Perioperative risk assessment with Euroscore and Euroscore II in patients with coronary artery or valvular disease

Paweł Czub, MD[a], Andrzej Cacko, MD, PhD[b,*], Monika Gawałko, MD[c], Emanuel Tataj, MS[b], Jakub Poliński, MD[b], Kacper Pawlik, MD[b], Romuald Cichoń, MD, PhD[a], Piotr Hendzel, MD, PhD[a]

Abstract

Nowadays, both the European System for Cardiac Operative Risk Evaluation (EuroSCORE) logistic (ESL) and EuroSCORE II (ESII) models are used worldwide in predicting in-hospital mortality after cardiac operation. However, these scales are based on different populations and represent different medical approaches. The aim of the study was to assess the effectiveness of the ESL and the ESII risk scores in predicting in-hospital death and prolonged hospitalization in intensive care unit (ICU) after coronary artery bypass grafting (CABG), aortic valve replacement (AVR), and mitral valve replacement (MVR) by comparison of an estimated risk and a real-life observation at a reference cardiac surgery unit.

This retrospective study was based on medical records of patients who underwent a CABG, AVR, or MVR at a reference cardiac surgery unit in a 2-year period. Primary endpoint was defined as in-hospital death. Secondary endpoint was a prolonged hospitalization at the ICU, defined as longer than 3 days.

The study encompassed 586 patients [114 (23.1%) female, mean age 65.8 ± 10.5 years], including 493 patients undergoing CABG, 66 patients undergoing AVR, and 27 patients undergoing MVR. The ESL and ESII risk scores were higher in MVR subgroup ($31.7\% \pm 30.5\%$ and $15.3\% \pm 19.4\%$) and AVR subgroup ($9.7\% \pm 11.6\%$ and $3.2\% \pm 4.2\%$) than in CABG subgroup ($6.9\% \pm 10.4\%$ and $2.5\% \pm 4.1\%$; $P < .001$). Subgroups of patients were significantly different in terms of clinical, biochemical, and echocardiography factors. Primary endpoint occurred in 36 (6.1%) patients: 21 (4.3%), 7 (10.6%), and 8 (29.7%) in CABG, AVR, and MVR subgroups, respectively. The ESII underestimated the risk of mortality. Secondary endpoint occurred in 210 (35.8%) patients: 172 (34.9%), 22 (33.4%), and 16 (59.3%) in CABG, AVR, and MVR subgroups, respectively.

In the study, the perioperative risk estimated with the ESL and the ESII risk scores was compared with a real-life outcome among over 500 patients. Regardless of the type of surgery, result in the ESL was better correlated with the risk of in-hospital death.

Abbreviations: AUC = area under the curve, AVR = aortic valve replacement, CABG = coronary artery bypass grafting, CAD = coronary artery disease, ESA = European System for Cardiac Operative Risk Evaluation additive model, ESL = European System for Cardiac Operative Risk Evaluation logistic model, EuroSCORE = European System for Cardiac Operative Risk Evaluation, H-L = Hosmer–Lemenshow test, ICU = intensive care unit, MVR = mitral valve replacement, VD = valvular disease.

Keywords: cardiac surgery, EuroSCORE II, logistic EuroSCORE, mortality, preoperative evaluation, risk assessment

1. Introduction

Proper patient's risk stratification is crucial for selecting the best strategy in planning for a cardiac surgery treatment.[1] Moreover, unified risk evaluation allows to compare patients' outcomes between the facilities.[2] The most commonly used risk scores in both coronary artery disease (CAD) and valvular disease (VD) are European System for Cardiac Operative Risk Evaluation [EuroSCORE additive (ESA) and logistic model (ESL)] and EuroSCORE II (ESII), with the second one promoted by the experts of the European Society of Cardiology in current guidelines.[3]

