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ARTYKUŁ ORYGINALNY / *ORIGINAL ARTICLE*

EuroSCORE II does not show better accuracy nor predictive power in comparison to original EuroSCORE: a single-centre study

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Abstract

Background: EuroSCORE is used to predict postoperative mortality in patients undergoing cardiac surgery. Its updated version was published in 2011.

Aim: To assess whether EuroSCORE II (ESII) predicts more accurately postoperative mortality after cardiac surgery in comparison with additive (addES) and logistic EuroSCORE (logES).

Methods: A total of 461 patients (aged 21–88 years, 63.4% of men) who underwent cardiac surgery (December 2010 – June 2011) were included into the prospective research. For each patient ESII, addES and logES were calculated. Accuracy, calibration, and clinical performance of these models were assessed with receiver operating characteristics analyses using the area under the curve and the Hosmer-Lemeshow test. Out of this population, a group of 300 coronary artery bypass grafting (CABG) patients (aged 42–85 years, 73% of men) was selected and statistically analysed using the same methods.

Results: The mortality rate was 5.21%. Predicted mortality rates were as follows: addES 4.68%, logES 4.57%, and ESII 1.89%; the accuracy was: 0.589, 0.728, and 0.726, respectively. Only logES presented good predictive power (Hosmer-Lemeshow test: $\chi^2 = 12.79$, $p = 0.12$). In the CABG patients, the postoperative mortality rate was 5.33%. Predicted mortality rates were as follows: addES 4.69%, logES 4.59%, and ESII 1.88%; the accuracy was: 0.512, 0.691, and 0.687, respectively. In the Hosmer-Lemeshow test also logES presented good predictive power ($\chi^2 = 10.72$, $p = 0.218$).

Conclusions: EuroSCORE II did not estimate mortality risk better in comparison to its previous versions, in the entire studied population or in the CABG patients. On the basis of the analysed data, it seems that the closest to the actual risk of death for the Polish population is the EuroSCORE logistic model.

Key words: cardiac surgery, EuroSCORE, mortality, risk stratification

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INTRODUCTION

EuroSCORE (which stands for **Euro**pean **S**ystem for **C**ardiac **O**perative **R**isk **E**valuation) [1] is used to predict operative mortality in patients undergoing cardiac surgery. The scoring system was prepared using the most reliable and objective risk factors out of 97 risk factors collected from nearly 20,000 patients from 128 hospitals in eight European countries. All of the selected risk factors were divided into three groups: patient-related, cardiac-related, and operative-related factors. If a risk factor is observed in a patient, it is assigned a number or percentage. The approximate percentage of operative risk is established by adding all the weights.

EuroSCORE was first presented at the Brussels meeting of the European Association for Cardio-Thoracic Surgery (EACTS) in 1998 and published in 1999 [1]. However, this system is out of date nowadays. A new version of EuroSCORE, which is called EuroSCORE II [2], was established on the basis of new data and presented at the 2011 EACTS in Lisbon.

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Table 1. Comparison of EuroSCORE I and EuroSCORE II

EuroSCORE I	EuroSCORE II
Patient-related risk factors	
Age	
Gender	
Chronic pulmonary disease	
Extracardiac arteriopathy	
Creatinine value > 200 µmol/L	Renal impairment
Neurological dysfunction	Poor mobility
Previous cardiac surgery	
Active endocarditis	
Critical preoperative state	
–	Diabetes on insulin
Cardiac-related risk factors	
Unstable angina	NYHA class
–	CCS class 4 angina
Left ventricular function	
Recent myocardial infarction	
Pulmonary hypertension	
Operation-related risk factors	
Emergency	Urgency
Other than isolated CABG	Weight of the intervention
Post-infarct septal rupture	/excluded/
Surgery on thoracic aorta	

CABG — coronary artery bypass graft; CCS — Canadian Cardiovascular Society; NYHA — New York Heart Association

EuroSCORE II in comparison to EuroSCORE I

Compared to EuroSCORE I, new risk factors and definitions have been added to EuroSCORE II. The modifications are presented in Table 1. EuroSCORE II includes ten patient-related risk factors. Nine of them remained the same as in EuroSCORE I (with changed definitions for some of them), and diabetes on insulin therapy was added. Patient-related factors now include: age, gender, renal impairment (creatinine clearance instead of serum creatinine value > 200 µmol/L), chronic pulmonary disease, extracardiac arteriopathy (with amputation for arterial disease added), poor mobility (defined as 'severe impairment of mobility secondary to musculoskeletal or neurological dysfunction' instead of 'neurological dysfunction'), previous cardiac surgery, active endocarditis, and critical preoperative state.

