Association between admission mean platelet volume and ST segment resolution after thrombolytic therapy for acute myocardial infarction

Özgür Kırbaş, Özge Kurmuş[1], Cemal Köseoğlu[1], Bilge Duran Karaduman[1], Ayşe Saatçi Yaşar[1], Recai Alemdar[1], Sina Ali[1], Mehmet Bilge[1]

Clinic of Cardiology, Türkiye Yüksek İhtisas Hospital, Ankara-*Turkey*
[1]Clinic of Cardiology, Atatürk Education and Research Hospital, Ankara-*Turkey*

Abstract

Objective: Mean platelet volume (MPV), one of the indices of platelet reactivity has been shown to be related to impaired angiographic reperfusion in ST-segment elevation myocardial infarction (STEMI) patients treated with primary angioplasty or thrombolytics. However data regarding MPV and its association with ST-segment resolution; an indicator of epicardial and tissue level reperfusion in the setting of STEMI are limited. In this study, we aimed to investigate whether MPV on admission is associated with ST-segment resolution in STEMI patients treated with thrombolytics.
Methods: We retrospectively evaluated 232 consecutive patients with a diagnosis of first STEMI who were administered thrombolytic therapy within 12 hours of onset of chest pain. ST segment resolution based on baseline and 90 minute electrocardiographies were measured. Patients were grouped into two as with <50% and ≥50% ST-segment resolution. Admission MPV was measured and compared between two groups.
Results: Admission MPV was higher in patients with <50% ST-segment resolution than patients with ≥50% ST-segment resolution (9.9±1.3 fL vs. 8.5±1.1 fL respectively, p<0.001). The receiver operating characteristic analysis yielded a cut-off value of 9.3 fL to predict ST-segment resolution, with sensivity and specifity being 66.7% and 77.9%, respectively. In-hospital mortality rate was high in patients with <50% ST -segment resolution (p=0.002).
Conclusion: High MPV on admission in STEMI patients treated with thrombolytics is associated with impaired ST segment resolution.
(Anadolu Kardiyol Derg 2014; 14: 728-32)
Key words: mean platelet volume, ST-segment resolution, STEMI

Introduction

Platelets are one of the important targets in the treatment of acute coronary syndromes since they are involved in acute atherothrombotic process from the beginning. They play a significant role during the occlusion and reperfusion period of myocardial infarction and they also strongly contribute to the microvascular obstruction, tissue level perfusion and maintenance of vessel patency (1, 2). Their reactivity is a key pathophysiological issue and it has been shown that platelet size, simply measured by mean platelet volume (MPV) is correlated with platelet activity (3, 4). Large platelets have a greater content of granules, increased thromboxane syntesis, B-thromboglobulin, serotonin release, increased expression of P-selectin, glycoprotein IIb/IIIa and fibrinogen receptors (5-7). Thus they are more active and more prone to aggregate than small ones and this might indicate that they are much related to thrombolytic resistant thrombus formation (6, 8). Moreover, MPV on admission which is an easy method to assess platelet size and function has been reported as a strong marker of both impaired epicardial flow and increased mortality in ST elevation myocardial infarction (STEMI) patients (9).

Early recanalization of the infarct related artery (IRA) by either thrombolytics or percutaneous coronary intervention (PCI) is the main goal in the treatment of acute myocardial infarction. But the eventual aim is to provide reperfusion at the tissue level as well as in the infarct related artery (10, 11). Resolution of ST elevation has been shown as an aggreable marker that reflects both epicardial and myocardial reperfusion (12, 13). In addition, early and complete resolution of ST -segment in the setting of acute myocardial infarction is associated with smaller infarct size, greater ejection fraction and reduced morbidity and mortality (14, 15). In this study, we aimed to study the relation between admission MPV and ST-segment resolution in STEMI patients treated with thrombolytics within 12 hours of the onset of chest pain.

