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A simple risk score in acute ST-elevation myocardial infarction: Modified ACEF (age, creatinine, and ejection fraction) score

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Background/aim: The aim of this study was to evaluate if the modified ACEF (age, creatinine, and ejection fraction) score is a predictor of major adverse cardiac and cerebrovascular events during 1 year of follow-up in patients with ST-segment elevation myocardial infarction (STEMI) who underwent primary percutaneous coronary intervention (PCI).

Materials and methods: We retrospectively enrolled 1632 consecutive patients who were admitted to our emergency department diagnosed with STEMI within 12 h of chest pain and treated with primary PCI. The modified ACEF score, determined with a simplified scoring system, was calculated. The patients were grouped into tertiles according to this score (group I mACEF < 1.03, group II mACEF 1.03–1.37, group III > 1.37) . The clinical and angiographic data were compared among the tertiles.

Results: In patients with the highest mACEF tertile, out-of-hospital cardiac arrest (1.3%, 1.8%, and 4.1% consecutively; P = 0.003), Killip class ≥ II (P < 0.001), and cardiogenic shock were more common and ejection fraction was lower (P < 0.001). Moreover, in the 1-year follow-up, there was a statistically significant difference between cardiac mortality, target vessel revascularization, stroke, reinfarction, and major adverse cardiac and cerebrovascular events of the groups, while the rates of stent thrombosis were similar.

Conclusion: The modified ACEF score is a predictor of cardiac mortality and morbidity during 1-year follow-up.

Key words: Acute ST-elevation myocardial infarction, ACEF score, mortality

1. Introduction

The incidence of ST-segment elevation myocardial infarction (STEMI) has been increasing over the last two decades and it continues to be a significant public health problem throughout the world (1). Primary percutaneous coronary intervention (p-PCI) has become the treatment of choice for acute STEMI, as it improves both in-hospital and long-term mortality. Despite this improvement, in-hospital mortality rates are reported to be as high as 7%–10% in some registry reports (2). Therefore, risk stratification is essential for clinical decision and management. Various risk scores such as Thrombolysis in Myocardial Infarction (TIMI), GRACE, and ZWOLLE have been applied (3–5). Besides angiographic variables, clinical data, such as the presence of anemia and renal impairment, are independent risk factors for in-hospital cardiovascular mortality.

The modified ACEF (age, creatinine, and ejection fraction) score is a simple scoring system calculated with basic data and associated with renal dysfunction and clinical adverse events during follow-up after treatment for myocardial infarction (MI) and complex coronary interventions (6). The aim of this study was to evaluate whether the mACEF is a predictor of major adverse cardiac and cerebrovascular events during 1 year of follow-up in patients treated with p-PCI for acute STEMI.

2. Materials and methods

2.1. Study population

We retrospectively evaluated 1910 patients who were admitted to our center with STEMI within 12 h of chest pain and treated with p-PCI between January 2007 and June 2010. One hundred forty-four patients who lacked one or more of the variables required to calculate the modified ACEF score were excluded. Additionally, 134 patients were excluded due to absence of follow-up records. The remaining 1632 patients formed the study population.

The inclusion criteria were as follows:

1. Admission to hospital within 12 h (18 h for cardiogenic shock) of chest pain.

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2. Presence of ≥1 mm ST segment elevation on at least 2 consecutive leads (≥2 mm for V1–V3) of surface ECG or new left bundle branch block together with chest pain.

Written informed consent was obtained from all study patients on admission and the study was approved by the hospital's ethics committee.

2.2. Modified ACEF score

A modified ACEF score was calculated for all patients using left ventricular ejection fraction, age, and creatinine clearance, which is calculated by the Cockcroft–Gault equation as follows: age/EF + 1 point for every 10 mL/min reduction in creatinine clearance below 60 mL/min/1.73 m^2 (up to a maximum of 6 points) (7,8).

2.3. Definitions and clinical follow-up

The risk factors, medications, reperfusion times, and other clinical-demographic properties were obtained from hospital records and files. On admission, blood samples were obtained from all patients for hemogram, creatinine, and troponin I measurements. Following the p-PCI procedure, a transthoracic echocardiographic evaluation was performed for all patients (Vivid, GE, Horten, Norway) during the hospital stay and left ventricular ejection fractions (LVEFs) were calculated using the modified Simpson's formula (9). Surface electrocardiography (ECG) was recorded before the procedure, at the 90th minute after the procedure to evaluate ST segment resolution (STR), and twice daily thereafter until discharge.

