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RESEARCH ARTICLE

Evaluation of Different Risk Scores in Coronary Artery Bypass Grafting Surgery

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ABSTRACT

Objectives: This study aimed to compare the European System for Cardiac Operative Risk Evaluation (EuroSCORE) II and the Age-Creatinine Ejection Fraction (ACEF) II scoring systems in adult patients undergoing elective coronary artery bypass grafting (CABG) surgery and to determine the contribution of obesity to mortality and morbidity.

Methods: A total of 175 patients over 18 years of age scheduled for elective isolated CABG surgery were randomly included in this prospective observational study. Demographic data, comorbidities, weight and height measurements, results of transthoracic echocardiography, and pulmonary function tests were recorded in the anesthesia outpatient or inpatient clinic. EuroSCORE II and ACEF II risk scores were obtained. The postoperative 30-day mortality of the study participants was recorded.

Results: The mean age was 60±12 years, and 24% (n=42) of the patients were female. The postoperative 30-day mortality rate was 3.4% (n=6). Chronic obstructive pulmonary disease, low creatinine clearance, and high creatinine levels were significantly associated with postoperative 30-day mortality (all p-values < 0.050). According to ROC analysis, EuroSCORE II (area under the curve [AUC]=0.675) and ACEF II (AUC=0.551) were not sensitive predictors, whereas body mass index (BMI) demonstrated better predictive ability (AUC=0.709) for postoperative 30-day mortality. The postoperative 30-day mortality correlated positively with EuroSCORE II and ACEF II but negatively with BMI. The postoperative 30-day mortality in patients with high EuroSCORE II and high ACEF II was 5% (n=6) and 4.3% (n=6), respectively.

Conclusion: BMI was a potentially good predictive factor for postoperative 30-day mortality. The postoperative 30-day mortality correlated positively with EuroSCORE II and ACEF II and negatively with BMI.

Keywords: ACEF II, BMI, CABG, EuroSCORE II, mortality, obesity

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Introduction

Coronary artery disease (CAD) is recognized as the leading disease in terms of both mortality and global burden of disease in studies undertaken by the World Health Organization (WHO).[1] Although the relationship between CAD and the level of development of countries is controversial, it has been suggested that racial differences, chronic problems in developed societies, insufficient health spending, traditional diets and lifestyles, an older population, and some genetic factors may play a role.[2,3] Physical inactivity, a high-fat diet, predisposition to atherosclerosis, smoking history, and the presence of metabolic syndrome are risk factors and prognostic factors in patients diagnosed with CAD.[4]

Abdominal obesity, a component of metabolic syndrome, has been shown to affect the microvascular structure in major body organs, including the heart, brain, kidney, and skeletal muscle.[5,6] Notably, impaired cardiac microcirculation reduces contractility and causes ventricular hypertrophy, substantially raising mortality.[5,6] Obesity and

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atherosclerotic vascular pathologies are associated with an increase in cardiovascular mortality.[7] It is well known that obesity is measured using the Body Mass Index (BMI). There is a positive correlation between BMI and cardiovascular pathologies.[5]

Conservative treatment with pharmacological agents and invasive treatment methods is used in the management of patients with CAD.[8,9] Invasive surgical techniques have been observed to increase survival and improve prognosis. Coronary artery bypass grafting (CABG) is known to be the most commonly used surgical technique for these purposes.[10] CABG is performed in groups of patients who are refractory to pharmacological treatment or percutaneous coronary intervention, or who have a history of recurrent angina, myocardial infarction (MI), or persistent coronary angina after treatment.[11]

Given the high mortality rates associated with invasive coronary procedures, risk assessment before surgery is essential. This reduces healthcare expenditures for financing surgical procedures and improves postoperative care.[12] Numerous preoperative risk assessment techniques exist.[13]

