Quality of Life After Bypass Surgery for Unstable Angina
5-Year Follow-up Results of a Veterans Affairs Cooperative Study

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To assess the effect of bypass surgery on outcome from unstable angina, 468 patients were randomized to medical treatment (237 patients) or surgery plus medical treatment (231 patients) and have been followed for comparison of survival, cardiac end points, and quality of life; the latter end point is discussed in the present report. Data were available at 3 and 5 years for 80% and 82% of patients in the medical group, respectively, and 77% and 80% of patients in the surgery group, respectively. At 3 months after randomization to therapy, 79.8% of patients in the surgery group reported subjective improvement, compared with 58% of the medical group. 12.6% of the surgery group reported no change compared with 24.5% of the medical group, and 5.5% of the surgery group reported worsening compared with 24.5% of the medical group (p<0.01 by χ²). Similar data were found for chest pain status, and the benefit to the surgery group remained statistically significant through 5 years of follow-up. Crossover rate to surgery was 43% by 5 years. Treadmill duration was increased in the surgery group compared with the medical group (6.5±0.25 versus 5.3±0.25 minutes at 6 months, p<0.01), and a significant difference was again demonstrated at 3 and 5 years. A trend toward decreased recurrence of unstable angina was present in the surgery group at 1 year (six of 168 [3.6%] versus 13 of 187 [6.9%] in the medical group, p=0.158), but the two groups were similar at 3 and 5 years. Patients in the surgery group used less nitroglycerin and propranolol than their medical counterparts at 1 and 3 years of follow-up (p<0.01), but by 5 years these variables were similar. Working status never differed between the two groups. Thus, bypass surgery produces immediate improvement in quality-of-life variables, and the effects in some end points were shown to persist for 5 years after surgery. Other beneficial effects of surgery diminish by 5 years. (Circulation 1991;83:87-95)

The end points of myocardial infarction and mortality and the assessment of quality of life are the principal means by which therapies have been compared in randomized studies of coronary artery bypass surgery.1-4 The Veterans Affairs Cooperative Study of Unstable Angina, the largest such study to date, recently reported 3-year data5 showing no overall difference in mortality or incidence of myocardial infarction for patients treated with medications alone compared with patients treated with surgery plus medications. However, the study was designed a priori to assess benefit from surgery in a subgroup of patients with abnormal left ventricular function, and survival at 3 years was significantly enhanced by surgery in this subgroup.6 With regard to quality of life, relief of angina and improved functional capacity are major objectives of coronary artery bypass surgery. This report summarizes the 5-year effects of medicine alone compared with surgery plus medications on symptoms, exercise performance, and work status for patients participating in the Veterans Affairs' Cooperative Study.

Methods

Study Eligibility

Male patients less than 70 years old who were admitted with chest pain to any of the participating
hospitals were screened for inclusion into the study. Reasons for exclusion from the study have been summarized. Any patient in whom a myocardial infarction occurred within the 3 months before the study was excluded.

Unstable angina was defined according to clinical presentation as type I or type II. Type I comprised patients with angina pectoris that had been present for more than 2 months. Progression of symptoms was required to be considered a type I patient, as demonstrated by an increase in severity (doubling of nitrate dose) or frequency (doubling of the average number of attacks per day) or by the appearance of angina at rest within 8 weeks of consideration for entry into the study. Type I also included angina pectoris with a duration of 2 months or less in which pain was produced by less-than-ordinary activity (New York Heart Association functional class III) and angina of recent onset with recurrent pain at rest accompanied by electrocardiographic changes. Thus, type I comprised patients with angina of increasing severity (IA), rest angina (IB), or recent onset angina (IC). Type II unstable angina included recurrent episodes of prolonged pain resistant to nitrates. In contrast to type I, at least one episode of chest pain at rest lasting 15 minutes or more accompanied by ST segment or T wave changes must have occurred within 10 days of the date of entry into the study for the patient to be considered as having type II angina.

Treatment

The principal medical regimen consisted of nitrates and propranolol, alone or in combination, as prescribed by the investigators. Calcium channel-blocking agents had not been approved for use when the study was initiated but became part of the medical regimen in the final 2 years of the accession period. Diet, weight reduction, cessation of smoking, systematic exercise, and regulation of work and leisure activities were considered part of medical treatment. Aortocoronary saphenous vein bypass grafting was performed as described by Favaloro. One patient received an internal mammary bypass because of unsuitability of veins for bypass. Initially, cardiopulmonary bypass with moderate hemodilution, mild hypothermia, and aortic cross-clamping was used. Later, cold potassium cardioplegia was used; it became routine by 1978.