Before the procedure all patients are given a 600 mg clopidogrel loading dose p.o., 300 mg chewable aspirin p.o., and 10,000 U standard heparin I.V. (60 U/kg for patients who received tirofiban). Application of preprocedural tirofiban was left to the operator's preference and angiographic properties. All percutaneous interventions were performed by high patient volume operators by the femoral artery route, using standard techniques. Either direct stenting or conventional stenting was applied according to coronary anatomy, lesion properties, and operator's preference. Postprocedural TIMI flow, myocardial blush grade (MBG), and the presence of distal embolization (DE) were recorded. The patients were followed in the coronary intensive care unit after hemodynamic stabilization was achieved. All patients were given 75 mg/day klopidogrel p.o. and 150 mg/day aspirin p.o. after the procedure.

Glomerular filtration rate (GFR) was calculated according to the Cockcroft–Gault formula. No reflow was defined as the presence of TIMI <3 flow in the absence of postprocedural spasm, dissection, or other secondary reasons. Distal embolization was diagnosed in the presence of a distal filling defect with an abrupt "cut-off" in one or more peripheral coronary branches of the IRA. MBG was evaluated according to preestablished criteria (10). STR was evaluated from the postprocedural 90th minute ECG; >70% STR was defined as complete and <30% STR was called no resolution (11).

2.4. Clinical end-points

One year of clinical follow-up was recorded from outpatient records, rehospitalization records, and phone calls with all study patients. Survival status of the patients who could not be reached otherwise was confirmed from the institution of statistics and population directorate. Although the data collection was retrospective in our study, long term follow-up was performed prospectively. The patients were called regularly every 3–6 months and 134 patients (6%) whose records could not be reached despite all efforts were labeled as lost to follow-up during the long term and excluded from the study.

The main objective of this study was to investigate the possible role of mACEF scores in the prediction of 1-year outcomes of STEMI patients treated with p-PCI. The primary end-point was major adverse cardiac and cerebrovascular events (MACCEs), defined as a composite of cardiac mortality, stroke, reinfarction, stent thrombosis, and target vessel revascularization (TVR). Cerebrovascular events, including stroke, transient ischemic attacks, and reversible ischemic neurologic deficits, were considered. All repeat revascularization procedures on the index vessel were recorded as TVR. Stent thrombosis was defined based on angiographic documentation of a complete occlusion (TIMI grade 0 or 1 flow) or angiographic documentation of a flow-limiting thrombus (TIMI grade 1 or 2 flow) (11).

2.5. Statistics

Continuous variables were expressed as mean ± SD or median (interquartile range) and categorical variables were given as percentages. The differences between continuous variables were evaluated by analysis of variance or Kruskal–Wallis test as appropriate and the differences between categorical variables were evaluated by chi-square or Fisher exact test as appropriate. One-year survival was evaluated by Kaplan–Meier survival analysis and the difference between two curves was evaluated by log-rank test. Receiver operating characteristic (ROC) analyses were used to compare the performance and prognostic power of the SS and CSS for 1-year clinical outcomes. The predictive validities were quantified as the area under the ROC curves (c-statistics), and the comparisons of c-statistics were performed with MedCalc statistics software (version 11.3.8.0, Mariakerke, Belgium). $P < 0.05$ was accepted as statistically significant in all analyses. All statistical analyses were performed with SPSS 11.5 (SPSS Inc., Chicago, IL, USA).

3. Results

The patients were grouped according to mACEF tertiles. Baseline characteristics are given in Table 1. In patients

Table 1. Baseline clinical and angiographic characteristics according to mACEF tertiles.

