Aortic Valve Replacement in Patients Over 70 Years Old: Determinants of Early Death

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Introduction and objectives. There is controversy regarding the risk factors associated with early death in geriatric patients undergoing aortic valve replacement. We analyzed the risks in these patients and established an accurate model for predicting in-hospital mortality.

Patients and method. Univariate and multivariate analyses were made of the risk factors associated with early death in a group of 129 patients older than 70 years who underwent aortic valve replacement (May 1994-June 2001). The variables obtained by multivariate logistic regression were combined to produce an equation for the prediction of early death. The equation was tested using a receiver operating characteristic curve.

Results. Univariate analysis identified four factors related to early death: NYHA III-IV ($p < 0.0001$), ejection fraction < 40% ($p < 0.05$), aortic regurgitation ($p < 0.05$) and high left ventricular mass index ($p < 0.05$). Multivariate analysis revealed three independent risk factors: NYHA III-IV ($p < 0.01$), aortic regurgitation ($p < 0.05$), and small body surface area ($p < 0.05$). A lower mortality was observed in patients with a larger body surface area (0% for > 1.90 m^2, 20% for < 1.40 m^2). The estimated mortality with the predictive model was 7.06%, which was similar to the observed mortality of 7.80% (area under the ROC curve 0.87) and better than estimates obtained with the EuroSCORE (6.5%; area under the ROC curve 0.56).

Conclusions. Risk factors associated with early death after aortic valve replacement in geriatric patients include functional status, aortic regurgitation, and small body surface area. Our model based on these factors accurately predicted operative mortality in our patients. Gender, prosthesis size, and pump time were not identified as risk factors.

Key words: *Aging. Surgery. Morbidity.*

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Recambio valvular aórtico en pacientes mayores de 70 años: determinantes de mortalidad temprana

Introducción y objetivos. Los factores más importantes asociados a la mortalidad temprana en el recambio valvular aórtico del anciano son controvertidos. Realizamos un análisis de riesgo en estos pacientes y elaboramos un modelo predictivo de mortalidad aplicable a nuestro entorno.

Pacientes y método. Se realizó un análisis uni y multivariante de los principales factores asociados a la mortalidad hospitalaria en 129 pacientes mayores de 70 años intervenidos de recambio valvular aórtico, entre mayo de 1994 y junio de 2001. Se elaboró un modelo predictor de mortalidad mediante un análisis de regresión logística, y el poder discriminante del modelo predictivo se evaluó mediante curvas ROC.

Resultados. Los factores relacionados con mayor mortalidad en el análisis univariante fueron: clase funcional III-IV de la NYHA ($p < 0{,}0001$), FE < 40% ($p < 0{,}05$), insuficiencia aórtica ($p < 0{,}05$) e índice de masa ventricular izquierda elevado ($p < 0{,}05$). En el análisis multivariante, las variables significativamente asociadas con la mortalidad fueron una clase funcional III-IV de la NYHA ($p < 0{,}01$), la insuficiencia aórtica ($p < 0{,}05$) y una reducida superficie corporal ($p < 0{,}05$), observándose una menor mortalidad cuanto mayor era la superficie corporal (0% si > 1,90 m^2, frente a 20% si < 1,40 m^2). La mortalidad estimada por el modelo predictivo fue del 7,06%, muy similar a la mortalidad observada (7,80%) (con área bajo la curva ROC de 0,87), y superior a la calculada mediante el EuroSCORE (6,5%; área menor bajo curva ROC de 0,56).

Conclusiones. Los factores asociados a una mayor mortalidad en el recambio valvular aórtico en pacientes ancianos son el grado funcional previo, la existencia de insuficiencia aórtica y la reducida superficie corporal. El modelo predictivo basado en estos factores tiene un alto poder discriminativo en nuestros pacientes. El sexo, el tamaño protésico y los tiempos de circulación extracorpórea no han influido directamente en la mortalidad.

