Aortic Valve Replacement in Patients 70 Years and Older

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Summary

Background: Aortic valvular disease is the most common valvular lesion among elderly patients. Because of changing demographics, it has become increasingly frequent. Aortic valve replacement (AVR) is the only effective treatment for aortic valvular disease.

Hypothesis: This study was undertaken to evaluate the results of AVR in an elderly population.

Methods: Data were retrospectively analyzed in 117 consecutive patients (mean age 73.8 years) who underwent AVR between 1991 and 2002.

Results: Pure or predominant severe aortic stenosis was present in 108 patients. Nine patients had severe aortic regurgitation. Before valve replacement, 62.4% of the patients were in New York Heart Association (NYHA) functional class III–IV. A bioprosthesis was implanted in 62.4% of the patients, and 37.6% received a mechanical valve. Concomitant cardiac surgical procedures were performed in 25 patients (coronary artery bypass graft in 22, mitral valve replacement in 3). There were 17 deaths, giving a perioperative mortality rate of 14.5%. Multivariate logistic regression showed that repeat surgery for bleeding, prolonged cardiopulmonary bypass time, postoperative respiratory failure, and postoperative acute renal insufficiency were significant independent predictors of operative mortality. Of the 100 hospital survivors, 78 were followed for a mean of 42.9 months. There were six deaths during follow-up; only two of these were cardiac related. Five-year actuarial survival for all patients and for hospital survivors were 70 and 91.1%, respectively. One year post surgery, all patients were in NYHA functional class I–II.

Conclusion: In a selected patient population, AVR in the elderly is associated with acceptable mortality and morbidity. The outlook for hospital operative survivors is excellent with improved quality of life and an expected survival normal for this particular age.

Key words: elderly, aortic stenosis, aortic valve replacement

Introduction

The life-span of the world population has increased progressively over the past half-century. As a result, the segment of the population, aged ≥ 70 years, has been rapidly expanding. With the aging of the population, the degenerative diseases, particularly cardiovascular disease, are becoming increasingly frequent.

As symptomatic heart disease affects the elderly, the need for cardiac operations in this population continues to grow. Advances in anesthetic and surgical techniques, as well as better perioperative care, have resulted in a significant improvement in perioperative and long-term outcome after cardiac surgery in these patients. Degenerative calcifying aortic lesions are extremely common in elderly persons. Furthermore, these lesions constitute a progressive disease with a grim prognosis.^{1,2} Aortic valve replacement (AVR) is the only effective treatment for severe aortic valvular disease. The purpose of the present retrospective study was to evaluate the results of AVR in patients aged ≥ 70 years operated at our institution.

Patients and Methods

The study series comprises 117 patients aged ≥ 70 years who underwent AVR at our institution between January 1, 1991, and January 1, 2002. Data were obtained by retrospective review of medical records, echocardiograms, catheterization and coronary artery findings, perioperative data, and pathology reports.

M-mode, two-dimensional, and Doppler echocardiography were performed preoperatively in all patients. Echocardiographic data were not available in six patients. Retrograde left heart catheterization and coronary arteriography were also ob-

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tained in all patients. In 13 cases (11.1%) it was not possible to obtain access to the left ventricle. Coronary artery disease was defined as a reduction of an epicardial vessel diameter by at least 50% in one view.

All patients were operated on by the same surgical team. Aortic valve replacement was performed using standard cardiopulmonary bypass technique. Surgical mortality was defined as occurring during hospitalization or within the 30 days following surgical intervention. Pathology reports were available for all explanted valves. Chronic anticoagulation with coumarin derivatives was maintained in all patients with a mechanical valve. Patients with bioprosthesis were placed in oral anticoagulant therapy for the first 3 months. Anticoagulation was continued indefinitely when atrial fibrillation was present. Follow-up data were obtained by retrospective review of the records registered at the outpatient department. Occasionally, the information was obtained by telephone contact with the patient or a family member.

