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Prognostic Factors for In-Hospital and Long-Term Survival in Patients with Acute ST-Segment Elevation Myocardial Infarction after Percutaneous Coronary Intervention

Lin-Lin Hou,[1, 2] Chao Gao,[2] Jun Feng,[2] Zhen-Fei Chen,[2] Jing Zhang,[2] Yong-Jin Jiang,[2] Xue-Xiang Li[3] and Bang-Ning Wang[1]

[1]Department of Cardiology, The First Affiliated Hospital of Anhui Medical University, Hefei, Anhui, P.R. China
[2]Department of Cardiology, The Second People Hospital of Hefei, Hefei, Anhui, P.R. China
[3]Department of Emergency Medicine, The Second Hospital of Anhui Medical University, Hefei, Anhui, P.R. China

Acute ST segment elevation myocardial infarction (STEMI) is one of the causes of death and disability in patients with cardiovascular diseases. This study aimed to investigate the prognostic factors of in-hospital and long-term survival in patients with acute STEMI undergoing percutaneous coronary intervention (PCI). Patients with STEMI undergoing PCI were divided into the death group (n = 54) and the survival group (n = 306) based on the outcomes during hospitalization. The routine blood and biochemistry tests, Killip classes and global registry of acute coronary events (GRACE) risk score were detected. The 1-, 2- and 3-year survival rates after PCI was observed through a 3-year follow-up. The survival factors, survival rates and multivariate analyses were conducted using Logistic regression analysis, Kaplan-Meier survival analysis and Cox proportional hazards regression. The incidence of cardiogenic shock and anterior wall MI (AWMI), the serum levels of γ-glutamyl endopeptidase (γ-GGT) and creatine kinase isoenzyme MB (CK-MB), Killip classes and GRACE risk score were higher in the death group, compared with the survival group. AWMI, cardiogenic shock, high serum levels of γ-GGT and CK-MB, Killip class III-IV and high GRACE risk scores were associated with in-hospital mortality. AWMI, cardiogenic shock, Killip class III-IV and high GRACE risk scores were correlated with a poor long-term survival. Our findings have demonstrated that AWMI, cardiogenic shock, high serum levels of γ-GGT and CK-MB, Killip class III-IV, and high GRACE risk scores are risk factors for in-hospital and long-term prognosis of acute STEMI patients.

Keywords: acute ST-segment elevation myocardial infarction; in-hospital survival; long-term survival; percutaneous coronary intervention; prognostic factor
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Introduction

Acute myocardial infarction (AMI) refers to the drastically reduced or interrupted blood supply of the coronary arteries, leading to myocardial ischemia (Wong et al. 2012). It is characterized by dull chest pain, arrhythmia, shock and heart failure (Boateng and Sanborn 2013). Existing evidence proves that AMI is mainly caused by overworking, overeating, smoking, drinking or constipation (Task Force Members et al. 2012). In 2013, the global incidence rate of AMI was 8.6 million (Global Burden of Disease Study 2013 Collaborators 2015). According to a presenting electrocardiogram, AMI can be categorized into non-ST-elevation myocardial infarction (NSTEMI) and ST elevation myocardial infarction (STEMI) (Terkelsen et al. 2005). It has been reported that more than 3 million people are currently diagnosed with a ST-segment elevation MI (STEMI) (White and Chew 2008). According to Euro Heart Survey, the in-hospital mortality rate of patients with STEMI ranges from 6% to 14% (Cabello et al. 2013). Due to the improvement of medical equipment and medical care, the mortality of AMI is decreasing. However, a steadily increasing incidence rate of AMI can still be observed (Takii et al. 2010). Therefore, there is an increased need for conducting research to identify the factors that affect the survival and prognosis of patients with AMI following percutaneous coronary intervention (PCI).

The treatment of AMI is based on its category. Patients with NSTEMI should be medically stabilized and scheduled for an early (within days) interventional approach, whereas patients with STEMI should be treated acutely with thrombolysis or primary PCI (Terkelsen et al. 2005). Many studies have shown that PCI surgery can effectively clear the obstruction in the coronary blood ves-

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Correspondence: Bang-Ning Wang, Department of Cardiology, The First Affiliated Hospital of Anhui Medical University, No. 218 Jixi Road, Hefei, Anhui Province 230022, P.R. China.
e-mail: wangbangning@medmail.com.cn

sels and restore myocardial blood supply, reducing the incidence of various cardiovascular diseases caused by AMI (Roe et al. 2010; Kappetein et al. 2013). Recent studies also point out that although the applicability of PCI surgery is not dependent on age, the rate of success of PCI surgery is significantly associated with age (Gharacholou et al. 2011; Kala et al. 2012). The no-reflow phenomenon is considered to be a risk factor for patients with acute STEMI undergoing primary PCI therapy (Ndrepepa et al. 2010). In addition, history of diabetes, no pre-infarction angina, mean platelet volume, white blood cell count, reperfusion time, and formation of collateral circulation are also independent risk factors of the no-reflow phenomenon after PCI (Harrison et al. 2013). A previous study also found that high serum uric acid level during hospitalization is associated with impaired coronary flow after PCI in patients with STEMI (Spoon et al. 2010). Therefore, the prognosis for patients with STEMI undergoing PCI is likely to be multifactorial, and the identification of prognostic risk factors may provide a certain clinical guidance for the management of STEMI. This study included 360 patients with STEMI undergoing PCI and aimed to identify the prognostic factors for in-hospital and long-term survival for patients with STEMI undergoing PCI in China.

Materials and Methods

Ethical statement

The study was conducted in accordance with the standard medical ethics, after the approval of the ethics committee of the First Affiliated Hospital of Anhui Medical University was obtained. Written informed consent for each patient was also obtained.