Since the day of publication in 1999, the ESA risk scale had been used successfully in adverse events prediction during coronary artery bypass grafting (CABG)[4] until an alternative method of risk evaluation, the ESL, was promoted in 2003.[5] As both models tend to overestimate the risk of in-hospital death among the low-risk patients, the additive one radically underestimates the risk in the group of high-risk patients.[5,6] The ESII risk score was a result of a huge European project focused on enlargement of representation of patients qualified to aortic valve replacement (AVR) or mitral valve replacement (MVR) in a risk stratification model.[7]

Nowadays, both the ESL and the ESII are used worldwide in predicting in-hospital mortality after cardiac operation. However, these scales are based on different populations and represent different medical approaches. Nevertheless, the data about the effectiveness of the ESL and the ESII in predicting outcome

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among patients with isolated VD are not consistent. Moreover, as we know that hospitalization in an intensive care unit (ICU) generates the relevant amount of an overall hospitalization cost, it is unknown whether the ESL or the ESII effectively predicts longer patient's stay in the ICU.[8]

The aim of the study was to assess the effectiveness of the ESL and the ESII risk scores in predicting in-hospital death and prolonged hospitalization in ICU after CABG, AVR, or MVR by comparison of an estimated risk and a real-life observation at a reference cardiac surgery unit.

2. Materials and methods

This retrospective study was based on medical records of patients who underwent a CABG, AVR, or MVR at a reference cardiac surgery unit in a university hospital in Mazovia (Poland) in a 2-year period. This study was approved by the Institutional Bioethical Committee (No: AKBE/39/12).

The inclusion criteria were the presence of CAD or VD and undergoing isolated CABG, AVR, or MVR surgery. Patients with missing data necessary to calculate the ESL or the ESII risk scores or with any missing data regarding hospital stay were excluded. For each patient demography, clinical, laboratory, transthoracic echocardiography, operative, and postoperative data were collected. Also, discharge times from ICU and hospital were recorded, and death was noted. Study protocol is presented in Fig. 1.

Primary endpoint was defined as in-hospital death. Secondary endpoint was a prolonged hospitalization at the ICU, defined as longer than 3 days.

2.1. Statistical analysis

Univariate statistical analysis was performed with *Statistica* v. 12 (StatSoft Inc, Tulsa, OK). Discrete variables were presented as means ± standard deviation, while categorical variables as number and percentage of subjects. Qualitative variables between patients' subgroups were compared using Chi-square Pearson test (with Yates correction for continuity - if it was required due to the quantity of patients in subgroups). For discrete variables, Mann–Whitney *U* test was performed (consequently, a nonparametric test to ensure clarity of the analysis) or Kruskal–Wallis test (analysis of variance, ANOVA) when more than 2 subgroups were compared. Each time the *P* value < .05 was considered as an indicator of a statistical difference. Hosmer–Lemenshow (H–L) test was used for the assessment of the goodness of fit of risk scores in predicting the primary outcomes (the *P* > .05 indicates proper matching).

