Coronary Angioplasty Versus Bypass Surgery in Patients >70 Years Old Matched for Ventricular Function

JAMES H. O'KEEFE, JR., MD, FACC, MATTHEW B. SUTTON, MD, BEN D. McCALLISTER, MD, FACC, JAMES L. VACEK, MD, FACC, JEFFREY M. PIEHLER, MD, FACC, ROBERT W. LIGON, MS, GEOFFREY O. HARTZLER, MD, FACC

Kansas City, Missouri

Objectives. This study compared the relative risks and benefits of coronary angioplasty and coronary artery bypass graft surgery in patients >70 years old.

Background. Few objective, comparative data exist to guide the clinician in the decision to use bypass surgery or angioplasty in elderly patients.

Methods. The study was a case-control, retrospective analysis of 195 consecutive patients who underwent bypass surgery in 1987 and 1988 and were compared with a concurrent cohort of 195 coronary angioplasty-treated patients. The groups were matched for left ventricular function, age and gender mix.

Results. The in-hospital morbidity and mortality rates were significantly lower in the coronary angioplasty-treated patients. Mean postprocedural hospital stay was 4.8 and 14.3 days for angioplasty and surgical group patients, respectively (p < 0.001). In-hospital death occurred in 2% of angioplasty-treated patients compared with 9% of surgically treated patients (p = 0.007). Serious in-hospital stroke occurred in no patient in the angioplasty group and in 5% of patients in the surgical group (p < 0.0001). Q wave infarction occurred in 1% of angioplasty-treated patients and 6% of bypass-treated patients (p = 0.01). The 5-year actuarial survival rate was similar in the two groups: 63% in the angioplasty group, 65% in the bypass group (p = NS). However, surgical group patients experienced less recurrent angina, required fewer repeat revascularization procedures and had fewer Q wave infarctions during follow-up compared with angioplasty group patients.

Conclusions. When performed in patients >70 years old, angioplasty and coronary bypass surgery result in similar long-term survival rates but otherwise distinctly different clinical courses.

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Elderly patients today comprise the most rapidly expanding segment of our population. Coronary artery disease becomes progressively more prevalent with increasing age (1). For these reasons, cardiologists and cardiovascular surgeons are increasingly faced with difficult decisions with regard to the need for revascularization and the type of procedure to select in these elderly patients. Although both coronary angioplasty and coronary artery bypass graft surgery have been commonly used in elderly patients for many years, there is a paucity of objective, comparative data to help guide clinicians and patients in this decision. Instead, the clinician must rely on anecdotal experience, noncomparative observational data and clinical intuition. Randomized trials comparing bypass surgery and coronary angioplasty are in progress, but these are being performed in selected groups and may not be relevant to the more diverse population seen in a typical clinical practice, particularly the elderly cohort.

The nonrandomized, observational studies that have compared coronary angioplasty and bypass surgery have been flawed by important baseline differences between the two groups (2–5). In most medical centers today, a selection bias exists whereby patients undergoing coronary artery bypass graft surgery often have poorer left ventricular systolic function compared with angioplasty-treated patients (2–6). Left ventricular function has a profound effect on both short- and long-term outcome in patients with coronary artery disease (6–9). Thus, comparative studies of bypass surgery- and angioplasty-treated patients with baseline differences in left ventricular function are difficult to interpret.

The purpose of the current study was to compare the relative risks and benefits of coronary angioplasty and bypass surgery in patients >70 years old. The groups were matched for left ventricular systolic function as measured by ejection fraction and were similar with respect to most other major angiographic and demographic variables.
Methods

Patients. This study was a retrospective analysis of 390 elderly patients who underwent either elective coronary artery bypass graft surgery or elective coronary angioplasty between January 1, 1987 and December 31, 1988. The surgical group represented a consecutive series of 195 patients >70 years old who underwent elective coronary artery bypass graft surgery at the Mid-America Heart Institute at St. Luke's Hospital in Kansas City, Missouri. The angioplasty group included concurrent cohort of 195 similar patients randomly selected from the same time frame and matched for 1) left ventricular systolic function, as measured by ejection fraction on the preprocedural left ventriculogram, 2) age, and 3) gender. Patients were excluded if significant left main coronary artery disease was noted (≥50% lumen diameter stenosis). Demographic, clinical and angiographic data were compared using the Student t test, chi-square test or Fisher exact test when appropriate. All reported p values were two-tailed. Long-term survival was compared using the Kaplan-Meyer method. Long-term survival curves included procedural and in-hospital mortality rates. Late results were compared using univariate actuarial (life table) and multiple regression (Cox) survival analyses.

