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CORONARY SLOW FLOW AND CHA_2DS_2-VASC-HSF SCORE IN STABLE ISCHEMIC HEART DISEASE

STABİL İSKEMİK KALP HASTALIĞINDA KORONER YAVAŞ AKIM VE CHA_2DS_2-VASC-HSF SKORU

Pelin KARACA ÖZER[1], Mustafa Lütfi YAVUZ[1], Emre YALÇIN[1], Elif AYDUK GÖVDELİ[1], Mehmet AYDOĞAN[2], Samim EMET[1], Ali ELİTOK[1]

[1]İstanbul University, İstanbul Faculty of Medicine, Department of Cardiology, İstanbul, Türkiye
[2]Bitlis Tatvan State Hospital, Bitlis, Türkiye

ORCID ID: P.K.Ö. 0000-0002-1085-5462; M.L.Y. 0000-0002-4082-7518; E.Y. 0000-0001-8686-2645; E.A.G. 0000-0002-6595-4812; M.A. 0000-0003-1342-3590; S.E. 0000-0002-2806-4335; A.E. 0000-0002-0786-5096

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ABSTRACT

Objective: The coronary slow flow phenomenon (CSFP) and its causes are still not fully explained. We investigated the functionality and usefulness of the CHA_2DS_2-VASc-HSF score in the diagnosis of CSFP in stable ischemic heart disease.

Material and Methods: Patients with no obstructive coronary artery disease (CAD) and CSFP detected as a result of coronary angiography were included in the study. Patients with CSFP were compared with those without. Coronary blood flow velocity was evaluated by calculating the TIMI frame count (TFC) from coronary angiography images. In addition to the traditional CHADS scores of the patients, the CHA_2DS_2-VASc-HSF score was also calculated.

Results: According to our study results, the CHA_2DS_2-VASc-HSF score was higher in patients with CSFP than in those without (3.75±1.27 vs. 2.85±1.11; p<0.001). There was no difference between the $CHADS_2$ and CHA_2DS_2-VASc scores of the two groups. In logistic regression models, Hs-troponin-T and CHA_2DS_2-VASc-HSF scores were determined as independent predictors of CSFP. CHA_2DS_2-VASc-HSF score and TFC were positively correlated in the CSFP group (r=0.848, p<0.001). The sensitivity of CHA_2DS_2-VASc-HSF was determined as 56%, the specificity was 74%, and the cut-off value was 3.5 in detecting the presence of CSFP.

Conclusion: This study shows the association of CHA_2DS_2-VASc-HSF score with CSFP, suggesting that it can be used to predict CSFP and its severity.

Keywords: CHA_2DS_2-VASc-HSF score, coronary slow flow, non-obstructive coronary artery

ÖZ

Amaç: Koroner yavaş akım fenomeni (KYA) ve nedenleri hala tam olarak açıklanamamıştır. Bu çalışmada stabil iskemik kalp hastalığında KYA tanısında CHA_2DS_2-VASc-HSF skorunun işlevselliğini ve kullanışlılığı araştırıldı.

Gereç ve Yöntemler: Çalışmaya obstrüktif koroner arter hastalığı (KAH) olmayan ve koroner anjiyografi sonucunda KYA saptanan hastalar dahil edildi. KYA'lı hastalar olmayanlarla karşılaştırıldı. Koroner kan akış hızı, koroner anjiyografi görüntülerinden TIMI kare sayısı (TFC) hesaplanarak değerlendirildi. Hastaların geleneksel CHADS skorlarına ek olarak CHA_2DS_2-VASc-HSF skoru da hesaplandı.

Bulgular: KYA'lı hastalar olmayan hastalara kıyasla daha yüksek CHA_2DS_2-VASc-HSF skoruna sahipti (3,75±1,27'ye karşı 2,85±1,11; p<0,001). İki grubun $CHADS_2$ ve CHA_2DS_2-VASc skorları arasında fark yoktu. Lojistik regresyon modellerinde, CHA_2DS_2-VASc-HSF skoru ve Hs-troponin-T, KYA'nın bağımsız belirleyicileriydi. CHA_2DS_2-VASc-HSF skoru ve TFC, KYA grubunda pozitif korelasyon gösterdi (r=0,848, p<0,001). CHA_2DS_2-VASc-HSF'nin KYA'nın varlığını tespit etmede duyarlılığı %56, özgüllüğü %74, kesme değeri ise 3,5 olarak belirlendi.

