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Submitted on November 25, 2009
Accepted on November 3, 2010

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Analysis of specific pre-operative model to valve surgery and relationship with the length of stay in intensive care unit

Análise de um modelo de risco pré-operatório específico para cirurgia valvar e a relação com o tempo de internação em unidade de terapia intensiva

ABSTRACT

Objectives: The length of stay after prolonged cardiac surgery has been associated with poor immediate outcomes and increased costs. This study aimed to evaluate the predictive power of the Ambler Score to anticipate the length of stay in the intensive care unit.

Methods: This was a retrospective cohort study based on data collected from 110 patients undergoing valve replacement surgery alone or in combination with other procedures. Additive and logistic Ambler Scores were obtained and their predictive performances calculated using the Receiver Operating Characteristic curve. The normal length stay in the intensive care unit was assumed to be ≤3 days and prolonged >3 days. The areas under the receiver operating curves for both the additive and logistic models were compared using the Hanley-MacNeil test.

Results: The mean intensive care unit length of stay was 4.2 days. Sixty-three patients were male. The logistic model showed areas under the receiver operating characteristic curve of 0.73 and 0.79 for hospitalization > 3 days and ≤ 3 days, respectively, showing good discriminative power. For the additive model, the areas were 0.63 and 0.59 for hospitalization > 3 days and ≤ 3 days, respectively, a poor discriminative power.

Conclusions: In our database, prolonged length of stay in the intensive care unit was positively correlated with the logistic Ambler score. The performance of the logistic Ambler Score had good discriminative power for correlation with the intensive care unit length of stay.

Keywords: Risk factors; Preoperative care; Aortic valve/surgery; Length of stay; Intensive care units

INTRODUCTION

The cardiovascular surgery profile is changing, as the number of patients undergoing coronary artery bypass grafting (CABG) surgery remains stable or drops, while the number of valve replacement surgeries steadily grows.[1] The reported mortality in Brazil, based on more than 115,000 cardiac surgeries between 2000 and 2003, was 8%. Among risk factors for death after valve surgery outstand: advanced age, female gender, chronic obstructive pulmonary disease (COPD), heart failure functional class, ventricular dysfunction, surgical priority, pulmonary artery hypertension, renal dysfunction, valve disease associated with ischemic heart disease, reoperation and infective endocarditis.[2] Heart surgery still accounts for considerable healthcare expenditures.[3]

Countless preoperative risk assessment models were proposed in the last two decades for both short term postoperative mortality and morbidity risk

assessment, given the continued research on preoperative variables able to influence immediate surgery outcomes. However, these models were mostly developed focused on CABG. In this context, the use of valve disease-specific preoperative score, in different profile populations, is highly relevant.[3,4]

Considering the advances both in surgical management and intensive care, high-risk patients who otherwise would have the heart surgery contraindicated, are currently considered suitable for cardiac surgery, leading to higher long intensive care unit (ICU) stay rates.[5,6] In European countries as well as in the United States, where usually more ICU beds are available, is common the lack of ICU beds. Similarly Brazil has not enough beds.[7] Albler's Score (AS) is an easy to use tool, works with simple variables and uses regular preoperative tests and easy to measure risk factors, rendering it feasible for any institution.[8]

This study aimed to evaluate the correlation between the AS model and the postoperative ICU length of stay (LOS).

METHODS

The medical records of 110 consecutive patients in a university hospital undergoing valve replacement surgery, either alone or associated with other procedure(s), between January 2007 and July 2008, were retrospectively assessed. The clinical and demographic characteristics, as well as preoperative variables, were organized according to Ambler et al.[1] The data were collected using a standardized sheets which included social, demographic, clinical, pre-, intra- and postoperative variables. The patients were evaluated from the pre-surgery admission to the hospital to the ICU discharge. The principal study endpoint was the length of ICU stay reported in days. The study was conducted after approval by the Hospital Escola Álvaro Alvim's Ethics Committee, approval number 325534, being assured the medical records data privacy and confidentiality for their use exclusively to fulfill this study purposes.