Statistical Analysis

Student's *t*-test for continuous data and chi-square test for discrete variables were used to screen variables in the univariate analysis. Data consisting of 51 pre- and perioperative risk factors were analyzed as possible predictors of perioperative and late mortality. To determine the independent predictors of mortality, variables considered marginally significant ($p \leq 0.05$) in the univariate analysis were entered as covariates in a multivariate stepwise logistic regression model. Survival rates were estimated according to the method of Kaplan-Meier. Actuarial point estimates are given as percentages with 95% confidence interval (CI). Data collected were analyzed with the aid of SPSS version 10.0 software package (Statistical Package for Social Sciences, SPSS, Inc., Chicago, Ill., USA).

Results

Clinical Characteristics of the Study Group

The clinical characteristics of the 117 patients (72 men [61.5%], 45 women [38.5%], with a mean age of 73.8 ± 3.5 years; 11 [9.4%] octogenarians) are listed in Table I. The vast majority of the patients had severe aortic stenosis or combined severe aortic stenosis and mild regurgitation ($n = 108$, 92.3%); only 7.7% of the patients had pure severe aortic regurgitation. Valvular disease included calcific lesions in almost all patients (96.6%), bicuspid valve (9.3%), rheumatic disease (7.3%), bioprosthetic failure (2.6%), and infective endocarditis (1.7%).

Comorbid conditions were fairly common. Twenty-two patients (18.8%) were in New York Heart Association (NYHA) functional class II and 73 patients (62.4%) were in class III–IV (Table I). Significant coronary artery disease was present in 22 patients (18.8%). Coronary artery bypass graft (CABG) procedures were performed in all these patients. Three patients (2.6%) underwent concomitant mitral valve replacement.

TABLE I Clinical data in 117 patients aged ≥ 70 years undergoing aortic valve replacement

Gender, n	
Male	72 (61.5)
Female	45 (38.5)
Age (years $M \pm SD$)	73.8 ± 3.5
Valvular lesions, n	
Mixed aortic stenosis and regurgitation ^a	59 (50.4)
Isolated aortic stenosis	49 (41.9)
Isolated aortic regurgitation	9 (7.7)
Comorbidity, n	
Smoking	63 (53.8)
Systemic hypertension	51 (43.6)
Chronic obstructive lung disease	38 (32.5)
Diabetes mellitus	17 (14.5)
Previous myocardial infarction	10 (8.5)
Atrial fibrillation	9 (7.7)
Chronic renal insufficiency	5 (4.3)
Previous cerebrovascular accident	4 (3.4)
Infective endocarditis	2 (1.7)
Symptoms, n	
Dyspnea	95 (81.2)
Heart failure	73 (62.4)
Angina pectoris	51 (43.6)
Syncope	25 (21.4)
NYHA class I	22 (18.8)
NYHA class II	22 (18.8)
NYHA class III–IV	73 (62.4)
Coronary artery disease, n	
Triple-vessel disease	8 (6.8)
Double-vessel disease	7 (6.0)
Single-vessel disease	7 (6.0)

Parenthetical numbers are percents.

^a Regurgitation less than 2/4.

Abbreviations: n = number, NYHA = New York Heart Association.

A summary of the preoperative hemodynamic data in the 108 patients with pure or predominant aortic stenosis is listed in Table II. The systolic pressure gradient across the aortic valve was ≥ 50 mmHg in 100 patients (93.5%). Left ventricular ejection fraction was $\leq 35\%$ in 10 patients (9.6%). Two-thirds of the patients (63.1%) had an aortic valve area ≤ 0.6 cm². The seven patients with transaortic gradients ≤ 49 mmHg underwent concomitant CABG or mitral valve replacement.

Perioperative Data

The valve model inserted depended on heart rhythm, contraindications to the use of anticoagulant therapy, and the preference of both the surgeon and the patient. The different types of prostheses used are listed in Table III.