3. Results

The data of 723 patients were screened. Finally, 586 patients [114 (23.1%) female, mean age 65.8 ± 10.5 years] were considered in the analysis, including 493 patients (mean age 66 ± 10.2 years) undergoing CABG, 66 patients (mean age 63.8 ± 12.1 years) undergoing AVR, and 27 patients (mean age 67 ± 11.9 years) undergoing MVR. Over 90% of patients with CABG were operated off-pomp, all of them through full sternotomy, and complete revascularization was the aim of the CABG in every case. Thus, the group of patients with CABG may be considered as homogenous. The ESL and ESII risk scores were higher in
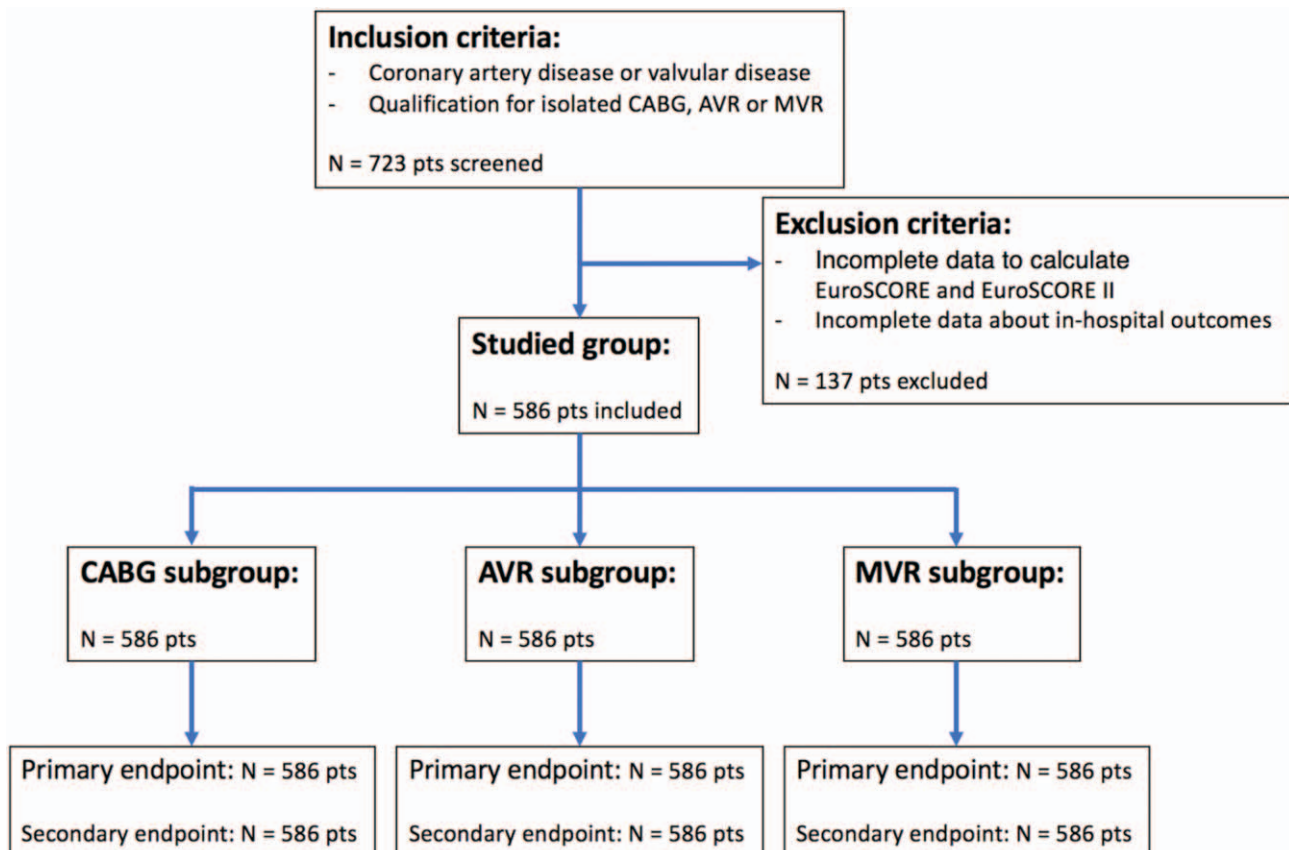

Figure 1. Study protocol. AVR = aortic valve replacement, CABG = coronary artery bypass grafting, EuroSCORE = European System for Cardiac Operative Risk Evaluation, MVR = mitral valve replacement, pts = patients.

Table 1

Overall subjects' characteristic patients and in subgroups due to the type of surgery.

