Original paper

Simple risk stratification for a complex coronary phenotype: association of the ACEF score with coronary slow flow

Bihter Senturk[1], Mehmet Kıs[1], Huseyin Dursun[1], Inci T. Colluoglu[2], Cisem Oktay[1], Mehmet B. Yılmaz[1]

[1]Department of Cardiology, Faculty of Medicine, Dokuz Eylul University, Izmir, Turkey
[2]Department of Cardiology, Faculty of Medicine, Karabük University, Karabük, Turkey

Adv Interv Cardiol 2026; 22, 2 (84): 224–230
DOI: https://doi.org/10.5114/aic.2026.161983

Abstract

Introduction: There is a lack of scientific evidence regarding the association between the ACEF score and the prediction of coronary slow flow (CSF).

Aim: To investigate the relationship between the ACEF score and CSF.

Material and methods: This retrospective, single-center study enrolled 257 patients who underwent elective coronary angiography between January 2024 and August 2025. Patients were stratified into two groups: the CSF group (n = 121) and the normal coronary flow (NCF) group (n = 136). Receiver operating characteristic (ROC) curve analysis evaluated the accuracy of the ACEF score, glycated hemoglobin (HbA1c), and low-density lipoprotein cholesterol (LDL-C) in predicting CSF. The incremental value of the ACEF score relative to its components was assessed using C-statistics, IDI, and NRI. Logistic regression was conducted to evaluate independent predictors of CSF presence. The model included sex, hypertension, peripheral artery disease, atrial fibrillation, hemoglobin, white blood cell count, platelet count, HbA1c, triglycerides, LDL-C, high-density lipoprotein cholesterol (HDL-C), and the ACEF score.

Results: In ROC analysis, the cut-off value of the ACEF risk score was 0.94, with 81% sensitivity and 53% specificity for predicting CSF (AUC = 0.763, 95% CI: 0.706–0.821). For HbA1c, the optimal cut-off value was 5.44%, with a sensitivity of 70% and a specificity of 52% to predict CSF (AUC = 0.610, 95% CI: 0.538–0.682). The risk of CSF increased by 28% for every 0.1-unit increase in the ACEF score (OR per 0.1-unit increase: 1.278, 95% CI: 1.168–1.396). The ACEF score demonstrated superior discrimination (AUC: 0.763 vs. 0.729, p = 0.018) and significant incremental predictive value (IDI = 0.052, p < 0.001) compared to its individual components.

Conclusions: This study suggests that the ACEF score is closely associated with the presence of CSF, independent of its individual components. The discriminatory ability of the ACEF score was superior to that of HbA1c in patients with CSF.

Key words: ACEF score, coronary slow flow, glycated hemoglobin, coronary artery disease.

Summary

Current evidence on clinical predictors of coronary slow flow (CSF) remains limited, and the role of simple risk scores in identifying patients at risk has not been well established. In this retrospective study of patients undergoing elective coronary angiography, the ACEF score was strongly associated with CSF compared to its individual components and demonstrated superior discriminatory ability compared with glycated hemoglobin. The ACEF score emerged as an independent predictor of CSF in multivariable analysis. These findings suggest that the ACEF score may serve as a practical and readily available tool for risk stratification in daily clinical practice and warrant further prospective validation.

Introduction

Coronary slow flow (CSF), also termed cardiac syndrome Y, is characterized by angiographically normal or near-normal coronary arteries with delayed distal vessel opacification. Beyond its angiographic presentation, CSF is associated with significant clinical sequelae, including recurrent angina, acute coronary syndrome, and increased risk of sudden cardiac death [1]. In recent years, although there has been a rising trend in CSF occurrence in follow-up studies, evidence on its risk factors remains scarce

Corresponding author:
Bihter Senturk, Department of Cardiology, Faculty of Medicine, Dokuz Eylul University, Izmir, Turkey, e-mail: drbihter@hotmail.com
Received: 2.02.2026, **accepted:** 16.03.2026, **online publication:** 20.05.2026.

Copyright © Termedia Sp. z o. o. Creative Commons licenses: This is an Open Access article distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International (CC BY -NC -SA 4.0). License (http://creativecommons.org/licenses/by-nc-sa/4.0/).

