

# Cardiac surgery in octogenarians

## Peri-operative outcome and long-term results

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**Aims** Because the elderly are increasingly referred for operation, we reviewed the results of cardiac surgery in patients of 80 years or older.

**Methods and Results** Records of 182 consecutive octogenarians who had had cardiac operations between 1992 and 1998 were reviewed. Follow-up was 100% complete. Seventy patients had coronary grafting (CABG), 70 aortic valve replacement, 30 aortic valve replacement+CABG, and 12 mitral valve repair/replacement. Rates of hospital death, stroke, and prolonged stay (>14 days) were as follows: CABG: 7 (10%), 2 (2.8%) and 41 (58%); aortic valve replacement: 6 (8.5%), 2 (2.8%) and 32 (45.7%); aortic valve replacement+CABG: 8 (26.5%), 1 (3.8%) and 14 (46.6%); mitral valve repair/replacement: 3 (25%), 1 (8.3%) and 5 (41.6%). Multivariate predictors ( $P<0.05$ ) of hospital death were New York Heart Association functional class, urgent procedure, prolonged cardiopulmonary bypass time, and, after aortic valve replacement, previous percutaneous aortic valvuloplasty. Ascending aortic atheromatous disease was predictive of stroke, while pre-operative myocardial infarction was predictive of prolonged hospital

stay. Actuarial 5-year survival was as follows: CABG,  $65.8 \pm 8.8\%$ ; aortic valve replacement,  $63.6 \pm 7.1\%$ ; aortic valve replacement+CABG,  $62.4 \pm 6.8\%$ ; mitral valve repair/replacement,  $57.1 \pm 5.6\%$ ; and total,  $63.0 \pm 5.6\%$ . Multivariate predictors of late death were pre-operative myocardial infarction, and urgent procedure. Ninety per cent of long-term survivors were in New York Heart Association class I or II, and 87% believed having a heart operation after age 80 years was a good choice.

**Conclusion** Cardiac operations are successful in most octogenarians with increased hospital mortality, and longer hospital stay. Long-term survival and quality of life are good.

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**Key Words:** Aortic valve, cardiac surgery, octogenarians, quality of life.

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## Introduction

The increase in lifespan of European and American populations over the past decades has resulted in a significant increase in the number of people aged more than 80 years. Based on statistical data derived from population studies, life expectancy varies from an average of approximately 8.1 years at the age of 80 years to

6.0 years at the age of 89 years<sup>[1]</sup>. Studies<sup>[2,3]</sup> have also shown that more than 25% of octogenarians are functionally limited by cardiovascular disease.

During the last decade, we have observed a significant increase in the number of patients aged 80 years and more who are referred for cardiac surgery, and this despite a context of growing control of health care expenditures, where one might think that expensive procedures, such as cardiac operations, would be limited in such elderly patients.

Recent studies have shown that cardiac surgical procedures performed in elderly patients, in otherwise good physical and mental health, can improve mortality, morbidity, and quality of life of those patients<sup>[4–7]</sup>. However, results are still incomplete, especially for valve procedures.

To analyse these issues further, we have reviewed our early and long-term results in patients aged 80 years and

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over who underwent cardiac surgery at our institution, between January 1992 and December 1998.

## Methods

### *Patients*

Records of 182 patients who underwent a cardiac surgical procedure were reviewed (retrospective study). A total of 46 pre-operative, operative, and postoperative variables were recorded. Follow-up information was obtained from all hospital survivors through clinic visits and annual letters, and was 100% complete. Mean follow-up was 38.2 months, and cumulative follow-up was 459 patient-years. Between February and May 1999, all known survivors were questioned to determine general health status, presence or absence of chest pain, dyspnoea or angina pectoris, postoperative New York Heart Association (NYHA) functional class, and quality of life.

