Late Results Following Emergency Saphenous Vein Bypass Grafting For Unstable Angina

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SUMMARY
Fifty-five consecutive patients with intermittent resting chest pain persisting more than 24 hours after hospitalization and accompanied by ECG changes representative of ischemia were operated urgently more than one year ago. Recent cases with shorter follow-up are excluded. Twenty-eight patients had single grafts, 23 had double grafts, three had triple grafts, and one a quadruple graft. There were three operative deaths (5%) and one sudden late death (2%). There were six early MIs and three late MIs. Follow-up ranges from 12 to 52 months (mean 24 months) with nine patients followed for four years. Actuarial analysis indicates a projected survival rate of 93% three years postoperative. Twenty-three survivors are Functional Class I, 19 are FC II, and eight are FC III. Functional class could not be determined in one survivor. Thirty patients had postoperative angiography one week to 32 months postop. 35/51 grafts were patent. Only three patients had no patent grafts. There were no significant differences between mean preoperative and postoperative left ventricular end-diastolic pressures (assessed in 20 patients) or ejection fractions (assessed in ten patients). The extremely low mortality early and late postop (7%), the low incidence of MI (16%), and the excellent functional results after extended follow-up indicate that emergency saphenous vein bypass grafting is an effective therapy for unstable angina.

Additional Indexing Words:
Ischemic heart disease
Open heart surgery
Functional class
Actuarial analysis
Coronary artery disease

Unstable Angina is a clinical syndrome in patients with coronary artery disease for which there is no specific medical therapy that is both widely accepted and effective. It has been suggested that the prognosis after hospitalization is benign, and that, in general, such patients should be treated conservatively in the acute phase. On the other hand, others have described good results early after saphenous vein aortocoronary bypass grafting, although long-term follow-up of large numbers of postoperative patients has not yet been reported. In addition, although it has been stated that unstable angina is intermediate in gravity between chronic stable angina and acute myocardial infarction, descriptions of the clinical picture have varied substantially.

We report our experience with 55 consecutive unselected patients who had emergency coronary arteriography and SVBG for unstable angina more than one year ago. Patients with shorter follow-up are intentionally excluded to allow more accurate analysis of long-term results. The clinical syndrome in our patients is precisely described, and it conforms to that of the "high-risk" subgroups in other series. Long-term follow-up for more than four years after operation is analyzed by actuarial techniques.

Definition
The term unstable angina is used in this study to denote a clinical syndrome in which anginal episodes occur with increasing frequency and/or severity (crescendo) and culminate in recurrent attacks of chest pain at rest that continue to occur more than 24 hours after hospitalization despite supportive measures. Transient electrocardiographic evidence of myocardial ischemia such as ST depression or elevation or T wave inversion is present during at least one episode of chest pain. In occasional patients transient ventricular arrhythmias during chest pain have similar significance. Myocardial infarction (MI) cannot be documented by serum enzyme studies or by electrocardiography. Narrowing of the lumen of one or more coronary arteries by at least 50% can be demonstrated angiographically. Patients may or may not have a history of prior chronic angina and/or myocardial infarction.

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Clinical Material

Fifty-five consecutive patients with unstable angina as defined above had coronary arteriography and emergency SVBG at the University of Oregon Medical School, St. Vincent, and Portland VA Hospitals from September, 1969, to February, 1973. All patients had recurrent chest pain at rest for at least 24 hours after admission. The intervals between hospital admission and operation are displayed in figure 1. All but six patients had operations more than 48 hours after admission, and the mean interval was four days. There were 38 men and 17 women who ranged in age from 35 to 68 years (mean 53 years). Thirty-four patients had a history of chronic angina with recent acceleration; 21 had their first episode of angina less than three months before admission. Thirteen had ECG evidence of a previous MI.

Preoperative serum cholesterol determinations were performed in 37 patients. Values ranged from 123 to 338 mg% with a mean of 258 ± 7.8 (SE). Eighteen of these patients also had serum triglyceride determinations. Values ranged from 90 to 450 with a mean of 198 ± 23 (SE). Five patients had diabetes mellitus; three were receiving oral hypoglycemic agents, and two required insulin. Eleven patients were known to be chronically hypertensive.

Seventeen patients had a single coronary artery involved, 16 had two, 20 had three, and two had four (including a diagonal branch of the left anterior descending). Single grafts were performed in 28 patients, double grafts in 23, triple grafts in three, and a quadruple graft in one patient. Thus, 87 of 117 arteries with 50% or greater narrowing received bypass grafts, and 24 patients had residual disease that could not be or was not bypassed for reasons discussed below.