[2]. Consequently, an established standard of care for the prophylaxis and treatment of CSF remains undefined.

Microvascular dysfunction, endothelial dysfunction, subclinical diffuse atherosclerosis, and small vessel disease have all been implicated in the pathogenesis of CSF [3]. All these factors lead to impaired coronary flow and subsequent ventricular dysfunction [4]. Prior studies have demonstrated compromised ventricular function in patients with CSF [5]. In addition, impaired renal function appears to be associated with slower coronary flow [6, 7]. Yılmaz *et al.* found a negative correlation between glomerular filtration rate (GFR) and Thrombolysis in Myocardial Infarction (TIMI) frame count in patients with impaired renal function [6]. Finally, CSF has been reported to occur more frequently in elderly individuals. Kalaycı *et al*. identified advanced age, elevated triglyceride levels, and smoking as predictors of CSF [8]. Although individual variables such as advanced age, elevated creatinine levels, and impaired ventricular function have been associated with CSF, the combined predictive value of these factors – quantified by the ACEF score – remains unclear.

Aim

We aimed to investigate the relationship between the ACEF score and CSF presence in the current study.

Material and methods

We conducted a single-center retrospective study including 257 consecutive patients who underwent femoral-access coronary angiography (CAG) between January 2024 and August 2025 for clinical suspicion of coronary artery disease and/or objective evidence of myocardial ischemia on myocardial perfusion scintigraphy and/or positive exercise stress testing. All included patients had angiographically normal coronary arteries with no detectable luminal stenosis. Based on coronary flow characteristics, the study population was stratified into two predefined groups: the CSF group and the normal coronary flow (NCF) group. Angiographic CSF was defined as normal coronary arteries without any lesions and delayed distal vessel contrast opacification (TIMI-2 flow [requiring ≥ 3 beats to opacify the vessel]) in at least one coronary artery [9, 10]. NCF was stringently defined as the absence of angiographic stenosis, haziness, ectasia, tortuosity, or spasm. An experienced interventional cardiologist, blinded to the ACEF risk score, evaluated the coronary angiography images from the cineangiography recordings and assigned the TIMI flow grades for each coronary artery.

Comorbidities (hypertension, diabetes mellitus, hyperlipidemia, chronic kidney disease, peripheral artery disease, atrial fibrillation), medications (antiplatelet drugs, statins, β-blockers, angiotensin-converting enzyme inhibitors, angiotensin receptor blockers, oral antidiabetics, and insulin), laboratory (hemoglobin, white blood cell count [WBC], platelet count, glucose, glycated hemoglobin [HbA1c], blood urine nitrogen, creatinine, sodium, potassium, total cholesterol, triglycerides, low-density lipoprotein cholesterol [LDL-C], high-density lipoprotein cholesterol [HDL-C]), echocardiographic (LVEF), and procedural data were retrospectively obtained from the institutional catheterization laboratory database and hospital electronic medical records.

The ACEF risk score was calculated using the following previously established formula: ACEF = (age/left ventricular ejection fraction (LVEF)) + 1 (if creatinine > 2.0 mg/dl) [11].

Patients who met any of the following criteria were excluded: coronary artery disease (including coronary ectasia, coronary spasm, or any degree of stenosis or haziness), coronary tortuosity, acute coronary syndrome, decompensated heart failure, severe valvular disease, acute kidney failure, hepatic dysfunction, severe kidney disease (estimated GFR < 15 ml/min 1.73 m^2), current hemodialysis, malignancies, and active infections.