Subjects

Between January 2008 and December 2012, 360 patients with STEMI who underwent PCI were selected from the Department of Cardiology of the First Affiliated Hospital of Anhui Medical University. Selected patients included 238 males and 122 females with a mean age of 64.60 ± 7.89 years (range from 42 to 88). The eligible patients with STEMI were identified and selected based on the following criteria (Alpert et al. 2000): (1) the patient had typical STEMI chest pain that persisted ≥ 30 mins; (2) ST-segment changes on the electrocardiogram (ECG) indicating ischemia [ST-segment depression or transient elevation (≥ 1 mm) in at least two contiguous leads]; (3) the levels of creatine kinase or creatine kinase isoenzyme were at least twice the upper limit of normal. Inclusion criteria: (1) patients met the diagnostic criteria for STEMI; (2) patients had completed data of clinical characteristics and follow up; (3) patients were excluded from sub-acute or old STEMI. Exclusion criteria: (1) patients had a major trauma or bleeding, or underwent a major surgical procedure recently; (2) patients with complicated disease such as severe cardiac arrhythmia or congenital heart disease; (3) patients with severe systemic diseases such as malignant tumor or multiple organ failure; and (4) patients with sub-acute or old STEMI. All patients with at least one infarct-related artery underwent acute PCI surgery and had at least one stent inserted. All subjects were assigned into the survival group or the death group based on their outcome during hospitalization.

Data collection

Information including age, sex, medical history and STEMI complications was collected and ECG, cardiac color Doppler ultrasound and routine blood tests were performed at admission. The day after admission, fasting blood was collected from the patients early in the morning to perform biochemistry tests. STEMI complications included cardiogenic shock, heart failure, and arrhythmia, while medical history included hypertension, type-2 diabetes mellitus (T2DM), hyperlipidemia, stroke, smoking and drinking alcohol. The blood tests were performed to measure the following parameters: red cell distribution width (RDW), platelet count (PLT), platelet distribution width (PDW) and mean platelet volume (MPV). Blood biochemistry tests that were performed included serum total cholesterol (TC), high-density lipoprotein (HDL), low-density lipoprotein (LDL), triglycerides (TG), glucose (GLU), C-reactive protein (CRP), γ-glutamyl endopeptidase (γ-GGT), albumin (ALB), uric acid (UA) and prealbumin (PA). An ECG and cardiac color Doppler ultrasound were performed within a day of admission. The heart failure of patients with STEMI was graded according to the hemodynamic severity using the Killip classification (Killip and Kimball 1967) as follows: Killip class I (no new damage); Killip class II (mild to moderate heart failure, pulmonary crackles < 50% lung field, third heart sound and pulmonary congestion on the chest radiography); Killip class III (severe heart failure, rales lung sound > 50% lung); and Killip class IV (cardiogenic shock). Based on eight indicators (age, heart rate, blood pressure, serum creatinine level, Killip classes of heart failure, cardiac arrest prior to admission, depression of ST segment and cardiac enzymes), a global registry of acute coronary events (GRACE) risk score (Antman et al. 2008) was determined which can be categorized into: low-risk, GRACE risk score ≤ 108; intermediate risk, GRACE risk score = 109~140; and high risk, GRACE risk score > 140.

Coronary angiography and percutaneous coronary intervention

Coronary angiography was conducted in compliance with the guidelines of the American College of Cardiology and the American Heart Association (Austen et al. 1975). Patients were administered 300 mg of aspirin and 300 mg of clopidogrel orally at admission. Using the Judkins technique, a 5F sheath was inserted via the radial or femoral artery followed by an injection of heparin (6,000 units). An angiographic catheter was inserted through the sheath to capture the left and right coronary angiography as well as the conventional multi-position projection. Each angiography lasted at least six cardiac cycles, which provided a clear view of the crown artery, vascular tree and the main branches of blood vessels openings. The site of STEMI was determined based on the ECG and coronary angiography. PCI was strictly performed in accordance with the US PCI treatment guidelines (Smith et al. 2006) by two experienced cardiology physicians. The standard guide wire, balloon catheters, and coronary stents were used during the PCI surgery. The PCI surgery only covered the infarct-related artery as confirmed by ECG and angiography. The coronary angiography data of all patients were collected, such as thrombus aspiration, uses of antithrombotic drug, intra-aortic balloon pump, combined conduction block, and multi-vessel disease. Surviving patients were prescribed aspirin, clopidogrel, statins, and β-blockers according to their blood pressure and heart rate after discharge.

Follow-up

A 3-year follow-up study was conducted for surviving patients

by hospital referral and telephone survey every two months from the discharge date to December 31, 2015. At the end of the follow-up, 11 patients were lost to follow-up.

Statistical analysis

Statistical Package for Social Sciences 21.0 statistical software was used for statistical analysis. Quantitative data is expressed as mean ± standard deviation (SD) and compared using the *t* test. Measurement data is expressed as a percentage or rate and compared with the χ^2 test. Logistic regression analysis was used to analyze the prognostic factors for in-hospital survival of patients with STEMI. The receiver operating characteristic (ROC) curve was used to determine the accuracy of these prognostic factors. The Univariate Kaplan-Meier analysis was used to calculate the survival rate of patients with STEMI and Cox proportional hazard models were used to conduct a multivariate analysis on the prognostic factors of long-term survival for patients with STEMI. Variables included in the model were the ones that differ between groups. $P < 0.05$ was considered statistically significant.