Randomization and Follow-up

Patient accession occurred between June 1976 and June 1982. Informed consent procedures, reasons for exclusion, and randomization methods are presented elsewhere. Patients were assigned to either medical treatment alone or surgery plus medical treatment. Treatment was considered to start on the assigned operation date for medically treated patients or on the actual operation date for surgically treated patients. The patients were stratified according to ventricular function and type of unstable angina. Ventricular function was defined as normal if the left ventricular ejection fraction was 0.50 or more and the left ventricular end-diastolic pressure was less than 16 mm Hg. Follow-up began with the assigned starting date of treatment.

The primary end point of the study was mortality. Secondary end points, including hospitalization for nonfatal Q wave and non-Q wave infarction, recurrent episodes of unstable angina, stable angina, postcardiomyopathy syndrome, cerebrovascular accident, systemic or pulmonary embolus, phlebitis, atrial fibrillation or flutter, ventricular arrhythmia, heart block, acute or chronic left ventricular failure or "right-sided" congestive failure, sustained cardiac arrhythmia, disabling complications of coronary disease, and graft occlusion, in the surgical group were considered to impact on quality of life and were examined. Tertiary objectives investigated with respect to quality of life included persisting symptoms of angina pectoris not requiring hospitalization as evaluated by systematic angina questionnaire. Patients were evaluated at trimonthly outpatient visits for the first 2 years after randomization and twice a year thereafter. Variables assessed at patient follow-up included chest pain status and the use of medications. Overall subjective status was assessed as improved, unchanged, or worsened. Exercise tolerance was assessed by the Bruce multistage treadmill test at 6 months and 12 months and then at 12-month intervals through the 60-month follow-up period. No nitrates or propranolol were given for 6 hours before the exercise test, and a conclusive test required that a patient attain 85% of his predicted maximum heart rate. Individuals conducting the exercise tests were not blinded to the experimental conditions (not considered feasible due to the presence of surgical scar). Data encoded from treadmill testing included duration of performed exercise, maximum heart rate and blood pressure, ST segment changes, symptoms, and reason for stopping the test.

Statistics

All data accruing from the study were submitted to the Veterans Affairs Cooperative Studies Coordinating Center, West Haven, Conn. Comparisons of the treatment groups were carried out at entry and at multiple points through 5 years of follow-up using the principle of analysis according to treatment assigned. Between-group differences in discrete variables, such as chest pain status or work status, were tested by χ² analysis. The t test was used to assess mean differences in continuous variables derived from the exercise test. Life-table methods were used to compare curves for new cardiovascular hospitalizations, and the Mantel-Haenszel χ² test was used to compare the overall cumulative curves. Also used was the method of censored crossovers, a secondary method of analysis that excludes treatment nonadherers at the time of crossover. The percentage of medical treatment failures was estimated by life-table procedures in which patients who died were withdrawn...
from analysis on the date of death. All probability values represent two-sided tests of significance.

Results

Completeness of Follow-up

Randomization distributed patients equally to treatment groups according to their clinical presentations and left ventricular functions; these results are published elsewhere. Between June 1976 and June 1982, 468 patients were randomized at 12 participating centers—237 to medication alone and 231 to surgery plus medication. Follow-up at 5 years was 100% complete for vital status but was less complete for nonvital indicators, usually because the data were not obtained or were obtained outside scheduled follow-up. At 3 and 5 years, quality-of-life data (except treadmill status) were available for 80% (167 of 208) and 82% (158 of 194), respectively, of surviving patients in the medical group and 77% (162 of 211) and 80% (155 of 198), respectively, of those in the surgery group. Follow-up treadmill data at 3 and 5 years were available in 64% (107 of 167) and 53% (84 of 158), respectively, of the medical group and 59% (96 of 162) and 53% (82 of 155), respectively, of the surgery group who returned for annual clinic visits through 5 years. In the majority of cases, the discrepancy between percentages representing clinic follow-up and treadmill data was due to the stable clinical status of the patient. Through 5 years of follow-up, 135 of 237 patients (57%) in the medical group had adhered to assigned treatment (i.e., did not receive coronary artery bypass surgery). At 1 year, 28% had crossed over to surgical therapy; 34% had crossed over by 2 years, and 43% had crossed over by 5 years.

