

The relationship between intracoronary thrombus burden and atherogenic index in patients with ST-elevation myocardial infarction

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Abstract. – OBJECTIVE: Increased coronary thrombus load is a strong predictor of adverse cardiovascular (CV) outcomes. Identifying predictors of intracoronary thrombus burden may contribute to the management of ST-segment elevation myocardial infarction (STEMI). We aimed at evaluating the relationship between the atherogenic index (ATI) and coronary thrombus burden in patients presenting with STEMI.

PATIENTS AND METHODS: 139 patients who presented with STEMI and underwent primary percutaneous coronary intervention were included in this study. Angiographic thrombus burden was classified as previously defined in the myocardial infarction (TIMI) study group.

RESULTS: The patients were divided into two groups as those with high and low thrombus load. Independent predictors of high thrombus burden were ATI (OR: 4.23, 95% CI: 2.38-7.5; $p < 0.001$), serum creatinine level (OR: 17.4, 95% CI: 3.03-101.4; $p = 0.001$) and non-LAD involvement (OR: 0.363, 95% CI: 0.14-0.92; $p = 0.034$). The association of ATI with thrombus load was independent from HDL and TGL levels.

CONCLUSIONS: The atherogenic index can be used as a reliable marker for increased coronary thrombus burden, which is associated with adverse CV outcomes.

Key Words:

Thrombus burden, ST-elevation myocardial infarction, Atherogenic index.

plaque, followed by the interaction of the thrombotic subendothelial matrix and plaque with the circulating platelets¹.

Thrombus load can be highly variable, but its presence increases the risk of distal embolization, no-reflow, sudden closure, stent thrombosis, revascularization, myocardial infarction, and death²⁻⁵.

The atherogenic index of plasma (AIP), a logarithmically converted ratio of triglyceride to HDL cholesterol, was shown to be a strong predictor for atherosclerosis and coronary heart disease⁶⁻⁹. AIP reflects the true relationship between protective and atherogenic lipoprotein¹⁰. An AIP value below 0.11 is associated with lower CVD risk, and values between 0.11 and 0.21 and above 0.21 are associated with moderate and increased risks, respectively^{6,10}.

It is important to identify the determinants of intracoronary thrombus burden. Some studies^{11,12} have identified a relationship between parameters such as bilirubin and red cell distribution width (RDW) and thrombus burden. However, there is no study in the literature evaluating the relationship between atherogenic index (ATI) and thrombus burden in patients with STEMI. We hypothesized that ATI might be associated with thrombus burden and aimed at revealing this in our study.

Introduction

Partial or complete occlusion of the infarct-related artery (IRA) by an intracoronary thrombus is the pathognomonic feature of patients presenting with ST-elevation myocardial infarction (STEMI). In most cases, the source of thrombogenesis is the erosion of the atherosclerotic

Patients and Methods

The Study Population

139 consecutive patients who presented to the emergency department between January 2020 and May 2021 and underwent primary PCI with the diagnosis of STEMI were included in this prospective cross-sectional observational study.

The diagnosis and treatment of STEMI were performed according to the recommendations of current guidelines¹³. The study protocol was reviewed and approved by the Recep Tayyip Erdogan University Clinical Research Ethics Committee and performed according to the principles of the Declaration of Helsinki. Details of the study were explained to patients and written informed consent was obtained from participations.

Exclusion Criteria

Patients who received thrombolytics before primary PCI, those with stent thrombosis, systemic inflammatory diseases, anemia, malignancy, chronic renal failure (eGFR < 30), chronic liver disease, hematological diseases, recent infection, history of blood transfusion in the last 3 months, and patients who underwent CABG were not included in the study.

Obtaining the Demographic Data

All patients were evaluated by an experienced cardiologist and demographic data were recorded. Hypertension was defined as having a systolic blood pressure ≥ 140 mm Hg and/or diastolic blood pressure ≥ 90 mm Hg on repeat measurements or using any antihypertensive drug. Diabetes mellitus was defined as having a fasting plasma glucose level of > 126 mg/dL or > 200 mg/dL at any measurement or using any antidiabetic drug.

