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Performance of the EuroSCORE II and the STS score for cardiac surgery in octogenarians

EuroSCORE II ve STS skorlarının 80 yaş ve üzeri kalp cerrahisi hastalarında performansı

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ABSTRACT

Background: We aimed to investigate the predictive value of Society of Thoracic Surgeons (STS) and European System for Cardiac Operative Risk Evaluation (EuroSCORE II) scores for mortality in octogenarian cardiac surgery patients.

Methods: Between January 2016 and December 2019, cardiac operations performed in 116 octogenarian patients (73 males, 43 females; mean age: 82.9±3.1 years; range, 80 to 97 years) were retrospectively analyzed. The patients with and without mortality were compared for their demographic and operative factors. The STS and EuroSCORE II scores, and observed mortality rates were assessed.

Results: Mean STS score was 3.7±11.1 and mean EuroSCORE II was 5.2±5.4. For any operation type, the mean EuroSCORE II was significantly higher (8.1±7.4 *vs*. 4.1±4.0, respectively; p=0.006) in the patients with mortality. For elective operations, the mean EuroSCORE II was higher in cases with mortality (7.2±7.3 *vs*. 3.7±3.9, respectively; p=0.006); however, for urgent cases, there was no significant difference between the scores. Using the receiver operating characteristic curve, the EuroSCORE II had a higher area under the curve for all cases and elective cases than the STS scores.

Conclusion: The EuroSCORE II performed better than the STS score for mortality prediction in octogenarians, whereas the predictions of either scoring system was unsatisfactory for urgent surgery and combined procedures. Population-based validation studies are needed for a better risk scoring system in this age group.

Keywords: Cardiac surgery, mortality, octogenarian, risk scores.

ÖZ

Amaç: Bu çalışmada Göğüs Cerrahisi Derneği (STS) ve Avrupa Kardiyak Operatif Risk Değerlendirme Sistemi II (EuroSCORE II) skorlarının 80 yaş ve üzeri kalp cerrahisi hastalarında mortalite için öngördürücü değeri araştırıldı.

Çalışma planı: Ocak 2016 - Aralık 2019 tarihleri arasında 80 yaş ve üzeri 116 hastada (73 erkek, 43 kadın; ort. yaş: 82.9±3.1 yıl; dağılım, 80-97 yıl) gerçekleştirilen kalp ameliyatları retrospektif olarak incelendi. Mortalite görülen ve görülmeyen hastalar demografik ve cerrahi faktörler açısından karşılaştırıldı. STS, EuroSCORE II skorları ve gözlenen mortalite oranları karşılaştırıldı.

Bulgular: Ortalama STS skoru 3.7±11.1 ve ortalama EuroSCORE II 5.2±5.4 idi. Tüm cerrahi türlerinde, ortalama EuroSCORE II mortalite gözlenen hastalarda daha yüksekti (sırasıyla, 4.1±4.0'e kıyasla 8.1±7.4; p=0.006). Elektif cerrahilerde ortalama EuroSCORE II mortalite görülen olgularda daha yüksekti (sırasıyla, 3.7±3.9'a kıyasla 7.2±7.3; p=0.006); ancak, acil olgularda skorlar arasında bir fark gözlenmedi. Alıcı işletim karakteristik eğrisi ile STS skorlarına kıyasla, EuroSCORE II'nin eğri altında kalan alanı tüm olgularda ve elektif olgularda daha yüksekti.

Sonuç: EuroSCORE II 80 yaş ve üzeri hastalarda STS skoruna kıyasla mortaliteyi öngörmede daha iyi bir performans gösterirken, acil cerrahiler ve kombine işlemlerde iki skorlama sisteminin öngördürücülüğü yetersizdi. Bu yaş grubunda daha iyi bir risk skorlama sistemi için toplum tabanlı validasyon çalışmalarına ihtiyaç vardır.

Anahtar sözcükler: Kalp cerrahisi , mortalite, 80 yaş ve üzeri, risk skorları.