Cardiac catheterization was repeated at 1 year of follow-up in 140 of 209 in the surgery group (67%). All grafts were patent in 76 of 140 patients (54.3%). Of the 64 patients in whom not all grafts were patent, 12 patients had no patent grafts.

Recurrence of Hospitalizations and Unstable Angina

The recurrence rates of unstable angina in the medical and surgical groups are summarized in Table 1. At 1 year, more than twice as many patients in the medical group than patients in the surgery group experienced additional unstable angina, but the difference was not statistically significant. At 3 and 5 years, no significant between-group differences were present. Similarly, no significant between-group differences were found in the incidence rates of myocardial infarction and death (Table 1). No differences were found for these three variables when the two groups were analyzed according to unstable angina subtype. Data on new hospitalizations for cardiac causes are summarized in Figure 1. When hospitalizations for all cardiac causes were considered, the cumulative percentage of new admissions was significantly greater at 6 months in the medical group than in the surgery group (log rank \( \chi^2 \), \( p=0.001 \), and this relation remained significant through 60 months of follow-up. Ninety-eight of 340 cardiovascular hospitalizations (29%) in the medical group were for coronary artery bypass surgery compared with two of 231 hospitalizations (1%) in the surgery group. Forty-eight percent of surgical group (110 of 231) compared with 63% of the medical group (149 of 237) had one or more new cardiovascular hospitalizations at 5 years of follow-up (\( p=0.001 \)). Patients in the medicine group spent 4,359 days in the hospital during 5 years of follow-up, an average of 4.1 days, compared with 2,772 total days, or an average of 2.6 days per patient, for the surgery group.

Patient Subjective Status and Chest Pain

In contrast to the several end points described above in which the medical and surgical groups were similar, subjective status improved significantly in the surgery group, as assessed at the initial 3-month follow-up (Figure 2). Significantly fewer patients worsened in the surgery group compared with the medical group (6.0% [11 of 183] versus 14.6% [29 of 199]). More subjects in the surgery group responded that they were improved (146 of 183 [79.8%]) than in the medical group (116 of 200 [58%]) (\( p<0.01 \)). Subjective status at later visits tended to be assessed in comparison to the most recent prior clinic visit and was usually “unchanged,” making the initial 3-month visit a better index of the comparative effect on subjective status of the two treatments. Surgery also resulted in a significant reduction in chest pain (Figure 3), and this relation remained statistically significant throughout the 5 years of follow-up. Specifically, at 5 years, 52 of 158 patients in the medical group (32.9%) were free of chest pain, whereas 85 of 155 patients in the surgery group (54.8%) had no chest pain (\( p<0.01 \)). In support of a reduction in angina pectoris was that patients in the surgery group used less sublingual nitroglycerin than those in the medical group, and this relation remained statistically significant through 5 years of follow-up, with
58% of patients in the surgery group using no nitroglycerin compared with 47.7% in the medical group \((p=0.05)\). Collectively, these data indicate improved subjective status and a more symptom-free state for patients managed by surgery.

**Medication Use**

Use of propranolol and long-acting nitrates also decreased in response to bypass surgery. Data are summarized in Figure 4. At baseline, the two were similar with regard to the number of patients being treated and not treated with β-blockade. At 1 and 3 years, the number of patients not taking propranolol was significantly greater in the surgery group compared with the medical group. As with other quality-of-life variables, the difference was no longer significant at 5 years. At baseline, a larger percentage of the surgery group was using long-acting nitrates compared with the medical group (195 of 227 [85.9%] versus 179 of 235 [76.2%]) \((p=0.01)\). However, in follow-up, the number of patients requiring long-acting nitrates became significantly smaller in the surgery than in the medical group, and the effect was sustained throughout the 5 years.

**Work Status**

Patient work status is summarized in Figure 5. As has been shown in previous randomized trials of coronary surgery, work status was not significantly improved by surgery. No significant difference existed between the two groups throughout 5 years of follow-up, although the percentage of individuals who were working was consistently larger in the surgery cohort than in the medical group.