Sonuç: Bu çalışma CHA_2DS_2-VASc-HSF skorunun KYA ile ilişkisini göstererek KYA ve ciddiyetini tahmin etmek için kullanılabileceğini düşündürmektedir.

Anahtar Kelimeler: CHA_2DS_2-VASc-HSF skoru, koroner yavaş akım, obstrüktif olmayan koroner arter

Corresponding Author/Sorumlu Yazar: Pelin KARACA ÖZER **E-mail:** pkaracaozer@gmail.com

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INTRODUCTION

The delayed opacification observed in non-obstructive epicardial coronary arteries is called the coronary slow flow phenomenon (CSFP) (1, 2). Most patients with CSFP usually describe angina and are referred for coronary angiography. It is suggested that endothelial dysfunction, microvascular disease, or atherosclerosis may be among the causes of CSFP (3-5).

The traditional CHADS scores were created for atrial fibrillation (AF) and they enable evaluation of the risk of thromboembolism and the need for anticoagulant treatment (6). The parameters of these scores are atherosclerosis risk factors. Although these scores are used in clinical practice for atrial fibrillation, they are useful in predicting CAD severity. It has also shown that it may be useful in providing information about the prognosis of acute coronary syndrome (7-9). The CHA2DS2-VASc-HSF score was created by adding important CAD risk factors such as the family history of CAD, smoking, and hyperlipidemia. The gender category was also changed from female to male. Previous studies have shown that CHADS scoring systems may be useful in predicting both CAD severity (10, 11) and no-reflow phenomenon (12). Moreover, the CHA2DS2-VASc-HSF score was more predictive than other CHADS scores. Based on the aforementioned studies, we hypothesized that this score may be associated with CSFP.

MATERIALS and METHODS

Study population

This study included consecutive patients over 18 years of age with CSFP who underwent elective coronary angiography (CA) with suspicion of ischemic heart disease between April 2021 and July 2022. The CSFP group was compared with controls with normal coronary flow based on CA. Non-invasive ischemia tests demonstrated that all patients had stable angina and evidence of myocardial ischemia.

Patients with one of the following were excluded: acute coronary syndromes; presence of obstructive CAD; prior coronary intervention. The Declaration of Helsinki was complied with in our study. The study was approved by the Clinical Ethics Committee of Istanbul University, Istanbul Faculty of Medicine (Date: 21.10.2022, No:19). An informed consent was not obtained from the study group because the design was retrospective.

Calculation of CHADS Scores

Clinical and demographic characteristics, echocardiographic and laboratory data on all patients, were obtained from the patients' medical records.

The CHADS2 score: Congestive heart failure (C)=1 point; Hypertension (HTN)=1 point; Age (A)=1 point; Diabetes (DM)=1 point; Stroke (S)=2 points. The maximum score is 6.

The CHA2DS2-VASc score adds to the CHADS2 score: Vascular disease (V)=1 point; Age 65 to 74 years (A)=1 point; female gender (Sc)=1 point; age>75 years (A2)=2 points. The maximum score is 9.

The CHA2DS2-VASc-HSF score includes Hyperlipidemia (H)=1 point; Smoking (S)=1 point; Family history (F), and male gender (Sc)=1 point; in addition to the CHA2DS2-VASc score. The maximum score is 12.

TIMI frame count measurement

Two independent cardiologists evaluated coronary angiograms retrospectively. Coronary arteries with <50% stenosis were defined as non-obstructive. Thrombolysis in Myocardial Infarction (TIMI) Frame Count (TFC) was calculated by the following technique: The frame count in the left anterior descending coronary artery (LAD) was divided by 1.7 (corrected LAD). The mean TFC was the average of the left circumflex, right coronary, and corrected LAD values. The mean TFC >27 was considered CSFP (2).