With consistently improving life expectancy over the decades, an increasing number of octogenarians require cardiac surgery. These patients are likely to present with many comorbidities and face higher rates of morbidity and mortality after cardiac operations than patients under the age of 80.[1] Although available risk scoring systems provide a satisfactory mortality prediction for patients undergoing cardiac surgery, their performance is debatable for the octogenarian population.[2]

The Society of Thoracic Surgeons (STS) score is extensively used for predicting early and late mortality after cardiac operations. It is also advantageous in providing information on other postoperative outcomes including length of stay, stroke, and reoperations. Although it is valuable for isolated coronary and valve surgery, one of the shortcomings of the STS score is that it cannot be applied to ablation surgery or multiple valve operations.[3] The logistic European System for Cardiac Operative Risk Evaluation (EuroSCORE) II has been used for a long time and, compared to the STS score, is applicable over a wider variety of cardiac operations.[4] On the other hand, the EuroSCORE II has been modeled with fewer patients than the STS score and the incorporated variables used to predict mortality are not as extensive.[5] For elderly cardiac surgery patients, the logistic EuroSCORE II tends to overestimate mortality, while the STS score gives lower than observed estimates.[6]

The complexity of the octogenarian group may affect the predictive ability of the scoring systems. Despite the reproduced validity of mortality and morbidity prediction for other age groups, many reports have been published debating their application in octogenarians. Observed mortality among octogenarians is often higher than predicted by the risk scoring systems, while still acceptable when considered in the light of the expected survival of the patients in this age group.[7] Thus, calculating the operative risk of octogenarians with the present risk scoring systems raises the one-size-fits-all concern for surgeons.

In the present study, we attempted to discuss an important question about the validity of EuroSCORE II and STS for mortality in octogenarians undergoing cardiac surgery. We, therefore, aimed to investigate the predictive value of STS and EuroSCORE II scores for mortality in octogenarian cardiac surgery patients based on their compatibility with observed mortality.

PATIENTS AND METHODS

This single-center, retrospective study was conducted at Dr. Siyami Ersek Thoracic and Cardiovascular Surgery Training and Research Hospital, Department of Cardiovascular Surgery between January 2016 and December 2019. All elective and urgent cardiac operations throughout the study period were analyzed. There were 7,506 cardiac operations in our institution and 116 of them were performed in octogenarians (73 males, 43 females; mean age: 82.9±3.1 years; range, 80 to 97 years) that were included in the study. Prior to surgery, a written informed consent was obtained from each patient. The study protocol was approved by the Institutional Review Board of Dr. Siyami Ersek Thoracic and Cardiovascular Surgery Training and Research Hospital (16.07.2020/No.28001928-604.01.01). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Patients' demographics, operative data including aortic clamp and cardiopulmonary bypass times were recorded. The STS and EuroSCORE II scores were calculated for each patient using the online calculators at riskcalc.sts.org and www.euroscore.org. Preoperative creatinine clearance was calculated according to the Chronic Kidney Disease Epidemiology Collaboration method. An ejection fraction of >50% was defined as normal, between 30% and 50% as moderate, and <30% as low. Pulmonary artery systolic pressures were recorded as moderate for 31 to 55 mmHg and severe for >55 mmHg. For postoperative endpoints, STS definitions were used. Mortality was as all death events occurring within 30 days after surgery and as deaths in the hospital where the operation took place even after 30 days. Postoperative events including stroke, dialysis requirement, and reoperation were recorded. Stroke was defined as acute hemorrhage or infarction of the brain, spinal cord, or the retina lasting for >24 h. Length of hospital and intensive care unit stay was recorded in days. Postoperative infection included infections at any site including pneumonia, superficial wound infections, deep sternal wound infections, and septicemia. Patients with and without mortality were compared for their demographic and operative factors. Predicted and observed mortalities were compared for both scoring systems.

Statistical analysis

Statistical analysis was performed using the Number Cruncher Statistical System (NCSS 2007) version 1 software (NCSS LLC, Kaysville, UT, USA). Normality was tested with the Shapiro-Wilk test. Descriptive data

