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Validation of MagedanzSCORE as a predictor of mediastinitis after coronary artery bypass graft surgery

Validação do MagedanzSCORE como preditor de mediastinite após cirurgia de revascularização miocárdica

Michel Pompeu Barros de Oliveira Sá[1], Evelyn Soares Figueira[2], Cecília Andrade Santos[2], Omar Jacobina Figueiredo[2], Renato Oliveira Albuquerque Lima[2], Fábio Gonçalves de Rueda[2], Rodrigo Renda de Escobar[2], Alexandre Magno Macário Nunes Soares[2], Ricardo de Carvalho Lima[3]

Abstract

Objective: The aim of this study is to evaluate the applicability of a new score for predicting mediastinitis – MagedanzSCORE – in patients undergoing coronary artery bypass graft (CABG) surgery in the Division of Cardiovascular Surgery of Pronto Socorro Cardiológico de Pernambuco – PROCAPE.

Methods: Retrospective study involving 500 patients operated between May/2007 and April/2010. The registers contained all the information used to calculate the MagedanzSCORE. The outcome of interest was mediastinitis. We calculated sensitivity, specificity, positive predictive value, negative predictive value, concordance and accuracy. The accuracy of the model was evaluated by ROC (receiver operating characteristic) curve.

Results: The incidence of mediastinitis was 5.6%, with a lethality rate of 32.1%. In univariate analysis, the five variables of the MagedanzSCORE were predictors of postoperative mediastinitis: chronic obstructive pulmonary disease (OR 6.42; 95.0% CI 2.76-14.96; *P*<0.001), obesity (OR 3.06; 95.0% CI 1.32-7.09; *P*=0.009), surgical reintervention (OR 82.40; 95.0% CI 30.40-223.30; *P*<0.001), multiple transfusion (OR 3.33; 95.0% CI 1.52-7.29; *P*=0.003) and stable angina class IV or unstable (OR 2.59; 95.0% CI 1.19-7.64; *P*=0.016) according to Canadian Cardiovascular Society. The score had a sensitivity of 96.4%, specificity of 90.0%, positive predictive value of 36.5%, negative predictive value of 99.8% and 90.4% concordance. The accuracy measured by the area under the ROC curve was 96.2% (95.0% CI 94.5%-97.9%).

Conclusions: The MagedanzSCORE proved to be a simple and objective index, revealing a satisfactory predictor of development of postoperative mediastinitis in patients undergoing CABG surgery at our institution.

Descriptors: Risk factors. Mediastinitis. Coronary artery bypass. Myocardial revascularization.

Resumo

Objetivo: O objetivo deste estudo é avaliar a aplicabilidade de um novo escore de predição de mediastinite – MagedanzSCORE – em pacientes submetidos à cirurgia de revascularização miocárdica (CRM) na Divisão de Cirurgia Cardiovascular do Pronto Socorro Cardiológico de Pernambuco – PROCAPE.

Métodos: Estudo retrospectivo envolvendo 500 pacientes operados entre maio/2007 e abril/2010. Os registros continham todas as informações utilizadas para calcular o MagedanzSCORE. O desfecho de interesse foi mediastinite. Foram calculados sensibilidade, especificidade, valor preditivo positivo, valor preditivo negativo, concordância e acurácia. A acurácia do modelo foi avaliada pelo ROC (*receiver operating characteristic curve*).

1. MD, MSc
2. MD
3. MD, MSc, PhD, ChM

Work done at Division of Cardiovascular Surgery of Pronto Socorro Cardiológico de Pernambuco - PROCAPE; University of Pernambuco – UPE, Recife, PE, Brazil.

Correspondence
Michel Pompeu Barros de Oliveira Sá. Av. Eng. Domingos Ferreira, 4172/405 – Bairro Boa Viagem– Recife, PE, Brazil – CEP 51021-040
E-mail: michel_pompeu@yahoo.com.br

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Resultados: A incidência de mediastinite foi de 5,6%, com
uma taxa de letalidade de 32,1%. Na análise univariada, as
cinco variáveis do MagedanzSCORE foram preditoras de
mediastinite no pós-operatório: doença pulmonar obstrutiva
crônica (OR 6,42; IC 95,0% 2,76-14,96; *P*<0,001), obesidade
(OR 3,06; IC 95,0% 1,32-7,09; *P*=0,009), reintervenção
cirúrgica (OR 82,40; IC 95,0% 30,40-223,30; p<0,001),
transfusões múltiplas (OR 3,33; IC 95,0% 1,52-7,29; *P*=0,003)
e angina estável classe IV ou instável (OR 2,59; IC 95,0%
1,19-7,64; *P*=0,016) de acordo com a Sociedade Canadense
de Cardiologia. O escore teve uma sensibilidade de 96,4%,
especificidade de 90,0%, valor preditivo positivo de 36,5%,
valor preditivo negativo de 99,8% e 90,4% de concordância.
A acurácia medida pela área sob a curva ROC foi 96,2% (IC
95,0% 94,5%-97,9%).

