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*Clinical Investigation*

# Value of ACEF-II Score in Predicting Major Adverse Cardiac Events in Patients With Non–ST-Segment Elevation Myocardial Infarction and Unstable Angina

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**Keywords:** Angina, unstable; major adverse cardiac events; non-ST elevated myocardial infarction; outcome assessment; prognosis

## Abstract

**Background:** A score based on age, creatinine level, and ejection fraction as well as hematocrit value and the presence of emergency surgery (ACEF-II) has been proposed to have predictive value for risk stratification in cardiac surgery. This study aimed to evaluate its utility in patients with non–ST-segment elevation myocardial infarction and unstable angina (NSTEMI-ACS) to predict 1-year major adverse cardiac events (MACE).

**Methods:** In all, 768 patients with NSTEMI-ACS were enrolled in the study. After propensity score matching, the MACE and control groups comprised 168 patients each. Blood samples were drawn from patients during emergency department admission and hospitalization. The Global Registry of Acute Coronary Events, Acute Coronary Treatment and Intervention Outcome Network Intensive Care Unit risk, ACEF, and ACEF-II scores of each patient were evaluated.

**Results:** Mean (SD) age of the study population was 63.07 (12.39) years; 547 (71.2%) patients were male. After propensity score matching for 7 variables, a comparison of the matched groups revealed that patients with MACE had higher heart rates and rates of ST-segment deviation, cardiac arrest, and creatinine levels and lower left ventricular ejection fraction and albumin, hemoglobin, hematocrit, systolic blood pressure, and oxygen saturation values. Multivariate logistic regression analysis revealed that ACEF-II score had the highest odds ratio of the evaluated scores, at 1.41 (95% CI, 1.12-1.81; $P$ = .005). The ACEF score did not reach statistical significance for the prediction of 1-year MACE according to multivariate analysis. In addition to type of risk score, left ventricular ejection fraction and heart rate had predictive value for 1-year MACE. An ACEF-II score cutoff of 1.82 predicted 1-year MACE, with a sensitivity of 61.2% and a specificity of 76.2%.

**Conclusion:** ACEF-II score, which is easy to calculate, could be used to predict 1-year MACE in patients with NSTEMI-ACS.

## Introduction

The term *acute coronary syndrome* (ACS) encompasses clinical syndromes, including ST-segment elevation myocardial infarction (STEMI), non–STEMI (NSTEMI), and unstable angina, all of which are characterized by partial or complete occlusion of blood flow in the coronary arteries, resulting in ischemia or infarction of myocardial tissue. Because the pathophysiologic processes underlying STEMI differ from those underlying NSTEMI and unstable angina (NSTEMI-ACS), the acute and long-term management of these

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syndromes also differs.[1,2] Similarly, the short-term and long-term prognoses of NSTEMI-ACS differ from those of STEMI. Although patients with STEMI have poor short-term outcomes and high rates of in-hospital mortality, the clinical profile and long-term prognosis of patients with NSTEMI-ACS are worse than those of patients with STEMI.[3] In general, patients with NSTEMI-ACS are older, have higher rates of comorbidities and coronary artery disease, and are less likely to receive optimal medical therapy upon hospital discharge than patients with STEMI.[3-5] Current guidelines have recommended that risk stratification of patients with NSTEMI-ACS should be based on clinical findings; vital signs; electrocardiographic findings; and biochemical variables, including high-sensitivity cardiac troponin values.[1] Lower rates of mortality have been seen in patients with higher risk profiles who undergo early invasive treatment.[1]

To date, several risk scores have been investigated to assess their prognostic value in patients with NSTEMI-ACS. Studies have shown that the Global Registry of Acute Coronary Events (GRACE) score provides both in-hospital and 6-month prognostic information for patients with ACS.[6,7] As such, the GRACE risk score can be used for risk stratification in patients with level IIa evidence.[1] The Acute Coronary Treatment and Intervention Outcome Network Intensive Care Unit (ACTION-ICU) score has been found to predict in-hospital complications in patients with NSTEMI requiring ICU admission.[8] This score requires several variables to calculate, however, and its long-term prognostic value has not been evaluated. Interest in simplified approaches to risk assessment has led researchers to develop new scoring systems. The age, creatinine level, and ejection fraction (ACEF) score has been proposed to assess outcomes among patients undergoing elective cardiac surgery.[9] This score also provides information about major adverse cardiac events (MACE), kidney failure, bleeding, and thrombotic events after percutaneous coronary intervention.[10-13] Kristic et al[14] reported that the ACEF score had better long-term predictive value than the GRACE score and the Synergy of Percutaneous Coronary Intervention With Taxus and Cardiac Surgery score in patients with NSTEMI-ACS who received either invasive or conservative treatment approaches.