Cardiac-related factors have been widened by the patients' New York Heart Association (NYHA) class and pulmonary hypertension has been divided into two categories (moderate: pulmonary artery [PA] systolic pressure 31–55 mm Hg; and severe: PA systolic pressure > 55 mm Hg). The remaining risk factors in this group are as follows: Canadian Cardiovascular Society (CCS) class 4 angina, left ventricular function, and recent myocardial infarction.

A few changes in operative-related factors have been introduced. The 'urgency' of the procedure has been added instead of only 'emergency' operation, which was taken into consideration in EuroSCORE, and the 'post infarct septal rupture' risk factor has been excluded. The authors have brought in the 'weight of the intervention' instead of 'other than isolated coronary artery bypass grafting (CABG)', which is now divided into four classes: isolated CABG, single non-CABG, two procedures, and three procedures. The 'surgery on thoracic aorta' has remained in the model.

The aim of this study is to assess whether EuroSCORE II is more accurate in predicting mortality (construed as mortality occurring in the period of 30 days following cardiac surgery) in comparison to additive and logistic EuroSCORE.

METHODS

This prospective study included 461 consecutive patients who underwent cardiac surgery between December 2010 and June 2011. The inclusion criteria were as follows: adults at the age of 95 years or younger (EuroSCORE II is not validated in patients over this age) and lack of congenital heart disease. None of patients were excluded from the analysis. The information about patients' death after discharge from the hospital was received from the outpatient clinic.

The groups of surgical procedures defined by EuroSCORE II are described in Table 2. 'Single non-CABG' includes one of the following procedures: valvular replacements and plastics, aortic and miscellaneous interventions such as cardiac tumours, pulmonary embolectomy, atrial septal closure, etc.

For the studied cohort, demographic, clinical, laboratory, and operative data including patient-related factors and cardiac-related factors were collected in the computerised database. All patients underwent transthoracic echocardiography with a quantitative assessment of pulmonary artery pressure in our department. Creatinine clearance was calculated by the Cockcroft-Gault formula. The logistic and additive EuroSCORE as well as the EuroSCORE II mortality rate scores were calculated for each patient using the on-line calculator available online at www.euroscore.org.

The majority of our patients underwent CABG (n = 300), so we also decided to analyse this group separately.

Statistical analysis

Quantitative variables are presented as mean ± standard deviation (SD) or median (interquartile range [IQR]), whereas categorical ones are presented as cardinality and percentage. The Shapiro-Wilk test assessed the normality assumption for continuous variables, and, in spite of normal distribution ($p > 0.05$), the t-test for comparing two means was applied. The Kruskal-Wallis test was used to calculate the statistical significance of three predicted mortality rates. The risk-adjusted mortality index was estimated by dividing the observed mortality rates by the predicted ones [2]. The

Table 2. Patients' risk profile

Risk factor	Percentage (%) or median (IQR)	
	Entire cohort	CABG patients
Age [years]	64 (59–71)	64 (59–71)
Male	292 (63.4%)	219 (73%)
Creatinine clearance [mL/min]:		
Normal	257 (55.7%)	167 (55.7%)
Moderate	163 (35.4%)	107 (35.7%)
Severe	41 (9.0%)	25 (8.3%)
Dialysis	0 (0%)	0 (0%)
Extracardiac arteriopathy	70 (15.2%)	51 (17%)
Poor mobility	22 (4.8%)	13 (4.3%)
Previous cardiac surgery	9 (2.0%)	2 (0.7%)
Chronic lung disease	36 (7.8%)	26 (8.7%)
Active endocarditis	5 (1.1%)	0 (0%)
Critical preoperative state	9 (1.95%)	5 (1.7%)
Diabetes on insulin	56 (12.2%)	47 (15.7%)
NYHA III	133 (28.9%)	51 (17%)
NYHA IV	19 (4.1%)	8 (2.7%)
CCS IV	16 (3.5%)	14 (4.7%)
LVEF:		
Good (> 50%)	265 (57.5%)	154 (51.3%)
Moderate (31–50%)	176 (38.2%)	131 (43.7%)
Poor (21–30%)	18 (3.9%)	14 (4.7%)
Very poor (< 20%)	2 (0.4%)	1 (0.3%)
Recent myocardial infarction	158 (22.7%)	147 (49%)
Pulmonary hypertension:		
Moderate	1 (0.2%)	0 (0%)
Severe	2 (0.4%)	0 (0%)
Urgency:		
Elective	440 (95.4%)	284 (94.7%)
Urgent	17 (3.7%)	16 (5.3%)
Emergency	4 (0.9%)	0 (0%)
Weight of the intervention:		
Isolated CABG	300 (65.1%)	300 (100%)
Single non-CABG	108 (23.4%)	
Two procedures	43 (9.3%)	
Three procedures	6 (1.3%)	
Surgery on thoracic aorta	4 (0.9%)	