Results

Baseline characteristics of patients with STEMI in the death and survival groups

The baseline characteristics of patients with STEMI in the death (n = 54) and survival (n = 306) groups are shown in Table 1. There were significant differences between them in terms of mean age; history of hyperlipidemia, T2DM and smoking; infarct location, cardiogenic shock, arrhythmias (ventricular premature beats, non-sustained ventricular tachycardia, ventricular tachycardia and ventricular fibrillation) and heart failure (all $P < 0.05$). However, the two groups were comparable in terms of sex, hypertension history, history of stroke and drinking alcohol ($P > 0.05$).

Serum biochemical indices and clinicopathological features of patients with STEMI in the death and survival groups

Comparison of the blood biochemical indices and clinicopathological features of patients with STEMI in the death and survival groups are shown in Table 2. The death and survival groups exhibited no difference with respect to RDW, PLT, PDW, MPV, TC, HDL, LDL, GLU, TG, CRP, ALB, UA, PA, the usage of antithrombotic drug, combined conduction block or multi-vessel disease ($P > 0.05$). The death group had significantly higher levels of γ-GGT and CK-MB, higher rates of thrombus aspiration and usage of intra-aortic balloon pump, higher Killip classes and GRACE risk score, compared with the survival group ($P < 0.05$).

Logistic regression analysis of potential prognostic factors of in-hospital survival for patients with STEMI

Death and survival rates during hospitalization were selected as the dependent variables and the baseline and clinicopathological features were chosen as the independent variables in the logistic regression analysis. The baseline characteristics included age, hyperlipidemia, T2DM, smoking, cardiogenic shock, arrhythmias, heart failure and anterior wall MI (AWMI). The clinicopathological features included serum γ-GGT, thrombus aspiration, the use of intra-aortic balloon pump, Killip class, and GRACE risk score. The logistic regression analysis revealed that AWMI,

Table 1. Comparisons of baseline characteristics of STEMI patients between the survival group and the death group.

Characteristics	Survival group (n = 306)	Death group (n = 54)	*P* values
Age (years)	64.12 ± 7.82	67.28 ± 7.81	0.007
Gender			
Male/Female (n)	199/107	39/15	0.304
Family history			
Hypertension [n (%)]	75 (24.51)	15 (27.78)	0.609
High cholesterol [n (%)]	60 (19.61)	21 (38.89)	0.002
Type 2 diabetes mellitus [n (%)]	66 (21.57)	20 (37.04)	0.014
Stroke [n (%)]	57 (18.63)	7 (12.96)	0.316
Lifestyle			
Smoking [n (%)]	129 (42.16)	39 (72.22)	< 0.001
Drinking [n (%)]	113 (36.93)	27 (50.00)	0.069
Infarct location			
Anterior infarction [n (%)]	75 (24.51)	36 (66.67)	< 0.001
Others [n (%)]	231 (75.49)	18 (33.33)	
Postoperative complications			
Cardiogenic shock [n (%)]	42 (13.73)	30 (55.56)	< 0.001
Arrhythmia [n (%)]	105 (34.31)	33 (61.11)	< 0.001
Ventricular tachycardia [n (%)]	44 (14.38)	3 (5.56)	< 0.001
Non-sustained ventricular tachycardia [n (%)]	45 (14.71)	2 (3.70)	< 0.001
Ventricular fibrillation [n (%)]	16 (5.23)	28 (51.85)	< 0.001
Heart failure [n (%)]	69 (22.55)	19 (35.19)	0.046

STEMI, acute ST-segment elevation myocardial infarction.

Table 2. Comparisons of blood biochemical indexes and clinical features of STEMI patients between the survival group and the death group.

Clinical features	Survival group (n = 306)	Death group (n = 54)	*P* values
Blood routine			
RDW (%)	13.05 ± 0.74	13.13 ± 0.96	0.486
PLT (× 10^9/L)	221.17 ± 72.72	219.80 ± 87.24	0.846
PDW (%)	15.22 ± 1.76	15.50 ± 1.83	0.285
MPV (fl)	11.43 ± 1.48	11.54 ± 1.89	0.630
Blood biochemistry			
TC (mmol/L)	4.56 ± 0.93	4.65 ± 1.24	0.535
HDL (mmol/L)	1.13 ± 0.17	1.16 ± 0.24	0.265
LDL (mmol/L)	2.65 ± 0.53	2.72 ± 0.46	0.363
TG (mmol/L)	1.80 ± 1.00	1.72 ± 0.42	0.563
GLU (mmol/L)	6.12 ± 2.59	6.28 ± 2.08	0.667
CRP (mg/L)	7.66 ± 3.91	7.86 ± 2.56	0.717
γ-GGT (U/L)	36.13 ± 15.99	48.22 ± 16.84	< 0.001
ALB (g/L)	37.17 ± 4.49	37.77 ± 6.37	0.399
UA (μmol/L)	344.87 ± 64.29	340.72 ± 78.03	0.673
PA (mg/L)	178.34 ± 51.67	184.45 ± 73.21	0.455
CK-MB (U/L)	35.67 ± 8.90	51.12 ± 11.41	< 0.001
Killip classification			< 0.001
I-II [n (%)]	216 (82.93)	16 (29.63)	
III-IV [n (%)]	90 (17.07)	38 (70.37)	
Coronary angiography			
Thrombectomy [n (%)]	24 (7.84)	15 (27.78)	< 0.001
Antithrombotic drug [n (%)]	51 (16.67)	15 (27.78)	0.052
Intra-aortic balloon pump [n (%)]	45 (11.76)	18 (33.33)	< 0.001
Combined conduction block [n (%)]	15 (4.90)	6 (11.11)	0.073
Multi-vessel disease [n (%)]	27 (8.82)	9 (16.67)	0.077
GRACE risk score	123.47 ± 34.50	172.13 ± 43.29	< 0.001

STEMI, acute ST-segment elevation myocardial infarction; WBC, white blood count; N, neutrophil; L, lymphocyte; N/L, neutrophil/lymphocyte ratio; RDW, red cell distribution width; PDW, platelet distribution width; MPV, mean platelet volume; GLU, glucose; TC; total cholesterol; HDL, high-density lipoprotein; LDL, low-density lipoprotein; TG, triglycerides; CRP, C-reactive protein; γ-GGT, γ-glutamyl endopeptidase; ALB, albumin; UA, uric acid; PA, prealbumin; CK-MB, creatine kinase isoenzyme MB; GRACE, global registry of acute coronary event.

cardiogenic shock, high serum levels of γ-GGT and CK-MB, Killip class III-IV and GRACE risk scores were associated with the in-hospital mortality of patients with STEMI (all $P < 0.05$) (Table 3).

