Validation of a New Surgical Risk Score for Heart Valve Surgery: VMCP

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Summary

Background: Some studies have developed scores for the assessment of surgical risk, particularly the EuroSCORE, which, however, is complex and difficult to apply. We suggest a new and simpler score, which is more appropriate for the clinical practice and for the assessment of surgical risk in patients with heart valve diseases.

Objective: This study was conducted to create and validate a simple and practical score to predict mortality and morbidity related to heart valve surgery.

Methods: Hospital data from 764 patients were collected, and the score was validated using two statistical models: death (= mortality) and length of hospital stay (LHS) > 10 days (= morbidity). The score was composed by four indexes (V [heart valve lesion], M [myocardial function], C [coronary artery disease], and P [pulmonary artery pressure]). A cut-off point was set for the score, and uni and multivariate analyses were performed to confirm whether the score would be able to predict mortality and morbidity. The existence of association with other risk factors was also studied.

Results: The score was validated with good internal consistency (0.65), and the best cut-off point for mortality and morbidity was 8. Scores > 8 can predict LHS > 10 days (odds ratio [OR] = 1.7; p = 0.006) and a higher death risk, at least in the univariate analysis (p = 0.049). However, the death risk could not be predicted in the multivariate analysis (p=0.258).

Conclusion: VMCP scores > 8 can predict LHS > 10 days and may be used as a new tool for the follow-up of patients with heart valve disease undergoing surgery. (Arq Bras Cardiol 2009;92(4):301-306)

Key words: Risk assessment; cardiac surgical procedures; heart valves/surgery.

Introduction

Recently, some studies have demonstrated changes in the management of patients with heart valve disease. One of them showed an association between aortic valve sclerosis and cardiovascular mortality and morbidity, even in asymptomatic patients[1]. In asymptomatic mitral regurgitation[2], an effective regurgitant orifice of at least 40 mm^2 is a good predictor of clinical outcome in the medical follow-up. However, it is difficult to define the best moment for indication of surgery in patients with heart valve disease and to predict surgical mortality and morbidity.

Rheumatic valve diseases are still common in developing countries[3]. For this reason, many patients undergo surgery very early in life[4], and frequently require reoperations during the natural history of the disease.

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Three phases are recognized in the natural history of patients with heart valve diseases: asymptomatic, symptomatic, and "transition phase", which is usually difficult to identify. Several adaptive changes such as cardiac chamber hypertrophy and dilatation occur, and advanced disease markers such as pulmonary hypertension and atrial fibrillation develop.

The onset of symptoms is an evidence for surgical indication[4], but the extent to which preoperative symptoms have a negative influence on postoperative survival remains controversial[5,6]. Some studies[6,7], however, have demonstrated that the indication of surgery in minimally symptomatic selected patients may be beneficial. In this group, we point out the importance of surgery for patients with heart valve disease accompanied by left ventricular dysfunction[7,8].

Other studies[9-11] used some parameters to evaluate the surgical risk in heart disease populations. EuroSCORE[12,13] is an excellent tool for the evaluation of cardiac surgery risk. However, this score was validated in an older population with a very low incidence of rheumatic disease, in addition to not being specific for heart valve surgery.

In view of these facts, we created a simplified score based on four critical situations for heart valve disease patients,

named VMCP. Thus, the VMCP score (V [heart valve lesion], M [myocardial function], C [coronary artery disease], and P [pulmonary artery pressure]) was used to identify patients with more severe preoperative disease and to correlate postoperative mortality and morbidity with heart valve surgery.

Methods

Medical records of 927 consecutive patients undergoing heart valve surgery in our Institution were analyzed. A total of 159 patients were excluded due to incomplete data, resulting in a final sample of 768 patients. Data collection from the medical records was conducted retrospectively, and the study protocol was approved by the institutional human research committee.

The mean age of this cohort was 50±17 years, 55% of the patients were women, 60% had rheumatic heart disease and 38% of the surgeries were reoperations. All patient demographics and clinical data are shown in Table 1.

