Mortality prediction following CABG surgery: comparison of EuroSCORE vs general risk scoring systems

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Background. The aim of the study was to compare the accuracy of general scoring systems on ICU arrival with preoperative evaluation using the EuroSCORE risk model in patients undergoing cardiac surgery.

Methods. Ethical committee approved a prospective observational study. Data for 514 consecutive CABG patients operated during one year period were collected. EuroSCORE risk score before surgery and APACHE II, SAPS II and MODS on ICU admission following surgery were calculated for all patients. Calibration of the risk stratification models was performed using the Hosmer-Lemeshow Goodness-of-Fit test, discrimination was made using Receiver Operative Characterictic (ROC) Curves. Predicted values of the risk scoring systems were compared with the actual mortality rate.

Results. The observed crude hospital mortality rate of patients during the study period was 2.7%. All risk scoring systems overestimated mortality (Apache II – 12.2%, SAPS II – 5.5%, MODS – 6.8%, EuroSCORE – 4.5%). Hovewer, the preoperative EuroSCORE Risk Stratification System performed better than the postoperative General Severity scoring systems on ICU admission, while the APACHE II system showed the worst discriminatory capability.

Conclusions. General Severity scoring systems on ICU arrival following cardiac surgery have worse discriminatory ability in predicting hospital mortality compared to the EuroSCORE Risk Evaluation System performed preoperatively.

Key words: risk evaluation, mortality, coronary bypass surgery

BACKGROUND

Improvement in medical treatment of heart diseases and achievements of interventional cardiology have changed the profile of patients undergoing cardiac surgery nowadays. Proportion of elderly patients, patients with referral patterns for surgical treatment later in the course of the disease and patients with greater incidence of comorbidities is inreasing. At the same time, advances in cardiac surgical and anaesthesiological techniques and improvement of myocardial protection have broadened the type and complexity of surgical procedures. An accurate and objective estimate of

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perioperative risk would have important consequences for the patient, clinicians and hospital administrators. The growing interest in risk-adjusted analysis of outcome has led to the development of quite a few predictive models for postoperative mortality in cardiac surgery (1–3). EuroSCORE, the European system for cardiac operative risk evaluation developed in more than 120 European centres, has become widely used for risk stratification in Europe (4). This scoring system identifies 17 preoperative risk factors divided into three groups: patient related factors, cardiac factors and surgery related factors. This system was validated in our patient population (5). General severity of illness systems for critically ill patients are widely used in intensive care units to evaluate the severity of the disease and likely outcome. The Acute Physiologic Score and Chronic Health Evaluation (APACHE) was introduced by Knaus in 1981 (6), modified into the APACHE II scoring system in 1984 (7), which became probably the best-known and most widely used score for risk evaluation. The SAPS II system

is used in clinical practice since 1993(8). It assesses the 12 physiologic variables in the first 24 hours of ICU admission. The Multiple Organ Dysfunction System (MODS) scores six organ systems: respiratory, cardiovascular, renal, hepatic, haematologic and central nervus system (9). Although most of them were not developed for use in cardiac surgical patients they are used in this patient population (10). The aim of the study was to compare the accuracy of general scoring systems on ICU arrival and with preoperative evaluation using the Euroscore risk model in patients undergoing cardiac surgery.

METHODS

A prospective observational local Ethical Committee aproved study (2007/09/28 No. EK-9) enrolled consecutive adult patients who underwent coronary artery bypass surgery (CABG) in our institution between September 1, 2006 and August 30, 2007. All patients were operated by the same group of surgeons, anaesthetic technique, management

