Prospective Assessment of Different Indices of Cardiac Risk for Patients Undergoing Noncardiac Surgeries

Roberto Henrique Heinisch, Caroline Ferrari Barbieri, João Rogério Nunes Filho, Glauce Lippi de Oliveira, Liana Miriam Miranda Heinisch

Florianópolis, SC - Brazil

Objective - *To compare the accuracy of 4 different indices of cardiac risk currently used for predicting perioperative cardiac complications.*

Methods - *We studied 119 patients at a university-affiliated hospital whose cardiac assessment had been required for noncardiac surgery. Predictive factors of high risk for perioperative cardiac complications were assessed through clinical history and physical examination, and the patients were followed up after surgery until the 4th postoperative day to assess the occurrence of cardiac events. All patients were classified according to 4 indices of cardiac risk: the Goldman risk-factor index, Detsky modified risk index, Larsen index, and the American Society of Anesthesiologists' physical status classification and their compared accuracies, examining the areas under their respective receiver operating characteristic (ROC) curves.*

Results - *Cardiac complications occurred in 16% of the patients. The areas under the ROC curves were equal for the Goldman risk-factor index, the Larsen index, and the American Society of Anesthesiologists' physical status classification: 0.48 (SEM ± 0.03). For the Detsky index, the value found was 0.38 (SEM ± 0.03). This difference in the values was not statistically significant.*

Conclusion - *The cardiac risk indices currently used did not show a better accuracy than that obtained randomly. None of the indices proved to be significantly better than the others. Studies to improve our ability to predict such complications are still required.*

Key words: cardiac complications, noncardiac surgeries, indices of risk

Universidade Federal de Santa Catarina
Mailing address: Roberto Henrique Heinisch – Rua Almirante Alvim, 377/1203 – 88015-380 – Florianópolis, SC, Brazil – E-mail: heinisch@hu.ufsc.br
English version by Stela Maris C. e Gandour

Preoperative clinical assessment of patients with suspected or documented cardiac disease is a common preoccupation of surgeons, anesthesiologists, cardiologists, and internists, because the surgical intervention is known to impose a circulatory overload on the organism, to which an ill heart is more vulnerable than is a healthy heart [1,2].

Evidence of the occurrence of perioperative cardiac complications in a sufficient number of patients has accumulated, justifying all efforts to decrease their incidence. Approximately 1 million of the 27 million patients undergoing surgery in the US per year are estimated to have cardiac complications [3]. This problem is even more relevant when an increase in the life expectancy of the population is considered, resulting in a greater proportion of elderly individuals, because the prevalence of cardiovascular diseases increases with age. Coincidentally, the greatest number of surgical procedures is performed in this age group (individuals above the age of 65 years) [4,5].

Several guidelines have been published to assess the cardiac risk for cardiac complications. All of them have emphasized the need for an accurate clinical assessment, identifying the clinical markers of increased perioperative cardiovascular risk, suggesting the use of cardiac risk indices [6]. This evaluation is particularly important because it can identify patients who need to correct their cardiac problems prior to surgery, many times causing a delay or even a cancellation of the procedure. Clinical screening is also vital, because it identifies high-risk individuals, who should be even more carefully monitored than they usually are. Therefore, if a cardiac event occurs, a rapid intervention may be performed in an attempt to decrease the negative consequences [3]. In addition, a clinical assessment is mandatory, because additional examinations or procedures, such as exercise or pharmacological stress tests, ambulatory electrocardiographic control, and coronary angioplasty, have failed to show a substantial effect in reducing perioperative cardiac morbidity, and, therefore, have been recommended only for select patients [6,7]. Due to the fact that more than 90% of the surgical patients do not benefit from additional

tests and procedures, which usually have high costs, a critical assessment of cardiac risk indices is essential, so they can be used in the most efficient possible manner [8].

Prior to the development of multifactorial indices specific for cardiac risk, the classification of the American Society of Anesthesiologists (ASA) was considered a good predictor of perioperative death [9]. However, it is not as efficient as the other indices, particularly in predicting cardiac events [10].