Coronary artery disease was defined as a reduction of vessel diameter by at least 50% in one view on coronary angiography. Stenosis to this degree in the left anterior descending system, circumflex system, or right coronary system was used for the criterion of single, double, or triple vessel disease. Urgent operations were defined as operative procedures performed in patients whose accelerated symptoms prompted urgent hospital admission for evaluation and who were judged to be too unstable for discharge before surgery. Operative mortality was any death occurring within 30 days of the operation or death during the same hospital admission as the operation. Postoperative course was followed up in terms of bleeding, cardiac and renal status, assisted ventilation duration, and neurological events. Congestive heart failure was determined by the presence of pulmonary congestion or opacities consistent with oedema on chest roentgenograms. Peri-operative myocardial infarction was defined as either a new Q wave or the elevation of the myocardial fraction of creatinine kinase in association with persistent ST segment changes or a new conduction abnormality. Stroke was defined as any neurological deficit lasting longer than 24 h, even if the deficit resolved before hospital discharge.

In cases of carotid stenosis of 80% or more, carotid endarterectomy was performed during the same anaesthesia, before the institution of extracorporeal circulation and the cardiac surgical procedure itself.

Anaesthesiological protocol was the same throughout this period, extracorporeal circulation was performed with a membrane oxygenator, and myocardial protection used cold crystalloid cardioplegia solution added to topical cooling.

### *Statistical analysis*

Distribution for all relevant variables was expressed either as percentages or as mean  $\pm$  standard deviation.

The effects of nominal risk factors, such as presence of angina, on early mortality were evaluated univariately with the chi-square test or Fisher's exact test. The effects of continuous variables, such as age, were univariately evaluated with two-sample t-tests or with Wilcoxon rank sum tests when necessary. Combinations of risk factors were multivariately evaluated with multiple logistic regression models. Survivorship to death, for all patients and for all hospital survivors, was estimated with the Kaplan-Meier method. To assess separately those risk factors related to late survival as distinct from operative deaths, we analysed only hospital survivors. Nominal risk factors for survival were assessed with log-rank tests. Continuous measurable risk factors, such as age, and combinations of risk factors, both nominal and continuous, were evaluated with Cox's proportional hazard models. A *P* value  $<0.05$  was considered statistically significant.

## Results

### *Patient population*

The population consisted of 182 consecutive patients ranging in age from 80 to 92 years (mean age:  $82.8 \pm 2.3$  years). Seventy patients (38.5%) had coronary artery bypass grafting (CABG), 70 patients (38.5%) aortic valve replacement, 30 patients (16.5%) aortic valve replacement+CABG, and 12 patients (6.5%) mitral valve repair or replacement.

Clinical characteristics of these patients are listed in Table 1.

#### *Aortic valvular replacement (n=100)\**

Most common presenting symptoms were dyspnoea on exertion in 84 patients, congestive heart failure in 61 patients, angina in 59 patients, and syncope in 23 patients.

Assessment of left ventricular function showed that nine patients had poor function, defined as an ejection fraction of  $<35\%$ . Mean ejection fraction was  $56.8 \pm 13.7\%$ . Mean valve area was  $0.57 \pm 0.16 \text{ cm}^2$ ; mean valve gradient was  $66.0 \pm 17.7 \text{ mmHg}$ . Mean left ventricular end-diastolic pressure was  $22.3 \pm 7.8 \text{ mmHg}$ . Thirty patients had significant coronary artery disease.

Aortic stenosis was the predominant valvular lesion in 80 patients, followed by combined aortic stenosis and insufficiency in 19 patients, and aortic insufficiency in one patient. Valvular disease involved calcified lesions in 95 patients, bicuspid valve in 14 patients, myxomatous degeneration in seven patients, rheumatic disease in two patients, and endocarditis in one patient. Three patients had significant ascending aortic atheromatous disease.

Stented bioprostheses were implanted in 89 patients, stentless bioprostheses in nine patients, and mechanical

\*In the aortic valve replacement group,  $n=100$  (obtained by adding 70 patients with aortic valve replacement alone and 30 patients with aortic valve replacement+CABG). Therefore, all absolute numbers are also percentages.