ROC curve analysis of prognostic factors of in-hospital survival for patients with STEMI

The ROC curve analysis of prognostic factors of in-hospital survival for patients with STEMI is shown in Fig. 1. The area under the ROC curve (AUC) for CK-MB and GRACE risk score were 0.855 and 0.809 respectively, which suggested that GRACE risk score has a higher predictive value for in-hospital survival for STEMI. The AUC for AWMI, cardiogenic shock and Killip class III-IV were 0.711, 0.709 and 0.705, respectively. These scores suggest moderate predictive values for in-hospital survival for patients with STEMI (Table 4).

Univariate Kaplan-Meier analysis and Cox proportional hazard models of potential prognostic factors of long-term survival for patients with STEMI

A total of 306 surviving patients were contacted for a 3-year follow-up. The shortest survival time within the follow-up period was one month, and the average survival time was 28.02 ± 10.98 months. The survival time was calculated from the day of being discharged to the day of death. The Kaplan-Meier survival curve analysis showed that the 1, 2, and 3-year survival rates were 89.22%, 68.83%, and 60.78%, respectively (Fig. 2). Cox proportional hazard models were applied to identify the prognostic factors for the long-term survival of patients with STEMI, which revealed that AWMI, cardiogenic shock, Killip class III-IV and high GRACE risk score were significant risk factors for the long term prognosis of patients with STEMI (Table 5).

Table 3. Logistic regression analysis of potential prognostic factors for in-hospital survival in STEMI patients undergoing PCI.

Factor	B	SE	*P* value	Exp(B) (95% CI)
Age	0.012	0.037	0.755	1.012 (0.940~1.089)
High cholesterol	0.177	0.708	0.803	1.193 (0.298~4.777)
Type 2 diabetes mellitus	0.728	0.638	0.254	2.071 (0.593~7.234)
Smoking history	0.024	0.658	0.971	1.024 (0.282~3.717)
Anterior infarction	1.394	0.638	0.029	4. (1.154~14.071)
Cardiogenic shock	1.753	0.719	0.015	5.770 (1.411~23.592)
Heart Failure	0.831	0.756	0.272	2.295 (0.522~10.095)
γ-GGT	0.061	0.022	0.007	1.063 (1.017~1.110)
CK-MB	0.209	0.041	< 0.001	1.232 (1.136~1.336)
Thrombus aspiration	1.163	0.814	0.153	3.199 (0.649~15.771)
Intra-aortic balloon pump	1.140	0.685	0.096	3.127 (0.817~11.969)
Killip class III-IV	1.675	0.637	0.009	5. 339 (1.531~18.620)
High GRACE score	0.045	0.009	< 0.001	1.046 (1.028~1.066)

STEMI, acute ST-segment elevation myocardial infarction; PCI, percutaneous coronary intervention; γ-GGT, γ-glutamyl endopeptidase; CK-MB, creatine kinase isoenzyme MB; GRACE, global registry of acute coronary event; B, Partial Regression Coefficient; SE, Standard Error; CI, confidence interval.

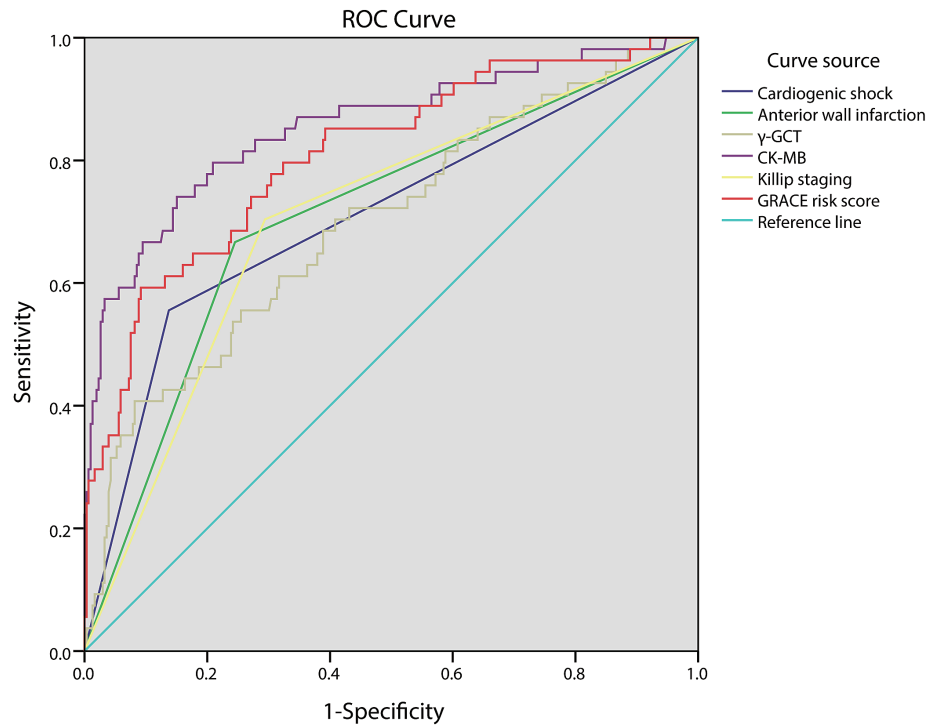

Fig. 1. ROC curve analysis of potential prognostic factors for in-hospital survival of patients with acute STEMI undergoing PCI.
ROC, receiver operator characteristic; STEMI, ST-segment elevation myocardial infarction; PCI, percutaneous coronary intervention.

