Minimally invasive direct coronary artery bypass versus off-pump coronary surgery through sternotomy

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ABSTRACT

INTRODUCTION

Although it is not a new technique, minimally invasive direct coronary artery bypass (MIDCAB) is employed only by a few surgeons in the UK. We compared our experience with MIDCAB with that of single vessel off-pump coronary artery bypass (OPCAB) graft surgery through a standard median sternotomy.

METHODS

Patients who underwent either MIDCAB or OPCAB between April 2008 and July 2011 were reviewed. Exclusion criteria included patients with an ejection fraction of <0.5 or previous cardiac surgery. Data were obtained retrospectively from our prospective database, medical records and through general practitioners.

RESULTS

Overall, 74 patients were analysed in the MIDCAB group and 78 in the OPCAB group. Their demographics and EuroSCORE (European System for Cardiac Operative Risk Evaluation) values were comparable \((p>0.05)\). There was no statistically significant difference in the two groups in terms of mortality, recurrent myocardial infarction, postoperative stroke, wound infection, atrial fibrillation or need for reintervention. The MIDCAB group had six conversions to a sternotomy. Eight patients in each group required blood transfusion, with the average transfusion being 1.8 units in the MIDCAB group and 3.2 units in the OPCAB group. The mean duration of ventilation and intensive care unit stay was 5.0 hours and 38.4 hours in the MIDCAB group and 5.4 and 47.8 hours in the OPCAB group. The mean hospital stay was significantly reduced in the MIDCAB population \((6.1 vs 8.5 \text { days}, p<0.05)\).

CONCLUSIONS

MIDCAB can be performed safely in appropriately selected patients with outcomes comparable with OPCAB. The potential benefits include shorter hospital stay, reduced need for blood transfusion and faster recovery.

KEYWORDS

Minimally invasive direct coronary artery bypass – Off-pump coronary revascularisation

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Coronary artery bypass surgery can be performed less invasively by avoiding cardiopulmonary bypass. Conventionally, this is performed through a median sternotomy. However, some patients may be suitable for surgical revascularisation via the minimally invasive route. Minimally invasive direct coronary artery bypass (MIDCAB) is the preferred approach for treating isolated disease of the left anterior descending (LAD) coronary artery at some centres. In most cases, the procedure is performed without the aid of cardiopulmonary bypass and can be extended to treating lesions of other coronaries using composite grafts and hybrid procedures. Potential advantages of the MIDCAB method include the limited surgical trauma, resulting in quicker recovery and improved mid-term quality of life.

However, this approach can be technically challenging. Concerns have been raised regarding slightly higher rates of adverse cardiac events than for conventional off-pump surgery. Many feel that the quality of the MIDCAB procedure can be maintained only when performed in a centre with a high caseload in order to allow surgeons to preserve a high levels of skills. We compared our experience with MIDCAB versus single graft left internal thoracic artery (LITA)–LAD off-pump coronary artery bypass (OPCAB) surgery performed on a beating heart via a median sternotomy.

METHODS

All of the 75 patients who underwent MIDCAB between April 2008 and July 2011 were compared with the 91 patients who underwent off-pump single graft LITA–LAD coronary surgery through a median sternotomy (OPCAB) during the same time period. Of these, we excluded the patients with an ejection fraction of <0.5 (1 in MIDCAB group, 13 in OPCAB group) and
those who had had previous cardiac surgery (2 in OPCAB group). An analysis was therefore performed of 74 patients in the MIDCAB group and 78 in the OPCAB group.

Data collection
This was an observational retrospective cohort study of prospectively collected data from medical records and a computerised database as well as by contacting the patient’s general practitioner when necessary. Outcome measures comprised early (within 30 days postoperatively) and late events. Late complications included late death (death after day 30), recurrent angina or myocardial infarction, reintervention (coronary artery bypass surgery or percutaneous coronary intervention) and late cerebrovascular accident.

Selection for MIDCAB or OPCAB
The feasibility of the minimally invasive approach was based on the requirement for surgical revascularisation to the LAD artery only and also, occasionally, to a large diagonal or intermediate branch in addition. Patients who had undergone previous cardiac surgery or required emergency surgery and those who had a body mass index over 40kg/m² were not considered for this technique. Certain patients were selected for a hybrid procedure involving insertion of a stent into a suitable right coronary artery lesion, commonly performed 2–3 days after the MIDCAB procedure during the same admission. The indications for and the limitations of MIDCAB were explained to the patients preoperatively, and the final decision for choosing a minimally invasive approach over a sternotomy was made by the patient.

Surgical technique
The surgical technique used for MIDCAB is similar to that described previously. After double lumen endotracheal intubation, an inflatable cushion is placed under the left hemithorax of the supine patient. An 8cm submammary skin incision is made, the pleura space is entered through the fourth intercostal space and the left lung is deflated. A retractor with long blades is placed and the LITA is harvested using long bade diathermy. After heparinisation, the anastomosis is performed on a beating heart with the aid of a stabiliser and an intracoronary shunt. Additional grafting of the diagonal or intermediate arteries is achieved as a y-graft, using the left radial artery connected end-to-side to the LITA. One chest drain is inserted in the left pleura and the incision is closed in layers.