Statistical analysis

Statistical Package 26.0 for Windows (IBM SPSS Corp., Armonk, NY, USA) was used for statistical analysis. To prevent selection bias, propensity score matching was performed to inverse probability weight the sample which underwent chart review for co-morbidities. The normality of data was analyzed with the Kolmogorov-Smirnov test. A Mann-Whitney U test was used to compare unpaired samples. Differences in categorical variables between groups were evaluated with the Chi-square test. Pearson or Spearman analysis was used to evaluate correlations. Logistic regression analysis was performed to determine the predictors of CSFP. Results were expressed as relative risk and 95% confidence interval. Receiver operating characteristic analysis was performed for the cutoff value of the score. Significance was defined as two-sided $p<0.05$.

RESULTS

In the present study, 68 consecutive CSFP patients who underwent coronary angiography and did not have obstructive CAD were compared with consecutive controls with normal coronary flow. Gender, age, and body mass index were not different between the two groups. Among the clinical features, smoking, hyperlipidemia, and family history of CAD were more common in the CSFP group than in the normal flow group (p=0.035, p=0.009, p=0.022, respectively). In addition to the diagnosis of hyperlipidemia, the diagnosis of hypertriglyceridemia (defined as triglyceride level >150 mg/dL) was more common in the CSFP group (p=0.004). While HTN was more common (59% vs. 47%) and BMI was higher (28.13±3.80 vs. 26.69±3.23 kg/m^2) in the CSFP group, the difference was not significant. Among the laboratory parameters, D-dimer, Hs-troponin-T (HsTn-T), hemoglobin, leukocytes, monocytes, and the monocytes/HDL ratio were higher in the CSFP group than in the normal flow group (p=0.002, p<0.001, p=0.028, p=0.033, p=0.023, p=0.027, respectively). The CHA2DS2-VASc-HSF score was found to be significantly lower in patients with normal flow than in patients with CSFP (2.85±1.11 vs. 3.75±1.27; p<0.001). CHA2DS2 and CHA2DS2-VASc were not different between groups (Table 1).

CSFP was most common in the LAD artery (41%), followed by the RCA artery (30%). The incidence of ectasia and tortuosity in the coronary arteries was higher in the CSFP group than in the normal flow group (p=0.012, p=0.028, respectively) (Table 2).v

