ORIGINAL ARTICLE

Assessment of the Prognostic Value of Monocyte-to-HDL Ratio in ST-Elevation Myocardial Infarction Patients Undergoing Primary Percutaneous Coronary Intervention

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Abstract

Background: The purpose of this study was to assess the prognostic value of the monocyte-to-high-density lipoprotein ratio (MHR) as a marker of inflammation in patients diagnosed with ST-segment elevation myocardial infarction (STEMI) who underwent primary percutaneous coronary intervention (PCI). **Materials and Methods:** This retrospective cross-sectional study was conducted on patients with a diagnosis of STEMI who underwent PCI between March 2021 and March 2022 at Madani Training and Research Hospital in Tabriz, Iran. Data regarding clinical and demographic properties, and laboratory parameters were obtained from medical records. Patients were categorized into two groups according to the median of admission MHR. **Results:** The study population consisted of 652 patients, 378 males (58%), and 275 females (42%), with a median age of 68 years (interquartile range: 57-77). Results showed that groups with higher MHR (>15.59) had higher rates of in-hospital mortality and higher major adverse cardiovascular events (MACEs) in comparison with the group featuring lower MHR (<15.59). Receiver operating characteristic (ROC) curves demonstrated that MHR could predict in-hospital mortality with a 75.7% sensitivity and 53.5% specificity, as well as predict MACE with 60.2% sensitivity and 59.7% specificity. Multivariate analyses indicated that MHR is an independent predictor of both in-hospital mortality (OR 1.05, 95% CI 1.02-1.08, P=0.002) and MACE (OR 1.05, 95% CI 1.02-1.08, P<0.001). **Conclusion:** This research indicated that the rise in MHR was independently associated with a higher risk of MACE and in-hospital mortality in STEMI patients undergoing primary PCI.
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Keywords: ST-elevation Myocardial Infarction; Inflammation; Monocyte HDL Ratio; Cardiovascular Events

Introduction

Coronary artery disease (CAD) is a major health concern leading to over 17.8 million deaths annually [1]. The underlying cause of CAD is atherosclerotic cardiovascular disease, which is associated with acute coronary syndrome (ACS) including ST-segment elevation myocardial infarction (STEMI), non-ST-segment elevation myocardial infarction

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(NSTEMI), and unstable angina. Atherosclerotic plaque rupture constitutes the major underlying cause of STEMI since its major components are, endothelial cells, leukocytes, and intimal smooth muscle cells [2].

Inflammation and lipid accumulation play a substantial role in the development of atherosclerosis and cardiovascular disease [3]. Chronic inflammation is associated with an increase in inflammatory mediators, cytokines, and adhesion molecules. This inflammatory response is closely related to the formation, progression, and rupture of atherosclerotic plaques [4]. Furthermore, the absorption of low-density lipoprotein (LDL-c) by macrophages in the vessel wall leads to the release of inflammatory cytokines and necrosis of the atherosclerotic plaque [5].

