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Aortic valve surgery in octogenarians: predictive factors for operative and long-term results☆

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Abstract

Objective: To assess factors influencing operative and long-term outcome in octogenarians undergoing aortic valve surgery (AVR). **Methods:** Records of 220 consecutive octogenarians having AVR between 1992 and 2004 were reviewed, and follow-up obtained (99% complete). Of the group (mean age: 82.8 years; 174 females), 142 patients (65%) were in New York Heart Association (NYHA) class III—IV, 22 (10%) had previous myocardial infarction, 11 (5%) had previous coronary artery bypass grafting (CABG), and 8 (4%) had percutaneous aortic valvuloplasty. There were 44 urgent procedures (20%), and additional CABG was performed in 58 patients (26%). **Results:** Operative mortality was 13% (9% for AVR, 24% for AVR + CABG). Among the 29 patients who died, 14 (48%) were operated on urgently (32% mortality for urgent procedures). Causes of hospital death were respiratory insufficiency or infection in 16 patients (16/29 = 55%), myocardial infarction in 8 (28%), stroke in 2 (7%), sepsis in 2 (7%), and renal failure in 1 (3%). Significant postoperative complications were atrial fibrillation in 48 patients (22%), respiratory insufficiency in 46 (21%), permanent atrio-ventricular bloc in 12 (5%), myocardial infarction in 10 (5%), hemodialysis in 4 (2%), and stroke in 4 (2%). Mean hospital and intensive care unit (ICU) stays were 17.6 ± 5.2 and 6.9 ± 3.4 days, respectively. Multivariate predictors ($p < 0.05$) of hospital death were urgent procedure, associated CABG, NYHA class IV, and percutaneous aortic valvuloplasty. Age, associated CABG, and urgent procedure were predictors of prolonged ICU stay. Mean follow-up was 58.2 months and actuarial 5-year survival was 73.2 ± 6.9%. Age, preoperative myocardial infarction, urgent procedure, and duration of ICU stay were independent predictors of late death. Among 130 patients alive at follow-up, 91% were angina free and 81% in class I—II. **Conclusions:** AVR in octogenarians can be performed with acceptable mortality, although significant morbidity. These results stress the importance of early operation on elderly patients with aortic valve disease, avoiding urgent procedures. Associated coronary artery disease is a harbinger of poor operative outcome. Long-term survival and functional recovery are excellent.

Keywords: Aortic valve; Cardiac surgery; Elderly; Octogenarians; Quality of life

1. Introduction

The increase in life span 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. With this aging of the population and the greater use of noninvasive diagnostic techniques, particularly echocardiography with two-dimensional Doppler ultrasonography, the diagnosis of symptomatic aortic valve disease, particularly aortic stenosis, is becoming increasingly common [1,2].

Recent reports reveal that cardiac operations for selected elderly individuals who have otherwise good physical and mental health can improve mortality, morbidity, and quality of life [3—5], but long-term results are incomplete, especially for valve disease. While previously uncommon, we have observed in our center, during the last 15 years, a significant increase in the number of patients aged 80 years and more who are being referred for aortic valve 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 elderly patients.

To analyze these issues further, we have reviewed our early and long-term results in patients aged 80 years and more who underwent aortic valve replacement (AVR) at our institution, between January 1992 and December 2004.

2. Methods

2.1. Population

Records of all 220 consecutive patients, aged 80 years or more, who underwent aortic valve replacement between

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January 1992 and December 2004 were reviewed (retrospective study). A total of 40 preoperative, operative, and postoperative variables were recorded and tested as possible predictors for operative events and long-term survival[1] (Appendix A). Follow-up information was obtained from all hospital survivors through clinic visits and annual letters, and was 99% complete. Mean follow-up was 58.2 months, and cumulative follow-up was 854 patient-years. Between January and March 2005, all known survivors were questioned to obtain information regarding general health status, presence or absence of chest pain, shortness of breath according to the New York Heart Association (NYHA) functional class, and quality of life. If subsequent hospitalization, death, or other events had occurred, the patient's physician or hospital record department was contacted to document the events and hospitalization.

Significant coronary artery disease was defined as a reduction of vessel diameter by at least 70% 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 edema on chest roentgenograms. Perioperative 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. Serum troponin measurement was not routinely available at the beginning of the series. As our routine intensive care unit (ICU) stay for patients without early postoperative complications was 48 h, we defined prolonged ICU stay as >2 days.

