

Assesment of CABDEAL score as predictor of neurological dysfunction after on-pump coronary artery bypass grafting surgery

Avaliação do escore CABDEAL como preditor de disfunção neurológica no pós-operatório de revascularização miocárdica com circulação extracorpórea

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DOI: 10.5935/1678-9741.20120072

RBCCV 44205-1403

Abstract

Introduction: Neurological dysfunction is a feared postoperative morbidity of cardiac surgery, an important cause of death and increased spending in hospitals. Its prediction, however, is still uncertain.

Objective: To assess the applicability of a preoperative score as a predictor of neurological dysfunction after coronary artery bypass grafting (CABG) under cardiopulmonary bypass (CPB).

Methods: Prospective study that evaluated 77 patients who underwent CABG from February to October 2011. Using the score CABDEAL (creatinine, age, body mass index, diabetes, emergency surgery, abnormality on ECG, lung disease), patients were grouped into high (CABDEAL \geq 4)

and low risk (CABDEAL < 4). The predictive value of the score was compared with intraoperative and postoperative variables (aortic clamping time, CPB and ventilation time) as predictors of encephalopathy and stroke. Data were analyzed with descriptive statistics and compared with the Fisher exact test. ROC curve analysis was performed to evaluate the accuracy of the model for the neurological outcomes. It was considered the significant value $P < 0.05$.

Results: The mortality rate was 2.6% (n=2). There were 2 episodes of stroke (2.6%) and 12 (15.5%) of encephalopathy. High risk CABDEAL ($P=0.0009$), ventilation time ($P=0.014$), CPB time ($P=0.02$) and aortic clamping time ($P=0.006$) were significantly associated with encephalopathy. The aortic clamping time was also associated with stroke ($P=0.03$) and

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Work performed at the Department of Cardiac Surgery, University Hospital, Federal University of Maranhão.

Presented at the 39th Congress of the Brazilian Society of Cardiovascular Surgery, Maceió, AL, from April 12th to 14th, 2012

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Article received on May 9th, 2012

Article accepted on July 6th, 2012

Abbreviations, acronyms & symbols	
AHA	American Heart Association
CPB	Cardiopulmonary bypass
CABG	Coronary artery bypass grafting
CVA	Cerebrovascular accident
ROC	Receiver Operating Characteristics
SUS	Unified Health System

death ($P=0.006$). CABDEAL score showed the largest area under the ROC curve rather than others variables.

Conclusion: In this study, the CABDEAL score stood out as the best predictor of encephalopathy after CABG when compared to the others intraoperative variables.

Keywords: Myocardial revascularization. Risk assessment. Morbidity. Brain damage.

Resumo

Introdução: As complicações neurológicas são temidas no pós-operatório das cirurgias cardíacas, sendo importante causa de óbito e de gastos hospitalares. Sua predição ainda é incerta.

Objetivo: Avaliar a aplicabilidade de um escore pré-operatório como preditor de disfunção neurológica no pós-operatório de revascularização miocárdica (RM) com circulação extracorpórea (CEC).

Métodos: Estudo prospectivo que avaliou 77 pacientes submetidos à RM no período de fevereiro a outubro de 2011. Utilizando-se o escore CABDEAL (*creatinine, age, body mass index, diabetes, emergency surgery, abnormality on ECG, lung disease*), os pacientes foram agrupados em alto ($CABDEAL \geq 4$) e baixo risco ($CABDEAL < 4$). Para os desfechos encefalopatia e acidente vascular encefálico (AVE), foram comparados os valores preditivos do escore e das variáveis intra e pós-operatórias (tempos de pinçamento aórtico, CEC e ventilação mecânica). O teste exato de Fischer foi usado na análise estatística. A análise da curva ROC foi utilizada para avaliar a acurácia do modelo para os desfechos neurológicos. Adotou-se o nível de significância $P < 0,05$.

