Arch Iran Med. April 2019;22(4):198-203

http www.aimjournal.ir

ARCHIVES OF IRANIAN MEDICINE

Open Access

Original Article

Mean Platelet Volume and Major Adverse Cardiac Events following Percutaneous Coronary Intervention

Younes Nozari, MD[1]; Maziar Parsa, MD[1]; Arash Jalali, PhD[1]; Hamid Ariannejad, MD[1]; Akbar Shafiee, MD, MSc[1*]

[1]Tehran Heart Center, Tehran University of Medical Sciences, Tehran, Iran

Abstract

Background: Mean platelet volume (MPV) has been introduced as a simple and accurate method for assessing platelet function, which can be used as a prognostic marker for cardiovascular events. We investigated whether pre-procedural MPV could predict major adverse cardiac events (MACE) in candidates for elective percutaneous coronary intervention (PCI).

Methods: In this large retrospective cohort, we reviewed the clinical and follow-up data of 4199 candidates (mean age = 59.9 ± 10.3 years; female patients = 1440 [34.3%]) for elective PCI due to unstable angina (UA) or non-ST segment elevation myocardial infarction (NSTEMI). The primary endpoint of the study was the incidence of MACE defined as in-hospital mortality, cardiac death, nonfatal MI, target lesion revascularization (TLR) or target vessel revascularization (TVR). Based on the MPV level tertiles, patients were categorized into three groups for further comparison.

Results: Higher MPV was significantly associated with older age ($P<0.001$), hypertension ($P<0.001$), diabetes mellitus ($P=0.003$), history of previous CABG ($P<0.001$) and lower levels of serum triglyceride ($P<0.001$). The frequency of 1-year MACE was 176 (4.1%) with no significant difference between the MPV tertile groups. The highest MPV tertile could significantly predict MACE in the univariable model (hazard ratio = 1.51, 95% confidence interval: 1.05–2.17; $P=0.026$). In the adjusted model, the highest MPV tertile was a borderline predictor for MACE (hazard ratio = 1.62, 95% CI: 0.98–2.68; $P=0.057$).

Conclusion: High MPV was associated with cardiovascular risk factors and older age while high MPV was a borderline independent predictor for 1-year MACE in the candidates for elective PCI.

Keywords: Coronary artery disease, Mean platelet volume, Major adverse cardiac events, Non-ST elevation myocardial infarction, Percutaneous coronary intervention, Platelet count

Cite this article as: Nozari Y, Parsa M, Jalali A, Ariannejad H, Shafiee A. Mean platelet volume and major adverse cardiac events following percutaneous coronary intervention. Arch Iran Med. 2019;22(4):198–203.

Received: November 26, 2018, Accepted: February 13, 2019, ePublished: April 1, 2019

Introduction

Cardiovascular disease is the major cause of death in the world and Iran is not an exception.[1,2] Within the past few decades, treatment of coronary artery disease (CAD) has shifted from invasive coronary artery bypass graft to less invasive measures like percutaneous coronary intervention (PCI).[3] As the main goal of treatment in CAD patients is to improve survival,[4] identification of prognostic factors for survival of patients who undergo PCI is crucial. To date, several studies have been conducted to recognize these factors and many of them such as advanced age, dyslipidemia, recent myocardial infarction (MI), and SYNTAX score have been proven as strong predictors of survival.[5-7] On the other hand, there are still many factors that have shown a controversial effect on the survival of the patients such as platelet indices.

As platelets and their function have a pivotal role in the treatment of patients following PCI, it is plausible that pre-procedural platelet indices and their changes following treatment can influence the survival of patients. MPV has been introduced as a simple and accurate method for assessing platelet function, which can be used as a prognostic marker for cardiovascular events.[8-10] However, data on the predictive value of MPV is inconsistent and some studies found no association between baseline MPV and prognosis of patients following PCI.[11] Therefore, we presumed that a comprehensive study on platelet indices, including MPV, in a large group of PCI candidates could elucidate this subject.

In the present study, we investigated whether preprocedural platelet indices could predict the clinical outcome, particularly major adverse cardiac events (MACE) in patients who undergo elective PCI due to unstable angina (UA) or non-ST segment elevation myocardial infarction (NSTEMI) at our center.

Materials and Methods

This retrospective study included all consecutive candidates for elective PCI due to UA or NSTEMI who were admitted to the Tehran Heart Center between April 2006 and March 2012 and completed their follow-up visits or reached the study endpoints. Data for the patients were retrieved from the Angiography registry of Tehran Heart Center,[12] and the study population was selected

***Corresponding Author:** Akbar Shafiee MD MSc, Department of Cardiovascular Research, Tehran Heart Center, North Kargar St., 1411713138, Tehran, Iran. Tel: +98 21 88029257, Fax: +98 21 88029256. Email: Dr_shafiee@alborzi.com

based on the study criteria. Our inclusion criteria were: age >18 years, presence of a pre-procedural comprehensive complete blood count (CBC) including platelet indices and completion of a one-year follow-up. The exclusion criteria were: positive factor V Leiden, history of any malignancy, hyperthyroidism, and end-stage renal disease.