Anesthesiological protocol was mainly 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.

At the time of follow-up, 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.

2.2. 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 hypertension, on early mortality were evaluated univariately with χ^2 test or Fisher's exact test. The effects of continuous variables, such as age, were univariately evaluated with Pearson's correlation test or with Wilcoxon rank sum tests when necessary. Combinations of risk factors were multivariably evaluated with multiple logistic regression models, using the stepwise method (for which input and output p-values were 0.10) to determine the best predictors. Survivorship to death, for all patients and for operative survivors only, was estimated with the Kaplan–Meier method. To assess separately those risk factors related to late survival as distinct from operative deaths, we analyzed only operative survivors. Nominal risk factors for survival and for prolonged hospital stay 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. All tests were two-sided. The proportional hazards assumptions were verified by assessing the parallelism of survival curves for nominal risk factors and by testing the independence to time for continuous variables. Moreover, the behavior of the Schoenfeld residuals was studied. For all continuous variables, we considered the logarithm of the variable and the polynomial until the third degree, to keep the form which improved the model at best.

Statistical analysis was performed using the software SAS (*SAS Institute Inc.*, Cary, NC, USA).

3. Results

3.1. Patient population and operative data

The population consisted of 220 consecutive patients ranging in age from 80 to 94 years who underwent AVR, either alone or in combination with other procedures. Clinical characteristics of these patients are listed in Table 1. Most common presenting symptoms were dyspnea on exertion or at rest in 180 patients (82%), congestive heart failure in 130

Table 1
Patient clinical characteristics

Variable	No. of patients (%)
Men	46 (21)
Women	174 (79)
Age (years)	82.8 ± 2.4
Status – elective	176 (80)
Status – urgent	44 (20)
NYHA – class III	76 (34)
NYHA – class IV	66 (30)
Previous MI	22 (10)
Diabetes mellitus	26 (12)
Hypertension	90 (41)
Hypercholesterolemia	24 (11)
Smoking	20 (9)
COPD	11 (5)
Preoperative atrial fibrillation	30 (14)
Preoperative pacemaker	21 (10)
Renal insufficiency	9 (4)
Previous vascular surgery	14 (6)
Previous CABG	11 (5)
Previous percutaneous aortic valvuloplasty	8 (4)

NYHA, New York Heart Association; MI, myocardial infarction; COPD, chronic obstructive pulmonary disease; CABG, coronary artery bypass grafting.

[1] Postoperative variables were only tested as possible predictors for long-term survival.

patients (59%), angina in 128 patients (58%), and syncopal episodes in 48 patients (22%).

Assessment of left ventricular (LV) function showed that 26 patients (12%) had poor function, defined as an ejection function of <40%. Mean ejection fraction was 56.8 ± 12.7%. Mean aortic valve area and gradient were 0.57 ± 0.16 cm^2 and 58.0 ± 21 mmHg, respectively, while mean LV end-diastolic pressure was 22.9 ± 6.7 mmHg. Fifty-eight patients (26%) had significant coronary artery disease, while 11 patients (5%) had previous coronary artery bypass grafting (CABG).

Aortic stenosis was the predominant valvular lesion in 174 patients (79%), followed by combined aortic stenosis and insufficiency in 40 patients (18%), and aortic insufficiency in 6 patients (3%). Valvular disease involved calcified lesions in 208 patients (94%), bicuspid valve in 26 patients (12%), myxomatous degeneration in 18 patients (8%), rheumatic disease in 5 patients (2%), and endocarditis in 4 patients (2%).

Stented bioprostheses were implanted in 194 patients (88%), stentless bioprostheses in 17 patients (8%), and mechanical valves in 9 patients (4%). Average valve size was 21.4 mm. Additional CABG was performed in 58 patients (26%), respectively for one-vessel disease in 20 (9%), two-vessel disease in 26 (12%), and three-vessel disease in 12 (5%). Mean cardiopulmonary bypass time was 105.4 ± 39.8 min, and mean aortic cross-clamp time was 67.3 ± 21.8 min.

3.2. Postoperative complications

Early postoperative complications are listed in Table 2. Arrhythmias occurred in 53 patients (24%), of whom 48 had atrial fibrillation or supraventricular tachycardia, and five had ventricular tachycardia. Among 46 patients (21%) requiring prolonged (>24 h) mechanical ventilation, 34 (15%) had pneumonia. Four patients (1.8%) developed cerebrovascular accident, of which one completely recovered before hospital discharge. Eighty-eight patients (40%) had no postoperative complications.

