Aortic Valve Replacement Without Myocardial Revascularization in Patients with Combined Aortic Valvular and Coronary Artery Disease

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SUMMARY  To test the hypothesis that coronary artery bypass grafting (CABG) is not routinely required in patients undergoing aortic valve replacement (AVR) who have coexistent coronary artery disease (CAD), we compared the results of operation in 55 consecutive symptomatic patients who had CAD and underwent AVR without CABG with results in another 142 patients without CAD who underwent AVR during the same period, and with published results from other centers in which CABG was used in patients with CAD who underwent AVR. Operative mortality was 4% in patients with CAD and 5% in patients without CAD. Late survival was not significantly different between the two groups when analyzed for the entire population (80% survival at 3 years in CAD patients, 82% for non-CAD patients), or for the subgroup of patients with aortic stenosis, aortic regurgitation or aortic stenosis plus regurgitation. Eight patients with CAD (15%) developed recurrent angina after AVR (mean follow-up 43 months); only three patients (6%) required CABG because of medically refractory angina (12–43 months). Operative mortality, operative infarction (9%), recurrent angina and long-term survival in patients with CAD after AVR were similar to those at other centers after AVR plus CABG. These data suggest that preoperative detection of CAD does not necessitate CABG in all patients at the time of AVR.

MANY SYMPTOMATIC PATIENTS who require aortic valve replacement have coexistent coronary artery disease, and myocardial revascularization has been recommended at the time of valve replacement for such patients.1-4 However, it has not been clearly demonstrated that long-term survival is significantly impaired when patients with aortic valvular plus coronary artery disease undergo aortic valve replacement alone. At the inception of this study, in 1972, we thought that routine coronary artery bypass might adversely influence survival because of prolongation of the operation and a possible increased risk of perioperative myocardial infarction. Therefore, we have not performed myocardial revascularization at the time of valve replacement in patients with coexistent coronary artery disease since 1972. The only exceptions have been patients with critical stenosis of the left main coronary artery and patients with mild aortic valvular disease and severe angina, because we felt that they might not respond to aortic valve replacement alone. The initial and long-term results of valve replacement without myocardial revascularization during a 6-year period in patients with combined aortic valvular plus coronary artery disease are presented in this report.

Methods

Patient Selection and Evaluation

All patients who underwent aortic valve replacement for chronic aortic valvular disease at the National Institutes of Health between January 1972 and December 1978 were evaluated consecutively in a prospective manner. The indication for operation in each patient was a history of exertional dyspnea, orthopnea or paroxysmal nocturnal dyspnea, an episode of pulmonary edema, or a history of angina pectoris or syncope. Patients were excluded from evaluation if they had clinically significant mitral
valvular or aortic root disease that required repair at
the time of aortic valve replacement. Two hundred ten
patients fulfilled the selection criteria. No patient at
our institution during this period was denied opera-
tion or excluded from the current study because of
severe congestive heart failure or poor left ventricular
function.

Aortic valvular disease was evaluated before opera-
tion by right- and left-heart catheterization. The
diagnosis of preponderant aortic stenosis was made in
patients with peak aortic valve gradients greater than
50 mm Hg and less-than-moderate valvular regurgita-
tion (failure of the cardiac apex to opacify during aor-
tic root cineangiography). Preponderant aortic regurgita-
tion was defined as moderate-to-severe val-
valvular regurgitation on aortic root cineangiography
(early opacification of the cardiac apex that did not
clear during the subsequent cardiac cycle) in patients
with peak valve gradients less than 30 mm Hg. Com-
bined aortic stenosis plus regurgitation was defined as
moderate-to-severe valvular regurgitation in patients
with peak valve gradients of 30 mm or greater.

Coronary artery anatomy was assessed in 182 of
210 patients (87%) by preoperative coronary cinean-
giography (148 patients), postoperative coro-
nary cineangiography (27 patients) or autopsies (seven patients). Of the 28 patients whose
coronary anatomy was not defined, 19 were younger
than 35 years of age and coronary arteriography was
not considered indicated on the basis of age and
clinical presentation; in the other nine patients (ages
43–72 years), data were unavailable. The 28 patients
in whom coronary anatomy was not defined were in-
cluded for analysis in the group of patients without
coronary artery disease; all these patients are alive
after operation, and none has developed recurrent
angina pectoris. Some of these 28 patients may have
had coronary artery disease at the time of operation
(especially the nine patients aged 35 years or older),
which would weight the survival analyses in favor of
the group without coronary artery disease and against
the group with coronary disease.

