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Coronary Artery Disease and Its Management: Influence on Survival in Patients Undergoing Aortic Valve Replacement

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Data from 1,156 patients ≥30 years of age who underwent aortic valve replacement alone or with coronary artery bypass grafting from 1967 through 1976 (early series) and 227 similar patients operated on during 1982 and 1983 (late series) were reviewed. In the early series, 414 patients (36%) had preoperative coronary arteriography (group 1): group 1A (n = 224) did not have coronary artery disease, group 1B (n = 78) had coronary artery disease but did not undergo bypass grafting and group 1C (n = 112) had coronary artery disease and underwent bypass grafting. The 742 patients in group 2 did not have preoperative arteriography. Operative mortality rates (30 day) in groups 1A, 1B, 1C and 2 were 4.5, 10.3, 6.3 and 6.3%, respectively (p = NS). The 10 year survival in both groups 1 and 2 was 54%; in groups 1A, 1B and 1C it was 63, 36 and 49%, respectively (1A and 1B, $p < 0.01$).

In the late series, the 227 patients were divided into similar groups (group 1A, n = 73; 1B, n = 32; 1C, n = 99), and 90% had preoperative coronary arteriography. Operative mortality rates (30 day) for groups 1A, 1B and 1C were 1.4, 9.4 and 4.0%, respectively; that for group 2 (no preoperative arteriography, n = 23) was 4.3%.

Definition of coronary anatomy by angiography seems important in most patients ≥50 years old who are candidates for aortic valve replacement, and bypass grafting is recommended for those with significant coronary artery disease.

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The necessity of defining coronary artery anatomy before performing aortic valve replacement and coronary artery bypass grafting in adults has been accepted in most centers for patients with arteriographic evidence of significant obstruction in one or more graftable coronary arteries (1–5). Although such an approach may seem reasonable, no controlled studies clearly document the validity of this strategy, and the topic has been a source of debate (2,6). Furthermore, several authors have questioned the need to perform routine cardiac catheterization (7,8) and coronary arteriography (9) before attempting open heart surgery for valvular disease.

To provide further data on these important questions, we reviewed the records of patients who underwent initial aortic valve replacement during two specific periods at the Mayo Clinic. Most of the patients in the early series had aortic valve replacement without preoperative coronary arteriography and most of those in the late series had coronary anatomy defined preoperatively.

The retrospective nature of the present study, a fault shared by all other studies of this topic, deserves emphasis at the outset. This results in important imbalances in preoperative characteristics between groups and compromises the interpretation of outcomes. However, because of the large series of patients who underwent aortic valve replacement at a single institution and had a long follow-up and also the unique sample of patients who did not have preoperative arteriography, the data seem to be of sufficient interest to warrant reporting and to attempt placing the observations in the perspective of current experience.

Methods

Selection of patients. Selective coronary arteriography was first performed at the Mayo Clinic in 1967. Therefore,

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we elected to review the data of patients aged ≥30 years who underwent initial aortic valve replacement at our institution from January 1, 1967 through December 31, 1976 (early series). To provide data about our current experience, we studied patients with similar inclusion criteria who had aortic valve replacement from January 1982 through December 1983 (late series). We excluded patients who had one or more of the following factors: 1) other valve repair or replacement, 2) other congenital heart disease, 3) combined ascending aortic surgery, 4) prior cardiac or aortic surgery, 5) active bacterial endocarditis, 6) coronary arteriography performed elsewhere, or 7) technically unsatisfactory coronary arteriograms.

Clinical data. Prospectively recorded clinical, laboratory and operative data were abstracted retrospectively from each patient's medical record. Angina pectoris was defined as a classic history of exertion- or emotion-induced chest pain or tightness. Undefined chest pain was characterized by a history of chest pain not fulfilling the requirements for a diagnosis of angina pectoris because of location, quality or precipitating events. Prior myocardial infarction was diagnosed in patients who had a history of chest pain associated with electrocardiographic (ECG) or cardiac enzyme changes that were consistent with this diagnosis. The cardiothoracic ratio was measured from the standard posteroanterior chest radiograph in all patients in the early series for whom such records were still available.