Laboratory Measurements

Peripheral venous blood samples were obtained from the patients at admission. Blood biochemical parameters including a basal lipid panel, fasting glucose, creatinine, and CRP levels were measured.

Samples were collected into tubes anticoagulated with EDTA to measure hemoglobin, white blood cell, neutrophil, and platelet counts. Samples were run on an automated blood cell counter, the Beckman Coulter analyzer.

The atherogenic index was calculated by using the following formula: $\log_{10}(\text{TG}/\text{HDL-C})^7$ and classified as follows: -0.3 to 0.1 indicated a low risk, 0.1 to 0.24 indicated a medium risk, and more than 0.24 indicated a high risk of CVD⁶.

Angiographic Data

All patients diagnosed with STEMI were given a loading dose of 300 mg aspirin and 600 mg clopidogrel on admission to the hospital, and 70 IU/kg unfractionated heparin during the PCI

procedure. Except for cardiogenic shock, primary PCI was performed only on the responsible artery. Standard Judkins technique and Siemens Axiom Sensis XP device (Siemens, Munich, Germany) were used to perform basal coronary angiography. The contrast agent used was iopromide (Ultravist-370 Schering AG, Berlin, Germany).

Thrombus grade was assessed after total occluded lesions had restored antegrade flow *via* guidewire or small balloon dilation. Angiographic thrombus burden was classified as previously defined in the myocardial infarction (TIMI) study group (12). The classification was performed by two invasive cardiologists unaware of research data, as follows: Grade 0 - No thrombus, Grade 1 - Probable thrombus, Grade 2 - The largest size of thrombus $< 1/2$ vessel diameter, Grade 3 - Largest size $> 1/2$ to $< 2x$ vessel diameter, Grade 4 - Largest size $> 2x$ vessel diameter and Grade 5 - Total vascular occlusion due to thrombus. Patients were classified as having low (Grade 1-3) and high thrombus load (Grade 4 and 5) according to the final thrombus score.

Statistical Analysis

Continuous variables were given as mean \pm standard deviation, and categorical variables as percentages and logarithmic transformations. Visual (histograms, probability plots), and analytical methods (Kolmogorov-Smirnov/Shapiro-Wilk's test) were used to determine whether the data were normally distributed. The student *t*-test was used to compare normally distributed parameters among the two groups, while the Mann-Whitney U-test test was used to compare non-normally distributed parameters. A *p*-value lower than 0.05 was considered statistically significant. Cross tabulations were used to compare the rates of patients with categorical variables. The Chi-square or Fisher's exact test (when Chi-square test assumptions did not hold due to low expected cell counts) was used to compare two different groups. In multivariate analysis (forward conditional), the possible factors identified with univariate analysis were assessed with logistic regression analysis to assess the independent predictors of high-grade thrombus load. Hosmer-Lemeshow goodness of fit statistics was used to evaluate model fit. A 5% type-I error level was used to infer statistical significance. Statistical analyses were performed using the SPSS software (Version 19.0, IBM Corp., Armonk, NY, USA).

Results

99 male and forty female patients with a mean age of 59.5 ±12.9 years were included in the analysis. The patients were divided into two groups as those with high (n=67) and low (n=72) thrombus load (Table I). When compared with the univariate analysis, hyperlipidemia (p=0.006), ATI (<0.001), WBC (p=0.041), fasting glucose level (0.024), serum creatinine level (0.004), triglyceride level (p<0.001), and CRP (p=0.022) were significantly higher in the high thrombus load group. Thrombus load was higher in patients in whom the LAD was not the responsible vessel (p<0.001). Remarkably, HDL cholesterol levels

were lower in those with high thrombus load (p=0.031). Although insignificant, there were more patients with a history of PCI among those with high thrombus load (p=0.080). Similarly, anemia and neutrophil levels were insignificantly higher in the high thrombus load group.

Parameters that were significant in univariate analysis were included in the multivariate logistic regression analysis, except for two (Table II). Since TGL and HDL levels used in the diagnosis of HPL were included in the multivariate analysis, HPL was not included. Also, because WBC and CRP are indicators of inflammation, only CRP was included after logarithmic transformation. Multivariate analysis revealed that

Table I. Univariate comparison of the two groups according to the presence of high-grade thrombus.