Sixty-eight of the 210 patients (32%) had coexistent
coronary artery disease, defined as ≥50% stenosis (as
judged by maximal reduction in luminal diameter) of
at least one major coronary artery. Our protocol
policy was to refrain from performing a bypass on the
coronary arteries at the time of aortic valve replace-
ment in patients with coexistent coronary artery dis-
 ease, except in patients with ≥50% stenosis of the left
main coronary artery (n = 6) and in patients whose
aortic valve disease was mild (<50 mm peak valve
gradient and less-than-moderate regurgitation), who
we believed might not derive improvement in angina
after valve replacement alone (n = 5). Coronary by-
pass was also performed in one patient with a discrete
left ventricular aneurysm that required aneurysm-
ectomy at the time of valve replacement and in one
patient with aortic stenosis and coronary artery disease
whose valve gradient could not be measured at cathe-
terization. Thus, 13 patients underwent combined valve
replacement plus myocardial revascularization, and
they are excluded from further analysis.

The remaining 197 patients, ages 20–76 years
(mean 53 years), constitute the study population; 78
had aortic stenosis, 64 had aortic regurgitation, and 55
had aortic stenosis and regurgitation. Fifty-five of the
197 patients (28%) had coexistent coronary artery dis-
 ease: 24 patients (44%) had ≥50% stenosis of one
major coronary artery, 21 (38%) had ≥50% stenosis
of two major coronary arteries, and 10 (18%) had ≥
50% stenosis of all three major coronary arteries.
Forty-three of the 55 patients (78%) had ≥70% steno-
sis of at least one major coronary artery. Ten of the 55
patients (18%) had a history of myocardial infarction.

In addition to cardiac catheterization, M-mode
echocardiographic studies were performed before
operation in 63 of the 64 patients with aortic
regurgitation, 71 of the 78 patients with aortic steno-
sis and 25 of the 55 patients with aortic stenosis
and regurgitation. Echocardiograms were obtained using
a 12.5-mm diameter, 2.25-MHz unfocused ultrasound
transducer and either an Ekoline 20A or a Hoffrel 201
ultrasound transceiver interfaced with a Honeywell
1856 strip-chart recorder. Echocardiographic mea-
surement of the left ventricular dimension at end-
diastole and end-systole were obtained with the ultra-
sound beam passing through the left ventricle caudal
to the tips of the mitral leaflets.6 Left ventricular
fractional shortening was computed as the quotient of
the difference between the left ventricular diastolic and
systolic dimensions divided by the diastolic dimension.

Aortic Valve Replacement

At operation, 80 patients (41%) received 2320 series
Starr-Edwards prostheses, 53 patients (26%) received
glutaraldehyde-fixed porcine heterograft prostheses,
41 patients (21%) received Björk-Shiley prostheses,
and 23 patients (12%) received 2400 series Starr-
Edwards prostheses. All 55 patients with coexistent
coronary artery disease underwent aortic valve
replacement without myocardial revascularization.
Cardiopulmonary bypass was performed using a disc
or bubble oxygenator that had a flow rate of 2.2
1/min/m². In addition to systemic hypothermia to
30–31°C in all patients, myocardial preservation tech-
niques included direct coronary artery perfusion with
blood cooled to 30°C in 75 patients (38%), topical iced
saline lavage (4°C) in 35 patients (18%), coronary
perfusion plus topical iced saline in 77 patients (39%)
and hyperkalemic cardioplegia in 10 patients (5%). The
type of prosthetic valve and the method of myo-
cardial preservation were not significantly different
between patients with and patients without coronary
artery disease.