Parameters	CABG (n=493)	AVR (n=66)	MVR (n=27)	P
Age, y	66.0±10.1	63.8±12.1	67.0±11.9	.40
Female	114 (23.1)	20 (30.3)	15 (55.6)	<.001
BMI, kg/m²	28.2±5.–9	27.3±4.6	26.3±4.7	.07
EuroSCORE Logistic, %	6.9±10.4	9.7±11.6	31.7±30.5	<.001
EuroSCORE II, %	2.5±4.1	3.2±4.2	15.3±19.4	<.001
Length of stay in the intensive care unit, d	4.3±5.6	6.4±15.8	9.4±16.7	.03
Length of hospitalization, d	13.5±13.7	18.3±17.1	25.4±22.8	.002
Surgery using extracorporeal circulation	51 (10.3)	66 (100)	27 (100)	<.001
Insulin-treated diabetes	124 (25.1)	51 (22.7)	3 (11.1)	.24
COPD	41 (8.3)	5 (7.6)	5 (18.5)	.18
Noncoronary atherosclerosis	74 (15)	4 (6)	2 (7.4)	.09
Neurological dysfunction	33 (6.7)	3 (4.5)	9 (33.3)	<.001
Prior heart surgery	7 (1.4)	6 (9.1)	7 (25.9)	<.001
Active endocarditis	0 (0)	16 (24.2)	15 (55.6)	<.001
Unstable angina	111 (22.5)	1 (1.52)	1 (3.7)	<.001
Recent myocardial infarction	227 (46)	2 (3)	1 (3.7)	<.001
Critical condition before surgery	10 (2.0)	3 (4.6)	5 (18.5)	<.001
Thoracic aorta surgery	0 (0)	1 (1.5)	0 (0)	.02
Dialysis	15 (3)	5 (7.6)	4 (14.8)	.002
Plasma creatinine concentration >200 μmol/L	36 (7.3)	9 (13.6)	10 (37)	<.001
NYHA class				
I	14 (2.8)	0 (0)	0 (0)	<.001
II	430 (87.2)	33 (50.0)	6 (22.2)	
III	47 (9.5)	32 (48.5)	13 (48.1)	
IV	1 (0.2)	1 (1.5)	8 (29.6)	
LVEF, %				
>50	278 (56.4)	49 (74.2)	12 (44.4)	<.001
31–50	187 (37.9)	13 (19.7)	13 (38.1)	
21–30	24 (4.9)	3 (4.6)	0 (0)	
<20	3 (0.6)	1 (1.5)	2 (7.4)	
Pulmonary hypertension, mm Hg				
Absence	456 (92.5)	60 (90.9)	10 (37.0)	<.001
31–55	34 (6.9)	4 (6.1)	10 (37.0)	
>55	3 (0.6)	2 (3.0)	6 (22.2)	
>60	1 (0.2)	2 (3.0)	4 (14.8)	
Operation mode				
Planned	307 (62.3)	42 (63.6)	9 (33.3)	.08
Urgent	156 (31.6)	22 (33.3)	13 (48.2)	
Sudden	28 (5.7)	2 (3.0)	5 (18.5)	
Emergency	1 (0.2)	0 (0)	0 (0)	
Creatinine clearance, mL/min				
>85	311 (63.1)	37 (56.1)	8 (29.6)	.002
50–85	120 (24.3)	21 (31.9)	9 (33.3)	
<50	46 (9.3)	3 (4.6)	6 (22.2)	

Continuous variables are shown as a mean±standard deviation; categorical variables are presented as absolute number (percentages).

AVR = aortic valve replacement, BMI = body mass index, CABG = coronary artery bypass grafting, COPD = chronic obstructive pulmonary disease, EuroSCORE = European System for Cardiac Operative Risk Evaluation, LVEF = left ventricular ejection fraction, MVR = mitral valve replacement, NYHA = New York Heart Association.

MVR subgroup (31.7% ± 30.5% and 15.3% ± 19.4%) and AVR subgroup (9.7% ± 11.6% and 3.2% ± 4.2%) than in the CABG subgroup (6.9% ± 10.4% and 2.5% ± 4.1%; $P < .001$). Subgroups of patients were significantly different in terms of clinical, biochemical, and echocardiography factors. Patients' characteristics are presented in Table 1.