**Treadmill Performance**

Figure 6 summarizes treadmill exercise duration at 6 months and at 1–5 years for medical and surgical patients in whom data were available at each interval. The increase in treadmill duration in the surgery

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**TABLE 1. Percentage of Patients With Reports of Unstable Angina, Effects of Treatment on Myocardial Infarction, and Deaths**

<table>
<thead>
<tr>
<th>Years on study</th>
<th>Medical group</th>
<th></th>
<th>Surgical group</th>
<th></th>
<th></th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>a/n</td>
<td>%</td>
<td>a/n</td>
<td>%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patients with reports of unstable angina</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>13/187</td>
<td>7.0</td>
<td>6/168</td>
<td>3.6</td>
<td></td>
<td>0.158</td>
</tr>
<tr>
<td>3</td>
<td>17/166</td>
<td>10.2</td>
<td>13/162</td>
<td>8.0</td>
<td></td>
<td>0.486</td>
</tr>
<tr>
<td>5</td>
<td>14/157</td>
<td>8.9</td>
<td>15/153</td>
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<td>0.789</td>
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<tr>
<td>Effect of treatment on myocardial infarction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>35/237</td>
<td>14.8</td>
<td>34/231</td>
<td>14.7</td>
<td></td>
<td>0.99</td>
</tr>
<tr>
<td>5</td>
<td>45/237</td>
<td>19.0</td>
<td>40/231</td>
<td>17.3</td>
<td></td>
<td>0.64</td>
</tr>
<tr>
<td>Patients who died</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>29/237</td>
<td>12.2</td>
<td>20/231</td>
<td>8.7</td>
<td></td>
<td>0.21</td>
</tr>
<tr>
<td>5</td>
<td>44/237</td>
<td>18.6</td>
<td>37/231</td>
<td>16.0</td>
<td></td>
<td>0.47</td>
</tr>
</tbody>
</table>

\(a\), Number of patients with event; \(n\), number of patients at risk.

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**FIGURE 2. Bar graphs of patient subjective status at initial 3-month outpatient follow-up examination. On the abscissa are three degrees of subjective status and percent of irrevocable patients (3% of surgical and 2% of medical group). A significantly smaller number of patients in surgery group were worsened or unchanged by treatment and a significantly larger number improved compared with medical group \(\chi^2\).**

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**FIGURE 3. Bar graphs of number of patients with or without chest pain by treatment assigned. Five-year data are from 312 of initial 468 randomized patients (67%). From initial follow-up through 5 years, surgery combined with medical therapy shows a sustained advantage in elimination of chest pain compared with medical therapy alone.**
group was statistically significant through 3 years and again at 5 years; the difference at 4 years was marginally significant at p=0.0596. Similarly, patients in the surgery group had improved heart rate and double-product responses to exercise compared with the medical cohort at 6 months (mean maximum heart rate was 138.1 beats/min and maximum double-product was $24.3 \times 10^3$ for surgery patients compared with 116.5 beats/min and $18.6 \times 10^3$ for medical patients; p<0.05), but these differences were no longer significant at 3 and 5 years (Table 2). Treadmill performance may be seen to have improved during follow-up in the medical group, a change potentially attributable to several factors, including medical crossovers and the addition of calcium channel blockers during the final 2 years of study accession.

**Censored Crossover Analysis**

To examine the effect of crossovers on analysis according to treatment assigned, data were redeveloped according to censored crossover method, and nonadherers to treatment were removed from analysis. Removal took place at the time of nonadherence. Eleven patients in the surgery group who did not receive surgery were excluded from analysis. Patients in the medical group who received surgery before the end of 1 year were excluded from the 1-year analysis; all who received surgery before 3 and 5 years were excluded from the respective 3- and 5-year analyses. In general, the censored crossover method did not yield substantial differences in data, as treatment with surgery reduced chest pain, reduced the number of patients requiring antianginal medication, decreased medication dosages for those remaining on drug, and improved the subjective status of patients. Exercise duration on treadmill and maximum double-product were enhanced by surgery, and the relation remained statistically significant throughout 5 years (Table 3). At 5 years, mean treadmill duration in the medical group was diminished by 14 seconds by excluding crossovers from analysis.

**Decreased Left Ventricular Ejection Fraction**

We have previously shown survival after bypass surgery to be a continuous function of left ventricular ejection fraction and that surgery was associated with decreased 2-year mortality among patients with decreased ejection fraction, in accord with previous randomized studies of coronary surgery compared with medical treatment alone. To determine if a similar beneficial effect on quality of life occurred in patients with abnormal left ventricular function, we carried out a subgroup analysis of treadmill exercise performance according to treatment assigned in patients with left ventricular ejection fraction less than 0.50. Results for double-product and exercise duration are summarized in Table 4. No significant between-group differences were found at 1, 3, or 5 years for double-product or duration. The magnitude of decreased exercise tolerance at 5 years in the surgery group with ejection less than 0.50 compared with the medical group is not statistically significant due to sample size; however, the trend may be due to several effects, including crossover and deletion due to death in the medical group.

