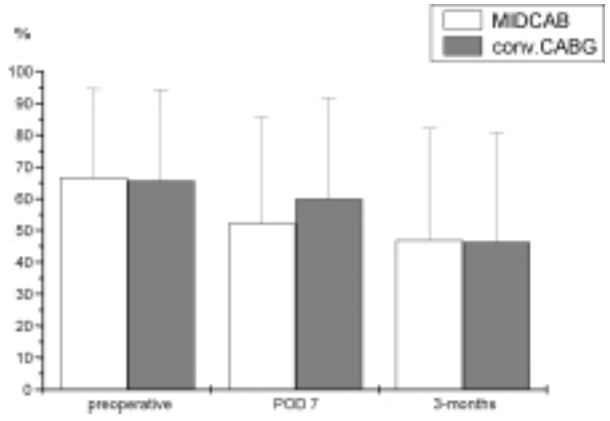

Figure 2f. Quality of life; degree of limitation by emotional problems (in percent)

patients were discharged still receiving pain medication with Indomethacine. Furthermore, even after three months, some of these patients complained about a limitation of their QOL due to pain, which was again significantly higher when compared to the MIDCAB group.

On the basis of our recent experience, a catheter-based intercostal drug medication with Bupivacaine has been introduced for postoperative pain management in MIDCAB patients. The intrapleural application of Bupivacaine for patients after MIDCAB procedures has already been described by others [Mehta 1998]. Based on our experience, an intercostal deposit of Bupivacaine that is reapplied at a dosage of 5 mg every 6 hours reduces the necessity for higher doses that might be absorbed by the huge pleural surface. In our experience, the intercostal application had a reasonable effect on pain release. The alternatively used epidural anesthesia for MIDCAB patients [Sanchez 1998] was not used at our institution, due to the potential risk of an interspinal hematoma in combination with heparinization.

Regarding QOL, there was an improvement in postoperative result with decreased limitation for all aspects asked by the questionnaire. This improvement is in conjunction with results from the literature [Chocron 1996, Engblom 1997]. Although a modified standard scoring system was used, the individual's QOL is hard to quantify. Therefore, the evaluation was done dimensionless, and the preoperative score, which described a level of limitations in terms of percentages for six different aspects of QOL, served as a baseline. Compared to the conventional approach, the minimally invasive technique resulted in some relevant differences in postoperative QOL three months postoperatively. The MIDCAB group showed a trend toward fewer limitations in terms of activities and sleep and a significant reduction of limitations regarding mobility and pain as a benefit of the minimally invasive procedure. Of course, there might be a psychological aspect of minimally invasive cardiac surgery. Since patients anticipate less pain from a smaller incision they may be motivated for early mobilization, resulting in earlier recovery. Nevertheless, this psychological aspect is part of daily life and highly associated with QOL in general.

There may be more differences during the first and second postoperative month that could not be determined due to the design of the presented study. With the current German standard of postoperative cardiac rehabilitation, earlier postoperative data are hard to obtain, and a weekly questionnaire would be helpful for further studies.

In conclusion few relevant differences were seen between the minimally invasive and conventional CABG. From the third postoperative day onwards, patients having a lateral mini-thoracotomy perceive less pain. Together with the avoidance of the negative impact of cardiopulmonary bypass, the minimally invasive approach results in improved activities, better mobilization, and in general an earlier recovery after coronary artery bypass surgery.

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REVIEW AND COMMENTARY

1. Editorial Board Member SC389 writes:

This is a very important issue in cardiac surgery outcomes and measures to which we should be paying more attention.

It does appear that the off pump patients were "healthier" and it may not be a fair comparison. It would be better with prospective risk stratified groups.

I would be interested in knowing the average number of grafts in each group and if there was any difference in patients with longer pump runs.

Authors' Response by Anno Diegeler, MD:

MIDCAB was mainly performed on patients having a one-vessel disease. In the conventional CABG group, only patients with two-vessel disease were included. The authors fully agree that a comparison of the two groups in regard to the preoperative findings is difficult, but given the current standards of medical and surgical treatment for coronary artery disease, it is impossible to enroll patients with an isolated LAD lesion for a conventional CABG procedure. Therefore, a randomization or statistically correct preoperative risk stratification could not be performed. The authors are aware of this significant limitation. It should however be mentioned that the number of grafts per se would not affect postoperative pain levels to a great extent. In all patients, the left ITA-graft was used. Additional vein grafting (except for the leg wound) should not have an impact on the pain levels caused by a thoracotomy or sternotomy incision.

