

# MIDCAB: Impact of Epicardial Stabilization Upon Outcomes

(#1999-9158 ... March 5, 1999)

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## ABSTRACT

**Background** : Minimally invasive direct coronary artery bypass (MIDCAB) has been criticized as compromising anastomotic patency. Epicardial mechanical stabilization devices purportedly facilitate left internal mammary artery (LIMA) anastomosis, thereby enhancing patency and outcome.

**Methods** : From June 1996 through January 1999, 39 patients underwent MIDCAB via a small left anterior thoracotomy for revascularization of the left anterior descending coronary artery (LAD) without cardiopulmonary bypass (CPB). Immediate postoperative coronary angiography was performed on 38 of the patients.

**Results** : Group 1 consisted of 11 patients who were operated upon without epicardial stabilization. Mean age was 64 years. Two had undergone previous coronary artery bypass (CAB). Predicted mortality was 4.3%. Angiographic anastomotic patency was 60%. Revisions on CPB in three cases increased LIMA patency to 90%. There was one intra-operative death. Average length of stay (LOS) was 5.4 days. Group 2 consisted of 28 patients operated on with mechanical epicardial stabilization. Predicted risk of mortality was 4.4%. Mean age was 66 years. Twelve had undergone previous CAB. Anastomotic patency at angiography was 97.4%. There were no intra-operative deaths and mean LOS was 3.0 days.

**Conclusions** : We conclude that mechanical epicardial stabilization has transformed the MIDCAB operation into one that offers excellent early patency and clinical outcomes. This operation is of particular value for revascularization of the anterior coronary circulation in patients with previous CAB; clinical results are significantly better than predicted for standard redo-CAB.

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## INTRODUCTION

Minimally invasive direct coronary artery bypass (MIDCAB) has been criticized of late as jeopardizing anastomotic patency and challenged as to its safety [Ancalmo 1997]. The MIDCAB procedure, via a small left anterior thoracotomy and left internal mammary artery (LIMA) revascularization of the left anterior descending (LAD) coronary artery without cardiopulmonary bypass, has excellent reported results [Calafiore 1997, Subramanian 1997]. Nevertheless, considerable controversy surrounds the concept of MIDCAB. If patency rates and clinical outcomes are comparable to those of conventional coronary artery bypass (CAB), avoidance of cardiopulmonary bypass (CPB) could importantly reduce the morbidity associated with CAB, particularly temporary and permanent cognitive dysfunction [Roach 1996].

Since the first reported large series by Calafiore, the MIDCAB operation has been in evolution. Reported results have varied between study centers, thus raising questions about the technical reproducibility of the procedure. The introduction of mechanical epicardial stabilization systems has improved the technical facility of this procedure. This report examines the effect of mechanical stabilization on both patency of the anastomosis and clinical outcomes for a consecutive series of MIDCAB patients.

## MATERIALS AND METHODS

A minimally invasive coronary revascularization program was instituted at Providence Portland Medical Center in May of 1996. The program consists of detailed informed consent (including review of current results), minimally invasive thoracic incisions, single vessel revascularization on the beating heart, extubation at the end of the operative procedure, immediate postoperative angiography in the catheterization laboratory, and 48-hour "fast-track" hospitalization for those patients who met criteria. Of the 47 patients who underwent minimally invasive CAB, 39

underwent a MIDCAB as defined above. These 39 cases form the basis of this report.

Patients in Group 1 were operated upon without mechanical epicardial stabilization. The operative protocol included preoperative alpha (clonidine) and beta (metoprolol) blockade to minimize cardiac motion. Heparin was used to maintain the ACT at 300 secs. Parenteral beta blockade and periodic boluses of intravenous adenosine were given to achieve cardiac standstill at coronary arteriotomy and for difficult heel and toe sutures during the anastomosis. Every effort was made to extubate the patients at the procedure's end. Intercostal bupivacaine blocks, parenteral morphine, oral non-steroidal anti-inflammatory agents and nitroglycerine infusions were routinely used. Heparin was reversed with one half the normal protamine dose prior to transportation to the angiography suite. Patients remained in the cardiac intensive care unit (CICU) 12-24 hours before transfer to the telemetry unit. Each patient was discharged home once fully ambulatory with stable rhythm, pain control, and oral intake.

Patients in Group 2 received epicardial stabilization via a mechanical retractor system (CardioThoracacic Systems, Cupertino, CA). Preoperative beta blockade was used in the majority of Group 2 cases. However, intra-operative pharmacological control of cardiac motion was abandoned as a goal; thus alpha blockade, parenteral beta blockade, and adenosine were not used. Otherwise, the intra-operative and postoperative management was identical to that of Group 1.