It has been proposed in recent years that adding clinical variables, including hematocrit value and the presence of emergency surgery, to the ACEF score (ACEF-II) better predicts outcomes following cardiac surgery. Given that the ACEF has better prognostic value than do other scoring systems used clinically in patients with NSTEMI-ACS, this research aimed to assess the value of the ACEF-II score in patients with NSTEMI-ACS and to compare its prognostic performance with the scores of GRACE, ACTION-ICU, and ACEF.

### Key Points:

- GRACE, ACTION-ICU, ACEF, and ACEF-II scores were compared in patients with NSTEMI-ACS.
- Compared with the other scores evaluated, ACEF-II score had the highest OR for predicting MACE.

### Abbreviations

ACEF, age, creatinine, ejection fraction

ACEF-II, age, creatinine level, and ejection fraction, as well as hematocrit value and the presence of emergency surgery

ACS, acute coronary syndrome

ACTION-ICU, Acute Coronary Treatment and Intervention Outcomes Network Intensive Care Unit

GRACE, Global Registry of Acute Coronary Events

ICU, intensive care unit

LVEF, left ventricular ejection fraction

MACE, major adverse cardiac events

NSTEMI, non–ST-segment elevation myocardial infarction

OR, odds ratio

STEMI, ST-segment elevation myocardial infarction

## Patients and Methods

This retrospective study was conducted at a single tertiary hospital. The records of patients with NSTEMI and unstable angina diagnosed between August 2016 and March 2022 were reviewed. The diagnosis of NSTEMI and unstable angina was made according to the criteria recommended by current guidelines.[1] Patients with acute infection, systemic inflammation, rheumatic disease, hematologic disease, malignancy, severe hepatic dysfunction, end-stage kidney failure, or missing data were excluded. After exclusion criteria were applied, 768 patients were eligible for study inclusion. Patients' clinical features and risk factors were recorded. Major adverse cardiac events were defined as 1-year mortality, stent thrombosis, and recurrent myocardial infarction. Data on death were obtained from hospital records and the National Health Records System. The Bakırköy Dr Sadi Konuk Education and Research

Hospital Ethics Committee approved the study (approval No. 237), which adhered to the tenets of the Declaration of Helsinki.

All patients underwent coronary angiography performed by 2 experienced interventional cardiologists. Coronary angiograms were obtained via femoral access using the Judkins technique (Siemens Healthineers Artis zee Cath Lab). Then, treatment decisions—including medical management, percutaneous coronary intervention, and coronary bypass graft surgery—were made by the heart team, which included an interventional cardiologist, a cardiovascular surgeon, and an imaging specialist. All patients received acetylsalicylic acid and a P2Y12 inhibitor as well as guideline-directed medical treatment. Blood samples were collected upon admission to the emergency department and during hospitalization in the coronary care unit. The samples were subsequently centrifuged at 3,000*g* for 10 minutes. Biochemical and hematologic assessments were performed using an AU2700 Chemistry Analyzer (Beckman Coulter) and a Sysmex XE-5000 Automated Hematology Analyzer.

Four different risk scores were calculated to assess patient risk. The clinical parameters that were used to calculate the GRACE risk score were creatinine levels, cardiac marker levels, age, heart rate, systolic blood pressure, presence of ST-segment deviation, cardiac arrest, and Killip classification of heart failure.[15] The GRACE risk score was the sum of the scores obtained for each parameter. The following clinical characteristics were used to calculate the ACTION-ICU score: age, serum creatinine and cardiac marker levels, heart rate, systolic blood pressure, the presence of ST-segment deviation and heart failure symptoms, history of revascularization, and chronic lung disease.[8] The ACEF risk score was calculated by dividing age by the left ventricular ejection fraction (LVEF, in %) and adding 1 point if the creatinine level was greater than 2 mg/dL.[9] The ACEF-II score was calculated from the following variables: age to LVEF ratio, serum creatinine level, history of emergency cardiac surgery, and hematocrit value.[16]

Propensity score matching of the 2 groups was performed according to baseline clinical variables, including age; body mass index; smoking status; presence of diabetes mellitus or peripheral artery disease; and use of angiotensin-converting enzyme inhibitors, angiotensin receptor blockers, or antidiabetic medication. After propensity score matching, a total of 336 patients were included in the study. The MACE and control groups comprised 168 patients each. Figure 1 shows the study flowchart.

