

Fibrinogen-to-albumin ratio predicts long-term outcomes for patients with ST-elevation myocardial infarction and multivessel disease: A prospective observational cohort study

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Abstract. The fibrinogen-to-albumin ratio index (FAR) is a valuable tool reflecting the systemic inflammation level and associated with the severity of coronary artery disease. However, the utility of the FAR in predicting the long-term prognosis of patients with ST-elevation myocardial infarction (STEMI) and multivessel disease has remained to be determined. A total of 424 patients diagnosed with STEMI and multivessel disease were recruited for the present study. They were given emergent percutaneous coronary intervention treatment and then completed a follow-up for primary (all-cause mortality) and secondary endpoints (major adverse cardiac events, including MI, stroke, emergent revascularization and rehospitalization due to heart failure). The association between FAR and the Synergy Between Percutaneous Coronary Intervention with Taxus and Cardiac Surgery (SYNTAX) score was investigated, while receiver operating characteristic curve analysis was adopted to assess the ability of the FAR to predict long-term outcomes. The long-term survival of high and low FAR groups was compared by drawing Kaplan-Meier survival curves. Multivariate Cox regression analysis was adopted to evaluate the risk factors of primary and secondary endpoints. The FAR was revealed to have a linear correlation with the SYNTAX score ($y=0.022x+17.737$; $P=0.015$). Furthermore,

the FAR was a significant predictor of all-cause death with a cut-off value of 128.4 (area under the curve, 0.832; $P<0.001$). A significant difference was determined between the high FAR group and the low FAR group in terms of the proportion of patients with the primary endpoint ($P<0.001$) and secondary endpoint ($P=0.001$). It was demonstrated that the FAR was an independent risk factor for all-cause death of patients with STEMI and multivessel disease (hazard ratio, 1.029; 95% CI: 1.020-1.037; $P<0.001$). In summary, the FAR is a valuable biomarker associated with STEMI and may be useful in the prediction of the long-term prognosis of patients with STEMI and multivessel disease.

Introduction

Among all patients with acute coronary syndrome (ACS), ~50% suffer from atherosclerosis involving multiple vessels or the entire coronary tree (1). Compared with single-vessel disease, ST-elevation myocardial infarction (STEMI) with multivessel disease is associated with a worse prognosis (2). The results of the Abciximab Intracoronary versus intravenously Drug Application in STEMI demonstrated that although multivessel coronary artery disease (CAD) is not associated with reduced success of reperfusion, multivessel disease is associated with a high risk of adverse clinical outcomes (2). Treatment strategies for STEMI and multivessel disease remain controversial, including percutaneous coronary intervention (PCI) for the culprit vessel or non-culprit vessels, as well as the time-point (3). A useful tool is required for evaluating the condition and predicting the prognosis to aid clinical judgment. The Synergy Between Percutaneous Coronary Intervention with Taxus and Cardiac Surgery (SYNTAX) scoring system is the most widely used tool to determine the extent and severity of CAD. The SYNTAX score is positively correlated with all-cause mortality of patients with CAD after PCI (4). However, the SYNTAX scoring system is complex and there is currently limited data on the effectiveness of SYNTAX score in predicting the prognosis of STEMI patients with multivessel disease.

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The fibrinogen-to-albumin ratio (FAR) is the ratio between serum fibrinogen levels and serum albumin. Being part of the inflammatory reaction and processes associated with thrombosis, fibrinogen is a biomarker for the risk of stroke and MI (5). At the same time, hypoalbuminemia is also associated with severe MI and heart failure (6). The FAR is a valuable biomarker in the prediction of the prognosis of multiple tumors, including esophageal squamous cell carcinoma (7), non-small cell lung cancer (8), colorectal cancer (9) and gallbladder cancer (10). A previous study proved that the FAR is significantly associated with the SYNTAX score and could predict the severity of CAD in patients with STEMI (11). Hence, it was hypothesized in the present study that the FAR may be linked to the long-term prognosis of patients with STEMI and multivessel disease.

Materials and methods

Study population. The patients were recruited from the emergency department to participate in the present prospective observational cohort study. All patients included were required to fulfill the following criteria: i) Age ≥ 18 years; ii) diagnosis with STEMI and multiple vessel disease based on coronary angiography; iii) the patient received revascularization treatment of PCI; iv) the patient remained alive during the hospital stay; v) the patient and their family provided written informed consent to participate in the study. The exclusion criteria were as follows: i) Patients who were diagnosed with Non-ST elevation myocardial infarction or unstable angina; ii) patients who were in a coma or unconscious; iii) patients with cancers, severe infections, serious organ dysfunction or other serious diseases; iv) patients and families who were not able to cooperate with the follow-up process.