Statistical analysis

All statistical analyses were conducted using IBM SPSS Statistics for Windows, Version 31.0 (IBM Corp., Armonk, NY). The Kolmogorov-Smirnov test was used to assess the normality of the distributions of the variables. Continuous variables conforming to a normal distribution were expressed as mean ± standard deviation and compared using Student's *t*-test. In contrast, those exhibiting a non-normal distribution were presented as median (interquartile range, IQR [Q1–Q3]) and analyzed using the Mann-Whitney *U* test. Categorical variables were summarized as frequencies and percentages and compared via Pearson's χ^2 test or Fisher's exact test, as appropriate. Multivariate binary logistic regression analysis using the enter method was performed to investigate the association between the ACEF score and CSF, and between age, creatinine, and LVEF as individual variables and CSF, adjusting for potential confounders to enhance the validity of the results. The model included clinically important variables, as well as those with *p*-values ≤ 0.1 identified in univariate analysis. Model 1 included age, creatinine, LVEF, sex, hypertension, peripheral artery disease, atrial fibrillation, hemoglobin, white blood cell count, platelet count, HbA1c, triglycerides, LDL-C, and HDL-C. Covariates incorporated into the model, which defined as the Model 2, included sex, hypertension, peripheral artery disease, atrial fibrillation, hemoglobin, white blood cell count, platelet count, HbA1c, triglycerides, LDL-C, HDL-C, and ACEF score. Statistical significance was defined as a two-tailed *p*-value ≤ 0.05. Receiver operating characteristic (ROC) curve analysis was conducted to determine the optimal ACEF score, LDL-C, and HbA1c cut-off values for predicting CSF. The discriminative performance of the models was evaluated using the C-statistic (area under

the receiver operating characteristic curve), and the statistical significance of the differences in area under the curve (AUC) was determined using the DeLong test. To further quantify the added value of the integrated score, we calculated the integrated discrimination improvement (IDI) and the category-free net reclassification improvement (NRI) by using the R integration plug-in within the SPSS environment. These metrics assess the ability of the score to better categorize the risk of events compared to the individual variables. Overall model fit and parsimony were compared using the likelihood ratio (LR) test and the Akaike information criterion (AIC), where a lower AIC indicates superior model efficiency. A two-tailed *p*-value of < 0.05 was considered statistically significant for all analyses.

Results

The baseline characteristics of patients in the two groups, categorized by coronary flow characteristics, are presented in Table I. In the context of coronary flow characteristics, 121 patients who underwent CAG were identified as meeting the criteria for CSF, whereas NCF was observed in 136 patients who underwent CAG. Patients with CSF had a significantly higher mean age compared to those with NCF (60.90 ±12.15 vs. 52.33 ±12.83, $p < 0.001$). Additionally, patients with CSF demonstrated a lower LVEF (52.85 ±9.55 vs. 56.15 ±7.29, $p = 0.002$), as well as elevated levels of creatinine (1.15 ±0.55 vs. 1.02 ±0.47, $p = 0.049$), LDL-C (113.15 ±38.03 vs. 103.73 ±34.70, $p = 0.047$), HbA1c (5.92 [5.36–6.36] vs. 5.40

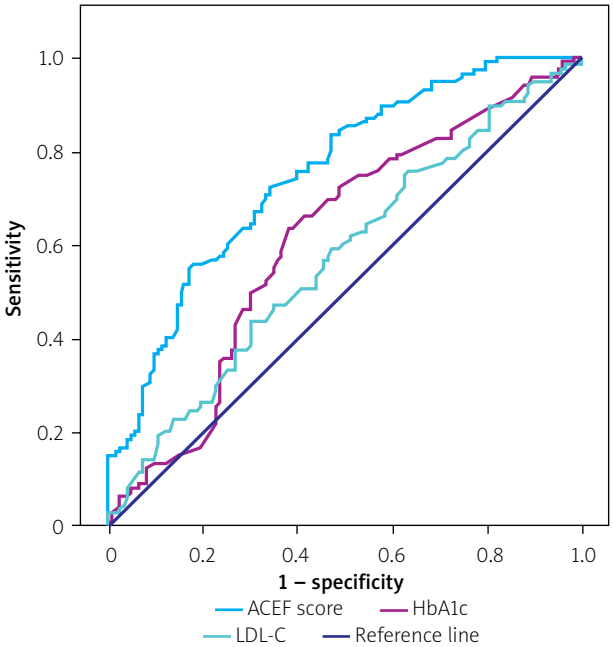
Table I. Baseline characteristics of the study population