Definitions. Transmural myocardial infarction was defined as the appearance of new Q waves supported by creatine kinase, MB fraction enzyme elevation. In-hospital death was defined as all-cause mortality during the index hospital stay. Baseline left ventricular ejection fraction was documented by left ventriculography at cardiac catheterization or echocardiography, or both. Incomplete revascularization was defined as any lesion ≥50% lumen diameter stenosis in a major epicardial coronary artery or branch (≥1.5 mm in diameter) that was either not attempted or not successfully dilated during the angioplasty procedure or not bypassed during the surgical procedure. The diagnosis of cerebrovascular accident required all three of the following: 1) neurologic findings on history and physical examination consistent with a diagnosis of stroke; 2) computed tomographic or magnetic resonance image documentation, or both; and 3) a persistent neurologic deficit at the time of dismissal.

Coronary angioplasty procedure. Percutaneous transluminal coronary angioplasty was performed using standard techniques described elsewhere (10). Complete revascularization through dilation of all significant stenoses during a single procedure was our strategy whenever possible. Patients were pretreated with aspirin (325 mg); dipyridamole (75 mg three times daily) and a calcium channel blocking agent were also often used. On arrival in the catheterization laboratory, patients received lidocaine, sublingual nitrates and verapamil. A dextran infusion was variably used depending on operator preference. At the beginning of the procedure an intravenous bolus injection of 10,000 U of heparin was given, followed by a bolus of ~5,000 U/h of elapsed time during the procedure. Aspirin, 325 mg daily, was continued indefinitely after the procedure.

Coronary artery bypass graft surgery. Patients underwent coronary artery bypass graft surgery using cold cardioplegia. The left internal mammary graft was used to bypass the left anterior descending coronary artery whenever possible. Reversed saphenous vein graft segments were generally used to bypass diseased vessels in the left circumflex or right coronary systems. Patients were given aspirin (325 mg daily) and dipyridamole (75 mg three times daily) at discharge from hospital.

Baseline characteristics. The baseline demographics and angiographic descriptors of the two groups are presented in Table 1. Angioplasty and bypass group patients were identical with respect to left ventricular systolic function. Mean left ventricular ejection fraction was 46.8 ± 15% and 46.7 ± 15% in angioplasty and bypass group patients, respectively. The groups were also indistinguishable with respect to mean age (75 years) and gender mix (two of three patients in both groups were male). Multivessel disease was the dominant pathoanatomy in both groups but was seen somewhat more frequently in those patients who underwent bypass surgery. Coronary artery disease involving two or more of the major epicardial coronary systems was seen in 97% of surgical group patients and in 84% of angioplasty group patients (p < 0.001). A mean of 3.7 distal anastomoses per patient were performed in surgically treated patients. A mean of 2.1 vessels were dilated in angioplasty-treated patients. Previous revascularization procedures were noted more frequently in angioplasty-treated patients. Unstable angina was the indication for revascularization in 53% of angioplasty and 63% of surgical group patients.

Follow-up. Prospective long-term follow-up data were obtained from mailed questionnaires, telephone interviews and follow-up patient visits. This information was stored in a computer data base and updated on a systematic, periodic basis. Four patients (1%) were lost to follow-up. The mean (±SD) duration of follow-up for the 390 patients was 38 ± 19 months.