CABG — coronary artery bypass graft; CCS — Canadian Cardiovascular Society; LVEF — left ventricular ejection fraction; NYHA — New York Heart Association

accuracy of all compared models was performed according to the receiver operating characteristics (ROC) analyses using the area under the curve (AUC, c-statistic) and its 95% confidence Interval (CI). A value of c-statistic between 0.7 and 0.8 was considered to be accurate for use as a predictive model [3, 4]. Another index for assessing discriminatory power used in this paper was the Brier score, which is the quadratic difference between the predicted mortality rate and the observed outcome calculated for each patient. It was assumed that it ranged from 0 to 0.25 for a perfect model [5–7]. The Hosmer-Lemeshow goodness-of-fit test, which compares the observed to predicted values by decile of predicted probability, was calculated to explore the calibration of each of the above-mentioned models. The statistics was compared with a χ^2 distribution and the p-value was recorded. The statistical analysis was carried out with the use of Statistica 10.0 PL software (StatSoft, Cracow, Poland). The results were considered statistically significant when $p < 0.05$.

RESULTS

Patients' characteristics

Demographic characteristics of the studied population with patient-, cardiac-, and operation-related factors are given in Table 2. The study involved 461 patients aged 21–88 years. There were more men than women ($p < 0.0001$). Isolated CABG was performed in 300 (65.1%) patients; single non-CABG comprised 108 (23.4%) interventions. Fifty-three (11.5%) patients underwent mixed procedures. Most patients had normal creatinine clearance (55.7%), a good left ventricular ejection fraction (LVEF; 57.5%), NYHA functional class lower than III (66.81%), and were admitted to the hospital electively (95.4%).

In the CABG-patients, the median age was the same as in the entire cohort (64 years, IQR 59–71), and men constituted the majority of this group (73% vs. 63.4%, $p = 0.005$).

Observed and predicted mortalities

The observed mortality rate in the cohort studied was 5.21%, whereas the predicted postoperative mortality by logistic EuroSCORE (logES), additive EuroSCORE (addES), and EuroSCORE II (ESII) were as follows: 4.57% (95% CI 3.88–5.27), 4.68% (95% CI 4.37–4.99), and 1.89% (95% CI 1.62–2.15), respectively (Table 3).

In CABG-patients, the observed mortality rate was slightly higher than in all analysed groups (5.33%). Predicted mortalities were described as 4.59% (95% CI 3.87–5.30) by logES, 4.69% (95% CI 4.38–5.01) by addES, and as 1.88% (95% CI 1.61–2.16) by ESII (Table 3).

Analysis of patient deaths

Of all deaths analysed, 16 were associated with CABG, five with aortic valve replacement, one with mitral valve replacement, one with mitral valvuloplasty, and one patient underwent CABG + aortic valve replacement.

The most common postoperative complications included: respiratory failure, multi-organ failure, bleeding/rethora-

Table 3. Predicted postoperative mortality rates, Hosmer-Lemeshow test, and risk-adjusted mortality rate (RAMR)

Risk stratification model	Predicted mortality rate [%] (95% CI)*	Hosmer-Lemeshow test (p)	RAMR
Entire cohort			
Additive EuroSCORE	4.68 (4.37–4.99)	0.045	1.11
Logistic EuroSCORE	4.57 (3.88–5.27)	0.12	1.14
EuroSCORE II	1.89 (1.62–2.15)	< 0.001	2.76
Patients undergoing CABG			
Additive EuroSCORE	4.69 (4.38–5.01)	0.001	1.14
Logistic EuroSCORE	4.59 (3.87–5.30)	0.218	1.16
EuroSCORE II	1.88 (1.61–2.16)	< 0.001	2.84

