

# Acute Myocardial Infarction: OPCAB Is an Alternative Approach for Treatment

(#2000-51547 ... September 25, 2000)

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## ABSTRACT

**Background:** Mortality in intensive care units among patients with acute myocardial infarction (AMI) may reach 10-20%, and with cardiogenic shock 50-100%. Moreover, the mortality rate at one year is about 15%, and 25-40% of survivors suffer from recurrent angina. In this report, we describe the surgical results of high-risk patients with AMI who were operated on within 96 hours of the infarction.

**Methods:** From January 1998 through July 2000, among 348 patients who underwent off-pump coronary surgery at the [institution removed for review], 26 consecutive patients (7.5%) were operated on for acute myocardial infarction. Patients with AMI secondary to failed percutaneous transluminal coronary angioplasty (PTCA) were not included in the study group. Four patients (15.3%) were admitted to surgery in cardiogenic shock, four (15.3%) with life-threatening ventricular arrhythmias, and one patient with a rupture of the posterior left ventricular wall. Repeated ventricular fibrillations were recorded in the operating room in three patients (11.5%). In 16 patients, conventional off-pump coronary artery bypass (OPCAB) surgery through median sternotomy was performed using 1-3 saphenous vein grafts, and 10 patients underwent minimally invasive coronary artery bypass (MICAB) with the endoscopic dissection of the left internal mammary artery (LIMA) for single- or double-vessel revascularization.

**Results:** A mean time of  $620 \pm 45$  minutes (range 180 min. to 96 hours) was recorded between first symptoms and surgical reperfusion. The mortality rate was 7.7% (N = 2). Major complications, which included cerebrovascular accident (CVA), were observed in one patient and resulted in a morbidity rate of 3.8%. The mean number of grafts per patient was 1.8. Twenty-two patients (84.6%) under-

went complete revascularization, but four patients (15.4%) with multivessel coronary disease and unstable hemodynamics received incomplete revascularization as a result of not grafting the obtuse marginal or posterior lateral branches of the circumflex coronary artery. In the early postoperative period, all patients were asymptomatic. Early angiographic study was undertaken from five to fifteen days postoperatively in 12 patients (46%); the angiography demonstrated the patency of all studied grafts and the recovery of left ventricular function.

**Conclusion:** Off-pump coronary surgery after AMI can be performed with an acceptable mortality rate and low risk of major complications, and offers prospects for early rehabilitation.

## INTRODUCTION

Mortality in intensive care units among patients with acute myocardial infarction (AMI) may reach 10-20%, and with cardiogenic shock 50-100%. Moreover, the mortality rate at one year is about 15%, and 25-40% of survivors suffer from recurrent angina.

Acute myocardial infarction can be successfully treated with thrombolysis or coronary catheter intervention, but mortality rate still remains high. Surgical treatment—coronary artery bypass grafting (CABG)—is the most effective procedure for coronary atherosclerosis. Experience with early surgical revascularization after AMI began in the mid-1960s. Kolesov reported good results of performing emergent mammary-to-coronary anastomoses in 35 patients with AMI and cardiogenic shock [Kolesov 1966]. Subsequently, Favalaro and colleagues published their initial experience with surgical treatment of 29 patients with AMI [Favalaro 1971]. Despite relatively high mortality rates (i.e., 8.6% for Kolesov and 10.3% for Favalaro), both surgeons considered urgent and emergent coronary surgery very promising.

Enthusiasm for emergent CABG in patients with AMI has diminished with the widespread use of cardiopul-

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*Submitted September 21, 2000; accepted September 29, 2000*

monary bypass (CPB) due to the high risk of fatal outcome and severe complications [Tomasco 1997]. The ischemic myocardium cannot endure the side effects of CPB and cardiac arrest, and several authors have reported a 20-30% mortality rate in patients with AMI undergoing conventional CABG with CPB [Kirklin 1993, Tomasco 1997].