Table 1. Demographic and operative characteristics of octogenarian patients (n=116)

	n	%	Mean±SD	Median	IQR
Age (year)			82.9±3.1		
Sex					
Male	73	62.9			
Female	43	37.1			
Body mass index (kg/m²)			28.5±4.7		
Body mass index (n=95)					
Normal	27	28.4			
Overweight	32	33.7			
Obese class I	24	25.3			
Obese class II	12	12.6			
Operation					
Elective	89	76.7			
Urgent	27	23.3			
Operation type					
CABG	65	56.0			
Mitral valve surgery	20	17.2			
Aortic valve surgery	10	8.6			
Aortic valve surgery + CABG	16	13.8			
Mitral valve surgery + CABG	5	4.3			
Diabetes mellitus	54	46.6			
Hypertension	52	44.8			
Preoperative pulmonary artery pressure			30.9±13.1		
Pulmonary hypertension					
Normal	68	58.6			
Moderate	42	36.2			
Severe	6	5.2			
Cardiopulmonary bypass time			118.6±37.4		
Aortic cross clamp time				85	64-118
Creatinine clearance			62.3±17.7		
Preoperative ejection fraction			51.6±9.7		
Preoperative ejection fraction (n=110)					
Normal	63	57.3			
Moderate	40	36.4			
Low	7	6.4			
Peripheral arterial disease	2	1.8			
History of stroke	3	2.6			
Postoperative stroke	7	6.0			
Postoperative renal failure	16	13.8			
Postoperative infection	12	10.3			
Reoperation	30	25.9			
Mechanical ventilation time (days)				1	1-2
Length of stay in the intensive care				2	1-3
Total length of stay				7	6-12
EuroSCORE II			5.2±5.4		
Society of thoracic surgeons			3.7±11.1		
Mortality	32	27.6			

SD: Standard deviation; IQR: Interquartile range; CABG: Coronary artery bypass grafting.

were expressed in mean ± standard deviation (SD), median (min-max) or number and frequency. Groups were compared with the Student's t-test for variables with normal distribution, Mann-Whitney U test for variables without normal distribution, and Pearson's chi-square test, Fisher's exact test, and Fisher-Freeman-Halton exact test, when appropriate for categorical variables. The receiver operating characteristic (ROC) curves were constructed for the two scoring systems and their area under the curve (AUC) values were compared using the DeLong's method. A *p* value of <0.05 was considered statistically significant.

RESULTS

Baseline demographic and operative characteristics of the patients are shown in Table 1.

Table 2. Comparison of patient characteristics according to mortality

	No mortality (n=84)					Mortality (n=32)					
	n	%	Mean±SD	Median	IQR	n	%	Mean±SD	Median	IQR	*p*
Age (year)			82.4±2.5					84.1±4.1			0.030
Sex											0.625
Female	30	35.7				13	40.6				
Body mass index (kg/m²)			28.3±4.6					29.4±4.5			0.351
Body mass index (n=95)											0.836
Normal	24	32.0				5	25.0				
Overweight	25	33.3				5	25.0				
Obese class I	17	22.7				7	35.0				
Obese class II	9	12.0				3	15.0				
Operation											0.006
Elective	70	94.6				19	59.4				
Urgent	14	16.7				13	40.6				
Operation type											0.023
CABG	53	63.1				12	37.5				
Mitral valve surgery	14	16.7				6	18.8				
Aortic valve surgery	4	4.8				6	18.8				
Aortic valve surgery + CABG	11	13.1				5	15.7				
Mitral valve surgery + CABG	2	2.4				3	9.4				
Diabetes mellitus	33	39.3				21	65.7				0.011
Hypertension	34	40.5				18	56.3				0.127
Preoperative pulmonary artery pressure			30.0±12.3					33.4±15.0			0.209
Pulmonary hypertension											0.070
Normal	49	58.3				19	59.4				
Moderate	33	39.3				9	28.1				
Severe	2	2.4				4	12.5				
Cardiopulmonary bypass time			115.7±35.8					126.2±40.9			0.176
Aortic cross clamp time				81	58-118				85	75-126	0.172
Creatinine clearance			65.3±15.4					54.4±20.9			**0.010**
Preoperative ejection fraction			52.3±9.5					49.3±10.0			0.152
Preoperative ejection fraction (n=110)											0.396
Normal	50	59.5				13	46.4				
Moderate	27	32.1				13	46.4				
Low	5	59.5				2	6.3				
Peripheral arterial disease	2	2.4				0	0				0.999
History of stroke	3	3.6				0	0				0.565
Postoperative stroke	4	4.8				3	9.4				0.377
Postoperative renal failure	4	4.8				12	37.5				**<0.001**
Postoperative infection	5	6.0				7	21.9				**0.013**
Reoperation	13	15.5				17	53.1				**<0.001**
Mechanical ventilation time (days)	1	1.1				2	1.5				**<0.001**
Length of stay in the intensive care	1	1.2				2	1.5				**0.006**
Total length of stay				7.5	7-12				4	1-10.5	**<0.001**

SD: Standard deviation; IQR: Interquartile range; CABG: Coronary artery bypass grafting.