*For both groups p < 0.0001; CABG — coronary artery bypass grafting; CI — confidence interval

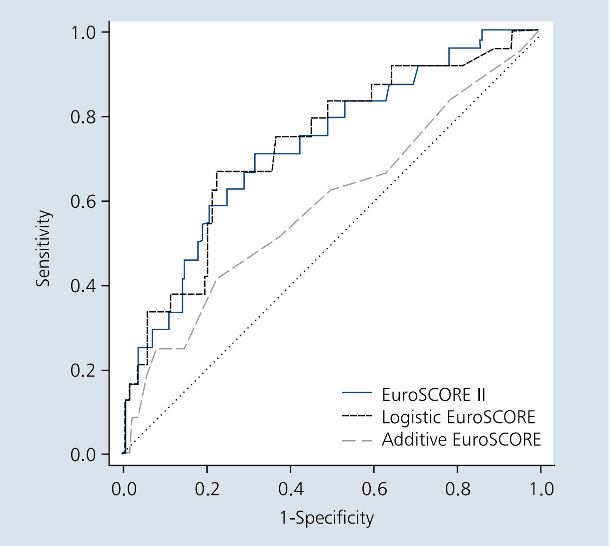

Figure 1. Receiver operating characteristics curves of EuroSCORE II and its previous versions for the entire study cohort

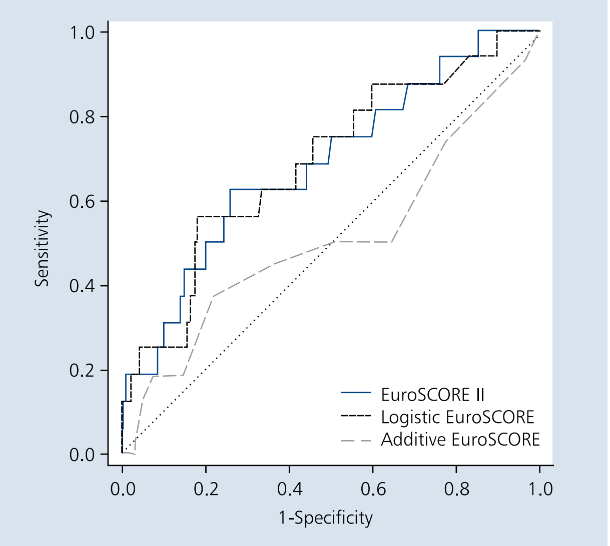

Figure 2. Receiver operating characteristics curves of EuroSCORE II and its previous versions for patients undergoing coronary artery bypass grafting

cotomy, cardiogenic shock, neurological complications, and postoperative myocardial infarction.

Medians in this group were as follows: addES 5.5%, logES 6.46%, ESII 2.6%.

Discriminatory power

The ROC curves for entire cohort and patients undergoing CABG were presented in Figures 1 and 2. The c-statistic for ESII was calculated as 0.726 (95% CI 0.620–0.832) and was almost the same as for logES ($p > 0.05$) and higher in comparison with the AUC of the additive model ($p < 0.05$). The AUC for ESII in the group of CABG patients was 0.687 (95% CI 0.549–0.826), and in comparison with logES and addES the conclusions are the same as for the whole group of analysed patients (Table 4). The brief score of addES, logES, and ESII for the entire cohort amounted to 0.049, 0.049, and 0.050, respectively, and for CABG patients, it was as follows: 0.050, 0.050, and 0.052, respectively.

Calibration

The Hosmer-Lemeshow test (HL) value for both ESII and addES was not significant ($\chi^2 = 30.52$, $p = 0.00002$; $\chi^2 = 15.80$, $p = 0.045$, respectively) indicating a poor predictive power. For logES, the value of that statistic was $\chi^2 = 12.79$ ($p = 0.12$) and did not present the lack of calibration.

In the case of patients after CABG operation, the values of HL were alike and amounted to ESII: $\chi^2 = 35.66$, $p = 0.00002$; for addES: $\chi^2 = 26.21$, $p = 0.0009$; and for logES: $\chi^2 = 10.72$, $p = 0.218$, which appeared to provide more accurate probabilities of all three scores.

The risk-adjusted mortality rate (RAMR) results were presented in Table 3.