Thirty patients had postoperative catheterization studies an average of nine months postoperatively (range, one week to 32 months). One patient was studied at a postoperative interval of one week, three at intervals of two months, and the remaining 26 were studied more than three months postoperatively.

An attempt was made to study all operated patients from four to six months postoperatively. Unimproved patients readily consented, but symptomatic patients and their referring physicians were less willing to accept restudy. Postoperative studies were thus performed in 11 of 23 patients (48%) in postoperative FC I, in 12 of 19 (63%) in FC II, but in eight of eight (100%) in FC III.

Methods

Preoperative catheterization was performed in all patients and included cinearteriograms, cut-film selective right and left coronary arteriograms in several projections, and left ventricular (LV) cineangiograms by the percutaneous transfemoral approach. Left ventricular systolic and end-diastolic pressures were recorded prior to cineangiography. Uniplane selective left ventricular cineangiography was performed in the right anterior oblique position at 60 frames per second using 30-40 cc of Renografin-76. Left ventricular angiograms were evaluated by an observer who had no prior knowledge of the patient’s clinical status, coronary artery anatomy, or the status of the grafts. Ventriculograms with frequent extrasystoles, inadequate opacification, or improper centering of the image were not analyzed. Ejection fraction (EF) was calculated by a previously described method. Systolic wall motion was assessed by superimposing the end-systolic silhouette on the end-diastolic silhouette using the long axis and its bisected perpendicular. ECGs and serum enzyme determinations were obtained upon admission to the hospital and at least daily thereafter until operation. Postoperatively each patient had serial electrocardiograms and serum enzyme determinations for three or four consecutive days and weekly thereafter until discharge, unless more frequent studies were indicated. Subsequent ECGs were obtained at the time of postoperative angiography and at periodic follow-up examinations. All ECGs were reviewed for evidence of myocardial infarction (MI) by an investigator who had no prior knowledge of the patients’ clinical histories, coronary arteriograms, or LV angiograms. The diagnosis and electrocardiographic localization of perioperative and postoperative infarction were based on the development of 0.04 sec q waves in the appropriate leads according to the criteria of myocardial infarction developed by Gunnar and McConahay and their coworkers. Standard enzyme tests have been shown to yield a large number of false positive and false negative diagnoses immediately after coronary bypass operations.

Our previously described operative technique, which includes cardiopulmonary bypass with moderate hemodilution and mild hypothermia (30°-32°C.), was applied throughout the study, with a few major changes as experience increased. Beginning in 1972, distal anastomoses were performed with the aorta cross-clamped and the heart fibrillating; regular use of a left ventricular venting catheter was abandoned. Proximal anastomoses were performed with a partially occluding aortic clamp in the beating heart. During the first two years of this experience few vessels with less than 70% obstruction were grafted, and diseased circumflex arteries were not grafted unless they appeared to provide the sole vascular supply to the posterior wall of the heart. Subsequently, all major vessels with 50% or greater obstruction were grafted whenever feasible if they supplied areas of viable myocardium since such narrowings reduce cross-sectional area by 75% and impair blood flow.

Follow-up data were collected by direct examination of the patients by their cardiologists or by the authors, and by questionnaire and telephone interview. The functional classification system (FC) of the New York Heart Association was used: patients with unstable angina were FC IV preoperatively by definition.

Figure 1

Interval between the time of hospital admission and operation in 55 patients. Average interval was four days.
Results

Early Mortality and Morbidity

There were no deaths due to emergency coronary arteriography during the period of this study. The usual interval between arteriography and operation was less than 24 hours, and no patient offered an operation died while awaiting it.

There were three operative deaths (5.4%). One patient had complete occlusions of the left anterior descending (LAD) and circumflex coronary arteries, and more than 70% stenosis of the right coronary artery. He had a cardiac arrest upon entering the operating room, but cardiac massage was instituted, anesthesia was induced, and grafts were inserted into the right coronary and LAD. The latter was a tiny (less than one millimeter lumen diameter), diffusely diseased vessel. The patient could not be taken off bypass. A second patient with more than 70% stenosis of all three major coronary arteries had multiple ventricular extrastyles preoperatively. He could not be taken off bypass after grafting of the LAD and right coronary arteries. At operation an acute antero-apical infarction appeared to have occurred in the left ventricle. The third death resulted from an aortic dissection caused by the arterial cannula in the ascending aorta.