Parameter	Patients with CSF (*n* = 121)	Patients with NCF (*n* = 136)	*P*-value
Age [years]	60.90 ±12.15	52.33 ±12.83	< 0.001
Sex (male/female)	66/55	77/59	0.739
Comorbidities, *n* (%)			
Hypertension	71 (58.7)	66 (48.5)	0.104
Diabetes mellitus	25 (20.7)	24 (17.6)	0.539
Hyperlipidemia	44 (36.4)	42 (30.9)	0.353
Chronic kidney disease	13 (10.7)	10 (7.4)	0.342
Peripheral artery disease	13 (10.7)	6 (4.4)	0.053
Atrial fibrillation	9 (7.4)	5 (3.7)	0.185
Left ventricular ejection fraction (%)	52.85 ±9.55	56.15 ±7.29	0.002
Laboratory variables			
Hemoglobin [g/dl]	13.35 ±1.80	13.17 ±2.08	0.469
White blood cell count [10^3/µl]	8.92 ±1.97	8.62 ±1.87	0.216
Platelet count [10^3/µl]	268.41 ±74.27	266.03 ±64.92	0.784
Glucose [mg/dl]	110.89 ±27.52	115.15 ±50.39	0.409
HbA1c (%)	5.92 (5.36–6.36)	5.40 (5.10–6.21)	< 0.001
Blood urine nitrogen [mg/dl]	23.00 (12.30–32.00)	19.20 (11.10–31.00)	0.351
Creatinine [mg/dl]	1.15 ±0.55	1.02 ±0.47	0.049
Sodium [mmol/l]	138.30 ±3.18	138.27 ±2.81	0.946
Potassium [mmol/l]	4.37 ±0.44	4.29 ±0.52	0.169
Total cholesterol [mg/dl]	193.16 ±45.51	187.87 ±46.21	0.373
Triglycerides [mg/dl]	165.77 ±62.57	182.95 ±114.15	0.155
LDL-C [mg/dl]	113.15 ±38.03	103.73 ±34.70	0.047
HDL-C [mg/dl]	42.80 ±10.94	44.33 ±9.26	0.244
ACEF score	1.20 (0.99–1.53)	0.91 (0.72–1.10)	< 0.001
Medications, *n* (%)			
Antiplatelet drugs	44 (36.4)	37 (27.2)	0.115
Statins	32 (26.4)	34 (28.1)	0.773
B-blockers	43 (35.5)	42 (30.9)	0.429
ACEI	38 (31.4)	37 (27.2)	0.460
ARB	17 (14.0)	14 (10.3)	0.356
Oral antidiabetics	19 (15.7)	25 (20.7)	0.317
Insulin	5 (4.1)	12 (9.9)	0.078

CSF – coronary slow flow, NCF – normal coronary flow, HbA1c – glycated hemoglobin, LDL – low-density lipoprotein cholesterol, HDL-C – high-density lipoprotein cholesterol, ACEI – angiotensin-converting enzyme inhibitors, ARB – angiotensin receptor blockers, ACEF – age, creatinine, left ventricular ejection fraction.

[5.10–6.21], $p < 0.001$), and ACEF score (1.20 [0.99–1.53] vs. 0.91 [0.72–1.10], $p < 0.001$) compared to patients with NCF (Table I). No differences were observed in the prevalence of comorbidities or in the use rates of each medication (Table I). In addition, 22 (8.5%) patients had creatinine levels exceeding 2.0 mg/dl. Among these individuals, 5 (1.9%) were diagnosed with CSF.

Receiver operating characteristic curve analysis demonstrated area under the curve (AUC) values of 0.763 (95% CI: 0.706–0.821) for the ACEF score, 0.610 (95% CI: 0.538–0.682) for HbA1c, and 0.569 (95% CI: 0.497–0.642) for LDL-C, respectively (Figure 1). The optimal cut-off value for the ACEF score was 0.94, with a sensitivity of 81% and a specificity of 53%. At this cut-off value, positive predictive value (PPV) was 59.7% and negative predictive value (NPV) was 73.5%. For HbA1c, the optimal cut-off value was 5.44%, with a sensitivity of 70% and a specificity of 52% for predicting CSF. PPV was 57.2% and NPV was 67.6%. In addition, for every 0.1-unit increase in the ACEF score, the risk of CSF increased by 28% (OR per 0.1-unit increase: 1.278 [95% CI: 1.168–1.396, $p < 0.001$] (Table II). When we evaluated age, creatinine, and LVEF as separate variables in the logistic regression analysis, we found that age (OR = 1.049, 95% CI: 1.025–1.073) and LVEF (OR = 0.957, 95% CI: 0.924–0.991) were independent predictors of CSF (Table III). The ACEF score demonstrated a significantly higher C-statistic than the multivariable model comprising its individual components (0.763, 95% CI: 0.706–0.821 vs. 0.729, 95% CI: 0.668–0.790; DeLong $p = 0.018$). The addition of the ACEF score yielded a significant improvement in the integrated discrimination index (IDI) of 0.052 (95% CI: 0.022–0.082, $p < 0.001$), confirming its incremental predictive value. Moreover, the ACEF-based model showed better overall fit and parsimony (AIC: 296.4 vs. 318.9) (Table IV).