Resultados: A taxa de mortalidade foi de 2,6% ($n=2$). Ocorreram dois episódios de AVE (2,6%) e 12 (15,5%) de encefalopatia. O desfecho encefalopatia associou-se significativamente com CABDEAL de alto risco ($P=0,0009$), tempo de ventilação mecânica ($P=0,014$), tempo de CEC ($P=0,02$), e tempo de pinçamento aórtico ($P=0,006$); este último associou-se também com AVE ($P=0,03$) e óbito ($P=0,006$). O escore CABDEAL apresentou maior área sob a curva ROC do que as demais variáveis para o desfecho encefalopatia.

Conclusão: Na amostra estudada, o escore CABDEAL foi melhor preditor de encefalopatia no pós-operatório de RM quando comparado às variáveis intraoperatórias analisadas.

Descritores: Revascularização miocárdica. Medição de risco. Morbidade. Dano cerebral.

INTRODUCTION

Surgery for coronary artery bypass (CABG) is the major surgical procedure most commonly performed worldwide [1]. According to the American Heart Association (AHA), only in the United States, from 1996 to 2006, the number of cardiac surgeries reached the mark of 7,235,000 procedures. Only in 2006, 448,000 CABG surgeries were performed [2]. However, in spite of its broad execution and development over the years, it still implies certain risks for the patient.

Among the complications, cerebrovascular accident (CVA) and other ischemic neurologic events are the most feared after CABG. The risk of stroke in patients undergoing CABG is estimated at 2%. This rate increases significantly according the age increase of the patient, in elderly patients reaching the value of 9% [3].

Another dysfunction expected, although less studied is the encephalopathy, presented as delirium, confusion, coma and convulsions in the immediate postoperative

period. This morbidity is associated with the increase in hospital stay and mortality [4]. It is a common complication in cardiac intensive care units and its incidence varies from approximately 8.4% to 32% [5,6].

The problem involving the brain damage in cardiac surgery is multifactorial, including risk factors in the pre-, intra- and postoperative period, such as age, gender, previous neurological disease, carotid artery disease, microembolisms, perfusion disorders, metabolic disorders, inflammatory responses [7]. The prevalence of these complications is very variable and depends mainly on the pacing in postoperative neurological outcome [8].

Predictive models can be used to estimate the chances of these complications and others, allowing to choose the best treatment for the patient and the consequent reduction in morbidity and mortality [9]. However, the majority models evaluates the mortality as the main outcome, there are few that contemplate postoperative morbidities such as stroke, mediastinitis and atrial fibrillation [10-13].

Among the existing, the CABDEAL (Creatinine, Age, Body Mass Index, Diabetes, Emergency Surgery, Abnormal ECG, Lung Disease), a score proposed by Kurki et al. study [14], proved to be easily applied and a good predictor of morbidity [15,16].

Studies involving neurological events in the postoperative period of CABG surgery allow us to realize the importance of predicting these complications, both for patient management and to decrease hospital costs involved in treatment. Thus, this study aimed to identify risk factors predictive for the occurrence of stroke and encephalopathy in the postoperative period of CABG surgery with cardiopulmonary bypass and evaluate the applicability of CABDEAL score, as a predictor of these morbidities when compared to intra-and postoperative variables.

METHODS

Type of study

This is an analytical, longitudinal, descriptive and prospective study, conducted at the Department of Cardiac Surgery, University Hospital, Federal University of Maranhão, President Dutra Unit (HU-UFMA) in São Luís - MA.

Sample

The convenience sample is consisted of all patients undergoing on-pump CABG during the period from February to October 2011.

Inclusion criteria

The study included all patients undergoing isolated on-pump CABG during the study period.

Exclusion criteria

Patients who underwent to another concomitant cardiac surgery as: valve replacement, correction of congenital defect, aortic surgery, carotid endarterectomy and reoperations were not included in this study.

Data Collection

Data Collection, by filling out an application form, was obtained after the patients have signed the consent form. In the preoperative period, the data collected were: age, body mass index, value of preoperative creatinine, presence of abnormal preoperative electrocardiogram, hypertension, diabetes, emergency surgery, prior stroke and presence of chronic obstructive pulmonary disease.

In the postoperative period, the following information were collected: duration of surgery, cardiopulmonary bypass time, aortic clamping time, duration of mechanical ventilation, length of hospital

stay, presence of atrial fibrillation, stroke in the trans and postoperative period and presence of delirium, convulsions and coma or death.