Monocytes play a critical role in the development and progression of atherosclerosis, and their number can be a predictor of heart events [6]. In inflammatory or pro-thrombotic states, monocytes can express tissue factors and become pro-coagulants [7]. Additionally, activated monocytes release circulatory pre-inflammatory cytokines that can damage the elastic layer and cause atherosclerotic plaque rupture [8]. In contrast, high-density lipoprotein (HDL-c) has anti-inflammatory, antioxidant, and anti-thrombotic effects. The low level of HDL-c in patients is associated with an increased hospital mortality risk following myocardial infarction (MI). HDL-c protects endothelial cells from inflammation and oxidative stress by controlling the activation and proliferation of monocytes and preventing their absorption into the artery wall. It has also been shown that HDL-c, as an anti-atherosclerotic agent, can inhibit the expression of tissue factor in monocytes by preventing P38 mitogen-activated protein kinase activation and inhibiting phosphoinositide 3-kinase (PI3K) [9, 10]. It is hypothesized that there is a relation between the number of monocytes, the low HDL-c levels, and the progression of atherosclerosis and consequently cardiovascular accidents. Previous studies have found that regression of coronary atherosclerotic plaques after treatment with pravastatin is associated with increases in serum HDL-c and decreases in peripheral blood monocyte counts [11]. This has led to the introduction of the monocyte-to-high-density lipoprotein ratio (MHR) as a novel cardiovascular biomarker that may be more effective than individual measurements of monocyte count and HDL-c levels in predicting both short-term and long-term outcomes of CAD [12, 13]. Several studies have shown that MHR during hospitalization in ACS patients is significantly associated with C-reactive protein (CRP) and other inflammatory indices, and patients with higher MHR are at higher risk of in-hospital death, major adverse cardiovascular events (MACEs), and stent thrombosis [7, 14-16]. Given these findings, this research was designed to assess the correlation between the admission MHR values, in-hospital mortality, and MACE in patients who had experienced STEMI and undergone primary percutaneous coronary intervention (PCI).

Materials and Methods

This retrospective cross-sectional study analyzed the medical records of patients with a diagnosis of STEMI who underwent primary PCI between March 2021 and March 2022 at Madani Training and Research Hospital, Tabriz, Iran. Patients who presented within 12 hours of the onset of symptoms (typical chest pain lasting for more than 30 minutes) and had ST-segment elevation of 1 mm or greater in at least two consecutive leads were included in the study. Subjects with clinical signs of heart failure (HF), history of MI, active cancer, hematological proliferative disorders, active hepatobiliary diseases, chronic antihyperlipidemic treatment, active infection, chronic inflammatory disease, receiving steroid therapy, autoimmune disease, and those without a recorded measurement of admission laboratory parameters including cholesterol levels before PCI were excluded from this study. In this study, patients were divided into two groups according to the median of their admission MHR.

Data regarding clinical and demographic properties and laboratory parameters were obtained from medical records. The study protocol was approved by the local ethics committee. This study was approved by a regional research ethics committee under the code IR.TBZMED.REC.1401.794.

Statistical Analysis

Data were reported as mean ± standard deviation (SD) or median (interquartile range) for parametric variables and percentages for categorical variables. The normality of continuous variables was confirmed by the Kolmogorov-Smirnov tests. Differences between groups were determined using the Mann-Whitney U test or independent t-test, as applicable; categorical variables were tested using Chi-square or Fisher exact tests, as applicable. Receiver operating characteristic curves were generated to determine MHR cutoff values for in-hospital mortality and MACEs. Univariate and multivariate binary logistic regression analyses were performed to identify independent predictors of in-hospital mortality and MACEs. Significance was set at P < 0.05. All statistical calculations were performed using SPSS software (version 16.0 for Windows, SPSS, Inc., Chicago, IL).

Results

A total number of 652 patients (378 males, 58% and 275 females,42%); with a median age of 68 years old (interquartile range (IQR) : 57-77) were included in the study. Among patients, 93 (14.3%) experienced MACEs. Out of the encountered events, 27 (4.1%) had ventricular tachycardia/ventricular fibrillation, 24 (3.7%) showed reinfarction, 6 (0.9%) had cardiopulmonary arrest, 3 (0.5%) had torsades de pointes and pulmonary embolism, and 37 (5.7%) expired during hospital follow-up.

Patients were categorized into two groups according to the median of their admission MHR: Group 1 (n=326) had an MHR lower than 15.59, and Group 2 (n=326) had an MHR higher than 15.59. The comparison of baseline, clinical, and laboratory parameters between groups is summarized in Table-1.