Table 1 - Characterization of clinical and demographic variables

Variables	Results
Age	50.2±16.7
Male gender	346 (45.1%)
BMI > 30	99 (12.9%)
Rheumatic fever	458 (59.6%)
Hypertension	258(33.6%)
Diabetes	49 (6.4%)
Smoking	141 (18.4%)
Dyslipidemia	113 (14.7%)
Chronic obstructive pulmonary disease	44 (5.7%)
Functional class III-IV	581 (75.7%)
Previous stroke	42 (5.5%)
Previous cardiogenic shock	12 (1.6%)
Atrial fibrilation	223 (29.0%)
Renal failure	43 (5.6%)
Reoperation	292 (38.0%)
Previous endocarditis	57 (7.4%)
Death	44 (5.7%)
Time of extracorporeal circulation (minutes)	95.7 ± 34.4
Left ventricular ejection fraction	0.66 ± 0.12
Mitral valve disease	
Stenosis	306 (39.9%)
Regurgitation	295 (38.4%)
Prosthesis dysfunction	167 (21.7%)
Aortic valve disease	
Stenosis	396 (51.6%)
Regurgitation	225 (29.3%)
Prosthesis dysfunction	147 (19.1%)

Surgical mortality and morbidity, as well as the presence of comorbidities and in-hospital parameters were analyzed. The parameters studied included length of hospital stay (LHS), length of ICU stay, duration of extracorporeal circulation, surgical procedure report, emergency surgery, reoperation, and pre and postoperative complications.

Mortality was defined as intraoperative patient death or death during hospital stay. Morbidity was defined based on the mean length of hospital stay in our institution (10 days) and was considered as a length of hospital stay longer than 10 days.

The following preoperative comorbidities were studied: hypertension (defined as blood pressure ≥ 140/90 mmHg), diabetes (fasting plasma glucose ≥ 126 mg/dl), rheumatic fever, cigarette smoking (yes or no, and the amount of cigarettes smoked per day), dyslipidemia (total cholesterol > 240 mg/dl and LDL > 160 mg/dl), renal failure (creatinine > 2 mg/dl), heart failure, stroke and atrial fibrillation.

With the purpose of creating a simple and practical index - the VMCP score and index - four parameters considered fundamental to characterize heart valve disease were used (Table 2): (V [heart valve lesion], M [myocardial function], C [coronary artery disease], and P [pulmonary artery pressure]). Each of these parameters was classified into four categories, and the sum of the points of the four index parameters, for instance, V3M2C2P2, result in the score 9 (3+2+2+2).

The criteria used for the classification of each variable included clinical and laboratory parameters used in the routine assessment of patients with heart valve disease. Variable V was based on history, clinical examination (presence of symptoms and cardiac auscultation) and echocardiographic diagnosis (single or multiple heart valve lesions). For the definition of mild, moderate or severe heart valve lesion, the criteria described in the guidelines for heart valve disease of the American Heart Association/American College of Cardiology[14] were used. Thus, for instance, mitral stenosis was considered mild if the valve area was greater than 1.5 cm^2. Mild lesions, provided that multivalvular and that the patient was symptomatic, were also classified as V4. As regards the presence of symptoms, we considered parameters going from dyspnea (functional class I to IV) to angina and signs of low output such as syncope. Variable M analyzed myocardial function as assessed by left ventricular ejection fraction and echocardiographically quantified using the Teichholz method. Variable C analyzed the coronary circulation based on coronary angiography. Finally, variable P used the pulmonary artery pressure to evaluate the presence and degree of pulmonary hypertension, as indirectly assessed by right ventricular systolic pressure and quantified by tricuspid regurgitation observed on echocardiography.

Statistical analysis

The statistical analysis was carried out using the SPSS for Windows software (version 13.0). Data on continuous variables were analyzed using the *t* test and data on categorical variables were analyzed using the chi-square test. Continuous variables were expressed as mean ± standard deviation (SD), and categorical variables as a number (percentage, %). P values < 0.05 were considered statistically significant.