Length of hospital and ICU stays averaged 17.6 ± 5.2 and 6.9 ± 3.4 days, respectively, while median hospital and ICU stays were 15 and 5 days, respectively. Ninety patients (40%) had a prolonged hospital stay (>15 days). Excluding 24 patients who stayed in the hospital for more than 30 days, average hospital stay was 14.4 ± 4.5 days, and average intensive care unit stay was 3.8 ± 2.6 days.

Table 2
Operative results

Variable	No. of patients (%)
Death	29 (13)
Stroke	4 (2)
Myocardial infarction	10 (4)
Arrhythmias	53 (24)
Permanent atrio-ventricular block	12 (5)
Pneumonia	34 (15)
Prolonged mechanical ventilation (>24 h)	46 (21)
Dialysis	11 (5)
Reexploration for bleeding	9 (4)
Pericardial drainage	7 (3)
Sternal wound reoperation	3 (1)

Table 3
Variables associated with operative mortality and prolonged hospital stay, by multivariable analysis

Variables	*p*-value	OR (95% CI)
Predictive of operative mortality		
Urgent procedure	0.003	4.3 (2.3–7.0)
Associated CABG	0.009	3.9 (1.8–5.7)
NYHA functional class	0.01	2.2 (1.2–3.9)
Percutaneous aortic valvuloplasty	0.04	1.7 (0.9–3.6)
Predictive of prolonged hospital stay[a] (>15 days)		
Age	0.006	0.9 (0.9–1.0)
Associated CABG	0.009	0.7 (0.6–0.9)
Urgent procedure	0.01	0.4 (0.2–0.8)

OR, odds ratio; CI, confidence interval; CABG, coronary artery bypass grafting; NYHA, New York Heart Association.

[a] The model assessed the probability of leaving the hospital, and therefore a risk ratio of less than 1% is predictive of prolonged hospital stay.

3.3. Hospital mortality

Hospital deaths occurred in 29 patients (13%) of which 22 (10%) represent 30-day mortality. Of the 29 patients, 21 (72%) were women and 14 (48%) were operated on urgently. Fifteen patients (15/162 = 9%) had aortic valve replacement alone, and 14 (14/58 = 24%) had combined AVR–CABG. Seventeen patients (17/66 = 26%) were in NYHA class IV. Six patients (6/8 = 75%) with previous percutaneous aortic valvuloplasty and one patient (1/11 = 9%) with previous CABG died. Causes of hospital death were respiratory insufficiency or infection in 16 patients (16/29 = 55%), myocardial infarction in 8 (28%), stroke in 2 (7%), sepsis in 2 (7%), and renal failure in 1 (3%).

During the 1992–1998 operative period, 16/102 (16%) patients died, while 13/118 (11%) patients died during the 1999–2004 operative period (NS).

Independent variables predicting early mortality or prolonged hospital stay on multivariable logistic regression analysis are listed in Table 3.

3.4. Late mortality

One hundred and ninety-one patients were discharged from hospital. A total of 59 patients have died at follow-up, among which 17 (29%) from cardiac causes, while 2 patients (1%) were lost to follow-up.

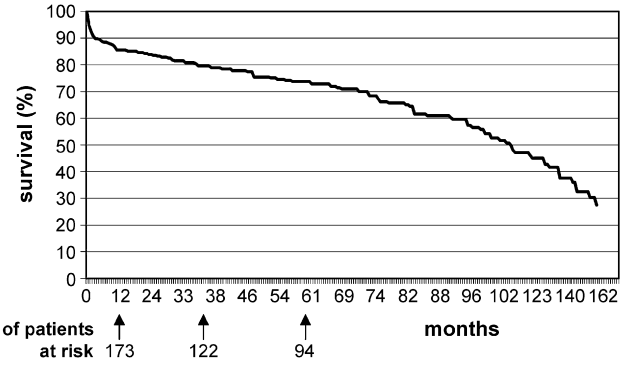

Fig. 1. Survival curve of all patients aged 80 years or older undergoing aortic valve replacement.

