Early Myocardial Revascularization for Postinfarction Angina: Results and Long-Term Follow-Up

ARUN K. SINGH, MD, FACC, ROBERT RIVERA, RN, GEORGE N. COOPER, JR., MD, KARL E. KARLSON, MD, FACC

Providence, Rhode Island

Within 30 days of acute myocardial infarction, 108 consecutive patients underwent urgent surgical myocardial revascularization for postinfarction angina between July 1976 and March 1983. There were 84 men and 24 women whose mean age was 59.6 ± 9.5 years (range 34 to 80). Group I (15 patients, 14%) underwent surgery within 48 hours, Group II (47 patients, 43%) between 3 and 7 days and Group III (46 patients, 43%) within 30 days. Fifty-nine patients (55%) had transmural infarction. The ejection fraction was less than 40% in 21 patients (19%). Left ventricular end-diastolic pressure was 20 mm Hg or greater in 42 patients (39%). The incidence of single, double, triple vessel and 70% or greater left main coronary artery stenosis was 4, 20, 59 and 17%, respectively.

There were two deaths (1.8%) within 30 days of operation. The incidence of intraaortic balloon pumping was higher in patients operated on earlier after myocardial infarction (53% of Group I versus 22% of Group III). Statistically, there were no differences in the use of inotropic agents or the occurrence of arrhythmias or postoperative myocardial infarction in the three groups. Late follow-up (mean 35 months, range 18 to 98) is complete for all patients (100%). There were four late myocardial infarctions and eight deaths. Actuarial survival was 87% at 5 years. Seventy-three percent of the 108 patients were free of angina and the condition of 14% improved.

These results indicate that myocardial revascularization in the first 30 days after myocardial infarction can be accomplished with morbidity and mortality rates similar to those of an elective operation for chronic angina refractory to medical management.

(J Am Coll Cardiol 1985;6:1121–5)

Persistent or recurrent angina pectoris after myocardial infarction suggests the existence of viable ischemic myocardium either surrounding the infarct zone or distal to it. Despite marked improvement in medical therapy, the reinfarction rate remains high and is associated with a poor prognosis (1–3). Urgent myocardial revascularization in these patients has been an attractive therapeutic alternative to reduce infarct extension. Early reports (4–10) of patients undergoing coronary artery bypass grafting soon after myocardial infarction noted they had an increased operative mortality compared with other patients undergoing revascularization months or years after infarction. Recently, Jones et al. (11) and Williams et al. (12) reported good results with bypass surgery in patients with postinfarction angina. Controversy remains, however, and many clinicians continue to treat these patients on a medical regimen (3,13). We have offered early myocardial revascularization to patients with postinfarction angina refractory to medical treatment and report our experience with 108 consecutive patients.

Methods

Patients. From July 1976 to March 1983, 108 consecutive patients underwent urgent coronary artery bypass grafting for postinfarction angina within 30 days of myocardial infarction. The age range of the patients was 30 to 80 years (mean 59.6 ± 9.5). Men outnumbered women 3.4 to 1. All patients had a documented myocardial infarction with elevation of the serum creatine kinase-MB fraction or diagnostic electrocardiographic changes (for example, the appearance of a new Q wave, loss of the R wave, acute ST-T depression or T wave inversion). The infarcts were localized on the basis of the electrocardiogram and ventriculogram: 45% of the patients had anterior wall, 42% inferior wall and 13% posterolateral wall infarction. Fifty-five percent of the infarcts were transmural (Fig. 1).
Selective coronary arteriography and left ventriculography were performed on all patients before the operation. The distribution of single, double, triple vessel and 70% or greater left main coronary artery stenosis was 4, 20, 59 and 17%, respectively. Twenty-one patients (19%) had an ejection fraction of less than 40%, and 30 patients (29%) had elevated left ventricle end-diastolic pressure (>20 mm Hg). Every patient received maximal medical therapy (beta-receptor blocking agents, isosorbide dinitrate [Isordil], nitrates, slow channel calcium blockers). Other causes of chest pain, such as pericarditis, were excluded before surgery. Most episodes of angina were associated with electrocardiographic changes.

