Lesions of the Target Vessel During Minimally Invasive Myocardial Revascularization

Francesco Alessandrini, MD, Mario Gaudino, MD, Franco Glieca, MD, Nicola Luciani, MD, Felice Luca Piancone, MD, Marco Zimarino, MD, and Gianfederico Possati, MD

Department of Cardiac Surgery, Catholic University, Rome, and Department of Cardiology, “R. Calai” Hospital, Gualdo Tadino, Italy

Background. Minimally invasive coronary artery bypass grafting has recently been introduced into cardiac surgery. In this report we discuss the incidence of surgically induced distal target vessel stenosis in patients who undergo the minimally invasive coronary artery bypass grafting procedure, which represents a major drawback of the procedure in our experience.

Methods. Doppler evaluation of mammary artery flow was performed postoperatively in all 55 patients who underwent minimally invasive coronary artery bypass grafting at our institution. Angiography was performed in the first 35 consecutive patients for control purposes and in 2 patients who complained of angina recurrence.

Results. In 32 of the first 35 consecutive patients, the anastomosis was found to be functioning normally and the distal left anterior descending artery was normal; in the remaining 3 patients we found mammary artery occlusion, anastomotic stenosis, and stenosis of the anastomosis and the distal left anterior descending artery in 1 patient each. A distal left anterior descending artery stenosis was found in the only 2 patients who underwent late angiography.

Conclusions. Surgically induced distal target vessel stenosis represents a major drawback of minimally invasive coronary artery bypass grafting in our experience. Further improvement in the means of achieving coronary artery occlusion, as well as in anticoagulant and antiplatelet therapy, is mandatory before minimally invasive coronary artery bypass grafting can be confidently accepted into clinical practice.


Since its introduction into clinical practice, minimally invasive direct coronary artery bypass grafting (MIDCABG) has had an extraordinary impact on coronary artery bypass surgery. After the first reports of the procedure from Benetti and colleagues [1] and Subramanian (lecture to the Egyptian Society of Cardiology, Cairo, Egypt, April 1995), a growing number of surgical teams all around the world started to perform minimally invasive coronary artery revascularizations [2–8]. We began performing MIDCABG in January 1995 [9], and since then, we have used this technique in 55 patients. However, we are surprised by and concerned about the number of surgically induced coronary lesions that we have found postoperatively at angiography. In this article we discuss the incidence of these iatrogenic coronary artery lesions in patients who undergo MIDCABG and the possible causes.

Material and Methods

Patient Population

From January 1995 to December 1996, 55 patients underwent MIDCABG at the Cardiac Surgery Department of the Catholic University of Rome. The main preoperative data in these patients are summarized in Table 1.

In 39 patients (70.9%) there was an isolated lesion of the left anterior descending artery (LAD), whereas the remaining 16 patients who underwent the MIDCABG procedure had two- or three-vessel disease. Thirteen of the 16 had reversible ischemia present only in the LAD region. The other 3 patients had end-stage systemic disorders (hepatic cirrhosis, lung cancer, and mediastinal cancer, respectively) and underwent it as a palliative procedure.

Surgical Technique

The chest was opened in the fourth left intercostal space, and the ribs were retracted using a small Finocchietto’s retractor. In the first 3 patients the junction between the fourth rib and the cartilage was sectioned. The pericardium was incised vertically and the LAD exposed.

The left internal mammary artery (LIMA) was harvested skeletonized in 15 patients and pedicled in the remaining patients. Usually LIMA harvesting was performed under direct vision; a thoracoscopy was used for this in the last 3 patients. After systemic heparinization (1 mg/kg), the LIMA was divided, injected with a papaverine solution, and its flow and quality carefully evaluated.