	AUC	95% CI	*P*-value
ACEF score	0.763	0.706–0.821	< 0.001
HbA1c	0.610	0.538–0.682	0.003
LDL-C	0.569	0.497–0.642	0.061

Figure 1. ROC analysis shows the areas under the curves for ACEF score, HbA1c, and LDL-C

ACEF score, age, creatinine, left ventricular ejection fraction, AUC – area under the curve, CI – confidence interval.

Discussion

The main findings of the current study can be summarized as follows: (1) patients with CSF may exhibit characteristics including advanced age, impaired left ventricular function, and decreased renal function, as well as high HbA1c and LDL-C levels; (2) a high ACEF score and HbA1c level may effectively discriminate between the presence and the absence of CSF; (3) a high ACEF score itself, but not individual components such as creatinine, may independently predict the presence of CSF in patients with suspected chronic coronary syndrome; (4) a high ACEF score may provide significant incremental predictive value beyond its individual components.

Table II. Independent predictors for the presence of coronary slow flow

Variables	OR (per 0.1-unit increase)	95% CI	*P*-value
ACEF score	1.278	1.168–1.396	< 0.001

ACEF – age, creatinine, left ventricular ejection fraction, OR – odds ratio, CI – confidence interval. Model 2, included sex, hypertension, peripheral artery disease, atrial fibrillation, hemoglobin, white blood cell count, platelet count, HbA1c, triglycerides, LDL-C, HDL-C, and ACEF score.

Table III. Independent predictors for the presence of coronary slow flow

Variables	OR	95% CI	*P*-value
Age	1.049	1.025–1.073	< 0.001
Creatinine	1.743	0.962–3.157	0.067
LVEF	0.957	0.924–0.991	0.013

OR – odds ratio, CI – confidence interval, LVEF – left ventricular ejection fraction. Model 1 included age, creatinine, LVEF, sex, hypertension, peripheral artery disease, atrial fibrillation, hemoglobin, white blood cell count, platelet count, HbA1c, triglycerides, LDL-C, and HDL-C.

Table IV. Incremental predictive value of the ACEF score compared to its individual components

Variable	Model 1 (independent variables: age + LVEF + creatinine)	Model 2 (Composite ACEF Score)	*P*-value
Discrimination			
C-statistic AUC	0.729 (0.668–0.790)	0.763 (0.706–0.821)	0.018 (DeLong)
Reclassification			
Category-free NRI	Reference	0.067	0.591
IDI	Reference	0.052	< 0.001
Model fit			
Log-likelihood	–155.46	–146.21	< 0.001
AIC	318.9	296.4	

AUC – area under the curve, NRI – net reclassification improvement, IDI – integrated discrimination improvement, AIC – Akaike information criterion.

Our findings offer a significant contribution to the existing literature. Previous studies have identified metabolic dysregulation as a potential predictor of CSF. A study by Yılmaz *et al.* demonstrated that patients exhibiting CSF had higher levels of total cholesterol and LDL-C, alongside a higher prevalence of metabolic syndrome compared to those with NCF [12]. Moreover, metabolic syndrome has been correlated with higher TIMI frame count, indicating a potential mechanistic link. Turhan *et al*. further reported a positive correlation between fasting blood glucose levels and TIMI frame count [13]. Yılmaz *et al.* reported a strong correlation between HbA1c level and TIMI frame count; the incidence of CSF was significantly higher in patients with HbA1c ≥ 7.0% [14]. In alignment with these observations, our study found that while fasting blood glucose levels did not differ significantly between CSF and NCF groups, HbA1c – a more reliable biomarker reflecting chronic glycemic control – and LDL-C levels were significantly elevated in patients with CSF relative to those with NCF.