DISCUSSION

We present the results of medium-risk patients' analysis operated on in one Polish centre.

Table 4. Accuracy and differences between EuroSCORE II and its previous versions

Risk stratification model	AUC (95% CI)	Comparison with EuroSCORE II	P
Entire cohort			
Additive EuroSCORE	0.589 (0.460–0.718)	0.1367	0.022
Logistic EuroSCORE	0.728 (0.621–0.836)	0.0025	NS
EuroSCORE II	0.726 (0.620–0.832)	-	–
Patients undergoing CABG			
Additive EuroSCORE	0.512 (0.344–0.681)	0.175	0.037
Logistic EuroSCORE	0.691 (0.553–0.828)	0.004	NS
EuroSCORE II	0.687 (0.549–0.826)	-	–

AUC — area under the curve; CABG — coronary artery bypass grafting; CI — confidence interval; NS — non significant

The mortality rate in our study was at the level of 5.21% and it did not differ with the background of other similar studies, in which this value ranged from 2.2% to 5.66% [8–13]. For our CABG patients, this value was 5.33%. Biancari et al. [5] and Mediratta et al. [14] reported mortality rates of 3.7% and 1.1%, respectively (for patients under the age of 65 years). The lower mortality rate in these groups of CABG patients may be connected with the demographic profile of their cohorts — e.g. the majority of cases were males, who have a lower risk of postoperative mortality than women (77.8% and 85.6%, respectively), and a higher percentage of diabetic patients treated with insulin or with the diagnosis of respiratory diseases.

One of the most important findings of our study is that, besides the applied modifications, EuroSCORE II did not improve the prediction of postoperative mortality in any of the groups studied. As shown in Figure 1 and Table 3, there were no significant differences in accuracy between EuroSCORE II and logistic EuroSCORE (ESII: AUC 0.726; logES: AUC 0.728, $p = 0.94$; Brief score: 0.049 for both models). Apart from this fact, such outcomes suggest that ESII as well as logES have similar and acceptable prediction of cardiac surgery in our population. This effect is also consistent with the general tendency present in the results of other investigations. An Italian study performed on a group of 12,325 patients showed the same accuracy for both logES and ESII (AUC 0.82, $p = 0.93$) [15]. In the presented study, the Brief score confirmed these results, which were estimated for logES and ESII as: 0.026, 0.021, respectively. In another study from Italy (a total of 1090 patients) the accuracy of ESII was also not significantly higher than other scores (logES: AUC 0.79; ESII: AUC 0.81) [8]. The same tendency appeared also in the study of two European centres in Birmingham and Rotterdam on a group of 933 patients [16].

The report from Finland (1027 patients) presented better accuracy of EuroSCORE II (ESII: AUC 0.852 vs. logES: AUC 0.838) in a group of patients undergoing CABG [5]. Our calculations were different from those in that research, and logES was non-significantly higher than ESII (AUC: 0.728 vs. 0.726, $p > 0.05$, Brief score: 0.050, 0.052, respectively). In both of our analysed groups, addES had the weakest discriminative power with the lowest value of c-statistic of 0.589 (Brief score: 0.049) for the entire cohort and 0.512 (Brief score: 0.050) for CABG patients, which is not surprising. The differences between AUC of addES and the AUC of ESII in both examined groups were statistically significant (Table 4). In contrast to this data, the addES remained good in three studies performed by Kunt et al. [9], Toumpoulis et al. [17], and in a CABG cohort from Akgül et al. [11]: AUC: 0.70 and 0.72, 0.992, respectively.

Within all the evaluated models in the studied patients, only logES in both analysed groups did not fail the HL test, which provided acceptable predictive power in the entire cohort and in CABG patients (Table 3). The outcomes of other studies were not unanimous. Higher results for logES were obtained only in two reports from European institutions with p-values ranging from 0.30 [8] to 0.45 [16]. It is interesting that only in one of the newest performed studies, ESII demonstrated tolerable calibration ($p = 0.12$) [8]. For the group of CABG patients, a British study revealed that ESII as well as logES provided accurate probabilities ($p = 0.052$ and $p = 0.41$, respectively) [18]. As shown in Table 3, all examined predicting models had RAMR above 1.0 and overestimated the predicted mortality for the entire cohort as well as for CABG-patients. Carnero-Alcazar et al. [10] observed similarly that for a global group, ESII overestimated postoperative mortality risk (RAMR: 1.27) and slightly underestimated it in the case of coronary patients (RAMR: 0.94). It was also proven that among these two groups of patients, logES also underestimated mortality [10].