Table 2 - **VMPC index and score systematization**

V - valve or prosthesis	M - myocardium	C - coronary artery	P - pulmonary artery systolic pressure (on echocardiography)
V1 - Mild/moderate valve lesion	M1 - Ejection fraction > 60%	C1 - Normal coronary arteries or patient without coronary angiography	P1 - PAP < 30 mmHg
V2 - Asymptomatic severe valve lesion	M2 - Ejection fraction between 60% and 50%	C2 - Coronary obstruction up to 60%	P2 - PAP between 30 and 60 mmHg
V3 - Symptomatic single valve lesion	M3 - Ejection fraction between 50% and 30%	C3 - Critical one-vessel obstruction	P3 - PAP between 60 and 100 mmHg
V4 - Symptomatic multivalvular lesion	M4 - Ejection fraction <30%	C4 - Critical multivessel obstruction	P4 - PAP > 100 mmHg

Internal score consistency was assessed using alpha (Cronbach) and the area under the curve was estimated. The mean length of hospital stay in our institution (10 days) was used to define the cut-off point of the score.

ROC curves were used to define the most appropriate cut-off values for the score to predict length of hospital stay longer than 10 days and death. The Mann-Whitney test was used for the comparison of mean score differences for clinical and demographic variables.

The chi-square test and multiple logistic regression models were used for the analysis of risk factors for death and length of hospital stay > 10 days. Dependent variables of the analysis were death and length of hospital stay > 10 days, and independent variables were the clinical and demographic variables analyzed. The cut-off point used for the score was 8. Also, the Hosmer-Lemeshow test was used for a better model performance.

Results

Most of the patients were females (55%), 60% had rheumatic heart valve disease, and 38% of the surgeries were reoperations (Table 1).

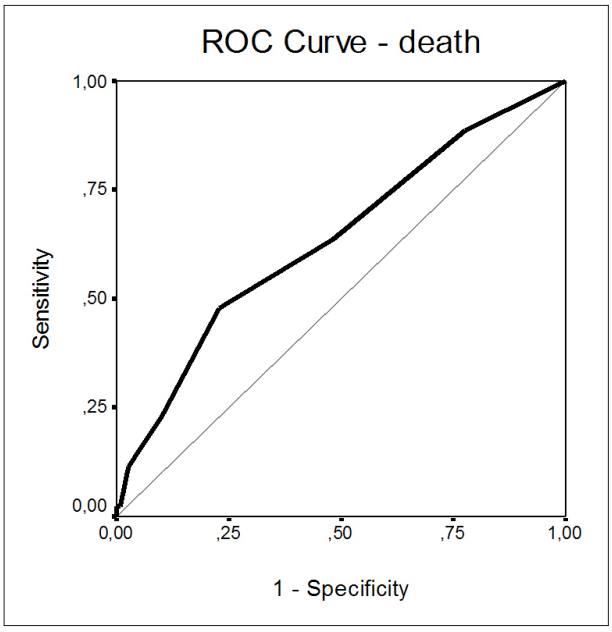

Figure 1 - ROC for death.

Score validation

The internal consistency was good (Cronbach's Alpha = 0.65) for the score, thus showing that the parameters used to comprise the score were correlated.

ROC curves were used to define the best cut-off point for the score. In relation to the ROC curve, the area under the curve was 0.64 for death (Figure 1) and 0.61 for length of hospital stay longer than 10 days (Figure 2); the best cut-off point was 8 for both. Then, the score was divided into VMCP < 8 and VMCP ≥ 8.

Considering the score as a quantitative variable, a significant difference was found for the mean scores for: rheumatic fever (7.5 *vs* 7.8; p< 0.001), renal failure (7.6 *vs* 8.5; p<0.001), atrial fibrillation (7.5 *vs* 8.1; p<0.001), reoperation (7.5 *vs* 8.0; p<0.001) and death (7.6 *vs* 8.4; p=0.002).