Operative deaths were defined as those that oc-
curred within 30 days of operation. Operative myo-
cardial infarction was defined as the development of
new electrocardiographic Q waves within 24 hours
after operation. Serial serum enzyme and isoenzyme
determinations were obtained in many patients, but
the number of such assays was insufficient to aid in assessing the incidence of operative infarction.

**Patient Follow-up**

The follow-up period after operation ranged from 9 months to 7.8 years (mean 3.7 years). All patients who survived 6 months after operation underwent repeat inpatient evaluation (range 5–11 months after operation), except for patients residing outside the United States. Thereafter, patients were evaluated every 1–2 years as outpatients.

**Statistical Methods**

Preoperative differences between patients with associated coronary artery disease and those without coronary artery disease were analyzed by the t test and Fisher’s exact test as appropriate. Survival curves were plotted by the Kaplan-Meier life-table method and statistical analysis of the survival data was performed by the method of Mantel and Haenszel.

**Results**

**Preoperative Data**

Patients with associated coronary artery disease ranged in age from 38–76 years and were significantly older (p < 0.001) than patients without associated coronary disease, who ranged in age from 20–75 years (table 1). Preoperative pulmonary artery wedge pressure, left ventricular end-diastolic pressure, cardiac index and peak aortic valve gradients were not different between the two groups (table 1). Before operation, 47 patients with coexistent coronary artery disease (85%) and 110 patients without coronary artery disease (77%) complained of angina pectoris. The prevalence of preoperative angina among patients with the different valve lesions is shown in table 2.

**Operative Mortality and Operative Infarction**

Operative mortality and the incidence of operative myocardial infarction are shown in table 3. There were no significant differences in operative deaths or the development of new Q waves or left bundle branch block between patients with and those without coronary artery disease.

**Angina Pectoris After Valve Replacement**

Five patients (4%) without coronary artery disease complained of postoperative chest pain that required coronary arteriography at the time of the 6-month postoperative catheterization. All had normal coronary arteriograms and normally functioning prosthetic aortic valves; chest pain in these patients was felt not to be caused by myocardial ischemia.

After operation, 12 patients with coexistent coronary artery disease (23%) complained of angina pec-
toris. In four of these 12 patients, however, angina was related to the development of prosthetic valve complications: severe hemolytic anemia in two, perivalvular leak with fatal congestive heart failure in one, and prosthetic valvular stenosis in one (65 mm Hg peak prosthetic gradient). This latter patient is symptom-free 4.8 years after a second aortic valve replacement without myocardial revascularization. In five of the 12 patients, angina has been controlled by medical management: antihypertensive therapy in one patient and antianginal therapy (propranolol and long-acting nitrate preparations) in four patients. In the three remaining patients (6% of patients with associated coronary artery disease), angina was unresponsive to medical therapy, and repeat coronary arteriography and coronary artery bypass were performed 11 months to 3.5 years after initial aortic valve replacement. Repeat arteriography revealed progression of coronary artery disease in two of the three patients, with critical narrowing in vessels that would not have required bypass at the time of the first operation.

One patient with recurrent angina and six other patients with associated coronary artery disease developed acute myocardial infarctions 11 months to 5 years (average 2.7 years) after operation, documented by new Q waves, diagnostic enzyme elevations, or both. No patient died at the time of this acute event, although two patients later died from congestive heart failure (4 and 13 months after infarction) and one patient died from a second myocardial infarction (4.4 years after the first). A life-table analysis with myocardial infarction as the end-point revealed that 81% of patients had not suffered myocardial infarction at 5 years after operation, which yielded an infarction rate of 3.8% per year.

**Long-term Postoperative Survival**

Seven of the 142 patients without associated coronary artery disease died at operation, and 19 died late (3 months to 3.8 years) after operation (table 4).

Two of the 55 patients with associated coronary artery disease died at operation, and 11 died late (8 months to 7 years) after operation. Four of these deaths were related to coronary artery disease: one patient died from a second acute myocardial infarction 7 years after operation, two patients died from congestive heart failure after myocardial infarction, and one patient died during a coronary artery bypass operation (at another institution) 3.5 years after valve replacement. The incidence of other causes of death was not significantly different between patients with and patients without associated coronary artery disease (table 4). Survival was not influenced by the type of prosthetic valve or the method of myocardial preservation employed at operation.