Table 1. Baseline Data

<table>
<thead>
<tr>
<th></th>
<th>PTCA (n = 195)</th>
<th>CAGB (n = 195)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age (yr)</td>
<td>75</td>
<td>75</td>
<td>NS</td>
</tr>
<tr>
<td>Male</td>
<td>133 (68%)</td>
<td>131 (67%)</td>
<td>NS</td>
</tr>
<tr>
<td>Female</td>
<td>62 (32%)</td>
<td>64 (33%)</td>
<td>NS</td>
</tr>
<tr>
<td>Previous CABG</td>
<td>49 (25%)</td>
<td>17 (9%)</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Previous PTCA</td>
<td>64 (33%)</td>
<td>24 (12%)</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Diseased vessels</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>31 (16%)</td>
<td>6 (3%)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>69 (35%)</td>
<td>45 (23%)</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>3</td>
<td>95 (49%)</td>
<td>144 (76%)</td>
<td></td>
</tr>
<tr>
<td>Mean LVEF</td>
<td>47%</td>
<td>47%</td>
<td>NS</td>
</tr>
<tr>
<td>Unstable angina</td>
<td>103 (53%)</td>
<td>123 (63%)</td>
<td>0.05</td>
</tr>
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PTCA = percutaneous transluminal coronary angioplasty; CAGB = coronary artery bypass graft surgery; LVEF = left ventricular ejection fraction.
Table 2. In-Hospital Complications

<table>
<thead>
<tr>
<th></th>
<th>PTCA</th>
<th>CABG</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-hospital death</td>
<td>4 (2%)</td>
<td>17 (9%)</td>
<td>0.007</td>
</tr>
<tr>
<td>CVA</td>
<td>0</td>
<td>10 (5%)</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Q wave MI</td>
<td>2 (1%)</td>
<td>12 (6%)</td>
<td>0.014</td>
</tr>
<tr>
<td>Urgent CABG</td>
<td>2 (1%)</td>
<td>0</td>
<td>&lt; 0.0001</td>
</tr>
</tbody>
</table>

CVA = cerebrovascular accident; MI = myocardial infarction; other abbreviations as in Table 1.

Results

In-hospital complications occurred more frequently in bypass group patients (Table 2). Death during the initial hospital stay occurred in four patients (2%) in the angioplasty group and 17 patients (9%) in the bypass group (p = 0.007). Stroke and Q wave myocardial infarction also occurred significantly more often in bypass group patients. The mean duration of hospital stay was 4.8 ± 5.6 days in angioplasty group patients and 14.3 ± 11 days in bypass group patients (p < 0.001). The average daily hospital charge was $2,940/day for angioplasty group patients and $2,236/day for surgical group patients. The total hospital charge for the index revascularization hospital stay was $11,652 ± $7,574 for angioplasty and $31,334 ± $24,520 for surgery.

Long-term actuarial survival rate curves, including in-hospital mortality, were not significantly different (Fig. 1). Although survival rates at 1 week favored angioplasty, this advantage was entirely lost by 1 year, and the curves appeared to parallel each other over the ensuing 4 years of follow-up. Complete revascularization was achieved in 194 bypass group patients (99%) and 74 angioplasty group patients (37%) (p < 0.0001). The survival rate of angioplasty group patients with complete revascularization was identical to that of the surgical group; however, the long-term survival rate of angioplasty group patients with incomplete revascularization was significantly lower (Fig. 2). Event-free survival (freedom from death or Q wave infarction) was significantly better in the surgically treated patients (Fig. 3). At the end of 5 years, 59% of bypass group patients and 40% of angioplasty group patients were free from recurrent cardiac events. Freedom from repeat revascularization was also different in the two groups (Fig. 4). Of the angioplasty group patients >50% required repeat revascularization during the 5-year follow-up. In addition, surgical group patients experienced superior relief from recurrent angina during follow-up (Fig. 5). Late cardiac events during follow-up for the two groups are displayed in Table 3.

Multivariate correlates of mortality rate during long-term follow-up as determined by the Cox proportional hazards survival model were left ventricular ejection fraction ≤40%, unstable angina at presentation and incomplete revascularization. Mode of revascularization (angioplasty or bypass surgery) was not an independent predictor of long-term survival rate by multivariate analysis.