The 2011 ESC Guidelines for the Management of Acute Myocardial Infarction in Patients Presenting With ST-segment Elevation were followed in the present study (12), according to which STEMI was defined as electrocardiographic ST-segment elevation >2 mm in 2 or more contiguous chest leads or ≥ 1 mm in 2 or more limb leads or new onset of left bundle-branch block, together with chest pain or other typical symptoms and elevated troponin levels >99 th percentile (13).

A total of 562 patients (Table I) with STEMI and multiple vessel disease meeting the criteria were recruited for the present study from July 2012 to September 2013 at Xianyang Central Hospital (Xianyang, China). Written informed consent was acquired from the patients and their family. The Medical Ethics Committee of Xianyang Central Hospital (Xianyang, China) approved the present study (no. 20120535). The study design is presented in the flowchart in Fig. 1.

In-hospital treatment. Coronary angiography and interventional therapy were routinely performed. The 'infarct-related artery only' strategy for PCT was adopted in the present study (14). Successful PCI was defined as coronary angiography indicating residual lumen stenosis of $<10\%$ and a blood flow classification of Thrombolysis in MI grade 3 (15). In patients with emergency PCI, 300 mg aspirin was administered as soon as possible prior to surgery, and furthermore, oral clopidogrel 300–600 mg or ticagrelor 180 mg was administered orally. Patients were given oral aspirin 100 mg/day

and clopidogrel 75 mg/day (or ticagrelor 90 mg twice daily) for at least 1 year according to the 2011 ESC Guidelines for the Management of Acute Myocardial Infarction in Patients Presenting With ST-segment Elevation (12).

Data collection. Clinical data were collected from the electronic medical record database of Xianyang Central Hospital. The FAR was calculated from serum fibrinogen and albumin concentrations on admission. Plasma fibrinogen levels were detected by the coagulation method using STA CompactMax automatic coagulation analyzer (Diagnostica Stago Ltd.) and high-sensitivity c-reactive protein (hs-CRP) was detected by immunoturbidimetry using an AU5400 automatic biochemical analyzer (Olympus Corporation). Albumin levels and myocardial injury markers, including cardiac troponin T (cTnT) as well as creatinine kinase (CK)-MB, creatinine, NT-proB-type natriuretic peptide (NT-proBNP), alanine aminotransferase (ALT) and aspartate aminotransferase (AST) were also tested using the Abbott Architect C16000 autoanalyzer (Abbott Laboratories) on admission.

Clinical endpoints. The primary endpoint was defined as all-cause mortality during follow-up and the secondary endpoint was a composite of major adverse cardiac events (MACE), including myocardial infarction (MI), stroke, unscheduled revascularization and rehospitalization due to heart failure.

Follow-up. All patients enrolled were followed up by telephone or visits to the original clinics where they were enrolled every year for a total of 5 years. The parameters determined during follow-up included survival status, recent readmission and other complications. The data of cases with self-dropout or missed contact were considered as censored data.

Statistical analysis. SPSS version 19.0 (IBM Corp) was used for statistical analysis in the present study. The variables were first subjected to a normality of distribution test (Kolmogorov-Smirnov test). Continuous variables following a normal distribution were expressed as the mean \pm standard deviation and categorical variables were presented as proportions, while continuous variables that did not fit a normal distribution were described as the median and interquartile range. Comparison of continuous variables between different groups was performed using one-way analysis of variance and Tukey's multiple-comparisons test of independent samples. The Kruskal-Wallis test and Dunn's multiple-comparisons test were adopted for comparison of different groups for non-normal distributed variables of independent samples. A χ^2 test was performed for comparisons of categorical variables. Linear regression analysis was used to examine the correlation between the SYNTAX score and the FAR.

A receiver operating characteristic (ROC) curve analysis was also performed to determine the best cut-off value of the FAR in predicting all-cause death, based on which all patients were divided into a high FAR group and a low FAR group. The Cox proportional hazards model was adopted as the regression method to determine hazard ratios (HR) compare the relative hazard between the high FAR group and the low FAR group. Univariate analysis between covariates and endpoints

Table I. Demographic characteristics and clinical data of the patients enrolled stratified by the endpoints.