One preoperative risk scoring system, the Cardiac Operative Risk Scores for European Systems (EuroSCORE), was first tested in patients undergoing invasive cardiac surgery in 1995 and published as applicable in 1999.[14] An update in 2011 resulted in EuroSCORE II (Appendix 1).[15] EuroSCORE, consisting of eighteen independent risk factors, is obtained by processing information in three different categories according to patient origin, cardiac characteristics, and type of surgery, and provides postoperative mortality risk scoring.[15]

The Age-Creatinine Ejection Fraction (ACEF) scoring system was studied as a preoperative risk scoring system in patients undergoing cardiac surgery between 2001 and 2003 and was published in 2009.[16] The variables used were age, creatinine, and left ventricular ejection fraction.[16] With the addition of surgical severity and preoperative anemia as independent variables, ACEF II was established in 2019.[17]

The prediction of morbidity and mortality after high-risk CABG surgery is of great importance for the anesthesia team to determine the appropriate clinical and therapeutic approach. At present, EuroSCORE II and ACEF II have been widely used for the assessment of mortality and morbidity. This study aimed to determine whether EuroSCORE II and ACEF II are superior to each other and to evaluate the effect of obesity on mortality and morbidity in adult patients undergoing elective CABG surgery.

Methods

This study is a prospective observational study conducted between October 2022 and January 2023 at the Department of Anesthesiology and Resuscitation of the Ministry of Health University (MHU) Dr. Siyami Ersek Cardiovascular and Thoracic Surgery Center Training and Research Hospital. The study was approved by the Clinical Research Ethics Committee of Haydarpaşa Research and Training Hospital with the decision of the Board of Directors dated 15/08/2022 and number 169. The study adhered to the ethical principles outlined in the Declaration of Helsinki.

Those aged 18 years or older undergoing elective isolated CABG were included in our study, while those younger than 18 years, those undergoing combined valve and CABG surgery, redo patients, and those wishing to withdraw voluntarily were excluded. All participants signed an informed consent form.

A total of 175 patients were enrolled in the study, who were randomly selected to undergo CABG surgery. Pre-anesthetic evaluation was performed in the anesthetic outpatient or inpatient clinic. Clinical status, laboratory findings, and radiological investigations were considered. Weight and height measurements, comorbidities, laboratory blood values (creatinine, glucose, hemogram), results of transthoracic echocardiography, and pulmonary function tests were recorded. Glomerular filtration rate (GFR), calculated according to the Cockcroft and Gault formula (140-age) × weight (kg) × [0.85 if female] /72 × (serum Cr [mg/dL]), was used for renal function assessment.[18]

EuroSCORE II (Appendix 1)[15] and ACEF II[17] were calculated for each participant. The EuroSCORE II includes 18 parameters under three different headings: 1) Patient-related factors (age, gender, presence of chronic lung disease, extracardiac arteriopathy, limited mobility, history of previous cardiac surgery, active endocarditis, creatinine clearance, insulin-dependent DM, and preoperative evaluation), 2) Cardiac factors [presence of resting angina, history of MI within the last 90 days, presence of pulmonary hypertension, New York Heart Association (NYHA) classification, and LVEF value], and 3) Cardiac surgery-related factors (whether thoracic aortic surgery is performed, urgency of surgery, and severity of surgery).[15]

The ACEF II risk scoring system consists of age (Age-A), creatinine clearance (Creatinine-C), left ventricular ejection fraction (Ejection Fraction-EF), urgency of surgery, and preoperative anemia.[17] The scoring of ACEF II is as follows: two points are added if the creatinine value is >2 mg/dL, three points if the operation is urgent, and 0.2 points if the hematocrit (Htc) is <36%.

ACEFII=Age/EF+2(Creatinine<2mg dL)+3 (Emergency)+0,2 (<%36HTC)

The type of surgery patients underwent and whether it was elective or urgent were recorded. On the first postoperative day, all patients' vital signs, hemogram, and biochemical values were recorded. The mortality rate in the first 30 days after surgery was recorded.