All patients were followed (both in hospital and for the first 30 days) for complications. Follow-up was 100% complete. Data is reported through February 1, 1999. Angiographic patency is defined as a patent internal thoracic artery to LAD anastomosis with antegrade TIMI 3 flow.

**RESULTS**

Thirty-nine patients underwent MIDCAB during this two and one half-year period. Demographic data for MIDCAB patients in both groups are shown in Table 1 (⊙). Hospital mortality for the entire series was 2.6% (1 of 39, see Figure 1 ⊙). A Bayesian risk assessment model (Health Data Research, Portland, OR, USA) was used to predict operative mortality for all patients. Predicted risk for the series was 4.3% (individual patient range 0.19% - 26.18%). The single mortality occurred in Group 1. This patient's post-proce-

Table 1. Demographics

Demographic Data	Group 1 No Stabilization (N=11)	Group 2 Stabilization (N=28)
Sex		
males	9	24
females	2	4
Age	64 years (range 48 - 76)	66 years (range 37 - 82)
Previous CAB	2	12

**MIDCAB 30 DAY MORTALITY**

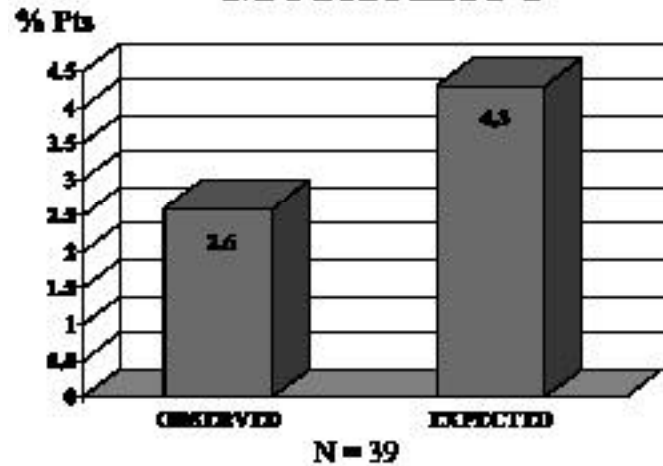


Figure 1. Hospital mortality for MIDCAB patients, observed versus expected.

dures angiogram demonstrated occlusion of the graft. The LIMA graft was revised on cardiopulmonary bypass via median sternotomy. She died on the first postoperative night from electromechanical dissociation. The new graft was patent at autopsy. No patient in Group 2 died.

Angiographic follow-up was 97.9% complete. One patient in Group 2 refused study. Immediate angiographic patency rose from 60% (6 of 10) in Group 1 to 97.4% (26 of 27) in Group 2 (see Figure 2 ⊙). The patient with an occlusion in Group 2 had retrograde but no antegrade flow in his LIMA graft and was returned to surgery for full sternotomy with grafting of the distal LAD on CPB. Angiographically perfect patency [Calafiore 1997] was demonstrated in 70% of patients of both groups combined (see Figure 3 ⊙). The remaining 30% of immediate angiograms showed stenosis of over 50%. One such patient was re-stud-

**MIDCAB LIMA PATENCY**

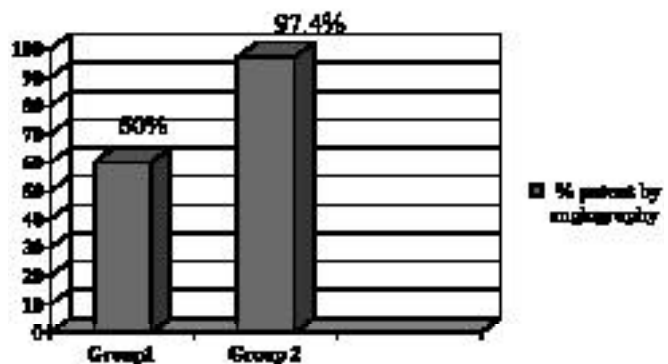


Figure 2. The percentage of patients with a patent LIMA-LAD anastomosis with antegrade, TIMI-3 flow in Group 1 (no stabilization) and Group 2 (with stabilization)



FIGURE 3. Left lateral view of LIMA to LAD anastomosis with "perfect patency"