**Table 1 Patient clinical characteristics**

Variable	AVR (n=100)* No. of patients	CABG (n=70) No. of patients (%)	MVR (n=12) No. of patients (%)
Males	21	50 (71)	5 (42)
Females	79	20 (29)	7 (58)
Age (years)	82.8 ± 2.4	82.1 ± 2.0	82.9 ± 2.3
Status—elective	79	61 (87)	9 (75)
Status—urgent	21	9 (13)	3 (25)
New York Heart Association, class III	36	4 (6)	5 (42)
New York Heart Association, class IV	31	8 (11)	7 (58)
Previous myocardial infarction	10	30 (43)	1 (8)
Diabetes mellitus	11	13 (19)	1 (8)
Hypertension	40	42 (60)	3 (25)
Hypercholesterolaemia	10	25 (36)	2 (16)
Tobacco abuse	8	14 (20)	1 (8)
Chronic obstructive pulmonary disease	4	6 (8)	1 (8)
Atrial fibrillation	16	14 (20)	5 (42)
Permanent pacing	10	7 (10)	1 (8)
Renal insufficiency	4	2 (3)	1 (8)
Previous peripheral vascular surgery	7	4 (6)	—
Previous percutaneous aortic valvuloplasty	3	—	—

AVR=aortic valve replacement; MVR=mitral valve repair/replacement.

\*In the aortic valve replacement group, n=100 (obtained by adding 70 patients with aortic valve replacement alone and 30 patients with aortic valve replacement+CABG). Therefore, all absolute numbers are also percentages.

valves in two patients. Average valve size was 21.1 mm. Additional CABG was performed in 30 patients, respectively for one-vessel disease in 14 patients, two-vessel disease in 11 patients, and three-vessel disease in five patients. Mean cardiopulmonary bypass time was 103.5 ± 40.5 min, and mean aortic cross clamp time was 66.0 ± 21.4 min. For isolated aortic valve replacement procedures, mean cardiopulmonary bypass time and mean aortic cross-clamp time were, respectively, 93.7 ± 35.3 min and 61.8 ± 21.0 min, while for combined aortic valve replacement+CABG they were 128.6 ± 38.0 min and 79.0 ± 18.9 min, respectively.

Carotid endarterectomy was performed additionally in three patients, including two patients in the aortic valve replacement+CABG group.

#### *Coronary artery bypass grafting (n=70)*

Most patients (66 patients: 94%) had unstable angina, but only nine patients (13%) were operated under urgent conditions. Twelve patients (17%) were in New York Heart Association (NYHA) class III or IV. Thirty patients (43%) had a history of myocardial infarction, including one (1.5%) less than a week before surgery and seven (10%) less than a month before myocardial revascularization.

Six patients (8%) had previous coronary angioplasty, with stenting in two patients. One patient (1.5%) had a history of aortocoronary bypass 11 years before. Nine patients (13%) had an ejection fraction <35%; mean ejection fraction was 58.9 ± 12.7%.

Operative findings revealed moderate or severe ascending aortic atheromatous disease in 12 patients (17%). Surgery consisted of single CABG in one patient (1.5%), double in 12 patients (17%), triple in 34 patients (48.5%), quadruple in 18 patients (25.5%), quintuple in

four patients (6%), and sextuple in one patient (1.5%). The left internal mammary artery was used in 32 patients (45%) (implanted on the left anterior descending coronary artery in 30 patients and on the first marginal circumflex branch in two patients), and the right internal mammary artery was used to bypass the right coronary artery in two patients (3%). The left radial artery was harvested and implanted on the first marginal circumflex artery in two patients (3%). Mean cardiopulmonary bypass time was 94.7 ± 32.9 min and mean aortic cross-clamping time was 46.1 ± 15.7 min.

Carotid endarterectomy was performed additionally in seven patients (10%).

#### *Mitral valve repair or replacement (n=12)*

All patients operated on for mitral valve disease were in NYHA functional class III or IV. Five patients (42%) were in chronic atrial fibrillation. One patient (8%) had had previous percutaneous mitral valvuloplasty.

One patient (8%) had an ejection fraction <35%; mean ejection fraction was 60.7 ± 10.3%. Insufficiency was the predominant valvular lesion in eight patients (67%), while three patients (25%) had combined stenosis and insufficiency. Only one patient had pure mitral stenosis. Valvular disease involved calcified lesions in nine patients, myxomatous degeneration in six patients, and rheumatic disease in two patients.