The serum levels of white blood cells (WBC), neutrophils, lymphocytes, monocytes, and MHR values were significantly higher in group 2 compared to group 1 (P<0.001). The serum hemoglobin level was significantly lower in group 2 compared to group 1 (P<0.001). The frequency of patients with a smoking history, Killip>1, and multiple vessel disease were significantly higher in group 2 compared to group 1 (32.2% vs. 19.9%,

81.9% vs. 79.8%, 79.4% vs. 68.1%; P< 0.001, P=0.05 and P<0.01 respectively). Patients in group 1 had higher values of left ventricular ejection fraction (LVEF) compared to group 2 (P=0.05). The in-hospital mortality rates and MACE were significantly higher in group 2 compared to group 1 (29% vs. 8%, 61% vs. 32%; P<0.001 and P=0.001). Other parameters were not significantly different between groups.

In the ROC curve analysis, MHR levels on admission above 16.1 predicted in-hospital mortality with a sensitivity of 75.7% and a specificity of 53.5% (area under the curve: 0.715; P<0.001, Figure-1), levels above 17.96 predicted MACE with a sensitivity of 60.2% and a specificity of 59.7% (area under the curve: 0.622; P<0.001, Figure-2).

Univariate and multivariate regression analyses were performed to examine the possible predictors of in-hospital mortality in the study population. In univariate regression analysis, BMI, MHR, Killip>1 and >1 vessel disease correlated with in-hospital mortality. In multivariate regression analysis, BMI, Killip>1, and MHR (OR 1.05, 95% CI 1.02-1.08, P=0.002) independently predicted in-hospital mortality (Table-2).

Univariate and multivariate regression analyses were also conducted to analyze the possible predictors of MACE in the study population. In the univariate regression analysis, age, BMI, Cr, troponin, Killip>1, LVEF, and MHR were correlated with MACE. In the multivariate regression analysis, age, BMI, troponin, LVEF, and MHR (OR 1.05, 95% CI 1.02-1.08, P<0.001) independently predicted MACE (Table-3).

Discussion

In this study, by analyzing the correlation between hospital admission MHR and in-hospital mortality and MACE in patients with STEMI who underwent primary PCI, we found that BMI, Killip>1, and MHR values were independently associated with in-hospital mortality, while age, BMI, troponin, LVEF, and MHR levels independently predicted MACE.

Atherosclerosis and plaque rupture due to STEMI are strongly associated with inflam-

Table 1. Comparison of Demographic, Clinical, and Laboratory Parameters between Groups According to Admission MHR

Variables	Group 1 n=326 MHR<15.59	Group 2 n=326 MHR>15.59	P-value
Demographic			
Age (years)	67.5 (55-77)	69(60-78)	0.01
Male, n (%)	189 (58)	189 (58)	1
BMI, kg/m²	24.2 (21.5-26.5)	24.2 (21.6-26.7)	0.26
Diabetes mellitus, n (%)	102 (31.3)	105 (32.2)	0.8
Hypertension, n (%)	144 (44.2)	165 (50.6)	0.1
Hyperlipidemia, n (%)	138 (42.3)	156 (47.9)	0.15
Coronary syndrome, n (%)	92 (28.2)	86 (26.4)	0.59
Family history of CAD, n (%)	104 (31.9)	98 (30.1)	0.61
Smoking, n (%)	65 (19.9)	105 (32.2)	<0.001
SBP (mmHg)	110 (100-110)	110 (100-115)	0.52
DBP (mmHg)	70 (60-70)	70 (60-75)	0.63
HR (bpm)	84 (77-93)	85 (77-92)	0.78
Laboratory parameters			
Hemoglobin (mg/dl)	14.6 (12.8-15.9)	13.8 (12-15.5)	<0.001
Platelet (/mm³)	220 (140.6-292.2)	211 (148.3-308.2)	0.51
WBC (10³ mL)	9.2 (6.9-13.2)	15.1 (10.6-19.1)	<0.001
Neutrophil (10³ mL)	1.5 (0.9-3.6)	3.5 (1.75-5.72)	<0.001
Lymphocyte (10³ mL)	6.5 (4.4-9.4)	9.6 (6.56-12.8)	<0.001
Monocyte (10³ mL)	0.39 (0.27-0.49)	0.98(0.79-1.23)	<0.001
Total cholesterol (mg/dl)	185 (179-191)	186 (179-193)	0.35
Triglyceride (mg/dl)	170.33±16.15	170±17.01	0.8
LDL (mg/dl)	126 (120-136)	128 (119-137)	0.46
HDL (mg/dl)	41 (39-44)	41 (38-43)	0.07
VLDL (mg/dl)	15 (13-16)	15 (14-16)	0.83
MHR	9.65 (6.88-12.62)	23.6 (19.4-29.7)	<0.001
Creatinine, mg/dL	1.1 (0.9-1.3)	1.09 (0.9-1.3)	0.84
Troponin I, ng/mL	6.5 (5.37-9.6)	6.5 (5.5-8.3)	0.85
CRP, mg/L	3.3 (2.6-4.1)	3.3 (2.5-3.9)	0.31
Killip class>1, n (%)	260 (79.8)	267 (81.9)	0.05
Angiographic characteristics			
Culprit artery, n (%)			
LAD	216 (66.3)	202 (62)	0.25
CX	134 (41.1)	137 (42)	0.81
RCA	137 (42)	134 (41.1)	0.81
Multiple-vessel disease, n (%)	222 (68.1)	259 (79.4)	<0.001

