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Comparative prognostic performance of six nutritional risk scores in predicting early outcomes after open heart surgery: a prospective cohort study

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Comparative Prognostic Performance of Six Nutritional Risk Scores in Predicting Early Outcomes After Open Heart Surgery: A Prospective Cohort Study

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Note: No large language model (LLM) was used in the generation of study data or analyses. Assistance with language editing was performed using AI tools, documented in the Methods section.

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ABSTRACT

Background:

Preoperative nutritional status is a critical determinant of outcomes in cardiac surgery, yet its integration into conventional surgical risk assessment remains limited. This study aimed to compare the prognostic value of six nutritional scoring systems and evaluate whether combining them with European System for Cardiac Operative Risk Evaluation II (EuroSCORE II) improves prediction of 30-day mortality and postoperative complications in patients undergoing open heart surgery.

Methods:

In this prospective cohort study, 120 adult patients undergoing elective open heart surgery were assessed preoperatively using six nutritional indices: Controlling Nutritional Status (CONUT), Nutritional Risk Screening 2002 (NRS2002), Malnutrition Universal Screening Tool (MUST), Nutritional Risk Index (NRI), Subjective Global Assessment (SGA), and Mini Nutritional Assessment (MNA). The primary endpoint was 30-day all-cause mortality. Secondary outcomes included major postoperative complications and length of stay. Logistic regression models, receiver operating characteristic (ROC) curve analyses, and model fit statistics were used to assess predictive performance.

Results:

In univariable analysis, all six nutritional scores were associated with 30-

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day mortality. In multivariable models including EuroSCORE II and each nutritional index, only the Mini Nutritional Assessment (MNA) remained an independent predictor ($p = 0.020$). The addition of MNA to EuroSCORE II significantly improved overall model fit (Likelihood Ratio Test, $p = 0.020$) and increased the Nagelkerke R^2 from 0.259 to 0.342. The area under the ROC curve (AUC) also increased from 0.842 to 0.864, indicating enhanced discriminative ability for 30-day mortality. Higher nutritional risk was also associated with prolonged intensive care unit (ICU)/hospital stay and increased rates of atrial fibrillation, pneumonia, and acute kidney injury.

Conclusion:

MNA is an independent predictor of early postoperative mortality in cardiac surgery patients and provides incremental prognostic value when added to EuroSCORE II. Incorporating nutritional assessment into preoperative evaluation may enhance risk stratification and support targeted interventions to improve surgical outcomes.

Trial registration: Not applicable.

Key words: Malnutrition; Nutritional assessment; Open-heart surgery; Mini Nutritional Assessment; EuroSCORE II; Postoperative complications; Risk stratification

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INTRODUCTION

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Cardiac surgery is a major operative intervention accompanied by significant physiological stress and a substantial risk of postoperative morbidity and mortality. Preoperative nutritional status has been recognized as a critical determinant influencing surgical outcomes, particularly in patients undergoing open heart surgery. Malnutrition in this population is associated with delayed wound healing, increased susceptibility to infections, organ dysfunction, and elevated mortality rates(1). Moreover, the perioperative period is characterized by a hypercatabolic state, insulin resistance, heightened inflammatory responses, and protein loss, all of which further exacerbate the impact of malnutrition on clinical outcomes(2,3).

The prevalence of malnutrition among patients undergoing cardiac surgery varies according to the assessment method and population studied, with reported rates ranging from approximately 20% to 45% in European and Middle Eastern cohorts (4). In Türkiye, recent studies using the NRS2002 and PNI tools have identified malnutrition risk in 20–25% of patients scheduled for open-heart surgery (5,6). These results highlight the substantial burden of nutritional risk in the regional cardiac surgery population and emphasize the need for routine preoperative nutritional assessment. However, nutritional risk screening is not consistently incorporated into preoperative risk stratification protocols in many cardiac surgery centers.

Multiple nutritional assessment tools have been developed to objectively evaluate patients' nutritional risk, including the Controlling Nutritional

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Status (CONUT) score (7), Nutritional Risk Screening 2002 (NRS2002) (8), Malnutrition Universal Screening Tool (MUST) (9), Nutritional Risk Index (NRI) (10), Subjective Global Assessment (SGA) (11), and Mini Nutritional Assessment (MNA) (12). These instruments integrate biochemical

anthropometric, and clinical parameters, offering multifaceted insights into patients' nutritional conditions. While these tools have been validated in various clinical contexts, comparative data regarding their predictive value for early postoperative outcomes in cardiac surgery remain limited (13–15).