Off-pump coronary surgery through a sternotomy was performed as per conventional methods.

Postoperative care and follow-up
Immediately after closure of the incision, 0.25% bupivacaine is used for local infiltration. Intravenous infusion of morphine is used for 24 hours, followed by oral analgesics. The timing of discharge from the hospital was decided based on clinical and the patient’s social criteria without particular consideration of the MIDCAB or OPCAB procedures.

Statistical analysis
Statistical analysis was performed with the StatView® 5.0 statistical software package (SAS Institute, Cary, NC, US).

Results
Between April 2008 and July 2011, a total of 75 patients underwent MIDCAB and 91 had OPCAB. In order to have a comparable population, patients with an ejection fraction of <0.5 were excluded from both the groups (1 in MIDCAB group and 13 in OPCAB group) as well as those who had had previous cardiac surgery (2 in OPCAB group). The closing interval was two months and the follow-up rate was 100% for MIDCAB patients and 93% for OPCAB patients.

After applying the exclusion criteria, there were 74 patients in the MIDCAB group and 78 in the OPCAB group. The mean age in the two groups was 63.49 and 64.28 years respectively. Demographics in the two groups were comparable (p>0.05) (Table 1). The overall EuroSCORE (European System for Cardiac Operative Risk Evaluation) was lower in the MIDCAB group (mean: 2.5, range: 0.9–9) than in the OPCAB group (mean: 3.8, range: 1–10) (p<0.05) owing to patient selection.

Overall, MIDCAB was performed successfully in 69 (95.2%) of the 74 patients taken up for MIDCAB. There were six conversions (8.1%) to a sternotomy. Isolated LAD revascularisation was performed in 54 patients (72.9%) while 9 (12.2%) received 2 grafts and 6 (8.1%) underwent a hybrid procedure.
There were six conversions to a sternotomy due to epicardial adhesions or adipose cover rendering the identification of the mid-LAD artery difficult in four patients, injury to the thoracic artery in one patient and ventricular fibrillation arrest (that occurred prior to performing the anastomosis) in a further patient. The use of cardiopulmonary bypass was not necessary in any of these patients following the sternotomy. Four of these patients underwent successful anastomosis of the LITA to the LAD while two patients underwent percutaneous coronary intervention at a later date. None of these patients suffered a myocardial infarction or any other major complications.

Blood transfusion was required in eight patients in each group. However, the transfusion requirement was lower in the MIDCAB group (1.8 vs 3.2 units per transfused patient). The mean hospital stay was significantly reduced in the MIDCAB population (6.2 vs 8.2 days, \( p < 0.05 \)). The mean intensive care unit stay in the MIDCAB group was 38.36 hours compared with 47.87 hours for OPCAB patients. This difference was not statistically significant (Table 2).

### Early postoperative outcomes

In the MIDCAB group, there was no early mortality or rethoracotomy for postoperative bleeding. Of the four wound infections, surgical wound debridement became necessary in one patient. Two patients (2.7%) suffered a cerebrovascular accident after hospital discharge but within the early postoperative period. Neither of these resulted in long-term disability. There were no early myocardial infarctions. There was one case of postoperative lung herniation and two cases of surgical emphysema. Early postoperative coronary angiography was performed in 12 patients, including the 6 hybrid procedure patients. Angiography did not demonstrate any perianastomotic stenoses (Fig 1). Table 3 shows a comparison of early postoperative outcomes for MIDCAB and OPCAB patients.

### Late postoperative outcomes

In the MIDCAB group, one patient died owing to metastatic liver disease five months postoperatively. One patient had to undergo reoperative coronary artery bypass surgery as the LITA had been anastomosed erroneously to a large proximal diagonal artery. At reoperation, the LAD was found deeply intramyocardially, necessitating the use of a cardiopulmonary bypass. Subsequently, the patient made an uneventful recovery and remains well 30 months later.

One patient required late percutaneous coronary intervention for an occluded LAD while a further patient suffered a...
non-ST elevation myocardial infarction although on further investigation, the graft was found to be patent. One patient represented with a type A aortic dissection, for which he underwent successful repair with an interposition graft. The previous coronary anastomosis remained patent.

Logistic regression analysis failed to identify any correlations between patient characteristics and complications, even after all postoperative complications were pooled together. There was no significant difference in any of the late postoperative outcomes on comparison with the OPCAB group (Table 4).

