reduction of myocardial blood flow, demonstrated by thallium-201 scintigraphy, as a cause of variant angina. Circulation 54: 280, 1976

Emergency Revascularization for Unstable Angina

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SUMMARY Emergency revascularization for unstable angina (defined according to criteria of the National Cooperative Study Group) was performed in 100 consecutive patients. The mean interval from onset of pain to operation was one day. Nineteen patients had single-vessel narrowing of greater than 70% of lumen diameter, 32 double-vessel obstruction and 49 triple-vessel disease. Fourteen of these patients had left main trunk obstruction. Four patients died within 30 days, three from complications of myocardial infarction. Seventeen of 96 (18%) early survivors sustained perioperative infarction. After a mean follow-up of 42 months, four late deaths and three late infarctions occurred. Postoperative angiography in 47 patients (mean interval 14 months) showed 86% graft patency. Of 92 survivors, 72 are symptom-free. Three of the four operative deaths occurred within 24 hours postoperatively; in each of these, postmortem examination confirmed a recent myocardial infarction which antedated the operation, despite the absence of new infarction in the preoperative electrocardiogram or elevation of cardiac enzymes. Results from this emergency series suggest that, although myocardium may be salvaged in some instances, in other cases infarction has already occurred and treatment might better be directed toward alleviation of acute ischemia to provide a stable period in which diagnostic studies are performed and acute myocardial infarction may be ruled out.

SINCE MYOCARDIAL INFARCTION is a retrospective diagnosis, anginal pain that may precede myocardial infarction is unpredictable and difficult to classify. Depending on criteria for definition, the syndromes of unstable angina probably have varying prognoses. The National Cooperative Study Group has created a homogeneous category for definition purposes and undertaken a randomized prospective study of medical and surgical treatment. Their protocol required a period of stabilization and observation to rule out infarction. Until recently, our therapeutic approach to unstable angina included immediate operation whenever the angiograms were completed, i.e., to dispense with the traditional "cooling off" period.

Our protocol for surgical treatment of unstable angina has been relatively uniform over the past five years. Patients who were thought to have unstable angina were admitted to the coronary care unit, treated with sedation and nitrates, and if severe coronary atherosclerosis was documented by arteriography, the patient was offered emergency revascularization. The interval from admission to operation was brief in most instances, and the objective was to provide expeditious emergency revascularization. In this analysis, we selected consecutive patients who met the criteria of the National Cooperative Study, except that we included patients with severe left main coronary disease. The results reported here represent our initial approach to the surgical treatment of unstable angina.

Clinical Material

One hundred consecutive patients who underwent emergency revascularization for unstable angina between December 1970 and January 1976 were reviewed retrospectively. Excluded from this report are patients with unstable angina who became stable during an initial period of observation and had elective surgery later and patients who had previous graft surgery.

Criteria used to define the study group were: 1) episodes of angina at rest, either of new onset or a changing pattern, more frequent, more severe, more prolonged, or occurring at rest, and which was
sufficiently severe to cause admission to the intensive care unit within seven days before surgery; 2) transient ST or T wave changes indicative of ischemia without the development of new Q waves or loss of R waves suggestive of myocardial infarction; 3) cardiac enzyme levels <50% above the upper limit of normal within 24 hours before surgery; and 4) angiographic studies confirming the presence of coronary disease with a lesion >70% in one or more of the major coronary arteries with technically graftable distal vessels and preserved ventricular contraction in the area of proposed graft.

The study group included 81 men and 19 women, aged 36–72 years (mean 54.5 years). Angiography was performed by the Sones technique. Nineteen patients had single-vessel disease, 32 double-vessel disease, and 49 triple-vessel disease. Fourteen of these patients had lost main trunk obstruction. The anterior descending coronary artery was obstructed >70% in 95% of the cases. Fourteen patients had narrowing >70% in the left main coronary artery, and 37 had a documented prior myocardial infarction. The mean interval between admission and operation was one day. Surviving patients were followed a minimum of 18 months (mean follow-up 42 months), and postoperative cardiac catheterization was done in 47 of the surviving 96 patients at a mean interval of 13.8 months (range one week–72 months).

Results

Four patients died within 30 days of surgery, and four died five to 48 months after surgery. Three of the early deaths occurred within 24 hours of surgery and at autopsy all six grafts were patent, but there was clear evidence of a recent myocardial infarction antedating the operative procedure. The fourth patient died from low cardiac output and renal failure four weeks postoperatively. Four patients required early reoperation for postoperative bleeding, and had an uneventful postoperative course. Two patients had superficial infection which responded to conservative therapy. Seventeen (18%) of the 96 early survivors showed definite myocardial infarction in the immediate postoperative period confirmed by new Q waves and elevation of serum glutamic oxaloacetic transaminase (SGOT) above 100 units. Of the four late deaths, one resulted from a noncardiac cause, two resulted from documented acute myocardial infarction and one was sudden. Three survivors have sustained documented late myocardial infarction. These patients have undergone subsequent reoperations, one for graft failure at three months and two for symptoms resulting from progressive atherosclerosis at 15 and 34 months postoperatively.