Table 1: Comparison of patients with slow coronary flow and normal flow

Variables	Total patients (n=136)	Patients with normal flow (n=68)	Patients with slow flow (n=68)	p-value
Demographic/clinical parameters				
Age (years)	57.10±11.1	56.91±10.8	57.29±11.5	0.842
Gender				
Male, n (%)	92 (67.6)	45 (66)	47 (69)	0.714
Female, n (%)	44 (32.4)	23 (34)	21 (31)	
Body mass index (kg/m^2)	27.77±3.7	26.69±3.23	28.13±3.80	0.096
Hypertension, n (%)	72 (52.9)	32 (47)	40 (59)	0.168
Diabetes mellitus, n (%)	42 (30.9)	18 (13.2)	24 (17.6)	0.265
Congestive heart failure, n (%)	14 (10.3)	6 (4.4)	8 (5.9)	0.573
Stroke/TIA, n (%)	6 (4.4)	2 (1.5)	4 (2.9)	0.680
Smoking, n (%)	54 (39.7)	21 (15.4)	33 (24.3)	0.035*
Hyperlipidemia, n (%)	59 (43.4)	22 (16.2)	37 (27.2)	0.009*
Hypertriglyceridemia, n (%)	65 (47.8)	24 (17.6)	41 (30.1)	0.004*
Family history, n (%)	53 (39)	20 (14.7)	33 (24.3)	0.022*
AF, n (%)	18 (13.2)	6 (4.4)	12 (8.8)	0.129
Chronic kidney disease, n (%)	11 (8.1)	8 (5.9)	3 (2.2)	0.116
Malignancy, n (%)	4 (2.9)	3 (2.2)	1 (0.7)	0.310
Laboratory parameters				
Creatinine (mg/dl)	0.85 (0.5-13.6)	0.8 (0.5-13.6)	0.88 (0.5-7.7)	0.974
Total cholesterol (mg/dL)	194.59±41.9	192.72±43.1	196.89±40.7	0.332
High density lipoprotein (mg/dL)	43.0±11.7	43.39±11	42.62±12.3	0.405
Low density lipoprotein (mg/dL)	121.36±35.3	117.34±31.8	125.32±38.2	0.189
Triglyceride (mg/dL)	160.25±79.1	158.40±93.9	162.08±61.9	0.191
C-reactive protein (mg/L)	2.4 (0.2-69)	2.25 (0.25-69)	3.8 (0.2-39)	0.159
D-dimer (µg/L)	546.78±341.6	474.41±341.9	619.141±328.8	0.002*
Hemoglobin (gr/L)	13.32±1.7	13.01±1.6	13.63±1.6	0.028*
WBC (10^3/µL)	7.24±1.7	6.95±1.8	7.54±1.7	0.033*
Neutrophile (10^3/µL)	4.39±1.4	4.36±1.3	4.42±1.4	0.848
Lymphocyte (10^3/µL)	2.18±0.7	2.11±0.8	2.23±0.6	0.135
Monocyte (10^3/µL)	0.58±0.2	0.55±0.2	0.62±0.2	0.023*
Platelet (10^3/µL)	240.65±67.86	235.54±73.7	245.75±61.7	0.382
HbA_1C (%)	6.46±2.4	6.32±2.6	6.65±2.2	0.394
AST (U/L)	21.09±13.5	20.78±12.3	21.38±14.6	0.630
ALT (U/L)	19 (2.7-128)	18 (4-128)	19.5 (2.7-87)	0.482
Uric acid (mg/dL)	5.68±1.7	5.63±1.8	5.73±1.7	0.534
Hs-troponin-T (pg/mL)	3.5 (3-193)	3 (3-25)	10 (3-193)	<0.001*
Pro-BNP (pg/mL)	135.5 (20-5406)	139 (20-2615)	133 (20-5406)	0.825
Monocyte/HDL-C ratio	14 (4-34)	13 (4-29)	15 (4-34)	0.027*
Scores				
$CHADS_2$ score	1 (0-4)	1 (0-3)	1 (0-4)	0.233
CHA_2DS_2-VASc score	1 (0-5)	1 (0-4)	1 (0-5)	0.566
CHA_2DS_2-VASc-HSF score	3 (1-7)	3 (1-5)	4 (1-7)	<0.001*

AF: Atrial fibrillation; hs-troponin-T: Highly sensitive troponin-T, HbA_1C: Glycated hemoglobin, AST: Aspartate aminotransferase, ALT: Alanine transaminase, pro-BNP: Pro brain natriuretic peptide, *: p<0.05

Table 2: Coronary angiographic features of the study group

Variables	Total patients (n=136)	Patients with normal flow (n=68)	Patients with slow flow (n=68)	p-value
Slow flow vessel, n (%)				
Left main	14 (10.3)	-	14 (10.3)	-
Left anterior descending	56 (41.2)	-	56 (41.2)	-
Left circumflex	38 (27.9)	-	38 (27.9)	-
Right	41 (30.1)	-	41 (30.1)	-
Coronary Ectasia, n (%)	23 (16.9)	6 (4.4)	17 (12.5)	0.012*
Coronary Tortuosity, n (%)	11 (8.1)	2 (1.5)	9 (6.6)	0.028*

*: p<0.05

Table 3: Correlation of TIMI frame count with laboratory parameters, age, and scores in the coronary slow flow phenomenon group

	Variable	R	p-value
TIMI frame count	Age	0.214	0.080
	Total cholesterol	0.017	0.909
	HDL	-0.094	0.445
	LDL	0.164	0.182
	Triglyceride	0.392	0.001*
	CRP	-0.022	0.868
	D-dimer	0.037	0.797
	Hemoglobin	0.057	0.642
	WBC	0.113	0.357
	Neutrophile	0.129	0.354
	Lymphocyte	0.087	0.534
	Monocyte	0.091	0.460
	Platelet	-0.004	0.971
	HbA_1c	0.289	0.152
	AST	-0.095	0.488
	ALT	0.035	0.799
	Uric acid	-0.006	0.962
	Hs-troponin-T	0.165	0.291
	Pro-BNP	0.050	0.724
	$CHADS_2$ score	0.523	<0.001*
	CHA_2DS_2-VASc score	0.424	<0.001*
	CHA_2DS_2-VASc-HSF score	0.848	<0.001*