Statistical analysis

The comparison between the ≤ 3 days and > 3 days LOS groups variables was conducted using the Student's t test. The predictive AS performance was analyzed using the Receiver of Operating Characteristic (ROC) curve. Were assumed as normal length of stay the cases with ≤ 3 days LOS and prolonged those with > 3 days (1 day equal to 24 hours in the ICU). The ROC curves were plotted for both additive and logistic AS analysis. The area under the ROC curve (AUC) was correlated to the contingency coefficient C, evaluating the test's predictive power, which was defined as > 0.8 excellent, >0.75 very good and >0.7 good discriminative power. A 0.5 value was defined as indefinite discriminative power. The additive and logistic models' AUCs were compared using the Hanley-MacNeil test. The SPSS 13.0 software was used for the analysis.

RESULTS

One hundred and ten patients underwent valve surgery either alone or associated to other procedure(s). The AS variables and the surgeries performed are displayed in table 1. The mean additive AS was 6 (range 1-17) and the logistic 5% (range 0.2% to 30.10%).

Table 1 – Patients' Clinical and Demographic characteristics according to the Ambler Score

Ambler score variables	Results
Age	57.4±14.6
BMI	23.2±8.6
Gender	
Male	63 (57.3)
Female	47 (42.7)
Creatinine >2.27 mg/dL	18 (16.3)
Type of surgery	
Aortic valve replacement	53 (48.2)
Mitral valve replacement	36 (41.8)
Mitral and aortic valve replacement	11 (10.0)
Associated tricuspid surgery	6 (5.4)
Dialysis	2 (1.8)
AF – AVB	38 (34.5)
VT – VF	1 (0.91)
Hipertensão arterial sistêmica	89 (81.0)
Diabetes mellitus	34 (31.0)
Ejection fraction	
30-50%	24 (21.9)
<30%	7 (6.4)
Surgical priority	
Urgency	3 (2.7)
Emergency	1 (0.9)
Previous cardiac surgery	
1	20 (18.2)
≥ 2	2 (1.8)

BMI – Body Mass Index; AF-ABV – atrial fibrillation – atrioventricular block; VT-VF – Ventricular tachycardia – ventricular fibrillation. Results expressed as mean ± standard deviation or number (%)

The ICU LOS ranged from 2 to 20 days, and the mean LOS was 4.2±2.6 days. The Table 2 displays the mean length of stay, categorized as either normal or prolonged, as well as the patients' distribution according to their additive and logistic predictive risks. Forty three (39%) patients stayed in the ICU longer than 3 days and 67 (61%) stayed ≤ 3 days. Table 3 shows the differences between the baseline characteristics for the ≤ 3 days and > 3 days groups, where comparatively, the > 3 days patients had higher AS measured risk levels.

Table 2 – Ambler score distribution and intensive care unit length of stay

Ambler score	N (%)	ICU length of stay (days)
Logistic		
<2.5%	58 (52.7)	3.08 ± 0.75
2.5 a 10%	35 (31.8)	4.91 ± 2.21
>10%	17 (15.5)	7.58 ± 4.57
Additive		
0-5	63 (57.2)	3.14 ± 0.87
6-10	34 (30.9)	5.61 ± 3.55
>10	12 (10.9)	6.16 ± 3.45

ICU – intensive care unit. Results expressed as mean ± standard deviation or number (%).

In table 3, when the variables differences for the ≤ 3 days and > 3 days groups are analyzed, significant differences are found for age, with the >3 days group being older (60.1 ± 10.7 years, p=0.04); the normal LOS group had more women than the prolonged LOS group (46.3% versus 34.9%; p=0.03); patients undergoing aortic valve replacement were predominantly female (58.2% versus 32.5%; p = 0.02). The table 4 presents the values found for each group according to the coefficient C and Hanley-MacNeil test.