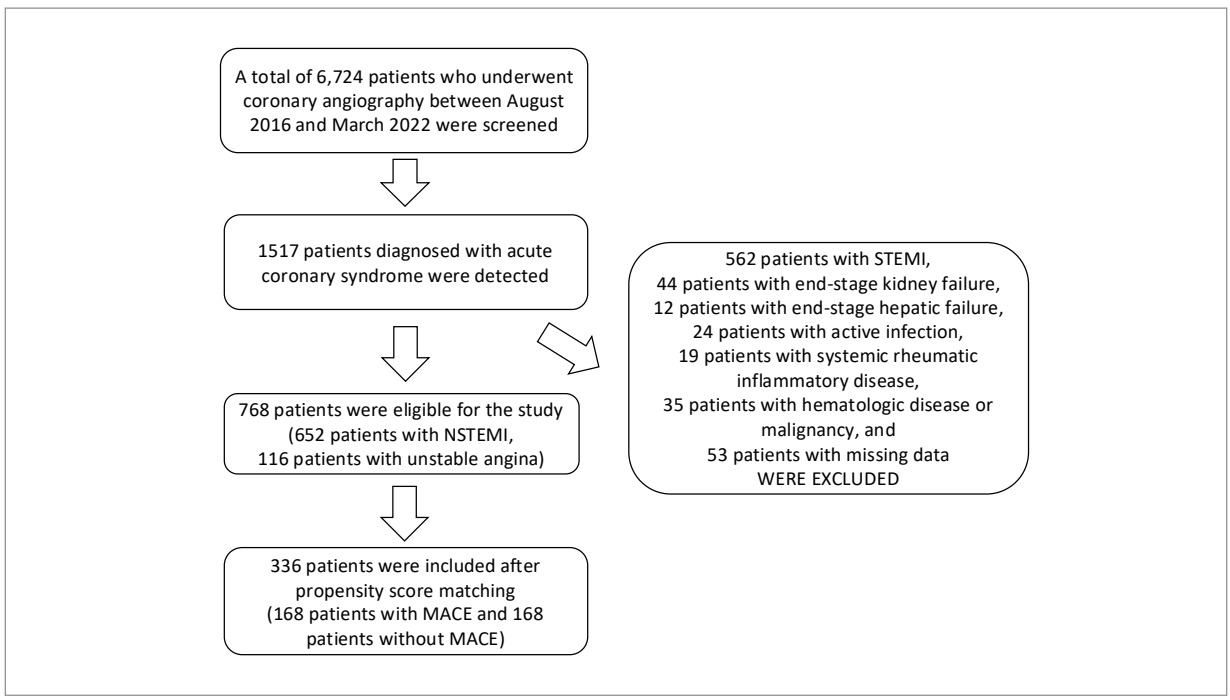


**Fig. 1** Flowchart of the study.

NSTEMI, non–ST-segment elevation myocardial infarction; STEMI, ST-elevation myocardial infarction.

### Statistical Analysis

Parametric data are expressed as mean (SD). Categorical variables are expressed as numbers and percentages. Comparisons between groups with or without MACE were made using Mann-Whitney *U* test or independent-samples *t* test according to the distribution of the data. Categorical variables were compared using $\chi^2$ test. To adjust the data for confounding variables, a propensity score matching analysis was performed, with 1-to-1 matching. The propensity score was estimated using a multivariate logistic regression model with 7 variables: age; body mass index; the presence of diabetes and peripheral artery disease; smoking status; use of angiotensin-converting enzyme inhibitors or angiotensin receptor blockers; and use of antidiabetic medication. Because researchers aimed to evaluate the ability of clinical scoring systems to predict MACE, the variables included in the clinical scoring systems were not matched. The balance of the baseline covariates in the matched cohort was examined using standardized mean differences. Successful matching was defined as a standardized mean difference less than 0.10. A receiver operating characteristic curve and the associated area under the curve value and CI were used to determine the cutoff ACEF-II score for 1-year MACE. The optimum cutoff was determined based on the Youden index, and the selectivity and sensitivity values were determined according to this cutoff. Univariate logistic regression was conducted to determine the independent prognosticators of 1-year MACE. Variables found to be statistically significant in the univariate analysis were analyzed again using multivariable regression. A 2-tailed $P<.05$ was considered statistically significant. SPSS, version 29, statistical software (IBM Corp) was used to analyze the collected data.

## Results

The mean (SD) age of the study population was 63.07 (12.39) years; 547 (71.2%) participants were male. In the unmatched patient groups, patients who experienced MACE (n = 195) were more likely to be older; use fewer angiotensin-converting enzyme inhibitors and angiotensin receptor blockers; have diabetes, peripheral artery disease, chronic obstructive pulmonary disease, or ST-segment deviation revealed on electrocardiogram; experience in-hospital shock or cardiac arrest; have a lower body mass index and LVEF and lower values of systolic blood pressure, high-density lipoprotein cholesterol, hemoglobin, and oxygen saturation; and have a higher heart rate and neutrophil count and higher levels of creatinine and cardiac troponin-C. Type of NSTEMI-ACS and patient sex did not differ between the 2 groups. The clinical and laboratory characteristics of the unmatched groups are shown in Table I.