Survival after aortic valve replacement for the 55 patients with associated coronary artery disease was 80% at 3 years and 74% at 4 years (fig. 1). The 142 patients without coronary artery disease had a 3-year survival of 82% and a 4-year survival of 77%. Long-term survival was not significantly different between the two groups. Moreover, coronary artery disease did not influence survival (fig. 2) within the subgroups of patients with aortic stenosis (3-year survival 88 ± 5% in patients without coronary disease vs 85 ± 8% in patients with coronary artery disease), aortic regurgitation (79 ± 7% vs 65 ± 18% 3-year survival) and combined aortic stenosis plus regurgitation (72 ± 9% vs 81 ± 10% 3-year survival). Survival in patients with aortic stenosis was significantly better (p < 0.05) than in patients with aortic regurgitation, as previously described.

While the survival curves in patients with aortic regurgitation were not statistically different between patients with and patients without associated coronary artery disease, many patients with aortic regurgitation have preoperative left ventricular systolic dysfunction and are at risk of late death after

![Figure 1. Survival after aortic valve replacement. Long-term survival was not significantly different between patients with associated coronary artery disease (CAD) and patients without CAD.](http://circ.ahajournals.org/)

### Table 4. Cause of Death

<table>
<thead>
<tr>
<th></th>
<th>No CAD (n = 142)</th>
<th>CAD (n = 55)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operative deaths</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>Late postoperative deaths</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CHF</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>Sudden</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Valve dysfunction</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Endocarditis</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Second MI</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>CHF after MI</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>CABG</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Total deaths</td>
<td>26</td>
<td>13</td>
</tr>
</tbody>
</table>

*Abbreviations: CAD = coronary artery disease; CABG = coronary artery bypass operation; CHF = congestive heart failure; MI = myocardial infarction.*
valve replacement from congestive heart failure. These patients might mask differences in survival in aortic regurgitation between the groups of patients with and without coronary disease. To examine this possibility, patients were subdivided on the basis of left ventricular function. The 63 of 64 aortic regurgitation patients with preoperative echocardiographic studies were placed in subgroups based on left ventricular fractional shortening (table 5). This measurement has been shown to be highly associated with subsequent late postoperative death from congestive heart failure and to correlate closely with resting left ventricular ejection fraction by technetium-99m radio-nuclide cineangiography. Patients without coronary disease and with normal left ventricular fractional shortening (29% or greater) had significantly greater 3-year survival (p < 0.01) than those with subnormal fractional shortening (table 5). The same trend was observed in patients with coronary disease, although the difference in survival between patients with normal and subnormal fractional shortening was not significant because of the small numbers of patients involved and the large standard errors (table 5). Within the subdivision of either normal or subnormal fractional shortening, the presence of coronary artery disease did not significantly influence survival. Patients with aortic regurgitation and severely depressed left ventricular fractional shortening (25% or less) represented a high-risk group, as previously demonstrated, with greater than 50% 3-year postoperative mortality. Coexistent coronary artery disease did not significantly alter 3-year survival within this selected subgroup (table 5).

A similar analysis in patients with aortic stenosis and with aortic stenosis and regurgitation was not performed because only two of 103 patients (2%) with preoperative echocardiograms were in the high-risk group. Moreover, in patients with aortic stenosis, no preoperative echocardiographic or hemodynamic variable identifies patients with a poor long-term prognosis because of irreversible myocardial dysfunction.

The survival analysis of the entire 142 patients without coronary disease was repeated after exclusion of the 28 patients younger than 35 years of age. This analysis was performed because 19 of these patients (68%) did not undergo coronary arteriography but were assumed not to have coronary artery disease, and because 16 of these patients (57%) had aortic regurgitation. Both factors might obscure differences in survival between the group of patients with and without coronary disease that would become apparent only after matching for age and for type of valve lesion. These 28 patients had a 3-year survival of 84 ± 9% and a 4-year survival of 72 ± 13%. Survival in the remaining 114 patients without coronary disease aged 35 years or greater was 80 ± 4% at 3 years and 78 ± 5% at 4 years. Survival curves for either age group without coronary artery disease was not

![Figure 2](https://circ.ahajournals.org/)

**Figure 2.** Survival 3 years after aortic valve replacement for the entire population and for the subgroups of patients with aortic stenosis (AS), aortic stenosis plus regurgitation (AS/AR), and aortic regurgitation (AR). The number of patients at operation for each group is indicated within each bar. Associated coronary artery disease (CAD) did not significantly affect survival. The SEM is shown at top of each bar.