The LAD was then occluded. At the beginning of our experience (ie, in the first 15 patients), we used looping
Table 1. Main Preoperative Data

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>40</td>
</tr>
<tr>
<td>Female</td>
<td>15</td>
</tr>
<tr>
<td>Mean age (y)</td>
<td>60 (range 43–81)</td>
</tr>
<tr>
<td>Age &gt;70 y</td>
<td>16 (29%)</td>
</tr>
<tr>
<td>Unstable angina</td>
<td>23 (41.8%)</td>
</tr>
<tr>
<td>Previous acute myocardial infarction</td>
<td>35 (63.6%)</td>
</tr>
<tr>
<td>Reoperation</td>
<td>1 (1.8%)</td>
</tr>
<tr>
<td>Mean ejection fraction</td>
<td>0.63% (0.15–0.88)</td>
</tr>
<tr>
<td>Ejection fraction &lt;0.35</td>
<td>4 (7.2%)</td>
</tr>
</tbody>
</table>

5-0 Prolene (Ethicon, Somerville, NJ) sutures for coronary occlusion. We then switched to using snare made of silicone elastomer (Intercor; ERCL, Serquigny, France) that were passed twice around the vessel.

The LAD was kept occluded during the preparation of the distal end of the LIMA in order to evaluate the hemodynamic and electrocardiographic effects of the coronary artery occlusion.

The patient received esmolol at a rate of 100 μg · kg⁻¹ · min⁻¹ (Brevibloc; Ohmeda PPD Inc, NJ) keeping the heart rate at 45 to 50 beats/min, and the anastomosis was performed with continuous 7-0 or 8-0 polypropylene single or double running sutures.

After completion of the anastomosis, accessory stitches were used to secure the conduit if the LIMA was pedicled.

Angiographic and Doppler Control
Angiography was performed postoperatively at the department of cardiology of either the Catholic University of Rome or the R. Calai Hospital of Gualdo Tadino. Early angiography was performed for control purposes in the first 35 consecutive patients before discharge or within 15 days of the operation. Successive patients underwent predischarge Doppler echocardiographic evaluation of LIMA flow using an Acuson 128 XP/10; a wide diastolic waveform was considered to indicate a normally functioning anastomosis.

Follow-up
All patients were regularly followed up at our institution. All patients underwent thallium 201 stress myocardial scintigraphy 1 and 6 months postoperatively and then every year thereafter.

Results

Operative Data
The mean LAD occlusion time was 29 minutes (range, 20 to 42 minutes). The mean anastomotic time was 18 minutes (range, 16 to 29 minutes). Temporary occlusion of the LAD was never associated with major electrocardiographic, arrhythmic, or hemodynamic changes.

Clinical Results
One patient died in the hospital. Two days after operation this patient suffered a large anterior myocardial infarction complicated by cardiogenic shock. In a attempt to improve his hemodynamics, we performed an additional emergency saphenous graft procedure on the LAD, without performing repeat angiography. However, irreversible cardiogenic shock occurred after the reoperation and the patient died 2 days later. A thrombosed LIMA graft, a normally functioning saphenous graft, and a large, recent anterior myocardial infarct were found at postmortem examination.

Two patients underwent conventional myocardial revascularization during the same hospitalization after angiography showed a malfunctioning LIMA graft. These 2 patients were then excluded from the follow-up study.

A third patient, shown by angiography to have stenosis at the level of LIMA-LAD anastomosis, refused reoperation.

The mean 12-hour blood loss was 175 mL (range, 30 to 880 mL). One patient was reoperated on for control of excessive bleeding.

No other major complications occurred. The duration of ventilation was 3 ± 1.5 hours. The mean stay in the intensive care unit was 6.2 ± 2 hours, and the mean hospital stay was 4 ± 1 days.

Follow-up
The 52 patients were all regularly followed up at our institution, and follow-up in these patients was 100% complete. The mean follow-up was 13 months (range, 1 to 22 months).

One patient died of hepatic insufficiency 14 months postoperatively. Two patients complained of angina recurrence after discharge from the hospital (3 and 6 months postoperatively). These patients had not undergone early angiography. In both a new echo-Doppler study of LIMA flow, performed after rehospitalization, showed a poor diastolic component that was clearly reduced in comparison with the findings at the first postoperative study (Fig 1). Both patients underwent angiography and then reoperation through a median sternotomy because of a malfunctioning LIMA anastomosis.

Thus 49 patients were available for mid-term follow-up: 48 (97.9%) are angina free and have scintigraphic evidence of no inducible ischemia in the LAD region.