Baseline demographics, past medical history, classic cardiovascular risk factors (diabetes mellitus, hypertension, dyslipidemia, and smoking) family history of CAD, pre-procedural laboratory measurements (CBC and biochemistry), and clinical and angiographic characteristics were recorded for each subject at time of admission and were later retrieved from the database of our center.

Coronary artery angiography was performed at the catheterization laboratory of Tehran Heart Center under local anesthesia by an expert interventional cardiologist. CAD was classified based on the clinical vessel score and the patients were categorized as having single-vessel, two-vessel, or three-vessel disease and the atherosclerotic vessel(s) was treated by balloon angioplasty or stenting based on the interventional cardiologist's decision.

The follow-up data, including all the events from the time of PCI, were collected by scheduled clinic evaluations or direct telephone interviews and recorded in our database. In this study, we considered the data of one-year follow-up for all patients. The primary endpoint of the study was the time from PCI to the occurrence of MACE or the end of follow-up, whichever came first. MACE was defined as in-hospital mortality, cardiac death, nonfatal MI, target lesion revascularization (TLR) or target vessel revascularization (TVR). A comprehensive definition of the procedural and follow-up data at our center has been published previously.[5-7]

Based on the MPV level tertiles, patients were categorized into three groups for comparison. All study variables, as well as elements of MACE, were compared between the study groups. We also compared the survival of the patients between the MPV categories and identified the predictive factors for MACE in our study population.

Statistical Methods

Continuous variables are presented as mean ± standard deviations and compared between the three groups of MPV using the one-way ANOVA test or the Kruskal-Wallis H-test, as appropriate. Categorical variables are presented as counts and percentages and were compared with the chi-square test or Fisher's exact test when appropriate. Survival curves were generated using the Kaplan–Meier method, and the log-rank test was employed to evaluate differences between the groups. Variables reported as a confounder in the literature as well as those simultaneously associated with MPV and MACE with $P < 0.2$ in our data, were considered as potential confounders. Cox proportional-hazards model was applied to assess the effect of MPV on MACE adjusted for potential confounders. We reported the effects of MPV through hazard ratios and corresponding 95% confidence intervals (CI). SPSS version 21.0 (Chicago, Illinois, USA) was used to conduct statistical analyses.

Results

In this study, data of 4,199 patients (mean age = 59.9 ± 10.3 years; female patients = 1440 [34.3%]) who met our study criteria were included for analysis. We noticed that 132 (3.1%) patients were completely lost to follow-up. Also, 146 (3.5%) patients had an incomplete follow-up. Dyslipidemia was the most frequent cardiovascular risk factor (68.8%) and over half of the patients (56.6%) had a coronary lesion in the LAD territory. Around 2.5% of the patients underwent balloon angioplasty and the rest underwent stenting. Mean of the MPV was 9.7 ± 1.1 in the study population and patients were divided into three groups based on the tertiles value of MPV (tertile 1: MPV ≤ 9.2 fl; tertile 2:9.2 < MPV < 10.1 and tertile 3: MPV ≥ 10.1).

The patients with larger platelet volumes were significantly older than the other two groups ($P < 0.001$) and the frequency of hypertension and diabetes mellitus were significantly higher in them ($P < 0.001$ and $P = 0.003$, respectively). On the other hand, the history of previous CABG was significantly lower in patients with smaller platelet size ($P < 0.001$) and they also had higher levels of serum triglyceride ($P < 0.001$). The use of clopidogrel and statins were also higher in the MPV tertile group 3 ($P = 0.002$ and $P < 0.001$). Other demographic and clinical characteristics did not have any significant difference between the MPV tertile groups, as shown in detail in Table 1.

Comparison of the echocardiographic characteristics showed that the ejection fraction was significantly higher in patients with lower MPV ($P = 0.001$), although this difference was no likely to be clinically important. Most of the angiographic and angioplastic characteristics were similar between the 3 groups (Table 2); however, a lesion in the left main artery was more frequent in patients with larger platelet size ($P = 0.01$).

Within a one-year follow-up, the observed total MACE for all patients was 176 (4.1%) (Annual incidence = 3.7 per thousand persons [95% CI: 3.2–4.3]). Although there was a tendency for higher MACE by the increase in the platelet volume, there was no significant difference between the MPV tertile groups for total MACE and its elements. Details of the 1-year incidence rate of MACE in the study population and the MPV subgroups are shown in Table 3.