A total of 168 patient pairs with and without MACE, respectively, were identified through propensity score matching. After propensity score matching for 7 variables, a comparison of the matched groups revealed that patients with MACE had higher heart rates, rates of ST-segment deviation and cardiac arrest, and creatinine levels and lower LVEF; oxygen saturation; albumin, hemoglobin, and hematocrit values; and lower systolic blood pressure. Two-group comparisons after propensity score matching are shown in Table I.

According to the results of univariate logistic regression analysis, the presence of ST-segment deviation on electrocardiogram (odds ratio [OR], 6.44), LVEF (OR, 0.95), creatinine (OR, 2.34), albumin (OR, 0.45), hemoglobin (OR, 0.85), heart rate (OR, 1.03), systolic blood pressure (OR, 0.99), oxygen saturation (OR, 0.87), cardiac arrest (OR, 8.35), GRACE score (OR, 1.02), ACTION-ICU score (OR, 1.25), ACEF score (OR, 2.14), and ACEF-II score (OR, 1.65) were found to be independent predictors of 1-year MACE (Table II). In all, 4 types of multivariate regression analyses that included 4 risk scores separately were performed. Results revealed that among the risk scores, the ACEF-II score had the highest OR, at 1.41. The ACEF score did not reach statistical significance for the prediction of 1-year MACE, according to multivariate analysis. In addition to the type of risk score, LVEF and heart rate also had predictive value for 1-year MACE (Table III).

A receiver operating characteristic curve analysis revealed that the ACEF-II score had the ability to detect 1-year MACE (area under the curve, 0.63; $P < .001$; 95% CI, 0.57-0.69) (Fig. 2). An ACEF-II cutoff score of 1.82 predicted 1-year MACE, with a sensitivity of 61.2% and a specificity of 76.2%.

## Discussion

Results of this research suggest that the ACEF-II score provides the best information regarding 1-year MACE rates compared with more complex risk scores, including the GRACE and ACTION-ICU risk scores. Furthermore, findings suggest that the ACEF-II score better

**TABLE I. Clinical and Biochemical Characteristics of Unmatched and Matched Patient Groups**

| | | Unmathced patient groups | | | Mathced patient groups | | | |
|---|---|---|---|---|---|---|---|---|
| **Variables** | **Full Sample (n=768)** | **MACE (–) (n=573)** | **MACE (+) (n=195)** | ***P*** | **MACE (–) (n=168)** | **MACE (+) (n=168)** | ***P*** | **SMD** |
| Age, mean (SD), y | 63.07 (2.39) | 61.36 (11.85) | 68.12 (12.58) | <.001 | 67.02 (12.19) | 66.91 (12.73) | .98 | 0.008 |
| Sex, No. (%) | | | | .10 | | | >.99 | — |
| Female | 221 (28.8) | 156 (27.2) | 65 (33.3) | | 55 (32.7) | 55 (32.7) | | |
| Male | 547 (71.2) | 417 (72.8) | 130 (71.2) | | 113 (67.3) | 113 (67.3) | | |
| Body mass index, mean (SD) | 28.65 (9.50) | 28.75 (5.89) | 28.34 (15.95) | <.001 | 28.67 (6.12) | 28.76 (17.10) | .07 | 0.007 |
| Hypertension, No. (%) | 702 (91.4) | 522 (91.1) | 180 (92.3) | .60 | 158 (94) | 154 (91.7) | .40 | — |
| Diabetes, No. (%) | 285 (37.1) | 194 (33.9) | 91 (46.7) | .001 | 72 (42.9) | 73 (43.5) | .91 | 0.001 |
| Hyperlipidemia, No. (%) | 657 (85.5) | 489 (85.3) | 168 (86.2) | .78 | 158 (94) | 154 (91.7) | .40 | — |
| β-Blocker, No. (%) | 664 (86.5) | 494 (86.2) | 170 (87.2) | .73 | 142 (84.5) | 149 (88.7) | .26 | — |
| Angiotensin-converting enzyme inhibitor/ angiotensin receptor blocker, No. (%) | 609 (79.3) | 474 (82.7) | 135 (69.2) | <.001 | 136 (81) | 133 (79.2) | .68 | 0.05 |
| Calcium channel blocker, No. (%) | 243 (31.6) | 172 (30) | 71 (36.4) | .10 | 61 (38.1) | 58 (34.5) | .50 | — |
| Diuretic, No. (%) | 252 (32.8) | 178 (31.1) | 74 (37.9) | .08 | 64 (38.1) | 61 (36.3) | .74 | — |
| Statin, No. (%) | 324 (42.2) | 231 (40.3) | 93 (47.7) | .07 | 75 (44.6) | 79 (47) | .66 | — |
| Acetylsalicylic acid, No. (%) | 660 (85.9l | 494 (86.2) | 166 (85.1) | .71 | 142 (84.5) | 142 (84.5) | >.99 | — |
| Antidiabetic, No. (%) | 285 (37.1) | 193 (33.7) | 92 (47.2) | .001 | 72 (42.9) | 73 (43.5) | .91 | 0.001 |
| Peripheral artery disease, No. (%) | 143 (18.6) | 70 (12.2) | 73 (37.4) | <.001 | 50 (29.8) | 49 (29.2) | .91 | 0.001 |
| Chronic obstructive pulmonary disease, No. (%) | 124 (16.1) | 83 (14.5) | 41 (21) | .03 | 32 (19) | 33 (19.6) | .89 | |
| Smoking status, No. (%) | | | | .007 | | | .99 | 0.008 |
| No-smoking | 341 (44.4) | 250 (43.6) | 91 (46.6) | | 92 (54.8) | 92 (54.4) | | |
| Current smoker | 272 (35.4) | 219 (38.2) | 53 (27.2) | | 38 (22.6) | 39 (23.1) | | |
| Former smoker | 155 (20.2) | 104 (18.2) | 51 (26.2) | | 38 (22.6) | 38 (22.5) | | |
| ACS type, No. (%) | | | | .05 | | | .76 | |
| NSTEMI | 652 (84.9) | 498 (83.4) | 174 (89.2) | | 143 (85.1) | 145 (86.3) | | |
| Unstable angina | 116 (15.1) | 95 (16.6) | 21 (10.2) | | 25 (14.9) | 23 (13.7) | | |