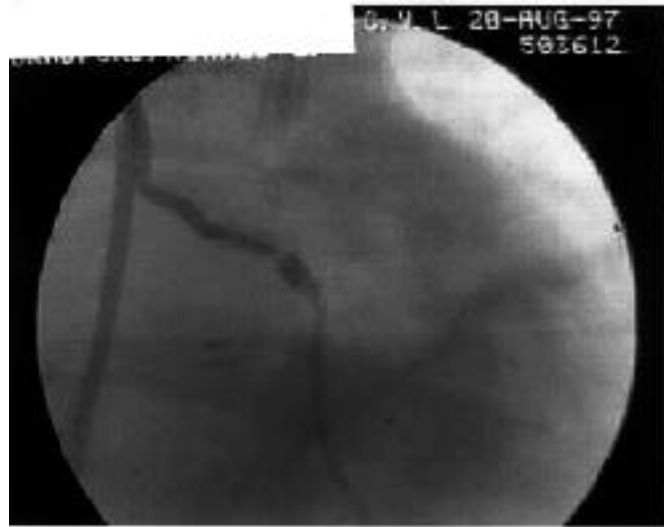


FIGURE 4. Steep LAO (left anterior oblique) view of LIMA with SVG extension with early stenosis at the artery to vein anastomosis.

ied one month later and the stenosis had diminished from 80% to 20% (see Figures 4a and 4b).

Intra-operative complications for both groups are shown in Table 2. Three of 39 patients (7.7%) undergoing minimally invasive coronary revascularization had LIMA injuries during harvest. Two had saphenous vein graft extensions and the right inferior epigastric artery was used for extension of the graft in one patient. All were patent at angiography. The single emergency conversion to CPB occurred in Group 1 and was attributed to complications from the intra-operative use of pharmacological agents used to minimize cardiac motion.

Figure 5 illustrates the impact of epicardial stabilization on length of hospital stay (LOS). Complications, which led to prolongation of LOS or re-admission, are shown in Table 3. There were two cerebrovascular accidents (CVA) in Group 2. One was attributed to postoperative atrial fibrillation and resolved completely. One patient had a CVA after hospital discharge that led to permanent monocular blindness.

survival, when compared with saphenous vein, is clear and reproducible [Grondin 1984, Loop 1986]. A recent report documented poor patency for off-pump coronary artery bypass (OPCAB) grafts [Gundry 1998]. It is important to note, however, that this series was performed without mechanical epicardial stabilization. We, and others [Santocoy 1998], are of the opinion that OPCAB with mechanical epicardial stabilization is a completely different operation than those previously reported. Our LIMA anastomotic patency rate of 97.4% achieved with mechanical epicardial stabilization compares favorably with the 96-100% patency rates reported by others [Subramanian 1997, Posati 1998]. The paucity of published information on immediate postoperative LIMA anastomotic patency on CPB is well known [Mack 1998]; but the available evidence suggests that it is in this same range. Clinical outcomes (patency, conversion to CPB) improved significantly with the introduction of mechanical epicardial stabilization.

We believe that the CVA rate of 5.1% in our series, versus a predicted rate of 3.1%, is an aberration. The MIDCAB

**DISCUSSION**

The major concern with the MIDCAB procedure in the cardiothoracic surgical community is potential compromise of patency of the LIMA to LAD anastomosis. The impact of a patent LIMA to LAD anastomosis on long-term

Table 2. Intra-operative MIDCAB Complications

Intra-operative Complication	Group 1 No Stabilization (N=11)	Group 2 Stabilization (N=28)
Elective conversion to CPB	3	1
Emergency conversion to CPB	1	0
LIMA extension	1	3

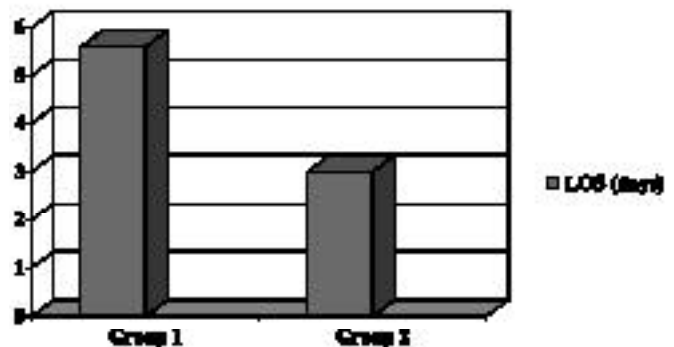


FIGURE 5. The demonstrable reduction in LOS in Group 2 patients, with use of mechanical stabilization.