The cardiac risk index reported by Goldman et al [11] was the first multifactorial model specifically for perioperative cardiac complications to be widely used. Through extensive research, the authors identified 9 statistically significant and clinically important cardiac risk factors, and they attributed values to each of them. In the preoperative assessment, each factor is added, and the greater the sum, the greater the risk of cardiac death and life-threatening cardiac events (myocardial infarction, pulmonary edema, and ventricular tachycardia).

Detsky et al [12] added to the original model of Goldman the presence of angina and a remote history of myocardial infarction. The Detsky index was also modified when the American College of Physicians (ACP) suggested stratifying the patients into 3 risk groups [6].

Another model not so widely used, however, was developed by Larsen et al [13]. It differs from the original index proposed by Goldman et al, because it does not consider electrocardiographic alterations and particularly emphasizes angina pectoris, remote myocardial infarction, and a previous history of heart failure. Even though not frequently used, other risk models have been reported [14,15].

Even though these indices have been validated and continue to be used, they have been largely criticized. They have limited value for the correct management of specific patients, because they do not consider some individual factors. For example, a patient with angina would have his surgical risk underestimated if he were assessed according to the index by Goldman et al, which does not consider angina as a risk factor [11]. Another problem with most multifactorial indices is the fact that they do not adequately value the type of surgical procedure performed and the imposed circulatory load. A review with guidelines for perioperative cardiovascular evaluation has been published by the American Heart Association/American College of Cardiology (AHA/ACC) to help clinicians in attenuating those difficulties [7].

Even though cardiac complications may constitute the most extensively studied area in perioperative medicine [3], prospective studies assessing and directly comparing the accuracy of different indices of risk, which are currently used in large populations, are still lacking [8]. And this is exactly the objective of the present study.

Methods

We carried out an observational, prospective, longitudinal, controlled study, ie, a controlled cohort study, which initially assessed 141 patients at the wards of the surgical clinics of the Hospital Universitário of the Universidade Federal de Santa Catarina from 1996 to 2000. All patients undergoing a noncardiac surgical procedure and evaluated by a cardiologist, or a resident in internal medicine being trained in cardiology, in the preoperative period were included in the study.

Data were gathered in the wards of the surgical clinics as follows:

1) Data were collected from medical records to assess clinical history and physical examination at hospital admission with identification of signals and symptoms considered predictors, markers, or factors of increased risk for potential postoperative cardiovascular complications. The following anamnesis data, a physical examination, and complementary tests were considered relevant for the study: age; sex; color; whether patient was bedridden or somewhat ambulatory; history of acute myocardial infarction; history of anginal precordial pain; history of congestive heart failure; signs and symptoms of left ventricular dysfunction; presence of peripheral vascular insufficiency; history of valvular heart diseases; presence of electrocardiographic alterations; alterations in laboratory tests (electrolytes, glycemia, biochemical tests of renal and hepatic function); risk factors for heart disease (positive familial history of heart disease, diabetes mellitus, hypercholesterolemia, and systemic arterial hypertension); history of concomitant diseases in other systems; and the patient's nutritional status. In regard to the surgical procedure performed, the following characteristics were considered of interest: elective, urgent, or emergency surgery; type of surgery - vascular, abdominal, orthopedic, urologic, proctologic, or thoracic surgery.

2) Interviews with the patients to confirm data on history and physical examination, and also to complement information not recorded in the medical record. During this phase, the objectives of the study were presented to the patient, and his or her written consent to participate in the study was required.

3) During the surgery, the following cardiovascular complications were checked: acute myocardial infarction; congestive heart failure; cardiopulmonary arrest with asystolia or ventricular fibrillation or with electromechanical dissociation; supraventricular arrhythmias; ventricular arrhythmias; arterial hypotension or hypertension; cardiogenic shock; and death due to cardiac causes.

