One-Year Clinical Outcome After Minimally Invasive Direct Coronary Artery Bypass

Roxana Mehran, MD; George Dangas, MD, PhD; Sotiris C. Stamou, MD, PhD; Albert J. Pfister, MD; Mercedes K.C. Dullum, MD; Martin B. Leon, MD; Paul J. Corso, MD

Background—Minimally invasive coronary artery bypass (MIDCAB) is a new surgical technique by which the left internal mammary artery is anastomosed under direct visualization to the left anterior descending artery without cardiopulmonary bypass.

Methods and Results—We followed all 274 patients who underwent MIDCAB from the time it was introduced at a single center. In-hospital and 1-year clinical events were source-documented and adjudicated. The in-hospital major acute cardiac event rate was 2.2%; this included a 1.1% mortality rate. At 1 year, the respective rates were 7.8% and 2.5%. When compared with the initial 100 procedures, the subsequent 174 procedures had shorter vessel occlusion times (10.6 ± 5 versus 14 ± 6 minutes; P = 0.009), times to extubation (6 ± 3 versus 14 ± 10 hours; P < 0.001), and lengths of hospital stay (2.1 ± 1.9 versus 3.2 ± 3.1 days; P = 0.04). Cumulative 1-year adverse cardiac events were 11% in the initial 100 cases and 6% in the subsequent 174 cases (P = 0.17).

Conclusions—Excellent clinical results can be achieved with the MIDCAB technique. The clinical adverse event rate may decrease with accumulated experience. (Circulation. 2000;102:2799-2802.)

Key Words: coronary disease • surgery • grafting

Minimally invasive direct coronary artery bypass grafting (MIDCAB) through a small left anterior thoracotomy without cardiopulmonary bypass has been employed with increasing frequency in the past decade. Despite initial encouraging morbidity and mortality results with the technique,1–3 concerns have been raised about the accuracy and quality of the anastomosis between the left internal mammary artery (LIMA) and the left anterior descending artery (LAD).4–7 Furthermore, MIDCAB results may depend on surgical indications, the selection of patients undergoing the procedure, and the technical experience of the surgeon.

The purpose of the present study was to investigate early and late clinical outcomes after MIDCAB in a consecutive series of patients who were followed for 1 year after the procedure.

Methods

A total of 274 patients underwent MIDCAB at the Washington Hospital Center from June 1996 (when it was introduced) through May 1998; the same group of cardiac surgeons operated on all patients. We excluded the 3401 patients who underwent conventional coronary artery bypass grafting (CABG) and the 335 patients who had beating heart (off-pump) CABG with a complete median sternotomy.

Major indications for MIDCAB included (1) isolated disease to the anterior descending or first diagonal artery; (2) multivessel disease in patients with significant concurrent medical illnesses for whom cardiopulmonary bypass posed a significant risk, such as patients with chronic renal failure, diffuse atherosclerosis of the ascending aorta, advanced age, or respiratory insufficiency8; and (3) patients who had religious convictions that precluded the use of blood products.

Hospital charts were prospectively reviewed, and patients were followed clinically for 1 year. Clinical events were source-documented and adjudicated. Data were recorded in the computerized database maintained by the Cardiovascular Research Foundation.

Statistical Analysis

Descriptive statistics were largely employed. Comparisons were performed between the initial 100 cases and the subsequent 174 cases. Categorical variables were compared using Fisher’s exact test. Continuous variables were expressed as mean ± SD and compared with Student’s t test. P < 0.05 was considered significant. SPSS software 9.0 was used.

Results

Baseline characteristics are summarized in Table 1. Unstable angina, diabetes, hypertension, and hyperlipidemia were frequent. The initial 100 cases included fewer patients requiring redo-CABG than the subsequent 174 cases.

In-hospital results are presented in Table 2. Conversion to on-pump CABG was required in only 1 patient. No patient
needed a conversion to off-pump CABG via median sternotomy. Certain procedural variables seemed to improve with accumulated experience.