The ACEF score integrates key clinical parameters – age, creatinine level, and LVEF – to provide an indirect yet robust assessment of patient risk. This scoring system serves as a valuable diagnostic tool and prognostic indicator for adverse outcomes in individuals with various cardiac diseases, including infective endocarditis, myocardial infarction with non-obstructive coronary arteries, acute fulminant myocarditis, and atrial fibrillation [15–18]. The ACEF score was originally developed to stratify the risk of adverse events in patients undergoing elective cardiac surgery [11]. The ACEF score has also demonstrated significant predictive validity in patients undergoing percutaneous coronary intervention, irrespective of presentation with acute or chronic coronary syndromes [19–21]. Notably, the LEADERS study revealed a strong association between increased ACEF score and increased incidence of cardiac death and myocardial infarction [19]. Subsequently, this risk stratification model has been extended to predict the presence and severity of coronary artery disease, including multi-vessel disease and left main coronary artery involvement [22–24], thereby reinforcing its clinical applicability across a spectrum of cardiovascular conditions. In our study, we evaluated the ACEF score for its ability to predict CSF diagnosis. A higher ACEF score was significantly associated with accurate classification of CSF. It emerged as an independent predictor of its presence, even after adjustment for confounding variables such as hypertension, peripheral artery disease, and HbA1c, triglyceride, and LDL-C levels. Given the multifactorial etiology of CSF, baseline coronary blood flow is primarily regulated by autoregulatory mechanisms. The pathogenesis of CSF involves an imbalance in these mechanisms, characterized by increased endothelin and sympathetic activity alongside reduced nitric oxide bioavailability and parasympathetic tone, all of which critically impair coronary blood flow [4]. Considering that advanced age and impaired renal and cardiac function contribute to these dysregulations, the association between elevated ACEF score and the development of CSF is biologically plausible. Finally, our findings may help understand a higher ACEF score and a higher risk for CSF development.

A notable finding in our study is the independent predictive value of LVEF for CSF. While traditionally viewed as a predisposing risk factor, contemporary evidence suggests that the relationship between LVEF and CSF may be more complex and potentially bidirectional. Chronic microvascular ischemia, a hallmark of CSF, can result in recurrent, subclinical myocardial stunning and subsequent fibrosis, eventually leading to a reduction in systolic function. This suggests that a lower LVEF in CSF patients might not only be an upstream predictor but also a downstream consequence of long-term microvascular hypoperfusion [25–27]. Recent studies support this hypothesis, demonstrating that patients with persistent CSF show progressive subtle reductions in global longitudinal strain and ejection fraction over time [25, 28]. Therefore, the ACEF score, by incorporating LVEF, likely captures the cumulative burden of microvascular and myocardial damage and serves as a robust marker of disease severity.

Based on the ROC curve analysis of the current study, the ACEF score demonstrated superior discriminative ability for predicting CSF compared to HbA1c levels.

This finding aligns with results reported in prior investigations [20, 23, 29]. The ACEF score incorporates three critical pathophysiological variables that are closely associated with CSF. Consequently, unlike HbA1c levels alone, these composite parameters may underlie the enhanced predictive performance of the ACEF score in identifying patients at risk for CSF. Additionally, while elevated HbA1c levels are strongly associated with microvascular dysfunction and increased inflammatory burden, the ACEF score's integration of hemodynamic and renal parameters appears to capture a broader spectrum of the pathophysiological processes underlying CSF [22, 30]. However, the moderate specificity observed for the ACEF score in our population may suggest that its clinical utility is best achieved when used in conjunction with metabolic profiles. Recent studies emphasize that microvascular phenotypes, such as CSF, are multifactorial and require a holistic approach to risk assessment [31]. Therefore, the ACEF score can be considered a valuable supportive tool in the risk-stratification hierarchy, providing incremental prognostic information beyond HbA1c alone, rather than replacing traditional diagnostic standards.