Variables	High grade thrombus (-) (n = 72)	High grade thrombus (+) (n = 67)	p-value
Laboratory and Demographic Parameters			
Age (year)	58.3 ± 11.9	60.9 ± 13.9	0.246
BMI (kg/m ²)	29.5 ± 3.03	29.8 ± 4	0.655
Gender (male)	49 (68.1)	50 (74.6)	0.479
Previous PCI n (%)	15 (20.8)	22 (32.8)	0.080
Previous MI n (%)	18 (25)	21 (31.3)	0.260
Type 2 DM n (%)	15 (20.8)	20 (29.9)	0.258
Hypertension n (%)	67 (93.1)	60 (89.6)	0.552
Current smoker n (%)	52 (72.2)	45 (67.2)	0.581
Hyperlipidemia n (%)	70 (97.2)	56 (83.6)	0.006
Diagnosis (STEMI) n (%)	55 (76.4)	52 (77.6)	0.864
IRA (LAD)	36 (50)	21 (31.3)	0.038
Atherogenic Index	1.7 ± 0.85	2.6 ± 0.7	< 0.001
WBC (10 ³ /μL)	11.3 ± 3.6	12.7 ± 4.4	0.041
Hemoglobin (g/L)	14.5 ± 1.6	13.9 ± 1.9	0.059
Platelet (10 ³ /μL)	234 ± 71.6	246 ± 117.6	0.481
Neutrophil (10 ³ /μL)	8.2 ± 3.7	9.6 ± 4.6	0.052
Glucose (Fasting) (mg/dL)	153.6 ± 74	188.2 ± 102	0.024
Serum creatinine (mg/dL)	0.88 ± 1.24	1.06 ± 0.46	0.004
Total Cholesterol (mg/dL)	208.08 ± 54.9	209 ± 54.8	0.922
LDL Cholesterol (mg/dL)	139.1 ± 44.6	135.2 ± 45.6	0.616
HDL Cholesterol (mg/dL)	43.5 ± 9.3	40.1 ± 9.3	0.031
Triglyceride (mg/dL)	132.1 ± 73	188 ± 98.9	< 0.001
*CRP (Ln)	2.1 ± 1.5	2.7 ± 1.3	0.022
Medication			
Acetylsalicylic acid n (%)	70 (97.2)	67 (100)	0.266
Beta-Blocker n (%)	64 (88.9)	57 (85.1)	0.615
ACE Inh. n (%)	56 (77.8)	53 (79.1)	0.849
ARB n (%)	4 (5.6)	2 (3)	0.682
Statin n (%)	66 (91.7)	66 (98.5)	0.117
P2Y12 Inh. n (%)	69 (95.8)	66 (98.5)	0.621
OAD/Ins n (%)	15 (20.8)	20 (29.7)	0.152

IRA: Infarct related artery; BMI, Body mass index; HDL, High-density lipoprotein; LDL, Low-density lipoprotein; NS; not significant; PCI, Percutaneous coronary intervention; Inh: Inhibitor; ACE: Angiotensin-Converting Enzyme Inhb.; ARB: Angiotensin Receptor Blockers; OAD: Oral Antidiabetic Agents; WBC: White Blood Cell. Continuous variables were given as mean ± SD. *Since it is a nonparametric value, logarithmic transformation was performed.

Table II. Multivariate binary logistic regression analysis.

Variables	Univariate			Multivariate		
	OR	CI (95%)	p-value	OR	CI (95%)	p-value
HPL	0.145	0.031-0.683	0.031			
Atherogenic Index*	3.465	2.202-5.450	< 0.001	4.239	2.384-7.527	< 0.001
WBC	1.093	1.002-1.192	0.046			
Glucose*	1.005	1.001-1.009	0.033			
Serum Creatinine*	6.956	1.755-27.573	0.006	17.541	3.033-101.4	0.001
HDL Cholesterol*	0.959	0.923-0.997	0.034			
TGL*	1.009	1.004-1.0013	0.001			
CRP (Ln)*	1.312	1.036-1.665	0.025			
IRA (LAD)*	0.457	0.228-0.913	0.027	0.363	0.142-0.927	0.034

*The marked parameters were included in the multivariate logistic regression analysis, in which the forward conditional method was used.