Continue on next page

Continues of **Table 1.** Comparison of Demographic, Clinical, and Laboratory Parameters between Groups According to Admission MHR

LVEF, %	37.5 (30-50)	35 (25-45)	0.05
MACE, n (%)	32 (9.8)	61 (18.7)	0.001
Mortality, n (%)	8 (2.5)	29 (8.9)	<0.001

Data are expressed as median and interquartile range (IQR) for parametric variables and percentage for categorical variables.

Abbreviations: **BMI:** body mass index; **CRP:** C-reactive protein; **CX:** circumflex coronary artery; **DBP:** diastolic blood pressure; **HDL:** high density lipoprotein; **HR:** heart rate; **RCA:** right coronary artery; **LAD:** left anterior descending coronary artery; **LDL:** low-density lipoprotein; **LVEF:** left ventricular ejection fraction; **MACE:** major adverse cardiac events; **MHR:** monocyte-to-high-density lipoprotein; **SBP:** Systolic blood pressure; **VLDL:** very low-density lipoprotein; **WBC:** white blood cell.
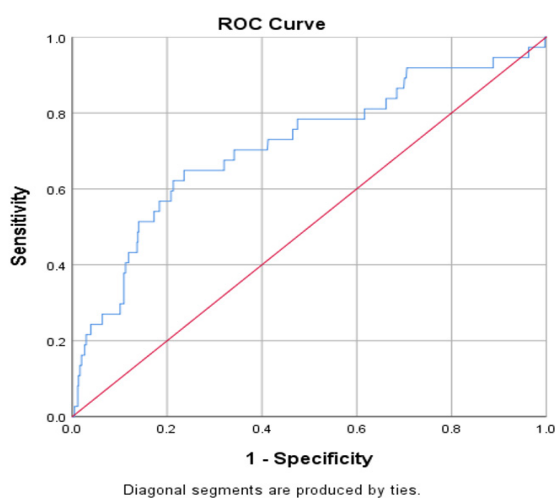

Figure 1. ROC curve analysis showing the predictive cut-off value of MHR for in-hospital mortality. Abbreviations: MHR: monocyte to HDL ratio; ROC: receiver operating curve
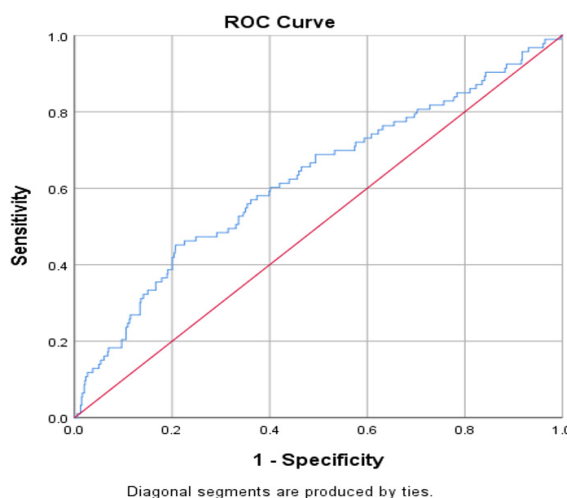