Mitral valve replacement with a stented bioprosthesis was performed in nine patients (75%), while three patients (25%) with mitral insufficiency had a valvuloplasty, with posterior quadrangular resection and implantation of a Carpentier ring. In addition, CABG was performed in four patients, respectively for single-vessel disease in three patients and for two-vessel disease in one patient. Mean cardiopulmonary bypass time was

**Table 2** *Operative results*

Variable	AVR (n=100)* No. of patients	CABG (n=70) No. of patients (%)	MVR (n=12) No. of patients (%)
Deaths	14	7 (10)	3 (25)
Cerebrovascular accident	2	2 (3)	1 (8)
Myocardial infarction	7	7 (10)	2 (16)
Pneumonia	15	4 (6)	—
Prolonged mechanical ventilation (>48 h)	24	11 (16)	1 (8)
Permanent pacing	5	—	2 (16)
Dialysis	4	2 (3)	3 (25)
Arrhythmias	24	17 (24)	3 (25)
Reoperation for bleeding	5	2 (3)	—
Reoperation for sternal instability	1	2 (3)	—
Pericardial drainage	4	—	—
Hospital stay (days)	19.6 ± 11.4	17.8 ± 10.5	16.6 ± 8.9
Prolonged hospital stay (>14 days)	46	41 (58)	5 (42)
ICU stay (days)	7.8 ± 9.5	5.8 ± 5.2	7.6 ± 9.8

Abbreviations as for Table 1.

\*In the aortic valve replacement group, n=100 (obtained by adding 70 patients with aortic valve replacement alone and 30 patients with aortic valve replacement+CABG). Therefore, all absolute numbers are also percentages.

109.7 ± 41.7 min, and mean aortic cross clamp time was 76.7 ± 27.9 min. For isolated mitral valve procedures, mean cardiopulmonary bypass time and mean aortic cross-clamp time were, respectively, 98.4 ± 29.8 min and 70.8 ± 17.4 min, while for combined mitral valve repair/replacement+CABG they were 123.8 ± 54.5 min and 84.0 ± 39.3 min, respectively.

### *Postoperative complications*

Early postoperative complications are listed in Table 2.

Arrhythmias occurred in 44 patients (24%), of whom 39 had atrial fibrillation or supraventricular tachycardia, and five had ventricular tachycardia. Among 36 patients (20%) requiring prolonged (>2 days) mechanical ventilation, 19 had pneumonia. Five patients (3%) developed a cerebrovascular accident, of whom one completely recovered before hospital discharge. Seven patients (4%) had a pacemaker implanted because of a permanent atrioventricular block. Fourteen patients (8%) underwent reintervention because of mediastinal bleeding (seven patients), sternal instability (three patients) or pericardial effusion with haemodynamic instability (four patients).

Seventy-five patients (41%) had no postoperative complications. More precisely, morbidity was 63% after aortic valve replacement, 50% after CABG, and 75% after mitral valve surgery.

Length of hospital stay averaged 18.8 ± 12.2 days, including six patients with stays longer than 50 days. Average length of stay in the intensive care unit was 6.8 ± 7.3 days.

died after isolated aortic valve replacement, seven patients (10%) after CABG, three patients (25%) after mitral valve repair/replacement, and eight patients (26.5%) after aortic valve replacement+CABG (Table 2).

Of the 24 patients, nine were men and 15 were women. Seven patients were operated on urgently and 17 were operated on electively. Twelve patients were in NYHA class IV. Three patients with previous percutaneous aortic valvuloplasty died after aortic valve replacement. Causes of hospital death were myocardial infarction in 12 patients, respiratory insufficiency in eight, and multi-system organ failure in four. After aortic valve replacement, the most frequent cause of death was pulmonary insufficiency (responsible for 5/6 deaths), while after CABG or aortic valve replacement+CABG, the most frequent cause of death was myocardial infarction (responsible for 9/15 deaths). After mitral valve surgery, mortality was essentially (2/3 deaths) due to cardiac cause.

Univariate analysis of 46 perioperative variables showed five variables (Table 3) associated with operative mortality. Only four variables, NYHA functional class IV, urgent procedure, prolonged extra-corporeal circulation, and, in the group of patients operated on for aortic valve replacement, previous percutaneous valvuloplasty remained statistically significant independent variables predicting early mortality on multivariate logistic regression analysis.