We then evaluated the predictive effect of MPV for MACE in the study population. The results of the univariable analysis showed that the highest MPV tertile could significantly predict MACE in the study population (hazard ratio = 1.51, 95% confidence interval: 1.05–2.17;

Table 1. Demographic and Clinical Characteristics of the Patients Based on the Mean Platelet Volume Tertiles

Characteristic	Low MPV (n = 1508)	Normal MPV (n = 1327)	High MPV (n = 1364)	Total (n = 4199)	*P* Value
Age, year	59.4 ± 10.3	59.3 ± 10.4	61.0 ± 10.0	59.9 ± 10.3	<0.001
Male gender, n (%)	1014 (67.2)	878 (66.2)	867 (63.6)	2759 (65.7)	0.106
BMI, kg/m^2	27.8 ± 4.4	27.9 ± 4.4	28.2 ± 4.7	28.0 ± 4.5	0.142
Family history of CAD, n (%)	255 (16.9)	248 (18.8)	255 (18.8)	758 (18.1)	0.336
Smoking, n (%)	333 (22.1)	301 (22.7)	308 (22.6)	942 (22.4)	0.918
Dyslipidemia, n (%)	1039 (68.9)	909 (68.5)	937 (68.7)	2885 (68.7)	0.974
Hypertension, n (%)	837 (55.5)	807 (60.8)	867 (63.6)	2511 (59.8)	<0.001
Diabetes mellitus, n (%)	443 (29.4)	444 (33.5)	480 (35.2)	1367 (32.6)	0.003
Opium addiction, n (%)	218 (14.5)	178 (13.4)	182 (13.3)	578 (13.8)	0.622
Past medical history					
Renal failure, n (%)	22 (1.5)	29 (2.2)	30 (2.2)	81 (1.9)	0.253
CHF, n (%)	14 (0.9)	24 (1.8)	27 (2.0)	65 (1.5)	0.48
COPD, n (%)	42 (2.8)	55 (4.1)	56 (4.1)	153 (3.6)	0.84
CVA, n (%)	3 (0.2)	2 (0.2)	1 (0.1)	6 (0.1)	0.785
Previous PCI, n (%)	202 (13.4)	210 (15.8)	217 (15.9)	629 (15.0)	0.098
Previous CABG, n (%)	95 (6.3)	145 (10.9)	140 (10.3)	380 (9.0)	<0.001
Drug history					
ASA, n (%)	1487 (98.6)	1316 (99.2)	1349 (98.9)	4152 (98.9)	0.362
Clopidogrel, n (%)	1383 (91.7)	1254 (94.5)	1288 (94.4)	3925 (93.5)	0.002
Statins, n (%)	1152 (81.9)	1120 (86.5)	1185 (88.2)	3457 (82.3)	<0.001
Laboratory tests					
Total cholesterol, mg/dL	175.1 ± 45.5	172.0 ± 45.9	174.2 ± 49.8	173.9 ± 47.1	0.353
Triglyceride, mg/dL	154.0 [114.0, 215.0]	146.0 [105.0, 212.7]	139.5 [101.0, 189.2]	147.0 [106.5, 209.0]	<0.001
LDL, mg/dL	102.0 [80.0, 132.0]	101.0 [77.0, 129.0]	103.0 [78.0, 132.2]	102.0 [78.5, 131.0]	0.496
HDL, mg/dL	40.6±10.8	40.7±10.6	41.4±11.1	40.9±10.8	0.265
FBS, mg/dL	104.0 [92.0, 130.0]	103.0 [90.0, 131.0]	103.0 [91.0, 138.0]	103.0 [91.0, 132.0]	0.393
Creatinine, mg/dL	0.9 [0.8, 1.1]	0.9 [0.8, 1.1]	0.9 [0.8, 1.1]	0.9 [0.8, 1.1]	0.747
Hemoglobin, mg/dL	13.9 ± 1.7	14.1 ± 1.7	14.1 ± 1.7	14.0 ± 1.7	0.099

BMI, Body mass index; CABG, Coronary artery bypass graft; CAD, Coronary artery disease; CHF, Congestive heart failure; COPD, Chronic obstructive pulmonary disease; CVA, Cerebrovascular accident; FBS, Fastening blood sugar; HDL, High density lipoprotein; LDL, Low density lipoprotein; MPV, Mean platelet volume; PCI, Percutaneous coronary intervention

Table 2. Comparison of the Angiographic and Angioplastic Characteristics of the Study Groups