Address for Correspondence: Dr. Özge Kurmuş, Atatürk Eğitim ve Araştırma Hastanesi, Kardiyoloji Kliniği; Ankara-*Türkiye*
Phone: +90 505 525 33 18 E-mail: ozge_kurmus@yahoo.com
Accepted Date: 06.12.2013 **Available Online Date:** 02.04.2014

DOI:10.5152/akd.2014.5078

Methods

Data from 232 patients with a diagnosis of first STEMI were studied. All patients received trombolytic therapy within 12 hours of the onset of chest pain. STEMI was diagnosed based on a history of a typical chest pain lasting 30 minutes or more and ST segment elevation of 1 mm or more in at least two contiguous leads or 2 mm or more in leads V1 through V3 on the electrocardiography (ECG). All patients had 12 lead standard ECG immediately before start of thrombolytic therapy and at 90 minutes after initiation of thrombolytics. Patients with complete LBBB on admission ECG were excluded. ST-segment measurements were done 60 ms after the J point in the single lead with maximal ST-segment elevation. At 90 minutes this lead was examined for the achievement of ≥50% ST segment resolution. All data were analyzed by a single investigator blinded to the study, using electronic caliper. Traditional variables that have been used to assess response to thrombolytic therapy were relief of chest pain, ST-segment resolution and reperfusion arrhythmias. Patients with lack of resolution of ST elevation by at least 50% in the worst lead at 90 minutes were considered to proceed rescue PCI. In all patients, venous peripheral blood samples for complete blood count were drawn on admission and MPV had been measured before any medication was given. Blood samples were taken into standardized, EDTA containing tubes. Platelet parameters including count and MPV were determined by Beckman Coulter LH 780 Hematology Analyzer. Measurements were completed within one hour of blood sampling in order to avoid the EDTA induced platelet swelling with time. One hundred and eighteen patients received streptokinase (1.5 million U over 60 min) and 114 patients received t-PA (15 mg bolus followed by an infusion of 0.75 mg/kg over 30 min-maximum 50 mg and an infusion of 0.5 mg/kg over 60 min-maximum 35 mg), at the discretion of the treating operator. As an adjunctive therapy, 300 mg aspirin was given to all patients on admission and daily thereafter. A loading dose of 300 mg clopidogrel followed by 75 mg once daily was given to the patients who are younger than 75 years old and loading dose was not administered to the patients older than 75 years of age. All patients received enoxaparin according to the body weight, age and renal function.

Patients with a history of significant coronary artery disease, percutaneous coronary intervention, bypass surgery, receiving oral anticoagulation medicine, bleeding diathesis, malignancy, inflammatory disease and hepatic or renal insufficiency were not enrolled in this study.

The study was approved by the local Ethics Committee of Ataturk Education and Research Hospital. Data from subjects were analyzed retrospectively.

Statistical analysis

Results of continuous data were presented as mean±standard deviation. Student t test was used to determine differences in continuous variables between groups and Mann-Whitney test was used for the variables with and without normal distribution. Categorical variables presented as percentages were compared with Pearson chi-square or Fisher exact-test. Sperman correlation coefficient was calculated to evaluate the association between two continuous variables. The impact of admission MPV on ST-segment resolution was assessed using multivariate logistic regression model adjusting age, sex, diabetes mellitus, hypertension, smoking history, time to treatment, thrombolytic modality and myocardial infarction localization. The receiver operating characteristic (ROC) curve was used to demonstrate MPV cut-off value for predicting the achievement of ≥50% ST segment resolution. Results were considered significant when the p value was <0.05. All statistical analysis were performed using SPSS 11.5.

Results

Patients were divided into two groups based on the presence of ≥50% ST-segment resolution. Of the 232 patients, ≥50% ST-segment resolution was present in 154 patients (66%) and absent in 78 patients (34%). The two groups did not differ for diabetes mellitus, hyperlipidemia, hypertension, body mass index but the patients with ≥50% ST-segment resolution were younger (mean age: 58 vs. 65 years) and history of smoking was higher in this group (65% vs. 47%) (Table 1). Among the patients with <50% ST-segment resolution there were more female patients and there was no significant difference regarding the thrombolytic therapy (t-PA vs. streptokinase) between two groups. Patients were divided into two groups according to the localization of myocardial infarction as anterior versus non-anterior myocardial infarction. Patients with <50% ST-segment resolution were more likely to have anterior myocardial infarction than the patients with ≥50% ST-segment resolution (59% vs. 39% p=0.004). Significant difference was found concerning in-hospital mortality rate between two groups (11.4% in patients with <50% ST-segment resolution and 3.2% in patients with ≥50% ST segment resolution p=0.002). When the haematological parameters were compared between two groups, patients with <50% ST-segment resolution had higher admission MPV than the patients with ≥50% ST-segment resolution (9.9±1.3 fL vs. 8.5±1.1 fL respectively, p<0.001) (Fig. 1). Platelet and white blood cell counts were not different between two groups (Table 1). When the patients were divided into two groups based on time to treatment as ≤3 hours and >3 hours from chest pain, MPV was higher among the patients with <50% ST-segment resolution in both two groups (p<0.001 and p<0.001 respectively). Higher MPV remained significantly associated with <50% ST-segment resolution in patients with anterior myocardial infarction as well as non-anterior myocardial infarction (p<0.001 and p<0.001 respectively). When the patients were compared according to the thrombolytic modality, in both streptokinase and t-PA group, higher MPV was associated with <50% ST-segment resolution (p<0,001 and p<0.001 respectively). High MPV on admission was an independent predictor of impaired ST segment resolution in a univariate analysis as well as multivariate analysis adjusting age, sex, diabetes mellitus, hypertension, smoking history, time to