### Table 5. Three-year Survival in Patients with Aortic Regurgitation

<table>
<thead>
<tr>
<th>CAD</th>
<th>Number at operation</th>
<th>3-year survival*</th>
<th>No CAD</th>
<th>Number at operation</th>
<th>3-year survival*</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAD</td>
<td>11</td>
<td>65 ± 18</td>
<td>No CAD</td>
<td>53</td>
<td>79 ± 7</td>
</tr>
<tr>
<td>LVFS ≥ 29%</td>
<td>18</td>
<td>94 ± 5 (p &lt; 0.01)</td>
<td>LVFS ≤ 29%</td>
<td>34</td>
<td>66 ± 11</td>
</tr>
<tr>
<td>LVFS &gt; 25%</td>
<td>35</td>
<td>92 ± 6 (p &lt; 0.01)</td>
<td>LVFS ≤ 25%</td>
<td>17</td>
<td>47 ± 16</td>
</tr>
</tbody>
</table>

*Survival = standard error (Kaplan-Meier method)†.
†Echocardiograms were obtained in 63 of the 64 patients.

Abbreviations: AR = aortic regurgitation; CAD = coronary artery disease; LVFS = left ventricular fractional shortening (normal ≥ 29%).
Table 6. Severity of Coronary Artery Disease

<table>
<thead>
<tr>
<th>Patients with ≥ 50% stenosis</th>
<th>Number at operation</th>
<th>3-year survival</th>
<th>4-year survival</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-vessel disease</td>
<td>24</td>
<td>75 ± 11</td>
<td>64 ± 21</td>
</tr>
<tr>
<td>2-vessel disease</td>
<td>21</td>
<td>81 ± 8</td>
<td>77 ± 8</td>
</tr>
<tr>
<td>3-vessel disease</td>
<td>10</td>
<td>90 ± 9</td>
<td>61 ± 25</td>
</tr>
</tbody>
</table>

Patients with ≥ 70% stenosis

Number at operation | 3-year survival | 4-year survival |
<table>
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<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>43</td>
<td>81 ± 8</td>
<td>73 ± 9</td>
</tr>
</tbody>
</table>

*Survival ± standard error (Kaplan-Meier method).*

different from that of the patients with associated coronary disease.

The severity of coronary artery disease also did not influence survival. Survival 3 years after operation was 75% for patients with disease of one coronary artery, 81% for patients with disease of two coronary arteries, and 90% for patients with disease of three coronary arteries (Table 6). Fifty-six percent of patients had at least two-vessel coronary artery disease and survival in these patients was no worse than in patients with one-vessel disease. When the 43 patient subgroup with coronary arterial luminal narrowing of 70% or greater was analyzed (Table 6), long-term survival was no different (81% at 3 years and 73% at 4 years).

Comparison with Results of Combined Valve Replacement Plus Myocardial Revascularization

Operative mortality and the incidence of operative myocardial infarction in patients with coexistent coronary artery disease in the current series were comparable (Table 7) to those of patients undergoing combined aortic valve replacement plus myocardial revascularization at four other medical centers: 80 patients operated upon at the Cleveland Clinic from 1967-1972, 220 patients at the University of Oregon from 1970-1977, 220 patients at the University of Alabama from 1970–1977, and 101 patients at Stanford University from 1972–1977. Operative mortality (4%) and the incidence of operative myocardial infarction (9%) in the current series were not different from the other series of valve replacement plus revascularization (mortality 5–9% and infarction 8–16%).