Characteristic	Low MPV (n = 1508)	Normal MPV (n = 1327)	High MPV (n = 1364)	Total (n = 4199)	*P* Value
EF, %	51.4 ± 8.6	50.2 ± 9.4	50.3 ± 9.5	50.6 ± 9.2	0.001
Mean RVD	3.2 ± 0.5	3.1 ± 0.5	3.1 ± 0.4	3.1 ± 0.5	0.162
Stent length (sum)	28.0 [18.0, 36.0]	28.0 [18.0, 36.0]	28.0 [18.0, 36.0]	28.0 [18.0, 36.0]	0.644
Mean stent length	23.0 [18.0, 28.0]	23.0 [18.0, 28.0]	23.0 [18.0, 28.0]	23.0 [18.0, 28.0]	0.341
Stent diameter	3.1 ± 0.4	3.0 ± 0.4	3.0 ± 0.4	3.1 ± 0.4	0.098
LAD territory, n (%)	876 (58.1)	761 (57.3)	740 (54.3)	2377 (56.6)	0.094
RCA territory, n (%)	480 (31.8)	402 (30.3)	415 (30.4)	1297 (30.9)	0.612
LCX territory	427 (28.3)	409 (30.8)	442 (32.4)	1278 (30.4)	0.055
Multistage PCI	265 (17.6)	231 (17.4)	227 (16.6)	723 (17.2)	0.785
Stent type, n (%)					0.361
Bare metal	271 (18.0)	210 (15.8)	210 (15.4)	691 (16.5)	
DES	1108 (73.5)	981 (73.9)	1014 (74.3)	3103 (73.9)	
Hybrid	98 (6.5)	100 (7.5)	103 (7.6)	301 (7.2)	
POBA	31 (2.1)	36 (2.7)	37 (2.7)	104 (2.5)	
SVG, n (%)	39 (2.6)	52 (3.9)	45 (3.3)	136 (3.2)	0.134
LIMA, n (%)	4 (0.3)	1 (0.1)	2 (0.1)	7 (0.2)	0.577
Left main, n (%)	1 (0.1)	2 (0.2)	9 (0.7)	12 (0.3)	0.01

DES, Drug-eluting stent; EF, Ejection fraction; LAD, left anterior descending; LCX, Left circumflex; LIMA, Left internal mammary artery; PCI, Percutaneous coronary intervention; POBA, Plain old balloon angioplasty; RCA, Right coronary artery; RVD, right ventricular diameter; SVG, Saphenous vein graft.

Table 3. The 1-Year Incidence Rate of Major Adverse Cardiac Events in the Total Study Population and the MPV subgroups

Characteristic	Low MPV*	Normal MPV	High MPV	Total
Total MACE	2.9 (2.2–3.9)	3.9 (3.0–-5.1)	4.5 (3.5–5.7)	3.7 (3.2–4.3)
TVR	1.5 (1.0–2.2)	1.7 (1.1–2.5)	2.3 (1.7–3.2)	1.8 (1.5–2.2)
TLR	0.8 (0.5–1.4)	0.8 (0.4–1.4)	1.0 (0.6–1.6)	0.9 (0.6–1.2)
Non-fatal MI	0.5 (0.3–1.0)	0.9 (0.5–1.6)	1.6 (1.0–2.4)	1.0 (0.7–1.3)
CABG	0.2 (0.1–0.6)	0.2 (0.1–0.06)	0.5 (-0.3–1.1)	0.3 (0.2–0.5)
Cardiac death	0.5 (0.2–1.0)	0.6 (0.3–1.2)	0.9 (0.5–1.5)	0.7 (0.5–0.9)
Non cardiac death	0.3 (0.1–0.7)	0.2 (0.1–0.6)	0.2 (0.1–0.6)	0.2 (0.1–0.4)

CABG, Coronary artery bypass graft; MACE, Major adverse cardiac events; MI, Myocardial infarction; MPV, mean platelets volume.
* Data are shown as 1-year incidence per 1000 people (95% confidence interval).

P = 0.026) (Table 4). After adjustment for confounding variables (listed in Table 4), it was revealed that the highest MPV tertile could be a borderline predictor for MACE in the candidates for elective PCI following UA or NSTEMI (hazard ratio = 1.62, 95% CI: 0.98–2.68; *P* = 0.057). The one-year MACE-free survival in the lowest MPV tertile group was 96.5% versus 94.7% in the highest MPV tertile group (Log-rank: *P* = 0.081). The Kaplan-Meier event-free survival curves of the patients during one-year follow-up, according to MPV tertiles are shown in Figure 1.