Figure 1. Actuarial survival rate in coronary angioplasty (squares) and coronary artery bypass graft surgery (circles) groups. The 5-year survival rate was 63% in angioplasty group patients and 65% in surgery group patients (p = NS). At hospital discharge (1 week) a survival rate advantage was noted in the coronary angioplasty group. The curves crossed over by 1 year and remained essentially identical thereafter.

Figure 2. Survival rate as a function of completeness of revascularization. The nearly all surgical group patients (circles) had complete revascularization (99%). The survival rate of angioplasty group patients with complete revascularization (squares) was equivalent to that of the surgical group. The survival rate of angioplasty group patients with incomplete revascularization (diamonds) was significantly lower than patients with complete revascularization.


Discussion

The most significant finding in this matched study of patients >70 years old was the nearly identical long-term survival rate in both angioplasty and bypass surgery groups. Although bypass surgery appeared to result in more complete and lasting coronary revascularization, this did not translate into an improved survival rate. The mean age of the patients in both groups was 75 years. Because of associated comorbidity and intrinsic limits on life expectancy, it may be difficult to demonstrate a long-term survival advantage for any intervention in a population of this age. This is especially true if the intervention entails a significant procedure-related mortality risk (as is the case with bypass surgery). These comparative survival rate statistics cannot be extrapolated to elderly patients with significant left main coronary disease because they were excluded from the current study.

In-hospital events. In this elderly cohort, procedural and in-hospital morbidity and mortality rates were significantly higher in patients who underwent bypass surgery compared with angioplasty-treated patients. Nearly one in 10 of surgically treated patients did not survive the initial hospital stay; an additional 5% had significant stroke. Several previous noncomparative studies evaluating bypass surgery in the elderly have documented increased risks with advancing age. This increased risk becomes apparent at ~60 to 65 years of age and increases rapidly after 70 years of age (11-16). The procedural risks of coronary angioplasty were also increased in elderly patients compared with younger cohorts. However, in elderly patients the absolute mortality rates with angioplasty have been significantly lower than those reported with coronary bypass surgery (17-22). The increased procedure-related morbidity with bypass surgery in the elderly was demonstrated by the different mean hospital stays from procedure until discharge for the two groups: >14 days for surgery group patients compared with 4.8 days for angioplasty group patients.

Events during follow-up. Recurrent angina occurred more often in patients who underwent coronary angioplasty, and >50% of these patients had a repeat revascularization procedure over the 5-year follow-up period. In contrast, patients who underwent bypass surgery rarely required a second procedure. Q wave myocardial infarction during follow-up was also increased in angioplasty group patients. The more complete and lasting revascularization probably accounted for the "crossover effect" noted in the two groups with respect to long-term follow-up mortality. Although the initial procedural mortality was significantly lower in angioplasty group patients compared with the bypass group patients (2% vs. 9%, respectively), by 1 year survival was equivalent in the two groups and remained so for the 5-year follow-up period (Fig. 1). This crossover of the survival curves during the first year has been seen in another comparative study at our institution (6). This phenomenon may in part be a manifestation of the frequent occurrence of incomplete revascularization and restenosis with coronary angioplasty (problems that are more common in patients with multivessel coronary artery disease) (23). The subgroup of angioplasty-treated patients with incomplete revascularization had a higher mortality rate during follow-up than patients with complete revascularization by angioplasty or surgery. In a previous study, we reported similar effects of complete revascularization in patients with multivessel disease and left ventricular dysfunction (left ventricular ejection fraction ≤40%) (6).

Table 3. Cardiac Events During Follow-Up

<table>
<thead>
<tr>
<th>Event</th>
<th>PTCA</th>
<th>CABG</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Death</td>
<td>62 (32%)</td>
<td>59 (30%)</td>
<td>NS</td>
</tr>
<tr>
<td>Q wave MI</td>
<td>17 (9%)</td>
<td>3 (2%)</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Repeat revascularization</td>
<td>75 (38%)</td>
<td>13 (7%)</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>CABG</td>
<td>33 (17%)</td>
<td>11 (6%)</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>PTCA</td>
<td>62 (32%)</td>
<td>13 (7%)</td>
<td>&lt; 0.0001</td>
</tr>
</tbody>
</table>