The patients were arbitrarily classified into three groups according to the interval between the infarction and surgery: Group I (less than 48 hours), 15 patients (14%); Group II (3 to 7 days), 47 patients (43%); and Group III (8 to 30 days), 46 patients (43%). Thirty-one patients (30%) required intraaortic balloon pumping to stabilize hemodynamic status. The cardioplegic solution was reinfused into the aortic root after completion of each distal anastomosis, on return of electromechanical activity or at intervals of 15 minutes. A single aortic cross-clamping was used for all proximal and distal anastomoses. The cross-clamp time ranged from 14 to 72 minutes (mean 56). Left and right atrial pressures were routinely monitored after bypass. Single coronary artery bypass grafting was performed in 3 (2%) of the 108 patients and three or more coronary bypass grafts were performed in 73 (69%). The mean number of grafts was 2.7 per patient. Additional procedures were also carried out: mitral valve replacement (three patients), ventricular aneurysmorrhaphy (five patients) and encircling endocardial ventriculotomy (one patient).

Results

Hospital mortality and morbidity. The 30 day operative mortality rate was 1.8% (2 patients) (Table 1). During the same period, our mortality rate for elective coronary artery bypass was 2%. One death was due to ventricular fibrillation in a patient whose postoperative electrocardiogram was recorded in all patients. Cardiopulmonary bypass was instituted using two caval cannulas and snaring the venae cavae. A non-blood prime was used and the perfusion temperature was lowered to 28 to 30°C. The left ventricle was decompressed through the right superior pulmonary vein. The aorta was cross-clamped, and cold cardioplegic solution (14) was immediately infused with a roller pump through a 14 gauge needle inserted into the aortic root. To ensure maintenance of a continuously cold heart, the pericardial sac was filled with cold Ringer's lactate solution (4°C) and saline slush.

All coronary bypasses were made with saphenous veins, and distal anastomoses were performed first. The first anastomosis was made to the artery with the most critical stenosis so that cardioplegic solution could be delivered through the vein graft to the ischemic myocardium (15). The cardioplegic solution was reinfused into the aortic root after completion of each distal anastomosis, on return of electromechanical activity or at intervals of 15 minutes. A single aortic cross-clamping was used for all proximal and distal anastomoses. The cross-clamp time ranged from 14 to 72 minutes (mean 56). Left and right atrial pressures were routinely monitored after bypass. Single coronary artery bypass grafting was performed in 3 (2%) of the 108 patients and three or more coronary bypass grafts were performed in 73 (69%). The mean number of grafts was 2.7 per patient. Additional procedures were also carried out: mitral valve replacement (three patients), ventricular aneurysmorrhaphy (five patients) and encircling endocardial ventriculotomy (one patient).

Table 1. Complications and Results of Early Revascularization Surgery in 108 Patients

<table>
<thead>
<tr>
<th>Group</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>Total</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Myocardial infarction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perioperative</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>5</td>
<td>4.6</td>
</tr>
<tr>
<td>Late</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>3.7</td>
</tr>
<tr>
<td>Ventricular arrhythmias</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>5</td>
<td>4.6</td>
</tr>
<tr>
<td>IABP (decreased CO)</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>2.8</td>
</tr>
<tr>
<td>Deaths</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Early</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1.8</td>
</tr>
<tr>
<td>Late</td>
<td>1</td>
<td>2</td>
<td>5</td>
<td>8</td>
<td>7.5</td>
</tr>
</tbody>
</table>

CO = cardiac output; IABP = intraaortic balloon pumping.
gram and creatine kinase-MB enzymes were normal. The second patient died on the third postoperative day from complications of an intraaortic balloon inserted preoperatively for hemodynamic instability and a left ventricular ejection fraction of 18%. He remained in low cardiac output failure postoperatively and developed thrombosis of the distal aorta, renal failure and necrosis of the calf muscles. Five patients had extension of infarction or new infarction distant from the original site perioperatively. Three of these patients required intraaortic balloon pumping; all survived. Ventricular arrhythmias, consisting of multifocal premature ventricular complexes, ventricular tachycardia and fibrillation occurred equally in each group (Table 1). Postoperative use of inotropic agents was similar in each group. The average hospital stay postoperatively was 10.4 days, similar to that of elective coronary artery bypass surgery.