ATI (OR:4.23, $p<0.001$), serum creatinine level (OR:17.4, $p=0.001$), and non-LAD involvement (OR:0.363, $p=0.034$) were independent predictors of high thrombus load.

Discussion

This study showed that serum creatinine level, ATI, and non-LAD lesions were independent predictors of increased thrombus load in patients with STEMI treated with primary PCI. The association of ATI with thrombus load was independent of HDL and TGL levels. As far as we know, the association of ATI with thrombus load in STEMI was first put forward in our study.

Coronary artery occlusion and thrombus following atherosclerotic plaque rupture are the main underlying causes of STEMI pathophysiology. It is known that increased thrombus load in patients with ACS is associated with distal embolization and no-reflow phenomenon, resulting in impaired coronary perfusion and decreased left ventricular ejection fraction after the procedure⁶. Despite some conflicting results in the literature¹⁴⁻¹⁶, increased thrombus load ($\geq 2x$ vessel diameter) was consistently found to be a strong predictor of major adverse cardiac events.

Low-density lipoprotein cholesterol (LDL-C) is an independent risk factor and an important intervention target for CAD. However, even if LDL-C is reduced to the target values, 50% of the cardiovascular risk remains¹⁷⁻¹⁹. Lipid metabolism studies^{20,21} examine the size of small, low-density lipoprotein (sdLDL), which is one of the lower fractions of LDL. Small, low-density lipoprotein is more atherogenic than floating LDL²¹.

Therefore, sdLDL is considered a risk factor for atherosclerosis and a predictor of CV disease^{21,22}. However, sdLDL measurement is limited in clinical practice due to its complexity and high cost. The atherogenic index of plasma (AIP) indirectly reflects sdLDL levels and is calculated using the log (TG/HDL-C) formula^{8,23}. This value was determined as an index to predict plasma atherosclerosis and CAD^{6,23}. In line with the previous studies^{8,21-23}, we showed that it may be related to thrombus load.

The filling of the distal microvascular bed by the thrombus is one of the most important mechanisms of the pathophysiology of no-reflow. In a study investigating the relationship between AIP and no-reflow in patients with STEMI, AIP was an independent predictor of no-reflow²⁴. In their study on male acute coronary syndrome (ACS) patients, Burke et al²⁵ observed a significant relationship between thrombosis caused by plaque rupture and high total cholesterol (TC), and high TC/HDL-C ratio. In our study, although total cholesterol and LDL values were similar, high TG and low HDL values were prominent among those with high thrombus burden. In a study²⁶ conducted in the Turkish population, high AIP values were a strong risk factor for CAD among both females and males, which was also valid in patients with ACS.

Multiple cross-sectional studies²⁷⁻²⁹ have reported that AIP is a strong predictor of CAD, independent of diabetes. Small low-density lipoprotein is strongly associated with atherosclerotic risk markers such as inflammation, thrombosis, hematological markers, and prediabetes. This study supports the hypothesis that sdLDL-C is a promising CVD risk biomarker³⁰.

Sigirci et al³¹ analyzed thrombus aspiration materials in STEMI patients and showed that thrombus volume was significantly higher in hyperglycemic patients compared with normoglycemic patients.

Thrombus components were found to differ between coronary artery vessels. For example, thrombus in the left anterior descending (LAD) artery tends to be higher in platelets, whereas thrombus in the right coronary artery (RCA) tends to comprise erythrocytes, and thrombus in RCA results in high thrombus burden³². In our study, the thrombus burden was higher in non-LAD vessels, consistent with the literature.

We found a significant relationship between high CRP values and thrombus burden, similar to the previous studies^{33,34}. In patients with a high thrombus burden, leukocytosis and neutrophil dominance were also significant, showing the effect of inflammation on the thrombus load. Thrombus burden was increased in patients with high serum creatinine values. It is known that reduced kidney function causes retention of vasoactive substances and causes metabolic changes that lead to increased ROS. These changes are believed to have a significant role in creating an atherogenic environment³⁵.