Most previous cardiac surgery studies have evaluated the prognostic value of a single nutritional score in isolation. For example, the CONUT score has been linked to increased rates of postoperative atrial fibrillation and mortality(13), whereas the NRS2002 score has been associated with prolonged intensive care unit stays(15). Although few studies have compared multiple nutritional scores within the same patient cohort, such analyses remain relatively uncommon, and robust evidence on their comparative predictive performance for early mortality and morbidity in cardiac surgery is still limited.

The absence of a standardized approach for nutritional risk assessment in this setting poses challenges for identifying patients most likely to benefit from targeted preoperative nutritional interventions. A comprehensive risk stratification system that incorporates both conventional clinical risk

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factors and nutritional parameters may enable more accurate prognostication and guide tailored perioperative management strategies.

Therefore, the present study aimed to compare the prognostic performance of six preoperative nutritional scoring systems for the prediction of 30-day morbidity and mortality among patients undergoing open heart surgery. By identifying the scoring system with the highest predictive accuracy and examining its additive value when combined with the EuroSCORE II, this study addresses an important knowledge gap in the field and may inform the integration of nutritional assessment into routine preoperative evaluation in cardiac surgery. Ultimately, this approach aims to enhance patient outcomes and optimize healthcare resource utilization.

METHODS

Study Design and Population

This prospective cohort study included all consecutive adult patients (≥18 years) undergoing elective open heart surgery at Dokuz Eylul University Hospital between February 2025 and July 2025. The exclusion criteria were as follows: age <18 years, psychiatric disorders, current parenteral nutrition, pregnancy or breastfeeding, emergency surgery, and history of malignancy. Eligible patients were enrolled consecutively and followed for 30 days post-operatively. The final study sample comprised 120 patients who met the inclusion criteria and provided written informed consent.

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Ethical considerations

The study protocol was approved by the Dokuz Eylul University Ethics Committee (Approval No: 9680-GOA). All procedures were conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants prior to enrollment.

Nutritional assessment

Preoperative nutritional status was assessed via six validated scoring systems:

1. **Controlling Nutritional Status (CONUT)** – based on serum albumin, total cholesterol, and lymphocyte count.
2. **Nutritional Risk Screening 2002 (NRS2002)** – based on nutritional screening questionnaires and clinical parameters.
3. **Malnutrition Universal Screening Tool (MUST)** - based on BMI, unplanned weight loss, and acute disease effects.
4. **Nutritional Risk Index (NRI)** – calculated from serum albumin and weight parameters.
5. **Subjective Global Assessment (SGA)** – based on clinical judgment via patient history and physical examination.
6. **Modified Nutritional Assessment (MNA)** – integrating biochemical and anthropometric data according to established methodology.

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All nutritional scores were calculated according to published protocols and categorized into risk strata on the basis of literature-defined thresholds (low, moderate, high risk) (Supplementary Table S1). Although the Mini Nutritional Assessment was originally developed for elderly populations, it has been widely applied in mixed-age adult cohorts, and its components reflect nutritional and functional vulnerability that may be relevant beyond chronological age.

Outcomes

The primary outcome was 30-day all-cause mortality. **The secondary** outcomes included postoperative complications (atrial fibrillation, bleeding, acute kidney injury, surgical site infection, pneumonia), length of stay in the intensive care unit (ICU) and hospital ward, and perioperative blood product use.

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Data collection

Data, including demographic information, comorbidities, nutritional assessment scores, operative details, and postoperative outcomes, were collected prospectively via standardized case report forms. Laboratory analyses were performed via validated automated analyzers at the hospital's central laboratory. Nutritional scores were calculated by trained personnel blinded to the patients' postoperative outcomes.