Variables	Patients without endpoints (n=291)	Patients with primary endpoint (n=38)	Patients with secondary endpoint (n=95)	P-value ^a
Demographics				
Age (years)	61.5±15.8	71.5±10.3 ^b	64.0±12.7 ^{b,c}	<0.001
Male sex	181 (62.2)	23 (60.5)	57 (60.0)	0.921
BMI (kg/m ²)	24.6±3.2	25.1±2.7	24.1±3.3	0.234
Smoking	108 (37.1)	8 (21.1)	36 (37.8)	0.136
LVEF	49.6±10.0	45.6±11.7	50.4±9.9	0.065
Comorbidities				
Heart failure	79 (27.1)	19 (50.0) ^b	16 (16.8) ^c	<0.001
Hypertension	68 (23.4)	16 (42.1) ^b	29 (30.5)	0.031
Diabetes mellitus	46 (15.8)	5 (13.2)	15 (15.8)	0.912
Chronic kidney disease	13 (4.5)	4 (10.5)	3 (3.2)	0.182
Chronic lung disease	34 (11.7)	3 (7.9)	8 (8.4)	0.569
Cerebrovascular disease	17 (5.8)	1 (2.6)	9 (9.5)	0.278
Tumor	8 (2.7)	1 (2.6)	3 (3.2)	0.976
Laboratory tests on admission				
Peak cTnT (ng/dl)	4.80 (2.90, 6.39)	5.43 (3.18, 6.90)	4.46 (2.93, 6.17)	0.403
Peak CK-MB (ng/dl)	552.1 (419.8, 668)	493.7 (379.7, 676.6)	593.6 (420.3, 717.2)	0.183
Creatinine (μmol/l)	103.1 (76.2, 131.4)	112.5 (72.8, 136.0)	94.0 (70.6, 122.5)	0.190
NT-proBNP (ng/l)	71.1 (27.3, 123.1)	91.3 (55.7, 168.4)	74.2 (35.9, 123.2)	0.073
hsCRP (mg/l)	21.5 (12.9, 30.2)	27.1 (21.6, 36.0) ^b	24.0 (15.3, 32.3)	0.008
ALT (U/l)	14 (6, 23)	17 (9, 24)	16 (8, 23)	0.289
AST (U/l)	20 (11, 29)	24 (10.5, 31.3)	21 (11, 30)	0.636
Fibrinogen (μg/ml)	278 (216, 336)	417 (277, 492) ^b	280 (217, 349) ^c	<0.001
Albumin (g/dl)	3.37 (3.11, 3.69)	3.14 (2.73, 3.38) ^b	3.32 (3.09, 3.56) ^c	<0.001
SYNTAX score	20 (16, 23)	24 (20, 30) ^b	19 (16, 22) ^c	<0.001
FAR	81.2 (63.4, 99.5)	136.6 (98.3, 156.3) ^b	84.0 (67.3, 106.0) ^c	<0.001

^aP-value for comparison of the three groups. ^bP<0.05 vs. patients without endpoints; ^cP<0.05 vs. patients with primary endpoint. Values are expressed as the mean ± standard deviation, n (%) or the median (interquartile range). BMI, body mass index; LVEF, left ventricular ejection fraction; cTnT, cardiac troponin T; CK-MB, creatine kinase-MB; NT-proBNP, NT-proB-type natriuretic peptide; hsCRP, high-sensitivity C-reactive protein; ALT, alanine aminotransferase; AST, aspartate aminotransferase; FAR, fibrinogen-to-albumin ratio.

was performed and covariates with P<0.10 were entered into the multivariate analysis. The survival status was compared between the two groups via Kaplan-Meier survival curves and log-rank tests. P<0.05 was considered to indicate statistical significance.

Results

Demographics and baseline characteristics. A total of 562 patients were enrolled in the current study, with an average age of (68.3±20.3 years), a male/female ratio of 64.9% (365/562). Among the 562 patients, 424 patients completed the 5-year follow-up. During this period, 38 cases of all-cause death occurred, while secondary endpoints were observed in 95 patients, including 41 cases of recurrent MI, 31 cases of unscheduled revascularization, 13 cases of rehospitalization due to heart failure and 10 cases of stroke. The remaining 291 patients did not reach any endpoint.

The demographics and baseline data of patients without endpoints, patients with the primary endpoints and patients with secondary endpoints we compared in Table I. The three groups had similar data in terms of sex ratio, body mass index and smoking status (all P>0.05). However, the patients with primary endpoints were significantly older than those in the other two groups (P<0.001). Furthermore, they had a significantly higher proportion of heart failure (P<0.001) and hypertension (P=0.031) than other two groups, but the three groups had no disparity in diabetes mellitus, chronic kidney disease, chronic lung disease, cerebrovascular disease and tumors (All P>0.05). As for laboratory test results on admission, no significant difference was identified among the three groups in peak cTnT, peak CK-MB, creatinine, NT-proBNP, ALT and AST (all P>0.05), while patients with primary or secondary endpoints had significantly higher hs-CRP (P<0.001) and fibrinogen (P<0.001) and lower albumin (P<0.001).