Palabras clave: *Geriatría. Cirugía. Morbilidad.*

INTRODUCTION

In past years, the age of patients who undergo heart surgery has significantly increased. The greater longevity of the population, together with the increase in the incidence of heart disease and aortic degenerative val-

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ABREVIATIONS

ECC: extracorporeal circulation.
CVA: cerebrovascular accident.
COPD: chronic obstructive pulmonary disease.
AF: atrial fibrillation.
EF: ejection fraction.
LVMI: left ventricular mass index.
BS: body surface.

ve disease are the principal factors involved in this phenomenon.[1] The latter factor is responsible for a substantial percentage of the interventions performed in patients of more than 70 years of age.

There is still controversy regarding the most important risk factors associated with early mortality in septuagenarian and octogenarian patients who undergo aortic valve replacement.[2] The use of small valve prostheses has been one of the classically accepted determinants of nosocomial death.[3,4] Other studies have downplayed this, giving greater relevance to female sex, reduced body surface (BS), or a prosthesis-patient mismatch.[3-6] Extracorporeal circulation (EEC) time is another factor that has been implicated in such mortality.[2]

We performed a retrospective study in which we analyzed all patients of 70 years of age or older who underwent aortic valve replacement in our hospital. Our aim was to find out the principal pre- and post-operative risk factors that had the most decisive influence on early mortality. In addition, we proposed the creation of a predictive model for nosocomial death that was applicable to our patients.

PATIENTS AND METHODS

We included in our study 129 patients of age 70 years or greater from a total of 614 patients who underwent aortic valve replacement in our hospital during the period from May 1994 to June 2001. We excluded from the study those patients who underwent other associated valve procedures, such as replacement or repair of the mitral valve. The majority of the interventions were elective and repeat surgeries were not included. All the procedures were performed with ECC and moderate hypothermia (28 to 32ºC). In the majority of cases a combination of anterograde cardioplegia via the aortic root and coronary ostium, or both, were used, and retrograded via the coronary sinus.

Among the pre-surgical variables analyzed were cardiovascular risk factors and associated morbidity. Similarly, we included other variables that were considered to be related to higher mortality rates in other studies.[1-3,6] Principal among these were: age, sex, BS, arterial hypertension (AHT), diabetes, smoking, dyslipemia, chronic obstructive pulmonary disease (COPD), previous chronic renal insufficiency, peripheral valve disease, old cerebrovascular accident (CVA), previous chronic atrial fibrillation (AF), associated heart disease, New York Heart Association (NYHA) functional class, level of angina according to the Canadian Cardiology Society,[7] old myocardial infarct, ejection fraction, left ventricular mass index (LVMI), type of aortic valve dysfunction and its etiology, associated mitral insufficiency, and size of the valve prosthesis. The BS (m^2) was calculated based on the patient´s weight and height. Previous COPD was confirmed via the pre-surgery performance of respiratory function tests on all patients. Chronic renal insufficiency was considered to exist in patients with a creatinine value higher than 2 mg/dL maintained indefinitely pre-surgery. Previous chronic AF was considered to be present when the arrhythmia lasted more than 6 months. The LVMI was calculated by using the Devereux formula8 applied to the data concerning the thickness and diameter of the left ventricle which were obtained from preoperative electrocardiograms. The LVMI was considered to be elevated when it had a value greater than the tenth highest in the series. We did not use the cut point proposed by Devereaux (134 g/m^2 in men and 110 g/m^2 in women) as the majority of our patients (82.9%) were had an LVMI higher than this point (107). This probably had an effect on the low BS in our patients. The selection of the valve prosthesis was based on the personal choice of the surgeon. In general terms, mechanical prostheses were used in younger patients and bioprostheses were used in older patients (with regard to the range of ages of the patients included in this study). The different types of prostheses used are summarized in Table 1. The size of the prosthesis used was determined in the operating room via the direct measurement of the valve ring.

On the other hand, peri-operative factors analyzed were: ECC time, duration of the myocardial ischemia by aortic clamp, and the principal complications that occurred during the early post-operative period.

From among all these variables we looked for those that had a signification relationship with nosocomial death and, later, we created a predictive model of said mortality. Finally, we evaluated the discriminatory capability of the model in our patients and compared it with the EuroSCORE,[9] study, which has been considered the reference source for risk scales.