Primary endpoint occurred in 36 (6.1%) patients: 21 (4.3%), 7 (10.6%), and 8 (29.7%) in CABG, AVR, and MVR subgroups, respectively. The ESII underestimated the risk of mortality. Secondary endpoint occurred in 210 (35.8%) patients: 172 (34.9%), 22 (33.4%), and 16 (59.3%) in CABG, AVR, and MVR subgroups, respectively.

The area under the curve (AUC) for the ESL and the ESII in predicting the primary endpoint was similar (P value for the difference in Chi-square test > .6 regardless of the type of operation; Fig. 2). The H–L test for the ESII was not significant in every subgroup, indicating a poor predictive power, but significant for the ESL. The AUC for the ESL and the ESII in predicting secondary endpoint were < 0.7. The AUC and goodness of fit for primary and secondary endpoint are presented in Table 2.

4. Discussion

The ESL and the ESII are results of clinical data analysis of about 20,000 patients each risk score.[4–7] Although both risk scores identify analogous risk factors and with comparable relevance, the ESL and the ESII results of risk stratification differ, especially
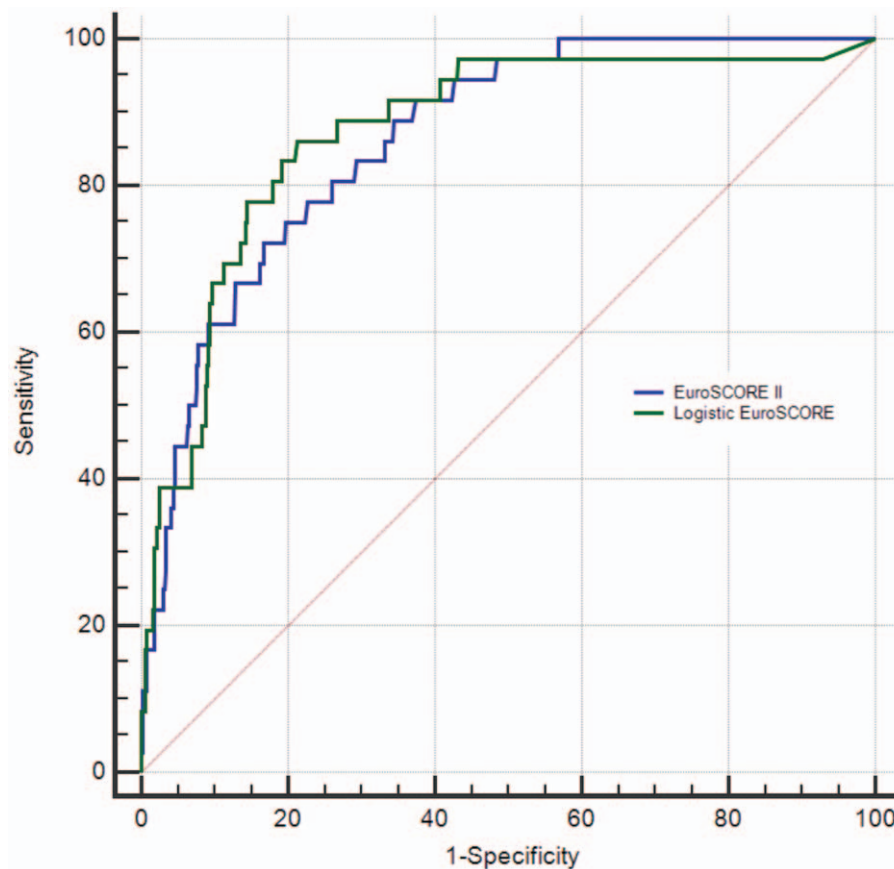
Figure 2. ROC curves of the EuroSCORE logistic and the EuroSCORE II for prognosis of in-hospital death. EuroSCORE = European System for Cardiac Operative Risk Evaluation.

for high-risk patients. Thus, the population, which the ESII was based on, was partially recruited in Central Europe; by intuition, the ESII appears to be more adequate for this population than the ESL. However, only about 10% of patients included into ESII formulation were recruited in Central Europe.