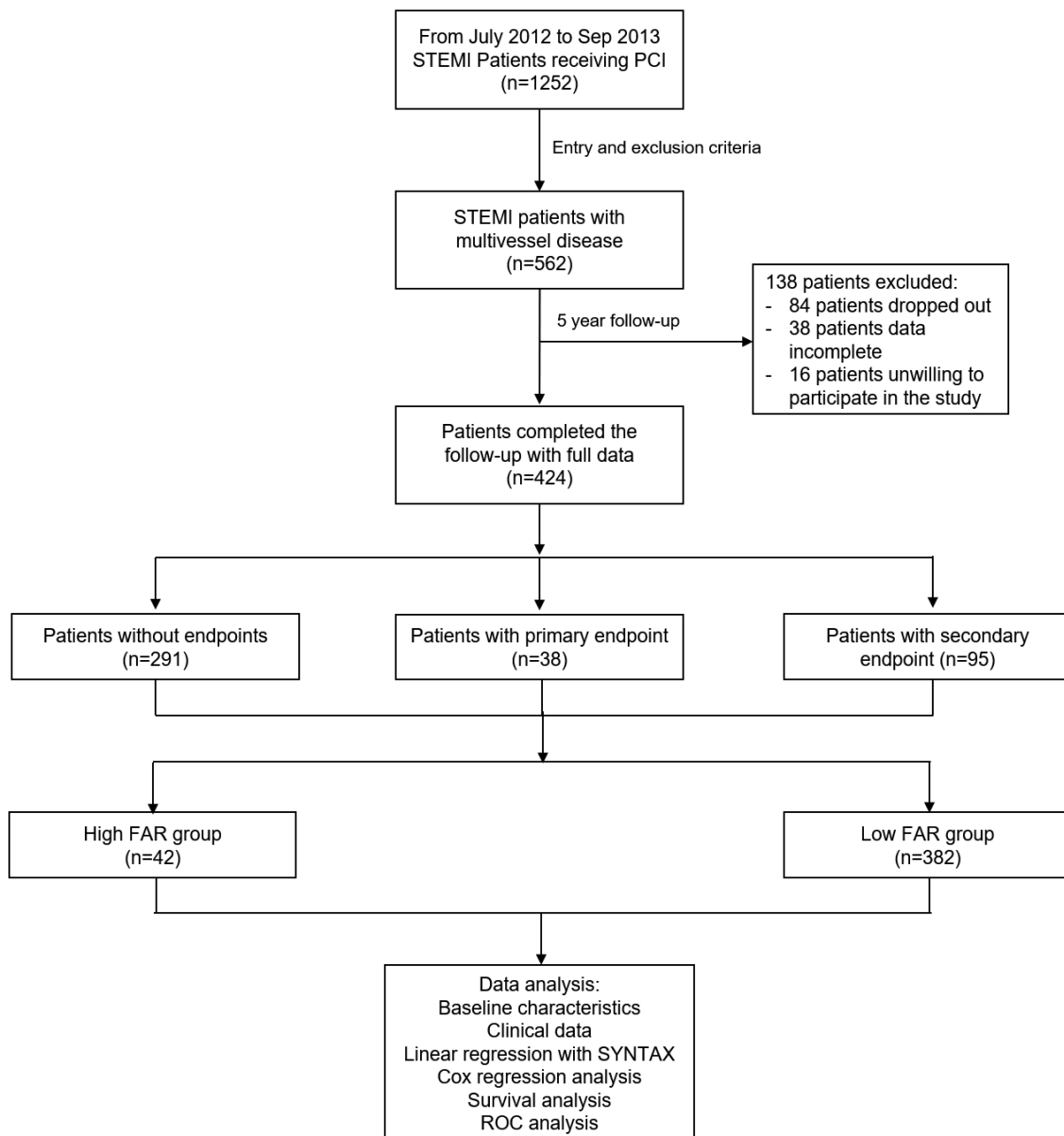


Figure 1. Flowchart depicting the study design. STEMI, ST-elevation myocardial infarction; PCI, percutaneous coronary intervention; FAR, fibrinogen-to-albumin ratio; SYNTAX, Synergy Between Percutaneous Coronary Intervention with Taxus and Cardiac Surgery; ROC, receiver operating characteristic.

Lesions and treatment. The coronary artery lesions and treatments were compared between the different groups (Table II). As for the angiographic findings, a great disparity between patients with and those without endpoints was apparent. The patients with the primary endpoint had a higher number of diseased arteries and this group had a higher proportion of patients with 3-vessel disease, left main CAD and chronic total occlusion (all $P < 0.01$). As a consequence, there was also a significant difference in the number of stents used in PCI among the three groups ($P < 0.001$). However, no significant difference was observed in culprit artery type, use of DES and medication at discharge (all $P > 0.05$).

Correlation between SYNTAX score and the FAR. The association between the SYNTAX score and FAR in patients with STEMI and multiple vessel disease was also validated. As presented in Table I, patients with primary outcomes had

a significantly higher SYNTAX score and FAR than the other two groups ($P < 0.001$). The correlation between the SYNTAX and the FAR was then examined by linear regression analysis, which demonstrated that the SYNTAX score had a linear correlation with the FAR ($r, 0.118$; $y, 0.022x + 17.737$; $P = 0.015$; Fig. 2).