Long-term follow-up and anginal status. All patients were seen by the referring cardiologist or questioned by telephone in September 1984. The follow-up was complete for all 106 patients, with a total of 3,783 patient-months (mean 35). Seventy-three percent of the patients were free of angina. Fourteen percent (15 of 106) were improved but have some degree of angina. Thirteen percent had severe angina and required maximal medical therapy. Nineteen of 21 patients who had an ejection fraction of less than 40% during coronary artery bypass surgery are alive and have remained in New York Heart Association functional class II for a mean follow-up period of 33 months. There were two late deaths in this group, one due to a cardiac event (3 years after surgery) and one after 5 years secondary to carcinoma. Three patients required reoperation 1 to 3 years after initial operation and now are completely asymptomatic. Postoperatively, left ventricular function was unchanged in these three patients from that recorded on the initial catheterization.

There were eight late deaths in the entire series, five due to a cardiac event, two due to end stage renal failure and infection and one secondary to carcinoma. Actuarial survival at 1 year is 95% and at 4 and 5 years 87% (Fig. 2). Repeat cardiac catheterization was performed 3 to 36 months after operation in 10 symptomatic patients. Graft patency was 82% (24 of 30 grafts). When left ventricular wall motion by postoperative angiography was compared with left ventricular wall motion the same patient at the time of original catheterization, most patients demonstrated either no change or improvement, as judged by ejection fraction.

Discussion

Prognosis of postinfarction angina and infarct extension. Postinfarction angina usually results from either incomplete infarction distal to an obstructed coronary artery or loss of collateral blood supply to the myocardium or in an area away from the original infarction, but supplied by another critically stenosed artery (16). It is associated with a high incidence of reinfarction (13 to 86%) and mortality (1–3, 17–19). Overall, mortality has been recorded as high as 15% during the first year and 30% by the third year after infarction. Approximately half of these deaths are sudden (13). Fraker et al. (2) retrospectively analyzed 458 patients admitted to their coronary care unit. Hospital mortality in patients with extension of infarction was 36%, versus 9% for patients without infarct extension. The early mortality associated with acute transmural infarction is approximately double that of subendocardial infarction (29 versus 14%) (20). Subsequent infarction, however, is significantly higher in the subendocardial group (26 to 46%) than in the transmural group (10 to 24%) (2, 8, 18, 21). One year survival for patients with infarct extension was 76% and for matched patients without extension was 91% (2). Almost one-half of the patients with subendocardial infarction will have an extension of the infarct an average of 10 days after the initial event (20), usually associated with double or triple vessel disease and well preserved ventricular function (17). It is clear from these studies that infarction extension carries a poor prognosis.

Role of ischemia at a distance. Schuster and Bulkley (16) described clinical and pathologic findings in 20 patients admitted with postinfarction angina. Twelve patients had postinfarction angina associated with transient ST-T wave changes in the electrocardiographic zone of the occluded vessel (that is, postinfarction ischemia in the infarct zone). In eight patients, however, postinfarction angina and transient ST-T wave changes developed in the electrocardiographic zone of a nonoccluded but critically narrowed vessel (that is, ischemia at a distance). Compared with patients who had ischemia in the infarct zone, patients who had ischemia at a distance were in a lower Killip class and experienced more deaths, ventricular arrhythmias and significantly smaller infarcts at autopsy. Thus, death in patients with ischemia at a distance appears to be related more to
the ischemic event than to the quantity of myocardium lost. This concept of ischemia at a distance leads many to proceed with prompt cardiac catheterization in such patients (5–8, 22). Persistent or recurrent pain after infarction implies that the cardiac event is not yet complete and suggests that more aggressive invasive management might improve patient survival (16, 23).

The mechanisms of early postinfarction angina are largely unknown. Coronary artery spasm is one of the possibilities and is known to occur in the acute phase of myocardial infarction (24). Apart from reopening and recollusion of a coronary artery by spasm (2), recannulization of thrombus followed by the formation of a new thrombus and infarction may be responsible. Many studies of intracoronary streptokinase have shown that these factors certainly do exist (25).