Discussion

In this retrospective cohort of 4199 patients undergoing PCI due to UA or NSTEMI at Tehran Heart Center, we found out them MPV at the time of admission could be a borderline predictor of one-year MACE in our study population after adjustment for confounding variables. We also showed that patients with higher MPV tended to be older, more diabetic and hypertensive and more likely to have a history of CABG. There was also a tendency toward a higher incidence of MACE in the higher MPV group, albeit not significant.

The role of platelets and their function in the development and treatment of cardiovascular disease has always been an interesting topic for clinical researchers. Various platelet indices are used to measure the platelet function, including metabolic, structural, morphological indices as well as indices related to bleeding and coagulation.[13-15] Size of the platelets is usually measured by MPV, an easy index for evaluating platelet function, and it has become a good biomarker for cardiovascular disease.[16,17]

Studies have shown the association of high MPV with classic cardiovascular risk factors, such as diabetes mellitus, hypertension, dyslipidemia, obesity and smoking.[18-21] Moreover, the independent predictive role of MPV for various cardiovascular and cerebrovascular conditions, such as ischemic stroke,[22] left atrial stasis in the context of atrial fibrillation[23] and MI,[24,25] have been described previously. By the way, its predictive role for the occurrence of MACE following PCI was inconsistent between the studies to date, and some studies even did not find any association between baseline MPV and MACE.[26] The

Table 4. The Predictive Effect of Mean Platelet Volume for Major Adverse Cardiac Events Following Percutaneous Coronary Angiography as Detected Via the Cox-Regression Model (Unadjusted and Adjusted For Confounding Variables)

Predictor	Hazard Ratio	95% CI	*P* Value[a]
Unadjusted			
Lowest tertile MPV	Ref	Ref	0.083
Middle tertile MPV	1.29	0.88–1.88	0.185
Highest tertile MPV	1.51	1.05–2.17	0.026
After adjustment for confounding variables[b]			
Lowest tertile MPV	Ref	Ref	0.092
Middle tertile MPV	1.04	0.59–1.82	0.884
Highest tertile MPV	1.62	0.98–2.68	0.057

CI, Confidence interval; MPV, Mean platelet volume; PCI, Percutaneous coronary intervention;
[a] $P < 0.05$ was considered as statistically significant.
[b] Confounding variables included Age, body mass index, ejection fraction, hemoglobin, diabetes, history of unstable angina, non-ST elevation myocardial infarction, ST-elevation myocardial infarction, renal failure, congestive heart failure, use of Plavix, previous percutaneous coronary angiography, previous coronary artery bypass graft, lesion in the left anterior descending artery territory, multistage percutaneous coronary intervention, lesion in left inferior mammary artery, lesion in saphenous vein graft.

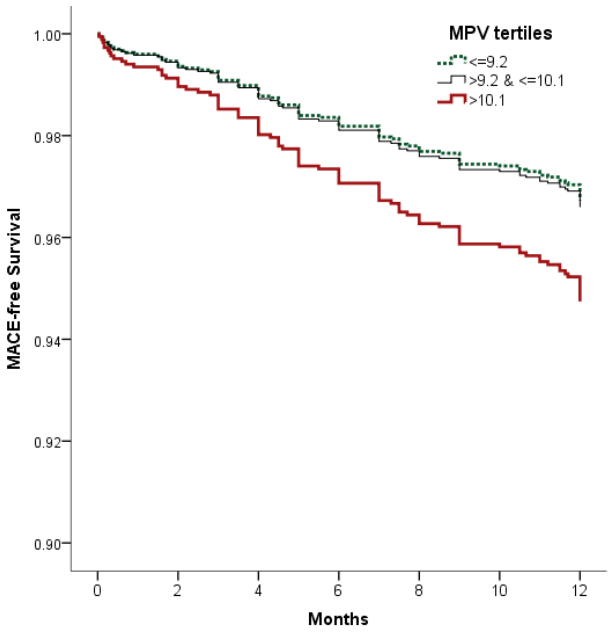

Figure 1. The Kaplan-Meier Event-Free Survival Curves of the Patients During the 1-Year Follow-Up, According to MPV Tertiles.

common denominator of the prior studies is that MPV was an independent predictor for MACE in most of them; nonetheless, the reported hazard ratio was varying in a wide range from one study to another. A recent study (n = 680) reported the highest odds ratio for the predictive value of MPV (odds ratio:11.35, 95% CI:2.481–51.994; *P* = 0.002) for MPV levels dichotomized at 9.6 fl.[27] However, the odds ratio for MPV ranged from 1.46 to 3.2.[10,28-32] which are more comparable to our study. Overall, it seems that the study population and selection criteria, as well as the study setting, have a noteworthy role in this difference. But the overall message of all these studies, is the important role of platelet function o the development of MACE and thereby, the rationale for antiplatelet therapy following PCI.