Statistical Analysis

Data analysis was performed using the Statistical Package for the Social Sciences (IBM® SPSS Statistics for Windows, v.23.0, Armonk, NY, USA). Descriptive statistics were used, and quantitative variables were described by mean, maximum (max), and minimum (min) values, while qualitative variables were described by percentages.

Normality was determined by Kolmogorov-Smirnov analysis. If the distributions were normal, the Student's t-test was used to make comparisons between the groups. Pearson's chi-squared test was used for the comparison analysis of qualitative variables, except when the sample size was low (≤5), in which case Fisher's exact test was used. Non-parametric continuous variables were reported as the median and were compared using the Mann-Whitney U test. The interquartile range (IQR) was also reported for median values. P-value<0.050 was considered statistically significant.

Receiver operating characteristic (ROC) analysis was used to determine whether the study scoring systems and BMI predicted mortality. The ROC curve was plotted using ROC analysis, and the area under the curve (AUC) was calculated. The 95% confidence interval (CI) was also calculated for each of the AUC values. In the present study, AUC values ≤0.599 were generally considered to indicate a lack of predictive ability (i.e., the ability to predict mortality based on the score). AUC between 0.6 and 0.7 was regarded as fair, between 0.7 and 0.8 as acceptable, between 0.8 and 0.9 as excellent, and above 0.9 as strong predictive ability. The parametric values with the best sensitivity and specificity on ROC analysis for both scoring systems and BMI were considered as cutoffs. For these cut-off values, the negative predictive value (NPV) and positive predictive value (PPV) were also calculated. According to the cut-off values, patients were then divided into low and high groups. Odds ratios (ORs) were calculated to determine the difference in mortality between these groups.

Results

A total of 175 patients were included in the study. The mean age of the participants was 60±12 years, and 24% (n=42) were female. The median BMI was calculated as 28.4 (IQR=5.0) kg/m^2. Whereas 88.6% (n=155) of the patients were classified as NYHA I-II, the remaining 11.4% (n=20) were classified as NYHA III-IV. The median EuroSCORE II was 0.92 (IQR=0.74), the ACEF II proportional score was 1.8% (IQR=0.8), and the ACEF II score was 1.2 (IQR=0.5). Clinical findings included extracardiac arteriopathy in 2.9% (n=5), limitation of movement in 0.6% (n=1), chronic obstructive pulmonary disease (COPD) in 8% (n=14), insulin-dependent diabetes mellitus (DM) in 9.1% (n=16), angina at rest in 33.7% (n=59), history of MI in the last 90 days in 28.6% (n=50), and history of pulmonary hypertension in 90.9% (n=159). A history of major cardiac surgery and active endocarditis was not present in any of the patients. Postoperative 30-day mortality was 3.4% (n=6). Table 1 presents the demographic and clinical data of the patients.

The differences between survivors and non-survivors are highlighted in Table 1. The presence of COPD (7.1% vs. 33.3%, p=0.005), creatinine clearance below 50 mL/min (based on GFR calculation) (5.3% vs. 33.3%, p=0.020), and elevated creatinine levels (0.94 [IQR=0.25] vs. 1.16 [IQR=0.41] mg/dL, p=0.030) were higher in non-survivor participants. Even though the mean EuroSCORE II, ACEF II proportional score, and ACEF II score were higher in non-survivors, they were not statistically significant (p=0.145, p=0.668, and p=0.671, respectively). In addition, although the BMI of non-survivors was lower than that of survivors (25.2 [IQR=6.3] kg/m^2 vs. 28.5 [IQR=4.9] kg/m^2), the difference was not statistically significant (p=0.083).

Table 2 shows the ROC analysis of the predictive value of EuroSCORE II, ACEF II proportional score, and ACEF II score for mortality. The predictive value of EuroSCORE II (AUC=0.675, 95%CI=0.490–0.860), ACEF II (AUC=0.551, 95%CI=0.380–0.723), and ACEF II score for mortality was insensitive (AUC=0.551, 95%CI=0.387–0.715) (Fig. 1).