Abbreviations as in Tables 1 and 2.
Stroke. Significant stroke during the initial hospital stay occurred in 5% of surgery group patients and in none of the angioplasty group patients. The incidence of perioperative stroke in the current series is higher than the typically reported stroke rates of ~1% to 2% in younger cohorts (24,25). Advanced age is a powerful risk factor for stroke in patients undergoing bypass surgery, with reported stroke rates of 2.6% to 8.3% in elderly patients (3,16-18,26-28). When patients contemplate the decision to undergo a procedure, debilitating stroke is usually a major consideration. The comparative stroke risks in this study strongly favored angioplasty and should be factored into decisions about revascularization procedures in elderly patients. These data were collected in 1987 and 1988, and it is possible that the occurrence of stroke with bypass surgery will decrease as preoperative screening, cardiopulmonary bypass techniques and prophylactic measures continue to evolve.

Cost. The total in-hospital charge for the index hospital stay was nearly $20,000/patient more for bypass group than angioplasty group patients. Although comparative long-term costs were not available for these two groups, the early cost advantage for angioplasty group patients was undoubtedly eroded to some degree by the increased need for repeat revascularization procedures in this group. Prospective economic data have been collected at this institution from a matched cohort of 200 patients with a mean age of 70 years who presented with multivessel coronary artery disease and underwent either bypass surgery or coronary angioplasty in 1986. The initial hospital stay charges were nearly identical to those noted for the 1987 and 1988 cohort of the current study, showing an impressive cost advantage for angioplasty group patients. However, over the mean follow-up period of 5 years, ~30% of the initial cost savings realized by the angioplasty strategy had been dissipated.

Study limitations. This was a nonrandomized, retrospective study with all the inherent limitations of such a trial. Some selection bias was unquestionably present in the two groups. We attempted to neutralize the most powerful variable with respect to short- and long-term survival (left ventricular systolic function) by matching the two groups for left ventricular ejection fraction. The two groups were similar in most respects, although surgical group patients had a higher incidence of multivessel coronary artery disease (97% vs. 84%) and unstable angina at baseline (63% vs. 53%). Specifically, the incidence of three-vessel disease was 77% in surgical versus 49% in angioplasty group patients. However, angioplasty group patients had undergone previous bypass surgery or percutaneous transluminal coronary angioplasty, or both, more often.

The sample size of the two groups were relatively small (a total of 390 patients were evaluated and followed up). These findings will need to be confirmed by larger, multicenter prospective and retrospective studies. Two randomized trials (Randomized Intervention Treatment of Angina [RITA] [29] and German Angioplasty Bypass Investigation [GABI] [30]) comparing bypass surgery and coronary angioplasty have recently reported preliminary results. These studies, performed in a younger cohort, documented an outcome similar to the current study. Angioplasty-treated patients were noted to have a lower rate of early mortality and morbidity, with an increased need for repeat revascularization during follow-up; but long-term survival rates were similar to surgically treated patients. The Bypass Angioplasty Revascularization Investigation (BARI) and the Emory Angioplasty Surgery Trial (EAST) are also randomized trials evaluating this question, but results are not yet available (31).

Conclusions. The elderly patients in our study who underwent revascularization had a similar survival rate but otherwise a distinctly different clinical outcome, depending on whether they were treated with bypass surgery or coronary angioplasty. Some elderly patients who are otherwise free of comorbidity may choose to undergo coronary bypass surgery despite the significant short-term risks, with the hope that this will probably be a more "curative" procedure without need for further intervention. However, the elderly patient in need of coronary revascularization who wishes to minimize procedural risks, including stroke, myocardial infarction and death, may choose coronary angioplasty, with the understanding that further procedures may be required. These data do not provide a clear mandate with respect to the superiority of either coronary bypass surgery or coronary angioplasty in the elderly patient. Rather, they help to characterize more definitively expected clinical outcomes depending on the mode of revascularization chosen. This information should facilitate more intelligent and informed decision making by the involved clinical physicians and the patients and their families.

References

9. Stevens T, Kahn JK, McCallister BD, et al. Safety and efficacy of...