Several limitations of the present study warrant consideration. First, the retrospective, single-center design and relatively limited sample size may constrain the generalizability of the findings. Second, data on cardiac clinical outcomes were unavailable, precluding prognostic assessment. Third, the pathophysiology of impaired coronary blood flow was not evaluated using invasive or advanced imaging modalities, such as coronary flow reserve or microcirculatory resistance, which could have provided additional objective insights. Since, according to Beltrame's diagnosis criteria, delayed distal vessel contrast opacification was defined as either TIMI-2 flow or a corrected TIMI frame rate > 27 frames (images acquired at 30 frames/s) [9], in our study, CSF was diagnosed with TIMI-2 flow observed in at least one coronary artery. The TIMI frame count was not calculated. Furthermore, intravascular ultrasound was not employed; assessment was limited to coronary angiography, which may have failed to detect subclinical atherosclerotic plaque.

Conclusions

Incorporating the ACEF score into the initial clinical assessment of patients undergoing CAG may provide clinicians with a valuable tool for predicting CSF likelihood beyond its individual components. This integration could facilitate early risk stratification, enabling more informed decision-making and potentially guiding tailored therapeutic strategies to improve patient outcomes.

Funding

No external funding.

Ethical approval

This study was approved by the Dokuz Eylül University Ethics Review Committee (approval number: 2025/39-07) and adhered to the principles outlined in the Declaration of Helsinki.

Conflict of interest

The authors declare no conflict of interest.

References

1. Aparicio A, Cuevas J, Morís C, Martín M. Slow coronary blood flow: pathogenesis and clinical implications. Eur Cardiol 2022; 17: e08.
2. Yu J, Yi D, Yang C, et al. Major adverse cardiovascular events and prognosis in patients with coronary slow flow. Curr Probl Cardiol 2024; 49: 102074.
3. Zhu Q, Wang S, Huang X, et al. Understanding the pathogenesis of coronary slow flow: recent advances. Trends Cardiovasc Med 2024; 34: 137-44.
4. Mayer M, Allan T, Harkin KL, et al. Angiographic coronary slow flow is not a valid surrogate for invasively diagnosed coronary microvascular dysfunction. JACC Cardiovasc Interv 2024; 17: 920-9.
5. Elsherbiny IA. Left ventricular function and exercise capacity in patients with slow coronary flow. Echocardiography 2012; 29: 158-64.
6. Yilmaz MB, Yalta K. Coronary flow slows as renal function worsens. Clin Cardiol 2009; 32: 278-82.
7. Iqhrammullah M, Rampengan D. Coronary slow-flow syndrome: a review on natural history of disease and best practices. Res Heart Yield Transl Med 2025; 20: 55-68.
8. Kalaycı B, Kalaycı S, Kokturk F. Proportional serum lipid parameters in coronary slow flow phenomenon. Türk Klinik Cardiovasc Sci 2019; 31: 21-8.
9. Beltrame JF. Defining the coronary slow flow phenomenon. Circ J 2012; 76: 818-20.
10. TIMI Study Group. The Thrombolysis in Myocardial Infarction (TIMI) trial. Phase I findings. N Engl J Med 1985; 312: 932-6.
11. Ranucci M, Castelvecchio S, Menicanti L, et al. Risk of assessing mortality risk in elective cardiac operations: age, creatinine, ejection fraction, and the law of parsimony. Circulation 2009; 119: 3053-61.
12. Yilmaz H, Demir I, Uyar Z. Clinical and coronary angiographic characteristics of patients with coronary slow flow. Acta Cardiol 2008; 63: 579-84.
13. Turhan H, Erbay AR, Yasar AS, et al. Impaired coronary blood flow in patients with metabolic syndrome: documented by Thrombolysis in Myocardial Infarction (TIMI) frame count method. Am Heart J 2004; 148: 789-94.
14. Yılmaz MB, Erdem A, Yontar OC, et al. Relationship between HbA_1c and coronary flow rate in patients with type 2 diabetes mellitus and angiographically normal coronary arteries. Turk Kardiyol Dern Ars 2010; 38: 405-10.
15. Wei XB, Su ZD, Liu YH, et al. Age, creatinine and ejection fraction (ACEF) score: a simple risk-stratified method for infective endocarditis. QJM 2019; 112: 900-6.
16. Gao S, Ma W, Huang S, et al. Predictive value of the age, creatinine, and ejection fraction score in patients with myocardial