The incidence of angina pectoris in patients with associated coronary artery disease after aortic valve replacement plus myocardial revascularization, as reported from these four medical centers (Table 7), has ranged from 11–35% of patients within mean follow-up periods of 1.6–2.9 years after operation. In the current series, angina was present in 23% of patients within a mean follow-up period of 3.7 years after aortic valve replacement alone. When the four patients whose angina was related to prosthetic valve complications are excluded from this analysis, the incidence of postoperative angina in the current series is 16%.

Finally, long-term survival of patients with coronary artery disease after aortic valve replacement alone in the current series (4-year survival of 74%) was compared to that of patients after combined aortic valve replacement plus myocardial revascularization reported from the Cleveland Clinic (3½-year survival of 65%), University of Oregon (4-year survival of 74%) and University of Alabama (4-year survival of 74%). The four survival curves were not significantly different (Fig. 3).

Discussion

Coronary artery disease coexists with aortic valve disease in many patients who require aortic valve replacement. Early studies identified these patients as a group with a higher operative mortality and a poorer long-term prognosis after operation than patients without associated coronary disease. Hence, modifications either in the timing of operation or in operative techniques (such as combining coronary artery bypass with valve replacement) appeared necessary to improve the outlook of such patients.

Table 7. Results of Operation in Patients with Associated Coronary Artery Disease

<table>
<thead>
<tr>
<th>AVR plus CABG</th>
<th>Number of patients at operation</th>
<th>Year of operation</th>
<th>Operative mortality</th>
<th>Operative infarction (ECG)</th>
<th>Postoperative angina pectoris</th>
<th>Mean follow-up (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stanford University</td>
<td>101</td>
<td>1972–1977</td>
<td>9%</td>
<td>12%</td>
<td>16%</td>
<td>1.6</td>
</tr>
<tr>
<td>University of Alabama</td>
<td>220</td>
<td>1970–1977</td>
<td>5%</td>
<td>11%</td>
<td>20%</td>
<td>1.9</td>
</tr>
<tr>
<td>University of Oregon</td>
<td>80</td>
<td>1970–1977</td>
<td>6%</td>
<td>8%</td>
<td>35%</td>
<td>2.6</td>
</tr>
<tr>
<td>Cleveland Clinic</td>
<td>80</td>
<td>1967–1972</td>
<td>9%</td>
<td>10%</td>
<td>11%</td>
<td>2.9</td>
</tr>
<tr>
<td>AVR alone</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NIH (all patients)</td>
<td>55</td>
<td>1972–1978</td>
<td>4%</td>
<td>9%</td>
<td>23%</td>
<td>3.7</td>
</tr>
<tr>
<td>NIH (excluding angina related to prosthetic valve dysfunction)</td>
<td>51</td>
<td>1972–1978</td>
<td>4%</td>
<td>9%</td>
<td>23%</td>
<td>3.7</td>
</tr>
</tbody>
</table>

Abbreviations: AVR = aortic valve replacement; CABG = coronary artery bypass grafting; NIH = National Institutes of Health.
The results of aortic valve replacement without myocardial revascularization in our 55 patients with associated coronary artery disease bear directly on this problem. In these patients, in whom aortic valvular disease was as hemodynamically severe as in 142 other patients without coronary artery disease (table 1), operative mortality was similar to that in the patients without coronary artery disease (4% vs 5%). Moreover, the incidence of operative myocardial infarction in patients with coronary artery disease (9%) was no greater than in patients without coronary disease (8%). The incidence of operative infarction by ECG in our patients without coronary artery disease falls within the range previously reported (1–14%) for patients without coronary disease undergoing aortic valve replacement using the same myocardial preservation technique we used.\(^1\), \(^8\), \(^18\), \(^20\) Finally, the long-term survival after aortic valve replacement in the patients with coronary artery disease (80% at 3 years and 74% at 4 years) was comparable to that in patients without coronary artery disease (fig. 1). Survival was not influenced by the extent of coronary artery disease (excluding left main coronary artery lesions) present before operation (table 6).