Table 3. Postoperative MIDCAB Complications (that affected LOS or Mortality)

Postoperative Complication	Group 1 No Stabilization (N=11)	Group 2 Stabilization (N=28)
Early graft failure requiring stent	1	0
Re-operation for kink of LIMA	1	0
Re-operation for bleeding	0	1
Atrial fibrillation	1	4
Post-cardiotomy syndrome	0	4
Cerebrovascular accident	0	2
Wound infection	0	0
Re-admit within 30 days post op	1	2

procedure, by avoidance of both CPB and manipulation of the ascending aorta, would be projected to carry with it a lower rate of neurologic complications than expected for traditional CAB. Though neither stroke event in our series resulted in total disability, our data does not allow us to draw a conclusion on the role of the MIDCAB in reducing peri-operative stroke with CAB.

The re-operative CAB population constitutes a relatively high-risk subset of operative candidates. Twelve of the 28 patients (43%) in Group 2 were re-operative patients with high-risk scores and predicted mortality rates. Nonetheless, these patients did well, an experience similar to that reported by Allen et al [Allen 1997]. Of the 90% of the patients who were free of hospital complications, the LOS was 2.3 days and there was only 1 re-admission to the hospital in the first 30 days of follow-up. Zenati reported diminished hospital costs with MIDCAB versus conventional CABG [Zenati 1997]. The low complication rates and reduced LOS in our MIDCAB patients undergoing redo-CAB confirm significant resource savings using MIDCAB as a clinical strategy. These results also suggest that MIDCAB actually offers outcomes significantly better than predicted for higher risk patients. As Zenati recently suggested, this may render risk models geared for conventional CAB invalid [Zenati 1998].

The immediate postoperative angiographic results are of particular interest. We demonstrated abnormalities in 30% of the postoperative angiograms. In our series, six of 27 Group 2 (22%) patients had anastomotic stenosis of over 50%. Subramanian has reported similar findings [Subramanian 1997]. Angiographic abnormalities could be due to spasm, thrombus, mechanical distortion or true mechanical stenosis. In spite of these angiographic abnormalities, only one patient in our series required late angioplasty of the anastomosis. The other patients remain free of clinical myocardial ischemia in the LAD distribution to date. The significance of early anastomotic abnormalities remains unclear. Our single patient who was re-studied at one month post-op had significant angiographic improvement. In short, the majority of these angiographic abnormalities do not appear to be clinically significant. In order to determine the true incidence and clinical significance of these early postoperative angiographic abnormalities, a comparative trial of

conventional arrested heart versus beating heart LIMA-to-LAD grafting with routine early angiography must be performed. One such trial, the POEM study (patency, outcomes, and economics at midterm), is near closure and results should be available within the next 12 months.

In summary, mechanical epicardial stabilization improves the technical ease of the MIDCAB operation permitting excellent clinical results. These clinical results were manifest in a lower than predicted complication and death rate as well as angiographic patency equal to that obtained with the combination of cardiopulmonary bypass and cardioplegic arrest. Application of these techniques to multivessel coronary revascularization is warranted. It remains to be seen how the MIDCAB procedure influences outcome in late follow-up.

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## REVIEW AND COMMENTARY

### 1. Editorial Board Member NS55 writes:

I do like their premise of trying to show the impact of mechanical stabilization, but they have not demonstrated this at all. If the changes in outcomes are at all different it could just as easily be attributed to multiple other factors, not the least of which is experience with the technique.

To dispense with the high stroke rate by calling it an aberration reveals no respect for the data and belies an underlying prejudice to make the data validate the technique rather than to draw conclusions from the data. This prejudice may have led the authors to draw conclusions that I do not believe are supported by the data.

I believe that the high stroke rate should be investigated with an open mind. Our early data would indicate that the off pump patients may actually be hypercoagulable and this, coupled with the fact that the incidence of atrial fibrillation is NOT lower in the off pump cases might lead to HIGHER stroke rates.

### Authors' Response by E. Charles Douville, MD:

While it is true that the series reported is a consecutive series, and the Group 1 patients (no stabilization) are the earliest ones in the series, we have little doubt that stabilization conferred the improvement in results. Our early problems were unrelated to LIMA harvest; they were attributable either to drug-induced bradycardia/hypotension or technical problems in performance of the anastomosis. It would surely be difficult to find experienced MIDCAB surgeons willing to return to the days of pharmacological cardiac standstill, given the technical facility offered by mechanical stabilization.

We disagree with the criticism that the characterization of a stroke rate of 5.1% as an aberration shows a lack of respect for the data. In a series of 39 patients, a rare, random event may skew the data. There were two CVA's in the series; one due to perioperative atrial fibrillation, which occurred on postoperative day 3 and the other in a severe vasculopath who developed intranuclear ophthalmoplegia. Our response to this data, noted in the manuscript, was to say that we did not have enough evidence to draw a conclusion as to the role of the MIDCAB in reducing CVA rates. We stand by this statement.