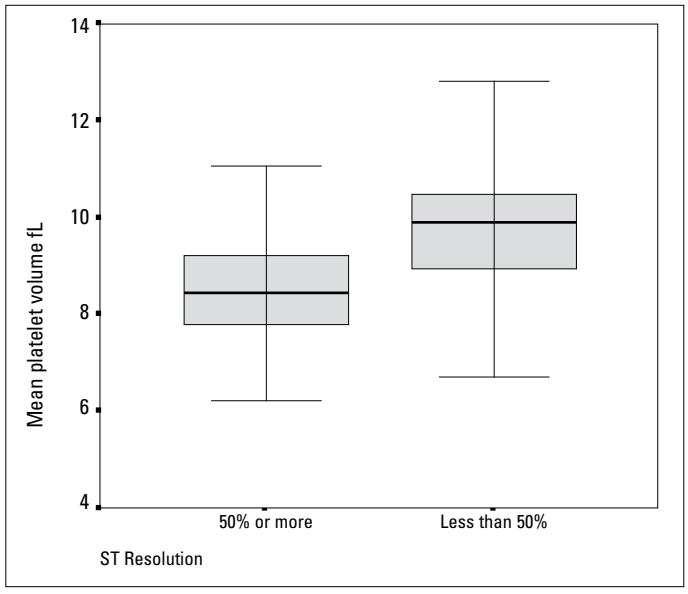

Figure 1. Mean platelet volumes according to ST-segment resolution

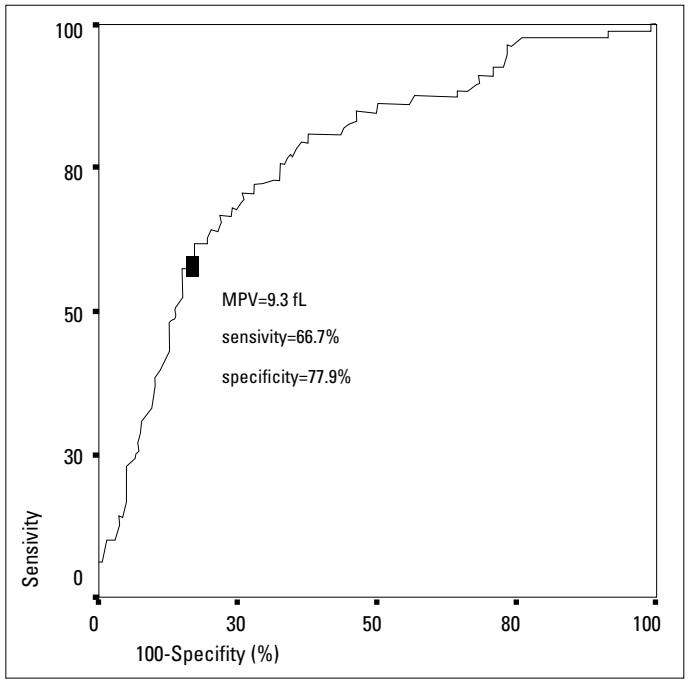

Figure 2. The receiver operating characteristics (ROC) curve for MPV for predicting ST segment resolution. The area under the ROC curve curve=0.76 (95% confidence interval 0.70-0.83)

treatment, thrombolytic modality and myocardial infarction localization (p<0.001 and p<0.001 respectively) (Table 2). The cut-off value for the prediction of ST-segment resolution was 9.3 fL as identified by ROC. The area under the ROC curve with MPV being used to detect ST-segment resolution was 0.76 (Fig. 2). A MPV value of 9.3 fL had a sensivity of 66.7% and specificity of 77.9%. We divided all patients into two groups of high MPV (≥9.31 fL) and low MPV (<9.31 fL). Failure of ST-segment resolution and in-hospital mortality was higher in the high MPV group (p<0.001 and p=0.04 respectively) (Table 3).