By multivariate analysis, aortic atheromatous disease was the only variable predictive of postoperative stroke, while pre-operative myocardial infarction was predictive of prolonged hospital stay (Table 3).

### *Operative mortality*

Hospital deaths occurred in 24 patients (13%) of which 20 (11%) represent 30-day mortality. Six patients (8.5%)

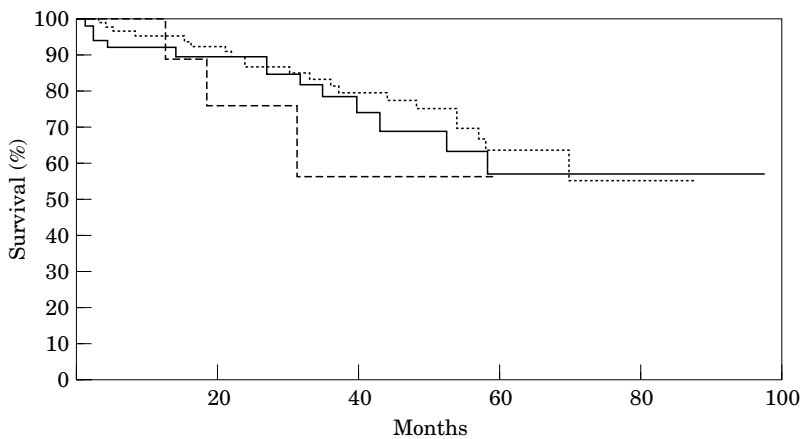
### *Late mortality*

A hundred and fifty-eight patients were discharged from hospital. A total of 39 patients have died at follow-up.

**Table 3** Variables associated with operative mortality and morbidity

Variables	Univariate analysis ( <i>P</i> value)	Multivariate analysis ( <i>P</i> value)
Predictive of operative mortality		
Duration of extra-corporeal circulation	<0.001	0.01
Previous percutaneous aortic valvuloplasty*	0.002	0.01
Previous myocardial infarction	0.006	0.052
NYHA functional class	0.011	0.035
Urgent procedure	0.028	0.02
Predictive of postoperative cerebrovascular accident		
Aortic atheromasia	0.005	0.02
Carotid disease	0.01	0.06
Predictive of prolonged hospital stay (>14 days)		
Previous myocardial infarction	0.02	0.04
Age	0.04	0.1

\*Only in the aortic valve replacement group.



**Figure 1** Survival curve of hospital survivors aged 80 years and older. ... aortic valve replacement; —=coronary artery bypass grafting; ---=mitral valve repair/replacement.

**Table 4** Long-term survival after cardiac surgery in the octogenarians

Survival	AVR	CABG	MVR	Total
One year	95.1 ± 2.4%	91.8 ± 3.5%	88.9 ± 10.5%	93.4 ± 2.0%
Three years	81.3 ± 4.7%	79.2 ± 6.1%	76.2 ± 14.8%	79.1 ± 3.8%
Five years	63.6 ± 7.1%	65.8 ± 8.8%	57.1 ± 19.8%	63.0 ± 5.6%

For abbreviations, see Table 1.

More precisely, 22 patients died after aortic valve replacement, 14 patients after CABG, and three patients after mitral valve surgery. Cardiac causes resulted in 16 deaths (41%), and non-cardiac causes resulted in 23 deaths (59%).

Long-term survival, for each surgical procedure, is depicted in Fig. 1 and Table 4. For hospital survivors, overall survival at 1, 3 and 5 years was 93.4 ± 2.0% (112 patients at risk), 79.1 ± 3.8% (62 patients at risk), and 63.0 ± 5.6% (28 patients at risk), respectively.

Univariate analysis of 40 perioperative variables showed five variables associated with late mortality

(Table 5). Two variables, urgent procedure and perioperative myocardial infarction, remained statistically significant as independent predictors of late mortality by multiple Cox-regression.

### Quality of life assessment

We did not experience valve-related complications, such as thromboembolism, bleeding events, prosthetic valve endocarditis, structural failure, or reoperation.