Table 1. Euroscore risk evaluation system

Risk factors	Score
Patient factors	
Age	1 point per 5 years or part thereof over 60 years
Sex	1 point for female gender
Chronic pulmonary disease	1 point for long-term use of steroids or bronchodilators for lung disease
Extracardiac arteriopathy	2 points for any of the following: claudication, carotid occlussion or >50% stenosis, previous or planned intervention on aorta, limb arteries or carotids
Neurologic dysfunction	2 points for severely affecting ambulation
Previous cardiac surgery	3 points for surgery requiring opening of the pericardium
Serum creatinin	2 points for preoperative creatinin > 200 µmol/l
Active endocarditis	3 points for the patient still under antibiotic treatment for endocarditis
Critical preoperative state	3 points for any of the following: ventricular tachycardia or fibrilation or aborted sudden death, preoperative cardiac massage, preoperative ventilation, preoperative inotropic support, intraaortic balloon counterpulsation or preoperative acute renal failure (anuria or oliguria)
Cardiac factors	
Unstable angina	2 points for rest angina requiring IV nitrates
LVEF 30–50%	1 point
LVEF < 30%	3 points
Recent myocardial infarction	2 points for MI < 90 days
Pulmonary hypertension	2 points for systolic PA pressure > 60 mmHg
Operation factors	
Emergency	2 points for carried out procedure before the begining of next working day
Other than isolated CABG	2 points for major cardiac procedure other or in addition to CABG
Surgery on thoracic aorta	3 points for disorder of ascending, arch or descending aorta
Postinfarction septal rupture	4 points

LVEF – left ventricle ejection fraction, MI – myocardial infarction, PA – pulmonary artery.

Table 2. Values used in calculation of APACHE II, SAPS II and MODS risk scoring systems

APACHE II	SAPS	MODS
Age	Age	
Heart rate	Heart rate	HRxCVP/MAP
MAP	Systolic BP	
A-a gradient, respiratory rate	PaO_2/FiO_2	PaO_2/FiO_2
Creatinine	Urine output, BUN	Creatinine
pH or HCO_3	HCO_3	
WBC, hematocrit	WBC	PLT
	Bilirubin	Bilirubin
Serum sodium	Serum sodium	
Serum potasium	Serum potasium	
Chronic illness	Chronic disease	
Emergency surgery	Type of admission	
Glasgow coma scale		Glasgow coma scale

MAP – mean arterial pressure, BP – blood pressure, WBC – white blood cells, PLT – platelets.

of cardiopulmonary bypass (CPB) and myocardial protection were similar during this time frame. Patients who were operated using off-pump technique were also included into the study. Patients with concominant valve repair or replacement procedures were excluded from the investigation. Data were prospectively collected as a part of routine clinical practice. Risk stratification using the EuroSCORE system (Table 1) was performed preoperatively in the operative room using the downloaded version from euroscore.org and stored on a personal computer in every operative room. Three general scoring systems were used for risk assessment after patient arrival to the intensive care unit (ICU): Apache II, SAPS and MODS. APACHE II and SAPS II are the most widely used scores in the ICU, consisting each of 12 slightly different variables, while MODS model scores consist of only six variables. The main physiological parameters used for risk evaluation for general score systems are presented in Table 2. All these scores were calculated by attending anaesthesiologist shortly after patients were transferred to the cardiac intensive care unit following surgery, when the laboratory exams were available. As a routine practice, blood gas analysis is performed for all patients after transferring them from the operative room to the ICU in our institution; these data were used for general risk scoring systems.

Primary endpoint was all-cause in-hospital mortality. The length of stay in the intensive care unit was used as a surrogate measure of morbidity. All data are presented as mean ± standard deviations for continuous variables and as percentages with 95%

CI for categorical variables. Predicted mortality rates were compared to the observed ones. Calibration of the models was performed using the Hosmer-Lemeshow Goodness-of-Fit test, discrimination was performed using Receiver Operative Characterictic (ROC) Curves. Statistical analysis was caried out using the SPSS 8.0 statistical package.

RESULTS

During this 12 month period 514 consecutive patients underwent isolated coronary artery bypass grafting procedure in our institution. Women accounted for 24 percent of patients who underwent CABG surgery. One hundred seventy six (34%) patients were older than 70 years, 170 (33%) had impaired left ventricle function, 64 (12%) had diabetes. The full profile of preoperative risk factors and comorbidities of study group patients are presented in Table 3.