Conclusões: O MagedanzSCORE provou ser um índice
simples e objetivo, revelando-se um preditor satisfatório de
desenvolvimento de mediastinite no pós-operatório de
pacientes submetidos à CRM em nossa instituição.

Descritores: Fatores de risco. Mediastinite. Ponte de
artéria coronária. Revascularização miocárdica.

INTRODUCTION

It is important that there are models for accurate
prediction of risks in the current practice of cardiac surgery.
These models allow surgeons and institutions to compare
results in a significant way. They are also useful in surgical
decision making, development of informed consent
preoperatively, quality and management of health care [1].
Few scores assess the postoperative morbidity [2].

Despite technological development and improvement
of health professionals, mediastinitis – deep wound
infection, with clinical evidence and / or microbiological
commitment of the retrosternal space, and may be associated
with sternal osteomyelitis with or without its instability –
also features a large challenge, since it determines a
significant increase in morbidity and mortality rates, hospital
costs and significant impact on social life of patients who
survive [3].

Magedanz et al. [2] developed a score for use in daily
practice to calculate the risk of mediastinitis after coronary
artery bypass grafting (CABG). The score includes variables
collected routinely and easy to use. We baptized this score
in our institution: the MagedanzSCORE.

Risk scoring systems are most applicable when the
characteristics of the patient preoperatively and treatment
profiles are comparable to those on which the system
originated. For this reason, any risk scoring system can be
used reliably when its validity was tested in the local patient
population [4]. The MagedanzSCORE has not been tested
outside the institution where it was created, so that we do
not know whether it is useful in predicting mediastinitis
after CABG in other populations, in the case, in our local
institution.

The aim of this study is to test the MagedanzSCORE on
the population that underwent CABG at our institution.

METHODS

Source Population
After approval by the ethics committee of institution,
we reviewed the records of patients undergoing CABG at
the Division of Cardiovascular Surgery of Pronto Socorro
Cardiológico de Pernambuco (PROCAPE) from May 2007
to April 2010. We excluded patients whose records did not
contain the necessary data concerning the variables to be
studied.

Study Design
It was a retrospective study of exposed and nonexposed
to certain factors (independent variables) with outcome
(dependent variable) followed by validation of a model (the
MagedanzSCORE).

The independent variables were: age (years), gender
(male or female), surgical reoperation (due to bleeding,
cardiac tamponade or other reason other than mediastinitis),
chronic obstructive pulmonary disease (COPD - diagnosed
clinically and / or radiological examination of the chest and
/ or spirometry and / or drug treatment - corticosteroids,
bronchodilators), obesity (BMI ≥ 30.0 kg / m²), stable angina
class IV / unstable by the Canadian Cardiovascular Society,
multiple transfusion postoperatively (more than 3 units of
any type of blood products).

The dependent variable was mediastinitis after surgical
procedure. This variable was categorized into yes or no.
Mediastinitis were considered with those who met the
criteria according to the *Centers for Disease Control and
Prevention* (CDC) [5]:

1. Patient has organisms cultured from mediastinal tissue
or fluid obtained during a surgical operation or needle
aspiration;

2. Patient has evidence of mediastinitis seen during a
surgical operation or histopathologic examination;

3. Patient has at least 1 of the following signs or
symptoms with no other recognized cause: fever (38ºC),
chest pain, or sternal instability and at least 1 of the
following:

a. purulent discharge from mediastinal area

b. organisms cultured from blood or discharge from
mediastinal area

c. mediastinal widening on radiography.

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Isolated superficial infections from sternal wound with stable and/or sterile sternal dehiscence and/or no macroscopic evidence of deep infection (purulent drainage) were not considered as having mediastinitis.

Each patient was evaluated for the presence or absence of the five risk factors established by MagedanzSCORE, respecting the definition of each of them and giving them the correct score (Table 1). Depending on the final score, each patient was placed in one of the four risk groups (low, medium, high or very high). We recorded the outcomes (development or non-development of mediastinitis).