HDL-C has cardioprotective effects, and many studies^{36,37} have shown that HDL-C improves endothelial function through its anti-inflammatory and antioxidative effects. In addition, HDL-C modulates monocyte activation, adhesion, and migration. The high thrombus burden in our study can be attributed to the lower HDL values in this group.

Limitations

The major limitations of this study include its single-center design and the small study population. Since our study was cross-sectional, it was not possible to obtain data on adverse events and mortality. Also, we evaluated the thrombus burden visually; a quantitative method would have yielded more objective results.

Conclusions

The atherogenic index, which is a simple and inexpensive marker, can help predicting intracoronary thrombus burden and related adverse events, as well as identify patients at high risk among those with STEMI. The atherogenic index can also complement other predictors for the detection of thrombus burden, if necessary.

Conflict of Interest

The Authors declare that they have no conflict of interests.

Ethics Approval

The study protocol was reviewed and approved by the institutional Ethics Committee and performed according to the principles of the Declaration of Helsinki.

Informed Consent

Written informed consent was obtained from all participations.

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This study received no financial assistance.

Authors' Contribution

Concept – N.E. Ha.D., CA.; Design – N.E., E.E. Hü.D. M.G.Ü.; Supervision – N.E., E.E. Hü.D. M.G.Ü.; Funding – N.E., Ha.D. H.K.; Materials – N.E., H.K.; Data Collection and/or processing – N.E., E.E. H.K.; Analysis and/or interpretation – N.E., Ha.D., CA.; Literature search – N.E., Hü.D. M.G.Ü.; Writing – N.E. Ha.D., CA.; Critical review – N.E. Ha.D., CA, E.E.

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References

- 1) Nabel EG, Braunwald E. A tale of coronary artery disease and myocardial infarction. *N Engl J Med* 2012; 366: 54-63.
- 2) Singh M, Lennon RJ, Holmes DR, Bell MR, Rihal CS. Correlates of procedural complications and a simple integer risk score for percutaneous coronary intervention. *J Am Coll Cardiol* 2002; 40: 387-393.
- 3) Singh M, Reeder GS, Ohman EM, Mathew V, Hillegass WB, Anderson RD, Gallup DS, Garratt KN, Holmes DR. Does the presence of thrombus seen on a coronary angiogram affect the outcome after percutaneous coronary angioplasty? An angiographic trials pool data experience. *J Am Coll Cardiol* 2001; 38: 624-630.
- 4) White CJ, Ramee SR, Collins TJ, Escobar AE, Karsan A, Shaw D, Suresh PJ, Bass TA, Heuser RR, Teirstein PS, Bonan R, Walter PD, Smalling RW. Coronary thrombi increase PTCA risk: angiography as a clinical tool. *Circ J* 1996; 93: 253-258.
- 5) Sianos G, Papafaklis MI, Daemen J, Vaina S, van Mieghem CA, van Domburg RT, Michalis LK,