Discussion

In recent years, PCI surgery has been widely used in the treatment of AMI (Roe et al. 2010; Qin et al. 2015). Identifying the risk factors of the prognosis for patients with acute STEMI undergoing PCI could certainly contribute to an improvement in survival rate as well as the quality of life for patients with STEMI.

Our study found that patients with a history of hyperlipidemia, T2DM, smoking, cardiogenic shock, arrhythmias, heart failure, AWMI, thrombus aspiration, intra-aortic balloon pump or Killip class III-IV were at high risk. The age, WBC count, neutrophils, neutral N/L ratio, γ-GGT and GRACE risk score of patients with STEMI were significantly higher in the death group than those in the survival group. The number and activity of immune cells and fac-

Table 4. ROC curve analysis of prognostic factors for in-hospital survival in STEMI patients undergoing PCI.

Factor	AUC	SE	Sig.	95% CI
Anterior infarction	0.711	0.040	< 0.001	0.633~0.789
Cardiogenic shock	0.709	0.043	< 0.001	0.625~0.793
γ-GGT	0.698	0.041	< 0.001	0.618~0.778
CK-MB	0.855	0.032	< 0.001	0.792~0.919
Killip class III-IV	0.705	0.039	< 0.001	0.628~0.781
Higher GRACE score	0.809	0.034	< 0.001	0.743~0.876

ROC, Receiver operating characteristic curve; STEMI, acute ST-segment elevation myocardial infarction; PCI, percutaneous coronary intervention; AUC, area under the curve; SE, standard error; CI, confidence interval; GRACE, global registry of acute coronary event.

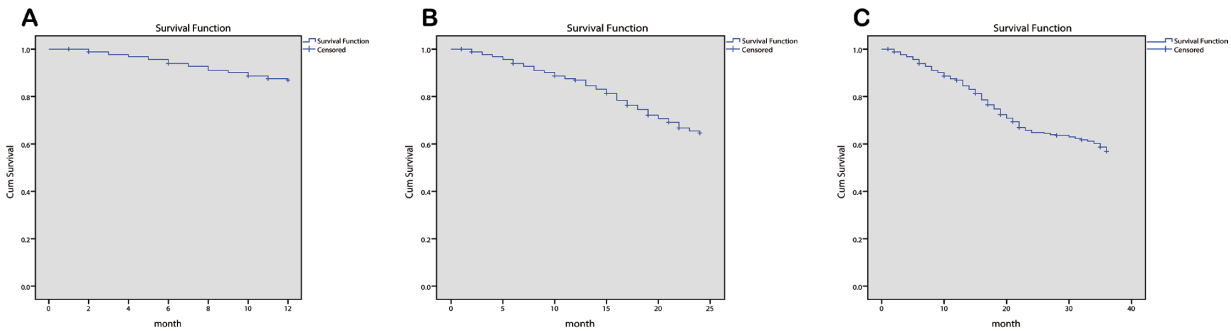

Fig. 2. Kaplan-Meier survival curve of 1-year, 2-year and 3-year survival of patients with STEMI in the survival group (n = 306).
A, Kaplan-Meier survival curves of 1-year survival of patients with STEMI in the survival group; B, Kaplan-Meier survival curve of 2-year survival of patients with STEMI in the survival group; Kaplan-Meier survival curve of 3-year survival of patients with STEMI in the survival group; STEMI, ST-segment elevation myocardial infarction; PCI, percutaneous coronary intervention.

Table 5. Multivariate Cox regression analysis of prognostic factors for long-term survival in STEMI patients undergoing PCI.

Factor	*B*	SE	Wald value	*P* value	OR (95% CI)
Anterior infarction	0.988	0.197	25.247	< 0.001	2.685 (1.826~3.946)
Cardiogenic shock	1.072	0.213	25.252	< 0.001	2.921 (1.923~4.437)
γ-GGT	0.011	0.006	3.232	0.072	1.011 (0.999~1.023)
CK-MB	0.001	0.010	0.015	0.904	1.009 (1.004~1.015)
Killip class III-IV	0.662	0.198	11.236	0.001	1.939 (1.317~2.856)
High GRACE score	0.009	0.003	12.624	< 0.001	1.009 (1.004~1.014)

STEMI, acute ST-segment elevation myocardial infarction; PCI, percutaneous coronary intervention; B, correlation coefficient; SE, standard error; OR, odds ratio; CI, confidence interval; GRACE, global registry of acute coronary event.