At the time of follow-up, NYHA functional class and activity level of the 119 patients who were still alive were

**Table 5** Peri-operative variables associated with long-term survival (hospital survivors)

Variables	Univariate analysis ( <i>P</i> value)	Multivariate analysis ( <i>P</i> value)
Pre-operative myocardial infarction	0.009	0.003
Urgent procedure	0.012	0.035
Pre-operative pacing	0.012	0.35
Combined valvular stenosis and insufficiency*	0.026	0.22
Ejection fraction <35%	0.042	0.64
Stented bioprosthesis*	0.065	0.34

\*Only in the aortic valve replacement group.

assessed. The majority of patients were in NYHA class I (79/119, 66%) or class II (29/119, 24%). Patient activity level was rated as heavy, defined as running or lifting heavy objects; moderate, defined as ability to do cleaning; light, defined as activities of daily living; and bedridden. Patients often rated their activity level as heavy (24/119, 20%), or moderate (58/119, 49%). Among the 119 long-term survivors, 87% believed that having heart surgery after age 80 years was a good choice, and similarly 86% felt as good as or better than they had pre-operatively.

## Discussion

The performance of the cardiac pump changes with natural ageing, even in the absence of any associated pathology. For example, at rest, ventricular compliance decreases, although systolic function is maintained. During exercise, both maximal heart rate and ejection fraction decrease, most likely because of a lesser response to circulating catecholamines. In an elderly person, cardiac adaptation to exercise requires, proportionally, a greater utilization of the Frank-Starling mechanism, rather than an increase in cardiac contractility<sup>[8–10]</sup>.

In 2000, there are more than 10 million people aged 80 years and above living in the European Union, and, because the population is ageing further, this number should increase during the coming years. In these octogenarians, the incidence of cardiovascular disease and of coronary insufficiency is, respectively, 40% and 18%; acquired heart disease is a leading cause of death among the elderly<sup>[11]</sup>.

Furthermore, these elderly patients often have associated diseases, such as chronic obstructive pulmonary disease, peripheral valvular disease, renal insufficiency, prostatic enlargement complicated by urinary retention, and degenerative cerebral disease<sup>[12–15]</sup>.

The answer to the question 'Should cardiac surgery be performed in the octogenarian?' is complex, and must take into account several elements, such as lack of synchronism between physiological age and chronological age, quality of life, risk/benefit ratio, and augmentation of health care costs, an element that is gaining more and more importance.

This work is a contribution to this question, analysing in detail the postoperative and long-term outcome of 182 octogenarians who have had cardiac surgery.

## Operative mortality and morbidity

Until the mid-1980s, it was uncommon to perform cardiac surgical procedures in octogenarians, because of the theoretical fear that an elderly person would be unable to withstand extracorporeal circulation, concern about the quality of the tissues, fear of multi-systemic disease, and incomplete appreciation of life expectancy of people having reached the age of 80 years. However, during the last decade, the number of octogenarians having cardiac surgery has rapidly increased, with acceptable mortality and morbidity rates<sup>[4–7]</sup>.

We report an operative mortality of 13%, with a 30-day mortality of 11%. More precisely, mortality was 8.5% after isolated aortic valve replacement, and 10% after myocardial revascularization. These results showed that cardiac surgical procedures can be performed with an acceptable risk in octogenarians.

We sought to define risk factors that would be predictors of early death in this elderly population. Multivariate logistic regression analysis showed that the only pre-operative risk factors associated with operative mortality were New York Heart Association functional class IV, prolonged extracorporeal circulation, and urgent procedure. In addition, a history of percutaneous aortic valvuloplasty was an independent risk factor for patients having aortic valve replacement. After surgery, myocardial infarction was a harbinger of a poorer outcome.

Poor left ventricular function also was predictive of hospital death in two series, respectively, from the Texas Heart Institute<sup>[16]</sup> and from the Johns Hopkins Hospital<sup>[17]</sup>. Elayada *et al.*<sup>[16]</sup> also found hypertension and concomitant surgical procedures to be associated with early mortality. Galloway *et al.*<sup>[18]</sup> showed emergency operation, isolated aortic regurgitation, and previous cardiac operation to be predictive of operative mortality. It is important to note that in our experience, previous aortic valvuloplasty was an independent factor predicting operative mortality. However, it is possible that those patients were initially felt to be poor surgical candidates.