ROC curves were plotted for additive and logistic AS analysis (Figure 1). Regarding the logistic AS, the LOS > 3 days AUC was 0.73, and for LOS ≤ 3 days

Table 3 – Ambler score variables distribution according to the intensive care unit length of stay

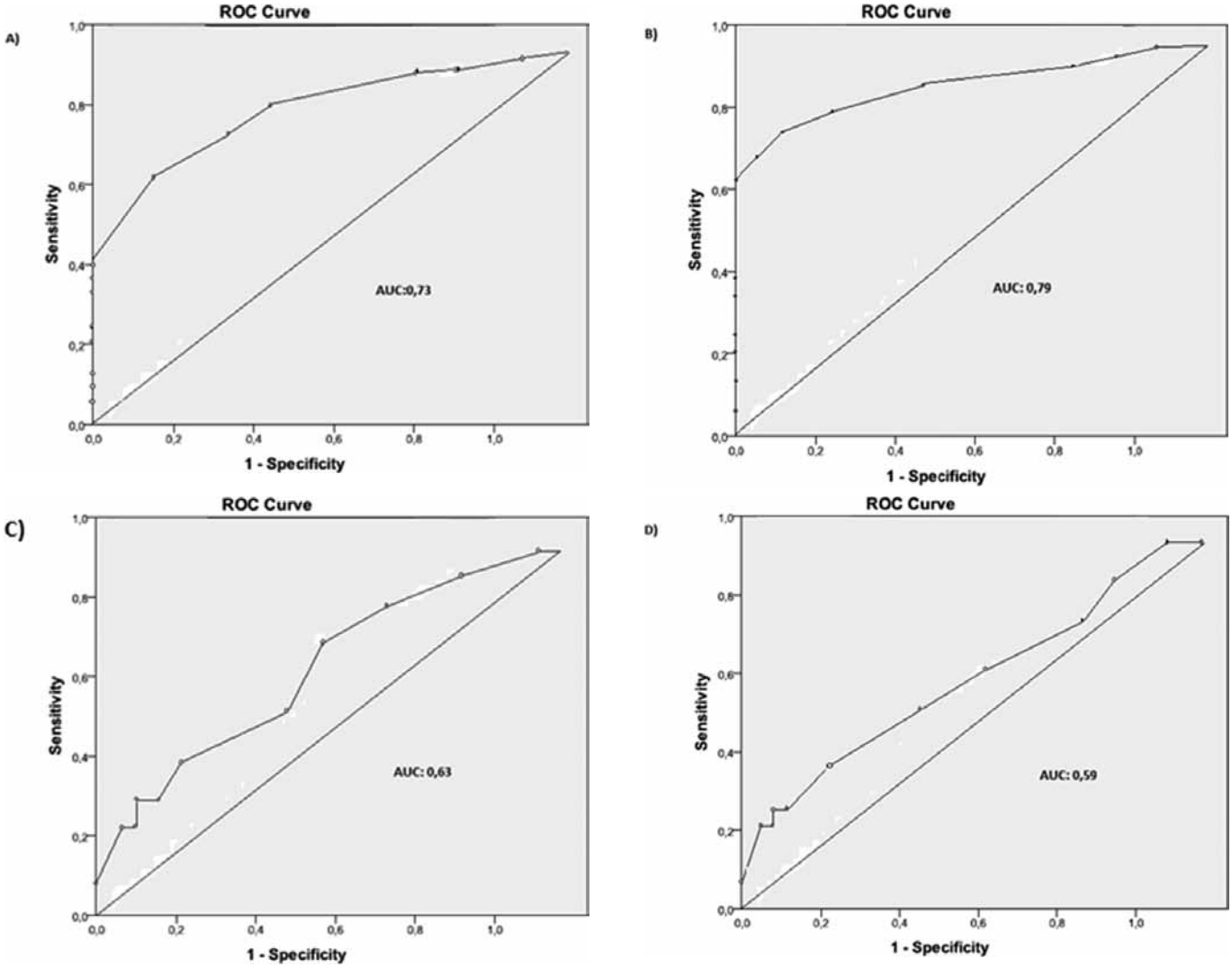
Variables	Normal Up to 3 days ICU stay time N (%)	Prolonged ICU stay time >3 days N (%)	p value
Age (mean and SD)	49.4 (14.5)	60.1 (10.7)	0.04
Female gender	31 (46.3)	15 (34.9)	0.03
BMI (mean and SD)	27.3(3.4)	28.5 (4.1)	0.56
Type of surgery			
Aortic valve replacement	39 (58.2)	14 (32.5)	0.002
Mitral valve replacement	23(34.3)	23 (53.5)	0.99
Mitral and aortic valve replacement	5 (7.4)	6 (13.5)	0.99
Associated tricuspid surgery	3 (4.5)	3 (4.5)	0.99
Creatinine >2.27 mg/dL	10 (14.9)	10 (14.9)	0.99
Dialysis	1 (1.5)	2 (4.6)	0.99
AF-AVB	23 (34.3)	18 (41.8)	0.5
VT-VF	1 (1.5)	0 (0)	0.99
Systemic arterial hypertension	51 (76.1)	41 (95.3)	0.38
Diabetes mellitus	16 (23.9)	21 (48.8)	0.48
Ejection fraction			
30-50%	16 (23.9)	15 (34.9)	0.99
<30%	3 (4.5)	6 (13.9)	0.49
Surgical priority			
Urgency	2 (3.1)	2 (4.6)	0.99
Emergency	0 (0)	1 (2.3)	0.99
Previous cardiac surgery			
1	20 (18.2)	10 (23.2)	0.11
≥ 2	2 (1.8)	1 (2.3)	0.99

