

# The MIDCAB approach in its various dimensions

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## ABSTRACT

**Introduction:** Minimally invasive direct coronary artery bypass grafting (MIDCAB) offers arterial revascularization of the left anterior descending coronary artery especially in lesions unsuitable for percutaneous coronary interventions. By avoidance of sternotomy and cardiopulmonary bypass its invasivity is less than that of conventional bypass surgery.

**Methods:** A literature search of all published minimal invasive direct coronary artery bypass grafting studies was performed for the period from January 1995 through November 2011. Additionally, the authors reviewed their experience in more than one thousand patients treated by minimal invasive direct coronary artery bypass grafting within the last 14 years at their institution.

**Results:** Early mortality ranged from 1.2 to 1.3%. Midterm mortality ranged up to 3.2%. At 6-month follow up 3.6% grafts were occluded and 7.2% had a significant stenosis which resulted in target vessel revascularization in 3.3% of cases. The conversion rate to sternotomy or cardiopulmonary bypass ranged between 1.2 and 6.2%.

**Conclusions:** In the past MIDCAB was predominantly used in patients with isolated lesions of the left anterior descending coronary artery. In combination with percutaneous interventions it provides an attractive option for full revascularization in multi vessel disease especially in older patients with significant comorbidities. Overall minimal invasive direct coronary artery bypass grafting is associated with few perioperative complications and with high graft patency rates in the mid-term and long-term course.

**Keywords:** coronary artery disease, arterial revascularization, MIDCAB, hybrid procedure, minimally invasive cardiac surgery.

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## INTRODUCTION

After the first description of a beating heart anastomosis between the mammary artery and a coronary artery by Kollesov (1) this concept wasn't established in clinical reality for decades. Since its reintroduction in the 1990s by Calafiore (2) and Subramanian (3) minimally invasive direct coronary artery bypass grafting (MIDCAB) into the

spectrum of surgical revascularization this technique has been further developed. Today it is a representative part of the cardiac surgical program in some institutions.

The procedure is regarded as less invasive than conventional coronary artery bypass (CABG) or off pump revascularization (OPCAB) and ranges in its invasivity close to percutaneous coronary interventions (PCI). MIDCAB can be regarded as an alternative treatment option besides the well established treatment procedures of revascularization.

MIDCAB has been mainly used in patients with proximal stenosis of the left anterior descending artery (LAD). In these patients

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often interventional treatment with PCI appears risky or impossible due to complex lesions, close relationship to the main stem or other coronary arteries or total occlusion of the target vessel. In other patients repeated interventions at the LAD remained without longstanding success.

Besides its original intention for revascularization of the LAD, MIDCAB can be a useful part of hybrid procedures in patients with multi vessel disease where a major coronary surgery procedure would not be well tolerated. Although multi vessel disease is a predictor of elevated mortality after CABG, the MIDCAB procedure can be performed as stand alone procedure with acceptable results in midterm morbidity and mortality, even though formally incomplete revascularization may remain (4). Several studies and our own experience proved that in selected patients with main stem stenosis or multi vessel disease MIDCAB can be safely performed (5). Complete revascularization can be achieved by a hybrid approach with accompanying PCI (5-6). Interestingly we found in our own collective that a significant part of the planned PCI has not been performed since the MIDCAB resulted in ongoing freedom from angina. This is particular true in multi vessel disease where the LAD is the dominating vessel.

As a rare indication we treated two children aged twelve and thirteen who had undergone a switch operation as babies for transposition of the greater arteries. Later they developed significant stenoses of the LAD and were successfully treated by MIDCAB with an uneventful postoperative course and restored coronary circulation.

Recently, we demonstrated that MIDCAB can be performed in octogenarians with satisfying midterm results. Especially these patients benefit from the marginal surgical trauma, less anesthesia and short ventilation duration and intensive care unit stay (7). A small subgroup of patients received

MIDCAB who suffered from severe bleeding complications due to dual antiplatelet medication after PCI with drug eluting stents.

## METHODS

The patient is placed under general anesthesia and is intubated with a double-lumen tube. Standard monitoring includes 5-lead electrocardiogram (ECG), arterial blood pressure, central venous pressure, nasopharyngeal temperature and peripheral oxygen saturation. The main features of the procedure consist of a small left anterior thoracotomy in the fourth or fifth intercostal space. The pleural cavity is opened and to facilitate harvesting of the graft the left lung is deflated. The left internal thoracic artery (LITA) is harvested as a pedicle up to the level of the first rib. A thoracic wall tilting device attached to the upper rib is useful to reach the proximal parts of the LITA. After completion of harvest the LITA is dissected distally at the level of the sixth intercostal space. Graft perfusion is controlled and local application of papaverine as vasodilating agent can optimize graft flow.

After opening the pericardium and placement of fraction sutures the target region is partially immobilized using a special mechanical stabilizer. Before occlusion of the LAD 100 IU/kg of unfractionated heparin are administered. In almost every case preconditioning is used by temporary occlusion of the LAD with encircling 4-0 tourniquets sutures over silicone tubing. After a short period of reperfusion the target vessel is incised. The field is kept free of blood by a humidified blower using fluid and carbon dioxide. The anastomosis between LITA and LAD is performed under direct vision using an 8/0 monofilament suture, whereas the first five stitches are performed in distance. In contrast to other groups videoscopi-

py as well as intracoronary shunts are not applied.