ROC curve analysis. A ROC curve analysis was performed to determine the value of the FAR in the prediction of the long-term outcomes of patients with STEMI and multivessel disease (Fig. 3). It was demonstrated that FAR is significant in predicting all-cause death with an AUC of 0.832 (95% CI for the AUC, 0.750-0.915; $P < 0.001$) at the ideal cut-off value of the FAR determined at 128.4. The sensitivity was 63.2% and the specificity was 95.3%.

Primary endpoint. Using the cut-off value of 128.4, the patients were divided into the high FAR group ($n = 42$) and

Table II. Lesions and treatment of the patients enrolled stratified by the endpoints.

Item	Patients without endpoints (n=291)	Patients with primary endpoint (n=38)	Patients with secondary endpoint (n=95)	P-value ^a
Angiographic findings				
Number of diseased arteries	2.3±0.5	2.7±0.4 ^b	2.2±0.3 ^c	<0.001
≥3-vessel disease	104 (35.7)	25 (65.8) ^b	45 (47.4)	0.001
LMCA disease	10 (3.4)	6 (15.8) ^b	5 (5.3) ^c	0.005
Chronic total occlusion	20 (6.9)	10 (26.3) ^b	11 (11.6)	0.001
Culprit artery				0.552
Left anterior descending artery	124 (42.6)	18 (47.4)	33 (34.7)	
Circumflex artery	51 (17.5)	8 (21.1)	21 (22.1)	
Right coronary artery	114 (39.2)	11 (28.9)	40 (42.1)	
Left main coronary artery	2 (0.7)	1 (2.6)	1 (1.1)	
PCI				
Number of stents	2.1±0.6	2.5±0.5 ^b	2.4±0.3 ^b	<0.001
Use of DES	80 (27.5)	15 (39.5)	28 (29.5)	0.308
Medication at discharge				
Aspirin	289 (99.3)	38 (100.0)	94 (98.9)	0.805
Clopidogrel	256 (88.0)	33 (86.8)	80 (84.2)	0.638
Ticagrelor	35 (12.0)	5 (13.2)	15 (15.8)	0.638

^aP-value for comparison of three groups. ^bP<0.05 vs. patients without endpoints; ^cP<0.05 vs. patients with primary endpoint. Values are expressed as the mean ± standard deviation or n (%).

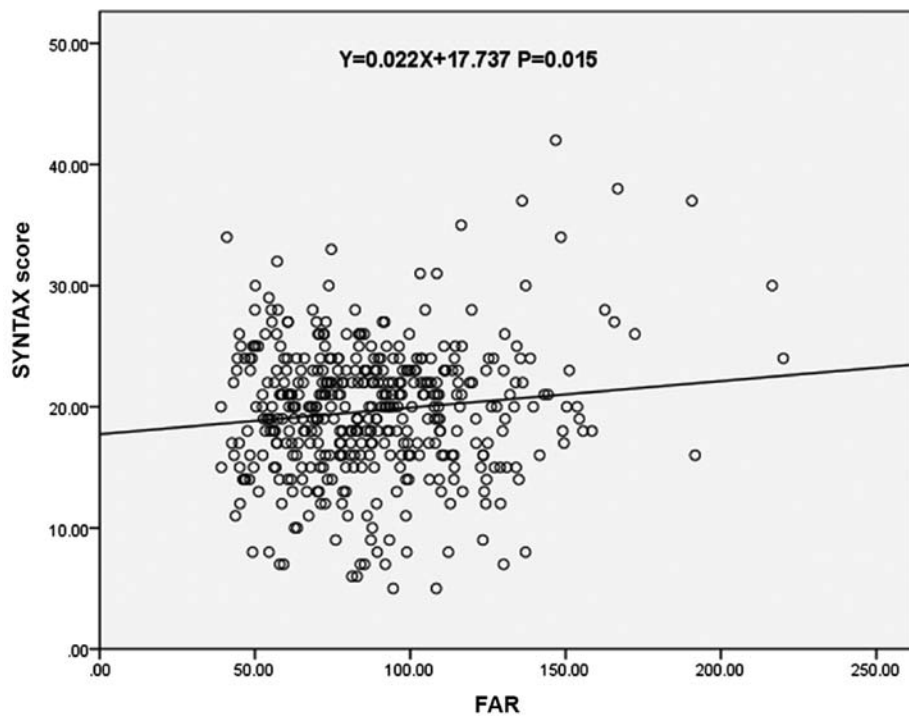


Figure 2. Scatter plot presentation of SYNTAX score and FAR. Linear regression formula: $Y=0.022X+17.737$ ($r=0.118$; $P=0.015$). FAR, fibrinogen-to-albumin ratio; SYNTAX, Synergy Between Percutaneous Coronary Intervention with Taxus and Cardiac Surgery.

the low FAR group (n=382), and the long-term survival was compared using Kaplan-Meier curves. The results indicated

that the two groups had significantly different survival curves. Compared with the low FAR group, the high FAR