Definitions of variables

Delirium, coma and convulsion were considered as evidence of the presence of encephalopathy in the immediate postoperative period [4].

The criteria for delirium was the same adopted in the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV), which includes the following: episodes of confusion, agitation, changes and fluctuations in the level of consciousness, acute problems of cognition, including memory and changes perceptions including hallucinations. The presence of these signs was documented by medical and nurses' staff from the hospital and it was collected through observation and records in the patient.

The presence of chronic obstructive pulmonary disease was observed in the preoperative period, through the execution of a spirometry, whose criteria was the same recommended by the protocol used by the author of the CABDEAL score: a value of forced expiratory volume of 1 second equal or less than 50% determined the presence of obstructive disease [10].

Prolonged hospital stay in this study was determined by length of stay exceeding six days, based on the historic series of the last year, whose median was 6 days.

To define prolonged ventilation time, it was considered as cutoff the median of 680 minutes, 160 minutes being the minimum and the maximum of 28,800 minutes.

Application of the score

The application of CABDEAL score consisted of analysis of the following variables: creatinine, age, body mass index, diabetes, emergency surgery, abnormal electrocardiogram, and obstructive pulmonary disease (Table 1).

The value of CABDEAL score ranges from 0 to 10, with the level 2 considered as the cutoff point. If the patient has a score of 0 or 1, the probability of post-operative morbidity is low (<15%). If the score is 2, this probability raises to 26%. Score 3 provides of 46%. A score of 4 or superior, the probability is higher than 75%. However, if the score reaches the value 8, the chance of morbidity is 100% [10].

For purposes of analysis and application of CABDEAL score, it was established a variable in the risk category, with a cutoff equal to 4 for best prediction of outcomes. CABDEAL score patients below to 4 were considered low risk, while those whose scores were higher or equal to 4 were considered high risk patients. The same procedure was repeated for clamping time and CPB time, generating as cutoff values for prolonged periods of 89 minutes and 105 minutes respectively.

Risk category in CABDEAL score, CPB time ≥ 105 minutes, clamping time ≥ 89 minutes, length of stay ≥ 6 days and mechanical ventilation time exceeding 680 minutes were evaluated as risk factors for hospital death and neurologic dysfunction.

Statistical analysis

Quantitative variables were presented as mean, median, standard deviation, percentages, odds ratios and confidence intervals. The Shapiro-Wilk test was used for testing the normality of the sample. The Chi-Square test was used in the qualitative variables, and when necessary was used the Fisher's exact test for correction. ROC curves were used to identify the best cutoff points of some continuous variables and, therefore, predict adverse postoperative events, determining the accuracy of the model.

The statistical significance was indicated by a value of $P < 0.05$.

The data were processed in the computer statistical programs STATA 11.0 (Stata Corporation, College Station, TX) and EPI INFO.

Ethical aspects

The research project was submitted to the University Hospital Presidente Dutra Ethics Committee, in accordance to Resolution 196/96 CNS-MS for research involving human subjects, and it was only implemented after approval under the consolidated stand number 248/10. All subjects involved in the study signed a consent form.

RESULTS

The sample consisted of 77 study patients, 17 (22.1%) women and 60 (77.9%) men whose ages ranged from 36 to 81 years with a mean of 61.3 ± 9.2 years. Seventy patients (90.91%) were hypertensive, and 8 (10.39%) reported previous stroke.

The value of CABDEAL score ranged from 0 to 7, and 47 (61%) patients were classified as low risk (score < 4) and 30 (39%) in high risk (score ≥ 4).

The mortality rate in the sample studied was 2.6% (two cases). Encephalopathy and stroke were present in 15.58% and 2.6% respectively.

By analyzing the association between the level of CABDEAL risk with the outcomes death and neurological morbidities, just encephalopathy was significantly associated with the preoperative score high risk ($P = 0.0009$). The CABDEAL of high risk was also associated with prolonged length of hospital stay ($P < 0.0001$).