Hs-troponin-T: Highly sensitive troponin-T, HbA_1C: Glycated hemoglobin, AST: Aspartate aminotransferase, ALT: alanine transaminase, pro-BNP: Pro brain natriuretic peptide, TIMI: Thrombolysis in myocardial infarction, *p<0.05, R: Correlation coefficient

In the Pearson correlation analysis, the CHA2DS2-VASc-HSF score showed a stronger correlation with TFC than CHADS2 and CHA2DS2-VASc scores in the CSFP group (r=0.848, r=0.424, r=0.523; respectively). The correlation analysis of TFC, including laboratory parameters, age, and scores in the CSFP group, is presented in Table 3.

Table 4: Multivariate regression analyses to predict slow flow phenomenon

4A

	OR	95% CI	p-value
Tortuosity	11.131	0.607-204.158	0.104
CHA2DS2-VASc-HSF score	1.798	1.062-3.045	0.029*
Pro-BNP	0.999	0.998-1.001	0.467
Hs-troponin-T	1.113	1.006-1.231	0.037*

4B

	OR	95% CI	p-value
Ectasia	4.000	0.395-40.549	0.241
CHA2DS2-VASc-HSF score	1.731	1.039-2.884	0.035*
Pro-BNP	1.000	0.999-1.001	0.920
Hs-troponin-T	1.100	1.001-1.208	0.047*

Hs-troponin-T: Highly sensitive troponin-T, pro-BNP: Pro brain natriuretic peptide, OR: Odds ratio, CI: Confidence interval, *p<0.05

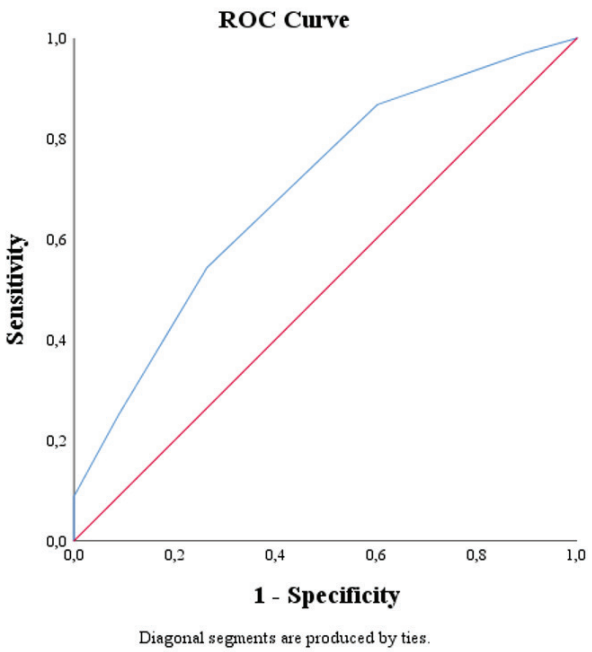

Figure 1: ROC curve analysis demonstrating the prediction of CSFP by the CHA2DS2-VASc-HSF score

The parameters affecting CSFP were evaluated by including clinic-demographic characteristics, laboratory parameters, and CHADS scores in logistic regression analyses. Although the incidence of ectasia and tortuosity in the coronary arteries was higher in the CSFP group than in the normal flow group, in regression models in which coronary ectasia and tortuosity were added, HsTn-T and CHA2DS2-VASc-HSF score were determined as independent predictors of CSFP (Table 4A and 4B). The sensitivity of CHA2DS2-VASc-HSF was determined as 56%, the specificity was 74%, and the cut-off value was 3.5 in detecting the presence of CSFP (AUC: 0.70, 95% CI 0.61–0.78; p<0.001) (Figure 1).