*Continued*


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**TABLE I. Clinical and Biochemical Characteristics of Unmatched and Matched Patient Groups (Continued)**

| Variables | Full Sample (n=768) | Unmathced patient groups | | | Mathced patient groups | | | SMD |
|---|---|---|---|---|---|---|---|---|
| | | MACE (–) (n=573) | MACE (+) (n=195) | *P* | MACE (–) (n=168) | MACE (+) (n=168) | *P* | |
| ST segment deviation | 120 (15.6) | 43 (7.5) | 77 (39.5) | <.001 | 15 (8.9) | 65 (38.7) | <.001 | |
| Shock | 9 (1.2) | 2 (0.3) | 7 (3.6) | <.001 | 1 (0.6) | 6 (3.6) | .12 | |
| Cardiac arrest | 10 (1.3) | 1 (0.17) | 9 (4.6) | <.001 | 0 (0) | 8 (4.8) | .004 | |
| Emergency revascularization | 34 (4.4) | 16 (2.9) | 18 (9.2) | <.001 | 5 (3) | 13 (7.7) | .59 | |
| LVEF, mean (SD), % | 54.45 (8.90) | 55.78 (8.02) | 50.55 (10.14) | <.001 | 55.33 (7.60) | 51.11 (9.90) | <.001 | |
| Creatinine, mean (SD), mg/dL | 0.97 (0.54) | 0.89 (0.35) | 1.22 (0.83) | <.001 | 0.93 (0.33) | 1.20 (0.86) | .007 | |
| Low-density lipoprotein cholesterol, mean (SD), mg/dL | 125.04 (41.79) | 126.24 (42.11) | 121.50 (40.73) | .14 | 121.40 (40.23) | 121.29 (40.98) | .88 | |
| Triglycerides, mean (SD), mg/dL | 168.91 (99.54) | 174.84 (105.42) | 151.48 (77.44) | .004 | 162.90 (86.31) | 153.42 (79.13) | .37 | |
| High-density lipoprotein cholesterol, mean (SD), mg/dL | 42.25 (19.11) | 42.64 (19.53) | 41.09 (17.84) | .02 | 42.54 (11.84) | 40.39 (10.24) | .10 | |
| Albumin, mean (SD), g/L | 4.04 (0.49) | 4.13 (0.44) | 3.77 (0.54) | <.001 | 4.01 (0.44) | 3.82 (0.52) | .003 | |
| Cardiac troponin-C, mean (SD), ng/L | 4203.47 (9324.78) | 3797.07 (8531.89) | 5393.50 (11273.38) | .009 | 3737.07 (6964.08) | 4735.54 (8622.60) | .19 | |
| Hemoglobin, mean (SD), g/dL | 13.08 (2.12) | 13.42 (2.01) | 12.07 (2.11) | <.001 | 12.87 (1.90) | 12.19 (2.10) | .004 | |
| Hematocrit, mean (SD), % | 39.24 (6.36) | 40.27 (6.03) | 36.21 (6.34) | <.001 | 38.62 (5.70) | 36.58 (6.31) | .004 | |
| Neutrophil, mean (SD), $\times 10^9$/L | 5.93 (2.69) | 5.82 (2.79) | 6.26 (2.36) | .014 | 5.77 (2.41) | 6.19 (2.35) | .05 | |
| Platelet count, mean (SD), $\times 10^9$/L | 257.68 (81.99) | 257.87 (82.69) | 248.60 (79.70) | .59 | 255.51 (88.94) | 261.36 (83.12) | .42 | |
| Heart rate, min, mean (SD) | 87.22 (18.71) | 84.25 (16.61) | 95.96 (21.63) | <.001 | 84.90 (16.88) | 94.85 (20.36) | <.001 | |
| Systolic blood pressure, mean (SD), mm Hg | 141.32 (30.50) | 143.01 (27.96) | 136.37 (59) | .001 | 143.05 (28.52) | 137.25 (35.45) | .04 | |