Coronary arteriography. During both periods of the study, patients with aortic valve disease were selected to undergo coronary arteriography by the cardiologist or cardiac surgeon. At the time of these decisions, no effort was made to implement a previously determined protocol of management; thus, patients were selected to have coronary arteriography according to what was considered the best approach for each individual patient.

During selective coronary arteriography, multiple views were obtained in an attempt to provide optimal display of the arteries. Angled views were not routinely obtained until 1974. For the purposes of this study, all arteriograms were reviewed and coded without knowledge of the preoperative diagnosis or subsequent management. The degree of coronary artery narrowing was expressed as the percent reduction of the internal diameter of the artery under study. The maximal degree of stenosis in any given artery was recorded, and no attempt was made to account for geometric features of individual lesions that might influence their functional significance. Coronary artery disease was considered significant if one or more coronary arteries had ≥50% narrowing. Left ventricular ejection fraction was obtained by using the area-length method in the right anterior oblique projection or by using videometric measurements of biplane left ventriculograms.

Cardiac surgery. All patients in the early series underwent cardiopulmonary bypass at flow rates of 2.0 to 2.4 liters/min per m^2 with systemic hypothermia and coronary perfusion, and the patients in the late series, in addition to systemic cooling, had hypothermic blood or crystalloid K^+ cardioplegia as the basic method of myocardial preservation. The final selection of the valve prosthesis and the decision to perform coronary artery bypass grafting were made by the responsible surgeon without reference to any previously defined protocol. Starr-Edwards and Björk-Shiley valves were placed in 59 and 19% of the patients in the early series and in 10 and 26% of the patients in the late series, respectively. Heterografts were placed in 3% of the patients in the early series and in 62% of the patients in the late series.

On the basis of the clinical examination, patients were classified as having pure aortic stenosis, combined aortic stenosis and aortic insufficiency or pure aortic insufficiency.

Pathologic findings. The aortic valve removed at the time of surgery was examined subsequently by one of the authors (W.D.E.), and the cause of the aortic valve abnormality was classified as follows: 1) congenital unicommissural valve, 2) congenital bicuspid valve, 3) postinflammatory (rheumatic) disease, 4) degenerative (senile) disease, 5) annular dilation (annuloaortic ectasia), or 6) infective endocarditis. All available postmortem material was reviewed to assess 1) the cause of death, 2) the presence and extent of coronary artery disease, and 3) the influence of any demonstrated coronary artery disease on the clinical course. Serial 3 mm sectioning of the coronary arteries was performed for analysis of the degree of coronary artery disease, as described by others (10).

Follow-up. Follow-up was conducted by letter questionnaire or telephone contact for patients in the early series who did not return for examination at the Mayo Clinic. The objectives of the follow-up were to determine survival, the presence of angina pectoris at any time during the postoperative follow-up, the subsequent need for coronary artery bypass grafting and the cause of death.

Statistics. Statistical methods included chi-square and log-rank tests (11), discriminant analysis (12) of factors important in early death and Cox regression analysis (13) of factors influencing long-term survival. Data on the presence of angina were not available for every patient each year after surgery. However, by letter questionnaire, examination or telephone interview, we determined whether angina pectoris had been present at any time during the follow-up and whether coronary artery bypass grafting was performed after initial aortic valve replacement.

Results

Patient groups. Patients in the early series consisted of 414 patients who underwent aortic valve replacement and had preoperative coronary arteriography (group 1) and of

JACC Vol. 10, No. 1
July 1987:66–72

742 patients who underwent aortic valve replacement and did not have preoperative coronary arteriography (group 2). The 414 patients in group 1 were classified as follows: 1A (n = 224), patients with normal coronary arteriograms or with minimal coronary artery disease (that is, <50% narrowing of any coronary artery); 1B (n = 78), patients with coronary artery disease as defined by >50% narrowing in at least one artery in whom coronary artery bypass grafting was not used in combination with aortic valve replacement; and 1C (n = 112), patients with significant coronary artery disease in at least one artery in whom bypass grafting was combined with aortic valve replacement. Patients in the late series consisted of 204 patients in group 1 and 23 patients in group 2; these group 1 patients were grouped according to the same classification as those in the early series and there were 73 patients in 1A, 32 in 1B and 99 in 1C.