- Serruys PW. Angiographic stent thrombosis after routine use of drug-eluting stents in ST-segment elevation myocardial infarction: the importance of thrombus burden. *J Am Coll Cardiol* 2007; 50: 573-583.
- 6) Dobiasova M. AIP--atherogenic index of plasma as a significant predictor of cardiovascular risk: from research to practice. *Vnitřní lékařství* 2006; 52: 64-71.
 - 7) Nwagha U, Ikekpeazu E, Ejezie F, Neboh E, Maduka I. Atherogenic index of plasma as useful predictor of cardiovascular risk among postmenopausal women in Enugu, Nigeria. *Afr health sci* 2010;10: 248-252.
 - 8) Dobiášová M, Frohlich J. The plasma parameter log (TG/HDL-C) as an atherogenic index: correlation with lipoprotein particle size and esterification rate in apob-lipoprotein-depleted plasma (FERHDL). *Clin Biochem* 2001; 34: 583-588.
 - 9) Tariq M, Ali R. Comparative study for atherogenic index of plasma (AIP) in patient with type 2 diabetes mellitus, β -thalassemia and hypothyroidism. *Inter J Chem Res* 2012; 2: 1-9.
 - 10) Dobiášová M, Frohlich J, Šedová M, Cheung MC, Brown BG. Cholesterol esterification and atherogenic index of plasma correlate with lipoprotein size and findings on coronary angiography. *J Lipid Res* 2011; 52: 566-571.
 - 11) Ranzani OT, Zampieri FG, Forte DN, Azevedo LCP, Park M. C-reactive protein/albumin ratio predicts 90-day mortality of septic patients. *PLoS One* 2013; 8: e59321.
 - 12) Gibson CM, de Lemos JA, Murphy SA, Marble SJ, McCabe CH, Cannon CP, Antman EP, Braunwald E and for the TIMI Study Group. Combination therapy with abciximab reduces angiographically evident thrombus in acute myocardial infarction: a TIMI 14 substudy. *Circ J* 2001; 103: 2550-2554.
 - 13) Ibanez B, James S, Agewall S, Antunes MJ, Bucciarelli-Ducci C, Bueno H, Caforio ALP, Crea F, Goudevenos JA, Halvorsen A, Hindricks G, Kasrati A, Lenzen MJ, Prescott E, Roffi M, Valgimigli M, Varenhorst C, Vranckx P, Widimsky P. 2017 ESC Guidelines for the management of acute myocardial infarction in patients presenting with ST-segment elevation: The Task Force for the management of acute myocardial infarction in patients presenting with ST-segment elevation of the European Society of Cardiology (ESC). *Eur Heart J* 2017; 39: 119-177.
 - 14) Tungsubutra W, Towashiraporn K, Tresukosol D, Chotinaiwattarakul C, Phankingthongkum R, Wongpraparut N, Panchavinnin P. One-year clinical outcomes of ST segment elevation myocardial infarction patients treated with emergent percutaneous coronary intervention: the impact of thrombus burden. *J Med Assoc Thai* 2014; 97: 139-146.
 - 15) Sianos G, Papafaklis MI, Serruys PW. Angiographic thrombus burden classification in patients with ST-segment elevation myocardial infarction treated with percutaneous coronary intervention. *J Invasive Cardiol* 2010; 22: 6-14.
 - 16) Singh M, Berger PB, Ting HH, Rihal CS, Wilson SH, Lennon RJ, Reeder GS, Bresnahan JF, Holmes jr DR. Influence of coronary thrombus on outcome of percutaneous coronary angioplasty in the current era (the Mayo Clinic experience). *Am J Cardiol* 2001; 88: 1091-1096.
 - 17) Wilson PW, Polonsky TS, Miedema MD, Khera A, Kosinski AS, Kuvin JT. Systematic review for the 2018 AHA/ACC/AACVPR/AAPA/ABC/ACPM/ADA/AGS/APHA/ASPC/NLA/PCNA guideline on the management of blood cholesterol: a report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. *Circ J* 2019; 139: e1144-e1161.
 - 18) Collaboration CTT. Efficacy and safety of LDL-lowering therapy among men and women: meta-analysis of individual data from 174,000 participants in 27 randomised trials. *Lancet* 2015; 385: 1397-1405.
 - 19) Baigent C, Blackwell L, Emberson J, Holland L, Reith C, Bhalra N, Peto R, Barnes EH, Keech A, Simes J, Collins R. Efficacy and safety of more intensive lowering of LDL cholesterol: a meta-analysis of data from 170,000 participants in 26 randomised trials. *Lancet* 2010; 376: 1670-1681.
 - 20) Hoogeveen RC, Gaubatz JW, Sun W, Dodge RC, Crosby JR, Jiang J, Couper D, Virani SS, Kathiresan S, Boerwinkle E, Ballantyne CM. Small dense low-density lipoprotein-cholesterol concentrations predict risk for coronary heart disease: the Atherosclerosis Risk in Communities (ARIC) study. *Arterioscler Thromb Vasc Biol* 2014; 34: 1069-1077.
 - 21) Ivanova EA, Myasoedova VA, Melnichenko AA, Grechko AV, Orekhov AN. Small dense low-density lipoprotein as biomarker for atherosclerotic diseases. *Longevity OMAC* 2017; 2017: 1-10.
 - 22) Vavlukis M, Kedev S. Effects of high intensity statin therapy in the treatment of diabetic dyslipidemia in patients with coronary artery disease. *Curr Pharm Des* 2018; 24: 427-441.
 - 23) Niroumand S, Khajedaluae M, Khadem-Rezaiyan M, Abrishami M, Juya M, Khodae G, Dadgarmoghaddam M. Atherogenic Index of Plasma (AIP): A marker of cardiovascular disease. *Med J Islam Repub Iran* 2015; 29: 240.
 - 24) Süleymanoğlu M, Rencüzoğulları İ, Karabağ Y, Çağdaş M, Yesin M, Gümüşdağ A, Cap M, Gök M, Yıldız İ. The relationship between atherogenic index of plasma and no-reflow in patients with acute ST-segment elevation myocardial infarction who underwent primary percutaneous coronary intervention. *Int J Cardiovasc Imaging* 2020: 1-8.
 - 25) Burke AP, Farb A, Malcom GT, Liang Y-h, Smialek J, Virmani R. Coronary risk factors and plaque morphology in men with coronary disease who died suddenly. *N Engl J Med* 1997; 336: 1276-1282.