DISCUSSION

We investigated the possible relationship between CHA2DS2-VASc-HSF scores and CSFP in patients who did not have obstructive CAD via elective CA. The results showed that the CHA2DS2-VASc-HSF score was higher in CSFP patients. TCF was correlated with the CHA2DS2-VASc-HSF score in patients with CSFP. The CHA2DS2-VASc-HSF score had sufficient cut-off value to distinguish individuals with CSFP. So far, there is no study showing the relationship of CHA2DS2-VASc-HSF score with CSFP in patients with chronic coronary syndrome.

CSFP is defined by the delay of contrast agent in the coronary artery during CA. Although its frequency varies in the literature, it has been reported as 1-7% (13). While patients with CSFP may be asymptomatic, they may present with stable angina pectoris, myocardial infarction, and even sudden cardiac death (14, 15). It is thought that atherosclerosis, microvascular disease, or endothelial dysfunction may play a role in the pathophysiology of this phenomenon (3, 4, 16). However, it is still not fully explained. Regardless of the cause, patients with CSFP are at high risk for cardiovascular events and often experience poor clinical outcomes (17). In our study, we found a statistically significant increase in HsTn-T in CSFP patients with stable ischemic heart disease. Also, HsTn-T was an independent predictor of CSFP. CSFP may reflect impaired coronary vasomotor reflex and cause myocardial injury in patients at rest. The patients with CSFP may not respond adequately to situations requiring high coronary flow demands (18). The poor prognostic results in CSPF may be explained by this. However, our study is not a follow-up study. Larger follow-up studies are needed to evaluate the prognosis of patients.

The CHA2DS2-VASc scoring system is recommended by the guidelines to evaluate stroke risk in patients with AF (19). DM, age, and HTN, which are the components of this score, are the main risk factors for CAD. Based on this, it has been shown that the CHA2DS2-VASc score can be an indicator of CAD and CAD severity (10, 11). In addition, male gender, hyperlipidemia, smoking, and family history, which are considered other major risk factors for the development of CAD, are among the factors that comprise the CHA2DS2-VASc-HSF score.

Modi et al. showed that CHADS scores were significantly associated with the Gensini score and that the CHA2DS2-VASc-HSF score was superior to other scores in predicting CAD severity with a cut-off value >3. A recent study showed that the new CHA2DS2-VASc-HSF score with a cut-off point of ≥4 predicted the no-reflow phenomenon in STEMI patients and was superior to the other two scores (12). Most patients with CAD have more than one atherosclerosis risk factor. The combination of these multiple risk factors increases the risk and severity of

CAD. Thus, the fact that the CHA2DS2-VASc-HSF score includes more risk factors may explain its better predictive value compared to other scores.

The pathophysiology of CSFP is not completely clear. Some studies investigating the mechanisms underlying CSFP have suggested that one or more of the definitive risk factors for CAD may play a role in its development. Studies have shown that HTN (20-23), obesity (23-25), or smoking (22, 26) are mainly responsible for CSFP, while male gender (23, 27, 28), family history of CAD (27), and hyperlipidemia (22,29) were also shown to be risk factors. In contrast to studies in which obesity was blamed, another study showed that low BMI is a predictor of CSFP (21). It has also been reported that patients with CSFP have higher triglyceride levels (27, 28, 30) or lower HDL levels (21). In our study, smoking, hyperlipidemia, and family history of CAD were more common in patients with CSFP than in the normal flow group. In addition to hyperlipidemia, hypertriglyceridemia was more common in the CSFP group.

The implementation of CHA2DS2-VASc-HSF risk scoring by physicians does not require additional cost in routine practice and is quite easy. The results of this study support that it can be used as a predictive score in the diagnosis of CSFP.

This study has many limitations. To list the most important, it was a single-center study and the number of patients analyzed was small. As the study design was retrospective, data are based on a review of patients' previous clinical histories. This may affect the calculation of scores and there is a possibility of bias.

CONCLUSION

The CHA2DS2-VASc-HSF score can be calculated easily and used in clinical practice to predict patients at risk for CSFP. Larger and prospective studies are needed to support the results of our study.

Ethics Committee Approval: This study was approved by Istanbul University, Istanbul Faculty of Medicine (Date: 21.10.2022, No:19).

Informed Consent: Since the study was in a retrospective design, informed consent was not required.

Peer Review: Externally peer-reviewed.