Statistical analysis

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Continuous variables were tested for normality via the Shapiro–Wilk test and are presented as the means ± standard deviations (SDs) or medians with interquartile ranges (IQRs), as appropriate. Categorical variables are expressed as frequencies and percentages. Univariate and multivariate logistic regression analyses were performed to evaluate associations between nutritional scores and mortality or morbidity. Model performance was assessed via the area under the receiver operating characteristic (ROC) curve (AUC) and the Nagelkerke R^2 statistic. The AUCs of EuroSCORE II alone versus EuroSCORE II plus nutritional indices were compared via the **likelihood ratio test** for model fit improvement. Correlations between nutritional scores and lengths of stay were evaluated via Spearman's rank correlation coefficient. A two-tailed p value <0.05 was considered statistically significant. Analyses were performed via SPSS (version XX, IBM Corp., Armonk, NY, USA).

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RESULTS

Baseline characteristics

A total of 120 patients were included in the study. The incidence of at least one postoperative complication was 55.0% (n = 66), and the 30-day mortality rate was 9.2% (n = 11). Patients who developed complications were significantly older (65.3 ± 10.3 vs. 58.6 ± 12.9 years, p = 0.006), had a lower left ventricular ejection fraction (50.0 ± 9.4% vs. 53.4 ± 7.1%, p = 0.029), had a higher EuroSCORE II (3.79 ± 5.3 vs. 1.70 ± 2.4, p = 0.002), and had a higher prevalence of COPD (10.6% vs. 0%, p = 0.014). Nonsurvivors had a significantly lower BMI (23.3 ± 4.1 vs. 27.4 ±

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4.7 kg/m², p = 0.012) and markedly higher EuroSCORE II (9.19 ± 9.3 vs. 2.21 ± 2.9, p < 0.001). Other baseline variables, including sex distribution, diabetes mellitus, hypertension, chronic kidney disease, and peripheral artery disease, were not significantly different (Table 1).

Table 1. Baseline characteristics of patients according to complication and mortality status

Variables	Without Complication (n=54)	With Complication (n=66)	p value (Complication)	Survivors (n=109)	Nonsurvivors (n=11)	p value (Mortality)
Age (years)	58.6 ± 12.9	65.3 ± 10.3	0.006	61.53 ± 11.9	69.6 ± 9.4	0.037
BMI (kg/m²)	27.4 ± 4.4	26.6 ± 4.2	0.204	27.4 ± 4.7	23.3 ± 4.1	0.012
Sex (Male)	37 (45.7%)	44 (54.3%)	0.829	74 (91.4%)	7 (8.6%)	0.774
LVEF (%)	53.4 ± 7.1	50.0 ± 9.4	0.029	51.8 ± 8.6	48.6 ± 8.1	0.168
EuroSCORE II	1.70 ± 2.4	3.79 ± 5.3	0.002	2.21 ± 2.9	9.19 ± 9.3	<0.001
Diabetes Mellitus	19 (38.8%)	30 (61.2%)	0.255	42 (85.7%)	7 (14.3%)	0.106
Hypertension	29 (41.4%)	41 (58.6%)	0.352	65 (92.9%)	5 (7.1%)	0.363
COPD	0 (0%)	7 (100%)	0.014	5 (71.4%)	2 (28.6%)	0.067
Chronic Kidney Disease	1 (25%)	3 (75%)	0.413	3 (75%)	1 (25%)	0.264

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Peripheral Artery Disease	2 (50%)	2 (50%)	0.838	3 (75%)	1 (25%)	0.264
Statin use	32 (%59.3)	18 (%27.3)	<0.001	47 (%43.1)	3 (%27.3)	0.357

Legend: Values are presented as the means ± standard deviations for continuous variables and as numbers (percentages) for categorical variables. p values were calculated via Student's t test for continuous variables and via the chi-square test or Fisher's exact test for categorical variables, as appropriate. BMI: Body mass index; LVEF: Left ventricular ejection fraction; COPD: Chronic obstructive pulmonary disease.