The majority of patient data was obtained from the Cormedica® (Pales Group®) database, in which patient data was entered prospectively. The echocardiographic data had been obtained from the Filemaker® informatics files in the echocardiography department of our hospital. The rest of the information was obtained from patient clinical histories.

TABLE 1. **Types of prostheses implanted**

Prosthesis	No.	%
Biológical		
Carpentier-Edwards	70	54.3
Biocor	12	9.3
Mechánical		
TOP-HAT Carbomedic	18	13.9
Carbomedics	9	6.9
St. Jude	6	4.7
Bicarbon-Sorin	6	4.7
Omnicarbon	6	4.7
ATS	2	1.5

Definitions

With regard to cardiovascular risk factors, we made the following determinations. AHT was considered to exist when this had been documented in the patient's personal history or when the systolic arterial pressure (SAP) was greater than 140 mm Hg or the diastolic arterial pressure (DAP) was greater than 90 mm Hg on at least 2 different occasions; diabetes when this was confirmed in the history regardless of its duration or the need for treatment; smoking if the habit existed previously and had been maintained at least up to a month prior to surgery; and dyslipemia if there was a history of hypercholesterolemia or hypertriglyceridemia diagnosed or treated, or both, by a physician.

With respect to prior co-morbidity, chronic renal insufficiency was considered to exist when creatinine values were higher than 2 mg/dL or 2 or more occasions during the year prior to surgery. Peripheral vasculopathy was considered present in the setting of any of the following: intermittent claudication, results that were positive for ischemia on non-invasive tests, a diagnosis of aneurysm of the abdominal aorta, or a history of surgery or intervention for peripheral vascular disease. The old term CVA included a history of CVA with reversible or irreversible neurological deficit, and transitory ischemic accidents. Chronic prior AF was considered to exist when the arrhythmia was present for more than 6 months.

Finally, early mortality was considered to be synonymous with nosocomial death or death during the first 30 days following surgery.

Statistical analysis

Sample description was expressed as mean and standard deviation for continuous variables and the distribution of frequencies in absolute numbers and percentages for the categorical variables. In later univariate analysis we applied the χ^2 test corrected with the exact Fisher test when necessary. In this analysis we compared individual risk factors with nosocomial death (death during the post-operative hospital stay). Later multivariate analysis included all variables that had a value of P=.1. This analysis was based on binomial logistical regression with the progressive inclusion of variables. All values of P<.05 were considered significant, and we calculated the odds ratio and confidence interval (CI) of 95% for each variable. Following this analysis we created a model that could predict the occurrence of the phenomenon of nosocomial death for our patients. This predictive model was compared to that of EuroSCORE, and both were evaluated by using ROC (Receiver Operating Characteristic) curves.

For statistical analysis we used the SPSS informatics package version 9.0.

RESULTS

Pre-operative characteristics

The mean patient age was 74.3 years±3.1 years (range, 70 to 88 years), with the following distribution by sex: 68 women (52.7%) and 61 men (47.3%). Mean estimated overall patient body surface was 1.65 m^2±0.15 m? (range, 1.32 to 2.06 m^2), this being significantly larger in men when estimating the difference by sex: 1.74 m^2±0.14 m^2 (1.44 to 2.06 m^2) versus 1.58 m^2±0.12 m^2 (1.32 to 1.80 m^2), P<.01.

The distribution of patients according to baseline disease can be summarized as: aortic valve stenosis in 90 patients (69.8%), aortic insufficiency in 12 patients (9.3%), and double lesion in 27 patients (20.9%). The most frequent origin of valve disease was degenerative in 87 patients (67.4%), followed by rheumatic in 40 patients (31%), and congenital in 2 patients (1.6%). In 28 patients associated coronary disease was found.

Peri- and post-operative data

Mean surgical times were: ECC time 112.05 minutes±35.41 minutes (range, 44 to 216 minutes) and aortic clamping time 75.89 minutes±27.72 minutes (range, 29 to152 minutes). Mean length of stay in the CCU was 5.11 days±3.70 days and the post-operative hospital stay was 12.76±7.07 days. Nosocomial death in the overall group was 7.8% (10 patients).