*Continued*


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**TABLE I. Clinical and Biochemical Characteristics of Unmatched and Matched Patient Groups (Continued)**

| Variables | Full Sample (n=768) | Unmathced patient groups | | *P* | Mathced patient groups | | *P* | SMD |
|---|---|---|---|---|---|---|---|---|
| | | MACE (–) (n=573) | MACE (+) (n=195) | | MACE (–) (n=168) | MACE (+) (n=168) | | |
| Diastolic blood pressure, mean (SD), mm Hg | 78.64 (14.73) | 79.21 (13.81) | 76.81 (17.31) | .007 | 76.37 (13.73) | 77.46 (17.11) | .81 | |
| Oxygen saturation, mean (SD), % | 95.47 (3.38) | 96.11 (2.57) | 93.59 (4.59) | .001 | 95.65 (2.95) | 93.80 (4.68) | <.001 | |
| GRACE risk score | 122.01±37.58 | 112.69±27.90 | 149.40±47.72 | <.001 | 123.40±28.78 | 145.56±45.41 | <.001 | |
| ACTION-ICU risk score, mean (SD) | 5.54 (3.13) | 4.77 (2.39) | 7.79 (3.86) | <.001 | 5.36 (2.46) | 7.48 (3.64) | <.001 | |
| ACEF score, mean (SD) | 1.22 (0.46) | 1.14 (0.36) | 1.47 (0.60) | <.001 | 1.26 (0.37) | 1.42 (0.55) | .03 | |
| ACEF-II score | 1.68 (1.18) | 1.43 (0.86) | 2.43 (1.61) | <.001 | 1.60 (0.86) | 2.29 (1.50) | <.001 | |

ACEF, age, creatinine, ejection fraction; ACEF-II, age, creatinine level, and ejection fraction as well as hematocrit value and the presence of emergency surgery; ACS, acute coronary syndrome; ACTION-ICU, Acute Coronary Treatment and Intervention Outcomes Network Intensive Care Unit; GRACE, Global Registry of Acute Coronary Events; LVEF, left ventricular ejection fraction; MACE, major adverse cardiac events; NSTEMI, non–ST-segment elevation myocardial infarction; SMD, standardized mean difference.

SI conversion factor: To convert mg/dL to μmol/L for creatinine, multiply by 88.4. To convert mg/dL to mmol/L for cholesterol, multiply by 0.0259. To convert mg/dL to mmol/L for triglycerides, multiply by 0.0113. To convert g/dL to g/L, multiply by 10. To convert % to Proportion of 1.0 (hematocrit), multiply by 0.01.

[a] Propensity score matching was based on age; body mass index; diabetes status; smoking status; use of angiotensin-converting enzyme inhibitor, angiotensin receptor blocker, or antidiabetic medication; and peripheral artery disease. Adequate matching was defined as a standardized mean difference <0.10.

[b] $P < .05$ was considered significant.


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**TABLE II. Univariate Logistic Regression Analysis for Prediction of MACE After Propensity Score Matching (n = 168)**

| | OR | 95% CI | *P* value[a] |
|---|---|---|---|
| ST-segment deviation | 6.44 | 3.48-11.90 | <.001 |
| LVEF | 0.95 | 0.92-0.87 | <.001 |
| Creatinine | 2.34 | 1.42-3.86 | .001 |
| Albumin | 0.45 | 0.27-0.72 | .001 |
| Hemoglobin | 0.85 | 0.76-0.94 | .002 |
| Heart rate | 1.03 | 1.02-1.04 | <.001 |
| Systolic blood pressure | 0.99 | 0.99-1.001 | .10 |
| Oxygen saturation | 0.87 | 0.81-0.93 | <.001 |
| Cardiac arrest | 8.35 | 1.03-67.52 | .047 |
| GRACE risk score | 1.02 | 1.01-1.02 | <.001 |
| ACTION-ICU score | 1.25 | 1.12-1.35 | <.001 |
| ACEF score | 2.14 | 1.32-3.46 | .002 |
| ACEF-II score | 1.65 | 1.34-2.04 | <.001 |

ACEF, age, creatinine, ejection fraction; ACEF-II, age, creatinine level, and ejection fraction as well as hematocrit value and the presence of emergency surgery; ACTION-ICU; Acute Coronary Treatment and Intervention Outcomes Network Intensive Care Unit; GRACE; Global Registry of Acute Coronary Events; LVEF, left ventricular ejection fraction; MACE; major adverse cardiac events.