- 26) Onat A, Can G, Kaya H, Hergenç G. "Atherogenic index of plasma" (log₁₀ triglyceride/high-density lipoprotein – cholesterol) predicts high blood pressure, diabetes, and vascular events. *J Clin Lipidol* 2010; 4: 89-98.
- 27) Cai G, Shi G, Xue S, Lu W. The atherogenic index of plasma is a strong and independent predictor for coronary artery disease in the Chinese Han population. *Medicine* 2017; 96.
- 28) Guo Q, Zhou S, Feng X, Yang J, Qiao J, Zhao Y, Shi D, Zhou Y. The sensibility of the new blood lipid indicator – atherogenic index of plasma (AIP) in menopausal women with coronary artery disease. *Lipids Health Dis* 2020; 19: 1-8.
- 29) Wu TT, Gao Y, Zheng YY, Ma YT, Xie X. Atherogenic index of plasma (AIP): a novel predictive indicator for the coronary artery disease in post-menopausal women. *Lipids Health Dis* 2018; 17: 1-7.
- 30) Hsu SHJ, Jang MH, Torng PL, Su TC. Positive association between small dense low-density lipoprotein cholesterol concentration and biomarkers of inflammation, thrombosis, and prediabetes in non-diabetic adults. *J Atheroscler Thromb* 2018: 43968.
- 31) Sigirci S, Yildiz SS, Keskin K, Cetinkal G, Ak-san G, Gürdal A, Cetin S, Kilci H, Kilickesmez K. The predictive value of stress hyperglycemia on thrombus burden in nondiabetic patients with st-segment elevation myocardial infarction. *Blood Coagul Fibrinolysis* 2019; 30: 270-276.
- 32) Ren H, Zheng Y, Hu X, Yang Y, Zhang Y, Sun Y. High thrombus burden: a review of mechanisms and treatments. *Int J Clin Exp Med* 2019; 12: 13068-13078.
- 33) Satılmış S, Durmuş G. Predictive accuracy of CHA₂DS₂-VASc score in determining the high thrombus burden in patients with non-ST-elevation myocardial infarction. *Acta Cardiol* 2021; 76: 140-146.
- 34) Duman H, Çinier G, Bakırcı EM, Duman H, Şimşek Z, Hamur H, Degirmenci H, Emlek N. Relationship between C-reactive protein to albumin ratio and thrombus burden in patients with acute coronary syndrome. *Clin Appl Thromb Hemost* 2019; 25: 1076029618824418.
- 35) Ross R. Atherosclerosis—an inflammatory disease. *N Engl J Med* 1999; 340: 115-126.
- 36) Murphy A, Chin-Dusting J, Sviridov D, Woollard KJ. The anti-inflammatory effects of high-density lipoproteins. *Curr Med Chem* 2009; 16: 667-675.
- 37) Murphy AJ, Woollard KJ. High-density lipoprotein: A potent inhibitor of inflammation. *Clin Exp Pharmacol Physiol* 2010; 37: 710-718.