Variables associated with mortality (univariate analysis)

The results of the univariate analysis are shown in tables 2 and 3. This analysis identified the following variables as being related to mortality: NYHA functional class III to IV (P<.0001), ejection fraction (EF)=40% (P<.05), aortic valve insufficiency (P<.05), and elevated LVMI (P<.05). In absolute terms, the mean LVMI of the patients who died was significantly greater than that of the surviving patients: 257.23

TABLE 2. **Univariate analysis; preoperative variables**

	Variable	No.	Mortality	%	*P*
Age, years	<75	78	6	7.7	1.0
	≥75	51	4	7.8	
Sex	Men	61	6	9.8	.51
	Women	68	4	5.9	
BS, m^2	<1.4	10	2	20.0	.13
	1.4-1.6	41	1	2.4	
	>1.6	69	7	10.1	
AHT	Yes	79	6	7.6	1.0
	No	50	4	8.0	
Diabetes	Yes	21	0	0	.36
	No	108	10	9.3	
Smoking	Yes	26	4	15.4	.11
	No	103	6	5.8	
Dyslipemia	Yes	32	2	6.3	1.0
	No	97	8	8.2	
COPD	Yes	20	2	10.0	.65
	No	109	8	7.3	
CRI	Yes	8	1	12.5	.48
	No	121	9	7.4	
Peripheral valve disease	Yes	6	0	0	1.0
	No	123	10	8.1	
Prior CVA	Yes	5	0	0	1.0
	No	124	10	8.1	
Chronic AF	Yes	9	1	11.1	.52
	No	120	9	7.5	
Heart disease	Yes	28	3	10.7	.45
	No	101	7	7.0	
NYHA	Class I	8	0	0	<.001
	Class II	74	0	0	
	Class III	37	6	16.2	
	Class IV	10	4	40.0	
CCS angina	Class I	96	7	7.3	.71
	Class II	18	1	5.6	
	Class III	13	2	15.4	
	Class IV	2	0	0	
No. AMI	0	122	9	7.4	.67
	1	6	1	16.7	
	2	1	0	0	
EF	≤40%	9	3	33.3	0.2
	>40%	96	6	6.3	
LVMI (g/m^2)	<270	99	5	5.1	.03
	>270	11	3	27.3	
AoS	Yes	90	5	5.6	.16
	No	39	5	12.8	
AoI	Yes	12	3	25.0	.05
	No	117	7	6.0	
DAoL	Yes	24	2	8.3	1.0
	No	105	8	7.6	
Rheumatic	Yes	40	1	2.5	.17
	No	89	9	10.1	
Degenerative	Yes	67	8	11.9	.09
	No	62	2	3.2	
Congenital	Yes	2	0	0	1.0
	No	127	10	7.9	
MiI	Yes	25	3	12.0	.40
	No	104	7	6.7	
Prosthesis, number	19 mm	28	3	10.7	.77
	21 mm	63	4	6.3	
	23-27 mm	38	3	7.9	

AHT indicates arterial hypertension; CRI, chronic renal insufficiency; DAoL, double aortic lesion; AoS, aortic stenosis; EF, ejection fraction; AoI, aortic insufficiency; MiI, mitral insufficiency; No. AMI, number

TABLE 3. **Univariate analysis: peri- and post-operative variables**

	Variable	No.	Mortality	%	*P*
ECC	>160 min	17	2	11.8	.62
	<160 min	112	8	7.1	
Aortic clamping time	>120 min	12	1	8.3	1.0
	<120 min	117	9	7.7	
Low cardiac load	Yes	6	1	16.7	.39
	No	123	9	7.3	
Cardiac tamponade	Yes	1	0	0	1.0
	No	128	10	7.8	
Post-operative AF	Yes	35	5	14.3	.13
	No	94	5	5.3	
Ventricular fibrillation	Yes	2	2	100	.005
	No	127	8	6.3	
Re-intubation	Yes	2	1	50	.15
	No	127	9	7.1	
Prolonged intubation	Yes	1	0	0	1.0
	No	128	10	7.8	
Respiratory insufficiency	Yes	3	1	33.3	.21
	No	126	9	7.1	