Postoperative acute myocardial infarction was defined as the presence of new Q waves on the electrocardiogram, associated or not with an important elevation in the CK-MB enzyme. Congestive heart failure was identified on physical examination by the presence of signals of left ventricular dysfunction, such as a 3rd cardiac sound, nocturnal paroxysmal dyspnea, orthopnea, jugular venous distension, acute pulmonary edema. Systemic arterial hypertension was defined as blood pressure levels > 140/90mmHg, and systemic arterial hypotension as systolic blood pressure levels < 90mmHg. Cardiogenic shock was considered when a combination of clinical signs of cardiac pump failure

occurred, among which we can cite the following: cold extremities, mottled skin, systolic blood pressure < 90mmHg, urinary output < 30 mL/h, low cardiac index (< 2 L/min/m^2), venous saturation of oxygen below 50%, and acidosis [17].

4) On the 4th postoperative day, new information on postoperative cardiovascular complications was gathered from the medical records, and, if necessary, the patient underwent a new examination. As complications relevant to the study, we considered those already cited.

5) Then the patients were classified according to the 4 following indices of cardiac risk for noncardiac surgical procedures commonly used: the multifactorial index by Goldman et al [11]; the index by Detsky et al [12]; the index by Larsen et al [13]; and the American Society of Anesthesiologists' physical status classification [9]. It is worth noting that, to better compare the indices, we used the Detsky risk index modified by the American College of Physicians, which divides the patients into 3 classes according to the following score: from 0 to 15 points, class I; from 20 to 30 points, class II; and over 30 points, class III [6]. It is also worth noting that, originally, the Larsen index was also not divided into classes. In this regard, we used the division suggested by Mangano and Goldman, which stratifies the values into 4 groups according to the risk estimated in their original article [18]: from 0 to 5 points (a 0.5% risk of complication); from 6 to 7 points (a 3.8% risk of complication); from 8 to 14 points (11%); and 15 points or above (a 58% risk of complication) [18]. In our study, each of these 4 risk groups was called class I, II, III, and IV, respectively.

The categorical variables were expressed according to their frequencies (number and percentage) and analyzed using the chi-square test. When the expected values were < 5, the Fisher exact test was used. The statistical significance value of $P<0.05$ was adopted.

To determine and compare the accuracy of different systems of stratification for each index, the areas under the receiver-operating characteristic (ROC) curves were calculated. The ROC curves were plotted on a graph with the values of sensitivity in the ordinate axis, and the proportion of false positives (1-specificity) in the abscissa axis. In regard to the interpretation of the ROC curve, the greater the area under the curve, the more accurate the diagnostic test is considered (in our case, the cardiac risk index). A good diagnostic test is the one whose area is closer to 100% of the area of the graph. Curves occupying 50% or less of the area of the graph indicate that the accuracy of the test is not better than the result that would be randomly obtained.

Sensitivity, specificity, and false positivity were calculated according to Fletcher et al [19]. The areas were compared using a nonparametric method according to the technique by Hanley and McNeil [20] (expected sensitivity between 60% and 75%). For this, specific software (ROC Curve Analyzer, developed by Robert M. Centor and Jerry Keightley) was used.

Data obtained were analyzed with the aid of the following software: Microsoft Excel ®, 5.0a version, Epi Info®, 6.0 version, and ROC Curve Analyzer.

Patients were instructed about the study objectives and methodology, and also about the absolutely voluntary character of their participation. Each patient provided a written informed consent. The protocol was approved by the Committee on Ethics and Research with Human Beings of the Universidade Federal de Santa Catarina.

Results

Initially, 141 patients were studied, of whom 22 (15.6%) did not undergo surgery. Stratifying the 141 patients assessed according to the index of cardiac risk by Goldman et al [11], we observed that class III patients had their surgeries canceled more frequently (fig. 1) ($p<0.05$).

Of the 119 patients operated upon (84.4% of the total patients assessed), 19 (16%) had perioperative cardiovascular complications, such as arrhythmias, systemic arterial hypertension, systemic arterial hypotension, congestive heart failure, and acute myocardial infarction. No death due to cardiac causes occurred. The frequency of each complication is shown in table I. It is worth noting that 1 single patient may have had more than 1 event, and this is why the sum of the percentages in table I exceeds 100%. However, each case - defined as an event or a combination of events - was counted only once, adding up to a total of 19 patients with complications.