The in-hospital major cardiac event rate was 2.2% (mortality rate, 1.1%). Angiograms for persistent postoperative chest pain were performed in 3 patients (1%) and showed a patent FitzGibbon grade A anastomosis.9

Clinical Outcome at 1 Year
At 1 year, the cumulative rates of major adverse cardiac events and mortality were 7.8% and 2.5%, respectively (Table 3). Adverse cardiac events rates at 1 year were 11% in the initial 100 cases and 6% in the subsequent 174 cases (P=0.17).

Causes of death in the initial 100-case subset were acute myocardial infarction (n=2), stroke (n=1), and ruptured aortic aneurysm (n=1). Causes of death in the subsequent 174-case subset were acute myocardial infarction (n=1) and myocardial failure during emergent CABG (n=1). The latter death occurred in a patient who developed acute occlusion of the left main artery and underwent emergent percutaneous transluminal coronary angioplasty and subsequent CABG 1 year after MIDCAB.

In the year after surgery, none of the patients who had angiographic follow-up showed a restenosed (>50% diameter stenosis) arterial bypass conduit.

Discussion
The concept of employing minimally invasive techniques for coronary revascularization proposes that patient morbidity and, potentially, mortality can ultimately be reduced without compromising the excellent results of conventional revascularization techniques. Despite encouraging early reports,1–3 concerns have been raised about the technical limitations of and the accuracy/durability of the anastomosis in MIDCAB surgery.10–13 Moreover, patients must be carefully screened for the procedure to ensure that they can tolerate single-lung ventilation and that their forced expiratory volume within 1 second is >60% of the normal value.

In the present study, we present the 1-year follow-up results of the first 274 MIDCAB cases. One-year clinical events were low, and there was a slight tendency for the event rate to improve with accumulated technical experience.

MIDCAB for reoperative bypass surgery was less frequent in the initial than in the subsequent phase of this study. Recent reports suggest that redo-CABG patients have better outcomes with off-pump than with on-pump CABG surgery.14,15 Avoidance of cardiopulmonary bypass has been associated with decreased rates of postoperative platelet dysfunction and systemic stress from inflammation.16 Over-manipulation of the atheromatous aorta may result in a significantly increased risk of stroke after conventional on-pump CABG.16 Not only does MIDCAB eliminate cardiopulmonary bypass, but it also obviates the need for aortic manipulation.

Postoperative pain management is crucial for successful early extubation. Because MIDCAB has been associated with significant pain during the early postoperative period,17 a more aggressive pain management protocol was adopted in our institution to allow for early extubation, minimize patient discomfort, expedite recovery, and permit early ambulation. In addition to improved pain control, the very low rate of postoperative atrial fibrillation may explain the short length of hospital stay after MIDCAB.18

Perioperative Outcome
Berger et al13 recently reported the early in-hospital patency rate of LIMA-to-LAD anastomosis without a stenosis >50% to be 91% after conventional on-pump CABG. In the present study, despite the absence of angiographic follow-up, the uneventful in-hospital recovery of >99% of the entire cohort seems encouraging for the MIDCAB operation. This is very