EEC indicates extracorporeal circulation time; AF, atrial fibrillation.

g/m^2±53.25 g/m^2 versus 195.65 g/m^2±52.28 g/m^2 (P<.002). Other variables showed a clear association with this mortality, but without reaching statistical significance: reduced BS (<1.40 m^2), smoking, disease being degenerative in origin, and some early post-operative complications, such as the appearance of AF, re-intubation, respiratory insufficiency, or bronchospasm. In addition, we found a clear relationship between mortality and the patient having had an episode of cardiac arrest due to ventricular fibrillation (P<.01). Other a priori important factors such as female sex, the use of small valve prostheses, or ECC time, did not have great repercussions on the mortality rate in our patients. We also analyzed the relationship between the absolute number of concomitant illnesses and mortality rates. The concomitant illnesses studied, or morbid episodes that were associated pre-operatively with each patient were: AHT, diabetes, COPD, renal insufficiency, peripheral valve disease, a history of CVA, previous chronic AF, and heart disease. None of these by itself was associated with greater mortality on univariate analysis. Similarly, we did not find a significant association between a greater number of concomitant illnesses by patient and a higher mortality rate (1.30±0.94 and 1.36±1.04 concomitant illnesses in dead and living patients, respectively; P=.851).

Upon analyzing BS we found a clear tendency toward a lower mortality rate if increasing BS values were taken into account (Figure 1), reaching a nonsocomial mortality rate of 0% in 8 patients with a BS>1.90 m^2. The mortality rate in the 10 patients with a lower BS (≤1.40 m^2) reached 20%, with a mean in the remaining patients (BS>1.4 m^2) of 7.3%.

TABLE 4. **Multivariate analysis: predictive variables for nosocomial death**

Variable	Odds ratio	95% CI	*P*
NYHA III-IV	24.98	3.59-173.56	.001
Aortic insufficiency	18.91	1.50-237.5	.02
BS	0.02	0.001-0.29	.02

BS indicates small body surface or ≤1.4 m^2.

With regard to the size of the prosthesis, a higher mortality rate was seen in those patients with the smallest prostheses, but this was without significant differences. The numbers obtained for prostheses size 19 mm, 21 mm, and 23 to 27 mm were 10.7%, 6.3%, and 7.9%, respectively. To estimate the possible relationship between small prosthesis size and reduced BS in our patients, we calculated the correlation between the 2 variables. The valve size and the BS had a high correlation (P<.001). The mean BS of patients who received a prosthesis size 19 mm, 21 mm, and 23 to 27 mm was 1.62 m$^{2\pm}$0.14 m^2, 1.63 m$^{2\pm}$0.14 m^2, and 1.73 m$^{2\pm}$0.15 m^2, respectively.

With regard to sex, mortality was no greater in women in spite of the fact that they had, in overall terms, a smaller mean BS. Taking into account sex and prostheses of size 19 mm, 21 mm, and 23 to 27 mm, the mean BS in women was 1.57 m$^{2\pm}$0.12 m^2 (range 1.32 to 1.77 m^2), 1.59 m$^{2\pm}$0.13 m^2 (range 135 to 1.80 m^2), and 1.57 m$^{2\pm}$0.11 m^2 (range 1.40 to 1.70 m^2), respectively, and in men was 1.76 m$^{2\pm}$0.13 m^2 (range 1.55 to 1.95 m^2), 1.71 m$^{2\pm\pm}$0.14 m^2 (range 1.44 to 1.91 m^2), and 1.76 m$^{2\pm}$0.14 m^2 (range 1.54 to 2.06