Of the 119 patients undergoing surgery, 82 (68.9%) were males and 37 (31%) were females. One hundred and fourteen (95.8%) patients were white and 5 (4.2%) were black. The mean age of the patients was 65±12 years (tab. II), 30 years and 89 years being the minimum and maximum ages, respectively.

Table III shows the data obtained when the patients operated upon were studied in regard to a clinical history positive for risk factors predictive of perioperative cardiac complications [7].

Table IV shows the 119 patients undergoing surgery distributed according to the different classes of risk for each cardiac risk index, and each class was correlated with the presence of perioperative complications. None of the classes of the different indices correlated with an increased risk for perioperative complications (tab. IV).

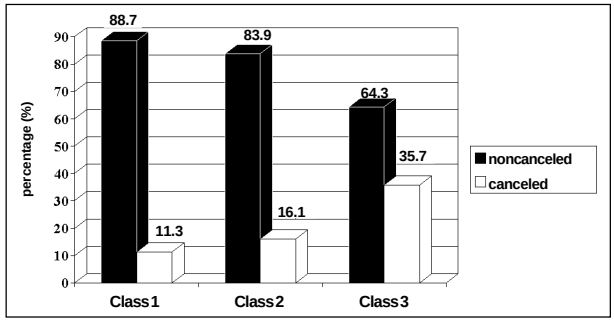

Fig. 1 - Distribution of the patients staying in surgical clinics and being assessed for surgical risk according to Goldman's classification of surgical risk and its relation with canceling or not the surgery at the Hospital Universitário of the Universidade Federal de Santa Catarina.

Table I - Distribution of the perioperative complications occurring in 19 patients being assessed on surgical risk according to the type of event

Type of complication*	Number of patients	Percentage of patients
Arrhythmia	8	42.1%
Systemic arterial hypertension	6	31.6%
Systemic arterial hypotension	5	26.3%
Congestive heart failure	5	26.3%
Acute myocardial infarction	1	5.3%

Source – data on assessment of surgical risk of patients staying at the surgical clinics of the Hospital Universitário of the Universidade Federal de Santa Catarina from 1996 to 2000. * As 1 patient may have had more than 1 type of complication, the sum of the percentages exceeds 100%.

Table II - Distribution of patients being assessed on surgical risk and who underwent surgery according to age, sex, and color

Characteristics	Results
Age group (mean ± standard deviation)	30-89 (65±12 years)
Male sex (percentage)	68.9%
White color	95.8%

Source - data on assessment of surgical risk of patients staying at the surgical clinics of the Hospital Universitário of the Universidade Federal de Santa Catarina from 1996 to 2000.

Table III - Distribution of the patients whose surgical risks were being assessed according to the presence of risk factors for perioperative cardiac events

Cardiovascular diseases[1]	Number of patients (%)
Age above 70 years	40 (33.6%)
AMI [2] within the last 6 months	1 (0.8%)
AMI more than 6 months before	9 (7.6%)
Angina pectoris	23 (19.3%)
Class III angina [3]	4 (3.4%)
Critical aortic stenosis	1 (0.8%)
Nonsinus rhythm or early atrial contractions	35 (29.4%)
Acute pulmonary edema	3 (2.5%)
Third cardiac sound	1 (0.8%)
Bedridden patient [4]	17 (14.3%)
Altered laboratory tests [5]	60 (50.4%)
Diabetes mellitus	29 (24.4%)
Type of surgery	
- aortic vascular	21 (17.6%)
- peripheral vascular	30 (25.2%)
- intraperitoneal/thoracic	33 (27.7%)
- emergency	7 (5.9%)

Source - data on assessment of surgical risk of patients staying at the surgical clinics of the Hospital Universitário of the Universidade Federal de Santa Catarina from 1996 to 2000. 1) One patient may have had more than 1 positive factor. 2) AMI – acute myocardial infarction. 3) According to the Canadian classification of angina pectoris [20]. 4) The patient should be bedridden due to noncardiac reasons. 5) The alterations considered in the laboratory tests were as follows: oxygen partial pressure (pO_2) < 60 mm Hg; carbon dioxide partial pressure (pCO_2) > 50 mm Hg; serum potassium (K) < 3.0 mEq/L; serum bicarbonate (HCO_3) < 20 mEq/L; urea > 50 mg/dL; creatinine > 3.0 mg/dL; and abnormal serum glutamic-oxaloacetic transaminase (SGOT).