Postoperative outcome was not related to the length of pump-run. It should be mentioned that all patients evaluated had an uneventful postoperative recovery. Patients with severe postoperative complications (one patient in each group respectively) were excluded from postoperative evaluation. It was not the aim of the study to compare the two groups regarding perioperative adverse events. The average number of grafts was 1.05 in the MIDCAB group, and 2.21 in the CABG group (which has been included in the table). Again this does not reflect the normal CABG population in our institution.

2. Editorial Board Member NM341 writes:

There is no mention of pain due to conduit harvest in the conventional CABG patients and whether that was accounted for in some way. In our institution, patients seem to experience more discomfort and require more analgesia for their leg incisions than for their median sternotomies. Clearly if SVG was used, this would skew pain assessment and quality of life evaluation in favor of MIDCAB. Please comment on what conduits were harvested and whether analgesic requirements due to harvest were taken into account.

I suspect the two groups differed significantly with respect to extent of disease as well as number of grafts performed. As described, the MIDCAB group all underwent single vessel LIMA to LAD, had no additional conduit harvest incisions, had shorter operations, etc. A prospective randomized trial comparing MIDCAB with standard single vessel CABG on CPB would be required. Nevertheless, the authors do show that patients with single vessel disease who have suitable habitus for MIDCAB (significantly less obesity in the MIDCAB group) do well post operatively.

Authors' Response by Anno Diegeler, MD:

Again, the authors acknowledge the limitations of the study that are discussed in the paper.

Regarding the additional leg-incision for saphenous vein harvesting, it is true that this may have an impact on postoperative pain perception, mobility and activity levels. It should be mentioned that SVG were mostly harvested from the calf due to the limited number of grafts required in the CABG group. Patients were interviewed for limitations related to their leg wounds. There was no patient who considered pain from the leg wound as a major factor for the overall well being and graded minor in severity as

compared to the sternotomy incision. However, it cannot be excluded that additional leg wounds may have an impact on the results to some degree due to the complex nature of subjective pain perception.

3. Editorial Board Member NC124 writes:

In the conventional CABG patients selected via a computer, it is not mentioned if they were single graft to LAD patients as in the MIDCAB group. I would think that if the conventional group were cases for 2,3,4, etc. grafts, the time of the operations and anesthesia would be much longer. Also, there was no mention if there were any redo cases.

Regarding ventilator time, we would expect longer times in the CPB group, as well with the amount of mediastinal bleeding. I would consider an adequate comparison regarding the surgical approach a series of off pump sternotomy versus MIDCAB.

Authors' Response by Anno Diegeler, MD:

As mentioned above, the authors tried to form a comparable group of patients with conventional CABG. Patients with diffuse multiple vessel disease requiring three or more grafts and redo procedures were excluded. Due to different indications for the two procedures, it was not possible to generate equal patient populations. A randomized trial, although highly desirable, is not possible at our institution due to the lack of an adequate number of patients referred for single vessel revascularization using conventional CABG technique. The time of postoperative ventilation did not differ significantly, probably due to preoperative selection criteria.

Regarding postoperative bleeding, one has take into account that patients after MIDCAB procedure did not receive a complete neutralization of the heparin dosage. In addition, patients in the conventional group received Aprotamin due to the standard protocol for all CPB-patients at the institution. Both factors influenced the postoperative blood loss, which was not significantly different between the groups.

4. Editorial Board Member LO23 writes:

The interpretation of the results of this study is extremely difficult because of the discrepant population groups studied. Early pain differences (Day 1) cannot be interpreted as such if the anaesthetic and ICU management of both groups is not standardized (no mention is made of this). In most units cardiopulmonary bypass patients are managed with high dose morphine or its analogues which is also usually administered in the ICU and these patients greater freedom from pain can be related to this effect. The authors make no mention of the anaesthetic and ICU management of these patients.

The long term quality of life cannot be compared if there is marked discrepancy in terms of cardiac function and extent of pathology—the discrepant LV function in the two groups cannot be minimized as the authors attempt to do. If this was a "computer matched" group, why the discrepant function? The differences in comorbid disease is also important.

Authors' Response by Anno Diegeler, MD:

Again, the differences in the patients' selection for both groups may have had an impact on the results and have to be taken into account for interpretation of the data.

The perioperative and postoperative anesthetic and analgesic drug management did not differ for both groups. Perioperative anesthesia was performed using Disoprivan and Sufentanil in both groups. Postoperatively, Pethidine (Dolantine™) and Piritramid (Dipidolor™) were applied on demand only.