Table 3. STS and EuroSCORE II according to mortality

			No mortality (n=84)	Mortality (n=32)	
			Mean±SD	Mean±SD	*p*
Operation	All patients (n=116)	STS	3.0±8.7	5.4±15.8	0.423
		EuroSCORE II	4.1±4.0	8.1±7.4	0.006
	Elective (n=89)	STS	3.2±9.5	7.7±20.3	0.165
		EuroSCORE II	3.7±3.9	7.2±7.3	0.006
	Urgent (n=27)	STS	2.1±0.9	2.0±1.0	0.869
		EuroSCORE II	6.3±4.2	9.5±7.5	0.181
Operation type	CABG (n=65)	STS	1.8±0.9	1.8±0.7	0.947
		EuroSCORE II	4.2±4.3	6±6.3	0.231
	Mitral valve surgery (n=20)	STS	7.6±21.1	16.6±35.6	0.489
		EuroSCORE II	2.5±1.0	11.5±11.2	0.006
	Aortic valve surgery (n=10)	STS	2.6±1.3	2.5±1.0	0.848
		EuroSCORE II	5.2±3.9	11.2±8.6	0.233
	Aortic valve surgery + CABG (n=16)	STS	3.3±1.7	2.3±1.3	0.260
		EuroSCORE II	4.7±3.9	6.1±2.9	0.494
	Mitral valve surgery + CABG (n=5)	STS	3.0±2.0	8.7±12.5	0.585
		EuroSCORE II	8.3±9.4	7.1±2.5	0.832

SD: Standard deviation; STS: Society of Thoracic Surgeons; EuroSCORE II: European System for Cardiac Operative Risk Evaluation II; CABG: Coronary artery bypass grafting.

The mean STS score of all octogenarian patients was 3.7±11.1 and the mean EuroSCORE II was 5.2±5.4. The most frequent type of operation was isolated coronary artery bypass grafting (CABG) in 56.0% of the patients, while 25.8% of the patients required isolated valve surgery and 18.1% required combined valve + CABG surgery.

Octogenarian patients with mortality had more frequently diabetes mellitus, lower creatinine clearance, postoperative dialysis requirement, and prolonged intubation. Mortality varied with the type of operation performed and was significantly higher (p=0.023) for CABG + mitral valve surgery and aortic valve surgery. Urgent operations had a higher mortality than elective operations (40.6% *vs*. 16.7%, respectively; p=0.006) (Table 2).

The patients with and without mortality were compared for their STS and EuroSCORE II calculations. For any operation type, the mean EuroSCORE II was significantly higher (8.1±7.4 *vs*. 4.1±4.0, respectively; p=0.006) in the patients with mortality. For elective operations, the mean EuroSCORE II was higher in cases with mortality (7.2±7.3 *vs*. 3.7±3.9, respectively;

p=0.006); however, for urgent cases, there was no significant difference between the scores. In addition, the STS scores did not significantly differ in terms of mortality among all patients, in elective cases, or urgent cases (Table 3).

Despite the finding that EuroSCORE II was better than the STS score in mortality prediction for our octogenarian patient population, the prediction was markedly lower than observed. The observed mortality for all patients, elective and urgent cases were 27.6%, 21.3%, and 48.1%, respectively while the predicted mortality rates ranged between 2 and 9% with EuroSCORE II and STS scores (Table 4). The CABG was the most frequently performed operation in study group (56%) and observed mortality rate was 18.5% *versus* a predicted mortality rate of 6±6.3% for EuroSCORE II and 1.8±0.7% STS scores.