Table 1. The demographics, baseline characteristics, echocardiographic and haematologic parameters of the patients

Variables	ST resolution <0.5 (n=78)	ST resolution ≥0.5 (n=154)	*P*
Age, years mean±SD	65.0±11.4	58.1±12.3	<0.001
Man, n (%)	51 (65.4%)	123 (79.9%)	0.378
Woman, n (%)	27 (34.6%)	31 (20.1%)	0.016
BMI, kg/m^2 mean±SD	24.6±3.0	24.3±3.1	0.625
Smoking, n (%)	37 (47.4%)	101 (65.6%)	0.008
Diabetes mellitus, N (%)	23 (29.5%)	36 (23.4%)	0.313
Hypertension, n (%)	42 (53.8%)	54 (35.1%)	0.419
Anterior wall MI, n (%)	46 (59%)	60 (39%)	0.004
Thrombolytic agent-tPA, n (%)	35 (44.9%)	79 (51.3%)	0.355
Ejection fraction mean±SD	37.5±10.2	41.3±10.0	0.051
Laboratory values mean±SD MPV, fL	9.9±1.3	8.5±1.1	<0.001
Platelet (1000/µL)	250±48	245±47	0.649
White blood cell (1000/µL)	11.15±1.95	11.40±1.66	0.454
Hematocrit (%)	40.6±5.2	42.4±4.9	0.070
Peak CK-MB (U/L)	143.1±96.8	117.2±105.0	<0.001

MI - myocardial infarkt; MPV- mean platelet volume; SD - standard deviation

Table 2. Multivariate logistic regression analysis of the predictors which can affect on ST segment resolution

Variables	*P*	Odds ratio	95% CI
Age	0.112	1.032	0.993-1.072
Female gender	0.816	0.883	0.310-2.516
Diabetes mellitus	0.768	1.229	0.312-4.848
Hypertension	0.721	0.898	0.391-1.674
Smoking history	0.656	0.799	0.298-2.143
Time to treatment	0.625	0.985	0.966-1.039
Thrombolytic modality	0.236	1.466	0.573-1.975
Anterior wall MI	0.020	2.846	1.179-6.869
MPV≥9.31 fL	<0.001	9.728	4.253-22.253

MI - myocardial infarkt; MPV - mean platelet volume

Table 3. Comprasion of ST-segment resolution and in hospital mortality according to MPV level

Variables	MPV<9.31 fL n (%)	MPV≥9.31 fL n (%)	*P*
ST resolution <0.5	26 (33.3%)	52 (66.7%)	<0.001
ST resolution ≥0.5	120 (77.9%)	34 (22.1%)	<0.001
In-hospital mortality	5 (3.4%)	11 (12.7%)	0.04

Discussion

In the present study we found that higher admission MPV values were associated with impaired myocardial reperfusion, as evidenced by <50% ST-segment resolution in STEMI patients treated with thrombolytics. In addition, high MPV on admission was an independent predictor of impaired ST segment resolu-

tion after thrombolysis. Our findings suggest that higher MPV values may be related to thrombolytic failure.

When the thrombolytics are used in the treatment of acute myocardial infarction, reperfusion may fail to occur either due to stationary thrombus in epicardial vessel or microvascular occlusion (10, 16). ST-segment resolution is a simple and powerful tool to detect failed thrombolysis and it is considered a marker of microvascular perfusion (17). Several studies demonstrated that greater ST-segment resolution was associated with higher rates of IRA patency, less residual stenosis at angiography, smaller infarct size and better left ventricular systolic function (14, 15, 18). It was also shown that, ST-segment resolution was associated with lower 30 days and 1 year mortality rates (17, 19). When complete ST segment resolution is seen, successful reperfusion appears to have occurred at the tissue level (17). Patients with persistant ST segment elevation have increased morbidity and mortality despite a patent IRA likely due to microvascular occlusion (17).