Author Contributions: Conception/Design of Study- P.K.Ö., S.E., A.E.; Data Acquisition- M.L.Y., E.Y.; Data Analysis/Interpretation- P.K.Ö., E.A.G., M.A.; Drafting Manuscript- P.K.Ö., E.A.G., M.A.; Critical Revision of Manuscript- S.E., A.E.; Final Approval and Accountability- P.K.Ö., M.L.Y., E.Y., E.A.G., M.A., S.E., A.E.; Material and Technical Support- P.K.Ö., S.E., M.L.Y., E.Y.; Supervision- S.E., A.E.

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REFERENCES

1. Tambe AA, Demany MA, Zimmerman HA, Mascarenhas E. Angina pectoris and slow flow velocity of dye in coronary arteries--a new angiographic finding. Am Heart J 1972;84(1):66-71.
2. Gibson CM, Cannon CP, Daley WL, Dodge JT Jr, Alexander B Jr, Marble SJ, et al. TIMI frame count: a quantitative method of assessing coronary artery flow. Circulation 1996;93(5):879-88.
3. Beltrame JF, Limaye SB, Horowitz JD. The coronary slow flow phenomenon--a new coronary microvascular disorder. Cardiology 2002;97(4):197-202.
4. Fineschi M, Gori T. Coronary slow flow: description of a new "cardiac Y" syndrome. Int J Cardiol 2009;137(3):308-10.
5. Yilmaz H, Demir I, Uyar Z. Clinical and coronary angiographic characteristics of patients with coronary slow flow. Acta Cardiol 2008;63(5):579-84.
6. Lip GY, Nieuwlaat R, Pisters R, Lane DA, Crijns HJ. Refining clinical risk stratification for predicting stroke and thromboembolism in atrial fibrillation using a novel risk factor-based approach: the euro heart survey on atrial fibrillation. Chest. 2010;137(2):263-72.
7. Bozbay M, Uyarel H, Cicek G, Oz A, Keskin M, Murat A, et al. CHA_2DS_2-VASc Score Predicts In-Hospital and Long-Term Clinical Outcomes in Patients With ST-Segment Elevation Myocardial Infarction Who Were Undergoing Primary Percutaneous Coronary Intervention. Clin Appl Thromb Hemost 2017;23(2):132-8.
8. Trantalis G, Aggeli K, Toutouzas K, Synetos A, Latsios G, Drakopoulou M, et al. The prognostic value of CHA_2DS_2-VASc and GRACE risk scores in patients with ACS. Hellenic J Cardiol 2019;60(5):305-8.
9. Wang X, Pei C, Bai Y, Dai Q, Deng X, Liu Y, et al. Predictive Value of CHA_2DS_2-VASc Score for Ischemic Events in Patients Undergoing Percutaneous Coronary Intervention. Angiology 2019;70(9):878-86.
10. Modi R, Patted SV, Halkati PC, Porwal S, Ambar S, Mr P, et al. CHA_2DS_2-VASc-HSF score - New predictor of severity of coronary artery disease in 2976 patients. Int J Cardiol 2017;228:1002-6.
11. Uysal OK, Turkoglu C, Duran M, Kaya MG, Sahin DY, Gur M, et al. Predictive value of newly defined CHA2DS2-VASc-HSF score for severity of coronary artery disease in ST segment elevation myocardial infarction. Kardiol Pol 2016;74(9):954-60.
12. Zhang QY, Ma SM, Sun JY. New CHA_2DS_2-VASc-HSF score predicts the no-reflow phenomenon after primary percutaneous coronary intervention in patients with ST-segment elevation myocardial infarction. BMC Cardiovasc Disord 2020;20(1):346.
13. Hawkins BM, Stavrakis S, Rousan TA, Abu-Fadel M, Schechter E. Coronary slow flow--prevalence and clinical correlations. Circ J 2012;76(4):936-42.
14. Przybojewski JZ, Becker PH. Angina pectoris and acute myocardial infarction due to "slow-flow phenomenon" in nonatherosclerotic coronary arteries: a case report. Angiology 1986;37(10):751-61.
15. Saya S, Hennebry TA, Lozano P, Lazzara R, Schechter E. Coronary slow flow phenomenon and risk for sudden cardiac death due to

ventricular arrhythmias: a case report and review of literature. Clin Cardiol 2008;31(8):352-5.