Discussion

The first minimally invasive bypass grafting of the LAD with the LITA was reported by Vasilii Kolesov and performed via a left anterior thoracotomy.9 The MIDCAB procedure followed the popularisation of OPCAB and placed emphasis on its minimal access approach. The technique combines a favourable event free survival after surgical revascularisation of the LAD10 with the potentially quicker recovery.11 However, this approach is practised only by a few surgeons. This is possibly due to concerns raised by a few series reporting their early experiences in the era before the widespread usage of newer stabilisers.11

In a meta-analysis of 3,304 cases of MIDCAB surgery and 3,060 cases of off-pump surgery through a sternotomy, Stanbridge and Hadjinikolaou concluded that the stenosis rate was significantly reduced with stabilisation devices.11 Better stabilising devices have now become available and, with an increase in experience, off-pump coronary surgery has become more common. This should make the minimally invasive approach more attractive. We reviewed our experience with MIDCAB and compared it with the single graft coronary surgery performed via a median sternotomy in the same timeframe.

In reporting a study similar to ours, Karpuzoglu et al suggest that although MIDCAB grafting is a challenging technique, it may be performed safely on selected patients.12 In our series too, the MIDCAB cohort represented a low operative risk group with a mean logistic EuroSCORE of 2.5. The procedural success rate was 92% whereby six operations (8.1%) were converted to a sternotomy. This probably reflects primarily our early experience. In a review, Calafiore et al reported on 460 MIDCAB procedures with a conversion rate of 5.7% (n=26).13 Sixteen of these conversions were attributed to not being able to visualise the LAD, a problem also commonly faced by us.

No statistically significant difference in the groups was found in our study in terms of mortality. There are relatively few recently published large MIDCAB series. Holzhey et al reported on 1,347 MIDCAB procedures with up to 7 years of follow-up, demonstrating a freedom of major adverse events and angina of 89.5% after 5 years and 83.3% after 7 years.1 Their Kaplan–Meier analysis revealed a five-year survival rate of 91.9% (95% confidence interval [CI]: 90.1–95.8%) and a seven-year survival rate of 89.4% (95% CI: 86.7–92.1%).

A more recent study of MIDCAB patients has also shown an outcome comparable with OPCAB in terms of operative time, postoperative morbidity, postoperative course and in-hospital mortality.14 The authors also demonstrated
superior results concerning the need for blood transfusion and postoperative hospital stay in the MIDCAB group, which is consistent with the minimally invasive approach in our series.

The number of wound infections in the MIDCAB group (three superficial, one requiring debridement) was concerning as this exceeds our current rate of wound infections after a midline sternotomy although the difference was not statistically significant. We have taken this issue seriously and now place even greater importance on intraoperative sterility. We plan to audit our infection rates again in near future and are hopeful that these will be much reduced.

A study of 1,400 minimally invasive cardiac surgery procedures at the Cleveland Clinic demonstrated an overall wound infection rate of 2.9% and a deep infection rate of 1.9% but failed to show any significant difference when compared with traditional open heart surgery.16 Another retrospective review of 165 consecutive MIDCAB cases demonstrated wound complications in 15 patients (9.1%), including 2 incisional hernias (1.8%), 4 superficial dehiscences (2.4%), 3 wound infections (1.8%), 3 chronic pain syndromes (1.8%) and 2 seromas (1.2%).

In our study, postoperative pain and quality of life were not evaluated. As these two parameters are perceived advantages of MIDCAB (as compared with a sternotomy), a prospective study has been planned. Diegeler et al found in their prospective clinical trial that MIDCAB patients suffer more pain (vs OPCAB patients) in the first three postoperative days, probably as a result of the lateral thoracotomy.15 However, from day 4 onwards, MIDCAB patients are significantly better, experiencing less pain and showing better physical activity, even three months after surgery.

In our MIDCAB cohort, five patients underwent hybrid revascularisation (ie MIDCAB to the LAD followed by a preplanned stenting of either the first obtuse marginal \([n=5]\) or the right coronary artery \([n=2]\)) (Figs 1 and 2). This might depict another use of the MIDCAB technique. Indication may include keenness to avoid a median sternotomy either because of the patient's clinical condition or because of the patient's preference. Holzey et al reported on the short and long-term results of hybrid procedures in 117 patients. Two patients (1.9%) died postoperatively, and major adverse cardiac and cerebrovascular event (MACCE) free survival was 85.5\% (95\% CI: 76.9–94.1\%) and 75.3\% (95\% CI: 62.7–87.5\%) at one year and five years respectively.

**Limitations**

The main limitation of our analysis is its retrospective nature and the relatively small number of included patients. Furthermore, as this paper presents our early experience with this technique, long-term follow-up and evaluation is awaited. We also look forward to the results of our study on postoperative quality of life and pain tolerance.

**Conclusions**

MIDCAB is a feasible technique and can be performed safely in suitable patients. Postoperative outcomes in terms of mortality and MACCEs were satisfactory, rendering this procedure at least as safe as the option of OPCAB. Factors leading to these outcomes could potentially include appropriate patient selection and surgical experience in off-pump coronary surgery. Concerns regarding the rate of conversion to sternotomy and of wound infections are being addressed. The potential benefits of this technique include shorter hospital stay, reduced need for blood transfusion and faster recovery. It is likely that MIDCAB will become a significant component within our procedure spectrum of treatment for coronary artery disease.

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