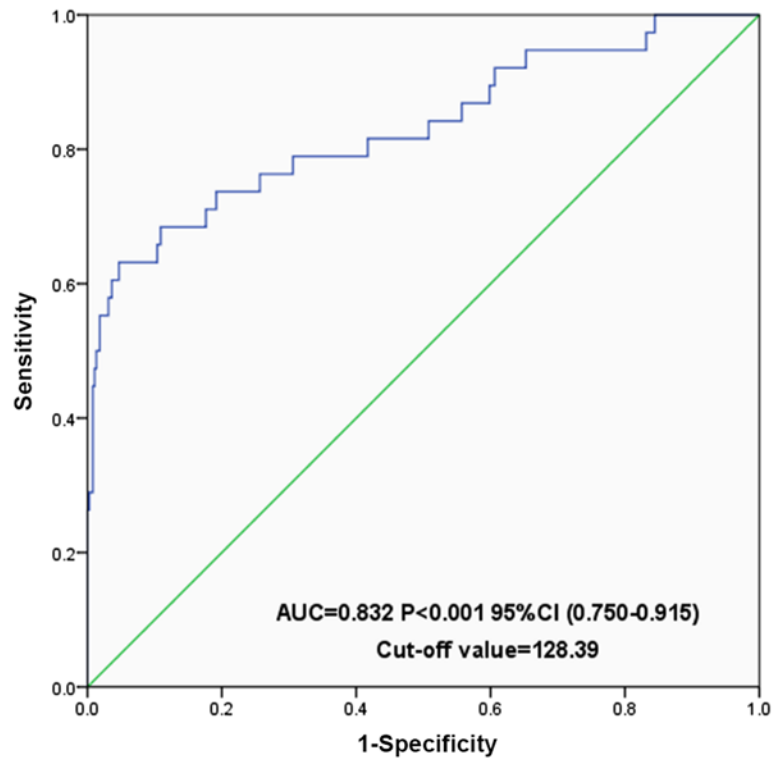


Figure 3. ROC curve for the fibrinogen-to-albumin ratio in predicting 5-year mortality. ROC, receiver operating characteristic; AUC, area under the ROC curve.

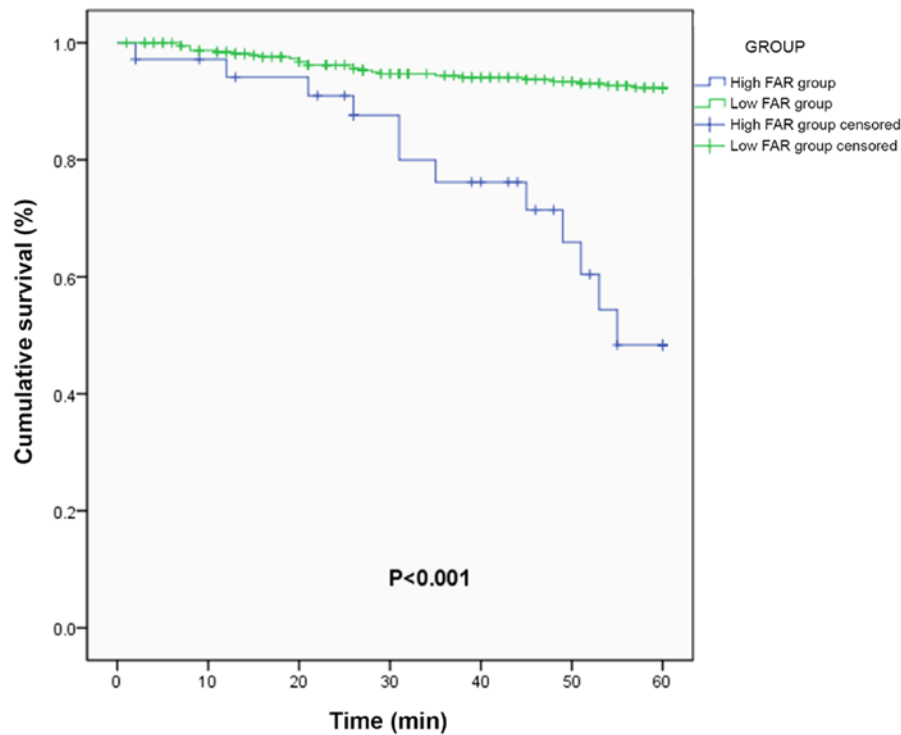


Figure 4. Kaplan-Meier survival curves for the primary endpoint for the high and the low FAR group (cut-off value, 128.4). FAR, fibrinogen-to-albumin ratio; m, months.

group had an unfavorable survival curve and a significantly lower survival rate ($P<0.001$; Fig. 4). Univariate Cox regression found that FAR was associated with worse prognosis (HR, 1.031; 95% CI, 1.023-1.040; $P<0.001$). Multivariate

Cox regression analysis demonstrated that the FAR was an independent risk factor for the all-cause death (HR, 1.029; 95% CI, 1.020-1.037; $P<0.001$; Table III), adjusted by age, heart failure, hs-CRP, and hypertension.