In our study, the frequency of patients who used statins clopidogrel was significantly higher in the higher MPV group. Despite the preventive effect of statins and antiplatelet agents on MACE in patients who undergo CABG,[33-36] it is plausible that some other factors may influence on the incidence of MACE, particularly in patients with larger platelet size.

Among cardiovascular risk factors and their association with MPV, the role of diabetes mellitus is not negligible. It has been shown that MPV is higher in diabetic patients.[37,38] We also observed a higher frequency of diabetic patients in the high MPV group. Therefore, it should be noted that systemic changes in diabetic patients may also play an important role in the development of MACE and thereby some of this effect may be related to diabetes but not high MPV alone.

The strength of our center is in the large number of the study population which is the largest study on this topic to our knowledge. However, there are some limitations to this study. First, the retrospective nature of the study may influence the findings, particularly the laboratory measurements. Second, the result of the MPV is very much dependant on the time interval from obtaining the blood and measurements. It is obvious that samples taken more than 2 hours prior to tests show larger values for MPV and we had no data about this. Third, we did not have the data for Aspirin or clopidogrel resistance in the study cohort, so we could not determine if they were predictors of MACE or not. Based on our institutional protocols, patients who undergo PCI are followed-up routinely for 1 year. Therefore, another limitation to our study is the limited duration of follow-up. And finally, our center is a university referral hospital for cardiovascular disease and patients who were treated in our center might probably be different from the general population.

In conclusion, this study showed that High MPV is a borderline independent predictor for 1-year MACE in the candidates for elective PCI after adjustment for confounding variables. Also, MPV was associated with cardiovascular risk factors as well as older age and diabetes mellitus. Due to various results obtained from different studies, performing a meta-analysis is recommended at this stage to fully elucidate the predictive value of MPV for MACE.

Authors' Contribution

Study concept: YN. Proposal: AS, MP. Data collection: MP, AS, HA. Data analysis: AJ. Manuscript drafting: AS. Critical review of the manuscript: AS, MP, HA, AJ. Final approval: All authors.

Conflict of Interest Disclosures

The authors have no conflicts of interest.

Ethical Statement

Written informed consent was obtained from each patient at the time of admission stating that their clinical data would be used anonymously for clinical research, and the study protocol was approved by the Board of Research at Tehran Heart Center and the Ethics Committee of Tehran University of Medical Sciences.

Acknowledgments

This study was the doctorate thesis of Dr. Maziar Parsa for obtaining a specialty in Cardiology. This work was supported by Tehran Heart Center and Tehran University of Medical Sciences. The authors sincerely thank the staff of the catheterization laboratory of Tehran Heart Center.

References

1. Kotseva K, Wood D, De Bacquer D, De Backer G, Rydén L, Jennings C, et al., EUROASPIRE IV: A European Society of Cardiology survey on the lifestyle, risk factor and therapeutic management of coronary patients from 24 European countries. Eur J Prev Cardiol. 2016;23(6):636-48. doi: 10.1177/2047487315569401.
2. Ahmadi A, Soori H, Sajjadi H, Nasri H, Mehrabi Y, Etemad K. Current status of the clinical epidemiology of myocardial infarction in men and women: a national cross-sectional study in iran. Int J Prev Med. 2015;6:14. doi: 10.4103/2008-7802.151822.
3. Wolk MJ, Bailey SR, Doherty JU, Douglas PS, Hendel RC, Kramer CM, et al. ACCF/AHA/ASE/ASNC/HFSA/HRS/SCAI/SCCT/SCMR/STS 2013 multimodality appropriate use criteria for the detection and risk assessment of stable ischemic heart disease: a report of the American College of Cardiology Foundation Appropriate Use Criteria Task Force, American Heart Association, American Society of Echocardiography, American Society of Nuclear Cardiology, Heart Failure Society of America, Heart Rhythm Society, Society for Cardiovascular Angiography and Interventions, Society of Cardiovascular Computed Tomography, Society for Cardiovascular Magnetic Resonance, and Society of Thoracic Surgeons. J Am Coll Cardiol. 2014;63(4):380-406. doi: 10.1016/j.jacc.2013.11.009.
4. Levine GN, Bates ER, Blankenship JC, Bailey SR, Bittl JA, Cercek B, et al. 2011 ACCF/AHA/SCAI guideline for percutaneous coronary intervention: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines and the Society for Cardiovascular Angiography and Interventions. Catheter Cardiovasc Interv. 2013;82(4):E266-355. doi: 10.1002/ccd.23390.
5. Kassaian SE, Saroukhani S, Alaeddini F, Salarifar M, Capodanno D, Poorhoseini H, et al. A risk scoring model to predict in-hospital and one-year major adverse cardiac events after percutaneous coronary intervention. J Tehran Heart Cent. 2015;10(4):167-75.
6. Poorhosseini H, Mousavi M, Nematipour E, Kassaian SE, Salarifar M, Alidoosti M, et al. Success rate, procedural complications and clinical outcomes of coronary interventions in octogenarians: a case-control study. J Tehran Heart Cent. 2011;6(3):126-33.
7. Safarian H, Alidoosti M, Shafiee A, Salarifar M, Poorhosseini H,