Nine patients had severe isolated aortic regurgitation. Three of these had acute dysfunction of an aortic bovine pericardium prosthesis that had been implanted between 9 and 15 years previously. At surgery, the bioprostheses were calcified and each had a ruptured cusp. All nine patients had transvalvular

TABLE II Hemodynamic assessment in 108 patients aged ≥ 70 years undergoing aortic valve replacement for isolated aortic stenosis or for mixed aortic stenosis and mild regurgitation

	N	M $\pm$ SD
Aortic gradient (mmHg)	107 ^a	83.7 $\pm$ 25.0
LV end-diastolic pressure (mmHg)	88	17.7 $\pm$ 9.1
LV ejection fraction (%)	104 ^b	57.5 $\pm$ 11.9
Aortic valve area (echo), cm ²	84	0.6 $\pm$ 0.2
Left atrial dimension, mm	80	41.5 $\pm$ 7.5
LV end-systolic dimension, mm	83	34.8 $\pm$ 9.0
LV end-diastolic dimension, mm	87	49.0 $\pm$ 8.1
Septum-diastolic thickness, mm	78	14.5 $\pm$ 2.7
LV posterior wall diastolic thickness, mm	76	13.3 $\pm$ 2.3

^a Cath 91, echo 16.^b Cath 15, echo 89.

Abbreviations: N = number, LV = left ventricular, SD = standard deviation.

TABLE III Aortic valve prostheses implanted in 117 patients aged ≥ 70 years

	N	%
Bioprosthetic valves		
Bovine pericardium ^a	55	
Porcine	18	
Total	73	62.4
Mechanical valves		
Bileaflet	26	
Disc	14	
Ball	4	
Total	44	37.6

^a Three patients also received a mitral bovine pericardium bioprosthesis.

aortic pressure gradients ≤ 25 mmHg and their ejection fraction ranged from 45 to 75%. Eight patients were in NYHA functional class III–IV. There were no perioperative or late deaths in this group.

Table IV details the perioperative data. Almost one-half of the patients ($n = 58$, 49.6%) experienced no major perioperative complications. Seventeen patients (14.5%) died within 30 days postoperatively. Among the 45 women in the series there were 9 deaths (20.0%), whereas 8 of the 72 men (11.1%) died perioperatively. This difference in operative mortality between men and women was not statistically significant. Twelve of these patients (70.6%) were in NYHA functional class III–IV. Two of the 22 patients (9.1%) who underwent AVR combined with CABG died, as did 1 of the 3 patients (33.3%) with combined mitral valve replacement. Causes of death are listed in Table V. One of the two patients who died of sepsis had candida septicemia. The 14 patients requiring repeat surgery for excessive bleeding accounted for 8 of the hospital deaths, and of the 24 patients who developed acute renal insufficiency in the immediate postoperative period, 8 died.

TABLE IV Perioperative data in 117 patients aged ≥ 70 years undergoing aortic valve replacement (AVR)

	N	M $\pm$ SD
Surgical procedure		
AVR	92 (78.6)	
Concomitant CABG	22 (18.8)	
Concomitant MVR	3 (2.6)	
CP bypass time (min)		117.6 $\pm$ 48.9
Aortic cross clamp time (min)		78.6 $\pm$ 26.0
Aortic prosthesis size (mm)		22.3 $\pm$ 1.9
Perioperative complications		
Acute renal insufficiency	24 (20.5)	
Repeat surgery	18 (15.4)	
For bleeding	14 (12.0)	
For mediastinitis	3 (2.6)	
For paraprosthetic leak	1 (0.9)	
Respiratory failure/infection	17 (14.5)	
Myocardial infarction	4 (3.4)	
Pericardial effusion	2 (1.7)	
Cerebrovascular accident	3 (2.6)	
Delirium	10 (8.5)	
Postoperative hospital stay (days)		
All patients		14.5 $\pm$ 10.1
100 Survivors		15.4 $\pm$ 10.0

Parenthetical numbers are percents.

Abbreviations: AVR = aortic valve replacement, CABG = coronary artery bypass graft, MVR = mitral valve replacement, CP = cardiopulmonary. Other abbreviations as in Table II.

TABLE V Causes of in-hospital death in 117 patients aged ≥ 70 years undergoing aortic valve replacement

	N	%
Left ventricular pump failure	6	5.1
Respiratory failure/infection	6	5.1
Sepsis	2	1.7
Cardiac tamponade	2	1.7
Multiple organ failure	1	0.9
Total	17	14.5

Univariate analysis identified 7 pre- and perioperative risk factors associated with 30-day hospital mortality. In multivariate logistic regression analysis, only repeat surgery for bleeding ($p = 0.002$), cardiopulmonary bypass time ($p = 0.02$), postoperative respiratory failure/infection ($p = 0.03$), and postoperative acute renal insufficiency ($p = 0.02$) remained statistically significant independent variables predictive of hospital mortality.