When patients were classified as low (n=55) and high (n=120) according to the EuroSCORE II threshold, none of the low-risk patients developed mortality, whereas all (n=6) of those with mortality were in the high-risk group (p=0.091) (Table 3). Classifying patients as low (n=97) and high (n=78) based on the threshold established for ACEF II proportional score, mortality was observed in 2.1% (n=2) of low-risk patients, whereas this rate increased to 5.1% (n=4) in high-risk patients (p=0.268) (Table 3). Regarding scoring, when patients were divided into low (n=34) and high (n=141) according to the ACEF II threshold, none of the low scorers developed mortality, whereas 4.3% (n=6) of the high scorers developed mortality (p=0.221) (Table 3).

Table 4 and Figure 2 show the ROC analysis of the predictive value of BMI for mortality. BMI had an acceptable prediction for mortality (AUC=0.709, 95%CI=0.635–0.775). When patients were categorized into low (n=55) and high (n=120) based on the BMI threshold value, mortality occurred in 9.1% (n=5) of those with low BMI, whereas mortality occurred in only 1 (0.8%) of those with high BMI (Table 4). This difference was statistically significant (p=0.005).

Table 1. Characteristics parameters of participants (n=175) and univariate analysis of survivors and nonsurvivors

	Overall (n=175)		Survivors (n=169)		Non-survivors (n=6)		p
	n	%	n	%	n	%	
Age (years)*	60	12	60	12	65	20	0.176
Gender							0.669
Female	42	24	41	24.3	1	16.7	
Male	133	76	128	75.7	5	83.3	
BMI (kg/m^2)*	28.4 (5.0)		28.5 (4.9)		25.2 (6.3)		0.083
Creatinine clearance							0.005
<50 ml/m	11	6.3	9	5.3	2	33.3	
≥50 ml/m	164	93.7	160	94.7	4	66.7	
Extracardiac arteriopathy	5	2.9	5	3.0	NA		NA
Limited mobility	1	0.6	1	0.6	NA		NA
Chronic lung disease	14	8	12	7.1	2	33.3	0.020
Critical preoperative condition	4	2.3	4	2.4	NA		NA
Insulin-dependent DM	16	9.1	15	8.9	1	16.7	0.515
Resting angina	59	33.7	57	33.7	2	33.3	0.984
Recent MI	50	28.6	47	27.8	3	50.0	0.355
NYHA classification							0.682
I-II	155	88.6	150	88.8	5	83.3	
III-IV	20	11.4	19	11.2	1	16.7	
EF (%)*	55 (15)		55.0 (15.0)		57.5 (15.0)		0.571
Pulmonary HT							0.515
Absent	16	9.1	15	8.9	1	16.7	
Present	159	90.9	154	91.1	5	83.3	
Creatinine (mg/dL)*	0.94 (0.25		0.94 (0.25)		1.16 (0.41)		0.030
Hematocrit (%)*	41.7 (7.3		41.7 (6.9)		36.6 (4.5)		0.118
EuroSCORE-II*	0.92 (0.74		0.92 (0.75)		1.31 (1.57)		0.145
ACEF-II (%)*	1.8 (0.8		1.95 (0.50)		1.80 (0.80)		0.668
ACEF-II score*	1.2 (0.5		1.20 (0.5)		1.25 (0.3)		0.671

Categoric variables presented as n (%) format. *: Numeric variables were presented as median and interquartile range. BMI is calculated as weight in kilograms divided by height in meters squared. BMI: Body mass index; DM: Diabetes mellitus; MI: Myocardial infarction; NYHA: New York heart association; EF: Ejection fraction; HT: Hypertension; EuroSCORE: European Systems for Determination of Cardiac Operative Risk Scores; ACEF: Age-creatinine ejection fraction; kg/m^2: Kilogram/meter2; NA: Not analyzed.