Forteen patients died what made the crude mortality rate 2.7% (14/514). All risk scoring systems overestimated mortality, but the predicted mortality did not differ significantly from each other, exept for APACHE II scoring system which overestimated the risk of mortality more than four times (Table 4).

The performance of risk scoring systems was assessed by evaluation of calibration and discrimination. Hosmer-Lemeshow Goddness-of-Fit test showed good calibration of all four risk stratification systems (Table 5). All four risk scoring systems were well-fitting models, showed nonsigni-

Table 3. Preoperative characteristics of patients

Variable	Mean ± SD or % (n = 514)
Age (years)	65 ± 9
BMI > 30	150 (29%)
Female gender	121 (24%)
Hypertension	445 (87%)
Diabetes	64 (12%)
Diabetes on insulin	18 (3.5%)
Chronic pulmonary disease	19 (3.7%)
Extracardiac arteriopathy	73 (14%)
Previous cardiac surgery	21 (4.1%)
Previous stroke	38 (7.3%)
Unstable angina	87 (17%)
LVEF < 50%	171 (33%)
Recent myocardial infarction	96 (19%)
Emergency surgery	13 (2.5%)

BMI – body mass index, LVEF – left ventricle ejection fraction.

ficance on the Goodness-of-Fit test, implying that the models estimated fit the data at an acceptable level. Discrimination, or the ability of scoring systems to distinguish between the patients who will survive and those who will not survive, was not as acccurate. However, postoperative General Severity scoring systems, based on physiological parameters, were not more accurate than the preoperative Euroscore risk stratification system. The area under curve ranging from 0.72 to 0.76 for Euroscore, SAPS II and MODS risk scoring systems showed an acceptable level of accuracy. APACHE II system with an area under curve of 0.68 showed the worst discriminatory capability (Table 5).

DISCUSSION

Scoring systems are very important in resource utilization, continuing quality improvement, comparison of institutional performance over time, comparison of performance between different institutions. As simple as possible in order to be user friendly and accurate as much as possibile in risk assessment are the main features of the ideal risk scoring system. Over the last three decades, a lot of scoring systems were introduced into clinical practice. Quite a number of systems have been developed for cardiac surgical patients in particular. Postoperative cardiac surgical patients are unique in several ways. First of all, the majority of patients are being operated on with the help of cardiopulmonary bypass, which together with the aortic cross-clamp time is a known factor having an impact on mortality (11). Postoperative mechanical lung ventilation is a standard of care in most cardiac surgical patients rather than status representing respiratory failure. Hypoxemia, defined by low PaO_2/FiO_2 ratio, is uncommonly seen after heart surgery requiring cardiopulmonary bypass, but mainly with a minimal effect on the postpperative course of the patients (12). Glasgow Coma Scale, a part of APACHE II and MODS risk stratification systems, could be affected by the patient postoperative sedation. Platelet count may not be the best indicator of coagulatory dysfunction early after cardiac dysfunction as the white blood cells (WBC) or hematocrit used in general risk scoring systems. Hemodilution, systemic inflamatory response to CPB might have an inpact on these parameters. On the other hand, some of physiological

Table 4. Predicted and observed mortality of different risk stratification systems

Risk stratification model	Predicted mortality	Observed mortality
Euroscore	4.5 ± 7.3%	2.7%
APACHE II	12.2 ± 5.6%	2.7%
SAPS II	5.5 ± 3.5%	2.7%
MODS	6.8 ± 3.5%	2.7%

Table 5. Performance of Euroscore, APACHE II, SAPS II and MODS scoring systems in predicting mortality following CABG surgery