Statistical Methods

Data were analyzed using percentage and descriptive statistics measures: mean, median and standard deviation. The following tests were used: t-Student with equal or unequal variances (for parametric variables) and chi-square test or Fisher's exact (as appropriate, for non-parametric variables). In the study of univariate association between categorical variables, the values of the Odds Ratio (OR) and a confidence interval (CI) for this parameter with a reliability of 95.0% were obtained.

Table 1. Factors associated with development of mediastinitis after CABG surgery and MagedanzSCORE

Clinical profile	Score
Reoperation	3
Chronic obstructive pulmonary disease	2
Obesity	2
Stable angina class IV/unstable	1
Postoperative multiple transfusion	1

We calculated sensitivity, specificity, positive predictive value and negative predictive value and established the best cut-off. We used the kappa statistic to assess agreement between the prediction of the outcome by the score and the observed in the study.

The accuracy (discrimination ability of the MagedanzSCORE) was calculated using the area under the ROC curve (receiver operating characteristic curve), built on the sensitivity (correct prediction of mediastinitis) and specificity (correct prediction of non-mediastinitis) calculated for each value of the score.

The level of significance in the decision of the statistical tests was 5%. The program used for data entry and retrieval of statistical calculations was SPSS (Statistical Package for Social Sciences) version 15.0.

RESULTS

Five-hundred and forty-two patients underwent CABG during the study period; 42 patients were excluded for lack of information regarding the study in the medical records. So we analyzed 500 patients undergoing CABG with a mean age of 62.1 ± 9.9 years, 59% male. The following clinical features were observed (Table 2): 5.6% underwent reoperation, 14.8% were obese, 9.4% had chronic obstructive pulmonary disease, 21.8% had multiple transfusions in the postoperative period and 36.2% had stable angina class IV or unstable angina. Mediastinitis was diagnosed in 28 patients (5.6%), of which 9 (32.1%) died. According to the MagedanzSCORE, 35.6% of study patients have low risk of mediastinitis, 49.6% medium risk, 11.4% high risk and 3.4% very high risk of mediastinitis.

Table 2. Study population profile.

Characteristics	Statistic
Demographic	
Total number of patients	500
Age - average $\pm$ SD* (min – max)	62.1 ± 9.9 (33.0 – 90.0)
Gender – n (%)	
Male	295 (59.0%)
Female	205 (41.0%)
Factors – n (%)	
Reoperation	28 (5.6%)
Obesity	74 (14.8%)
Chronic obstructive pulmonary disease	47 (9.4%)
Multiple transfusion	109 (21.8%)
Stable angina class IV / unstable	181 (36.2%)
Mediastinitis – n (%)	28 (5.6%)
Risk groups according to MagedanzSCORE – n (%)	
Low (score 0)	178 (35.6%)
Medium (score 1-2)	248 (49.6%)
High (score 3-4)	57 (11.4%)
Very high (score 5 or more)	17 (3.4%)

SD = standard-deviation

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Analyzing the variables proposed in MagedanzSCORE with the occurrence of mediastinitis, we observed that the requirement for reoperation is the one that was most associated with mediastinitis followed by COPD, multiple transfusion, obesity and angina, with statistically significant increase in the risk of mediastinitis with magnitude of 82.40, 6.42, 3.33, 3.06 and 2.59 times, respectively (Table 3). The odds ratio was calculated after adjusting for age of patients, so the risks are independent of patient age. There was no statistically significant difference in average age of the patients with (63.5 ± 8.0 years) and without mediastinitis (62.1 ± 10.0 years). There was also no statistically significant difference in the frequency of mediastinitis according to gender (Table 3).

The relationship between the risk classification and mediastinitis according to MagedanzSCORE, it was observed that 96.4% of patients diagnosed with mediastinitis in this study are classified as high risk and very high risk (Table 4). This shows a strong association with the proposed score.

According to the measures of sensitivity and specificity, the score 2 has the best probability of identifying the presence and absence of mediastinitis, presenting 96.4% sensitivity and 90.0% specificity (Table 5), being considered the best cut-off for the model. This cut-off separates the low/medium level from the high/very high level. In Table 6, it was considered as cut-off the score 2 for the presence of

mediastinitis according to MagedanzSCORE, being patients with low or medium risk being compared between patients with high and very high risk for mediastinitis. Observe that there is a concordance of 90.4% (excellent) with this cut-off. According to the Kappa index, the concordance between the score and observed in the study is moderate (0.488). However, the positive predictive value (probability of mediastinitis in patients classified as high risk and very high) was 36.5%, so it is expected that among 100 patients with high/very high risk score, only 37 are truly mediastinitis. Moreover, the score has a negative predictive value (probability of absence of mediastinitis in patients classified as low/medium risk) 99.8%, thus we can conclude that the use of the score has a great ability to identify the absence of future disease.