tors decline with age resulting in a weakened immune system and may explain why older patients are more prone to infections and thus have a worse prognosis for PCI (Nash et al. 2011; Truffa et al. 2012). Patients with T2DM are prone to malnutrition and disordered metabolism of sugar, protein and other important nutrients. Therefore, they are likely to have weak immune systems and prone to infections or other complications. These will have a certain influence on the prognosis of patients with STEMI undergoing PCI (Singh et al. 2011). A previous study showed that smoking affects the prognosis for PCI as well. Smoking for 20 minutes can damage the vascular endothelium and such vasoconstriction obstacles lead to platelet aggregation, the forming of atherosclerosis and an increased risk of STEMI (Zhang et al. 2015). Furthermore, another study found that cardiogenic shock and the survival of patients with STEMI after PCI are closely correlated (Mizuguchi et al. 2015). Cardiogenic shock is still the leading cause of hospital mortality in patients with STEMI. Its pathogenic mechanism involves a decreased coronary perfusion pressure and reduced ventricular pumping of blood. This may lead to decreased cardiac output or target organ hypo-perfusion causing multiple

organ dysfunction or significant systemic inflammatory response syndrome (Redfors et al. 2015; Goldberg et al. 2016). Another previous study suggested that an elevated white cell count in patients with STEMI is related to the body's stress response and changes due to coronary endothelial dysfunction. This up-regulates the production of inflammatory cells and cytokines, promotes rupture of atherosclerotic plaque(s) and capillary congestion, and induces and aggravates acute coronary disease (Bae et al. 2014). The pre-procedural neutrophil to lymphocyte ratio (N/L) ratio is a good indicator of the severity of atherosclerosis. A previous study revealed that patients with STEMI had significantly lower N/L ratio as well as WBC after treatment (Kaya et al. 2013). Studies have shown that thrombectomy primarily involves the removal of the coronary thrombus, which improves postoperative flow (thrombolysis in myocardial infarction: grade 3) and prevents stent thrombosis (Sardella et al. 2010; Mahmood et al. 2015). This avoids downstream embolic complications that may impair the myocardial perfusion (Sardella and Stio 2014). Additionally, previous evidence indicates that a higher Killip class is associated with more severe heart failures and higher probabilities of postoperative infection. This is especially the case for patients with a Killip class III or higher (Shiraishi et al. 2014). The GRACE risk score is a widely used prognostic scale for acute coronary syndrome and it has been shown to be a meaningful prognostic factor for in-hospital mortality in patients with STEMI (Nassar Junior et al. 2013).

In agreement with previous studies (Ekmekci et al. 2013; Velders et al. 2014), our results also indicate that advanced age and history of hyperlipidemia may increase the risk of adverse events mortality. Our study further demonstrated that AWMI, cardiogenic shock, high serum levels of γ-GGT and CK-MB, Killip class III-IV, and high GRACE risk scores correlate with the in-hospital mortality of patients with STEMI. The ROC curve analysis showed that the GRACE risk score has a high predictive value in the diagnosis of in hospital STEMI survival. The Cox proportional hazard models further confirmed that AWMI, cardiogenic shock, Killip class III-IV and the GRACE risk score are related to the long-term mortality of patients with STEMI.

In summary, this study retrospectively analyzed the data and evaluated the prognostic factors of 360 patients with STEMI who received PCI treatment. Our results demonstrated that AWMI, cardiogenic shock, Killip class III-IV and a high GRACE risk score is the prognostic factors for in-hospital and long term survival of patients with STEMI. It also demonstrated that serum CK-MB and γ-GGT may be prognostic factors for in-hospital survival of patients with STEMI. These findings provide a valuable tool for predicting the prognosis of patients with STEMI undergoing PCI. However, this study has certain limitations. The study was performed using statistical correlation analysis, therefore, we did not elucidate the relative importance of each prognostic factor identified in this study and the mechanism of each such factor identified in affecting the prognosis. In the future, we will focus on conducting new studies with larger sample sizes and clear contents to strengthen our results.

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Conflict of Interest

The authors declare no conflict of interest.

References

Alpert, J.S., Thygesen, K., Antman, E. & Bassand, J.P. (2000) Myocardial infarction redefined: a consensus document of The Joint European Society of Cardiology/American College of Cardiology Committee for the redefinition of myocardial infarction. *J. Am. Coll. Cardiol*., **36**, 959-969.

Antman, E.M., Hand, M., Armstrong, P.W., Bates, E.R., Green, L.A., Halasyamani, L.K., Hochman, J.S., Krumholz, H.M., Lamas, G.A., Mullany, C.J., Pearle, D.L., Sloan, M.A. & Smith, S.C. Jr.; 2004 Writing Committee Members (2008) 2007 Focused Update of the ACC/AHA 2004 Guidelines for the Management of Patients With ST-Elevation Myocardial Infarction. *Circulation*, **117**, 296-329.

Austen, W.G., Edwards, J.E., Frye, R.L., Gensini, G.G., Gott, V.L., Griffith, L.S., McGoon, D.C., Murphy, M.L. & Roe, B.B. (1975) A reporting system on patients evaluated for coronary artery disease. Report of the Ad Hoc Committee for Grading of Coronary Artery Disease, Council on Cardiovascular Surgery, American Heart Association. *Circulation*, **51**, 5-40.

Bae, M.H., Lee, J.H., Yang, D.H., Park, H.S., Cho, Y. & Chae, S.C. (2014) White blood cell, hemoglobin and platelet distribution width as short-term prognostic markers in patients with acute myocardial infarction. *J. Korean Med. Sci*., **29**, 519-526.

Boateng, S. & Sanborn, T. (2013) Acute myocardial infarction. *Dis. Mon*., **59**, 83-96.

Cabello, J.B., Burls, A., Emparanza, J.I., Bayliss, S. & Quinn, T. (2013) Oxygen therapy for acute myocardial infarction. *Cochrane Database Syst. Rev*., **2016**, doi: 10.1002/14651858.CD007160.pub4.

Ekmekci, A., Uluganyan, M., Tufan, F., Uyarel, H., Karaca, G., Kul, S., Gungor, B., Ertas, G., Erer, B., Sayar, N., Gul, M. & Eren, M. (2013) Impact of admission blood glucose levels on prognosis of elderly patients with ST elevation myocardial infarction treated by primary percutaneous coronary intervention. *J. Geriatr. Cardiol*., **10**, 310-316.