Table 2. ROC analysis of scoring systems for mortality

Scoring system	AUC	Threshold	Sensitivity (%)	Specificity (%)	NPV (%)	PPV (%)	p
EuroSCORE II (%)	0.675 (0.490–0.860)	>0.78	100.0	32.5	100.0	5.0	0.146
ACEF-II (%)	0.551 (0.380–0.723)	>1.8	66.6	56.2	97.9	5.1	0.670
ACEF-II (Score)	0.551 (0.387–0.715)	>0.9	100.0	20.1	100.0	4.3	0.673

Comparison	Difference between AUC	Z statistic	p
EuroSCORE II-ACEF II (%)	0.124	1.857	0.062
EuroSCORE II (%)-ACEF II (Score)	0.124	1.918	0.053
ACEF II (%)-ACEF II (Score)	0.001	0.038	0.969

AUC value was represented as value (95% Confidence Interval). ROC: Receiver operating characteristic; AUC: Area under the curve; NPV: Negative predictive value; PPV: Positive predictive value; EuroSCORE: European Systems for Determination of Cardiac Operative Risk Scores; ACEF: Age-Creatinine Ejection Fractio.

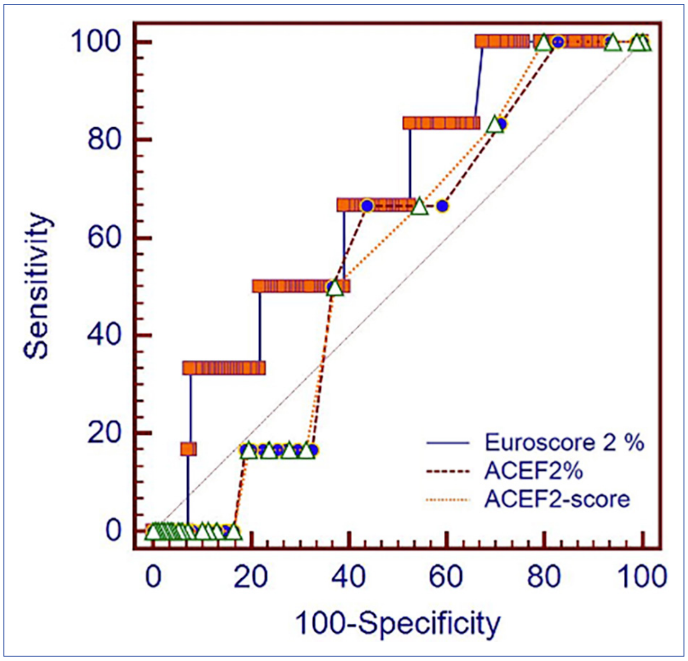

Figure 1. Comparison of ROC Analysis of scoring systems for mortality.

ROC: Receiver operating characteristic; EuroSCORE: European Systems for Determination of Cardiac Operative Risk Scores; ACEF: Age-Creatinine Ejection Fraction.

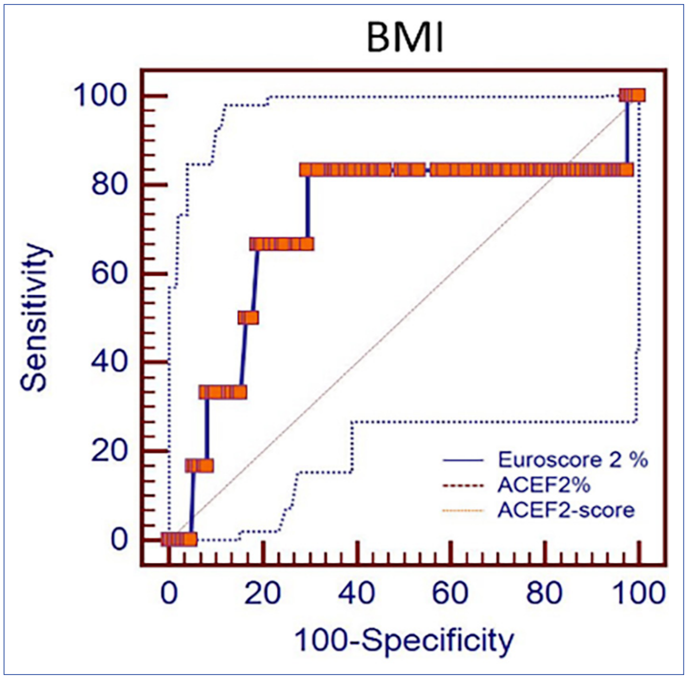

Figure 2. ROC analysis of BMI for mortality.