Table III. Multivariate Cox regression analysis of factors influencing the primary endpoint.

Risk factor	B	SE	Wald	P-value	HR	95% CI
Age ^a	0.043	0.013	10.669	0.001	1.044	1.017-1.071
Heart failure ^b	0.708	0.326	4.723	0.030	2.030	1.072-3.843
hs-CRP ^a	0.030	0.017	3.090	0.079	1.031	0.997-1.066
Hypertension ^b	0.907	0.339	7.146	0.008	2.477	1.274-4.816
FAR ^a	0.029	0.004	45.612	<0.001	1.029	1.020-1.037

^aContinuous variables. ^bCategorical variables. hs-CRP, high-sensitivity C-reactive protein; FAR, fibrinogen-to-albumin ratio; SE, standard error; HR, hazard ratio.

Table IV. Cox regression analysis of secondary endpoints for the high FAR group vs. low FAR group.

Factor	Unadjusted		Adjusted ^a	
	HR (95% CI)	P-value	HR (95% CI)	P-value
Secondary endpoint				
Myocardial infarction	1.79 (3.75-7.87)	<0.001	1.62 (3.49-7.52)	0.001
Stroke	0.21 (1.67-13.18)	0.628	0.23 (1.95-16.34)	0.537
Emergent revascularization	0.71 (2.03-5.82)	0.186	0.81 (2.4-7.15)	0.115
Readmission due to heart failure	0.15 (1.14-8.77)	0.901	0.13 (1.05-8.41)	0.961
Total secondary end-points	1.48 (2.56-4.45)	0.001	1.48 (2.62-4.63)	0.001

^aHR adjusted for covariates of age, heart failure, hypertension and hs-CRP. hs-CRP, high-sensitivity C-reactive protein; FAR, fibrinogen-to-albumin ratio; HR, hazard ratio.

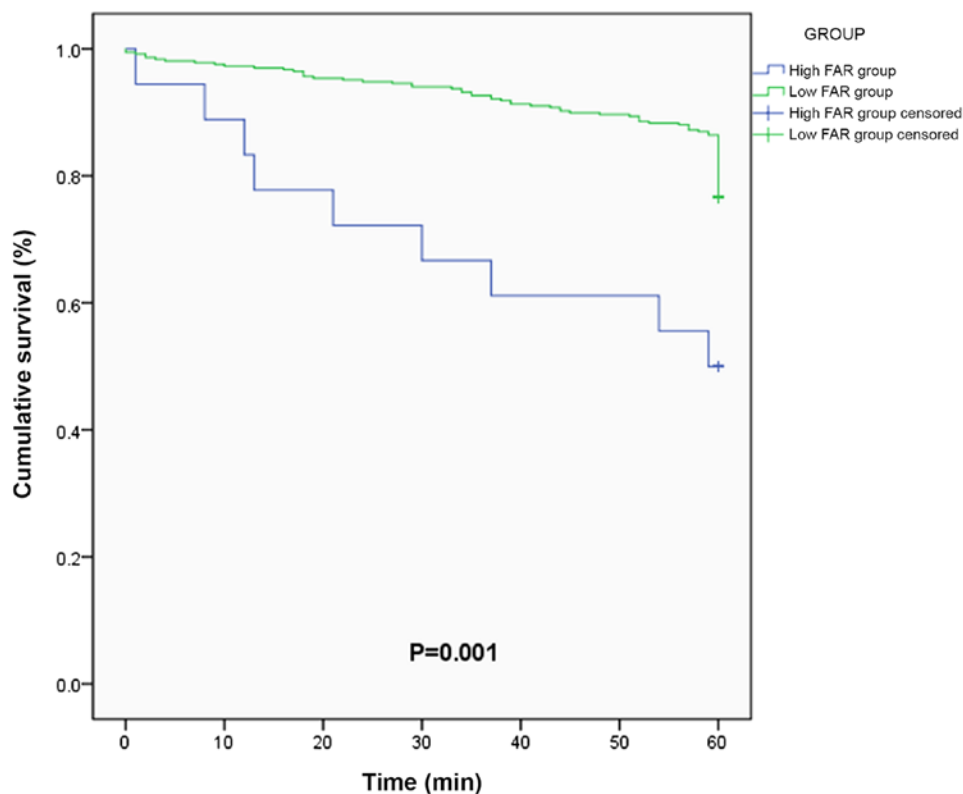


Figure 5. Kaplan-Meier curves for secondary endpoints for the high and the low FAR group (cut-off value, 128.4). FAR, fibrinogen-to-albumin ratio; m, months.