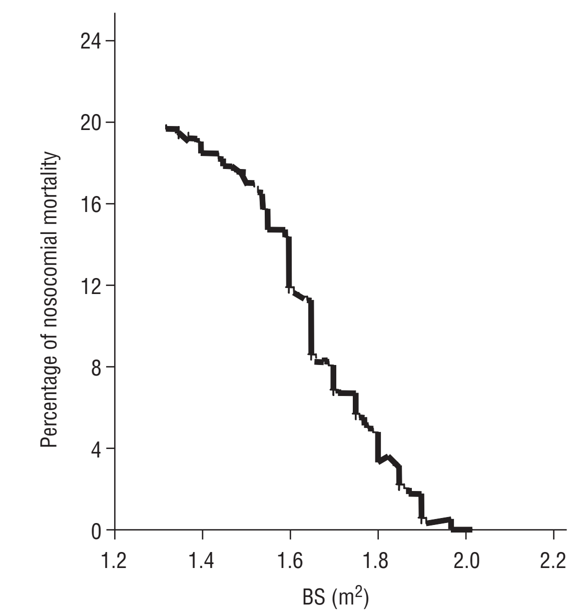

Fig. 1. Relationship between nosocomial mortality (%) and body surface of patients.

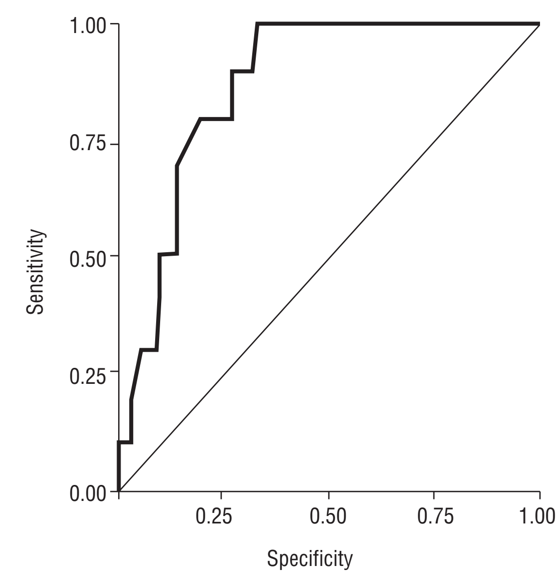

Fig. 2. ROC curve applied to the predictive model for mortality. Area below the curve 0.87.

m^2). Therefore, the disproportion in the prosthesis to patient relationship (prosthesis size to patient BS) was greater in men; in other words, for the same size prosthesis the BS was always greater in men, as was the case in the patients overall. The mortality rate according to sex for the smallest prostheses (19 mm) was also greater for men: 14.3% versus 9.5%. For 21 mm prostheses, the proportion of higher mortality rates was maintained in men: 13.6% versus 2.4%, but was inverted with larger prostheses (23 to 27 mm): 6.3% versus 16.7% in men and women. The 21 mm size prosthesis was used most often in women, and in men prostheses of size 23 to 27 mm were most often used. The distribution summary by sex and prostheses was: 21 patients (30.9%) for the 19 mm prosthesis, 41 patients (60.3%) for the 21 mm prosthesis, and 6 patients (8.8%) for the 23 to 27 mm prosthesis in the group of women (n=68), and 7 patients (11.5%) for the 19 mm prosthesis, 22 patients (36.1%) for the 21 mm prosthesis, and 32 patients (52.4%) for the 23 to 27 mm prosthesis in the group of men (n=61).

Regression model and equation predictive of mortality

Multivariate analysis identified 3 pre-operative risk factors that were predictive of nosocomial death: being in NYHA functional class III-IV ($P<.01$), the existence of aortic valve insufficiency ($P<.05$), and low BS or ≤ 1.4 m^2 ($P<.05$; Table 4).

These variables are included in an equation for predicting mortality:

Estimated mortality (%)=$100/1+e^{-x}$

with x being =7.317+3.218 NYHA+2.939 AoI–12.453 BS.

NYHA is the functional class (with a value of 1, 2, 3, and 4 for NYHA I, NYHA II, NYHA III, and NYHA IV, respectively), AoI is aortic insufficiency (with a value of 1 if present or 0 if absent), and BS is the body surface calculated from patient height and weight (value in m^2).

The mean mortality rate calculated with this formula was 7.06%, very close to the mortality rate reported (7.8%). This predictive model for mortality, the only one in existence following this analysis, was measured by using an ROC curve (Figure 2), with the area below the curve being 0.87, indicating a higher power of discrimination in our patients. We did the same by applying EuroSCORE, which predicted a mortality rate in our series of patients of 6.50%, and obtained an area below the curve of only 0.56 (Figure 3).