BMI: Body mass index.

Discussion

Our study showed that the risk of mortality increased with the higher ratio in the EuroSCORE II and ACEF II scoring systems, but it was not statistically significant. BMI unexpectedly showed a negative correlation with mortality, which was considered statistically significant, although BMI was reasonably predictive of mortality. We also found that the presence of COPD, low creatinine clearance, and high creatinine levels were all associated with mortality.

Boracci et al.,[19] in a prospective and multicentric study, found the ROC analysis of the EuroSCORE II to be good in predicting preoperative mortality for all surgical procedures except isolated CABG. Some studies, like the present study, have shown that EuroSCORE II is less successful in predicting the risk of death in cardiac surgery patients.[20,21]

A retrospective Chinese study evaluated the predictive value of ACEF and ACEF II for postoperative mortality after preoperative risk scoring.[22] In contrast to this study, we concluded that the accuracy of ACEF II in predicting mortality was not sensitive due to the small number of patients and the inclusion of only those patients who had undergone isolated CABG surgery. Another retrospective study found that the accuracy of ACEF II versus ACEF for predicting 2-year mortality was moderate.[23] In our study, ACEF II predicted moderate postoperative 30-day mortality. The value of this result is increased by the fact that our study was prospective.

In an Italian study, ROC analysis showed that EuroSCORE II was superior to ACEF II in all patients who underwent isolated valve, aortic, and CABG procedures.[24] The

Table 3. Group patients according to identified thresholds and comparison basis of the mortality status

	Threshold (β)	n	Survivors (n=169)	Non-survivors (n=6)	p	OR	95% CI
EuroSCORE II (%)	≤0.78	55	55 (100)	--	0.091	--[α]	--
	>0.78	120	114 (95)	6 (5)			
ACEF-II (%)	≤1.8	97	95 (97.9)	2 (2.1)	0.268	2.568	0.458–14.401
	>1.8	78	74 (94.9)	4 (5.1)			
ACEF-II (score)	≤0.9	34	34 (100)	--	0.221	--[α]	--
	>0.9	141	135 (95.7)	6 (4.3)			

Categoric variables presented as n (%) format. α: Odds ratio was not given because mortality was not observed among patients with low scores. β: These threshold values are the threshold values calculated in Table 2. OR: Odds ratio; CI: Confidence interval; EuroSCORE: European Systems for Determination of Cardiac Operative Risk Scores; ACEF: Age-Creatinine Ejection Fraction.

Table 4. ROC analysis of BMI in relation to mortality and grouping of patients according to identified threshold and comparison of these groups based on mortality status

	AUC	Threshold	Sensitivity (%)	Specificity (%)	NPV (%)	PPV (%)	p
BMI (kg/m²)	0.709 (0.635–0.775)	26.7	83.3	70.4	99.2	9.1	0.143

Threshold	n	Survivors (n=169)	Non-survivors (n=6)	p	OR	95% CI
>26.7	120	119 (99.2)	1 (0.8)	0.005	11.9	1.356–104.463
≤26.7	55	50 (90.9)	5 (9.1)			

Categoric variables presented as n (%) format. AUC value was represented as value (95% Confidence Interval). ROC: Receiver operating characteristic; BMI: Body mass index; AUC: Area under the curve; NPV: Negative predictive value; PPV: Positive predictive value; OR: Odds ratio; CI: Confidence interval; kg/m²: kilogram/meter2.

specificity and sensitivity of ACEF II were found to be better than EuroSCORE II for predicting postoperative cardiac complications.[24] In our study, there was no difference in the superiority of the two scoring systems. Variations in the number of patients included in the studies, heterogeneity in the characteristics of the participants, types of operations, and differences in the design of the studies (single-center versus multicenter, prospective versus retrospective, and so on) may be the reasons for the inconsistency of the results in the literature.