---

### TABLE 1. Preoperative Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Initial</th>
<th>Subsequent</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(n=274)</td>
<td>(n=100)</td>
<td>(n=174)</td>
<td></td>
</tr>
<tr>
<td>Age, y</td>
<td>62±12</td>
<td>63±12</td>
<td>62±13</td>
<td>0.8</td>
</tr>
<tr>
<td>Male sex, %</td>
<td>71</td>
<td>68</td>
<td>76</td>
<td>0.1</td>
</tr>
<tr>
<td>Diabetes mellitus, %</td>
<td>23</td>
<td>21</td>
<td>25</td>
<td>0.5</td>
</tr>
<tr>
<td>Hypertension, %</td>
<td>59</td>
<td>62</td>
<td>57</td>
<td>0.4</td>
</tr>
<tr>
<td>Hyperlipidemia, %</td>
<td>72</td>
<td>70</td>
<td>74</td>
<td>0.6</td>
</tr>
<tr>
<td>Renal insufficiency, %</td>
<td>9</td>
<td>5</td>
<td>11</td>
<td>0.1</td>
</tr>
<tr>
<td>New York Heart Association class III/IV, %</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>0.2</td>
</tr>
<tr>
<td>Moderate/severe left ventricular dysfunction, %</td>
<td>9</td>
<td>7</td>
<td>10</td>
<td>0.6</td>
</tr>
<tr>
<td>Unstable angina, %</td>
<td>64</td>
<td>70</td>
<td>60</td>
<td>0.2</td>
</tr>
<tr>
<td>Canadian Cardiological Society angina class III/IV, %</td>
<td>57</td>
<td>59</td>
<td>56</td>
<td>0.6</td>
</tr>
<tr>
<td>Prior myocardial infarction, %</td>
<td>36</td>
<td>35</td>
<td>37</td>
<td>0.8</td>
</tr>
<tr>
<td>Prior cardiac surgery, %</td>
<td>13</td>
<td>4</td>
<td>18</td>
<td>0.001</td>
</tr>
<tr>
<td>Prior stroke, %</td>
<td>5</td>
<td>6</td>
<td>5</td>
<td>0.8</td>
</tr>
<tr>
<td>Prior angioplasty, %</td>
<td>34</td>
<td>34</td>
<td>34</td>
<td>1.0</td>
</tr>
<tr>
<td>Body surface area, m²</td>
<td>2±0.2</td>
<td>2±0.2</td>
<td>2±0.2</td>
<td>0.6</td>
</tr>
</tbody>
</table>

Values are mean±SD or percent of patients.
close to the reported 98% in-hospital patency rate (with possible obstructive stenosis) of LIMA-to-LAD anastomosis after conventional on-pump CABG.\textsuperscript{13}

**Outcome at 1 Year**

A recent report indicated an excellent graft patency rate of LIMA-to-LAD anastomosis after MIDCAB\textsuperscript{19}: early and 6-mont patency rates were 97% and 95%, respectively, with a 3% reintervention rate. Despite the absence of early or late angiographic confirmation of patency in this study, the low repeat revascularization rate supports the safety of MIDCAB as a surgical option for the treatment of coronary artery disease.

**We documented a 1-year reintervention rate of 2.9% and a 1-year actuarial survival rate of 98%. These values were statistically similar between the initial 100 cases and the subsequent 174 cases, although mortality was arithmetically higher in the former group. This small but encouraging improvement in survival rate, as well as the durability of the anastomosis during the course of the study, likely reflects the importance of the learning curve in the long-term clinical outcome of patients after MIDCAB.**

**Limitations**

This was a retrospective study without angiographic follow-up. However, chart review, data entry, and adjudication of cardiac events were independently performed according to prespecified definitions. Multivariate analysis was not performed because of the very low total number of major events.

**Conclusions**

Excellent clinical results can be achieved with the MIDCAB technique. The clinical adverse event rate may decrease with accumulated experience.

**References**


One-Year Clinical Outcome After Minimally Invasive Direct Coronary Artery Bypass
Roxana Mehran, George Dangas, Sotiris C. Stamou, Albert J. Pfister, Mercedes K. C. Dullum,
Martin B. Leon and Paul J. Corso

Circulation. 2000;102:2799-2802
doi: 10.1161/01.CIR.102.23.2799

The online version of this article, along with updated information and services, is located on the
World Wide Web at:
http://circ.ahajournals.org/content/102/23/2799

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published
in Circulation can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial
Office. Once the online version of the published article for which permission is being requested is located,
click Request Permissions in the middle column of the Web page under Services. Further information about
this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to Circulation is online at:
http://circ.ahajournals.org//subscriptions/