It is known that there is still no perfect scoring system to assess the mortality rate for cardiac surgical patients. It might be a good idea to take into account also other risk factors, e.g. postoperative atrial fibrillation [19].

Limitations of the study

The main limitation of this research is the fact that the presented data originates from a single-centre study, and that is why the results may not be interpreted in relation to the whole population in Poland. Moreover, the number of patients included into this research as well as a relatively smaller group of 'non-CABG' are smaller than in similar studies performed in other European countries. Furthermore, the 'poor mobility' with its definition in EuroSCORE II was not estimated by using any objective scale. The data concerning complete/incomplete revascularisation was not analysed.

CONCLUSIONS

EuroSCORE II does not estimate mortality risk better than its previous versions in the entire studied population or in CABG patients. Logistic EuroSCORE is distinguished by the best predictive power and seems to be the most suitable for medium-risk Polish cardiac patients.

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EuroSCORE II nie jest lepszą skalą ryzyka okołooperacyjnego niż wcześniejsze modele: badanie jednoośrodkowe

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S t r e s z c z e n i e

Wstęp: Model EuroSCORE stosuje się do szacowania ryzyka śmiertelności okołooperacyjnej u pacjentów poddanych zabiegom kardiochirurgicznym. W 2011 r. wprowadzono nową wersję tego modelu.

Cel: Celem niniejszej pracy była ocena wartości predykcyjnej EuroSCORE II (ESII) w porównaniu z jego wcześniejszymi wersjami: addytywnym EuroSCORE (addES) i logistycznym EuroSCORE (logES).

Metody: Do prospektywnego badania włączono 461 pacjentów w wieku 21–88 lat (63,4% mężczyzn) operowanych w Klinice Kardiochirurgii Uniwersytetu Medycznego w Łodzi od grudnia 2010 do czerwca 2011 r., z powodu choroby wieńcowej (65%), wad zastawkowych (25%), tętniaków aorty piersiowej (1%) oraz poddawanych innym zabiegom (9%), takim jak zamknięcie ubytków wewnątrzsercowych, operacje guzów serca czy embolektomia płucna. Dla każdego pacjenta obliczono wartości addES, logES oraz ESII. Z analizowanej grupy wyodrębniono 300 pacjentów (w wieku 42–85 lat, 73% mężczyzn), u których przeprowadzono pomostowanie aortalno-wieńcowe (CABG). Otrzymane dane poddano analizie statystycznej: wykreślono krzywe ROC, porównano pola powierzchni pod krzywymi (AUC) oraz wykonano test Hosmera-Lemeshowa.

Wyniki: Śmiertelność okołooperacyjna w analizowanej grupie chorych wyniosła 5,21%. Przewidywana średnia śmiertelność operacyjna wyliczona za pomocą addES, logES oraz ESII wynosiła odpowiednio: 4,68%, 4,57% i 1,89%, natomiast AUC były następujące: dla addES — 0,589, dla logES — 0,728, dla ESII — 0,726. Wśród analizowanych modeli tylko logES prezentował dobre dopasowanie do danych (χ^2 = 12,79; p = 0,12). W grupie pacjentów poddanych CABG odsetek zgonów wynosił 5,33% i, podobnie jak w analizie całej grupy, był wyższy od wartości wyliczonych za pomocą porównywanych kalkulatorów: addES — 4,69%, logES — 4,59%, ESII — 1,88%. Wartości AUC były odpowiednio mniejsze: addES — 0,512, logES — 0,691, ESII — 0,687, natomiast wynik testu Hosmera-Lemeshowa był również najbardziej satysfakcjonujący dla logES (χ^2 = 10,72; p = 0,218).

Wnioski: EuroSCORE II nie ma wyższej wartości predykcyjnej ryzyka śmiertelności okołooperacyjnej wśród pacjentów poddanych operacjom kardiochirurgicznym niż wcześniejsze wersje tego modelu. Na podstawie analizowanych danych można stwierdzić, że najbliższy rzeczywistemu ryzyku zgonu dla polskiej populacji jest model logistyczny EuroSCORE.

Słowa kluczowe: kardiochirurgia, EuroSCORE, śmiertelność, stratyfikacja ryzyka

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