ICU – intensive care unit; SD – standard deviation; BMI – body mass index; AF-AVB – atrial fibrillation- atrioventricular block; VT-VF – ventricular tachycardia- ventricular fibrillation. Results expressed as mean ±standard deviation or number (%). Student's *t* test.

Table 4 – Ambler score predictive and logistic models coefficient C

	Additive Ambler score				Logistic Ambler score			
	Coefficient C	Standard error	p value	95% CI	Coefficient C	Standard error	p value	95% CI
< 3 days	0.63	18.73	<0.0001	1.0 to 26.9	0.79	23.47	<0.0001	1.0 to 33.5
> 3 days	0.59	18.8	<0.0001	1.0 to 22.0	0.73	23.52	<0.0001	1.0 to 27.3

CI – confidence interval.



AUC - area under the curve; ICU – intensive care unit. (A) Logistic Ambler Score: > 3 days; (B) Logistic Ambler Score: ≤ 3 days in ICU; (C) Additive Ambler Score: ≤ 3 days in ICU; (D) Additive Ambler Score: > 3 days in ICU.

Figure 1 – ROC (Receiver Operating Characteristic) curves for the additive and logistic models.

0.79. For the additive AS for > 3 days and ≤ 3 days, the results were 0.63 and 0.59, respectively. The contingency coefficient C values are shown in Table 4. The AUCs were significantly different according to the Hanley-MacNeil test. For the prolonged ICU stay group, the logistic AS showed a higher discriminative power versus the additive.

DISCUSSION

Continuously growing healthcare costs considerably pressure healthcare mangers, who are required to control costs while keeping quality levels. In this scenario, useful preoperative risk assessment models are relevant; however, most of them are focused on

mortality only. This study evaluated the relationship between the AS and the ICU length of stay after valve surgery, and our results showed good correlation between the logistic AS and the ICU length of stay.[7,9]

The predictive power for LOS was observed to be good when the logistic AS was correlated with > 3 days length of ICU stay, while for the additive model predictive power was indefinite. As far as we could assess, this is the first study designed to evaluate the prediction of ICU length of stay without the EuroSCORE. The 0.73 coefficient C found in our data indicates good logistic AS discriminative power for > 3 days stay. Yet, for the additive AS analysis, the coefficient C found was not compatible with good discriminative power.

In previous studies when cardiovascular outcomes were analyzed, in addition to longer ICU stays, increased multiple organ failure and therefore higher costs and mortality rates were found.[10,11]

The AS was developed to predict early mortality after valve surgery, and so far was not considered for ICU length of stay analysis. In our series, the logistic model was more used for daily clinic evaluation, although is not used in other sites due to its complexity. Some risk factors are included in this risk model, such as arterial hypertension, atrial fibrillation, body mass index, smoking status and diabetes, which are not part of EuroSCORE, demonstrating the need of a specific for valve surgery model.[12] The Parsonnet's Score is a previous example of a preoperative risk evaluation tool, which in addition to postoperative mortality was proven effective for ICU length of stay prediction.[13] According to our sample, when the groups are analyzed including aortic valve and age, these are possibly correlated with longer stay, as this illness is direct related with the elderly, known to have increased comorbidities and possibly longer ICU LOS. In our series the ≤ 3 days LOS group was predominant (p=0.002), likely due to the much younger age range versus the LOS > 3 days group (49.4 ± 14.5 versus 60.1 ± 10.7).