16. Beltrame JF, Limaye SB, Wuttke RD, Horowitz JD. Coronary hemodynamic and metabolic studies of the coronary slow flow phenomenon. Am Heart J 2003;146(1):84-90.
17. Yu J, Yi D, Yang C, Zhou X, Wang S, Zhang Z, et al. Major Adverse Cardiovascular Events and Prognosis in Patients With Coronary Slow Flow. Curr Probl Cardiol. 2023;49(1 Pt B):102074.
18. Erturk M, Caglar FN, Surgit O, Akturk IF, Somuncu U, Akgul O, Kurtar A, Isiksacan N, Caglar IM, Uslu N. High sensitive troponin-I in patients with slow coronary flow pattern. Kardiol Pol 2013;71(12):1245-50.
19. Hindricks G, Potpara T, Dagres N, Arbelo E, Bax JJ, Blomström-Lundqvist C, et al. Corrigendum to: 2020 ESC Guidelines for the diagnosis and management of atrial fibrillation developed in collaboration with the European Association for Cardio-Thoracic Surgery (EACTS): The Task Force for the diagnosis and management of atrial fibrillation of the European Society of Cardiology (ESC) Developed with the special contribution of the European Heart Rhythm Association (EHRA) of the ESC. Eur Heart J 2021;42(40):4194.
20. Moazenzadeh M, Azimzadeh BS, Zare J, Shokouhi M, Sheikhvatan M. Clinical features and main determinants of coronary slow flow phenomenon in Iranian patients. Eur J Cardiovasc Med 2010;(1):57-60.
21. Sanati H, Kiani R, Shakerian F, Firouzi A, Zahedmehr A, Peighambari M, et al. Coronary Slow Flow Phenomenon Clinical Findings and Predictors. Res Cardiovasc Med 2016;5(1):e30296.
22. Sanghvi S, Mathur R, Baroopal A, Kumar A. Clinical, demographic, risk factor and angiographic profile of coronary slow flow phenomenon: A single centre experience. Indian Heart J 2018;70 Suppl 3(Suppl 3):S290-4.
23. Faramarzzadeh R, Fekrat F, Haghtalab A. Evaluation of the relationship between clinical and laboratory risk factors in atherosclerosis patients with coronary slow flow: a case-control analysis. Egypt Heart J 2023;75(1):61.
24. Chaudhry MA, Smith M, Hanna EB, Lazzara R. Diverse spectrum of presentation of coronary slow flow phenomenon: a concise review of the literature. Cardiol Res Pract 2012;(2012):383181.
25. Mukhopadhyay S, Kumar M, Yusuf J, Gupta VK, Tyagi S. Risk factors and angiographic profile of coronary slow flow (CSF) phenomenon in North Indian population: An observational study. Indian Heart J 2018;70(3):405-9.
26. Arbel Y, Rind E, Banai S, Halkin A, Berliner S, Herz I, Mashav N, Thurm T, Keren G, Finkelstein A. Prevalence and predictors of slow flow in angiographically normal coronary arteries. Clin Hemorheol Microcirc 2012;52(1):5-14.
27. Alvarez C, Siu H. Coronary Slow-Flow Phenomenon as an Underrecognized and Treatable Source of Chest Pain: Case Series and Literature Review. J Investig Med High Impact Case Rep 2018;6:2324709618789194.
28. Ghaffari S, Tajlil A, Aslanabadi N, Separham A, Sohrabi B, Saeidi G, et al. Clinical and laboratory predictors of coronary slow flow in coronary angiography. Perfusion 2017;32(1):13-9.
29. Rouzbahani M, Farajolahi S, Montazeri N, Janjani P, Salehi N, Rai A, et al. Prevalence and predictors of slow coronary flow phenomenon in Kermanshah province. J Cardiovasc Thorac Res 2021;13(1):37-42.
30. Almeida MCC, Castro ML. Triglycerides-Glucose Index and Coronary Slow Flow: A New Diagnostic Tool? Arq Bras Cardiol 2023;120(6):e20230373.