The most common procedure was isolated CABG (69.2%), with a 30-day mortality rate of 7.2% and a mean EuroSCORE II of 1.85 ± 2.19. The highest mortality rates were observed for combined procedures, particularly CABG + MVR (50.0%) and CABG + AVR or MVR + TP (both 33.3%). These combined procedures were also associated with higher mean EuroSCORE II values than were isolated surgeries, suggesting a greater baseline surgical risk. (Table 2)

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Table 2. Mortality rates and EuroSCORE II scores by type of surgery

Surgery Type	Number of Patients (n)	Mortality (n)	Mortality Rate (%)	EuroSCORE II (mean ± SD)
ASD	5	0	0.0	0.99 ± 0.28
AVR	5	0	0.0	1.84 ± 1.76
AVR + MVR	1	0	0.0	1.97
AVR + Supracoronary tubular grafting	1	0	0.0	2.17

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Benthall	5	0	0.0	1.71 ± 0.63
CABG	83	6	7.2	1.85 ± 2.19
CABG + AVR	3	1	33.3	10.65 ± 8.30
CABG + MVR	6	3	50.0	16.02 ± 8.10
CABG + MVR + TP	1	0	0.0	8.73
MVR	5	0	0.0	2.96 ± 1.06
MVR + TP	3	1	33.3	2.57 ± 0.77
Supracoronary tubular grafting	2	0	0.0	1.06 ± 0.80

Legend: Mortality rates are calculated as the proportion of deaths among patients undergoing each type of surgery. The values are presented as absolute numbers and percentages. Abbreviations: ASD, atrial septal defect; AVR, aortic valve replacement; MVR, mitral valve replacement; TP, tricuspid valve plasty; CABG, coronary artery bypass grafting.

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Univariable Analysis for 30-Day Mortality

In the univariable logistic regression, all six nutritional indices—CONUT, NRS2002, MUST, NRI, SGA, and MNA—were significantly associated with 30-day mortality, alongside EuroSCORE II. The odds ratios ranged from 0.709 for MNA to 3.440 for SGA, with Nagelkerke R^2 values between 0.093 and 0.285 (Table 3).

Table 3. Univariable logistic regression analysis of nutritional scores and EuroSCORE II for the prediction of 30-day mortality

Variable	OR (95% CI)	p value	Nagelkerke R^2

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EuroSCORE II	1.233	<0.001	0.259
CONUT	1.361	0.018	0.093
NRS2002	2.006	0.002	0.167
MUST	2.445	<0.001	0.203
NRI	0.892	0.001	0.205
SGA	3.440	0.011	0.106
MNA	0.709	<0.001	0.285

Legend: OR: odds ratio; CI: confidence interval; EuroSCORE II: European System for Cardiac Operative Risk Evaluation II; CONUT: Controlling Nutritional Status; NRS2002: Nutritional Risk Screening 2002; MUST: Malnutrition Universal Screening Tool; NRI: Nutritional Risk Index; SGA: subjective global assessment; MNA: Mini Nutritional Assessment. Odds ratios, 95% confidence intervals, and p values are from univariable logistic regression analyses. Nagelkerke R^2 indicates the proportion of variance explained by each model.

Categorical nutritional risk and mortality

Categorical comparisons of nutritional risk scores revealed significant differences in 30-day mortality across the CONUT, NRS-2002, MUST, MNA, and SGA systems, with p values all less than 0.05. The highest mortality rates were observed in the high-risk groups of MNA (44.4%), SGA (35.0%), and CONUT (36.4%). (Table 4)

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Table 4. Distribution of mortality according to nutritional risk categories

Nutritional Score	Category	Mortality Present n (%)	Mortality Absent n (%)	p value
CONUT	Normal	3 (5.2%)	55 (94.8%)	
	Mild	4 (8.0%)	46 (92.0%)	
	Moderate	4 (36.4%)	7 (63.6%)	
	Severe	0 (0.0%)	1 (100.0%)	0.011

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NRS2002	Normal	3 (3.4%)	84 (96.6%)	
	At Risk	8 (24.2%)	25 (75.8%)	<0.001
MUST	Low Risk	3 (3.2%)	90 (96.8%)	
	Medium Risk	8 (30.8%)	18 (69.2%)	
	High Risk	0 (0.0%)	1 (100.0%)	<0.001
NRI	Normal	3 (3.8%)	76 (96.2%)	
	Mild	0 (0.0%)	6 (100.0%)	
	Moderate	8 (27.6%)	21 (72.4%)	
	Severe	0 (0.0%)	6 (100%)	0.001
MNA	Well Nourished	2 (2.6%)	75 (97.4%)	
	At Risk	5 (14.7%)	29 (85.3%)	
	Malnourished	4 (44.4%)	5 (55.6%)	<0.001
SGA	A	4 (4.2%)	92 (95.8%)	
	B	7 (35.0%)	13 (65.0%)	
	C	0 (0.0%)	4 (100.0%)	<0.001

Legend: CONUT: Controlling Nutritional Status; NRS2002: Nutritional Risk Screening 2002; MUST: Malnutrition Universal Screening Tool; NRI: Nutritional Risk Index; MNA: Mini Nutritional Assessment; SGA: Subjective Global Assessment. The values are presented as numbers (percentages). p values were calculated via the chi-square test or Fisher's exact test, as appropriate.