Preoperative characteristics. In the early series, no significant differences were noted between groups 1 and 2 in regard to sex, undefined chest pain, congestive heart failure, New York Heart Association functional class or distribution of the aortic valve abnormality as assessed clinically. However, patients in group 1 (preoperative coronary arteriography) were older than those in group 2 (no coronary arteriography) and had a greater incidence of angina pectoris and prior myocardial infarction.

Other significant differences were noted within group 1. Patients with arteriographic evidence of coronary artery disease (groups 1B and 1C) were older and more frequently experienced angina or myocardial infarction than did patients with arteriographically normal or mildly diseased coronary arteries (group 1A). The incidence of congestive heart failure was significantly greater in group 1B patients (49%) (no coronary artery grafting) than in group 1C patients (30%) (coronary artery grafting).

When the patients were compared according to the interval during which they had aortic valve replacement, the frequency of patients ≥70 years old who underwent surgery significantly increased from the early to the late series. The percent of patients ≥70 years old who underwent isolated aortic valve replacement or replacement and coronary artery bypass grafting increased from 13 to 30% and from 23 to 42%, respectively. The percent of patients with arteriographically demonstrated coronary artery disease who underwent combined valve replacement and bypass grafting increased from 59% in the early series to 76% in the late series.

Analysis of preoperative hemodynamic and left ventricular functional data revealed that patients in group 1C from both series had a lower peak systolic aortic gradient than did other patients in group 1. No other significant differences were noted among the three subgroups of group 1, except for a cardiothoracic ratio of 0.50 or more in 77% of patients in group 1B and in 34% of those in 1C.

When the characteristics of coronary artery disease in both series were evaluated (Table 1), patients in group 1C had a significantly greater frequency of triple vessel disease than did those in group 1B. The mean number of diseased vessels in the early and late series in patients who had aortic valve replacement and bypass grafting (group 1C) was 2.0 ± 0.08 and 2.3 ± 0.08, respectively. In group 1C, the incidence of significant left main coronary artery disease was 11% in the early series and 14% in the late series. In both series, analysis of preoperative coronary arteriograms revealed that patients in group 1C had more severe disease, as defined by the maximal stenosis in any involved artery, than did patients in group 1B. All patients with three vessel disease, when defined as stenosis of ≥70%, had combined valve replacement and bypass grafting.

Aortic valve disease. The incidence of degenerative (senile) aortic valve disease increased significantly from the

Table 1. Characteristics of Coronary Artery Disease in 348 Patients Who Underwent Aortic Valve Replacement During Two Intervals

	Early Series (1967–1976)					Late Series (1982–1983)				
	1B (CAD, no CABG)		1C (CAD, CABG)			1B (CAD, no CABG)		1C (CAD, CABG)		
Characteristic	No. of Patients	%	No. of Patients	%	p Value	No. of Patients	%	No. of Patients	%	p Value
Left main coronary artery disease	1	1	12	11	<0.05	1	3	14	14	NS
One vessel disease	51	65	43	38	<0.05	19	59	20	20	<0.05
Two vessel disease	17	22	31	28	NS	6	19	31	32	NS
Three vessel disease	10	13	38	34	<0.05	7	22	47	48	<0.01
No. of diseased vessels (mean ± SE)	1.7 ± 0.08		2.0 ± 0.08			1.6 ± 0.14		2.3 ± 0.08		
Grafts* patient (no.)	—		1.5 ± 0.06			—		2.1 ± 0.11		<0.01

*Distal anastomoses. CABG = coronary artery bypass grafting; CAD = coronary artery disease.