Gharacholou, S.M., Lopes, R.D., Alexander, K.P., Mehta, R.H., Stebbins, A.L., Pieper, K.S., James, S.K., Armstrong, P.W. & Granger, C.B. (2011) Age and outcomes in ST-segment elevation myocardial infarction treated with primary percutaneous coronary intervention: findings from the APEX-AMI trial. *Arch. Intern. Med*., **171**, 559-567.

Global Burden of Disease Study 2013 Collaborators (2015) Global, regional, and national incidence, prevalence, and years lived with disability for 301 acute and chronic diseases and injuries in 188 countries, 1990-2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet*, **386**, 743-800.

Goldberg, R.J., Makam, R.C., Yarzebski, J., McManus, D.D., Lessard, D. & Gore, J.M. (2016) Decade-Long Trends (2001-2011) in the Incidence and Hospital Death Rates Associated with the In-Hospital Development of Cardiogenic Shock after Acute Myocardial Infarction. *Circ. Cardiovasc. Qual. Outcomes*, **9**, 117-125.

Harrison, R.W., Aggarwal, A., Ou, F.S., Klein, L.W., Rumsfeld,

J.S., Roe, M.T. & Wang, T.Y. (2013) Incidence and outcomes of no-reflow phenomenon during percutaneous coronary intervention among patients with acute myocardial infarction. *Am. J. Cardiol*., **111**, 178-184.

Kala, P., Kanovsky, J., Rokyta, R., Smid, M., Pospisil, J., Knot, J., Rohac, F., Poloczek, M., Ondrus, T., Holicka, M., Spinar, J., Jarkovsky, J. & Dusek, L. (2012) Age-related treatment strategy and long-term outcome in acute myocardial infarction patients in the PCI era. *BMC Cardiovasc. Disord*., **12**, 31.

Kappetein, A.P., Head, S.J., Morice, M.C., Banning, A.P., Serruys, P.W., Mohr, F.W., Dawkins, K.D., Mack, M.J.; SYNTAX Investigators (2013) Treatment of complex coronary artery disease in patients with diabetes: 5-year results comparing outcomes of bypass surgery and percutaneous coronary intervention in the SYNTAX trial. *Eur. J. Cardiothorac. Surg*., **43**, 1006-1013.

Kaya, M.G., Akpek, M., Lam, Y.Y., Yarlioglues, M., Celik, T., Gunebakmaz, O., Duran, M., Ulucan, S., Keser, A., Oguzhan, A. & Gibson, M.C. (2013) Prognostic value of neutrophil/lymphocyte ratio in patients with ST-elevated myocardial infarction undergoing primary coronary intervention: a prospective, multicenter study. *Int. J. Cardiol*., **168**, 1154-1159.

Killip, T. 3rd & Kimball, J.T. (1967) Treatment of myocardial infarction in a coronary care unit. A two year experience with 250 patients. *Am. J. Cardiol*., **20**, 457-464.

Mahmood, M.M., Watt, J. & Ahmed, J.M. (2015) Thrombus aspiration during primary percutaneous coronary intervention for acute myocardial infarction: A review of clinical evidence and guidelines. *World J. Cardiol*., **7**, 889-894.

Mizuguchi, Y., Takahashi, A., Hashimoto, S., Yamada, T., Taniguchi, N., Nakajima, S. & Hata, T. (2015) Impact of the Presence of Chronic Total Occlusion in a Non-Infarct-Related Coronary Artery in Acute Myocardial Infarction Patients. *Int. Heart J*., **56**, 592-596.

Nash, M.C., Strom, J.A. & Pathak, E.B. (2011) Prevalence of major infections and adverse outcomes among hospitalized. ST-elevation myocardial infarction patients in Florida, 2006. *BMC Cardiovasc. Disord*., **11**, 69.

Nassar Junior, A.P., Mocelin, A.O., Andrade, F.M., Brauer, L., Giannini, F.P., Nunes, A.L. & Dias, C.A. (2013) SAPS 3, APACHE IV or GRACE: which score to choose for acute coronary syndrome patients in intensive care units? *Sao Paulo Med. J*., **131**, 173-178.

Ndrepepa, G., Tiroch, K., Fusaro, M., Keta, D., Seyfarth, M., Byrne, R.A., Pache, J., Alger, P., Mehilli, J., Schomig, A. & Kastrati, A. (2010) 5-year prognostic value of no-reflow phenomenon after percutaneous coronary intervention in patients with acute myocardial infarction. *J. Am. Coll. Cardiol*., **55**, 2383-2389.

Qin, Q., Qian, J., Fan, B., Ge, L. & Ge, J. (2015) Clinical Outcomes After Percutaneous Coronary Intervention in Acute Myocardial Infarction Due to Unprotected Left Main Coronary Artery Disease. *J. Invasive Cardiol*., **27**, E153-157.

Redfors, B., Angeras, O., Ramunddal, T., Dworeck, C., Haraldsson, I., Ioanes, D., Petursson, P., Libungan, B., Odenstedt, J., Stewart, J., Lodin, E., Wahlin, M., Albertsson, P., Matejka, G. & Omerovic, E. (2015) 17-year trends in incidence and prognosis of cardiogenic shock in patients with acute myocardial infarction in western Sweden. *Int. J. Cardiol*., **185**, 256-262.