Morbidity

In the univariate analysis, a significant association could be observed between length of hospital stay > 10 days and some variables (Table 3), especially a VMCP score > 8. This association was also observed in the multivariate analysis, which showed that a VMCP score > 8 is able to predict length of hospital stay > 10 days, that is, higher morbidity. The other variables: atrial fibrillation (Odds Ratio [OR] =2.2; p=0.001), rheumatic fever (OR=1.7; p=0.005), dyslipidemia (OR=1.9; p=0.039), cigarette smoking (OR=1.8; p=0.020), and previous endocarditis (OR=2.8; p=0.024) also remained as risk factors for morbidity in the multivariate analysis (Table 4).

Mortality

For mortality, the univariate analysis showed a statistically significant association between some variables and death (Table 5), including the VMCP score > 8. The multivariate analysis showed a higher number of deaths related to renal failure (OR=5.6; p<0.001), reoperation (OR=2.6; p=0.004), and diabetes (OR=3.0; p=0.014) (Table 6). However, in the multivariate analysis the VMCP score was not statistically significant (p=0.258), showing only a small increase in the odds ratio (1.46); its 95% confidence interval passed through value 1.0.

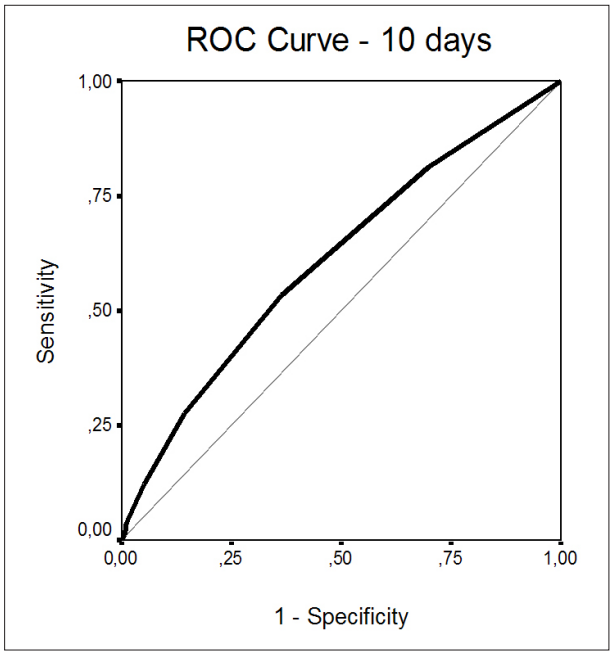

Figure 2 - ROC curve for length of hospital stay longer than 10 days.

Table 3 - Univariate analysis of risk factors for length of hospital stay > 10 days

Variable	Characteristic	No. (length of hospital stay >10 days)	p (χ^2)
Rheumatic fever	Yes	366(80.6%)	0.002
	No	208(70.7%)	
Dyslipidemia	Yes	94(85.5%)	0.019
	No	480(75.2%)	
Smoking	Yes	118(84.3%)	0.019
	No	456(75.0%)	
Atrial fibrilation	Yes	192(86.5%)	<0.001
	No	382(72.6%)	
Reoperation	Yes	230(81.3%)	0.022
	No	344(74.0%)	
VMCP score	>8	304(82.6%)	<0.001
	≤8	268(70.7%)	
Previous endocarditis	Yes	45(88.2%)	0.044
	No	529(75.9%)	

Table 4 - Multivariate analysis of risk factors for length of hospital stay > 10 days

Variable	p value	Odds Ratio	95% CI
VMCP > 8	0.006	1.66	1.15 – 2.40
Atrial fibrilation	0.001	2.16	1.39 – 3.37
Rheumatic fever	0.005	1.68	1.17 – 2.41
Dyslipidemia	0.039	1.85	1.03 – 3.32
Smoking	0.020	1.84	1.10 – 3.07
Previous endocarditis	0.024	2.78	1.14 – 6.77

P (Hosmer-Lemeshow Test) = 0.383.