Risk stratification model	Hosmer-Lemeshow Goodness-of-Fit Test		Area under ROC curve (95% CI)
	Chi^2	p value	
Euroscore	3.642	0.725	0.76 (0.64–0.89)
APACHE II	4.624	0.797	0.68 (0.52–0.84)
SAPS II	9.258	0.235	0.74 (0.61–0.88)
MODS	3.159	0.532	0.72 (0.58–0.87)

variables, like potassium concentration, might be affected by potassium used in cardioplegia for myocardial protection, lower body temperature – impact of anesthethic and perfusion technique used during the CPB, and these changes perhaps do not have any impact on patient mortality and morbidity. On the contrary, increased lactates concentration which has been proven to be an important predictor of bad outcome in pediatric and adult cardiac surgery (13, 14) was not included in the general risk scoring systems. In our study, discrimination of the general risk scoring system (APACHE II) used postoperatively was not as accurate as that of EuroSCORE risk stratification, based on preoperative patient characteristics. On the other hand, the SAPS II and MODS risk scoring systems showed no additional benefit to preoperative Euroscore risk evaluation. Scoring systems should not be used to make prediction in individual cases. They can be used to assist clinical decision making, although general risk scoring systems at ICU admission are not more accurate for risk assessment in cardiac surgical patients than the preoperative risk evaluation. Euroscore, SAPS II and MODS showed areas under the receiver operative characteristic curve greater than 70% and thus can be used as applicable models. APACHE II general risk scoring system, used to evaluate severity of patient's illness, showed to be a not applicable risk stratification model on ICU admission for patients after coronary artery bypass grafting surgery.

One of limitations of this study was that general risk scoring was performed only on ICU admission. For majority of CABG patients, that were treated in ICU for 24 hours following surgery, changes of physiological parameters, associated with CPB and myocardial protection techniques, were not clinically important. However, for more sick patients, daily assesement of organ dysfunction might be important and help stratifying high risk patients (15) with adverse outcome.

References

1. Higgins T. Quantifying risk and assessing outcome in cardiac surgery. J Cardiothorac Vasc Anesth. 1998; 12: 330–40.

2. Geissler H, Holzl F, Marohl S, Kuhn-Regnier F, Mehlhorn U, Sudkamp M, Vivie R. Risk stratification in heart surgery: comparison of six score systems. Eur J Cardiothorac Surg. 2000; 17: 400–6.

3. Nilsson J, Algotsson L, Hoglund P, Luhrs C, Brandt J. Comparison of 19 pre-operative risk stratification models in open-heart surgery. Eur Heart J. 2006; 27: 867–74.

4. Nashef SA, Roques F, Michel P, Gauducheau E, Lameshow S, Salamon R. European system for cardiac operative risk evaluation (EuroSCORE). Eur J Cardiothorac Surg. 1999; 16: 9–13.

5. Samalavicius R, Misiuriene I, Andriunaite D, Lipnevicius A, Baublys A, Uzdavinys G. Predictive value of euroscore for coronary revascularization procedures. Cardiovasc Surg. 2002; 10 Suppl 1: 126.

6. Knaus W, Zimmerman J, Wagner D. APACHE – Acute Physiology and Chronic Health Evaluation: a physiologically based classification system. Crit Care Med. 1981; 9: 591–7.

7. Knaus W, Draper E, Wagner D. APACHE II: A severity of disease classification system. Crit Care Med. 1985; 13: 818–29.

8. LeGall J, Lemeshow S, Soulnier F. A new Simplified Acute Physiology Score (SAPS II) based on a European / North American multicenter study. JAMA. 1993; 270: 2957–63.

9. Marshall J, Cook D, Christou N, Bernard G, Spring C, Sibald W. Multiple organ dysfunction score: a reliable descriptor of a complex clinical outcome. Crit Care Med. 1995; 23: 1638–52.

10. Martinez-Alario J, Tuesta I, Plascencia E, Santana M, Mora M. Mortality prediction in cardiac surgery patients. Comparative performance of Parsonnet and General Severity systems. Circulation. 1999; 99: 2378–82.