Secondary endpoints. The secondary endpoints were also compared between the high FAR and the low FAR groups, which were MACE including the recurrent MI, stroke, unscheduled revascularization and rehospitalization due to heart failure (Fig. 5). The high FAR group had a significantly higher incidence of secondary endpoints ($P=0.001$). The multivariate Cox regression analysis demonstrated that the FAR was an independent risk factor for total MACE (HR, 1.48; 95% CI, 2.62-4.63; $P=0.001$), even adjusted by age, heart failure, hypertension and hs-CRP in multivariate analysis (Table IV). Subgroup analysis for individual MACE indicated that only MI was significantly associated with the FAR (HR, 1.62; 95% CI, 3.49-7.52; $P<0.001$), while the other three endpoints were not (all $P>0.05$).

Discussion

Abundant pieces of evidence have linked the FAR with the severity and prognosis of CAD and demonstrated its value in risk stratification and prediction of the prognosis of STEMI (10,16-18). The present study not only investigated the association between the FAR and the SYNTAX score but explored the importance of the FAR in predicting the long-term outcomes for the patients with STEMI and multivessel disease. It was revealed that the FAR exhibited a linear correlation with the SYNTAX score, indicating its potential in assessing the severity. The observational cohort study proved that the FAR had potential value in predicting long-term outcomes. Of note, Cox regression analysis indicated no significant association between the FAR and stroke, unscheduled revascularization or rehospitalization for heart failure.

For patients with STEMI and multivessel disease, the prognosis remains unsatisfying. It was reported that patients with STEMI and multivessel CAD had poorer long-term mortality and a higher incidence of MACE (19). Different treatment strategies have been developed with controversies regarding their usefulness continuing. Previous observational and small randomized controlled trials have demonstrated conflicting results regarding the optimal treatment strategy (20). Specifically, complete vs. culprit-only revascularization has been compared. A review summarized current evidence on the different treatment options and concluded that the optimal revascularization strategy remains uncertain, while interventional cardiologists should determine the optimal reperfusion strategy based on concrete factors, including clinical characteristics, disease severity and complexity of lesions (1). A simple, cost-effective and sufficient risk assessment approach is required to predict the prognosis and direct the clinical strategy.

The SYNTAX scoring system is ubiquitously applied worldwide to assess the severity of CAD. Certain studies have also explored its value in prognosis prediction. Braga *et al* (4) reported on a retrospective cohort study on 535 patients with STEMI undergoing primary-PCI, who were divided into three groups according to their residual SYNTAX score (rSS): Complete revascularization ($rSS=0$; $n=198$), reasonable incomplete revascularization ($0<rSS<8$; $n=238$) and incomplete revascularization ($rSS\geq 8$; $n=99$). The study suggested that rSS was positively correlated with in-hospital

mortality and MACE (4). In the present study, the association between the SYNTAX score and FAR was analyzed, indicating a linear correlation between them. Compared with the SYNTAX score, the FAR has the advantages of simplicity, efficiency and sufficiency. A higher fibrinogen and lower albumin concentration are associated with worse outcomes for patients with CAD (21,22). As the combination of fibrinogen and albumin as a ratio, the FAR is more sensitive and accurate as a stratification marker for CAD. Cetin *et al* (16) investigated the predictive value of the FAR in ACS, which demonstrated that FAR may be used for the prediction of MACE in patients with ACS who have undergone PCI. Another study indicated that the baseline FAR was independently and significantly associated with angiographic no-reflow and short-term mortality in patients with ACS (18). Different from previous studies, the present study focused on long-term outcomes of patients with STEMI and multivessel disease using a prospective cohort design. The present and previous studies have indicated that the FAR is a biomarker reflecting the systemic inflammation level and associated with the severity of CAD. However, it should be emphasized that the FAR is a valuable biomarker in the prognosis prediction of multiple tumors, including esophageal squamous cell carcinoma, non-small cell lung cancer, colorectal cancer and gallbladder cancer. As a result, there is a possibility that the association between the FAR and the prognosis of patients with STEMI may be falsely positive, which requires further validation.

Several limitations of the present study must be noted. First, only one PCI strategy was selected in the present study, which limited the sample size and brought about certain bias. Furthermore, the long-term prognosis was affected by the compliance of patients, which was not recorded or considered in the present study. Finally, a comparison between the FAR and other markers, including hs-CRP, albumin and fibrinogen alone, may be helpful.

In conclusion, the FAR was correlated with long-term mortality and the incidence of MACE in patients with STEMI and multivessel disease, which may indicate the potential of the FAR to serve as a biomarker.

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Authors' contributions

GL and GXC designed and led the current study. MLL, HG, WNF and CMF collected and analyzed the patient data. GL and HG wrote the manuscript and WNF revised it. All authors read and approved the final manuscript.

Ethics approval and consent to participate

The present study was approved by the Medical Ethics Committee of Xianyang Central Hospital (Xianyang, China). The patients provided written informed consent regarding the use of their data.

Patient consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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