In our series, age itself was not a predictor. Similarly, age was not a predictor in the recent study by Tseng *et al.*<sup>[17]</sup>.

Our postoperative complication rate was somewhat high (59%). Pulmonary insufficiency or infection was one of the leading causes of postoperative morbidity. In these elderly patients, we are now having encouraging results with partial sternotomies, early extubation (less than 6 h postoperatively), and more vigorous pulmonary toilet. Among the 44 patients who developed postoperative arrhythmias, 39 had atrial fibrillation or supraventricular tachycardia that was rapidly treated with either intravenous antiarrhythmic agents or cardioversion. The incidence of other postoperative complications, such as stroke, dialysis, myocardial infarction, or reoperation, was comparable with other recent reports<sup>[17,19]</sup>.

During the period analysed, we observed a decrease in hospital stay in the more recent years. For the first 50 hospital survivors, hospital stay averaged 20.6 days, but was 16.1 days for the last 50 hospital survivors. Although average stay in the intensive care unit was 6.8 days for the study in total, it decreased to 5.2 days for the last 50 patients. At a time when health care costs are becoming increasingly high, shortening hospital stay can only be beneficial on the relative risk/benefit ratio of cardiac surgical procedures performed in octogenarians.

### *Long-term survival and quality of life*

For hospital survivors, survival at 1, 3, and 5 years was  $93.4 \pm 2.0\%$ ,  $79.1 \pm 3.8\%$ , and  $63.0 \pm 5.6\%$ , respectively. These survival rates are comparable with other studies and show good long-term survival despite advanced age<sup>[16,17,20]</sup>.

In our study, previous myocardial infarction and urgent procedure were pre-operative risk factors predictive of late mortality, by multivariate analysis. These results suggest that elderly patients should be referred for operation as early as possible to prevent urgent operations or advanced stage disease. Urgent operation was also predictive of late mortality in other recent studies<sup>[21,22]</sup>. When survival was stratified based on urgency of operation, our survival for elective surgery was  $96.1 \pm 1.9\%$ ,  $86.7 \pm 2.8\%$ , and  $74.1 \pm 6.5\%$  at 1, 3, and 5 years, respectively, as compared with  $89.8 \pm 4.9\%$ ,  $72.3 \pm 8.8\%$ , and  $42.7 \pm 16.7\%$  at 1, 3, and 5 years, respectively, for urgent operations. Clearly, referral of elderly patients before end-stage disease requiring urgent operations is paramount to long-term survival.

Of at least equal importance to the elderly as survival is quality of life. In this study, 87% of long-term survivors believed, in retrospect, that having decided to have cardiac surgery after age 80 years had been a good choice. Furthermore, at a mean follow-up of 38.2 months postoperatively, 72% of survivors were still living at home or with their families. Finally, we did not experience valve-related complications, such as bleeding

events, thromboembolism, prosthetic valve endocarditis, structural failure, or reoperation.

### *Aortic valve replacement*

Because of the greater use of non-invasive diagnostic techniques, particularly echocardiography with two-dimensional Doppler ultrasonography, the diagnosis of symptomatic aortic valve disease, particularly aortic stenosis, is becoming increasingly common<sup>[23]</sup>.

Because aortic valvular disease remains a frequent problem in the elderly, an increasing number of octogenarians are being referred for surgical correction of this symptomatic valvular disease. However, there is controversy regarding whether or not aortic valve replacement represents a reasonable use of health care resources, in this elderly population<sup>[6,24,25]</sup>.

The natural prognosis of severe aortic stenosis is ominous: 90% of patients with angina and syncope died within 3 years of the onset of symptoms and if heart failure was present death occurred within 2 years<sup>[26]</sup>. Balloon aortic valvuloplasty has been proposed as an alternative to operation in the treatment of aortic valve stenosis<sup>[27]</sup>. Nevertheless, published hospital mortality ranged from 3% to 10%<sup>[22,28]</sup>, and hospital morbidity from 10% to 25%. Furthermore, immediate restenosis (within 72 h) occurred in 25% of patients, and 66% had restenosis within 6 months<sup>[22]</sup>. Survival curves showed less than 80% survival at 1 year, and functional improvement did not occur in all patients<sup>[22]</sup>.