Figure 2. ROC curve analysis showing the predictive cut-off value of MHR for in-hospital MACE. Abbreviations: MACE: major adverse cardiovascular events; MHR: monocyte to HDL ratio; ROC: receiver operating curve

Table 2. Independent Predictors of Mortality According to the Univariate and Multivariate Regression Analyses

Variables	Univariate			Multivariate		
	OR	CI	P-value	OR	CI	P-value
Age (years)	1	0.97-1.02	0.97			
Male, n (%)	0.59	0.3-1.16	0.13			
BMI, kg/m²	1.44	1.31-1.58	<0.001	1.44	1.30-1.59	<0.001
MHR	1.06	1.04-1.09	<0.001	1.05	1.02-1.08	0.002
Creatinine, mg/dL	1.10	0.81-1.5	0.51			
Troponin I, ng/mL	0.94	0.85-1.03	0.23			
Killip class>1, n (%)	1.70	1.17-2.46	0.005	1.57	1.06-2.32	0.02
>1-vessel disease (multiple vessel diseases), n (%)	1.81	1.12-2.94	0.01	1.56	0.88-2.79	0.12
LVEF, %	0.97	0.94-1.004	0.08			

Abbreviations: **BMI:** body mass index; **CI:** confidence interval; **LVEF:** left ventricular ejection fraction; **MHR:** monocyte-to-high-density lipoprotein; **OR:** odds ratio

Table 3. Independent Predictors of MACE According to the Univariate and Multivariate Regression Analyses

Variables	Univariate			Multivariate		
	OR	CI	PV	OR	CI	PV
Age (years)	0.95	0.93-0.97	<0.001	0.94	0.92-0.97	<0.001
Male, n (%)	1.53	0.96-2.44	0.06			
BMI, kg/m²	1.24	1.17-1.31	<0.001	1.28	1.2-1.37	<0.001
MHR	1.04	1.02-1.06	<0.001	1.05	1.02-1.08	<0.001
Creatinine, mg/dL	1.33	1.09-1.62	0.005	1.15	.87-1.52	0.32
Troponin I, ng/mL	1.18	1.13-1.24	<0.001	1.22	1.15-1.29	<0.001
Killip class>1, n (%)	1.29	1.02-1.62	0.03	1.30	0.98-1.72	0.06
>1-vessel disease (multiple vessel disease), n (%)	1.18	0.87-1.61	0.27			
LVEF, %	0.94	0.92-0.96	<0.001	0.94	0.91-0.96	<0.001

Abbreviations: **BMI:** body mass index; **CI:** confidence interval; **LVEF:** left ventricular ejection fraction; **MACE:** major adverse cardiac events; **MHR:** monocyte-to-high-density lipoprotein; **OR:** odds ratio

mation, which can be promoted by circulating monocytes. Oxidative stress and inflammation have been related to atherosclerotic progression and have become important factors in predicting adverse CAD outcomes [17-20]. Monocyte activation is an early step in the beginning of the atherosclerosis process, as evidenced by an increased count of circulat-ing monocytes that is a predictor of plaque development. Endothelial cell dysfunction is the first stage of plaque development with mononuclear cells including monocytes and T lymphocytes attaching themselves to the endothelium. These cells in subendothelial space mature into macrophages and differentiate into foam cells by absorbing oxidized and other

LDL-c. Foam cells release proinflammatory cytokines and tissue factor that increases the local inflammatory response, digests the internal elastic lamina and results in thrombus formation and ACS [21-24]. Tissue factor expression has been shown to increase following PCI, further demonstrating the pivotal role of monocytes in inflammation, thrombosis, and endothelial dysfunction [25]. Therefore, it is evident that macrophages and their precursor cells, monocytes, are key players in all stages of atherosclerosis and their involvement can lead to STEMI.