Table 2. Early Mortality in 1,383 Patients Who Underwent Aortic Valve Replacement During Two Intervals

	Early Series (1967–1976)			Late Series (1982–1983)		
		Deaths			Deaths	
Group	No. of Patients	No.	%	No. of Patients	No.	%
1A (no CAD)	224	10	4.5	73	1	1.4
1B (CAD, no CABG)	78	8	10.3	32	3	9.4
1C (CAD, CABG)	112	7	6.3	99	4	4.0
1 (All patients)	414	25	6.0 6.1*	204	8	3.9 3.7*
2 (No arteriography)	742	47	6.3 6.2*	23	1	4.3 4.0*

*Adjusted to total group list. Differences within early and late series are not statistically significant. Abbreviations as in Table 1.

early period (4.8%) to the late period (34.2%), and the incidence of postinflammatory (rheumatic) valve disease decreased significantly (from 39.9 to 17.3%) ($p < 0.01$).

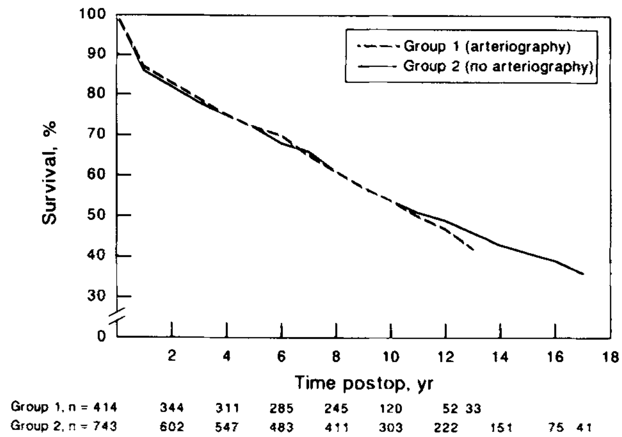
Mortality (Table 2). In the early series, the differences in early mortality, defined as death within 30 days of surgery, among the subgroups of patients in group 1 (1A, 4.5%; 1B, 10.3%; 1C, 6.3%) were not statistically significant. There was no difference in the overall mortality between groups 1 (6.0%) and 2 (6.3%). In the late series, the differences in early mortality among the subgroups of patients in group 1 (1A, 1.4%; 1B, 9.4%; 1C, 4.0%) were not statistically significant. There was one death in group 2 (4.3%). In the early series, 49 perioperative deaths (68%) were cardiac related: 28 (39%) were due to perioperative myocardial infarction in association with a low cardiac output, 9 (13%) were associated with an inability to come off cardiopulmonary bypass and 11 (15%) were sudden and presumed to be related to an acute arrhythmia; 1 patient died with congestive heart failure. In the late series, there were nine deaths (six cardiac related). Of the six patients with cardiac-related deaths, three died after a low cardiac output state and three died suddenly. In the early series, the mortality in patients <70 years old (5.7%) was not significantly different from that in patients ≥70 years old (9.3%). In the late series, however, the difference in mortality between these two groups was significant (1.4 versus 8.0%; $p < 0.05$).

Clinical predictors of 30 day hospital mortality were evaluated in all patients by univariate and multivariate logistic multiple regression analysis. The only significant variables influencing hospital mortality were functional class, year of surgery, age and sex. However, even when these four variables are used to predict operative mortality, only 68% of the deaths were correctly classified.

In group 1, multivariate logistic multiple regression analysis was used to examine the factors important in influencing hospital mortality. In the early series, the presence of diseased vessels with stenosis of ≥70% and a maximal stenosis of ≥50% in the left anterior descending coronary artery were the only variables influencing hospital mortality. In the late series, cardiac index was the only hemodynamic variable of significance.

Long-term survival. Of 1,084 patients who survived >30 days after surgery in the early series, only 3 had been lost to follow-up at 5 years. Survival curves include all patients until death or last follow-up regardless of subsequent surgery or type of prosthesis. When survival was analyzed to the time of reoperation or after exclusion of patients with a Braunwald-Cutter valve, the curves remained essentially the same. The 5, 10 and 15 year survival rates of all patients, including those who died perioperatively, were 72, 54 and 39%, respectively. The survival curves for patients in groups 1 and 2, including those who died within 30 days of operation, were almost identical (Fig. 1). The 5 year survival rates according to subgroups in group 1 were

Figure 1. Cumulative survival of all patients who underwent aortic valve replacement during the early period (1967–1976). Numbers below **horizontal axis** are numbers of patients in each group at risk. Postop = postoperative.