Based on the values of sensitivity, specificity, and false positivity (1-specificity) calculated for each class of the cardiac risk indices and shown in table V, a ROC curve was plotted (fig. 1). The areas under the ROC curves [± standard error of the mean (SEM)] were as follows: 0.48 (±0.03) for the Goldman risk-factor index; 0.48 (±0.03) for the ASA's physical status classification; 0.48 (±0.03) for the Larsen index, and 0.38 (±0.03) for the Detsky index. The difference between the areas of the 4 curves was not statistically significant (p>0.05).

Discussion

In the present study, we obtained data on a determined population of patients undergoing preoperative cardiac assessment due to possible noncardiac surgical procedures. We compared the performance of 4 different cardiac risk indices currently used to predict perioperative cardiac events. In general, their performances were poor, and no statistically significant difference was observed between them.

The poor performances were shown by the reduced areas under the ROC curves of the indices analyzed (fig. 2). The greatest area was 0.48, obtained with the index by Goldman et al [11], the ASA's physical status comparison [9], and the index by Larsen et al [13]. The 4 stratifying methods did not significantly differ. These results confirm the recent findings by Gilbert et al [8], who also obtained poor performances for all indices, even though they were slightly better than those we found. The values of the areas under the ROC curves found by those authors were: 0.62 for the ASA's index [9]; 0.64 for the index by Goldman et al [11]; and 0.60 for the index by Detsky et al [12]. In their study, Gilbert et al [8] did not analyze the index by Larsen et al [13].

Table IV - Distribution of the patients whose surgical risks were being assessed according to the cardiac risk index, and their relation with perioperative cardiac complications

Index	Class	Number of patients N	Cardiac events N (%)	P
Goldman	1	63	8 (12.7%)	NS†
	2	47	9 (19.1%)	NS
	3	9	2 (22.2%)	NS
	4	0	0	NS
ASA[1]	1	0	0	NS
	2	17	1 (5.9%)	NS
	3	90	15 (16.7%)	NS
	4	12	3 (25%)	NS
	5	0	0	
Larsen	1	77	11 (14.3%)	NS
	2	10	2 (20%)	NS
	3	8	1 (12.5%)	NS
	4	24	5 (20.8%)	NS
Detsky	1	117	19 (16.2%)	NS
	2	2	0	NS
	3	0	0	NS

Source - data on assessment of surgical risk of patients staying at the surgical clinics of the Hospital Universitário of the Universidade Federal de Santa Catarina from 1996 to 2000. † N.S.: nonsignificant. 1 – American Society of Anesthesiologists.

Table V – Values of sensitivity, specificity, and false positivity (1–specificity) calculated for each class of each cardiac risk index o

	Class	Sensitivity	Specificity	1-Specificity
Goldman	I	0.42	0.45	0.55
	II	0.47	0.62	0.38
	III	0.11	0.93	0.07
	IV	-	-	-
ASA	I	-	-	-
	II	0.05	0.84	0.16
	III	0.79	0.25	0.75
	IV	0.16	0.91	0.09
	V	-	-	-
Larsen	I	0.58	0.34	0.66
	II	0.11	0.92	0.08
	III	0.05	0.93	0.07
	IV	0.26	0.81	0.19
Detsky	I	1	0.02	0.98
	II	0	0.98	0.02
	III	0	-	-

Source – data on assessment of surgical risk of patients staying at the surgical clinics of the Hospital Universitário of the Universidade Federal de Santa Catarina from 1996 to 2000.