DISCUSSION

The age of patients undergoing cardiac surgery has increased significantly over the last decade. In a parallel manner, studies have been performed to evaluate the surgical results obtained in elderly patients.[10-16] Age is, in and of itself, a surgical risk factor and has

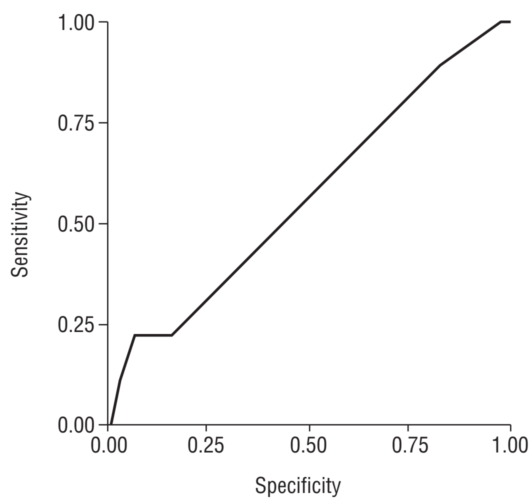

Fig. 3. ROC curve applied to EuroSCORE. Area below the curve 0.56.

been accepted as such by the different predictive scoring methods for mortality-morbidity. Nevertheless, improvements in the peri-operative management of these patients mean that results are now obtained that are very similar to those achieved in younger patients.[1,14] With valve surgery in the elderly, the early morbidity-mortality rates are acceptable and, in addition, the survival rates and long-term quality of life achieved are excellent.[16-19] In any case, in the concrete setting of an aortic valve replacement, there is still controversy concerning which factors are the most directly responsible for early mortality.[2]

Some studies have suggested that the use of smaller valve prostheses has a negative impact on nosocomial death, especially in this group of patients.[3,4] Nevertheless, there have been good results reported with the use of small prostheses with some particular models.[20] On the other hand, some authors have given more relevance to other factors, such as female sex, reduced BS, a disproportion in the prosthesis to patient relationship, and the amount of ECC time.[1-6]

Our analysis identifies 3 independent factors that are predictive of nosocomial mortality: being in NYHA functional class III-IV, having aortic valve insufficiency, and small body surface (by multivariate analysis). Other pre-operative factors significantly associated with mortality were an EF≤40% and an elevated LVMI (on univariate analysis).

The negative effect of an elevated pre-operative LVMI in patients who underwent aortic valve replacement was confirmed by Mehta et al[21] in a study that involved a significant number of patients. The findings showed greater hospital morbidity-mortality rates and longer hospital stays. In that study, low EF was also another parameter associated with greater mortality rates.

In the group of elderly patients who underwent surgery with ECC studied by Poveda et al,[1] the pre-operative variables with prognostic value were previous surgery and the urgency of the procedure, with the patient being in NYHA functional class IV also found to be significant in the aortic subgroup.

In the Bloomstein[2] study, the only risk factors for nosocomial death in elderly patients who underwent aortic valve replacement were reduced BS and prolonged ECC times, and no negative influence was found with the use of small prostheses. Thus, the relationship between the prosthesis size and the size of the patient (BS) could have greater repercussions than the simple consideration of the «small prosthesis» factor. In our patients, BS also had an influence on early mortality, with there being a clear tendency toward higher mortality rates in those patients with lower BS values (20% mortality in the subgroup of patients with a BS≤1.40 m^2). Conversely, when prosthesis size was considered we did not find significant differences in the mortality rate, even though this was higher when prostheses smaller than 19 mm were used. With regard to sex, overall mortality was no greater in women, in spite of the fact that they had a smaller mean BS. This data contradicts the findings of other authors.[3,4,6] In our study, overall mortality was greater in men, especially in those men in whom a small valve prosthesis was implanted (mortality rate of 14.3% in men versus 9.5% in women for the 19 mm prosthesis, and 13.6% versus 2.4% for the 21 mm prosthesis). In men, BS was significantly greater than in women, both in the group overall and in the subgroups according to prosthesis size; therefore the great prosthesis to patient disproportion seen in men may explain the higher mortality rate.