Nematipour E. The SYNTAX Score Can Predict Major Adverse Cardiac Events Following Percutaneous Coronary Intervention. Heart Views. 2014;15(4):99-105. doi: 10.4103/1995-705X.151081.
8. Boos CJ, Lip GY. Assessment of mean platelet volume in coronary artery disease - what does it mean? Thromb Res. 2007;120(1):11-3. doi: 10.1016/j.thromres.2006.09.002
9. Endler G, Klimesch A, Sunder-Plassmann H, Schillinger M, Exner M, Mannhalter C, et al. Mean platelet volume is an independent risk factor for myocardial infarction but not for coronary artery disease. Br J Haematol. 2002;117(2):399-404.
10. Estévez-Loureiro R, Salgado-Fernández J, Marzoa-Rivas R, Barge-Caballero E, Pérez-Pérez A, Noriega-Concepción V, et al. Mean platelet volume predicts patency of the infarct-related artery before mechanical reperfusion and short-term mortality in patients with ST-segment elevation myocardial infarction undergoing primary percutaneous coronary intervention. Thromb Res. 2009;124(5):536-40. doi: 10.1016/j.thromres.2009.03.012.
11. Shah B, Oberweis B, Tummala L, Amoroso NS, Lobach I, Sedlis SP, et al. Mean platelet volume and long-term mortality in patients undergoing percutaneous coronary intervention. Am J Cardiol. 2013;111(2):185-9. doi: 10.1016/j.amjcard.2012.09.014.
12. Soleimani A, Abbasi A, Kazzazi E, Hosseini K, Salirifar M, Darabian S, et al. Prevalence of left main coronary artery disease among patients with ischemic heart disease: insights from the Tehran Angiography Registry. Minerva Cardioangiol. 2009;57(2): 175-183.
13. Hunt FA. A rapid method for assessing megathrombocytes: its application to thrombocytotic and acquired thrombocytopenic states. Pathology. 1976;8(1):47-55.
14. Kamath S, Blann AD, Lip GY. Platelet activation: assessment and quantification. Eur Heart J. 2001;22(17): 1561-71. doi: 10.1053/euhj.2000.2515.
15. Holmsen H. Significance of testing platelet functions in vitro. Eur J Clin Invest. 1994;24(suppl 1): 3-8.
16. Harrison P. Platelet function analysis. Blood Rev. 2005;19(2): 111-23. doi: 10.1016/j.blre.2004.05.002.
17. Breddin HK. Can platelet aggregometry be standardized? Platelets. 2005;16(3-4):151-8.doi:10.1080/09537100400020161.
18. Papanas N, Symeonidis G, Maltezos E, Mavridis G, Karavageli E, Vosnakidis T, et al. Mean platelet volume in patients with type 2 diabetes mellitus. Platelets. 2004;15(8): 475-8. doi: 10.1080/0953710042000267707.
19. Nadar S, Blann A,Lip G. Platelet morphology and plasma indices of platelet activation in essential hypertension: effects of amlodipine-based antihypertensive therapy. Ann Med. 2004;36(7): 552-7.
20. Icli A, Aksoy F, Nar G, Kaymaz H, Alpay MF, Nar R, et al. Increased Mean Platelet Volume in Familial Hypercholesterolemia. Angiology. 2016;67(2): 146-50. doi: 10.1177/0003319715579781.
21. Sloan A, Gona P, Johnson AD. Cardiovascular correlates of platelet count and volume in the Framingham Heart Study. Ann. Epidemiol. 2015;25(7): 492-8. doi: 10.1016/j.annepidem.2015.01.010.
22. Ha SI, Choi DH, Ki YJ, Yang JS, Park G, Chung JW, et al. Stroke prediction using mean platelet volume in patients with atrial fibrillation. Platelets. 2011;22(6):408-14. doi: 10.3109/09537104.2011.560306.
23. Providencia R, Faustino A, Paiva L, Fernandes A, Barra S, Pimenta J, et al. Mean platelet volume is associated with the presence of left atrial stasis in patients with non-valvular atrial fibrillation. BMC Cardiovasc. Disord. 2013;13:40. doi: 10.1186/1471-2261-13-40.
24. Cangemi R, Casciaro M, Rossi E, Calvieri C, Bucci T, Calabrese CM, et al. Platelet activation is associated with myocardial infarction in patients with pneumonia. J Am Coll Cardiol. 2014;64(18): 1917-25. doi: 10.1016/j.jacc.2014.07.985.