To compare the discriminatory ability of the two scoring systems for mortality, the ROC curves were constructed (Figure 1). The AUC value for all operations, elective operations, and urgent operations were compared separately. The EuroSCORE II had

Table 4. Observed and predicted mortality rates

			%	Mean±SD
All patients (n=116)		STS		5.40±15.8
		EuroSCORE II		8.1±7.34
		Observed	27.6	
Timing of operation	Elective (n=89)	STS		7.7±20.3
		EuroSCORE II		7.2±7.3
		Observed	21.3	
	Urgent (n=27)	STS		2.0±1.0
		EuroSCORE II		9.5±7.5
		Observed	48.1	
Operation type	CABG (n=65)	STS		1.8±0.8
		EuroSCORE II		4.5±4.8
			18.5	
	Mitral valve surgery (n=20)	STS		6.3±17.6
		EuroSCORE II		5.2±7.2
		Observed	30.0	
	Aortic valve surgery (n=10)	STS		2.5±1.0
		EuroSCORE II		9.4±7.7
		Observed	60.0	
	Aortic valve + CABG (n=16)	STS		3.0±1.7
		EuroSCORE II		5.3±3.6
		Observed	33.3	
	Mitral valve + CABG (n=5)	STS		6.4±9.4
		EuroSCORE II		7.5±5.1
			60.0	

SD: Standard deviation; STS: Society of thoracic surgeons; EuroSCORE II: European System for Cardiac Operative Risk Evaluation II; CABG: Coronary artery bypass grafting.

a higher AUC for all operations (0.754 *vs.* 0.537, respectively; p=0.003). Although the EuroSCORE II had a higher AUC for urgent and elective operations as well, the differences over AUC of STS scores did not reach statistical significance (Table 5).

DISCUSSION

In our retrospective cohort of octogenarians, the EuroSCORE II performed better than STS in predicting mortality. For all cardiac operations, the EuroSCORE II could predict mortality with better discrimination, while the STS score could not provide a significant mortality prediction. Neither scoring system could significantly predict mortality in urgent cases. Based on our results, we can speculate that

the EuroSCORE II is better than STS score for risk prediction in this age group.

With the ongoing effort to improve and update risk prediction models to accommodate changing practices, the EuroSCORE model was revised in 2011 and the STS is recalibrated regularly. The two major scoring systems have their strengths and weaknesses for specific patient groups. With the aging population, more cardiac operations are performed in patients above 80 years of age, and both major risk scores have shortcomings for this age group.[8] Elderly patients >80 years of age were underrepresented in the model for the EuroSCORE II study, and only 21 patients above the age of 90 were included.[4]
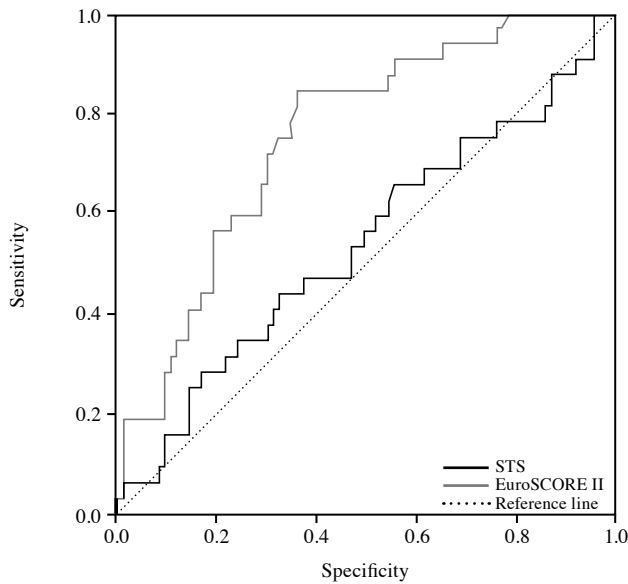
Figure 1. ROC curves for EuroSCORE II and STS score for mortality in all cardiac operations.

ROC: Receiver operating characteristic; STS: Society of Thoracic Surgeons; EuroSCORE II: European System for Cardiac Operative Risk Evaluation II.

Few studies validating the EuroSCORE and STS have focused on the aging population, and it is still unclear which one is more accurate in this setting. A study including octogenarians found an AUC of 0.745 for the EuroSCORE II and 0.694 for the STS for 30-day mortality, and another study including Greek cardiac surgery patients above the age of 60 years found the EuroSCORE to predict mortality with an AUC of 0.84.[9,10] While these two studies show the EuroSCORE II to be a better tool for the elderly, the Frailty in Cardiac Surgery Study in patients aged above 65 years revealed the comprehensive assessment of frailty (CAF) score to perform better than both scores with an AUC of 0.700, and the

STS score was better with an AUC of 0.748 than the EuroSCORE II with an AUC of 0.664.[11] The EuroSCORE II performed relatively better than the STS score in our octogenarian patients; however, we lack the data on frailty scores to assess whether they outperform EuroSCORE II in this patient population. While frailty scores appear to be better for octogenarians, they have not been extensively validated as the major scoring systems. The lack of a universally validated risk scoring system with a satisfactory performance in this specific patient population brings about the necessity for a population study on octogenarians in cardiac surgery.