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Multivariate analysis

When EuroSCORE II and individual nutritional scores were included in the multivariable logistic regression models, MNA emerged as the only independent predictor of 30-day mortality (p = 0.020). The addition of MNA to EuroSCORE II significantly improved the overall model fit

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(likelihood ratio test, p = 0.020) and increased the Nagelkerke R^2 from 0.259 to 0.342. The AUC also increased from 0.842 to 0.864, indicating enhanced discriminative ability (Table 5).

Table 5. Multivariable logistic regression models combining EuroSCORE II and nutritional scores for the prediction of 30-day mortality

Model	EuroSCORE II (p)	Nutrition Score (p)	Nagelkerke R^2
EuroSCORE II + CONUT	0.005	0.553	0.264
EuroSCORE II + NRS2002	0.025	0.334	0.272
EuroSCORE II + MUST	0.023	0.071	0.303
EuroSCORE II + NRI	0.018	0.061	0.312
EuroSCORE II + SGA	0.006	0.606	0.263
EuroSCORE II + MNA	0.068	0.020	0.342

Legend: EuroSCORE II: European System for Cardiac Operative Risk Evaluation II; CONUT: Controlling Nutritional Status; NRS2002: Nutritional Risk Screening 2002; MUST: Malnutrition Universal Screening Tool; NRI: Nutritional Risk Index; SGA: Subjective Global Assessment; MNA: Mini Nutritional Assessment. p values indicate the statistical significance of variables in multivariable logistic regression models. Nagelkerke R^2 indicates the proportion of variance explained by each model.

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ICU and Hospital Length of Stay

Prolonged ICU stay (>2 days) was significantly associated with a higher EuroSCORE II (p = 0.003), a higher SGA category (p = 0.015), and a

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lower MNA score (p = 0.021). Prolonged hospital stay (>10 days) was associated with higher NRS2002 (p < 0.001), MUST (p = 0.004), and SGA (p = 0.006) scores and lower MNA (p = 0.009) scores. Continuous score analysis confirmed these associations (Table 6).

Table 6. Univariable logistic regression analysis of nutritional scores and EuroSCORE II scores for prolonged ICU and hospital stays

Variable	OR (ICU >2 days)	p (ICU)	OR (Hospital >10 days)	p (Hospital)
EuroSCORE II	1.236	.010	1.286	.002
CONUT	1.105	.366	1.569	<.001
NRS2002	1.694	.007	2.871	<.001
MUST	1.279	.320	3.640	<.001
NRI	0.921	.002	0.836	<.001
SGA	3.346	.006	6.013	<.001
MNA	0.804	.003	0.642	<.001

Legend: OR: odds ratio; ICU: intensive care unit; EuroSCORE II: European System for Cardiac Operative Risk Evaluation II; CONUT: controlling nutritional status; NRS2002: Nutritional Risk Screening 2002; MUST: Malnutrition Universal Screening Tool; NRI: Nutritional Risk Index; SGA: subjective global assessment; MNA: Mini Nutritional Assessment. An ICU stay >2 days and a hospital stay >10 days were considered prolonged stays. p values were calculated from univariable logistic regression.

Postoperative Complications and Clinical Course Summary

Postoperative atrial fibrillation was the most frequent complication (34.2%), followed by bleeding (12.5%), pneumonia (10.8%), acute kidney injury (4.2%), and wound infection (9.2%). AF incidence was significantly greater in patients with elevated CONUT (p = 0.019), NRS2002 (p =

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0.028), and MUST (p = 0.012) scores; lower MNA (p = 0.001); and lower NRI (p = 0.001). Pneumonia occurred more often in those with higher NRS2002 (p = 0.018) and MUST (p = 0.015) values and lower MNA (p = 0.002) values. AKI was significantly associated with higher MUST (p = 0.031), higher SGA (p = 0.041), lower MNA (p = 0.001) and lower NRI (p=0.002). No nutritional index was significantly associated with bleeding or wound infection. (Table 7)