After a mean follow-up of 42 months, 72 patients (78%) were functional class I according to the criteria of the New York Heart Association, 15 (16%) class II, 4 (5%) class III, and one patient was considered class IV. Postoperative cardiac catheterization in 47 patients showed 78 of 91 grafts were patent (85.7%). Of 34 grafts to the anterior descending artery, 31 were patent (91.2%). Of nine patients who had sustained a perioperative infarction and underwent postoperative catheterization, four showed graft occlusion in the area of infarction indicated by new Q waves on the electrocardiogram. Postoperative left ventricular function was compared with the preoperative status by subjective comparison of myocardial segmental motion and left ventricular end-diastolic pressure. Thirty-eight of 47 patients undergoing recatheterization showed either no deterioration, or some degree of improvement when compared with preoperative left ventriculograms; nine showed deterioration of function, of whom six had an occluded graft to the area of new impairment by ventriculography, four had also shown electrocardiographic evidence of perioperative infarction.

In an attempt to delineate a high-risk subgroup of patients in this series, several factors were considered. In Table 1 the series has been subdivided into two groups by the mode of onset of symptoms: those who had an acute new onset of unstable angina pectoris and those who had unstable angina superimposed on a pattern of previously stable chronic angina. There were no deaths in the “new onset” group, which also had a lower incidence of triple-vessel disease (24% in acute vs 59% in chronic). There was a higher incidence of perioperative infarction in the “new onset” group (24%) compared with the chronic group (15%). In 62 patients among whom all lesions of 70% or more occlusion in major vessels were bypassed (complete revascularization), the combined early and late mortality was 3.2%. In contrast, 38 patients had incomplete revascularization due to ungraftable vessels, and the combined early and late mortality was 15.8% (P < 0.025).

Excluding the 14 patients with left main coronary artery disease, the early and late mortality was 3.5% and 2.5%. The preoperative extent of disease did not significantly affect mortality (Table 2).

Discussion

Many of the early studies of patients with unstable angina were associated with high rates of early mortality and myocardial infarction. In a 10-year follow-up of patients with unstable angina, Gazes et al. reported that the high-risk subgroup of patients with ECG changes had a 12-month survival of 57%. Within three months of the onset of unstable angina, myocardial infarction occurred in 35% of patients, with an associated mortality rate of 63%. These early

<table>
<thead>
<tr>
<th>Onset of Unstable Angina</th>
<th>Acute (29)</th>
<th>Chronic (71)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>27 (93.1%)</td>
<td>54 (68.5%)</td>
</tr>
<tr>
<td>Female</td>
<td>2 (6.9%)</td>
<td>17 (31.5%)</td>
</tr>
<tr>
<td>Early mortality</td>
<td>0</td>
<td>4 (5.6%)</td>
</tr>
<tr>
<td>Late mortality</td>
<td>0</td>
<td>4 (5.6%)</td>
</tr>
<tr>
<td>Perioperative myocardial infarction</td>
<td>7 (24.0%)</td>
<td>10 (14.9%)</td>
</tr>
</tbody>
</table>
TABLE 2. Emergency Revascularization for Unstable Angina

<table>
<thead>
<tr>
<th>Extent of disease</th>
<th>Preoperative extent atherosclerotic disease vs mortality</th>
<th>No.</th>
<th>Early mortality</th>
<th>Late* mortality</th>
<th>Total mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>SVD</td>
<td>19</td>
<td>1 (5.3%)</td>
<td>0 (0)</td>
<td>1 (5.3%)</td>
<td></td>
</tr>
<tr>
<td>DVD</td>
<td>28</td>
<td>1 (3.6%)</td>
<td>1 (3.6%)</td>
<td>2 (7.2%)</td>
<td></td>
</tr>
<tr>
<td>TVD</td>
<td>39</td>
<td>1 (2.6%)</td>
<td>1 (2.6%)</td>
<td>2 (5.2%)</td>
<td></td>
</tr>
<tr>
<td>LMT</td>
<td>14</td>
<td>1 (7.1%)</td>
<td>2 (14.2%)</td>
<td>3 (21.3%)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>4 (4%)</td>
<td>4 (4%)†</td>
<td>8 (8%)</td>
<td></td>
</tr>
</tbody>
</table>

Seventeen patients (18%) had perioperative infarction.
*Follow-up 12-78 months (mean 36 months).
†One non-cardiac death included.
Abbreviations: SVD = single-vessel disease; DVD = double-vessel disease; TVD = triple-vessel disease; LMT = left main trunk.

medical series did not have angiographic documentation of severe obstructive lesions in the coronary arteries. Bertolasi,6 Wisoff,6 Scanlon7 and their associates reported that 5–19% of patients with a preliminary diagnosis of unstable angina do not have severe coronary artery disease by angiography. Thus, any comparison of medical and surgical management of this condition must be in a strictly defined setting and include both clinical and angiographic documentation of significant obstructive coronary artery disease.