**Discussion**

The results of the present study demonstrate that the degree of improvement in patient subjective status and reduction or resolution in angina pectoris produced by a strategy of revascularization for unstable angina pectoris are superior to those produced by medical treatment alone. The initial 3-month interval was selected as the point at which patients would most effectively describe the effect of treatment on subjective status because later time intervals tended to yield comparisons with the immediate preceding evaluation rather than with the effect of treatment at randomization. It is worth noting that end points such as "subjective status" and "chest pain" are affected by patient bias (e.g., the patient's desire for relief from symptoms), so that analyses based on these variables must be interpreted with caution. However, in addition to improvement in subjective categories, randomization to surgery plus medications also resulted in a 3–5-year decrease in the number of patients who required β-blockade, long-acting nitrates, and nitroglycerin, a decrease in dose for those on medication, and a decrease in the number of hospitalizations for cardiac causes com-

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**Table 2. Mean Maximum Heart Rate and Double-Product Response on Treadmill Exercise Testing**

<table>
<thead>
<tr>
<th>Months after start of therapy</th>
<th>Heart rate</th>
<th>Double-product/1,000</th>
<th>Heart rate</th>
<th>Double-product/1,000</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Medical group</td>
<td>Surgical group</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>116.5</td>
<td>18.6</td>
<td>138.1*</td>
<td>24.3*</td>
</tr>
<tr>
<td></td>
<td>(n=141)</td>
<td></td>
<td>(n=138)</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>121.1</td>
<td>19.3</td>
<td>138.0*</td>
<td>24.1*</td>
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<td></td>
<td>(n=145)</td>
<td></td>
<td>(n=132)</td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>123.0</td>
<td>20.0</td>
<td>132.2*</td>
<td>22.3*</td>
</tr>
<tr>
<td></td>
<td>(n=107)</td>
<td></td>
<td>(n=96)</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>120.5</td>
<td>19.4</td>
<td>127.9†</td>
<td>21.5†</td>
</tr>
<tr>
<td></td>
<td>(n=83)</td>
<td></td>
<td>(n=79)</td>
<td></td>
</tr>
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</table>

*p<0.01 compared with respective variable in medical group.
†p<0.05.
pared with patients randomized to medical therapy. Exercise performance was also improved in the surgery-plus-medical-treatment group compared with patients receiving medical treatment alone, and the effect was sustained throughout 5 years. Thus, coronary artery bypass surgery plus medical therapy resulted in improvement in several aspects of quality of life compared with medical therapy alone. These findings are in accord with data from smaller randomized studies of unstable angina reported by Selden et al.\textsuperscript{13} and Pugh et al.\textsuperscript{14}

We have previously reported that survival and the incidence of myocardial infarction in unstable angina are not altered by surgical revascularization at 2 years of follow-up, except in the subgroup of patients with decreased ejection fraction, in whom mortality decreased for patients treated with surgery.\textsuperscript{6} However, recently completed analyses of 5-year follow-up data\textsuperscript{7} demonstrated an emerging trend toward improved survival at 3 years in the subset of patients with three-vessel disease who were randomized to surgery; the trend became statistically significant by 5 years (24\%\textsuperscript{2} of 114) mortality in the medical group versus 11\%\textsuperscript{2} of 102) in patients randomized to

\textbf{FIGURE 4.} Plots of status of drug therapy by treatment assigned. Significant reductions occurred in number of patients on propranolol, long-acting nitrates, and nitroglycerin in surgery group compared with medical therapy and persisted for 3–5 years.

\textbf{FIGURE 5.} Bar graphs of work status by treatment assigned throughout 5 years on study. Refer to key for grouping. Full- or part-time employment was considered “working.” Ordinate depicts number of patients. For each time point displayed, left bar is medical group and right is surgery group. Fraction of working individuals in each group remained relatively constant throughout 5 years. No significant difference in number of patients working was detected between the two groups.