JACC Vol. 10, No. 1
July 1987:66–72

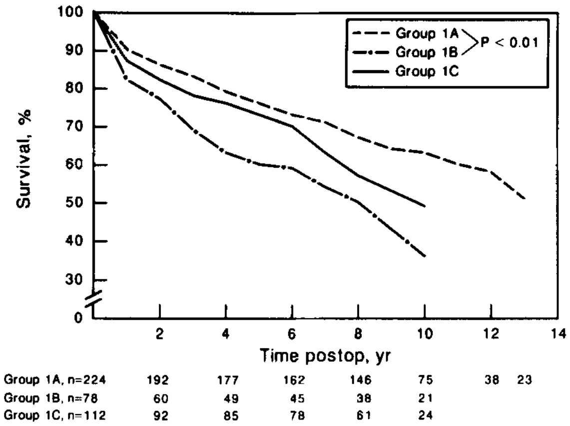


Figure 2. Cumulative survival of all patients who underwent aortic valve replacement during the two intervals (1967–1976 and 1982–1983) according to subgroup (1A, no coronary artery disease; 1B, coronary artery disease, no bypass grafting; 1C, coronary artery disease, bypass grafting). Numbers below **horizontal axis** are numbers of patients at risk. postop = postoperative.

76% in 1A, 60% in 1B and 73% in 1C; the 10 year survival rates were 63% in 1A, 36% in 1B and 49% in 1C (Fig. 2). The difference in survival between group 1A (no or minimal coronary artery disease) and group 1B (coronary artery disease and no bypass grafting) was significant ($p < 0.01$), but the difference between group 1B and 1C (coronary artery disease and bypass grafting) was not statistically significant.

To identify clinical characteristics that are of predictive value for long-term survival, we used the Cox multivariate stepwise regression analysis. Age and advanced functional class were found to affect long-term survival adversely. The 10 year survival rate was 60% in patients who did not have heart failure preoperatively and 45% in those who had heart failure ($p < 0.001$). The 10 year survival rate of patients in functional classes 1 and 2 was 69% and that of patients in classes 3 and 4 was 48% ($p < 0.001$).

Late death. Of the 557 late deaths, 309 (55%) were cardiac related. Of these 309 deaths, 99 were sudden and no definite diagnosis was made, 93 were related to congestive heart failure, 72 to myocardial infarction and 45 to prosthetic valve failure. Two patients died while undergoing reoperation for combined prosthetic valve dysfunction and bypass grafting. Cerebrovascular accidents accounted for 12% of the late deaths. The cause of death could not be definitely determined in 11% of the patients.

Relation between preoperative angina and coronary artery disease (Table 3). In the early series, 77% of patients who had coronary arteriography had angina pectoris preoperatively, and in the late series, 55% of patients had angina preoperatively. Of the patients with angina pectoris, 52% in the early series had significant coronary artery disease, as did 72% in the late series ($p < 0.02$). Of the patients without angina, 26% in the early series had coronary artery disease, as did 55% in the late series ($p < 0.01$).

Table 3. Relation Between Angina Pectoris and Coronary Artery Disease at Arteriography

	Patients With Coronary Artery Disease		
Angina Pectoris	Early Series (1967–1976)	Late Series (1982–1983)	p Value
Present (%)	52 (165 of 318)	72 (81 of 113)	<0.02
Absent (%)	26 (25 of 96)	55 (50 of 91)	<0.01

We arbitrarily defined high risk coronary artery disease as left main or triple vessel disease with a luminal diameter narrowing of ≥50%. When patients in both series were considered, a total of 121 patients had high risk coronary artery disease. To test the preoperative variables that may help in the prediction of such high risk disease, we performed logistic regression discrimination using the following variables: age, sex, functional class, prior myocardial infarction, chest pain (angina, undefined chest pain and no chest pain), congestive heart failure and type of valve abnormality (aortic stenosis or aortic insufficiency alone). Age and chest pain were the most powerful predictors of left main or triple vessel disease; 13% of these patients did not have angina, 9% had undefined chest pain, 6% had no chest pain and none was <50 years old.