Roe, M.T., Messenger, J.C., Weintraub, W.S., Cannon, C.P., Fonarow, G.C., Dai, D., Chen, A.Y., Klein, L.W., Masoudi, F.A., McKay, C., Hewitt, K., Brindis, R.G., Peterson, E.D. & Rumsfeld, J.S. (2010) Treatments, trends, and outcomes of acute myocardial infarction and percutaneous coronary intervention. *J. Am. Coll. Cardiol*., **56**, 254-263.

Sardella, G., Mancone, M., Canali, E., Di Roma, A., Benedetti, G., Stio, R., Badagliacca, R., Lucisano, L., Agati, L. & Fedele, F. (2010) Impact of thrombectomy with EXPort Catheter in Infarct-Related Artery during Primary Percutaneous Coronary Intervention (EXPIRA Trial) on cardiac death. *Am. J. Cardiol*., **106**, 624-629.

Sardella, G. & Stio, R.E. (2014) Thrombus aspiration in acute myocardial infarction: Rationale and indication. *World J. Cardiol*., **6**, 924-928.

Shiraishi, J., Kohno, Y., Nakamura, T., Yanagiuchi, T., Hashimoto, S., Ito, D., Kimura, M., Matsui, A., Yokoi, H., Arihara, M., Hyogo, M., Shima, T., Sawada, T., Matoba, S., Yamada, H., et al. (2014) Predictors of in-hospital outcomes after primary percutaneous coronary intervention for acute myocardial infarction in patients with a high Killip class. *Intern. Med*., **53**, 933-939.

Singh, M., Arora, R., Kodumuri, V., Khosla, S. & Jawad, E. (2011) Coronary revascularization in diabetic patients: current state of evidence. *Exp. Clin. Cardiol*., **16**, 16-22.

Smith, S.C. Jr., Feldman, T.E., Hirshfeld, J.W. Jr., Jacobs, A.K., Kern, M.J., King, S.B. 3rd, Morrison, D.A., O'Neill, W.W., Schaff, H.V., Whitlow, P.L., Williams, D.O., Antman, E.M., Smith, S.C. Jr., Adams, C.D., Anderson, J.L., et al. (2006) ACC/AHA/SCAI 2005 guideline update for percutaneous coronary intervention: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (ACC/AHA/SCAI Writing Committee to Update the 2001 Guidelines for Percutaneous Coronary Intervention). *J. Am. Coll. Cardiol*., **47**, e1-121.

Spoon, D.B., Lerman, A., Rule, A.D., Prasad, A., Lennon, R.J., Holmes, D.R. & Rihal, C.S. (2010) The association of serum uric acid levels with outcomes following percutaneous coronary intervention. *J. Interv. Cardiol*., **23**, 277-283.

Takii, T., Yasuda, S., Takahashi, J., Ito, K., Shiba, N., Shirato, K. & Shimokawa, H.; MIYAGI-AMI Study Investigators (2010) Trends in acute myocardial infarction incidence and mortality over 30 years in Japan: report from the MIYAGI-AMI Registry Study. *Circ. J*., **74**, 93-100.

Task Force Members; Steg, P.G., James, S.K., Atar, D., Badano, L.P., Blomstrom-Lundqvist, C., Borger, M.A., Di Mario, C., Dickstein, K., Ducrocq, G., Fernandez-Aviles, F., Gershlick, A.H., Giannuzzi, P., Halvorsen, S., Huber, K., et al. (2012) ESC Guidelines for the management of acute myocardial infarction in patients presenting with ST-segment elevation: the Task Force on the management of ST-segment elevation acute myocardial infarction of the European Society of Cardiology (ESC). *Eur. Heart J*., **33**, 2569-2619.

Terkelsen, C.J., Lassen, J.F., Norgaard, B.L., Gerdes, J.C., Jensen, T., Gotzsche, L.B., Nielsen, T.T. & Andersen, H.R. (2005) Mortality rates in patients with ST-elevation vs. non-ST-elevation acute myocardial infarction: observations from an unselected cohort. *Eur. Heart J*., **26**, 18-26.

Truffa, A.A., Granger, C.B., White, K.R., Newby, L.K., Mehta, R.H., Hochman, J.S., Patel, M.R., Pieper, K.S., Al-Khalidi, H.R., Armstrong, P.W. & Lopes, R.D. (2012) Serious infection after acute myocardial infarction: incidence, clinical features, and outcomes. *JACC Cardiovasc. Interv*., **5**, 769-776.

Velders, M.A., James, S.K., Libungan, B., Sarno, G., Frobert, O., Carlsson, J., Schalij, M.J., Albertsson, P. & Lagerqvist, B. (2014) Prognosis of elderly patients with ST-elevation myocardial infarction treated with primary percutaneous coronary intervention in 2001 to 2011: a report from the Swedish Coronary Angiography and Angioplasty Registry (SCAAR) registry. *Am. Heart J*., **167**, 666-673.

White, H.D. & Chew, D.P. (2008) Acute myocardial infarction. *Lancet*, **372**, 570-584.

Wong, C.P., Loh, S.Y., Loh, K.K., Ong, P.J., Foo, D. & Ho, H.H. (2012) Acute myocardial infarction: Clinical features and outcomes in young adults in Singapore. *World J. Cardiol*., **4**, 206-210.

Zhang, Y.J., Iqbal, J., van Klaveren, D., Campos, C.M., Holmes,

D.R., Kappetein, A.P., Morice, M.C., Banning, A.P., Grech, E.D., Bourantas, C.V., Onuma, Y., Garcia-Garcia, H.M., Mack, M.J., Colombo, A., Mohr, F.W., Steyerberg, E.W. & Serruys, P.W. (2015) Smoking is associated with adverse clinical outcomes in patients undergoing revascularization with PCI or CABG: the SYNTAX trial at 5-year follow-up. *J. Am. Coll. Cardiol*., **65**, 1107-1115.