In the same manner, EEC time also did not have great repercussions on the mortality rate of our patients, in contrast to the findings of other authors.[1-4,15] From the results of the study by Poveda et al1 it seems that the aortic group was the one that had a higher mortality rate in relation to longer surgical times (ischemia time >60 minutes and ECC time >90 minutes), although the authors emphasize that the references reflect longer times associated with an increase in mortality. In our study, the mean ischemia and ECC times were 75.89 minutes±27.72 minutes and 112.05 minutes±35.41 minutes, with wide ranges (29 to 152 minutes and 44 to 216 minutes, respectively); in spite of this, they did not have a significant influence on patient mortality. Although it is difficult to attribute this finding to our particular surgical activation protocol, it is obvious that improvements in myocardial protection and peri-operative management of these patients allow the performance of more complex procedures without a substantial increase in morbidity-mortality.

The third factor associated with greater mortality in our patients was the existence of significant aortic valve insufficiency. Its greatest deleterious effect was on the volume and function of the left ventricle as revealed by predominantly aortic valve stenosis, which may explain this association. In fact, in the majority of patients, its presence resulted in a worse functional class and lower pre-operative EF.

Associated heart disease resulted in greater mortality, which is in accordance with other studies. Nevertheless, in our patients this did not reach statistical significance (Table 2). This may be due to the reduced sample size (only 28 patients had associated heart disease).

Finally, we took into account an aspect that we consider to be of great interest in our day-to-day surgical activity. This regards the particular characteristics of the population in our environment that undergoes this type of surgery. In contrast to other countries and studies found in the literature, our elderly patients with aortic valve disease tend to have a reduced BS, especially where women are concerned, as well as frequent co-morbidity, which puts them at special surgical risk. In fact, when we considered the pre-operative LVMI of our patients, we found values much higher than those reported by other authors,[7,21,22] possibly due to the lower BS, together with other potential factors, such as a greater incidence of ventricular hypertrophy secondary to more developed valvulopathy at the time of surgery. When we applied the cut point proposed by Devereux8 to define an elevated LVMI (134 g/m^2 in men and 110 g/m^2 in women) to our patients, we noticed that the majority of them had numbers higher than said cut point (107 patients, 82.9%), which means increased surgical risk from the start. Therefore, in our study we took as a cut point the highest tenth of the Devereaux series (270 g/m^2 in the group overall). Given that the risk scales most often used in heart surgery do not take into account the BS of patients as a potential risk factor, we wanted to create a predictive model for mortality to be used in conjunction with other predictive factors obtained by multivariate analysis (NYHA functional class and presence of significant aortic insufficiency). The mortality rate predicted by the model was 7.06%, versus an observed mortality rate of 7.8%. Upon application of the EuroSCORE to this group of patients, we found an underestimation of the mortality rate (the mortality estimated by EuroSCORE was 6.50%), confirming its scant value upon application of analysis via ROC curves, obtaining an area below the curve of only 0.56. Our model achieved an area below the curve of 0.87, indicating a higher discriminatory power.

Study limitations

Although our study involved an overall group of patients of more than 70 years of age who consecutively underwent aortic valve replacement in our hospital, it is prone to all the problems of a retrospective analysis. The study was also limited by the relatively small sample size, given the reduced number of patients in this age range who undergo primary replacement of the aortic valve.

CONCLUSIONS

1. The pre-operative variables predictive of nosocomial death in patients of more than 70 years of age who undergo aortic valve replacement are NYHA functional class III-IV, aortic valve insufficiency, and reduced BS.

2. Other variables associated with said mortality are an EF≤40% and an elevated pre-operative LVMI.

3. Disproportionate prosthesis to patient size also had repercussions on mortality, especially in the group of male patients.

4. Smaller prosthesis size, prolonged ECC time, and female sex did not have a particular influence on said mortality rate.

5. The model for predicting the risk of mortality that was developed taking into consideration the variables of NYHA functional class, aortic insufficiency, and BS achieved a good prediction rate in our patients

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