To evaluate critically the possible errors in managing patients who did not have preoperative coronary arteriography, we carefully analyzed the presence of coronary artery disease at autopsy in group 2 patients of the early series. Autopsy was performed on 49 of the 72 patients in groups 1 and 2 who died early postoperatively. Seven of the eight patients in group 1B (no bypass grafting) of the early series who died had an autopsy. Of these seven patients, four had triple vessel disease, including an unrecognized stenosis of the left main coronary artery; two had double vessel disease, including one without angina; and one had single vessel disease. Of the 47 patients in group 2 (no preoperative arteriography) who died early postoperatively, 33 had an autopsy. Of these patients, 21 (64%) had evidence of coronary artery disease (stenosis of >50% in one or more vessels) and 11 had triple vessel disease, including 6 with stenosis of the left main coronary artery. In both groups 1 and 2, a total of 34 patients had evidence of coronary artery disease at autopsy. Nine patients did not have preoperative angina; of these, five had triple vessel disease, including one with stenosis of the left main coronary artery.

Postoperative angina pectoris and subsequent need for coronary artery bypass grafting. We analyzed only the early series of patients for the occurrence of angina postoperatively and subsequent bypass grafting. Angina occurred for the first time in 6 group 1 patients who survived aortic valve replacement and in 24 group 2 patients. Of the six group 1 patients, four were in subgroup A, one in B and one in C. Angina recurred in 98 group 1 patients (33 in 1A, 25 in 1B and 40 in 1C) and 82 group 2 patients. Subsequent bypass grafting after valve replacement was performed in 5 group 1 patients (1 in 1A, 3 in 1B and 1 in 1C) and 13 group 2 patients. The interval between initial valve replacement and subsequent bypass grafting ranged from 2.8 to 8.9 years (mean 6.4) for patients in group 1 and from 0.9 to 15.3 years (mean 7.3) for patients in group 2.

Discussion

Operative mortality and survival. No statistically significant difference was found in the rates of operative mortality and long-term survival when patients who had preoperative coronary arteriography were compared with those who did not have arteriography. Furthermore, the study failed to demonstrate conclusively a beneficial or adverse effect on survival of combined aortic valve replacement and bypass grafting in patients with arteriographically documented coronary artery disease. However, any comparison among patients who had and those who did not have preoperative coronary arteriography and subgroups of patients who had preoperative coronary arteriography must be interpreted with caution because of imbalances in the distribution of preoperative variables that may influence survival.

The best survival rates were in patients with normal or minimally diseased coronary arteries (group 1A) and patients who had valve replacement and bypass grafting (group 1C). The poorest survival rate was observed in a subgroup of patients (group 1B) who had a higher frequency of congestive heart failure, were older and had moderate coronary artery disease that was not treated with bypass grafting at the time of valve replacement. The impact of age on operative mortality in our series of patients is similar to that in the study by Magovern et al. (14), who found that patients who were >70 years old, had a poor preoperative functional class and underwent an emergency operation were at the greatest risk for aortic valve replacement.

Previous studies. Some studies have reported evidence in support of the combined procedure (3,4), but others have questioned it (6), and all share the common fault with our study of being observational without concurrent control groups of patients with coronary artery disease who did not undergo bypass grafting. The study by Bonow et al. (6), which concluded that bypass grafting at the time of valve replacement in patients with coronary artery disease did not improve survival, included 55 patients with coronary artery disease who did not undergo bypass grafting. Of these 55 patients, only 10 had triple vessel disease and the entire group was followed up for a mean of 3.7 years. These data seem insufficient to conclude that bypass grafting combined with aortic valve replacement is unnecessary in patients with significant coronary artery disease.