The many studies comparing therapeutic and surgical treatment of patients with AMI, particularly patients with unstable hemodynamics and cardiogenic shock, reveal that it is still a controversial subject and requires further attention [Berg 1975, DeWood 1980, Pfister 1992, Moshkovitz 1995, Buffolo 1996].

Minimally invasive and off-pump coronary artery bypass grafting (MICAB, OPCAB) are widely accepted and effective procedures. Both techniques allow operating on patients with complicated forms of ischemic heart disease and those with contraindications to CPB [Laborde 1989, Benetti 1991, Calafiore 1998]. Among these, patients with AMI represent an interesting and representative group.

At our institution we have employed OPCAB and MICAB technology since 1997, and in this report we describe the surgical results for high-risk patients with AMI who were operated on within 96 hours of the infarction.

## MATERIALS AND METHODS

From January 1998 through July 2000, among 348 patients who underwent off-pump coronary surgery in the [Scifosovskiy Research Emergency Center] 26 consecutive patients (7.5%) were operated on for acute myocardial infarction.

The group included twenty-two males and four females, and the mean age was  $49 \pm 6$  years (range 34 to 65 years). The diagnosis of AMI was made by the conventional electrocardiographic and enzyme criteria and was confirmed by coronary angiography that showed an occluded vessel with a regional wall motion abnormality on the left ventriculogram; seven patients (27%) had single-vessel disease, 19 patients (73%) had multivessel disease and, among these, five patients (19.2%) had more than 50% lesion stenosis of the left main coronary artery (LCA). The location of the infarction was anteroseptal in 21 (80.8%), inferior in four (15.4%), and posterolateral in one (3.8%). Patients with AMI secondary to failed percutaneous transluminal coronary angioplasty (PTCA) were not included in the study group.

Four patients (15.3%) were admitted to surgery in cardiogenic shock, four (15.3%) had life-threatening ventricular arrhythmias, and one had rupture of the posterior left ventricular wall. Repeated ventricular fibrillations were recorded in the operating room in three patients (11.5%).

### *Surgical Technique*

The major hemodynamic consideration was to maintain systemic blood pressure above 100 mm Hg to provide adequate coronary perfusion. Neither B-blockers nor calcium channel blockers were used to slow the heart rate. Heparin was administered in a dose of 2 to 3 mg/kg of body weight

before the internal thoracic artery or the saphenous veins were harvested to keep activated clotting time greater than 400 seconds. Heparin was not reversed with protamine sulfate at the end of the operation. A mean time of  $620 \pm 45$  minutes (range 180 min. to 96 hours) was recorded between first symptoms and surgical reperfusion.

In 16 patients, conventional OPCAB surgery through median sternotomy was performed using 1-3 saphenous vein grafts. First, proximal anastomoses were made on the partially clamped aorta. Local coronary occlusion and stabilization was carried out by placing double-looped 2/0 Prolene sutures and tourniquets proximally and distally to the site of the anastomosis. No routine ischemic preconditioning procedure was performed, except for cases of right coronary artery (RCA) bypass grafting when it was not occluded.

Exposure of the obtuse marginal and posterior lateral branches of the circumflex coronary artery was achieved by gentle, gradual rotation of the heart with the help of the assistant. This procedure sometimes took 10-15 minutes, and no stabilizing system was used.

Ten patients underwent MICAB with endoscopic dissection of the left internal mammary artery (LIMA) for single- or double-vessel revascularization: in this group, single-lung ventilation with collapse of the left lung was performed. Patients were placed in a semioblique position with the left arm placed above the head, leaving access for a sternotomy if necessary ("de cubitus" position). Three 10 mm thoracoports were positioned in the left pleural cavity at the level of the third and the seventh intercostal spaces on the anterior axillary line and at the level of the fifth intercostal spaces along the midaxillary line. A 10 mm, 30 degrees rigid thoracoscope, endoscissors, and endoforceps were used to dissect the whole length of the skeletonized LIMA from its origin at the subclavian artery to the bifurcation. LIMA-to-LAD anastomosis (N = 5) was performed through a 4-5 cm left minithoracotomy in the fourth or fifth intercostal space.