Four patients experienced major complications in the immediate postoperative period. Three required reoperations for bleeding, and these were uneventful. One patient had an old third degree burn of the thorax, and the anterior chest wall had been covered with thin skin grafts. Poor wound healing was to be expected, and she suffered a sternal wound dehiscence with mediastinitis. She recovered, but subsequently developed a mycotic aneurysm of the ascending aorta that was successfully repaired eleven months later; she remains well 31 months postoperatively.

Postoperative Myocardial Infarction

Six patients (11%) had ECG evidence of MI in the immediate postoperative period. Three additional patients (5%) developed ECG evidence of MI late postoperatively, two at one year, and one at 1½ years, without any change in their functional status.

Late Mortality and Functional Results

Follow-up ranged from 12 to 52 months (mean 24 mos). There was only one late death 12 months postoperatively: a 61-year old woman. She had a long history of frequent premature ventricular depolarizations, and she died suddenly and unexpectedly of a presumed arrhythmia. The survival experience of the entire group is displayed in an actuarial manner in figure 2. The probability of survival at the end of three years is 93%. Interval data for this actuarial curve are displayed in table 1. Prediction of survival beyond three years is limited by the small number of patients in the last two intervals.

Functional Classification (FC) was determined by NYHA criteria. Patients were assigned a postoperative FC no higher than that permitted by their general exercise tolerance, even if angina was absent; symptoms of fatigue or dyspnea were also considered. Of 51 survivors, 23 (45%) are in FC I, 19 (37%) are in FC II, and 8 (16%) are in FC III. None are in FC IV. FC could not be determined in one survivor.

Each patient's FC was assessed at the most recent complete evaluation, and the results on a time-related basis are displayed in figure 3. Relief of symptoms after operation seems a lasting effect, and most unsatisfactory results were apparent early in the patient's course.

Table 1

Interval Survival Data on Which Figure 2 Is Plotted (Modified Life Table on 55 Patients With Unstable Angina After Emergency Operation)

<table>
<thead>
<tr>
<th>Interval (years)</th>
<th>Number of patients entering interval</th>
<th>Number of patients dying in interval</th>
<th>Proportion of patients surviving interval</th>
<th>Cumulative proportion surviving</th>
<th>Standard error</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1/12</td>
<td>55</td>
<td>3</td>
<td>0.95</td>
<td>0.95</td>
<td>0.03</td>
</tr>
<tr>
<td>1/12-1</td>
<td>52</td>
<td>1</td>
<td>0.98</td>
<td>0.93</td>
<td>0.04</td>
</tr>
<tr>
<td>1-2</td>
<td>44</td>
<td>0</td>
<td>1.00</td>
<td>0.93</td>
<td>0.04</td>
</tr>
<tr>
<td>2-3</td>
<td>23</td>
<td>0</td>
<td>1.00</td>
<td>0.93</td>
<td>0.01</td>
</tr>
<tr>
<td>3-4</td>
<td>9</td>
<td>0</td>
<td>1.00</td>
<td>0.93</td>
<td>0.01</td>
</tr>
<tr>
<td>4-5</td>
<td>2</td>
<td>0</td>
<td>1.00</td>
<td>0.93</td>
<td>0.01</td>
</tr>
</tbody>
</table>

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EMERGENCY BYPASS AND UNSTABLE ANGINA

New York Heart Association Functional Class of survivors according to postoperative interval.

Postoperative Angiography

Fifty-three grafts in 31 patients were studied: 37 (70%) were patent and 16 (30%) were occluded. Twenty-eight of 31 patients (90%) had at least one patent graft.

These results do not reflect a random selection of patients for postoperative studies and were biased against patients with good functional results as discussed above. The over-all results of postoperative studies in all patients having SVBG in our institution have been recently presented. An 81% patency rate was found, with 89% of patients having at least one patent graft an average of seven months postoperatively.

Left Ventricular Function

Preoperative and postoperative left ventricular end diastolic pressure (LVEDP) determinations were available in 20 patients. All values are mean ± se. The mean LVEDP preoperatively was 12.2 ± 1.8 (range 2-35) and postoperatively it was 12.8 ± 1.1 (range 5-25). Five of 20 patients had an abnormal LVEDP (>14 mm Hg) preoperatively (15, 15, 19, 30 and 35 mm Hg); the LVEDP fell to less than 12 mm Hg postoperatively in four of these five patients. Left ventricular ejection fraction (EF) could be determined pre and postoperatively in ten patients. Mean EF preoperatively was 0.57 ± 0.04 (range 0.57–0.72), and postoperatively it was 0.61 ± 0.04 (range 0.46–0.79). Three of ten patients had an abnormal EF (<0.54) preoperatively (0.37, 0.38, 0.46), and it rose substantially in one (to 0.79). The differences in mean values are not statistically significant (paired t-test: P > 0.05).