Indications for coronary artery grafting. If one applies our current knowledge from prospective randomized trials and observational studies of bypass grafting alone (15–17), it seems important to identify patients with triple vessel disease, left main artery disease and important proximal left anterior descending artery disease as part of multivessel involvement and treat them with bypass grafting. Observations in our study that support the need for preoperative coronary arteriography and bypass grafting of significant multivessel disease include 1) the frequency of important nonbypassed multivessel coronary disease observed postmortem in patients who did not have preoperative coronary arteriography; 2) the significant relation between the severity of coronary artery disease and early mortality; and 3) the observation that the patients with the most severe coronary artery disease, in whom bypass grafting was performed, had long-term survival comparable with that in patients with normal or minimally diseased coronary arteries.

The persistence of a relatively high early mortality in patients with moderate coronary artery disease who did not have bypass grafting in the late series, although not statistically significant, suggests a high risk group that persists even with improvements in myocardial preservation, other intraoperative techniques and preoperative and postoperative care. The basis for this high mortality is not entirely clear, but it seems likely that the severity of coronary artery disease was underestimated at the time of arteriography. This conclusion is based on analysis of postmortem data on the severity of coronary artery disease, which showed a high frequency of more severe arterial obstructions than the preoperative arteriograms indicated. The problems involved in subjective interpretation of luminal diameter narrowing have been emphasized by the pathologist (10) and coronary physiologist (18). Although we cannot prove that bypass grafting would have improved survival in group 1B patients, it seems likely that this is the case. Although other investigators have recommended bypassing all coronary arteries with luminal diameter narrowing of >70%, our study suggests the need for careful review of lesions with moderate luminal diameter narrowing (50 to 70%) as well.

Role of angina pectoris. Smaller series (9) have suggested that all patients with hemodynamically significant aortic valve disease and important coronary artery disease can be expected to report angina pectoris. In contrast, we found that 14% of patients with triple vessel or left main coronary artery disease presented without angina. Exadactylos et al. (19) recently reviewed studies of patients with aortic stenosis and found that the incidence of patients with "significant coronary artery disease" who did not have chest pain ranged from 0 to 33%. This variability among studies seems to be related to the small numbers of patients and to variations in age and other clinical characteristics. Clearly, important coronary artery disease may be overlooked if one relies on only the presence of angina pectoris or any type of chest pain to select patients for preoperative arteriography, particularly in older patients.

Conclusions. In the early series (1967 through 1976) of patients who underwent aortic valve replacement, survival was the same for patients who had and those who did not have preoperative coronary arteriography; in patients who had preoperative coronary arteriography, no statistically significant difference in early mortality was documented among patients with normal arteriograms (4.5%), those with coronary artery disease who did not undergo bypass grafting (10.3%) or those with coronary artery disease who had bypass grafting (6.3%). The 5 and 10 year survival rates for these groups were, respectively, 76 and 63% ("normal" coronary arteriograms), 60 and 36% (coronary artery disease, no bypass grafting) and 73 and 49% (coronary artery disease, bypass grafting). The differences between the patients with "normal" arteriograms and those with coronary artery disease who did not have bypass grafting was statistically significant. In the late series (1982 and 1983), the early mortality rates were 1.4% in the patients with "normal" arteriograms, 9.4% in those with coronary artery disease who did not have bypass grafting and 4.0% in those with coronary artery disease who had bypass grafting. A higher early postoperative mortality rate was noted in the patients with coronary artery disease who did not have bypass grafting during both periods. These patients were older and had a greater frequency of congestive heart failure. In addition, at postmortem examination, the severity of coronary artery disease seems to be underestimated by arteriography.

This observation, in addition to the frequent finding of critical coronary artery disease in patients who die and have not had preoperative arteriography and bypass grafting, and survival data from isolated bypass grafting trials support the need for accurate identification of the presence and severity of coronary artery disease before aortic valve replacement and for bypass grafting in patients with significant coronary artery disease.

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