Thrombus formation in the setting of acute myocardial infarction is a complex dynamic process involving both thrombogenesis and thrombolysis and platelets are important components of this process. It has been shown that larger platelets are metabolically and enzymatically more active than smaller ones and aggregate easily (8). Larger platelets have more fibrinogen and glycoprotein IIb/IIIa receptors (5). They contain greater amount of thromboxane A2 and show greater aggregability to ADP (20, 21). In a meta-analysis drawn from 24 studies over 6000 subjects it has been reported that elevated MPV is associated with increased mortality following myocardial infarction (4). Among patients undergoing coronary angioplasty, MPV was significantly higher in patients who developed restenosis (4). In a study by Eisen et al. (22) it was shown that elevated MPV was a significant predictor of cardiovascular events including death in patients undergoing either an elective or urgent PCI.

Varasteh-ravan et al. (23) studied 280 STEMI patients treated with streptokinase and demonstrated that mean admission MPV was higher in patients with <70% ST-segment resolution compared to patients with ≥70% ST-segment resolution. Campo et al. (24) demonstrated that platelet reactivity that was evaluated in terms of cartridge ADP closure time and percentage of platelet aggregation was directly correlated with the degree of ST-segment resolution immediately after primary percutaneous intervention and the platelet reactivity at entry was higher in patients without >%50 ST-segment resolution. In the current study, we demonstrated that admission MPV, an indicator of platelet reactivity was associated with ST-segment resolution following thrombolytic therapy.

In the study by Pereg et al. (25) it was reported that thrombolysis failure defined as lack of ST-segment resolution at 90 minutes and need for rescue PCI, in-hospital mortality, unplanned PCI during hospitalization or complete occlusion of the culprit artery in a follow up angiography was significantly higher in patients with elevated MPV. But specific data about the relationship between MPV and ST -segment resolution has not been mentioned in that study.

Our findings extend those of previous studies in which higher MPV has been reported as a strong and an independent predictor of impaired angiographic reperfusion in STEMI treated with primary PCI or thrombolytic therapy (9, 26). We also found that higher MPV values were associated with impaired myocardial reperfusion. The method used in the present study differed from those studies in that we evaluated ST -segment resolution instead of TIMI flow and corrected TIMI frame count. Şarlı et al. (27) also demonstrated that increased MPV on admission is significantly associated with poor postinterventional myocardial blush grade in patients with STEMI and treated with primary PCI. Our findings may be important and useful because ST segment resolution is a marker of tissue level perfusion, an ultimate goal of all reperfusion strategies, and it is related to prognosis in STEMI patients.

We assume that in the presence of large platelets, thrombus burden may increase and the balance between thrombogenesis and thrombolysis may not be changed in favour of the thrombolysis because of ongoing exaggerated thrombosis due to activated platelets despite pharmacologic thrombolytic intervention. But multiple factors may play a role in the correlation of higher MPV with lack of ST-segment resolution. First of all, not only post-thrombolytic flow in the IRA but also prethrombolytic flow in the IRA may be poor in patients with higher MPV values. A recent study has suggested that higher MPV values were associated with poor pre-PCI flow in the IRA in acute STEMI treated with primary PCI (28). Also, it was suggested that platelet activation played a crucial role in the process of reocclusion (29) and reocclusion may be related to lack of ST-segment resolution.

Another reason of lack of ST segment resolution is no-reflow. A combination of mechanisms are likely be involved in this process. No-reflow occurs due to capillary plugging by platelet aggregates, distal embolization and vasoconstriction (30). Large platelets may cause enhanced microvascular obstruction and sustained vasoconstriction through higher thrombotic potential and increased release of vasoactive substance.

Elevated MPV may contribute to adverse events by another way. Platelet size has been shown to be associated with antiplatelet drug response. Guthikonda et al. (31) demonstrated that reticulated large platelets were associated with poor response to aspirin and clopidogrel. Also it was shown that mortality reduction from abciximab was achieved only in STEMI patients with higher MPV (9).

Study limitations

Our study has some limitations. First, it is a retrospective study. Because of its retrospective design, there are no avaible data about previous antiplatelet drug usage. It is possible that previous usage of antiplatelet drugs may have modulated MPV and response to thrombolytic therapy. Secondly, although measurement of MPV is easy, it is an indirect indicator of platelet reactivity. Finally, our findings demonstrated that higher MPV was associated with impaired ST segment resolution, but we cannot explain whether this relationship is due to effect of MPV on epicardial vessel occlusion or microvascular occlusion.