Results of surgical revascularization versus medical therapy. Early surgical reports (4,9,10,26–28) suggested that coronary artery bypass surgery can be performed safely during or shortly after acute myocardial infarction. It became an attractive option for some patients with postinfarction angina to decrease infarct extension and its sequelae. However, many centers continue to manage these patients medically (13, 19). Rogers et al. (13) found no statistical difference in 3 year survival between the patients treated surgically compared with those treated medically after acute myocardial infarction. However, 75% of those patients had no associated angina at the time of surgery, whereas in this series and others (11, 12) the major indication for surgical intervention was postinfarction angina. The early reports (4,10) of coronary artery bypass grafting carried out soon after myocardial infarction noted an increased operative mortality rate. Surgery for such patients was not routinely considered until Jones et al. (29) reported a series of 35 patients who underwent coronary artery bypass surgery within 30 days of infarction without an early or late death. This series has been extended to 116 patients without a hospital mortality (11).

During the same period of time Brundage et al. (3) and Bardet et al. (30) reported on a smaller group of patients with a mortality rate in the range of 7 to 9%. Recently, Williams et al. (12) reported their experience with 103 operations for postinfarction angina with a mortality rate of 1.8%. The mean ejection fraction in the group of Jones et al. (11) was 0.40 or less in 17.5% of the 97 patients and 0.35 or less in 10% of the patients, a value similar to that in our patients. However, 57% of our patients required urgent bypass surgery within a week of infarction compared with only 24% of the patients of Jones et al. and 31% of those of Williams et al. Eighty-two percent of the patients of Jones et al. had transmural infarction. However, 57% of our patients required urgent bypass surgery within a week of infarction compared with only 24% of the patients of Jones et al. and 31% of those of Williams et al. Eighty-two percent of the patients of Williams et al. had a subendocardial infarction, in contrast to those of Jones et al. and ours, the majority of whom have had transmural infarction.

Role of intraaortic balloon pump. Use of the intraaortic balloon pump was greater in our experience than in that of others (3, 11, 12) because more patients have undergone urgent cardiac catheterization and surgery during the first week after infarction and were in unstable condition. The intraaortic balloon pump is not necessary in most patients undergoing revascularization after myocardial infarction, but if the patient remains hemodynamically unstable despite maximal medical therapy or has significant ventricular dysfunction, intraaortic balloon pumping rapidly controls angina and stabilizes the patient’s condition before catheterization. Although there are complications from the intraaortic balloon pump it may be used safely if certain guidelines are followed (31).

Role of thrombolytic therapy and coronary angioplasty. Recently, thrombolytic therapy with intracoronary or intravenous streptokinase, urokinase or tissue plasminogen activator has been utilized in acute myocardial infarction (32–34). Reperfusion can be accomplished in 70% or more of patients with relief of pain and resolution of ST segment elevation. However, early thrombotic reocclusion remains a significant problem (17, 35). The majority of such patients will require definitive surgical therapy within a few days after thrombolysis. Patients with single vessel coronary stenosis with favorable anatomy may undergo percutaneous transluminal coronary angioplasty, although the long-term effects on survival are unknown. The use of coronary angioplasty for multiple vessel disease in the treatment of acute myocardial infarction has been encouraging (36, 37), but long-term studies of mortality and function are required before it becomes widely accepted. The complication rate after angioplasty, including acute occlusion of the artery, acute dissection, coronary aneurysm formation and reocclusion or stenosis, remains alarming (38, 39). Because 2% of our patients required only a single bypass, it is likely that the majority of this group of patients were not appropriate candidates for coronary angioplasty.

Conclusions. Although our patients with postinfarction angina, and those in other reports, were not randomly allocated to medical or surgical therapy, the results suggest that operation can be performed safely in these selected patients with fair distal vessels and adequate left ventricular function. However, each patient must be evaluated individually. Surgical morbidity and mortality have decreased with the use of intraaortic balloon support and better myocardial preservation, so that postoperative results are comparable with those after elective coronary artery bypass surgery.

We acknowledge the assistance of W. Martin DeLuca, PA, Steven Reinhardt, BS and Cynthia Santucci in the preparation of this manuscript.

References