In cases of double-vessel atherosclerosis (N = 5), we used several variants of MICAB technology with composite Y graft (LIMA + a.radialis) or sequential LIMA anastomoses: In two patients, one 6 cm incision, a reversed "L" minithoracotomy, was made to expose the LAD and RCA. In these patients, due to the vertical heart position, it was possible to retract the heart to the right to expose the LAD and then to the left to expose the RCA for performing a successful coronary anastomosis. In two patients, sequential LIMA anastomosis with the diagonal branch (side to side) and the LAD (end to side) was performed through the left anterior minithoracotomy. In one patient, a composite Y graft was anastomosed to the LAD and the obtuse marginal branch through an 8 cm left lateral minithoracotomy.

## RESULTS

The mortality rate was 7.7% (N = 2). One in-hospital death occurred in the operating room due to acute myocardial insufficiency, and one patient died on the 10th

postoperative day due to sepsis secondary to a perforated acute ulcer of the stomach. Nine patients (34.6%) required postoperative infusion of inotropic drugs; five patients (19.2%) required intra- and postoperative intra-aortic balloon counterpulsation. The mean time of postoperative ventilation was  $5 \pm 1$  hours, and intensive care unit (ICU) stay on average was  $42 \pm 5$  hours.

Major complications were observed in one patient, resulting in a morbidity rate of 3.8%, which included cerebrovascular accident requiring ICU stay to be prolonged up to five days. None of the other complications that are typical of CABG with CPB in high-risk patients were observed.

The mean number of grafts per patient was 1.8. Twenty-two patients (84.6%) underwent complete revascularization, but 15.4% of patients ( $N = 4$ ) with multivessel coronary disease and unstable hemodynamics received incomplete revascularization as a result of not grafting the obtuse marginal or posterior lateral branches of the circumflex coronary artery.

In the early postoperative period, all patients were asymptomatic. Early angiographic study was made from five to fifteen days postoperatively. The angiography demonstrated the patency of all studied grafts and the recovery of left ventricular function (Figure 1, ●).

## DISCUSSION

In our clinic, at the beginning stage of performing coronary surgery on the beating heart without CPB in patients with AMI, we consider the following indications for emergent operations (up to 12 hours from the onset of symptoms) and urgent operations (up to 30 days from the onset of first symptoms): refractory cardiogenic shock despite inotropic support and intra-aortic balloon pump (IABP) support; life-threatening ventricular arrhythmias, including ventricular fibrillation; recurrent angina despite maximal medication with coronary dilators and inotropic drugs.

Beating heart surgery allows avoidance of CPB and cardiac arrest. Thus, patients with severe ischemic cardiac dysfunction (including MI) may be operated on with relatively low surgical risk. In patients with stable hemodynamics and cardiac index higher than 2.8 L, we used MICAB surgery and performed complete revascularization in all cases. Patients with unstable hemodynamics and cardiogenic shock were operated on through median sternotomy and only LAD revascularization was performed. Later, two of these patients underwent successful angioplasty of the obtuse marginal branches on the 10th postoperative day.

During an off-pump coronary operation, the surgeon has an obvious advantage in being able to start a functioning graft right after creating a distal anastomosis. In our experience two patients with anteroseptal AMI and cardiogenic shock underwent LAD bypass grafting; after hemodynamic stabilization and regional wall motion recovery due to the patency of the LAD graft, complete revascularization with two additional grafts was performed.