By associating the time of CPB and aortic clamping with the outcome of encephalopathy, stroke and death, it was observed that CPB time ≥ 105 minutes was only associated with the occurrence of encephalopathy ($P = 0.02$), whereas the clamping time ≥ 89 minutes was significantly associated with all those three outcomes. The median ventilation time ≥ 680 minutes, in turn, was only significantly associated with the outcome of encephalopathy (Table 2).

The ROC curve analysis to evaluate the performance of variables predictive of postoperative encephalopathy showed that CABDEAL score presented the biggest area under the curve (area = 0.811 ± 0.053), being the best predictor of outcome in relation to other variables tested, whose sensitivity and specificity was 83% and 69.2%, respectively (Table 3/Figure 1).

Table 1. CABDEAL Score

Variable	Negative	Positive	Weight
Creatinin ($\mu\text{mol/L}$)*	≤ 110	≥ 111	2
Age	≤ 69	≥ 70	1
Body Mass Index	≤ 27	≥ 28	1
Diabetis	No	Yes	2
Emergency Surgery	No	Yes	2
Abnormality on ECG	No	Yes	1
Lung Disease	No	Yes	1

Kurki et al. Ann Thorac Surg 1996;61:1740-1745,

* $110 \mu\text{mol/L} = 1,2\text{mg/dl}$,

** ECG = Eletrocardiogram (non-sinus rhythm, ST Ischemia signs)

Note: Maximum score points: 10 points

Cutoff point: 2 (0-1: low probability of morbidity / ≥ 2 :

High) Risk of Morbidity: 0-1: 15%
 2: 26%
 3: 46%
 ≥ 4 : $> 75\%$
 8: 100%

Table 2. Association between predicting variables and the outcomes of encephalopathy, stroke and death in the postoperative of On-pump CABG

	Encephalopathy	P-value	Stroke	P-value	Death	P-value
	n (%)		n (%)		n (%)	
High-risk CABDEAL	10 (13%)	0.0009	1 (1.3%)	0.630	2 (2.6%)	0.148
Prolonged CPB time	7 (9.1%)	0.02	1 (1.3%)	0.492	2 (2.6%)	0.07
Prolonged aortic clamping time	6 (7.8%)	0.006	2 (2.6%)	0.03	2 (2.6%)	0.03
Extended Ventilation time	10 (13%)	0.014	2 (2.6%)	0.253	2 (2.6%)	0.253

Table 3. ROC curve analysis of the variables pre-and intraoperative predictors of encephalopathy in the postoperative of On-pump CABG

Index	Area under the curve	Standard Error	P-Value	Asymptotic confidence interval of 95%	
				LowerLimit	UpperLimit
Score	0.811	0.053	0.001	0.705	0.914
CPB	0.706	0.085	0.024	0.539	0.872
Aortic clamping	0.657	0.088	0.084	0.485	0.831

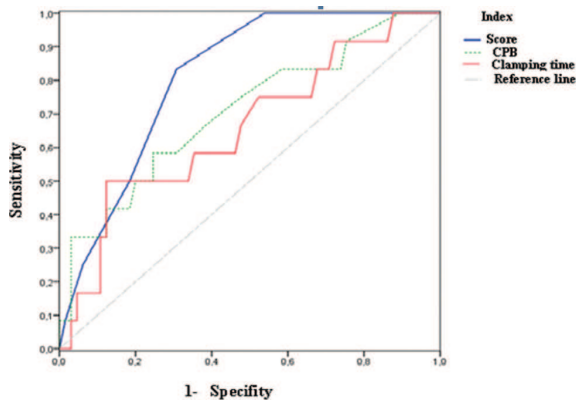


Fig.1 - Sensitivity and specificity of predicting variables of encephalopathy in the postoperative period of on-pump CABG

DISCUSSION

Estimates indicate that in 2020, cardiovascular diseases will contribute with 25 million deaths annually, and ischemic heart diseases appear as the first cause of mortality worldwide. In Brazil, they already represent 30% of admissions in SUS (Unified Health System) and are among the main causes of mortality [17].