Table 5 - Univariate analysis of risk factors for death

Variable	Characteristic	No (deaths)	p (χ^2)
Diabetes	Yes	8 (16.3%)	0.001
	No	36 (5.1%)	
Dyslipidemia	Yes	11 (10%)	0.043
	No	33 (5.1%)	
Renal failure	Yes	11 (25.6%)	<0.001
	No	33 (4.6%)	
Previous cardiogenic shock	Yes	4 (33.3%)	<0.001
	No	40 (5.4%)	
Reoperation	Yes	27 (9.3%)	0.001
	No	17 (3.6%)	
VMCP score	>8	28 (7.5%)	0.049
	≤8	16 (4.2%)	
Previous endocarditis	Yes	8 (14.0%)	0.006
	No	36 (5.2%)	

Table 6 - Multivariate analysis of risk factors for death

Variable	p value	Odds Ratio	95% CI
Renal failure	<0.001	5.62	2.51 - 12.62
Reoperation	0.004	2.63	1.37 - 5.04
Diabetes	0.014	3.04	1.25 - 7.39
VMCP > 8	0.258	1.46	0.75 - 2.83

P (Hosmer-Lemeshow Test) = 0.210.

Therefore, the VMCP score > 8 cannot be considered predictive of death, but only a risk factor for higher mortality.

Discussion

Adaptive changes frequently result in a long natural history in most patients with heart valve disease[4,5]. Throughout this history, surgery may be indicated, and is frequently fundamental for the improvement of symptoms[4]. Additionally, normal left ventricular function is essential for a better outcome of these patients[6,7].

In countries where rheumatic valve diseases[3] remain as a serious health problem some peculiarities have been observed in the comparison with patients with degenerative valve disease. These patients have lower mean age (50±17 years)[4]and lower number of conservative heart valve surgeries and, thus, a greater number of patients undergo reoperation (approximately 38% in our case series).

The routine follow-up of these patients is a good clinical practice to determine the best moment for surgery[15,16]. Waiting for the onset of symptoms[4,16], preventing irreversible reduction of the left ventricular function[15], in association with other well-established criteria defined in heart valve disease consensuses[14] help determine the right moment for surgical indication. The best moment is that in which the patient will have the best early and late prognosis.

We selected four clinical and laboratory variables to characterize a specific moment in the natural history of a group of patients with heart valve disease, thus creating the VMCP index and score.

This score proved to be an important tool to predict surgical morbidity in heart valve surgery. Simplicity and easiness of use are some of the advantages of the VMCP score. However, this score was not able to predict mortality in the multivariate analysis, perhaps because of the small sample size. This fact, however, did not reduce its value as an interesting new marker of severity. In association with other parameters, a VMCP score > 8 was observed to be related to more severely ill patients probably with worse prognosis. These patients require more intensive medical care both during hospitalization and after discharge. Thus, a VMCP score > 8 also means a more advanced natural history.

This study confirmed that the presence of comorbidities corresponded to longer length of hospital stay and higher death risk. Additionally, the presence of diabetes, renal failure and reoperation increase the death risk but not the length of hospital stay.

Atrial fibrillation, rheumatic etiology, dyslipidemia, cigarette smoking and previous endocarditis were identified as risk factors for a longer length of hospital stay. On the other hand, these comorbidities were not risk factors for death.

Studies on the EuroSCORE[12,13] are very elegant in the analysis of possible risk factors for higher surgical morbidity and mortality. This score uses some clinical and laboratory parameters, estimating mortality rate by the final score. As was observed in this study, decreased renal function, previous endocarditis, myocardial dysfunction, pulmonary hypertension and previous cardiac surgery are also parameters of a worse prognosis in the EuroSCORE.

Some parameters such as age, high blood glucose and serum creatinine level may increase the degree of prediction of the VMCP score, but their absence does not invalidate the method and they may be used in further studies.

The VMCP index and score are, therefore, a simple and useful clinical tool and can be used in the daily clinical practice. They can identify a group at a higher surgical risk for heart valve surgery, in addition to helping define the best moment for surgical indication during the clinical follow-up of patients with heart valve disease.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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Study Association

This study is not associated with any post-graduation program.

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