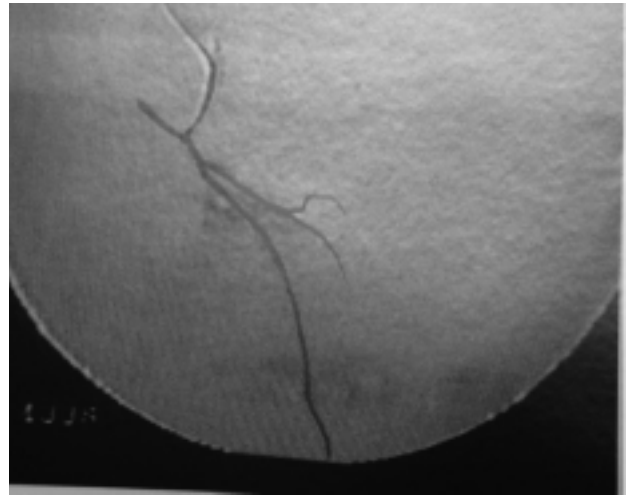


Figure 1.

## CONCLUSION

OPCAB and MICAB may be considered viable alternatives to conventional therapy for MI and may assume a place among myocardial revascularization techniques in patients with AMI. Moreover, one of the indications for CABG on the beating heart without CPB should be AMI. Off-pump coronary surgery in patients who have suffered AMI can be performed with an acceptable mortality rate and low risk of major complications, and offers prospects for early rehabilitation.

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## REVIEW AND COMMENTARY

*Invited Commentary from William E. Cohn, MD and Mark Ruel, MD, Harvard Medical School, Boston, MA*

Emergency coronary artery bypass grafting (CABG) for acute myocardial infarction (MI) has been performed for nearly thirty years [Scanlon 1971]. Nevertheless, despite tremendous advances in diagnostic and support modalities, results of CABG in this setting remain sub-optimal, particularly for patients who require surgery within 48 hours of diagnosis or for those in cardiogenic shock [Braxton 1995, Menon 2000].

The recent proliferation of minimally invasive cardiac surgical techniques has witnessed the emergence of researchers who champion the use of off-pump coronary artery bypass grafting (OPCAB) for emergency revascularization in patients with acute myocardial infarction (MI) [Benetti 1996, Mohr 1999]. Although these investigators report outcomes that range from acceptable to impressive, selection bias may preclude comparison with results of conventional CABG under similar circumstances. One fundamental question therefore remains: Is the use of emergency OPCAB in acute MI a choice based on rationally compelling evidence or a preference for an en vogue modality founded primarily on empirical support?

The concept of OPCAB surgery for acute MI patients is not new. Coronary surgeons have selectively applied it in the past in an attempt to avoid the deleterious effects of cardiopulmonary bypass (CPB) in stable MI patients with significant end-organ dysfunction. It is also generally accepted that acutely ischemic hearts subjected to CPB are at risk for developing severe myocardial edema despite expeditious revascularization, which can result in exacerbation of systolic and diastolic dysfunction and prevent successful weaning from CPB. For these reasons, avoidance of extra-corporeal circulation intuitively might seem desirable in these patients, but several factors must be considered before deciding to follow that course.

### **Hemodynamic Considerations**

The presence of severe hemodynamic instability in acute MI patients traditionally is an absolute contraindica-

tion to using an off-pump approach for revascularization. There is, however, a subset of patients who can be revascularized off-pump with success despite hemodynamic fragility. Several adjuvant tools are available to help temper these events short of CPB, such as the liberal use of intra-aortic balloon counterpulsation (IABP), the initial grafting of the culprit artery, and the use of aorto-coronary shunting, a technique that provides flow from the ascending aorta to the ischemic territory by way of an olive-tipped plastic catheter inserted through the coronary arteriotomy. Each of these techniques has the potential to improve perfusion and hemodynamics, in some cases more rapidly than the use of cardiopulmonary bypass. Furthermore, the routine use of right hemi-sternal elevation and right vertical pericardiotomy prior to addressing the lateral wall targets may limit right ventricular compression and help preserve hemodynamic stability during this particularly challenging part of the procedure.