Variables	mACEF < 1.03 (n = 544)	mACEF 1.03–1.37 (n = 545)	mACEF > 1.37 (n = 543)	P-value of trend
Age (years)	45.7 ± 7.2	57.1 ± 8.2	67.2 ± 9.9	<0.001
Male, %	87.9	84.8	68	<0.001
Diabetes, %	16	20.4	33.3	<0.001
Hypertension, %	25.4	41.5	56	<0.001
Smoking, %	71	57.2	36.6	<0.001
Dyslipidemia, %	47.4	39.4	33	<0.001
Family history of CAD, %	28	19.3	18	<0.001
Previous history of CAD, %	7.2	9.2	15.1	<0.001
Chronic renal disease, %	0	0	9.4	<0.001
Preinfarction angina, %	25.6	27.2	24.5	0.690
Out-of-hospital cardiac arrest, %	1.3	1.8	4.1	0.003
Killip class ≥II, %	7	11.9	30.2	<0.001
Cardiogenic shock, %	0.7	2	11.8	<0.001
Systolic blood pressure, mmHg	126 ± 21	132 ± 28	133 ± 40	0.001
Diastolic blood pressure, mmHg	76 ± 13	78 ± 17	78 ± 24	0.030
Pain to balloon time, min	136 ± 100	160 ± 115	206 ± 126	<0.001
Door to balloon time, min	30.5 ± 6.6	30.3 ± 10.2	31.6 ± 7.4	0.018
Heart rate, /min	75 ± 13	76 ± 15	78 ± 19	0.007
LV-EF, %	52 ± 5.7	48 ± 66	41.7 ± 7.8	<0.001
LDL-cholesterol, mg/dL	121 ± 38	113 ± 36	105 ± 38	<0.001
HDL-cholesterol, mg/dL	37 ± 11	38 ± 11	41 ± 14	<0.001
Triglyceride, mg/dL	158 ± 108	136 ± 88	120 ± 63	<0.001
Estimated GFR, mL/min/1.73 m^2	100 ± 21	92 ± 19	72 ± 28	<0.001
Anterior MI, %	40.4	46.8	59.3	<0.001
IRA, %				
LMCA	0.2	0.4	0.6	<0.001
LAD	41.4	47.2	58.6	
LCx	15.8	13.6	10.3	
RCA	40.6	37.1	30	
Diseased vessels, %				
One vessel	69.5	60.4	49	<0.001
Two vessels	24.8	29.4	36.5	
Three vessels	5.7	10.3	14.5	
Initial patency in IRA (TIMI 2/3), %	30.9	25.3	17.5	<0.001
CTO in non-IRA, %	4.6	5.9	11.2	<0.001
Total stent length, mm	18	18	20	0.005
Stent diameter, mm	3.0	3.0	3.0	0.582
Bare metal stent, %	95.1	94.5	96.5	0.287
Direct stenting, %	25	18.3	16.6	0.001
Postprocedural TIMI-III flow, %	98.9	93.2	79.4	<0.001
Postprocedural TMBG-II/III, %	64.2	50.8	24.4	<0.001
Postprocedural cTFC	19.3 ± 6.4	23 ± 12.1	29.9 ± 18.3	<0.001
Angiographic no-reflow, %	1.1 or 10.8	6.8 or 20	20.6 or 44.2	<0.001
Electrocardiographic no-reflow, %	16.7	33.6	61.9	<0.001

CAD: Coronary artery disease, LV-EF: left ventricular ejection fraction, LDL: low density lipoprotein, HDL: high density lipoprotein, IRA: infarct related artery, CTO: chronic total occlusion, TFC: TIMI frame count, TMBG: TIMI blush grade.

with the highest mACEF tertile, out-of-hospital cardiac arrest (1.3%, 1.8%, and 4.1% consecutively; P = 0.003), Killip class ≥ II (P < 0.001), and cardiogenic shock were more common and EF was lower (P < 0.001). Moreover, pain to balloon times were longer in the mACEF > 1.37 group.

Of the angiographic properties, LAD lesion and three-vessel disease were more common in the highest mACEF tertile group. The lesions were also more complex (long lesion, chronic total occlusion, etc.) in the mACEF > 1.37 group. When procedural success is concerned, angiographic and electrocardiographic no-reflow was more common, stent lengths were longer, and direct stenting was less common.

In the 1-year follow-up, there was a statistically significant difference between cardiac mortality, TVR, stroke, reinfarction, and MACCEs of the groups (Table 2), while the rates of stent thrombosis were similar. Predictive values and c-indices are given in Table 3.