Table 4
Variables associated with long-term survival (operative survivors), by multivariable analysis

Variables	*p*-value	HR (95% CI)
Preoperative variables		
Age	<0.0001	1.1 (1.0–1.1)
Previous myocardial infarction	0.005	2.3 (1.3–6.0)
Operative variables		
Urgent procedure	0.01	2.0 (1.2–2.3)
Postoperative variables		
Duration of ICU stay	0.002	2.7 (1.0–6.9)

HR, hazard ratio; CI, confidence interval; ICU, intensive care unit.

Long-term survival for the entire population (including operative deaths) is depicted in Fig. 1. Survival at 1, 3, and 5 years was $85.5 \pm 2.0\%$, $80.8 \pm 2.6\%$, and $73.2 \pm 3.9\%$, respectively. When stratified based on urgency of operation, survival for elective surgery was $88.1 \pm 1.9\%$, $84.3 \pm 2.8\%$, and $78.1 \pm 6.5\%$ at 1, 3, and 5 years, respectively, as compared with $82.8 \pm 6.9\%$, $76.6 \pm 10.8\%$, and $47.7 \pm 16.7\%$ ($p < 0.01$) at 1, 3, and 5 years, respectively, for urgent operations.

Independent predictors of late mortality by multiple Cox-regression are listed in Table 4. Furthermore, implantation of a stentless bioprosthesis showed a trend toward better long-term survival, but without reaching statistical significance ($p = 0.09$).

3.5. Quality of life assessment

Three patients, including one with a mechanical valve, developed thromboembolism complications. Two of those were peripheral emboli, successfully treated by surgical embolectomy, and one was responsible for a cerebro-vascular accident with mild permanent impairment. We did not experience other valve-related complications, such as bleeding events, prosthetic valve endocarditis, structural failure, or reoperation.

At the time of follow-up, NYHA functional class and activity level of the 130 alive patients were assessed. The majority of patients were in NYHA class I (64/130, 49%) or class II (41/130, 32%), while 118 patients (91%) were angina free. The majority of patients rated their activity level as heavy (27/130, 20%) or moderate (70/130, 54%). Among the 130 long-term survivors, 91% believed that having heart surgery after age 80 years was a good choice, and similarly 88% felt as good as or better than they had preoperatively.

4. Discussion

The elderly population continues to expand in western countries, and acquired heart disease is a leading cause of death among the elderly. Because aortic valvular disease remains a common problem in the elderly, increasing number of elderly patients are presenting for surgical evaluation of symptomatic valve disease.

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 [6]. Balloon aortic valvuloplasty has been proposed as an alternative to operation in the treatment of aortic valve stenosis [7]. Nevertheless, published hospital mortality ranged from 3 to 10% [8,9], and hospital morbidity from 10 to 25%. Furthermore, the majority of patients had restenosis within 6 months and survival curves showed 55–75% survival at 1 year [8,9].

4.1. Operative mortality and morbidity

Early reports of AVR in elderly patients showed high operative mortality rates; however, more recent reports have shown mortality rates of 2–10% for isolated AVR [3–5,10,11]. Recently, Chiappini et al. [5] and Collart et al. [11], respectively, reported a 8.5% and a 8.8% operative mortality after AVR in octogenarians.

Our hospital mortality for 162 patients who underwent isolated AVR was 9%, decreasing from 12% in the first half of the series to 7% in the second half. These results show that AVR 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, anesthesia, and postoperative critical care.

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 preoperative risk factors associated with operative mortality were urgent procedure, associated coronary artery surgery, NYHA functional class, and previous percutaneous valvuloplasty. While Collart et al. [11] did not report operative mortality to be higher in surgical urgency, we found urgent procedure to be the most significant risk factor for operative death.

Poor left ventricular function was also predictive of hospital death in several studies [4,5,10,11]. Elayada et al. [10] also found hypertension and concomitant surgical procedures to be associated with early mortality. Akins et al. [3] found chronic lung disease, preoperative intra-aortic balloon, and congestive heart failure to be preoperative predictors of hospital death.

It is important to note that in our experience, previous aortic valvuloplasty was an independent factor predicting operative mortality. Our operative mortality for AVR after failed valvuloplasty was 75% (6/8 patients), which was much higher than in the series of Otto et al. [9], who reported an operative mortality of 12% after failed aortic valvuloplasty. However, it is possible that, in our series, those patients referred for valvuloplasty were initially felt to be very poor surgical candidates.