Long-Term Follow-Up

The actuarial survival curve of the 117 patients is shown in Figure 1A. The overall 5-year survival was 70.0% (95% CI

FIG. 1 Actuarial (Kaplan-Meier) survival estimates: (A) from date of surgery for 117 patients in the study (including early deaths), and (B) for 78 hospital survivors included in follow-up. Numbers at bottom indicate patients at risk at beginning of periods.

63.8–76.2). Of the 100 patients who survived the operation, 22 were lost to follow-up. They had returned to their town of residence immediately after hospital discharge and reliable information could not be obtained. This group was essentially similar to that of 78 patients in whom follow-up data were available. Mean follow-up was 42.9 ± 33.2 months (range 2–127 months) for a total of 3,350 patient-months. Forty six patients (59.0%) had received a bioprosthesis, while a mechanical valve had been implanted in the remaining 32 patients (41.0%). Six patients died during this period. The causes of death are listed in Table VI; only two of these deaths were cardiac related. The actuarial survival for the 78 patients included in the follow-up is shown in Figure 1B. At 5 years, survival was 91.1% (95% CI 86.7–95.5). None of the preoperative variables tested to predict long-term survival was found to correlate significantly with this endpoint. The clinical functional status of all patients surviving postoperative hospitalization showed significant improvement at follow-up evaluation. One year post surgery, 66 (90.4%) patients were in NYHA functional class I and 7 (9.6%) were in class II. Five years after surgery, all patients but one were in functional class I or II: 22 (84.6%) patients were in class I, 3 (11.5%) were in class II, and one (3.8%) was in class III. Almost all patients had resumed normal activities for their age.

Discussion

Aortic stenosis is a potentially serious condition. Previous studies of natural history have shown a dismal outcome for pa-

tients who were treated medically. Once a patient with aortic stenosis develops angina, syncope, dyspnea, or heart failure, the life expectancy in the absence of surgical correction is 1.5 to 3 years.¹ Progression from mild to severe stenosis has been reported consistently and may be very rapid. A mean rate increase of the aortic gradient of 6.5 to 7 mmHg per year has been found by serial cardiac catheterization and by Doppler echocardiographic studies.²

Operative Results

Aortic valve replacement is the only effective treatment for patients with severe aortic valve disease. Balloon aortic valvulotomy, used as an alternative treatment years ago, has been abandoned because of the high prevalence of restenosis and the high complication rate.³ The overall perioperative mortality of 14.5% in the present series is acceptable and comparable with the experience of other investigators.^{4–11} Most of these studies included a variable proportion of patients who underwent simultaneous CABG or an additional valve procedure. These concomitant procedures in elderly patients undergoing AVR are known to be related to a significant increase in operative mortality.^{4,7,8} In the present study, CABG was not associated with increased mortality, probably because of a small sample size. An evident and strong decrease in mortality after isolated AVR in the elderly has been reported recently;^{12–18} this may be attributed to better patient selection, refined myocardial protection, shorter cardiopulmonary bypass time, and improved surgical technique.

In multivariate logistic regression analysis, repeat surgery for excessive operative bleeding, prolonged cardiopulmonary bypass time, postoperative respiratory failure/infection, and postoperative acute renal failure were identified as independent predictors of hospital mortality. Excessive bleeding was noted in 14 patients (12.0%) requiring reexploration. The prevalence of hemorrhage was similar to that in other studies. It has been reported that 5 to 15% of elderly patients undergoing AVR present with excessive bleeding requiring repeat surgery, and that this complication is associated with increased mortality.^{7,8,10,15,19} Prolonged cardiopulmonary bypass times have also been found to be independent predictors of perioperative mortality in other studies.^{13,18} Respiratory infection and failure were responsible for one-third of the operative deaths in this

TABLE VI Causes of mortality at follow-up study in 78 patients aged ≥ 70 years who underwent aortic valve replacement ($n = 6, 7.7\%$)

Cause	Prosthesis	Months post-op
Cerebral embolism	St. Jude	9
Chronic renal failure	Medtronic-Hall	34
Pneumonia	Medtronic-Hall	2
Leukemia	Hancock	96
Pancreatic cancer	Hancock	8
Infective endocarditis	Bovine pericardium	13

series. Early extubation, aggressive institution of pulmonary physiotherapy, and early mobilization should be implemented in these patients, resulting in a significant reduction of ventilatory support time.