In our study, BMI was significantly different and negatively correlated with mortality in the preoperative risk assessment. Studies have conflicting results in this respect. In a study by Minol et al.[25] using BMI and EuroSCORE II scores in patients undergoing isolated mitral valve surgery, high BMI was effective in predicting postoperative complications and superior to the preoperative scoring test. The fact that only patients undergoing minimally invasive cardiac surgery were included in that study may explain this difference. Another study reported that obesity had no prognostic significance for early mortality and that BMI did not make any difference in the length of hospital stay.[26] Engel et al.[27] found that a low BMI increased the risk of postoperative complications and mortality in patients undergoing CABG surgery. Furthermore, mortality and morbidity were not associated with higher BMI.

There is evidence in the literature that impaired preoperative renal function is related to postoperative morbidity and mortality.[28,29] In a study similar to ours, reduced renal function was found to increase postoperative complications, length of hospital stay, and mortality.[28] In a prospective study, Ponomarev et al.[30] showed that structural and functional pulmonary impairment was associated with significantly higher mortality in CABG patients with COPD, as in the current study.

Study limitations include a small sample size, single-center design, and short follow-up. However, our study is not without its strengths. To the best of our knowledge, this is the first study in the literature to investigate the predictive value of EuroSCORE II, ACEF II, and BMI together for postoperative mortality.

Conclusion

ACEF II and EuroSCORE II were not very sensitive in predicting mortality after major cardiac surgery. However, EuroSCORE II was slightly more sensitive than ACEF II in predicting mortality, although not significantly better. There was a straight-line relationship between preoperative risk and mortality in patients assessed by both scoring systems. Accompanying comorbidities of patients undergoing CABG may be closely related to mortality. Furthermore, obesity appears to show a negative association with mortality in patients undergoing CABG surgery, which was unexpected. The predictive value of BMI for mortality is at a level that may be considered good, and future long-term follow-up studies may better clarify the effects of preoperative scoring systems and BMI on morbidity and mortality.

Disclosures

Ethics Committee Approval: The study was approved by The Haydarpaşa Research and Training Hospital Clinical Research Ethics Committee (no: 169, date: 15/08/2022).

Authorship Contributions: Concept – E.K.K., Ş.T.K., O.E., İ.M.K.; Design – E.K.K., Ş.T.K., O.E., İ.M.K.; Supervision – E.K.K., Ş.T.K., O.E., İ.M.K.; Fundings – E.K.K., Ş.T.K.; Materials – E.K.K., Ş.T.K.; Data collection &/or processing – E.K.K., Ş.T.K., İ.M.K.; Analysis and/or interpretation – E.K.K., Ş.T.K.; Literature search – E.K.K., Ş.T.K.; Writing – E.K.K., Ş.T.K., O.E., İ.M.K.; Critical review – E.K.K., Ş.T.K.

Informed Consent: Written informed consent was obtained from all patients.

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Appendix 1. Parameters in the EuroSCORE II database

Patient-related Factors	Cardiac factors	Operational factors
Age	Resting angina	Thoracic aorta surgery
Gender	LVEF	Urgency of surgery
Chronic lung disease	MI history (last three months)	Severity of surgery
Extracardiac arteriopathy	Pulmonary hypertension	
Mobility	NYHA classification	
	Previous cardiac surgery	
	Active endocarditis	
	Renal failure	
	Insulin-dependent DM	
	Preoperative evaluation	

EuroSCORE: European Systems for Determination of Cardiac Operative Risk Scores; LVEF: Left ventricular ejection fraction; MI: Myocardial Infarction; NYHA: New York Heart Association; DM: Diabetes mellitus