Regardless of the type of surgery, result in the ESL was better correlated with the risk of in-hospital death; the goodness of fit with H–L tests was significant only for the ESL. In the literature, we can find publications presenting results H–L test supporting better calibration of the ESL than ESII, similar to our findings.[9–11]

It is worth pointing that the risk scores were evaluated independently among patients with CABG, AVR, and MVR. Most of the patients underwent isolated CABG. However, about 100 patients with valve replacement were sufficient to observe 15 in-hospital deaths and observe statistically significant correlations between the ESL and the ERII and patients' outcomes. Moreover, the value of the ESL was comparable to observed hospital mortality after AVR and MVR. It is an interesting finding, as more patients underwent valvular replacement in the ESII-baseline population (close to 50%) than the ESL-baseline population. Hence, to the best of our knowledge, the study is consistent with previous reports suggesting reflection on the position of the ESL in the guidelines, at least in risk stratification among patients with isolated VD.[9–11]

The median length of hospitalization at the ICU in studied group was about 3 days. As the prolonged hospitalization at the ICU is related with worse patient's prognosis, we expected that

Table 2

The EuroSCORE logistic and the EuroSCORE II goodness of fit in the prediction of primary and secondary endpoint.

Group	Primary endpoint N (%)	EuroSCORE II AUC (95% AUC)	EuroSCORE logistic AUC (95% AUC)	Secondary endpoint N (%)	EuroSCORE II AUC (95% AUC)	EuroSCORE logistic AUC (95% AUC)
CABG	21 (4.2)	0.87 (0.84–0.90) P = .04	0.86 (0.83–0.89) P = .29	172 (34.9)	0.67 (0.63–0.71) P < .001	0.66 (0.61–0.69) P < .001
AVR	7 (10.6)	0.79 (0.68–0.89) P < .001	0.84 (0.73–0.92) P = .89	22 (33.3)	0.63 (0.51–0.75) P < .001	0.68 (0.56–0.79) P < .001
MVR	8 (29.6)	0.73 (0.53–0.89) P < .001	0.80 (0.61–0.93) P = .30	16 (59.3)	0.54 (0.34–0.73) P < .001	0.52 (0.32–0.71) P < .001

AUC = area under the curve, AVR = aortic valve replacement, CABG = coronary artery bypass grafting, EuroSCORE = European System for Cardiac Operative Risk Evaluation, MVR = mitral valve replacement.

the ESL and the ESII will efficiently predict prolonged hospitalization at the ICU. The thesis was supported by the results of single-center studies, wherein the AUC for prolonged hospitalization at ICU for the ESL and ESII was 0.83 and 0.79, respectively.[9,12] In one of the most largest study, including 18,377 consecutive patients, the AUC for prolonged hospitalization at ICU for both ESA and ESL was 0.73.[13] Atashi et al[8] indicated the importance of identifying reliable risk scores for prediction of prolonged hospitalization at ICU in a large systematic review published in 2018. They pointed difficulties in defining new risk factors and possible advantages of validating currently available risk scores. Although in our study the ELS and the ESII achieved the AUC > 0.6 in the prediction of secondary endpoint in the subgroups of CABG and AVR patients, neither of the risk scores well-fitted the model in the H-L test. In our opinion, it is an important voice in the discussion due to high volume of patients included.