In contrast, HDL-c has well-known anti-inflammatory, antioxidant, and antithrombotic effects, particularly through suppressing monocyte activities and interrupting the differentiation of monocytes to macrophages, thus restricting the inflammatory response. HDL-c can also reduce the expression of adhesion molecules preventing monocyte recruitment to arterial walls [26, 27]. In addition, research has shown that an increased level of HDL-c is associated with reduced extramedullary monocytepoiesis in ACSs, suppressing the production of various chemokines, and thus interrupting the monocyte production and differentiation process from the spleen - a major source of monocytes in ACS. Consequently, lower levels of HDL-c and LDL-c have been reported as independent predictors of mortality in ACSs and other clinical illness diseases [28, 29].

In our study, serum cholesterol levels were lower in the MACE (+) group although this was not statistically significant and did not correlate with mortality and MACE in multivariate analysis. Nonetheless, HDL-c's various effects highlight the importance of its role in cardiovascular diseases. MHR has emerged as an important indicator of inflammatory status and adverse cardiovascular outcomes, with its pioneering study conducted by Kanbay *et al*. [30]. They reported an association between increased MHR and the presence of cardiovascular comorbidities in chronic kidney disease patients [31]. After that, Canpolat *et al.* found that patients with pre-ablation high MHR values increased the risk of AF recurrence after ablation. Moreover, a study by MHR demonstrated that MHR was a significant predictor of stent thrombosis, mor-

tality, and in-hospital MACE in patients with STEMI [32]. The association of monocytes and systemic inflammation, as well as the inhibitory effect of serum HDL-c on monocyte activation, suggested that an increased MHR may be predictive of adverse cardiovascular events in STEMI patients. Consequently, the monocyte-to-HDL-c ratio has been used as a new marker to predict clinical outcomes in several studies [16, 33].

We also concluded that MHR is effective in predicting mortality and MACEs. In our study, receiver operating characteristic curve analysis revealed that MHR greater than 16.1 is a cutoff value for mortality and MHR greater than 17.96 is a cutoff value for MACE. The results of multiple studies also have illustrated that high MHR was associated with in-hospital mortality among STEMI patients who underwent primary PCI [16, 30, 33] . The levels of various laboratory parameters related to inflammation have been studied in individuals with cardiovascular disease and were found to be able to predict mortality and MACE. Furthermore, the admission troponin I level was identified as a predictor of negative cardiovascular outcomes. Our research revealed that higher admission troponin I levels were independently related to MACE.

Conclusion

In this study demonstrated that admission MHR was an independent predictor of in-hospital mortality and MACE in patients with STEMI who underwent primary PCI. The results of this study suggest that MHR may be a useful biomarker for predicting adverse cardiovascular outcomes in patients with STEMI. Moreover, MHR can provide clinicians with additional information to facilitate the personalization of treatment strategies in these patients.

Conflict of Interest

The authors declare that there is no conflict of interest.

References

1. Brown JC, Gerhardt TE, Kwon E. Risk factors for coronary artery disease. search life sciences literature . 2022;:554410.

2. Heitzer T, Schlinzig T, Krohn K, Meinertz T, Münzel T. Endothelial dysfunction, oxidative stress, and risk of cardiovascular events in patients with coronary artery disease. Circulation. 2001;104(22):2673-8.

3. Sen N, Afsar B, Ozcan F, Buyukkaya E, Isleyen A, Akcay AB et al. The neutrophil to lymphocyte ratio was associated with impaired myocardial perfusion and long term adverse outcome in patients with ST-elevated myocardial infarction undergoing primary coronary intervention. Atherosclerosis. 2013;228(1):203-10.