Our cohort was composed nearly half of combined operations and aortic surgeries. Moreover, 23.3% of all of operations on octogenarians were urgent operations with a higher associated mortality rate. Urgent interventions and combined surgery are more frequent in elderly cardiac patients than in younger patients.[12,13] With 23.3% urgent operations and 18.1% combined valve and coronary surgery, our cohort reflects this trend. For combined operations, the EuroSCORE II tends to overestimate the risk, while it underestimates mortality for urgent operations.[5,14-16] For combined operations, the STS is better than EuroSCORE II;[17,18] however, it can nevertheless underestimate mortality in elderly.[19] Mortality for our urgent operations in our patients (48.1%) was almost twice as for elective operations (21.3%). A higher estimate of mortality was given by the EuroSCORE II for patients undergoing urgent operations. Nevertheless, the observed mortality was higher than the expected percentage.

For our isolated valve surgery patients, the EuroSCORE II, but not STS, was able to predict mortality. However, both scoring systems failed to provide significant predictions for other types of surgery. For urgent operations, neither EuroSCORE II nor STS helped predict mortality for our patients.

Table 5. ROC analyses for EuroSCORE II and STS score for mortality in octogenarian patients

		AUC	95% CI	*P* for AUC >0.5	*P* for difference between curves
All operations	STS	0.537	0.422-0.631	0.554	0.003
	EuroSCORE II	0.754	0.665-0.829	<0.001	
Timing of operation — Elective	STS	0.584	0.443-0.726	0.243	0.692
	EuroSCORE II	0.761	0.644-0.877	<0.001	
Timing of operation — Urgent	STS	0.524	0.281-0.766	0.848	0.058
	EuroSCORE II	0.615	0.392-0.838	0.310	

ROC: Receiver operating characteristic; EuroSCORE II: European System for Cardiac Operative Risk Evaluation II; STS: Society of thoracic surgeons; AUC: Area under the curve; CI: Confidence interval.

Although EuroSCORE II performed better overall, the limitations of these scores in our center to allow for clinical decision making in octogenarians stresses the need for a better risk model for these patients. Frailty assessment emerges as an important factor for elderly surgery candidates. Poor mobility is included in the EuroSCORE II; however, both major risk scores lack the many factors considered in frailty.[20] Among the various criteria used for frailty tests, gait speed emerges as a single factor that is valuable in mortality prediction[21] and the STS has incorporated gait speed into its risk factors. Incorporation of other factors of frailty could improve the model for the elderly age group.

As a tertiary referral center, the complexity and morbidity of our patient population is expected to be higher in all age groups. However, the EuroSCORE II and STS scores in our octogenarian patients did not reflect their actual complexity and associated morbidity. The predictive mortalities were much lower than the observed rates for each operation type. This finding indicates that the risk factor impact of the studied population while developing the scoring systems differs from the risk factor impact in the applied population. Such a difference between the predicted and observed mortality should give a reason to look for factors in the major scoring systems with impacts inconsistent in octogenarians and for other factors that perform better in this age group with the aim of a prediction system that better fits this specific population.

The main limitations of our study are its single-center design, the limited sample size, and its retrospective design. Therefore, the results may not be directly comparable to those from other institutions where demographics and surgical practices vary. Due to the limited number of octogenarian patients, subgroup analysis with individual operation types could not be performed. In addition, our study only analyzed mortality, but not the other endpoints predicted by the STS score. Our definition for postoperative infections was also different from the STS score model's definition which included only deep sternal wound infections. Further studies designed to compare the observed and predicted morbidities are necessary to validate the STS score in this respect.

In conclusion, despite the finding that the EuroSCORE II performed better than the STS score in mortality prediction for octogenarians undergoing cardiac operations, the observed mortality in our study was markedly higher than the predicted values. Instead of using a one-size-fits-all risk calculation in a complex patient group such as octogenarians, a more detailed risk scoring system for a better predictive performance is needed.

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