4. Discussion

The results of the present study demonstrate that the modified ACEF score may accurately identify 1-year major adverse cardiovascular-cerebrovascular events, particularly cardiac death and stroke in STEMI patients treated with p-PCI.

Coronary artery disease is the most common cause of death throughout the world. According to the guidelines of the European Society of Cardiology, one of every 6 men and 7 women dies from MI (12). STEMI is an important part of the acute coronary syndromes. In-hospital mortality rates ranged between 7% and 10% (2). With the increased application of p-PCI and developing pharmacological approaches, early and late mortality rates decreased significantly in patients with STEMI. However, the rates of mortality reduction differ significantly between trials, which emphasizes the importance of correct risk stratification. In patients with STEMI, previous MI, door to balloon time, the presence of diabetes, anemia, chronic

Table 2. One-year clinical outcomes in patients with STEMI according to mACEF score.

Variables (n and %)	mACEF < 1.03	mACEF 1.03–1.37	mACEF > 1.37	P-value*	P-value**	P-value I vs. II*	P-value I vs. III*	P-value II vs. III*
Cardiac mortality	4 (0.7)	8 (1.5)	114 (21)	<0.001	<0.001	0.234	<0.001	<0.001
TVR	62 (11.4)	94 (17.2)	97 (17.9)	<0.001	0.003	0.006	<0.001	0.113
Stroke	2 (0.4)	2 (0.4)	12 (2.2)	0.001	0.002	0.985	0.003	0.005
Reinfarction	16 (2.9)	20 (3.7)	38 (7.0)	<0.001	0.001	0.473	<0.001	0.003
Stent thrombosis	12 (2.2)	11 (2.0)	13 (2.4)	0.708	0.833	0.863	0.527	0.434
MACCE	78 (14.3)	113 (20.7)	230 (42.4)	<0.001	<0.001	0.007	<0.001	<0.001

*P-value for trend and between dual mACEF tertiles determined by log-rank test, **P-value for trend determined by chi-square test.

Table 3. Predictive values for MACCE.

	c-index	95% CI	P-value
Cardiac mortality	0.882	0.851–0.913	<0.001
TVR	0.556	0.519–0.594	0.004
Stroke	0.803	0.677–0.928	<0.001
Reinfarction	0.627	0.560–0.694	<0.001
Stent thrombosis	0.506	0.418–0.594	0.901
MACCE	0.689	0.659–0.720	<0.001

TVR: Target vessel revascularization, MACCE: major advanced cardiac and cerebrovascular events.

renal failure, and ejection fraction on admission are the main predictors of mortality. Risk scores such as TIMI, GRACE, PAMI, Zwolle, or CADILLAC are commonly applied as mortality indicators (3–6,13,14). Beyond clinical data, angiographic data are also used to predict the long-term prognosis, such as the SYNTAX score (15). However, all of these risk scoring systems have disadvantages.

The ACEF score is a simple method calculated using only age, creatinine clearance, and ejection fraction. In a multicenter study by Biondi-Zoccai et al., early and late-term complication rates were higher during complex coronary interventions (bifurcation lesions) in the high ACEF group (16). Pyxaras et al. identified high ACEF value to be an independent predictor of MACCE in patients with heavily calcific coronary lesions (17). In another study, Andò et al. determined high ACEF value to be an independent predictor of acute kidney injury after p-PCI (18).

In the present study, we identified that high mACEF value was associated with adverse clinical events during 1-year follow-up in patients treated with p-PCI.

Our study has some important limitations. Although the follow-up of all patients was performed prospectively, this study has a retrospective and single-center design. In order to prevent bias, in-hospital and follow-up data were collected by different investigators. Secondly, only patients with acute STEMI who underwent p-PCI were enrolled. Thus, the results of this study may not be extrapolated to other patient groups admitted with acute coronary syndrome or to patients not treated with PCI. A large-scale multicenter study is required to evaluate the effectiveness of the mACEF score in the risk stratification of other patient groups.

In conclusion, the modified ACEF score is a predictor of cardiac mortality, TVR, stroke, reinfarction, and MACCE during 1-year follow-up.

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