The presence of coronary artery disease also did not adversely influence survival among the subgroups of patients with aortic stenosis, aortic regurgitation and coronary stenosis and regurgitation (fig. 2). Moreover, when patients with aortic regurgitation were further divided into subgroups with normal and subnormal echocardiographic left ventricular function (resulting in subgroups with good and with poor long-term postoperative prognosis), coronary artery disease did not significantly affect long-term survival within each subgroup (table 5). Hence, in patients with aortic regurgitation, a major determinant of postoperative prognosis appears to be preoperative left ventricular function and not the presence or absence of coronary artery disease.

However, there are several potential weaknesses in this latter analysis. First, by subdividing the population with aortic regurgitation and coronary disease on the basis of left ventricular function, only a small number of patients remained in each coronary disease subgroup, resulting in excessively large standard errors in the survival analysis (table 5). A second potential weakness in this analysis is the use of M-mode echocardiography to assess global left ventricular systolic function. While echocardiographic left ventricular fractional shortening correlates well with resting radionuclide left ventricular ejection fraction in patients with aortic regurgitation without coronary artery disease,\(^9\) this may not be the case in patients with associated coronary artery disease. Thus, while our data suggest that the presence of coronary artery disease in patients with aortic regurgitation and left ventricular dysfunction does not adversely influence survival after aortic valve replacement without myocardial revascularization, potential differences in survival within this subgroup have not been definitively ruled out.

Of further importance in patients with aortic valve replacement...
disease and with associated coronary artery disease, the operative mortality and incidence of myocardial damage by ECG in the current series after aortic valve replacement alone compare favorably with those after combined aortic valve replacement and myocardial revascularization in other series (table 7).14 Long-term survival and the incidence of recurrent angina pectoris after operation in the current series were also comparable to the other series of combined valve replacement plus revascularization (fig. 3, table 7). These results cannot be ascribed to differences in age, type and severity of valvular heart disease, extent of coronary artery disease, prevalence of angina pectoris, or prevalence of previous myocardial infarction between our patients and patients in the other series.14

Survival among subgroups of patients with normal and subnormal left ventricular function in our series could not be compared with other series because these data have not been reported for combined aortic replacement plus revascularization.

Although operative and long-term postoperative mortality may be no worse after combined valve replacement plus myocardial revascularization compared to aortic valve replacement alone, other considerations militate against routine myocardial revascularization at the time of valve replacement in these patients. First, coronary artery bypass prolongs the operative procedure, with longer cardiopulmonary bypass and aortic crossclamp times,1 16 21 and may thereby increase the risk of operative myocardial infarction.4 20 22 Second, in two of the three patients in the current study who required late coronary bypass surgery after initial aortic valve replacement, coronary artery disease progressed, with critical stenoses developing in arteries that would not have been bypassed at the time of the first operation. Similar observations have been made in patients without aortic valve disease after myocardial revascularization, with a strong relation between recurrent angina pectoris and progression of atherosclerotic disease in the native coronary arteries.23 24 Angina pectoris after valve replacement recurs with the same frequency in patients who have undergone concomitant myocardial revascularization as in those who have not, so presumably, the percentage of patients in either group who require a second operation for relief of angina will also be similar. Finally, in patients with coronary artery disease and aortic valve disease, left ventricular wall tension and myocardial oxygen demand are increased, causing angina pectoris to appear earlier than it would during the course of coronary artery disease alone. After successful aortic valve replacement, with reduction in left ventricular mass and wall tension, the majority of patients become angina-free despite persistent critical coronary artery luminal narrowing. Thus, after aortic valve replacement plus revascularization, it is likely that the hemodynamic effects of valve replacement, not revascularization, are responsible for the relief of angina.

Prognosis after operation in certain subgroups of patients with combined aortic valvular and coronary artery disease may be enhanced by coronary artery bypass in addition to valve replacement. The results of the current study were not helpful in identifying such a subgroup. Myocardial revascularization may be necessary in certain patients at the time of valve replacement, and a carefully considered individual judgment based on all the clinical evidence should be made, but there are as yet no scientifically confirmed data on which such a judgment can be based. Further study will be necessary, for example, to determine whether coronary bypass operation should be performed routinely in the particular subgroup of aortic regurgitation and left ventricular dysfunction. Nevertheless, our results indicate that the detection of coronary artery disease before operation does not necessitate routine myocardial revascularization in all patients at the time of aortic valve replacement.

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