25. Klovaite J, Benn M, Yazdanyar S, Nordestgaard BG. High platelet volume and increased risk of myocardial infarction: 39,531 participants from the general population. J Thromb Haemost. 2011;9(1):49-56. doi: 10.1111/j.1538-7836.2010.04110.x.
26. Shah B, Oberweis B, Tummala L, Amoroso NS, Lobach I, Sedlis SP, et al. Mean platelet volume and long-term mortality in patients undergoing percutaneous coronary intervention. Am J Cardiol. 2013;111(2):185-9.
27. Seyyed-Mohammadzad MH, Eskandari R, Rezaei Y, Khademvatani K, Mehrpooya M, Rostamzadeh A, et al. Prognostic value of mean platelet volume in patients undergoing elective percutaneous coronary intervention. Anatol J Cardiol. 2015;15(1): 25-30. doi: 10.5152/akd.2014.5169.
28. Huczek Z, Kochman J, Filipiak KJ, Horszczaruk GJ, Grabowski M, Piatkowski R, et al., Mean platelet volume on admission predicts impaired reperfusion and long-term mortality in acute myocardial infarction treated with primary percutaneous coronary intervention. J Am Coll Cardiol. 2005;46(2):284-90. doi: 10.1016/j.jacc.2005.03.065.
29. Goncalves SC, Labinaz M, Le May M, Glover C, Froeschl M, Marquis JF, et al. Usefulness of mean platelet volume as a biomarker for long-term outcomes after percutaneous coronary intervention. Am J Cardiol. 2011;107(2):204-9. doi: 10.1016/j.amjcard.2010.08.068.
30. Niu X, Yang C, Zhang Y, Zhang H,Yao Y. Mean platelet volume on admission improves risk prediction in patients with acute coronary syndromes. Angiology. 2015;66(5):456-63. doi: 10.1177/0003319714536024.
31. Tekbas E, Kara AF, Ariturk Z, Cil H, Islamoglu Y, Elbey MA, et al. Mean platelet volume in predicting short- and long-term morbidity and mortality in patients with or without ST-segment elevation myocardial infarction. Scand J Clin Lab Invest. 2011;71(7):613-9. doi: 10.3109/00365513.2011.599416.
32. Liu Q, Wang T, Chen R, Liu C, Yue W, Hong J, et al. Mean platelet volume predicts left descending artery occlusion in patients with non-ST-elevation myocardial infarction. Platelets. 2014;25(4):246-51. doi: 10.3109/09537104.2013.810332.
33. Nafasi L, Rahmani R, Shafiee A, Salari A, Abdollahi A, Meysamie A. Can a high reloading dose of atorvastatin prior to percutaneous coronary intervention reduce periprocedural myocardial infarction? Curr Med Res Opin. 2014;30(3):381-6.
34. Wang L, Peng P, Zhang O, Xu X, Yang S, Zhao Y, et al. High-dose statin pretreatment decreases periprocedural myocardial infarction and cardiovascular events in patients undergoing elective percutaneous coronary intervention: a meta-analysis of twenty-four randomized controlled trials. PLoS One. 2014;9(12):e113352. doi: 10.1371/journal.pone.0113352.
35. D'ascenzo F, Taha S, Moretti C, Omede P, Grossomarra W, Persson J, et al. Meta-analysis of randomized controlled trials and adjusted observational results of use of clopidogrel, aspirin, and oral anticoagulants in patients undergoing percutaneous coronary intervention. Am J Cardiol. 2015;115(9):1185-93. doi: 10.1016/j.amjcard.2015.02.003.
36. Palmerini T, Sangiorgi D, Valgimigli M, Biondi-Zoccai G, Feres F, Abizaid A, et al. Short- versus long-term dual antiplatelet therapy after drug-eluting stent implantation: an individual patient data pairwise and network meta-analysis. J Am Coll Cardiol. 2015;65(11):1092-102. doi: 10.1016/j.jacc.2014.12.046.
37. Nozari Y, Bahrehmand M, Hosseini SK, Mahmoodian M,Sharafi A. Mean platelet volume as a predictor of one-year major adverse cardiac events following elective percutaneous coronary interventions. J Tehran Heart Cent. 2014;9(2):64-9.
38. Hekimsoy Z, Payzin B, Ornek T, Kandogan G. Mean platelet volume in Type 2 diabetic patients. J Diabetes Complications. 2004;18(3):173-6. doi: 10.1016/S1056-8727(02)00282-9.