infarction with nonobstructive coronary arteries. Clin Cardiol 2021; 44: 1011-8.
17. Liu L, Yang X, Gu Y, et al. Predictive value of the age, creatinine, and ejection fraction (ACEF) score in patients with acute fulminant myocarditis. Front Physiol 2021; 12: 596548.
18. Luo Y, Tang Y, Huang W, et al. Age, creatinine, and ejection fraction (ACEF) score as predictive values for late non-valvular atrial fibrillation recurrence after radiofrequency ablation. Clin Exp Hypertens 2023; 45: 2207784.
19. Wykrzykowska JJ, Garg S, Onuma Y, et al. Value of age, creatinine, and ejection fraction (ACEF Score) in assessing risk in patients undergoing percutaneous coronary interventions in the 'All-Comers' LEADERS trial. Circ Cardiovasc Interv 2011; 4: 47-56.
20. Kristić I, Crnčević N, Runjić F, et al. ACEF performed better than other risk scores in non-ST-elevation acute coronary syndrome during long term follow-up. BMC Cardiovasc Disord 2021; 21: 70.
21. Paolucci L, Mangiacapra F, Viscusi MM, et al. Prediction of 5-year mortality in patients with chronic coronary syndrome treated with elective percutaneous coronary intervention: role of the ACEF Score. J Cardiovasc Transl Res 2021; 14: 1125-30.
22. Xiong S, Yin S, Deng W, et al. Predictive value of the age, creatinine, and ejection fraction (ACEF) Score in cardiovascular disease among middle-aged population. J Clin Med 2022; 11: 6609.
23. Gao G, Zhang D, Song C, et al. Integrating the residual SYNTAX score to improve the predictive ability of the age, creatinine, and ejection fraction (ACEF) score for cardiac mortality in percutaneous coronary intervention patients. Catheter Cardiovasc Interv 2020; 95 Suppl 1: 534-41.
24. Jung JC, Ju JW, Chang HW, et al. Predictive performances of ACEF, ACEF II, updated ACEF II, and EuroSCORE II risk scores in patients undergoing isolated off-pump coronary artery bypass grafting. J Cardiothorac Vasc Anesth 2024; 38: 2932-8.
25. Backelin CN, Svedlund S, Bollano E, et al. Prevalence and importance of coronary microvascular dysfunction in patients with heart failure and reduced or mildly reduced ejection fraction. Open Heart 2025; 12: e003509.
26. Shabani P, Dong F, Yun J, et al. Does coronary microvascular dysfunction play a role in heart failure with reduced ejection fraction? J Mol Cell Cardiol 2025; 200: 61-7.
27. Toya T, Nagatomo Y, Ikegami Y, et al. Coronary microvascular dysfunction in heart failure patients. Front Cardiovasc Med 2023; 10: 1153994.
28. Shereef AS, Abdelmajeed MG, Alshair MH, et al. Coronary slow flow and its correlation with reduced left ventricle global longitudinal strain: a case-control study. Echo Res Pract 2024; 11: 2.
29. Dąbrowski EJ, Kralisz P, Nowak K, et al. Validation of EuroSCORE II, ACEF Score, CHA(2)DS(2)-VASc, and CHA(2)DS(2)-VA in patients undergoing left main coronary artery angioplasty: analysis from all-comers BIA-LM Registry. J Clin Med 2024; 13: 6907.
30. Sartore G, Ragazzi E, Caprino R, Lapolla A. Long-term HbA1c variability and macro-/micro-vascular complications in type 2 diabetes mellitus: a meta-analysis update. Acta Diabetol 2023; 60: 721-38.
31. Del Buono MG, Montone RA, Camilli M, et al. Coronary microvascular dysfunction across the spectrum of cardiovascular diseases: JACC state-of-the-art review. J Am Coll Cardiol 2021; 78: 1352-71.