The reviewer notes that their data shows that off-pump patients actually are hypercoagulable and this coupled with the fact that atrial fibrillation is not lower, may lead to higher stroke rates. We also find no difference in atrial fibrillation rates with on-pump CAB, off-pump CAB or MIDCAB; all 3 approaches average 15% in our institution. However, in our transsternal Off-pump

CAB series, our CVA rate is 2.8% versus a predicted rate of 4.9% (N=107). Over the same time period, our On-pump CAB CVA rate is 3.6% versus a predicted rate of 3.5% (N=280) We find no evidence that off-pump surgery is associated with higher CVA rates, based on our data. The hypercoagulability hypothesis raised by the reviewer is an interesting one; we are eager to hear more about this in the future.

### 2. Editorial Board Member NC124 writes:

It is obvious that mechanical stabilization is a good surgical resource when performing off-pump coronary surgery, and it is also a good method to perform post op coronary angiography; however, I am very concerned with the 30% of anastomotic abnormalities. I believe that a 50% stenosis, even though it has no hemodynamic significance should be questionable. I do not believe that if a patient is going to undergo a surgical procedure, we should be content with those results; especially because we do not know the long term implications. It is true that those anastomotic abnormalities can be fixed later by angioplasty, but that is not the intent of the operation. Off-pump coronary surgery has been established as a safe treatment alternative, however, we have to match our results and performance with conventional surgery. It is also true that conventional cases do not get as a routine a cath; however, in those cases that by any reason need to be cathed post op, early or late, most show no LIMA-LAD problems. There were no comments regarding the grafted vessels. Not every vessel is the same and the risk of performing a non-perfect anastomosis could be high in some patients; however if entered via a thoracotomy, there are not many options.

### Authors' Response by E. Charles Douville, MD:

We agree that the reported 22% anastomotic stenosis rate (of 50%, or Fitzgibbon grade B) for the LIMA to LAD MIDCAB is higher than expected. Calafiore(1998) has reported 4% and Mack (1998) 8% in recent publications. However Fitzgibbon (1978) reported 15% grade B stenoses at 6 month angiography for anastomoses done on the arrested heart. All of our arteriograms were performed at 60 to 90 minutes after completion of the anastomosis; this is earlier than those of most others and these stenoses may be attributable partially to the inflammatory response. The views were obtained in 2 views only; the worst stenosis in the 2 views is reported.

The methodology used in the POEM study, which requires standard angiography with catheter calibrated, computerized measured stenosis is superior and will lead to more accurate information. Although the early stenosis rate seems high, only one patient has required re-intervention; his was stented late at the site of LIMA to SVG extension. The others have had no clinical events to date. We plan follow-up arteriography in all of these patients as the basis for a future report.

As has been discussed by Mack and others, there is a paucity of published evidence as to the angiographic appearance of these LIMA-LAD anastomoses, on the beating as well as the arrested heart. We can make no further

comment as to the quality of the grafted vessels, but agree that limited access to the LAD with the LAST approach may force grafting to a sub-optimal site on the LAD.

**3. Editorial Board Member MY17 writes:**

There are other variables between group 1 and 2 apart from epicardial stabilization. These include, among others that the surgeons have gained more experience when they come to operate on the group 2 patients.

**Authors' Response by E. Charles Douville, MD:**

It is true that the improved results could also be attributed to experience gained by the time stabilization was available; the differences are so striking, however, that we did not believe that this was the major reason.

**4. Editorial Board Member LO23 writes:**

This study documents a high incidence of both CVA's and atrial fibrillation in patients not being put on car-

diopulmonary bypass. This is a concern as these are arguments for not using cardiopulmonary bypass, and the possible reasons (i.e., anaesthetic techniques etc.) should be more fully discussed.

**Authors' Response by E. Charles Douville, MD:**

In our program, the rate of new onset atrial fibrillation is the same for on-pump CAB, off-pump CAB and MID-CAB; it averages 15% with routine digoxin, beta blockade and magnesium supplementation. The higher than expected CVA rate, we feel, is attributable to the relatively small number of patients in the series and an extraordinarily rare CVA in association with postoperative atrial fibrillation. We would argue that the MIDCAB, with its avoidance of aortic manipulation, is an excellent way to minimize peri-operative CVA. The incidence, however, will never reach zero; at age 65 the population has a 2% to 3% annual CVA rate and some will occur following the MIDCAB.