All patients in this series had surgery within 24 hours of their admission with unstable angina, and the majority within 24 hours of cardiac catheterization. No attempt was made to stabilize them before surgery by the use of intraaortic balloon pumping or by routine use of propranolol. The early mortality and perioperative infarction rates were approximately four times higher than occurs in our experience with elective revascularization. The incidence of perioperative infarction is similar to other reports in which the incidence ranges from 11–18%,1, 6, 17, 7, 8

There have been three randomized prospective studies reported in which medical and surgical management for unstable angina were compared6–7 (table 3). After a 30-month follow-up, the National Cooperative Study Group6 found the early (hospital) infarction rate was twice as high for surgically treated patients (17% vs 8%); the mortality was equal (10%);

however, improvement in symptoms was better for the surgical cohort. The fact that 36% of the group originally randomized to medical treatment had operative intervention (49% of those with triple-vessel disease) precludes a meaningful comparison of longevity. This “crossover” reflects surgical treatment of medical failures. Nonetheless, conclusions of this study are important. They have shown that in most patients, unstable angina can be stabilized in the coronary care unit. Although high risk patients could not be accurately predicted angiographically, those with triple-vessel disease were more likely to require early surgical intervention. When complete revascularization was achieved, we consistently observed good late results in symptom relief.

In their initial report, Bertolasi et al.6 attempted to categorize the syndrome of unstable angina by creating homogeneous groups. One of these, the intermediate syndrome, corresponds to the National Cooperative randomized prospective study, and to our surgical patients. Bertolasi and coworkers (Bertolasi CA, Tronge JE, Turri D: Clinical spectrum of "unstable angina": unpublished data) updated this experience in 1977, and included 24 patients with intermediate syndrome randomized to medical treatment. The average follow-up was 50 months; seven patients (29%) died during the first four months. By the end of the second year 10 patients (42%) had died, and after 50 months the mortality was 50%. There was no crossover to surgical treatment.

The report by Selden and associates10 was a short-term study. Although no deaths or infarctions occurred during the hospital phase of treatment, at four months nine of the 20 patients medically randomized had been operated on, and the majority of the 11 remaining patients were severely disabled by angina pectoris (Rahimtoola SH: personal communication).

The patients in our surgical series fulfilled the criteria used by the National Cooperative Study Group with the exception that we included 14 patients with severe left main coronary artery narrowing. Also, in the National Cooperative Study, patients were observed for at least 48 hours before surgery, which allowed time to detect myocardial infarction; thus, those with evolving infarction should be excluded from the study group. In our 100 surgically treated patients, surgery for the majority of patients was performed

<table>
<thead>
<tr>
<th>Table 3. Emergency Revascularization for Unstable Angina</th>
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<tbody>
<tr>
<td>Results in Randomized Series</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>No. patients</td>
</tr>
<tr>
<td>Early infarction</td>
</tr>
<tr>
<td>Early mortality</td>
</tr>
<tr>
<td>Late infarction</td>
</tr>
<tr>
<td>Late mortality</td>
</tr>
<tr>
<td>Follow-up</td>
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</tbody>
</table>

Abbreviation: NCSG = National Cooperative Study Group.
within 24 hours of the first episode of unstable angina.

From our experience, emergency revascularization can be accomplished with low early mortality and good late results but with a relatively high incidence of perioperative infarction. This complication is related to the timing of the operative procedure. In some patients myocardial infarction began before, and evolved during and after the operation as verified by postmortem findings in three of our four operative deaths. Subjecting a patient with ischemia to anesthesia and anoxic arrest during the grafting procedure may potentially convert an ischemic area into infarction. Other potentially deleterious factors include reperfusion injury in an ischemic area, and the routine use of normothermic perfusion and anoxic arrest.

Levine et al. reported a series of patients with unstable angina by the criteria used in this series; the early mortality rate was 3.2% and the perioperative infarction rate was 2.2%. Patients refractory to medical management including rest, sedation, propranolol, nitrates, and pharmacologic afterload reducing agents received an intraaortic balloon pump. Within 24 hours after stabilization they underwent cardiac catheterization. Surgery was performed 24–48 hours after cardiac catheterization. This period allowed time to stabilize the patient, reduce ischemia, and exclude patients with evolving myocardial infarction. Judicious medical management combined with well-timed surgical intervention in selected patients may be ideal treatment. The high operative infarction rate in our series suggests that an early attempt to salvage myocardium increases the incidence of perioperative infarction — preoperative, intraoperative, and postoperative. This may be reduced by a longer period of stabilization, but not without risk of preoperative loss of myocardium. This approach may permit a reduction of myocardial ischemia and identification of those patients who have sustained permanent myocardial infarction. Evidence indicates that a decline in morbidity may be expected when patients are operated on electively rather than under emergency circumstances.

References

Emergency revascularization for unstable angina.
L A Golding, F D Loop, W C Sheldon, P C Taylor, L K Groves and D M Cosgrove

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