Angiographic Results
In 32 of the first 35 consecutive patients, angiography showed the anastomosis to be functioning normally and the LIMA and the LAD to be normal; in 3 remaining patients we found LIMA occlusion, anastomotic stenosis, and stenosis of the anastomosis and the LAD at the site of application of the occlusive sutures in 1 patient each (Fig 2).

Two patients underwent late angiography for control purposes. In both stenosis of the LAD at the level of the coronary occlusion was found (Fig 3, 4).

Thus a total of three surgically induced distal LAD lesions were found.
Comment

Coronary artery bypass grafting (CABG) without cardiopulmonary bypass implies the need for target coronary artery occlusion in order to provide a bloodless operative field. Benetti [10] and Buffolo [11] and their colleagues, who in the modern era reproposed the performance of beating-heart CABG, occlude the coronary artery using a Prolene suture passed proximally around the vessel and distally to the level of the anastomosis. These authors, who performed postoperative angiography for control only in a minority of cases (Benetti, 76 of 700 [10.8%]; Buffolo, 80 of 593 [13.4%]), did not report coronary artery lesions at the site of application of the occlusive stitches.

Likewise, in none of the published reports of series of beating-heart CABG or MIDCABG have target coronary lesions been consistently noted [2–8, 12–15]. However, even in these studies only a small percentage of patients underwent postoperative angiography.

At least two surgeons familiar with beating-heart revascularization have reported anecdotal cases of iatrogenic lesions of the target coronary artery at the level where the stay sutures were placed [16, 17]. This observation prompted these two authors to abandon this technique and to advise great caution in its routine use. More recently, Nataf and colleagues [18] found LAD occlusion distal to the site of anastomosis in 1 of their 15 MIDCABG patients who underwent postoperative angiography for control purposes.

Experimental studies on carotid and femoral arteries of animal models have shown that an adventitial lesion induced with different techniques (adventitial removal,
positioning of a hollow silicone elastomer collar around the vessel) may initiate the formation of intimal hyperplasia and atherosclerosis [19, 20]. Because the endothelial layer is by far the most fragile structure of the arterial wall, it seems highly possible that the stretching of the coronary vessel caused by the occlusive stitches can lead to various degrees of endothelial damage.

Finally, the possible role of low-dose systemic heparinization and normal platelet function (not impaired by the use of the cardiopulmonary bypass) in promoting...
intimal hyperplasia and thrombosis in patients who undergo no-pump CABG has already been stressed [23].

In our experience LAD lesions at the level of occlusive stitches were found in 3 patients, representing a major concern regarding the MIDCABG procedure. When examining the morphologic features of these surgically induced coronary lesions, we noted that there was a short, well-delimited stenosis at early angiography (see Fig 2), whereas there was a diffuse narrowing at late angiography (see Fig 3, 4).

Even if the temporal evolution of these stenoses cannot be conclusively determined from our cases, it seems likely that a focal, traumatic coronary lesion of small hemodynamic importance can evolve with time to become a diffuse coronary artery narrowing that is hemodynamically significant. This could explain why 2 patients who had normal early echo-Doppler control study had findings of late angina recurrence and were found to have Doppler and angiographic evidence of malfunctioning LIMA-LAD grafts a few months after operation.

In our series the occlusion of the coronary artery was achieved using Prolene or silicone elastomer stitches passed twice around the vessel. After the reported observation of the coronary artery lesions, we began to use silicone elastomer stitches passed only once under the coronary vessel and then simply pulled upward.

Our observations point up the need for further technical improvement in the means of occluding the coronary artery during a MIDCABG procedure; we believe that future studies should focus on ways to less traumatically occlude the coronary artery as well as on the possible importance of other nonsurgical factors, such as full-dose systemic heparinization and preoperative antiplatelet therapy, in reducing the risk of lesions in the target vessel.

We believe that the MIDCABG procedure is one of the most interesting innovations in coronary surgery in recent years and that in the near future its routine use will probably transform the surgical treatment of coronary artery disease. However, at present several technical aspects of the procedure, in particular the means of target vessel occlusion, must be substantially improved before the MIDCABG procedure can be accepted into everyday clinical practice.

References