Following completion of the anastomosis the pedicle is fixed with two sutures to avoid torsion of the graft. After restoration of blood flow heparin is antagonized with protamine. The initially mobilized prepericardial fat is fixed to the medial pericardium to cover the distal part of the IMA course. An infero-posterior chest tube is placed in the left pleural cavity. Closing of the thoracotomy including 2 transcostal sutures has to be performed with meticulous care to avoid contact of the graft with the chest wall or herniation of mediastinal structures. On table extubation and a short intensive care unit stay is intended in all patients.

## RESULTS

We started the MIDCAB program in our institution in 1998. Meanwhile over 1000 patients had been operated with a rather low conversion rate of 1.2%. The majority of patients had a single vessel disease (55.6%) and half of the patients were pre-treated with PCI or had a complete occlusion of the LAD. The overall 30 day mortality until end of 2010 was 1.2% (11/914), whereas a substantial amount of these patients was accepted with a high risk profile or for an ultima ratio approach.

Perioperative myocardial infarctions or cerebrovascular accidents were comparably rare events. Rethoracotomy for bleeding complications was necessary in 1.3%.

## DISCUSSION

When comparing PCI and MIDCAB several studies and a meta-analysis showed that overall mortality and myocardial infarction rates are similar, but MIDCAB is associated

with significantly lower rates of repeat target vessel revascularizations (8-11). It has to be taken in account that these studies compared MIDCAB with bare metal stents. Recently Thiele and co-workers (12) published a randomized trial with a non-inferiority design which compared PCI of the LAD with drug eluting stents and MIDCAB. The results were comparable concerning death and myocardial infarction but the rate of target vessel revascularization was still higher in the PCI group.

At our institution we apply in almost every case ischemic preconditioning (5 min. of ischemia followed by 2 min. of reperfusion). It's potentially beneficial effect on myocardial performance during and after ischemia is discussed controversially in clinical trials and experimental investigations (13-14). Nevertheless the temporary occlusion anticipates the expectable events during anastomosis like ST-elevation, rhythm disturbances and hemodynamic compromise. These events are more likely in partially occluded target vessels and closeness to other coronary vessels.

Our results come along with published data from other large series of MIDCAB (15). The perioperative mortality compares favourably with the 2.1% mortality for off-pump and 5.9% mortality for on-pump single bypass grafting as reported in the German Society for Thoracic and Cardiovascular Surgery in 2010 (16). Nevertheless long-term follow-up results and randomized prospective trials are needed to compare MIDCAB surgery with competing revascularization methods.

A meta-analysis of Kettering in 2008 summarizes the results of seventeen outcome studies of MIDCAB (17). Early and late death rates were 1.3 and 3.2%. At 6-month follow up 3.6% grafts were occluded and 7.2% had a significant stenosis which resulted in 3.3% in a target vessel revascularization. The incidence of myocardial

infarction was below 1%. With respect to the initial learning curve one could assume that the actual results of MIDCAB change for a better. For example the perioperative mortality in our institution declined to 0.7% within the last five years. A recent trial showed a graft patency rate of 100% after 12 months. These results invalidate the initial concerns about the suboptimal quality of beating heart anastomosis via an limited surgical access. Nevertheless these good results are highly dependent on an experienced surgeon.

*Limitations.* In a small amount of cases (1.2 to 1.7% literature and own results) the MIDCAB procedure can't be completed as planned. In some cases the LAD is not to be found due to intramuscular course or excessive epicardial fat tissue or it is situated too laterally to be reached with the LIMA graft. We saw this repeatedly in patients with long standing atrial fibrillation and resulting atrial and right ventricular enlargement. As a result we perform liberally preoperative CT Scans in these patients to judge the reachability in advance. In some cases it was possible to elongate the LITA with a venous interponate. The same strategy of prolongation can be used for injured LITAs for example in local dissection or electrocautery damage.

Malignant rhythm disturbances occur rarely under epicardial manipulation. If these are not of self-limitating nature cardioversion or defibrillation may be necessary. To prevent these events we advocate keeping the patient on high potassium level and sufficient mean arterial pressure. Additional administration of magnesium may be useful. In high risk patients amiodarone is prophylactically given. Since we repeatedly observed significant bradycardia during operation an epicardial pacing should become quickly available, when necessary. In addition external defibrillation adhesive pads should be used in high risk patients.

In situation with critical ischemia an intraluminal shunt is placed.

In the early era of MIDCAB, adhesions of the LITA to the thoracic chest wall occurred sporadically.

This can be associated with life-threatening bleedings due to disruption of the anastomotic site.

Due to events like this, closing of the operation site in several layers with especially covering the distal IMA course is of paramount importance. By means of that chest wall hernias can also be prevented.

## CONCLUSION

Overall we regard MIDCAB revascularization as a very valuable concept within the different options of surgical revascularization. From the beginning it could be proven that the MIDCAB approach is safe and efficient. By avoidance of sternotomy and heart-lung machine it represents a gentle way of effective revascularization of the most important coronary vessel with the best possible graft.

MIDCAB is not only applicable in isolated lesions of the LAD. Hybrid concepts are of growing interest in serving older patients with significant comorbidities.

MIDCAB is associated with a low level of complications perioperatively and with high graft patency rates in the mid-term and long-term course.

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