4. Libby P. Inflammation and cardiovascular disease mechanisms. The American journal of clinical nutrition. 2006;83(2):456S-60S.

5. Aukrust Pl, Halvorsen B, Yndestad A, Ueland T, Øie E, Otterdal K et al. Chemokines and cardiovascular risk. Arteriosclerosis, thrombosis, and vascular biology. 2008;28(11):1909-19.

6. Olivares R, Ducimetiere P, Claude JR. Monocyte count: a risk factor for coronary heart disease? American journal of epidemiology. 1993;137(1):49-53.

7. Ganjali S, Gotto Jr AM, Ruscica M, Atkin SL, Butler AE, Banach M, Sahebkar A. Monocyte-to-HDL-cholesterol ratio as a prognostic marker in cardiovascular diseases. Journal of cellular physiology. 2018;233(12):9237-46.

8. Moreno PR, Purushothaman KR, Fuster V, O'Connor WN. Intimomedial interface damage and adventitial inflammation is increased beneath disrupted atherosclerosis in the aorta: implications for plaque vulnerability. Circulation. 2002;105(21):2504-11.

9. Hafiane A, Genest J. High density lipoproteins: Measurement techniques and potential biomarkers of cardiovascular risk. BBA clinical. 2015;3:175-88.

10. Reddy VS, Bui QT, Jacobs JR, Begelman SM, Miller DP, French WJ. Relationship between serum low-density lipoprotein cholesterol and in-hospital mortality following acute myocardial infarction (the lipid paradox). The American journal of cardiology. 2015;115(5):557-62.

11. Tani S, Matsumoto M, Anazawa T, Kawamata H, Furuya S, Takahashi H et al. Development of a model for prediction of coronary atherosclerotic regression: evaluation of high-density lipoprotein cholesterol level and peripheral blood monocyte count. Heart and vessels. 2012;27:143-50.

12. Cetin MS, Cetin EHO, Kalender E, Aydin S, Topaloglu S, Kisacik HL, Temizhan A. Monocyte to HDL cholesterol ratio predicts coronary artery disease severity and future major cardiovascular adverse events in acute coronary syndrome. Heart, Lung and Circulation. 2016;25(11):1077-86.

13. Karataş MB, Çanga Y, Özcan KS, İpek G, Güngör B, Onuk T et al. Monocyte to high-density lipoprotein ratio as a new prognostic marker in patients with STEMI undergoing primary percutaneous coronary intervention. The American journal of emergency medicine. 2016;34(2):240-4.

14. Oylumlu M, Oylumlu M, Arik B, Demir M, Ozbek M, Arslan B et al. Monocyte to high-density lipoprotein cholesterol and lymphocyte to monocyte ratios are predictors of in-hospital and long-term mortality in patients with acute coronary syndrome. International Journal of Clinical Practice. 2021;75(5):e13973.

15. Zhang D-P, Baituola G, Wu T-T, Chen Y, Hou X-G, Yang Y et al. An elevated monocyte-to-high-density lipoprotein–cholesterol ratio is associated with mortality in patients with coronary artery disease who have undergone PCI. Bioscience Reports. 2020;40(8):BSR20201108.

16. Jiang M, Yang J, Zou H, Li M, Sun W, Kong X. Monocyte-to-high-density lipoprotein-cholesterol ratio (MHR) and the risk of all-cause and cardiovascular mortality: A nationwide cohort study in the United States. Lipids in Health and Disease. 2022;21(1):30.

17. Libby P. Inflammation during the life cycle of the atherosclerotic plaque. Cardiovascular Research. 2021;117(13):2525-36.

18. Ghattas A, Griffiths HR, Devitt A, Lip GY, Shantsila E. Monocytes in coronary artery disease and atherosclerosis: where are we now? Journal of the American College of Cardiology. 2013;62(17):1541-51.