[a] $P < .05$ was considered significant.

**TABLE III. Multivariable Logistic Regression for the Prediction of 1-Year MACE After Propensity Score Matching**

| | GRACE risk score model | | | ACTION-ICU score model | | | ACEF score model | | | ACEF-II score model | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | OR | 95% CI | *P* value[a] | OR | 95% CI | *P* value[a] | OR | 95% CI | *P* value[a] | OR | 95% CI | *P* value[a] |
| LVEF | 0.96 | 0.94-0.99 | .005 | 0.99 | 0.94-0.99 | .03 | | | | | | |
| Albumin | 0.93 | 0.53-1.65 | .81 | 0.95 | 0.53-1.68 | .86 | 0.83 | 0.45-1.53 | .55 | 0.94 | 0.53-1.67 | .83 |
| Hemoglobin | 0.93 | 0.82-1.06 | .30 | 0.93 | 0.82-1.69 | .30 | 0.93 | 0.81-1.03 | .25 | | | |
| ST-segment deviation | | | | | | | 4.27 | 2.20-8.30 | <.001 | 3.86 | 1.97-7.56 | <.001 |
| Heart rate | | | | | | | 1.02 | 1.01 -1.03 | .01 | 1.02 | 1.01-1.03 | .01 |
| Systolic blood pressure | | | | | | | 0.99 | 0.99-1.01 | .61 | 0.99 | 0.99-1.01 | .53 |
| GRACE risk score | 1.01 | 1.01-1.02 | .002 | | | | | | | | | |
| ACTION-ICU score | | | | 1.19 | 1.09-1.30 | <.001 | | | | | | |
| ACEF score | | | | | | | 1.31 | 0.75-2.23 | .34 | | | |
| ACEF-II score | | | | | | | | | | 1.41 | 1.12-1.81 | .005 |

ACEF, age, creatinine, ejection fraction; ACEF-II, age, creatinine level, and ejection fraction as well as hematocrit value and the presence of emergency surgery; ACTION-ICU, Acute Coronary Treatment and Intervention Outcomes Network Intensive Care Unit; GRACE, Global Registry of Acute Coronary Events; LVEF, left ventricular ejection fraction.

[a] $P < .05$ was considered significant.

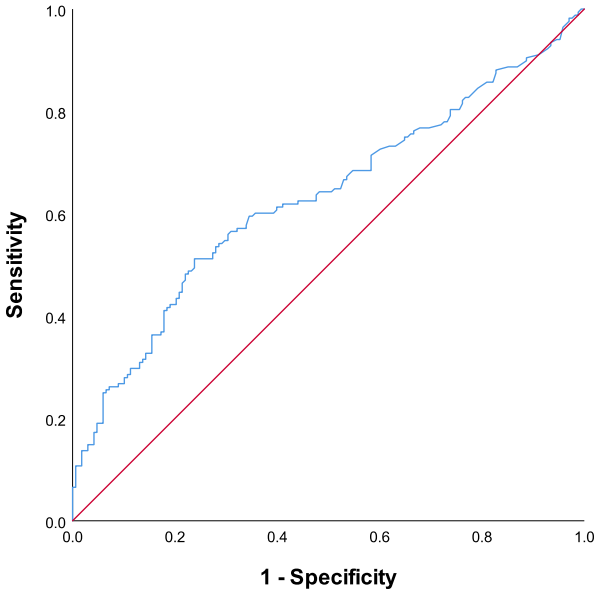


**Fig. 2** Receiver operating characteristic curve analysis of the score based on age, creatinine level, and ejection fraction, as well as hematocrit value and the presence of emergency surgery for the prediction of 1-year major adverse cardiac events.

predicted MACE than did the ACEF score among patients with NSTEMI-ACS.

Although a decrease in the incidence of STEMI has been reported in Europe and the United States, a similar decrease in the incidence of NSTEMI has not been reported.[17-19] Increased awareness and understanding of coronary artery risk factors and therapeutic strategies may result in a greater benefit of these interventions on the incidence of STEMI.[19,20] Similarly, although several studies have shown a reduction in STEMI mortality, NSTEMI mortality has remained unchanged, despite improvements in evidence-based therapies.[21,22] Therefore, the assessment of outcomes following NSTEMI is of great clinical interest. Early identification of patients at high risk of adverse events could save lives and improve long-term outcomes through the implementation of tailored therapies. Improved strategies to stratify patients according to risk are called for.