Table 4. Relationship between Magedanz SCORE and mediastinitis after CABG surgery

MAGEDANZ Class	Mediastinitis		Total
	Presence	Absence	
Low	0	178 (100.0%)	178
Medium	1 (0.4%)	247 (99.6%)	248
High	17 (29.8%)	40 (70.2%)	57
Very high	10 (58.8%)	7 (41.2%)	17
Total	28	472	500

Chi-square $x^2 = 177.6$ P-value = < 0.0001

Table 3. Association of demographic and clinical characteristics with the occurrence of mediastinitis after CABG surgery (univariate analyses)

Characteristics	Incidence of Mediastinitis	OR* CI** 95.0%	*P*-value
Gender			
Female	9 (4.4%)	1.00	-
Male	19 (6.4%)	1.51 (0.67 – 3.41)	0.322
Clinical profile			
Reoperation			
No	10 (2.1%)	1.00	-
Yes	18 (64.3%)	82.40 (30.40 – 223.30)	< 0.001
Obesity			
No	19 (4.5%)	1.00	-
Yes	9 (12.2%)	3.06 (1.32 – 7.09)	0.009
COPD***			
No	18 (4.0%)	1.00	-
Yes	10 (21.3%)	6.42 (2.76 – 14.96)	< 0.001
Multiple transfusion			
No	15 (3.8%)	1.00	-
Yes	13 (11.9%)	3.33 (1.52 – 7.29)	0.003
Angina			
No	12 (3.8%)	1.00	-
Yes	16 (8.8%)	2.59 (1.19 – 5.64)	0.016

*OR = Odds Ratio; **CI = Confidence interval; ***COPD = Chronic obstructive pulmonary disease

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Table 5. Evaluation of MagedanzSCORE in identifying the diagnosis of mediastinitis according to different levels of cut-off.

Score	Sensitivity CI*(95.0%)	Specificity CI(95.0%)	PPV**CI(95.0%)	NPV***CI(95.0%)
0	100.0%	37.7%(33.3 – 42.1)	8.7%(5.6 – 11.8)	100.0%
1	96.4%(89.6 – 100.0)	73.3%(69.3 – 77.3)	17.6%(11.6 – 23.7)	99.7%(99.1 – 100.0)
2	96.4%(89.6 – 100.0)	90.0%(87.3 – 92.7)	36.5%(25.5 – 47.5)	99.8%(99.3 – 100.0)
3	78.6%(63.4 – 93.8)	97.5%(96.0 – 98.9)	64.7%(48.6 – 80.8)	98.7%(97.7 – 99.7)
4	35.7%(18.0 – 53.5)	98.5%(97.4 – 99.6)	58.8%(35.4 – 82.2)	96.3%(94.6 – 98.0)
5	21.4%(6.2 – 36.6)	99.6%(99.0 – 100.0)	75.0%(45.0 – 100.0)	95.5%(93.7 – 97.3)
6	3.6%(0.0 – 10.4)	99.6%(99.0 – 100.0)	33.3%(0.0 – 86.7)	94.6%(92.6 – 96.6)
7	0	99.6%(99.0 – 100.0)	0	94.4%(92.3 – 96.4)
8	0	100.0%	0	94.4%(92.4 – 96.4)

*CI = Confidence interval**PPV = Positive predictive value; ***NPV = Negative predictive value. Observe the cut-off 2 (two) has the best sensitivity and specificity

Table 6. Relationship between MagedanzSCORE and mediastinitis after CABG surgery using the cut-off defined as SCORE 2.

MAGEDANZ Class	Mediastinitis		Statistics
	Presence	Absence	
Low/Medium	1	425	Concordance = 90.4%
			Kappa index = 0.488 (0.411 – 0.564)
High/Very high	27	47	Sensitivity = 96.4% (89.5 – 100.0)
			Specificity = 90.0% (87.3 – 92.7)
			PPV* = 36.5% (25.5 – 47.5)
			NPV** = 99.8% (99.3 – 100.0)