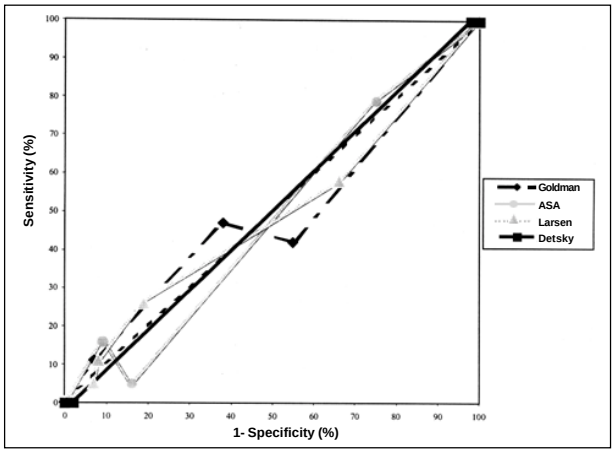

Fig. 2 - Receiver Operating Characteristic (ROC) curves of each cardiac risk index of the 119 patients staying in surgical clinics and being assessed for surgical risk, and who underwent surgery, at the Hospital Universitário of the Universidade Federal de Santa Catarina. The dotted line at 45° of the origin indicates that the result does not differ from the one that would be randomly obtained.

Based on the results obtained, one may infer that cardiac risk indices have a limited value for predicting cardiac events. One reason for this could be the fact that these indices ignore certain factors that may indirectly contribute to cardiac complications, such as difficulty in intubation, blood loss during surgery, infection, and many other events [16]. Another factor that limits the efficacy of the cardiac risk indices is that, frequently, 1 index is no longer adequate for a particular patient. One example is the index by Goldman et al [11], which does not consider angina pectoris a risk factor, and, therefore, underestimates the chances of complications for a patient with that symptom. For that patient, the index by Detsky et al [12] or that by Larsen et al [13] would be more appropriate, because those indices give particular importance to the intensity of the anginal pain. In addition, the clinician in charge of the preoperative cardiological assessment should pay special attention to the type of surgical procedure performed, an item that has not been sufficiently explored in most multifactorial indices of cardiac risk.

Combining all this information in a preoperative assessment is a hard task that clinicians frequently try to tackle based on their personal experience. Recently, the American Heart Association/American College of Cardiology published guidelines to help the professionals in their mission [7].

It is vital to stress, however, that our study had some limitations. One of them was the fact that all patients studied were referred for a cardiological evaluation for some reason. Even though this may have represented a selection bias, we believe that the rate of events in patients who had not been referred would be so low that we probably would not have significant results, unless we had a much greater sample. The fact that our patients had been referred may also have been the reason why the percentage of our complications (16%) was much greater than those obtained in other studies (3-4%) [11-13]. Our results are, therefore, more applicable to patients with a slightly higher risk rate than that in the general population.

Another limitation, and maybe the most important one, was the small number of patients studied. Certainly, with a greater case series, we would have detected a greater number of significant cardiac events, which would have increased the discriminating power of important events, and, possibly, the areas under the ROC curves for each cardiac risk index.

In addition to the already cited limitations, another difficulty was that, of all patients included in the study, 15.6% had their surgeries canceled after the clinical assessment. Of the 14 patients classified as Goldman's class III, 64.3% had their surgeries canceled, but of the 71 classified as Goldman's class I, only 11.3% did not undergo surgery (fig. 1). This may have impaired our results, because, most patients with a high surgical risk did not undergo surgery, which prevented us from accurately assessing the predictive value of each cardiac risk index.

Undoubtedly, the most important function of this study was to emphasize the difficulty faced by clinicians in estimating the perioperative cardiac risk of their patients. Cardiologists are commonly asked about the exact percentage of cardiac risk of a certain patient undergoing a surgical procedure. Our study shows that this answer is complex and almost impossible to be given, mainly considering only the currently available cardiac risk indices. One should always remember that the purpose of the preoperative assessment is not to provide medical authorization for surgery or to provide percentages of risk. The preoperative assessment aims to analyze the patient's current physical status, to provide recommendations, and to establish a clinical profile of the cardiac risk that aids the patient, the clinician, the surgeon, and the anesthesiologist to better decide upon therapeutical management [7].