Previous studies have shown that the majority of patients referred for coronary artery bypass reach increasingly elderly and with other comorbidities [18]. Following this trend, in our center, the majority of patients undergoing CABG surgery had a mean age of 61.3 years and their disease was often associated with comorbidities such as hypertension, obesity, diabetes, renal disease, lung and obesity [8,19].

Among the most feared adverse events in coronary artery bypass grafting are the stroke, and less discussed in literature, but not less important, the occurrence of encephalopathy [20]. Predicting these events, allows optimizing the clinical and surgical management of the patient, not only reducing the negative impact on their quality of life, but also the heavy financial burden in the hospital costs [21].

The most cited models of predicting still leave gaps since they stick specifically to the risk of death [18,19,22]

or when directed to neurological events, seek to provide only the risk of stroke [21,22].

In this study, we sought to test a score that could be a predictor, not only of stroke but also encephalopathy. The chosen CABDEAL score, although not specific to both complications, presents in its scope, the most prevalent risk factors for the determination of these events and, unlike other scores, can extend its prediction also to the risk of common diseases for this surgery such as central nervous system dysfunction, postoperative infection, arrhythmia, renal failure and death, in addition, it allows estimating the chance of the patient likely to have prolonged hospital stay.

The CABDEAL is a simple, short and mnemonic model in its variables and unlikely other scores, it is convenient to be applied at the bedside of the patient, facilitating the clinical routine [14,16]. Based on these principles, the authors of this study applied the score and compared the total value with the chance of development the following outcomes: postoperative stroke, encephalopathy, prolonged length of hospital stay and death. Subsequently with the objective of verifying its predictive power, it was compared with other known risk factors for this surgery, which are not included in its variables, but are cited as predisposing these complications, which are: cardiopulmonary bypass time, length of aortic clamping and the duration of mechanical ventilation [23,24].

In spite of the influence of CPB as a triggering factor independent of brain damage has already been well established, there is no consensus about the effect of aortic clamping time as the cause of these events. The 2.6% occurrence of stroke in this study did not present significant correlation with the high value of the score. However, it was associated to prolonged periods of CPB and aortic clamping [24]. There are few studies on the technique of clamping influencing the occurrence of neurological events. It is postulated that the continuous clamping bring greater risk of stroke and other neuropsychological disorders for the patient [25]. Kim et al. concluded that there is no difference in the incidence of postoperative stroke or hospital mortality in patients who had only a clamping compared with two clamping [26]. While, Antunes et al.

postulated that aortic clamping itself is single or intermittent, and it is also a risk factor for the occurrence of stroke, increasing the risk by 1.3 times for each additional period of aortic clamping [27]. Guaragna et al. [28] claim that these events are caused not only by the clamping time, but by the presence and location of plaques in the aorta that can lead to the formation of microbubbles that result from the manipulation of the aorta at the time of the application and removal of aortic clamps as shown by Barbut et al. [29].

In this study, the only postoperative variable which showed an association with the encephalopathy was prolonged mechanical ventilation. However, in the literature it is still not well established what the prolonged ventilation time would be, which may vary from 480 minutes up to 7-14 days [30]. It is accepted that postoperative extubation, which exceeds 8 hours, is significantly associated with neurological and / or lung complications. Thus, for analysis purposes, we adopted the cutoff point of 680 minutes, since that would be, therefore, within that interval related to the onset of complications [31].

Kurki et al. to propose the CABDEAL, evaluated 21 risk factors and extracted 7 as the most frequent (creatinine level, age, body mass index, diabetes, emergency surgery, ECG abnormalities and pulmonary disease) [15]. However, by analyzing scores of specific predictors of neurological morbidities, such as the one developed by the Northern New England Cardiovascular Disease Study Group and the Stroke Risk Index [11,12], it is observed that these variables are also part of these two models, which could explain the association of high risk CABDEAL with the occurrence of encephalopathy as noted in previous studies and in the present study.

The sample size and the absence of data in all the cases of the Doppler fluxometric preoperative evaluation of carotid system caused limitations in this study.

CONCLUSION

The score CABDEAL, in this study, proved to be a better predictor of neurological dysfunction in the postoperative period of CABG when compared to analyzed intraoperative variables, such as: cardiopulmonary bypass time and aortic clamping.

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