\textbf{FIGURE 6.} Bar graphs of treadmill duration data for medical and surgery patients in whom an exercise treadmill test (ETT) was obtained at 6 months and throughout 5 years of follow-up, analysis by treatment assigned. On horizontal are depicted number of patients having ETTs and respective intervals. Treadmill duration was significantly greater in surgery group than in the medical group at 6 months and at 1, 2, 3, and 5 years of follow-up; at the 4-year interval, $p=0.0596$. Note that exercise tolerance in the surgery group does not decrease; rather, it improves in the medical group, most probably as a result of a crossover effect of surgery.
surgery; \( p=0.014 \)). With specific regard to the subgroup of patients with three-vessel disease and normal ventricular function (146 patients), the 5-year mortality in the subjects randomized to the medical group was 21\% (16 of 76) compared with 11\% (eight of 70) of the surgery group (\( p=0.125 \)); whether this difference would have been significant had the sample size been larger is uncertain. In subjects with three-vessel disease and decreased ejection fraction, the mortality in the medical group was 29\% compared with 7\% in the surgery group (\( p=0.043 \)). The analysis of patients with three-vessel disease regardless of left ventricular function was planned at the study’s inception, as was randomization of a sufficient number of subjects to allow a comparison for the entire study population (one-vessel and multivessel disease) of normal ventricular function with abnormal function. On the other hand, analysis of the specific subset with three-vessel disease and normal ventricular function was unplanned (i.e., the randomization process was not stratified to this level). Primarily for this reason, the above data should not be interpreted to mean that surgery offers no benefit for unstable angina in patients with three-vessel disease and normal ventricular function. In fact, the strength of the trend for this subgroup suggests that a strategy of surgical revascularization should be strongly considered for such individuals.

Although surgical therapy reduced the number of new cardiac-related hospital admissions in the present study, recurrence of unstable angina pectoris did not differ significantly between the medical and surgical groups, which is in agreement with data from the National Institutes of Health study of unstable angina.\(^4\) Nor were the incidence rates of fatal and nonfatal myocardial infarction different for the two groups. Therefore, in unstable angina, bypass surgery can be demonstrated to be superior to medical therapy alone in some respects and for some patients, but there is no advantage to surgery in other patients. In these respects, results of our analysis are in accord with data from the Veterans Affairs study of stable angina pectoris\(^{15,16} \) and the Coronary Artery Surgery Study.\(^3\)

### Crossovers and Functional Capacity

As has been at issue in the previous large randomized trials of coronary surgery, the analysis of data is complicated by the presence of crossovers, specifically, the rate of crossover from medical therapy alone to surgery plus medical therapy, which reached 43\% at 5 years of follow-up. Analysis according to treatment received or a censored crossover analysis might bias the study in favor of medical therapy by removing the more ill patients from the medical cohort. Analysis by treatment assigned could similarly bias toward medical therapy if significant crossovers occur and surgery proves to be beneficial. No method of analysis satisfactorily and completely resolves this issue. However, the 5-year treadmill exercise results are instructive in this regard. Treadmill duration was improved through 3 years, marginally improved at 4 years, and again statistically signifi-

### TABLE 3. Treadmill Duration and Double-Product Analysis by Censored Crossover Method

<table>
<thead>
<tr>
<th>Years on study</th>
<th>Medical group</th>
<th>Surgical group</th>
<th>Medical group</th>
<th>Surgical group</th>
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<tr>
<td>1</td>
<td>5.77±2.78*</td>
<td>7.18±2.77</td>
<td>18.0±5.6*</td>
<td>24.3±6.3</td>
</tr>
<tr>
<td>( n=111 )</td>
<td>( n=124 )</td>
<td>( n=111 )</td>
<td>( n=124 )</td>
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<tr>
<td>3</td>
<td>6.33±2.59*</td>
<td>7.48±3.10</td>
<td>18.5±5.4*</td>
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<td>( n=91 )</td>
<td>( n=69 )</td>
<td>( n=91 )</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>6.06±2.28*</td>
<td>7.10±2.88</td>
<td>18.6±4.9*</td>
<td>21.6±6.3</td>
</tr>
<tr>
<td>( n=53 )</td>
<td>( n=12 )</td>
<td>( n=53 )</td>
<td>( n=12 )</td>
<td></td>
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</table>

\( n \), Number of patients analyzed.

Values are given as mean±SD.

Double-product is heart rate multiplied by blood pressure divided by 1,000.