Most of the studies validating EuroSCORE (ES) model in Europe enhanced its value in differentiating patients according to perioperative risk.[14–17] However, recent articles have suggested the unsatisfactory calibration of these algorithms; the original ES tends to overpredict mortality, while ESII underpredicts mortality. In study by Garcia-Valentin et al, [14] including 4000 Spanish patients undergoing cardiac surgery, the observed mortality rate was 6.5%, while predicted mortality rate by ESII was 5.7%. Similarly, in a single-center validation study in Dutch, the observed mortality was 2.4%, while both the ESA and ESL overestimated mortality (median predictive mortality of ESA and ESL: 5.0% and 10.7%, respectively), and ESII underestimated mortality (median predictive mortality: 1.6%).[15] It is important to point out that the ESL and ESII tend to overestimate even the risk of minimally invasive cardiac surgery (MICS).[18,19] Margaryan et al[18] reported that the ESII is not optimally calibrated for MICS and should be avoided in high-risk patients of more than 8% estimated morality. It could be explained by the fact that MICS is not performed routinely and applied in a limited group of patients; thus, general risk scoring systems may not be appropriate for this type of surgery.

The poor discrimination and calibration of the EuroSCORE models were also demonstrated in very high-risk octogenarians' patients. Provenchère et al[19] reported a high discriminatory power for the ESII among patients aged <80 years (AUC 0.81) but less satisfying among those aged ≥80 years (AUC 0.67) with acceptable calibration of ESII until 10%-predicted mortality in octogenarians. It should be an incentive to use the EuroSCORE values with extreme caution when taking medical decision or to use another risk evaluation system, for example, SinoSCORE, which appeared to have better predictive efficiency than ESII among the elderly patients.[20]

Although some risk scores are available, such as the Society of Thoracic Surgeons (STS) risk score, and may appear better prognostic predictors than the EuroSCORE,[21,22] these scores also have major limitations for practical use in this setting by insufficiently considering disease severity and not including major risk factors such as frailty, porcelain aorta, and chest radiation.[23,24] Therefore, it should be kept in mind that multidisciplinary heart team, instead of a risk score, is highly recommended as the best procedural strategy for any single patient.[3,25]

4.1. Study limitations

The main limitation of the study, common in the comparable publications, is the single-center character of the population.

Consequently, the number of patients with isolated VD is limited, as they represent the real-life population treated in the facility. Noteworthy, the number of patients was sufficient to observe relations between the ESL and the ESII scoring and the prevalence of primary endpoint. Due to risk scores validations for in-hospital mortality, observation ended with subject's discharge. Long-term follow-up is being performed to validate the ESL and the ESII prediction values for longer time-scale. Due to relatively low percentage of patients in AVR and MVR group, analysis per type of operation was not performed.

5. Conclusion

In the study, the perioperative risk estimated with the ESL and the ESII risk scores was compared with a real-life outcome among over 500 patients. Regardless of the type of surgery, result in the ESL was better correlated with the risk of in-hospital death.

Author contributions

Conceptualization: Paweł Czub, Andrzej Cacko, Monika Gawałko, Emanuel Tataj, Jakub Poliński, Kacper Pawlik, Romuald Cichoń, Piotr Hendzel

Data curation: Paweł Czub, Andrzej Cacko, Monika Gawałko, Emanuel Tataj, Jakub Poliński, Kacper Pawlik, Romuald Cichoń, Piotr Hendzel

Formal analysis: Paweł Czub, Andrzej Cacko, Monika Gawałko, Emanuel Tataj, Jakub Poliński, Kacper Pawlik, Romuald Cichoń, Piotr Hendzel

Methodology: Paweł Czub, Andrzej Cacko, Monika Gawałko, Emanuel Tataj, Jakub Poliński, Kacper Pawlik, Romuald Cichoń, Piotr Hendzel

Writing – original draft: Paweł Czub, Andrzej Cacko, Monika Gawałko, Emanuel Tataj, Jakub Poliński, Kacper Pawlik, Romuald Cichoń, Piotr Hendzel

Writing – review & editing: Paweł Czub, Andrzej Cacko, Monika Gawałko, Emanuel Tataj, Jakub Poliński, Kacper Pawlik, Romuald Cichoń, Piotr Hendzel

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