Discussion

Recent reports of clinical experience with unstable angina patients have differed considerably in early (hospital) and late mortality rates, in the observed incidences of MI, and in therapeutic recommendations. The discrepancies may be due to the wide range of clinical syndromes encompassed by these reports. Definitions of unstable angina have included patients with “angina on effort of recent onset” or “pain lasting at least 30 minutes and occurring within 24 hours prior to admission,” to “recurring pain at rest lasting longer than 20 minutes” or (in a high-risk subgroup) “prolonged ischemic pain after 48 hours of bed rest.” (All these definitions require the absence of ECG or enzymatic evidence of MI.)

It seems likely that debate will continue between advocates of surgical and medical therapy until there is acceptance of a precise definition of the various syndromes; comparisons can then be made between groups of patients observed in different institutions. Our definition of unstable angina excludes patients without episodes of pain that persist more than 24 hours after hospitalization. Our patients therefore resemble those in the high-risk subgroups of Krause and coworkers, and Gazes and coworkers, and it is useful to review their experience.

Krause, Hutter, and De Sanctis at the Massachusetts General Hospital studied 100 patients with “acute coronary insufficiency” followed up to 43 months (average 20 months). There were 22 cardiac deaths (22%), and five additional deaths due to noncardiac causes. Eight surviving patients had MI, and only 17 patients were pain free. However, 64 of their patients had subsidence of pain less than 12 hours after hospital admission and only 36 with persistent pain resemble our patients. The single hospital death occurred in this latter group, but the late deaths were not identified as to group.

Gazes and coworkers have recently provided a long-term study of unstable angina patients treated medically with careful identification of clinical subgroups and actuarial analysis of late mortality rates. In 140 patients followed ten years, the probability of surviving one year was 82%, two years 75%, three years 59%, and five years 61%. More importantly, 54 patients were identified as a high-risk subgroup because of continued pain after 48 hours of bed rest. Nineteen of 54 (35%) developed an acute MI within three months and 12 of these 19 (63%) died. The probability of surviving one year in this subgroup of 54 patients was 57%, two years 47%, three years 37%, and five years 27%. These high-risk patients resemble our own very closely, since all but six of our patients had operations more than 48 hours after admission (fig. 1).

It is also pertinent that coronary arteriography was performed in only five patients in the report by Krause and coworkers, and in none of the patients in the
Gazes study. It is widely recognized that patients with presumed angina (even unstable angina) may have normal coronary arteries, and such patients have a benign course and normal life expectancy.\(^{18-20}\) Such patients may have been included in the studies of Gazes, Krause, and their associates, but on the other hand, some of their patients may have been technically inoperable because of extensive or diffuse atherosclerotic coronary disease. One of our operative deaths occurred in an attempt to save a patient with diffuse disease that probably in retrospect was inoperable (see above). In general, however, our report deals with patients with operable coronary obstructions, and our results should be compared with those of medical therapy in similar patients.

Although preoperative and postoperative LV function studies in our patients did not reveal significant changes for the group as a whole, comparisons were possible in only a small number of patients, and the findings are not conclusive. Furthermore, most of our patients had normal LVEDP and EF determinations preoperatively, so that substantial changes would not be expected. It is noteworthy, however, that several of our patients did have objective evidence of impaired ventricular function preoperatively. It is unlikely that Gazes' study included a substantially greater number of patients with seriously compromised ventricular performance, since those with "significant cardiomegaly or evidence of congestive heart failure" were excluded in advance. Chatterjee and coworkers have demonstrated significant improvement of depressed LV function following SVBG for acute myocardial ischemia.\(^{21}\)

The distribution of coronary artery disease has been shown to influence significantly the prognosis of patients treated medically.\(^{22,23}\) For example, Oberman and coworkers found that 95% of patients with chronic angina and single vessel disease survived two years.\(^{24}\) It is therefore noteworthy that less than a third of our patients (17 of 55) had single vessel disease with its presumably favorable prognosis.

### Urgent vs Elective Operations

Results in our surgically-treated patients indicate gratifying survival and symptomatic relief following SVBG for high-risk patients with unstable angina. It is then pertinent to inquire whether coronary arteriography and SVBG should be performed as emergency procedures or following a period of medical management. In this regard Fischl, Herman, and Gorlin\(^{25}\) have analyzed a group of 23 patients with unstable angina ("intermediate coronary syndrome") defined by criteria that closely resemble our own. Twenty received propranolol acutely, 21 subsequently had angiographic demonstration of coronary obstruc-

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