11. Sivertseen E, Abdelnoor M, Fjeld N. Prolonged aortic cross-clamp time and cardiopulmonary bypass time have a gradient effect on early mortality in open heart surgery. Vasc Endovasc Surg. 1995; 29: 91–7.

12. Weiss Y, Merin G, Kaganov E. Postcardiopulmonary bypass hypoxemia: a prospective study on incidence, risk factors, and clinical significance. J Cardiothorac Vasc Anesth. 2000; 14: 506–13.

13. Samalavičius R, Misiurienė I, Urbonas K, Norkienė I, Kalinauskas G, Norkūnas G, Valaika A, Baublys A. Padidėjusi laktatų koncentracija plazmoje kaip prognostinis mirštamumo ir komplikacijų po

miokardo revaskuliarizavimo operacijų radimosi rodiklis. Lietuvos chirurgija. 2007; 5(3): 305–9. Lithuanian.

14. Haltherill M, Sajjankar T, Tibby S, Champion M, Anderson D, Marsh M, Murdoch I. A serum lactate as a predictor of mortality after pediatric heart surgery. Arch Dis Child. 1995; 77: 235–8.

15. Hekmat K, Kroener A, Stuetzer H, Schwinger R, Kampe S, Bennik G, Melhorn U. Daily assessment of organ dysfunction and survival in intensive care unit cardiac surgical patients. Ann Thorac Surg. 2005; 79: 1555–62.

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RIZIKOS ĮVERTINIMAS ATLIEKANT MIOKARDO REVASKULIARIZACIJOS OPERACIJAS: KARDIOCHIRURGINIAMS LIGONIAMS SUKURTOS EuroSCORE METODIKOS PALYGINIMAS SU INTENSYVIOJE TERAPIJOJE NAUDOJAMOMIS BENDROSIOMIS RIZIKOS SKALĖMIS

Santrauka

Įvadas. Tyrimo tikslas – palyginti intensyvioje terapijoje taikomų bendrųjų rizikos vertinimo skalių tikslumą su priešoperaciniu EuroSCORE rizikos įvertinimo modeliu, sukurtu naudoti tik ligoniams, kuriems atliekamos širdies operacijos.

Tyrimo medžiaga ir metodai. Prospektyviai ištirta 514 ligonių, kuriems per metus atliktos miokardo revaskuliarizacijos operacijos. Operacinė rizika buvo įvertinta EuroSCORE metodika prieš operaciją ir APACHE II, SAPS II ir MODS metodikomis ligoniams po operacijos atvykus į intensyvios terapijos skyrių. Rizikos vertinimo modelių tikslumui palyginti buvo naudotas Hosmer-Lemeshov testas ir veikimo pobūdžio charakteristikos kreivės (ROC curves). Prognozuotos rizikos vertinimo skalių reikšmės palygintos su faktiniu mirštamumu.

Rezultatai. Tiriamuoju laikotarpiu faktinis mirštamumas po miokardo revaskuliarizacijos operacijų buvo 2,7 %. Visos rizikos vertinimo skalės pervertino operacinę riziką (APACHE II – 12,2 %, SAPS II – 5,5 %, MODS – 6,8 %, EuroSCORE – 4,5 %). Vis dėlto priešoperacinis rizikos įvertinimas EuroSCORE sistema buvo tikslesnis nei bendrųjų rizikos vertinimo sistemų, o mažiausiai tiksli buvo viena plačiausiai intensyvioje terapijoje naudojamų APACHE II sistema.

Išvada. Ligoniams, kuriems atliekamos miokardo revaskuliarizacijos operacijos, intensyvioje terapijoje taikomos rizikos vertinimo skalės buvo mažiau tikslios prognozuojant pooperacinį mirštamumą nei priešoperaciniais rizikos veiksniais paremta EuroSCORE sistema.

Raktažodžiai: rizikos įvertinimas, mirštamumas, miokardo revaskuliarizacijos operacijos