*PPV = Positive predictive value; **NPV = Negative predictive value

According to the results presented in the area under the ROC curve (overall capacity of the measure used to discriminate individuals with and without the disease), measured by 96.2% (95.0% confidence interval 94.5%-97.9%), the MagedanzSCORE shown an excellent measure to identify patients with risk of development of postoperative mediastinitis (Figure 1).
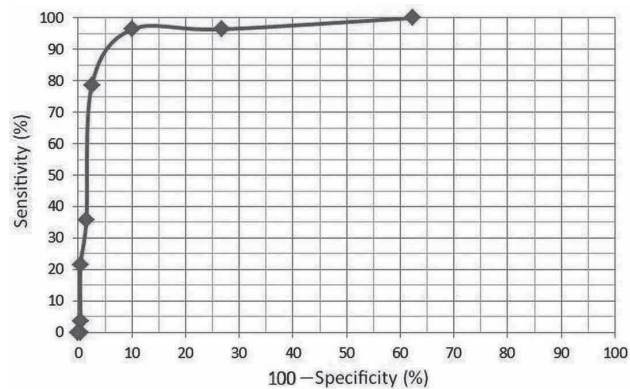

Fig. 1 – Receiver operating characteristic (ROC) curve - Area under the curve 96.2% (95.0% Confidence Interval 94.5%-97.9%). The curve is based on cut-off 2 (two) by MagedanzSCORE

DISCUSSION

The incidence of mediastinitis in this study was 5.6%, higher than in the original study Magedanz et al [2] which was 3.3% and slightly higher than the one described in the literature, ranging from 0.4% to 5.0% [6-8]. However, it should be noted that we are analyzing a risk group. A previous study in our institution [9] showed an incidence of mediastinitis of 2.4% among 1038 cardiovascular surgeries (involving all types of cardiac surgeries) and CABG was associated with increased risk compared with other cardiac surgeries (95% CI 3.44-8.30, $P = 0.0001$), justifying the high incidence on the present study.

Many factors have been associated with development of mediastinitis after cardiac surgery [3]. However, there is no consensus as to which factors are most important and how each is an independent predictor of risk for postoperative mediastinitis [3].

Reoperation was the most associated factor with mediastinitis at our institution. Other studies have also identified this variable as a strong predictor of deep sternal wound infection and mediastinitis [10,11]. It is expected that patients who are reoperated have increased risk of

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infection, considering that repeated surgical aggression exposes patients to contamination.

COPD was the second most associated factor with mediastinitis at our institution. Other studies have shown the correlation of chronic obstructive pulmonary disease and mediastinitis [12]. Chronic obstructive pulmonary disease causes mechanical problems, leading to sternum instability, which in those cases may suggest the harmful effect of smoking in the pathophysiology of mediastinal infection as well. Apart from that, it is more often possible for patients with chronic obstructive pulmonary disease to be colonized [13]. Patients with COPD are more susceptible to wound infection due to tissue hypoxemia [7]. Many of these patients require steroids in pre-and postoperatively, which could facilitate the emergence of infections [7]. Also possibly as a result of frequent coughing, which might contribute to wound dehiscence and thereby facilitate bacterial migration [13]. Patients with COPD also experience more frequent respiratory infections and prolonged weaning from artificial ventilation [14,15].

We also observed obesity as a risk factor associated to postoperative mediastinitis. Milano et al. [16] discuss some factors that may explain why obesity is a risk factor, such as, for example, the dose of the prophylactic antibiotic, which is not corrected on the basis of the patient's body mass index. They also suggest that skin preparation can be difficult and inadequate due to deep skin folds, and the adipose tissue itself, which may function as a substrate for infection. The etiology also relates to increased postoperative mechanical loads, facilitated bacterial contamination and bradytrophic properties of fatty tissue contribute to poor wound healing [17].

Our study showed that angina was associated with increased risk of mediastinitis in postoperative coronary artery bypass surgery. Only two studies [2,18] were identified citing the presence of angina as a predictor of risk of mediastinitis after CABG, however, none of these make any reference to possible pathogenetic mechanism of this relationship.

Loop et al. [11] showed that blood transfusions had a relative risk of causing sternal wound complications of 1.05 per unit. It is considered to be a risk factor for postoperative infection [19]. This may be explained by a decrease in immune function after homologous blood transfusion [11,20]. It has also been identified that the removal of blood transfusion reduces the risk of infections [21].

Risk stratification allows estimating the surgical operative risk facing the patient and evaluate the results and, ultimately, the quality of care of an institution. However, most current risk scores include little assessment of postoperative morbidity.

The MagedanzSCORE presented an excellent accuracy, since the discrimination power of the model in this study according to the ROC curve was 96.2% (95.0% Confidence Interval 94.5%-97.9%).

CONCLUSION

The MagedanzSCORE proved to be a simple and objective index, revealing a satisfactory predictor of development of postoperative mediastinitis in patients undergoing CABG surgery at our institution.

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