Until the ideal method for clinically establishing the chances of cardiac complications is discovered, studies about this area will always be welcome.

References

1. Cuoco MAR, Lagudis S. Avaliação cardiológica pré-operatória. In: Sousa AGMR, Mansur AJ, editores. SOCESP Cardiologia. São Paulo: Atheneu, 1996: 1127-35.
2. Batlouni M. Cirurgia não-cardíaca no paciente cardiopata. In: Azevedo AC, Sekef J, editores. Medicina Interna: Cardiologia, 2ª ed. São Paulo: Sarvier, 1988: 235-43.
3. Devereaux PJ, Ghali WA, Gigson NE, et al. Physician estimates of perioperative cardiac risk in patients undergoing noncardiac surgery. Arch Intern Med 1999; 159: 713-7.
4. Mangano DT. Perioperative cardiac morbidity. Anestesiology 1990; 72: 153-84.
5. Lubitz J, Deacon R. The rise in the incidence of hospitalizations for the aged, 1967 to 1979. Health Care Financing Review 1982; 3: 21-40.
6. Guidelines for assessing and managing the perioperative risk from coronary artery disease associated with major noncardiac surgery. American College of Physicians. Ann Intern Med 1997; 127: 309-12.
7. Eagle KA, Brundage BH, Chaitman BR, et al. Guidelines for perioperative cardiovascular evaluation of the noncardiac surgery. A report of the American Heart Association/ American College of Cardiology task force on practice guidelines. Circulation 1996; 93: 1278-317.
8. Gilbert K, Larocque B, Lawrence T. Prospective evaluation of cardiac risk indices for patients undergoing noncardiac surgery. Ann Intern Med 2000; 133: 356-9.
9. American Society of Anesthesiologists. New classification of physical status. Anesthesiology 1963; 24: 111.
10. Lewin I, Lerner AG, Green SH, Del Guercio LR, Siegel JH. Physical class and physiologic status in the prediction of operative mortality in the aged sick. Ann Surg 1971; 174: 217-31.
11. Goldman L, Caldera DL, Nussbaun SR, et al. Multifactorial index of cardiac risk in noncardiac surgical procedures. N Engl J Med 1977; 297: 845-50.
12. Detsky AS, Abrams HB, McLaughlin JR, et al. Predicting cardiac complications in patients undergoing non-cardiac surgery. J Gen Intern Med 1986; 1: 211-9.
13. Larsen SF, Olesen KH, Jacobsen E, et al. Prediction of cardiac risk in non-cardiac surgery. Eur Heart J 1987; 8: 179-85.
14. Michel LA, Jamart J, Bradpiece HA, Malt RA. Prediction of risk in noncardiac operations after cardiac operations. J Thorac Cardiovasc Surg 1990; 100: 595-605.
15. Hollenberg M, Mangano DT, Browner WS, London MJ, Tubau JF, Tateo IM. Predictors of perioperative myocardial ischemia in patients undergoing non-cardiac surgery: the study of peioperative ischemia research group. JAMA 1992; 268: 205-9.
16. Dupuis JY, Nathan HJ, Wynands JE. Clinical application of cardiac risk indices: how to avoid misleading numbers. Can J Anesth 1991; 38: 1055-64.
17. Antman, EM. Medical management of the patient undergoing cardiac surgery. In: Braunwald E, edictor. Heart disease -A textbook of Cardiovascular Medicine, 4ª ed. Philadelphia: WB Saunders Company, 1992: 1670-90.
18. Mangano DT, Goldman L. Preoperative assessment of patients with known or suspected coronary disease. N Engl J Med 1995; 333: 1750-6.
19. Fletcher H, Fletcher SW, Wagner EH. Epidemiologia clínica. Bases científicas da conduta médica. Porto Alegre: Artes Médicas, 1989: 223.
20. Hanley JA, McNeil BJ. A method of comparing the areas under the receiver operating characteristic curves derived from the same cases. Radiology 1983; 148: 839-43.