In our series, age itself was not a predictor for operative mortality. However, age was a predictor for prolonged ICU stay, as were associated CABG and urgent procedure.

Our postoperative complication rate was somewhat high (60%), but comparable to the recent series of Collart et al. [11] who reported a morbidity of 63%. Pulmonary insufficiency or infection was one of the leading causes of postoperative morbidity. Our 21% incidence of prolonged (>24 h) mechanical ventilation was somewhat higher than the 11% reported by Collart et al. [11], although these authors did not clearly define prolonged ventilation. In these elderly patients, we are now having encouraging results with early extubation (less than 6 h postoperatively) and more

vigorous pulmonary toilet. Among the 53 patients who developed postoperative arrhythmias, 48 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 [3–5,11]. In particular, our stroke rate (2%) was low.

4.2. Long-term survival and quality of life

For the entire population, survival at 1, 3, and 5 years was $85.5 \pm 2.0\%$, $80.8 \pm 2.6\%$, and $73.2 \pm 3.9\%$, respectively. These survival rates are comparable with other studies and show good long-term survival despite advanced age [4,5,10–12].

In our study, age, previous myocardial infarction, urgent procedure, and duration of ICU stay were 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 also was predictive of late mortality in other studies [8,13]. Survival stratified based on urgency of operation clearly emphasizes that referral of elderly patents before end-stage disease requiring urgent operations is important for long-term results.

Of at least equal importance to the elderly as survival is quality of life. In this study, 91% 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 58.5 months postoperatively, 68% of survivors were still living at home or with their families. Finally, concerning valve-related complications, thromboembolic events occurred in four patients, with permanent disability in only one patient, while no bleeding events, prosthetic valve endocarditis, structural failure, nor need for reoperation were observed.

We believe the bioprosthetic valve remains the safest cardiac valve substitute in the octogenarians. In the earlier part of the series, we implanted mechanical valves in a few patients in whom anticoagulant therapy was already indicated, but now also use bioprosthetic valves in those patients. An earlier report by Jamieson et al. [14] states that structural deterioration of tissue valves is limited in the elderly population. Recently, Suttie et al. [15] reported excellent long-term results after implantation of aortic bioprostheses in elderly patients.

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 on multivariate analysis. Recently, Ali et al. [16] reported, in a prospective randomized trial, that both stented and stentless bioprostheses are associated with excellent clinical and hemodynamic outcomes 1 year after AVR, and that, in patients with ventricular impairment, stentless valves could allow for greater improvement of left ventricular function postoperatively. It should, however, be emphasized that stentless bioprostheses are usually more difficult to suture in these elderly patients with often calcified Valsalva sinus and, therefore, require a longer clamping time than stented prostheses.

4.3. Combined aortic valve surgery and coronary artery bypass grafting

Aortic valve replacement combined with coronary artery bypass grafting resulted in a 24% early and a 10% late mortality. This is noticeably higher than the 6.3% early mortality reported by Akins et al. [3]. However, Langanay et al. [17] recently showed a gradual increase in mortality according to the number of disease vessels (no significant lesion 8.2%, single-vessel disease 11.5%, two-vessel 11.1%, and three-vessel 18.5%) or of associated bypasses (10.1% for isolated AVR vs 18.8% when multiple bypasses were associated).

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 [18]. Reports [19] in younger patient population 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 ischemic time and may not be appropriate in the 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 a primary indication for operation. Other possible options that we are now contemplating include preoperative percutaneous coronary interventions or off-pump bypass grafting.

5. Conclusions

In summary, AVR can be performed in patients 80 years old or older with acceptable mortality, good long-term results, and good quality of life. Preoperative risk factors associated with early mortality involve previous percutaneous valvuloplasty, associated CABG, and NYHA functional class IV, whereas age and myocardial infarction were predictors 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.

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Appendix A. Conference discussion

Dr P. Kappetein (*Rotterdam, The Netherlands*): If you look at this series retrospectively are there patients that you nowadays would consider for percutaneous aortic valve implantation?

Dr Kolh: Well, it would definitely be better to answer this question with a prospective study, but definitely yes, now that we are seeing these new techniques and their early results, I am impressed. On Saturday at the Techno-College, we saw a life case from Leipzig, an 88-year-old lady in whom was performed a percutaneous aortic valve replacement through the transfemoral approach, and who had full hemodynamic recovery within minutes. I think that is definitely something that should be considered, yes.