\(^* p<0.01 \)

### TABLE 4. Treadmill Duration and Double-Product in Patients With Left Ventricular Ejection Fraction of Less Than 0.50

<table>
<thead>
<tr>
<th>Years on study</th>
<th>Medical group</th>
<th>Surgical group</th>
<th>Medical group</th>
<th>Surgical group</th>
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</thead>
<tbody>
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<td>19.2±7.2</td>
<td>22.4±6.6</td>
</tr>
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<td>( n=26 )</td>
<td>( n=26 )</td>
<td>( n=26 )</td>
<td>( n=26 )</td>
<td></td>
</tr>
<tr>
<td>3</td>
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<td>6.78±2.26</td>
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<tr>
<td>( n=17 )</td>
<td>( n=19 )</td>
<td>( n=17 )</td>
<td>( n=19 )</td>
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<tr>
<td>5</td>
<td>7.19±3.07</td>
<td>5.83±1.93</td>
<td>21.7±7.7</td>
<td>18.9±8.3</td>
</tr>
<tr>
<td>( n=13 )</td>
<td>( n=12 )</td>
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\( n \), Number of patients analyzed.

Values are given as mean±SD.

Double-product is heart rate multiplied by blood pressure divided by 1,000.
cantly improved in the surgery cohort compared with the medical group at 5 years. Removal of subjects due to death and a beneficial effect on exercise duration by medical crossovers may account for the gradual increase in the performance of the medical group. Nevertheless, exercise results in the surgery group exceeded those of the medical group throughout follow-up with the marginal exception of year 4, which suggests a negligible crossover effect for this end point. Exercise duration in the surgery cohort, as seen in the medical cohort, also improved continuously through follow-up. This change was most probably due to removal as a result of death, but an effect of improved medical therapy (i.e., adherence to aspirin or calcium channel blockers) cannot be excluded. The general advantage to the surgery cohort compared with the medical group in other quality-of-life end points indicates that crossovers did not significantly affect outcome. This conclusion is supported by the results of the censored crossover analysis. Alternatively, on the basis of the treadmill data, the hypothesis could be developed that the potential quality-of-life benefits resulting from revascularization soon after the occurrence of unstable angina are diminished by a strategy of delayed revascularization.

Analysis of treadmill data may be limited by the percentage of completed treadmill tests in survivors, which was less than the percentage of patients returning for annual clinic follow-up. Usually, the treadmill tests were not performed because of the patient's stable status. Nevertheless, the percentages of available follow-up data were equivalent for medical and surgery groups and comparable to those obtained for surviving patients in quality-of-life analyses of other randomized studies of coronary artery surgery.3 Also, the approach of discontinuing propranolol 6 hours before exercise testing may have influenced the treadmill results because more patients in the medical group than in the surgery group received this therapy.

Work Status

The end point of work status was not significantly affected by surgery in this investigation, which is similar to results of previous randomized studies of coronary surgery.15 In view of improved subjective status and functional capacity, it would appear that other factors had a role in a patient's return to work. The percentage of subjects not working in both the medical and surgery cohorts was slightly increased at 1 year compared with baseline data, but the change was not significant. The percentages of patients working and those not working remained relatively constant throughout the 5 years of follow-up. Previous investigations3,15,17 have reported that preoperative work status is the strongest predictor of the postoperative status, and the results of the present study support this hypothesis.

Limitations

An avoidable shortcoming of the randomized trial is analogous to the uncertainty principle. As demonstrated by the addition of calcium channel-blocking agents and the development of cold potassium cardioplegia during patient accession in the present study, therapy evolves continuously, creating uncertainty in evaluating the relative merits of an individual therapy at a given time. Percutaneous transluminal coronary angioplasty, anticoagulation therapy, and thrombolytic therapy are newer modes of therapy that are having an impact on the management of patients with unstable angina pectoris. Our study addresses the role of surgical revascularization in unstable angina; the role of coronary angioplasty cannot be inferred from these findings.

Summary

Quality of life as assessed by improved treadmill performance, reduction in the need for medications, improved patient subjective status, and elimination of chest pain is enhanced in patients with unstable angina who are treated with bypass surgery, and the effects are sustained for 3–5 years. Benefits in quality of life must be balanced against the lack of difference between medically and surgically treated patients in recurrence of unstable angina, incidence of myocardial infarction, and mortality. A clinical judgment must be made in each patient regarding optimum therapy.

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References


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