19. Raberi VS, Ezati E, Zadeh RF. The relationship between the hematologic indices (PDW, WBC count, MPV) at the admission time and descending ST segment after thrombolysis in patients with myocardial

infarction. Amazon Investig. 2019;8(18):139-49.

20. Vatani KK, Raberi VS, Khalili N, Ajdari S. The Association Between the Serum Level of 25-Hydroxy Vitamin D and the Echocardiographic Indices of Left Ventricular Function in Patients With no Significant Coronary Artery Disease. Hypertension. 2020;45:220-4.

21. Groh L, Keating ST, Joosten LA, Netea MG, Riksen NP. Monocyte and macrophage immunometabolism in atherosclerosis. Seminars in immunopatholog. 2018;40:203-214.

22. Choi SH, Kim JH, Lim S, Lim JY, Kim KW, Park KS, Jang HC. Monocyte count as a predictor of cardiovascular mortality in older Korean people. Age and Ageing. 2017;46(3):433-8.

23. Tabrizi MT, Khezerlouy-Aghdam N, Raberi VS, Khosroshahi AJ. Aortic shelf as a normal variant diagnosed primarily as the aortic dissection: A case report. J Cardiovasc Thorac Res. 2020;12(3):234.

24. Tabrizi MT, Khezerlu N, Rabori VS, Sarvestani AH. The assessment of functional indices of left ventricular wall layers in cases with normal and high blood pressure by layer-specific strain methods. J Res Clin Med. 2022;10:7.

25. Palmerini T, Coller BS, Cervi V, Tomasi L, Marzocchi A, Marrozzini C et al. Monocyte-derived tissue factor contributes to stent thrombosis in an in vitro system. Journal of the American College of Cardiology. 2004;44(8):1570-7.

26. Soran H, Hama S, Yadav R, Durrington PN. HDL functionality. Current opinion in lipidology. 2012;23(4):353-66.

27. Karabacak M, Kahraman F, Sert M, Celik E, Adali MK, Varol E. Increased plasma monocyte chemoattractant protein-1 levels in patients with isolated low high-density lipoprotein cholesterol. Scandinavian journal of clinical and laboratory investigation. 2015;75(4):327-32.

28. Cutlip DE, Baim DS, Ho KK, Popma JJ, Lansky AJ, Cohen DJ et al. Stent thrombosis in the modern era: a pooled analysis of multicenter coronary stent clinical trials. Circulation. 2001;103(15):1967-71.

29. van der Laan AM, Hirsch A, Robbers LF, Nijveldt R, Lommerse I, Delewi R et al. A proinflammatory monocyte response is associated with myocardial injury and impaired functional outcome in patients with ST-segment elevation myocardial infarction: monocytes and myocardial infarction. American heart journal. 2012;163(1):57-65.

30. Villanueva DLE, Tiongson MD, Ramos JD, Llanes EJ. Monocyte to High-Density Lipoprotein Ratio (MHR) as a predictor of mortality and Major Adverse Cardiovascular Events (MACE) among ST Elevation Myocardial Infarction (STEMI) patients undergoing primary percutaneous coronary intervention: a meta-analysis. Lipids in health and disease. 2020;19:1-8.

31. Kanbay M, Solak Y, Unal HU, Kurt YG, Gok M, Cetinkaya H et al. Monocyte count/HDL cholesterol ratio and cardiovascular events in patients with chronic kidney disease. International urology and nephrology. 2014;46:1619-25.

32. Canpolat U, Çetin EH, Cetin S, Aydin S, Akboga MK, Yayla C et al. Association of monocyte-to-HDL cholesterol ratio with slow coronary flow is linked to systemic inflammation. Clinical and Applied Thrombosis/Hemostasis. 2016;22(5):476-82.

33. Wu T-T, Zheng Y-Y, Chen Y, Yu Z-X, Ma Y-T, Xie X. Monocyte to high-density lipoprotein cholesterol ratio as long-term prognostic marker in patients with coronary artery disease undergoing percutaneous coronary intervention. Lipids in health and disease. 2019;18:1-10.