Dr A. Abdelghany (*Cairo, Egypt*): As regards the predictive value for postoperative mortality and late mortality, you ignored the preoperative status of the patient as regards associated diseases like diabetes, pulmonary diseases, urinary infection. As regards to your patients, most of them are above 80. So I think some of them had renal infection, had preoperative pulmonary complications, most of them may be diabetic. This is my first comment.

Dr Kolh: I'm sorry, but I didn't understand most of your first comment.

Dr Kappetein: Can you please rephrase it a little bit in a short way, your first question?

Dr Abdelgany: He ignores the preoperative status of the patients as regards renal function, liver function, pulmonary function.

Dr Kolh: Most of those patients were in fairly good preoperative condition. In that period of time included in this retrospective study, we probably would not have operated on an octogenarian patient with extensive liver or kidney disease. Anyway, all those variables, creatinine level or liver function or pulmonary function, were included in the multivariate model. Some of those variables were significant with univariate analysis, which I didn't show because of the sake of time, but they were not significant in the multivariate analysis. You will see a list of all variables included in the model detailed in the manuscript, if accepted for publication.

Dr Abdelgany: Second is the operative risk factors as regards the degree of calcification of the aortic valve, atherosclerosis of the aorta, and the size of the valve you implant.

Dr Kolh: Well, some patients had ascending aorta calcifications. Three patients required some decalcification of the aorta. As I said, six patients had surgery on the ascending aorta. And what is your question regarding the valve? You mean where we implanted it?

Dr Abdelgany: The size of the valve.

Dr Kolh: Mean size was 21.4 mm. So most patients had a 21 mm valve implanted, some had a 23 mm, remember, most patients were female, and a few patients had a 19 mm valve.

Dr E. Raanani (*Tel Hashomer, Israel*): First, you showed a reduction in mortality and morbidity in the second period. What were the measures, if any, in order to reduce the mortality or to improve the results in the second period? And the second question is, a significant number of your patients had perioperative MI and died from it. And then you raised the question whether the coronary lesion should be addressed. Did the patients who died from myocardial infarction have incomplete revascularization or those patients had coronary bypass and did die?

Dr Kolh: For the first question, that is a retrospective study, so there is always a lot of bias. I think one of the main points is that we try now to put those patients on a fast track for extubation and more physical and respiratory therapy, and also we use short-action hypnotic agents so that they could be awakened earlier. I think this is one point. The second point is that probably between 1992 and 2004, some improvement in myocardial protection occurred.

Now, for your second question, actually I didn't show that, but we saw that myocardial infarction (MI) developed more frequently, although not significantly, in patients having combined surgery. Among the eight patients who died from MI, five were in the combined group and three were in the aortic valve replacement only group, while in the AVR alone group, main cause of death was respiratory problems. But to answer, most of these patients had complete revascularization. I am not sure that it is a problem of revascularization. I think those are actually different patients, patients with more vascular disease, with coronary and sometimes peripheral artery disease, as compared with patients with isolated aortic valve stenosis.

Appendix B. Variables tested for operative events and long-term survival

Preoperative variables
- Sex
- Age
- Angina
- Syncopal episodes
- Previous myocardial infarction
- Congestive heart failure
- New York Heart Association functional class
- Atrial fibrillation
- Diabetes mellitus
- Hypertension
- Hypercholesterolemia
- Tobacco abuse

Appendix B. (*Continued*)

- Chronic obstructive pulmonary disease
- Renal insufficiency
- Previous cardiac surgery
- Previous coronary artery bypass grafting
- Permanent cardiac pacing
- Previous percutaneous coronary intervention
- Previous percutaneous aortic valvuloplasty
- Previous vascular surgery
- Coexisting vascular disease
- Left main disease
- Number of diseased coronary arteries
- Ejection fraction
- End-systolic volume
- End-diastolic pressure

Operative variables
- Operative priority
- Cardiopulmonary bypass time

Appendix B. (*Continued*)

- Aortic cross-clamping time
- Cardiopulmonary bypass temperature
- Number of coronary artery bypass graftings

Postoperative variables (only tested for long-term survival)
- Stroke
- Myocardial infarction
- Arrhythmia
- Permanent atrio-ventricular bloc
- Prolonged mechanical ventilation (>24 h)
- Pneumonia
- Renal insufficiency
- Reoperation
- Length of hospital stay
- Length of ICU stay