Table 7. Postoperative complications in the study cohort

Complication	Number of Patients (n)	Percentage (%)
Mortality	11	9.2
Postoperative atrial fibrillation (AF)	41	34.2
Bleeding	15	12.5
Acute kidney injury (AKI)	5	4.2
Wound infection	11	9.2
Pneumonia	13	10.8

Legend: AF: Atrial fibrillation; AKI: Acute kidney injury. The values are presented as absolute numbers and percentages of the total study population (n = 120).

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ROC analysis demonstrated that the MNA had the highest AUC for predicting AF (0.657), pneumonia (0.697), and AKI (0.853) among all nutritional scores.

The mean perioperative red blood cell transfusion requirement was 1.98 ± 1.32 units, and the mean fresh frozen plasma use was 1.68 ± 1.72

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units. All nutritional scores except NRI were significantly associated with increased blood product use. The strongest associations for FFP were with NRS2002 and CONUT (both $p < 0.001$), whereas for RBC transfusion, the largest differences were between MNA categories ($p < 0.001$).

DISCUSSION

This prospective cohort study evaluated and compared the prognostic value of six widely used preoperative nutritional scoring systems—CONUT, NRS2002, MUST, NRI, SGA, and MNA—in the prediction of 30-day morbidity and mortality among patients undergoing elective open heart surgery. The findings indicate that all scores, with the exception of the NRI according to the categorical analysis, were significantly associated with early postoperative mortality according to the univariable models. Among these, the Mini Nutritional Assessment (MNA) demonstrated the strongest independent predictive ability after adjustment for EuroSCORE II. Importantly, the addition of MNA to EuroSCORE II enhanced the model's discriminative capacity for 30-day mortality, as reflected by an increase in the AUC from 0.842 to 0.864 and in the Nagelkerke R^2 from 0.259 to 0.342. Furthermore, lower MNA values were associated with prolonged intensive care unit and hospital stays; increased incidence rates of postoperative atrial fibrillation, pneumonia, and acute kidney injury; and greater perioperative blood product use.

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The prognostic impact of malnutrition in cardiac surgery has been consistently demonstrated in the literature (13,15,16). The reported prevalence rates range between 20% and 45% in European and Middle Eastern cohorts and 20–25% in studies from Türkiye (5,6). Previous studies have shown that malnutrition—often defined via a single nutritional score—is associated with increased postoperative complications and mortality. For example, CONUT score has been linked to late mortality after coronary artery bypass grafting (13,14), whereas NRS2002 score has been associated with prolonged intensive care unit stays(15). Although several studies have compared multiple nutritional indices within the same cohort, such analyses remain relatively scarce, and direct evidence on the comparative predictive accuracy of these tools for early postoperative outcomes in cardiac surgery patients is still limited.

The present study addresses this gap by directly comparing six nutritional scoring systems within the same cohort, allowing objective evaluation of their relative prognostic performance. Our results support previous observations that comprehensive nutritional assessments incorporating multiple domains—such as anthropometric, biochemical, and functional measures—are superior to single-parameter screening (1). Our findings suggest that MNA provides superior predictive value for early postoperative mortality. Unlike indices that rely on biochemical markers susceptible to short-term perioperative fluctuations, MNA is based on anthropometric parameters, offering a stable reflection of a patient’s body mass reserves and overall nutritional adequacy(12). This

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independence from biochemical variables may be particularly advantageous in cardiac surgery patients, many of whom receive lipid-lowering medications such as statins. In the present cohort, statin therapy was common (Table 1). These agents can reduce total cholesterol levels irrespective of nutritional status, potentially leading to misclassification in scores that incorporate cholesterol, such as CONUT, and thereby diminishing their predictive accuracy. By avoiding biochemical markers influenced by pharmacological treatment, MNA may more accurately reflect the underlying nutritional state in this population.

The additive prognostic value of MNA when combined with EuroSCORE II underscores the importance of integrating nutritional assessment into established cardiac surgical risk models. EuroSCORE II is widely used for operative risk estimation; however, it does not account for nutritional status, which has a substantial impact on postoperative recovery(17). By including MNA, clinicians may improve the identification of high-risk patients who could benefit from targeted nutritional optimization before surgery.