Several studies have documented that the operative mortality rates escalate with increasing age for patients undergoing AVR with or without concomitant CABG.^{5, 9, 19, 20} These patients are at higher risk not only because of age, but also because of associated comorbidity. However, consideration for surgical intervention should not be made on the basis of age per se; instead, case selection should be based on life expectancy of each patient in terms of other disease factors.

Several studies have indicated that the operative risk of AVR in the elderly increases with the development of left ventricular dysfunction.^{8–12, 15, 18} However, unlike these studies, the indices of left ventricular dysfunction, such as ejection fraction $< 35\%$ and NYHA functional class III–IV, were not associated with increased operative mortality in the present study. There is no clear explanation for this finding. A few other studies have also found that NYHA functional class was unrelated to operative mortality in patients aged ≥ 70 years⁴ and in octogenarians.¹⁹

Long-Term Outcome

The overall 5-year survival rate for the 117 patients included in this series was 70.0% (95% CI 63.8–76.2). Different studies have reported an overall 5-year survival of 60 to 70%.^{4–6, 10, 13, 15, 16} The outlook for this group of patients was excellent, with an expected survival normal for this particular age group and with good relief of symptoms. The actuarial survival rate at 5 years, in-hospital mortality excluded, of 91.1% (95% CI 86.7–95.5) is comparable with those of some series^{8, 11} and better than those of other studies reporting on hospital survivors.^{10, 13, 15–17} The most gratifying result in this study has been the improvement in these patients' quality of life, which is at least of equal importance as survival to the elderly. At 1 and 5 years of follow-up, 90% of the patients were asymptomatic and had resumed normal activities for their age. These results are consistent with those observed by others,^{15, 17} who have evaluated the long-term functional recovery after AVR in patients aged ≥ 70 years. They used quality of life assessment tools including the estimation of functional capacity, symptoms, and the patient's perception of total well being. Most of their patients stated that the operation had a significant impact on their health status and that they were functionally independent.

Aortic Valve Selection for the Elderly

Prosthesis selection for the elderly patient with aortic valve lesions has been a controversial issue.¹³ At the time of follow-up, no instance of structural bioprosthetic or mechanical valve failure was identified in any patient in the current study, and none of the patients had undergone repeat surgery for any cause of valve-related morbidity. There were no major bleeding episodes related to anticoagulation in the group of patients

who received long-term anticoagulant therapy. It would appear that these patients can be managed with either type of valve with similar early and late risks as long as there are no specific contraindications to anticoagulant therapy. Nevertheless, it has been shown that structural aortic biological valve deterioration is essentially nonexistent at 10 and 12 years in patients aged ≥ 70 years.^{21, 22} This limited structural degeneration coupled with the infrequent need for coumarin anticoagulation would make the bioprosthesis the valve replacement of choice for the elderly patient with aortic valvular lesions. However, from our data, a categorical recommendation about a choice of prosthesis cannot be offered because our follow-up was limited to 42.9 ± 33.2 months. The presence of chronic atrial fibrillation should prompt indication of a mechanical valve.

Conclusions

Aortic valve replacement for severe aortic stenosis can be performed in selected elderly patients with increased but acceptable mortality and morbidity rates. It is the procedure of choice and the only effective treatment in this setting. The long-term outcomes of AVR are clearly better than the results of untreated aortic stenosis. In elderly patients, AVR produces significant lessening of symptoms and possibly increased longevity of those surviving hospitalization. The improvement in quality of life further emphasizes the value of surgical treatment of severe aortic stenosis in this age group. Elderly patients should not be denied AVR on the basis of age alone.

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