Conclusion

In conclusion, our study demonstrates that MPV is an independent predictor of ST segment resolution in STEMI patients treated with thrombolytics. These findings may serve to the knowledge of the potential importance of MPV in the succesful thrombolysis and prognosis after a cardiovascular event.

Conflict of interest: None declared.

Peer-review: Externally peer-reviewed.

Authorship contributions: Concept - Ö.Kırbaş.; Design - Ö. Kurmuş.; Supervision - C.K.; Resource - A.S.Y.; Materials - R.A.; Data collection &/or processing - S.A.; Analysis &/or interpretation - B.D.K.; Literature search - M.B.; Writing - Ö.Kırbaş.

References

1. Davi G, Patrono C. Platelet activation and atherothrombosis. N Engl J Med 2007; 357: 2482-94. [CrossRef]
2. Meadows TA, Bhatt DL. Clinical aspects of platelet inhibitors and thrombus formation. Circ Res 2007; 100: 1261-75. [CrossRef]
3. Van der Loo B, Martin JF. A role for changes in platelet production in the cause of acute coronary syndromes. Arterioscler Thromb Vasc Biol 1999; 19: 672-9. [CrossRef]
4. Chu SG, Becker RC, Berger PB, Bhatt DL, Eikelboom JW, Konkle B, et al. Mean platelet volume as a predictor of cardiovascular risk: a systematic review and meta-analysis. J Thromb Haemost 2010; 8: 148-56. [CrossRef]
5. Giles H, Smith RE, Martin JF. Platelet glycoprotein IIb/IIIa and size are increased in acute myocardial infarction. Eur J Clin Invest 1994; 24: 69-72. [CrossRef]
6. Schoene NW. Design criteria: tests used to assess platelet function. Am J Clin Nutr 1997; 65: 1665-8.
7. Bath PM, Butterworth RJ. Platelet size: measurement, physiology and vascular disease. Blood Coagul Fibrinolysis 1996; 7: 157-61. [CrossRef]
8. Corash L, Tan H, Gralnick HR. Heterogenity of human whole blood platelet subpopulations. I. Relationship between buoyant density, cell volume, and ultrastructure. Blood 1977; 49: 71-87.
9. 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: 284-90. [CrossRef]
10. Matetzky S, Freimark D, Chouraqui P, Novikov I, Agranat O, Rabinowitz B, et al. The distinction between coronary and myocardial reperfusion after thrombolytic therapy by clinical markers of reperfusion. J Am Coll Cardiol 1998; 32: 1326-30. [CrossRef]
11. Claeys MJ, Bosmans J, Veenstra L, Jorens P, De RaedtH, Vrints CJ. Determinants and prognostic implications of persistent ST-segment elevation after primary angioplasty for acute myocardial infarction. Circulation 1999; 99: 1972-7. [CrossRef]
12. Doevendans PA, Gorgels AP, van der Zee R, Partouns J, Bar FW, Wellens HJ. Electrocardiographic diagnosis of reperfusion during thrombolytic therapy in acute myocardial infarction. Am J Cardiol 1995; 75: 1206-10. [CrossRef]
13. Van t' Hof AWJ, Liem A, de Boer MJ, Zijlstra F. Clinical value of 12-lead electrocardiogram after successful reperfusion therapy for acute myocardial infarction. Zwolle Myocardial infarction Study Group. Lancet 1997; 350: 615-9. [CrossRef]
14. Schroder R, Dissman R, Bruggemann T, Wegscheider K, Linderer T, Tebbe U, et al. Extent of early ST segment elevation resolution: a simple but strong predictor of outcome in patients with acute myocardial infarction. J Am Coll Cardiol 1994; 24: 384-91. [CrossRef]
15. Mauri R, Maggioni AP, Franzosi MG, De Vita C, Santoro E, Santoro L, et al. A simple electrocardiographic predictor of the outcome of patients with acute myocardial infarction treated with a thrombolytic agent. A Gruppo Italiano per lo Studio della Sopravvivenza nell'Infarto Miocardico (GISSI-2)-Derived Analysis. J Am Coll Cardiol 1994; 24: 600-7. [CrossRef]
16. de Lemos JA, Antman EM, Giugliano RP, Morrow DA, McCabe CH, Cutler SS, et al. Comparison of a 60- versus 90-minute determination of ST-segment resolution after thrombolytic therapy for acute myocardial infarction. In TIME-II Investigators. Intravenous nPA for Treatment of Infarcting Myocardium Early-II. Am J Cardiol 2000; 86: 1235-7. [CrossRef]