Although the mean EuroSCORE II value in isolated CABG patients was relatively low, several early mortality events occurred in patients classified as low surgical risk. This observation suggests that factors not captured by EuroSCORE II—particularly nutritional and functional vulnerability—may contribute to early postoperative mortality and supports the complementary prognostic role of nutritional assessment.

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From a clinical perspective, incorporating nutritional screening into the preoperative workflow is feasible and inexpensive and may guide individualized interventions such as dietary counseling, supplementation, or specialized perioperative nutrition plans (1,18). Given the associations between malnutrition and prolonged ICU/hospital stays, postoperative complications, and increased resource utilization, addressing nutritional risk may have both patient-centered and economic benefits.

Crucially, nutritional risk stratification should serve as a trigger for action rather than a purely descriptive exercise. Once identified, patients at nutritional risk may be directed toward appropriate perioperative care pathways—ranging from early postoperative nutritional support in urgent settings to preoperative optimization strategies when clinical circumstances permit—thereby translating risk identification into meaningful clinical benefit.

This study has notable strengths, including its prospective design, use of multiple validated nutritional assessment tools, and evaluation of both mortality and morbidity outcomes. Nonetheless, several limitations warrant consideration. The single-center design and modest sample size may limit generalizability, and the follow-up period was restricted to 30 days. Additionally, although key confounders were adjusted for, residual confounding cannot be entirely excluded. The relatively small number of mortality events limited the complexity of multivariable modeling and may have increased the risk of overfitting; therefore, the multivariable analyses were intentionally restricted to parsimonious, hypothesis-driven

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models and should be interpreted as exploratory. Multiple nutritional scores were evaluated within a pre-specified comparative framework, and the findings should be interpreted in light of the study's exploratory and hypothesis-generating nature. Finally, regional and ethnic differences in body composition and dietary patterns may influence the applicability of these results to other populations. While this study focused on early postoperative outcomes within 30 days, the same cohort is being prospectively followed to assess 1-year outcomes. This future analysis will enable evaluation of the long-term prognostic impact of preoperative nutritional status and determine whether the predictive superiority of MNA persists over extended follow-up periods.

CONCLUSION

In conclusion, the MNA independently predicted 30-day mortality after elective open heart surgery and improved prognostic accuracy when added to EuroSCORE II. Its independence from biochemical variables may provide an advantage in patients receiving lipid-lowering therapy. The incorporation of MNA into preoperative risk assessment could help identify high-risk patients and guide targeted nutritional interventions.

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List of abbreviations

AF – Atrial fibrillation

AKI – Acute kidney injury

ASD – Atrial septal defect

AUC – Area under the curve

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AVR – Aortic valve replacement

BMI – Body mass index

CABG – Coronary artery bypass grafting

CI – Confidence interval

CONUT – Controlling Nutritional Status

COPD – Chronic obstructive pulmonary disease

EuroSCORE II – European System for Cardiac Operative Risk Evaluation II

FFP – Fresh frozen plasma

ICU – Intensive care unit

IQR – Interquartile range

LVEF – Left ventricular ejection fraction

MNA – Mini Nutritional Assessment

MUST – Malnutrition Universal Screening Tool

NRI – Nutritional Risk Index

NRS2002 – Nutritional Risk Screening 2002

OR – Odds ratio

PNI – Prognostic Nutritional Index

ROC – Receiver operating characteristic

SD – Standard deviation

SGA – Subjective Global Assessment

TP – Tricuspid valve plasty

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Declarations

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Ethics approval and consent to participate

The study protocol was approved by the Dokuz Eylul University Ethics Committee (Approval No: 9680-GOA). All procedures were conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants prior to enrollment.

Consent for publication

Not applicable.

Availability of data and materials

All data generated or analysed during this study are included in this published article [Supplementary file].

.**Competing interests**

The authors declare that they have no competing interests.

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Authors' contributions

CS conceived and designed the study, performed the statistical analysis, and was a major contributor in writing the manuscript.

GKK contributed to writing and revising the manuscript.

GG **c**ollected and coded the patient data in a blinded manner without access to the study outcomes.

All authors read and approved the final manuscript.

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Authors' information

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