The GRACE risk score is one of the most popular risk scores developed in the preperfusion era. It is currently recommended in guidelines for risk stratification of patients with NSTEMI-ACS who receive evidence-based treatment according to their estimated risk. Its predictive value in patients with STEMI and in patients with NSTEMI-ACS has been demonstrated in various studies. A large registry of approximately 140,000 patients with ACS revealed good performance of the GRACE risk score in predicting in-hospital and 6-month mortality.[23] The GRACE risk score was found to be an effective discriminator of cardiac outcomes in patients with NSTEMI-ACS.[24,25] Yangiao et al[26] followed patients with NSTEMI for 4 years and reported that the GRACE score had a better discriminative value than did the Thrombolysis in Myocardial Infarction score for both in-hospital and long-term outcomes in East Asian patients.

The ACTION-ICU score was developed to identify hemodynamically stable patients who may experience clinical complications requiring ICU admission. This approach enables clinicians to optimize ICU resources during hospitalization of patients with NSTEMI-ACS. An ACTION-ICU risk score of 3 has been found to indicate that patients with NSTEMI are at low risk for experiencing in-hospital complications.[27] Some have proposed that the ACTION-ICU score has the power to predict in-hospital complications in patients with elevated troponin levels and without clinically significant coronary artery disease.[28]

There is a relative paucity of head-to-head comparisons of risk scores for assessing the prognosis for patients with NSTEMI-ACS. Palmerini et al[12] investigated the value of risk scoring systems in the assessment of 1-year adverse outcomes among patients with NSTEMI-ACS. In their study, risk scores that incorporate both clinical and anatomic variables in their algorithm had the best predictive accuracy, but ACEF and GRACE scores were found to have poor to modest ability to predict adverse cardiac outcomes.[12] Kristic et al[14] evaluated the long-term prognostic value of several risk scores in a group of patients with NSTEMI-ACS who underwent all treatment strategies discussed. They reported that the ACEF and Synergy of Percutaneous Coronary Intervention With Taxus and Cardiac Surgery-II percutaneous coronary intervention scores predicted MACE with acceptable specificity and sensitivity. In a study by Stähli et al,[29] higher ACEF scores were associated with increased in-hospital and midterm cardiac and cerebrovascular adverse events in patients with ACS. Dziewierz et al[30] reported that the ACEF score can predict not only in-hospital mortality but also clinical events, including bleeding, in patients undergoing conservative treatment for ACS. The addition of anemia and the presence of emergency surgery to the ACEF score results in the ACEF-II score. The ACEF-II score was found to have

good performance in predicting in-hospital mortality after off-pump coronary artery bypass graft surgery, with a C statistic of 0.83.[31]

The present study aimed to compare the clinical scores used for risk stratification of patients with NSTEMI-ACS. Because the scoring systems included several identical variables in their calculations, 4 different multivariate logistic analyses were performed. Compared with GRACE, ACTION-ICU, and ACEF-II scores, the ACEF score did not reach statistical significance for the prediction of 1-year MACE. These results indicate that the accuracy of the ACEF score was lower than that of the other assessed scores, supporting this study's hypothesis and indicating that the ACEF-II provided better prediction of 1-year risk than did ACTION-ICU and GRACE scores.

### Limitations

The present study had a retrospective design and was conducted at a single center. Patients were followed for only 1 year, and the effect of the clinical score on long-term outcomes was not evaluated. Anatomic risk scores were not evaluated, and comparisons of risk scores that included anatomic variables in their algorithm were not performed. Prospective randomized trials are needed to assess the value of different risk scores in patients with NSTEMI-ACS.

## Conclusion

The ACEF-II score, which requires 5 variables for its calculation, provides more information than does the ACEF score. This scoring system has fewer variables than the GRACE and ACTON-ICU scoring systems do and could be easier to use in clinical practice. Prospective multicenter studies are needed to further investigate the value of the ACEF-II score.

## Article Information

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**Author Contributions:** Yasin Yüksel, Cennet Yıldız, and Burak Ayça played critical roles during the study. The study design was planned by Burak Ayça and Yasin Yüksel. Supervision for the study was provided by Burak Ayça, Yasin Yüksel, and Cennet Yıldız. Statistical analysis was performed by Cennet Yıldız. Each author also participated in patient enrollment or referral. A literature search was conducted by all authors. The main writers were Cennet Yıldız and Burak Ayça. Yasin Yüksel, Cennet Yıldız, and Burak Ayça approved and edited the final manuscript. Cennet Yıldız and Burak Ayça helped with figures, tables, and spelling.

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