17. de Lemos JA, Antman EM, Giugliano RP, McCabe CH, Murphy SA, Van de Werf F, et al. ST- segment resolution and infarct related artery patency and flow after thrombolytic therapy. Thrombolysis in Myocardial Infarction (TIMI) 14 investigators. Am J Cardiol 2000; 85: 299-304. [CrossRef]
18. Llevadot J, Giugliano RP, McCabe CH, Cannon CP, Antman EM, Murphy S, et al. Degree of residual stenosis in the culprit coronary artery after thrombolytic administration. Am J Cardiol 2000; 85: 1409-13. [CrossRef]
19. Fu Y, Goodman S, Chang WC, Van de Werf F, Granger CB, Armstrong PW, et al. Time to treatment influences the impact of ST-segment resolution on one-year prognosis:insights from the assessment of the safety and efficacy of a new thrombolytic (ASSENT-2) trial. Circulation 2001; 104: 2653-9. [CrossRef]
20. Kamath S, Blann AD, Lip GY. Platelet activation: assessment and quantification. Eur Heart J 2001; 22: 1561-71. [CrossRef]
21. Karpatkin S, Khan Q, Freedman M. Heterogeneity of platelet function. Correlation with platelet volume. Am J Med 1978; 64: 542-6. [CrossRef]
22. Eisen A, Bental T, Assali A, Kornowski R, Lev EI. Mean platelet volume as a predictor for long-term outcome after percutaneous coronary intervention. J Thromb Thrombolysis 2013; 36: 469-74. [CrossRef]
23. Varasteh-ravan HR, Ali-Hassan-Sayegh S, Shokraneh S, Mozayan MR, Karimi-Bondarabadi AA. Relationship of admission mean platelet volume, platelet distribution width and white blood cells with ST resolution in patients with acute ST segment elevation myocardial infarction treated with streptokinase without history of previous cardiovascular surgery. Perspect Clin Res 2013; 4: 125-9. [CrossRef]
24. Campo G, Valgimigli M, Gemmati D, Percoco G, Tognazzo S, Cicchitelli G, et al. Value of platelet reactivity in predicting response to treatment and clinical outcome in patients undergoing primary coronary intervention: insights into the STRATEGY Study. J Am Coll Cardiol 2006; 11: 2178-85. [CrossRef]
25. Pereg D, Berlin T, Mosseri M. Mean platelet volume on admission correlates with impaired response to thrombolysis in patients with ST-elevation myocardial infarction. Platelets 2010; 21: 117-21. [CrossRef]
26. Yaşar AS, Bilen E, Yüksel IO, Arslantaş U, Karakaş F, Kırbaş A, et al. Association between admission mean platelet volume and coronary patency after thrombolytic therapy for acute myocardial infarction. Turk Kardiyol Dern Ars 2010; 38: 85-9.
27. Şarlı B, Baktır AO, Sağlam H, Arınç H, Kurtul S, Sivgin S, et al. Mean platelet volume is associated with poor postinterventional myocardial blush grade in patients with ST-segment elevation myocardial infarction. Coron Artery Dis 2013; 24: 285-9. [CrossRef]
28. Elbasan Z, Gür M, Şahin DY, Kuloğlu O, İçen YK, Türkoğlu C, et al. Association of mean platelet volume and pre- and postinterventional flow with infarct-related artery in ST- segment elevation myocardial infarction. Angiology 2013; 64: 440-6. [CrossRef]
29. Qasim A, Chauhan A, More RS. Failed thrombolysis in myocardial infarction. Int J Cardiol 2000; 75: 5-14. [CrossRef]
30. Niccoli G, Giubilato S, Russo E, Spaziani C, Leo A, Porto I, et al. Plasma levels of thromboxane A2 on admission are associated with no-reflow after primary percutaneous coronary intervention. Eur Heart J 2008; 29: 1843-50. [CrossRef]
31. Guthikonda S, Alviar CL, Vaduganathan M, Arikan M, Tellez A, DeLao T, et al. Role of reticulated platelets and platelet size heterogeneity on platelet activity after dual antiplatelet therapy with aspirin and clopidogrel in patients with stable coronary artery disease. J Am Coll 2008; 52: 743-9. [CrossRef]