Prolonged length of ICU stay, in addition to the extra financial burden added to the healthcare system, is also an issue for ICU beds availability. Therefore, a planned intervention would be convenient. With this focus, a preoperative risk based model may prove to be an essential cost-benefit analysis tool.[14] Kurki et al.[15] found close relationship between the preoperative risk score, evaluated by the Cleveland model, and the ICU length of stay. A preoperative risk score increase was associated with longer postoperative LOS.

Several series have proposed to identify preoperative risk factors associated with prolonged ICU stay, however all of them with limited samples.[16,17] Equally, Janssen et al.[18] recently published a risk model for > 3 days length of stay based in a 104 patients sample.

The power to predict prolonged length of ICU stay, and to assess the surgical risk and benefit, is essential. These can be objectively evaluated with a risk prediction model, allowing better communication with family members and improved safety. The herein results suggest that the AS logistic model is an useful tool to predict prolonged ICU stay; however its predictive performance is not of 100%.[18,19] The identification of patients with higher risk of prolonged ICU stay allows the management of beds, as well scheduling surgeries for the most convenient time.[20, 21] The use of these scores for higher postoperative morbidity and mortality risk patients prioritization is relevant to consider. Although not evaluated in our study, it could lead to early admission of higher risk of prolonged ICU stay patients.

This study has limitations that should be commented. Its retrospective nature prevents the preclusion of some confounding factors. Also, our sample was small when compared to the large samples required for validation and hardly achievable in single-center trials. In this study analysis the length of ICU stay was categorized as dichotomous variables. The ROC curve analysis is largely built based on the assumption of dichotomous results. Additional research on prediction of post-cardiac surgery ICU length of stay as continuous variable is warranted. Another important limitation to comment is that as our data were collected in one single center, our findings can not be extrapolated.

CONCLUSION

In our sample analysis the AS preoperative logistic risk model had better predictive power of ICU length of stay than the additive model. Nevertheless, considering the limitations of the currently available models, a tool to predict the ICU length of stay remains an unmet need.

RESUMO

Objetivos: O tempo de internação prolongado após cirurgia cardíaca é associado a resultados imediatos ruins e aumento dos custos. O objetivo deste estudo foi analisar o poder preditor do escore de Ambler na previsão do tempo de internação em unidade de terapia intensiva.

Métodos: Estudo de coorte retrospectiva com dados coletados de 110 pacientes submetidos à cirurgia de troca valvar isolada ou associada. Os valores do escore aditivo e logístico do escore de Ambler e as performances preditivas do escore de Ambler foram obtidos por meio da curva ROC. A estadia em unidade de terapia intensiva definiu-se como normal ≤3 dias e prolongada >3 dias. A área sobre as curvas dos modelos aditivo e logístico foram comparadas por meio do teste de Hanley-MacNeil.

Resultados: A média de permanência em unidade de terapia intensiva foi de 4,2 dias. Sessenta e três pacientes pertenciam ao sexo masculino. O modelo logístico apresentou área sob a curva ROC de 0,73 e 0,79 para internação >3 dias e ≤3 dias, respectivamente, apresentando bom poder discriminatório. No modelo aditivo, as áreas foram 0,63 e 0,59 para internação >3 dias e ≤3 dias, respectivamente, sem bom poder discriminatório.

Conclusões: Em nossa base de dados, o tempo de internação prolongado em unidade de terapia intensiva foi positivamente correlacionado com o escore de Ambler logístico. O desempenho do escore de Ambler logístico teve bom poder preditor para correlação do tempo de internação em unidade de terapia intensiva.

Descritores: Fatores de risco; Cuidados pré-operatórios; Valva aórtica/cirurgia; Tempo de internação; Unidades de terapia intensiva

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