### **Pulmonary Function**

The use of CPB during acute MI has the potential to exacerbate pulmonary function. Neutrophil-mediated lung injury secondary to cardiopulmonary bypass has long been recognized [Asimakopoulos 1999], and the presence of pre-operative pulmonary edema has been shown to be an independent predictor of post-CPB respiratory failure [Weiss 2000]. By avoiding CPB in these compromised patients, OPCAB could potentially decrease the postoperative ventilation period and the incidence of respiratory complications.

### **Bleeding**

In a prospective randomized study, Ascione et al. demonstrated that patients undergoing OPCAB bled significantly less and had a reduced need for transfusions when compared with patients undergoing conventional CABG [Ascione 1999]. Although these results have not been reproduced in acute MI patients following thrombolytic therapy, one may speculate that the avoidance of CPB in these extreme conditions could also effectively decrease blood loss and the amount of transfusions, which may in itself result in a slightly improved outcome [Spiess 1998, Hebert 1999].

### **No-Reflow Phenomenon**

The inability to perfuse ischemic myocardium despite the restoration of blood flow to large arteries supplying the affected territory, known as the no-reflow phenomenon, is a post-MI state of microcirculatory dysfunction that results from endothelial cell swelling and detachment, neutrophil adhesion, platelet plugging, and unopposed vasoconstrictor influences [Michaels 2000]. This pathological state not only significantly contributes to early infarct extension, but also carries long-term consequences in that successfully revascularized patients who exhibit this phenomenon show a persistent contractile deficit on follow-up, as well as a tendency towards decreased functional status and survival [Ito 1996, Brochet 1998, Matsumura 1998]. The systemic response to cardiopulmonary bypass not only shares much in common with the pathophysiology of the no-reflow phenomenon but could also effectively amplify it

This amplification, though as yet unproven, may account for the untoward outcome occasionally encountered following emergency revascularization of acute MI patients who appeared relatively stable preoperatively.

### Supply-Demand Imbalance

Perhaps the most convincing argument against the use of OPCAB in hemodynamically stable acute MI patients is that an off-pump approach invariably prolongs mechanical work and myocardial supply-demand imbalance during conditions of warm ischemia. In contrast, the heart can rapidly be relieved from supporting the circulation in patients revascularized on-pump. In classic experiments with dogs undergoing coronary ligation for two hours followed by reperfusion, Vinten-Johansen et al. demonstrated that animals randomized to cardiopulmonary bypass, left ventricular decompression, and cardioplegic arrest had smaller infarcts than those whose heart supported the circulation throughout the procedure [Vinten-Johansen 1986]. This is in contrast with the fact that CPB and anoxic cardioplegic arrest inherently cause some myocardial necrosis, a premise that was clinically corroborated in reports demonstrating that patients undergoing OPCAB have a lower incidence of perioperative MI and a decreased release of troponin-I than matched subjects revascularized on-pump [Ascione 1999, Cartier 2000, Wildhirt 2000]. Nevertheless, with experimental infarct models suggesting a benefit from CPB support and in the absence of randomized trials comparing OPCAB to on-pump CABG in acute MI patients, one must recognize that cardiac decompression and relief of mechanical work constitute arguments strongly in favor of the latter approach in this setting.

### Recommendations:

Despite some of the aforementioned factors suggesting that cardiopulmonary bypass is far from ideal in acute MI patients, it still offers unique advantages in that it rapidly provides complete hemodynamic support, unloads the heart, and allows for easy, expeditious, and complete revascularization. Although these benefits could in some patients be theoretically offset by the microcirculatory, pulmonary, and hematologic derangement secondary to CPB, there is as yet little clinical evidence to support the alternative use of OPCAB for emergency revascularization for patients with acute MI. Prospective randomized trials will be required before the relative merits of this evolving technique can be determined in this high-risk group.

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