Early reports of aortic valve replacement in elderly patients showed high operative mortality rates; however, recent reports have shown mortality rates of 2% to 10% for isolated aortic valve replacement<sup>[16,19]</sup>. In a recent study from Akins *et al.*<sup>[19]</sup>, hospital mortality in 105 octogenarians who had isolated aortic valve replacement was 7.6%. Similarly, Tseng *et al.*<sup>[17]</sup> reported a 6.1% operative mortality among 247 elderly patients (70 to 89 years old) who underwent isolated aortic valve replacement.

Our hospital mortality for 70 patients who underwent isolated aortic valve replacement was 8.5%. These results show that aortic valve replacement can be performed with an acceptable risk in patients older than 80 years of age. Significant improvement in surgical outcome has been ascribed to advances in myocardial protection, anaesthesia, and postoperative critical care.

We currently believe that the bioprosthetic valve is the safest cardiac valve substitute for octogenarians. A report by Jamieson *et al.*<sup>[29]</sup> states that structural deterioration of tissue valves is limited in the elderly population. Because systemic anticoagulation is rarely required, bioprosthetic valves have a reduced incidence of haemorrhagic and thrombotic complications compared with mechanical valves<sup>[30]</sup>. Furthermore, the use of stentless valves allows for implantation of larger prostheses, which in our study has beneficial effects on long-term survival, however without reaching statistical significance.

### Combined aortic valve replacement and coronary artery bypass grafting

Aortic valve replacement combined with coronary artery bypass grafting resulted in a 26.5% early and a 12.5% late mortality. This is noticeably higher than the 6.3% early mortality recently reported by Akins *et al.*<sup>[19]</sup>, but comparable to the 28% early and 40% late mortality reported by Fiore *et al.*<sup>[31]</sup>, which, however, is a somewhat older series. Our higher operative mortality could, in part, be explained by the significant preponderance of women (4:1). In other reports, female sex has been an independent predictor of both early and late mortality in the elderly, both for isolated aortic valve replacement<sup>[32]</sup>, and for aortic valve replacement with CABG<sup>[33]</sup>.

Conventional practice suggests that revascularization should be performed at the time of aortic valve replacement if major coronary artery stenosis is present, regardless of the presence or absence of angina<sup>[34]</sup>. Reports in younger patient populations indicate that myocardial revascularization does not increase the operative mortality of valve replacement, and the functional result may be improved by relieving the symptoms of angina and providing improved myocardial protection. This aggressive approach requires prolonged ischaemic time and may not be appropriate in octogenarians. We now tend to believe that in octogenarians, only those with critical (>80%) coronary lesions or severe angina should undergo concomitant coronary bypass grafting. Less than complete revascularization may be an acceptable alternative in this elderly subset of patients when congestive heart failure is the primary indication for operation.

### Mitral valve surgery

The experience reported here is limited, concerning only 12 patients who had mitral valve repair or replacement. However, operative mortality was high (25%), and we believe that this type of cardiac surgical procedure should be strictly reserved for patients without any other therapeutic option, and in good general condition, without co-morbid diseases. If mitral valvuloplasty preserves the geometry of the left ventricle, one must refrain from complex valvular reconstructions that would prohibitively increase aortic cross-clamp and extra-corporeal circulation times.

### Conclusions

In summary, cardiac surgery can be performed in patients 80 years old or older with acceptable mortality, good long-term results, and good quality of life. Pre-operative risk factors associated with early mortality involved previous percutaneous valvuloplasty and New York Heart Association functional class IV, whereas

myocardial infarction was a predictor of late mortality. Urgent procedure was an independent predictor of both early and late mortality.

We believe octogenarians with aortic valve disease should not be denied the benefits of surgery if they are reasonably good surgical candidates, are physiologically and mentally able to withstand the stress of surgery, and have good motivation for an improved life style. The operative decision must integrate, as for younger patients, the opinion of the family doctor, the cardiologist, the cardiac surgeon, the patient, and their family.

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