EJMO

DOI: 10.14744/ejmo.2024.27137
EJMO 2024;8(3):311–321

Research Article

Could Higher Platelet Indices on Admission Predict Re-Infarction & Adverse Outcomes in STEMI Patients Undergoing Primary Percutaneous Coronary Intervention (PPCI)? A Single-Center Experience

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Abstract

Objectives: Platelet indices, such as platelet distribution width (PDW), mean platelet volume (MPV), and plateletcrit (PCT), can provide insights into platelet activation. Large platelets are more active and have higher thrombotic potential than small platelets, suggesting that larger platelets play a role in ST-elevation myocardial infarction (STEMI). To assess PDW, MPV, and PCT and their relation to severity and validity for prediction of primary, secondary outcomes, and MACE in acute STEMI patients who underwent PPCI.

Methods: This prospective study included 115 consecutive STEMI patients who underwent PPCI. Admission blood samples were measured for MPV, PDW, and PCT. The SYNTAX and Gensini (GS) scores were used to quantify the severity of CAD. Patients were followed up for a period of 3 to 6 months with regard to primary and secondary clinical outcomes.

Results: PDW had a moderate positive correlation with SYNTAX score (r=0.321, p<0.001) and GS (r=0.270, p=0.002), and a negative correlation with TIMI Risk (r=-0.199, p=0.017) and ejection fraction (r=-0.170, p=0.034). Also, MPV had a significant positive correlation with SYNTAX score (r=0.235, p=0.006). PDW had the highest diagnostic accuracy for the prediction of the primary outcome and MACE.

Conclusion: PDW, a low-cost and easily measured laboratory test, could be used as a predictor of re-infarction and adverse outcomes in STEMI patients.

Keywords: Mean platelet volume, Platelet distribution width, plateletcrit, primary percutaneous coronary intervention, ST-elevation myocardial infarction

Cite This Article: *Elmoniem AE, Thabet AF, El-Hameed IH, Abdelmegid MAK, Rayan AAR, Moeen S. Could Higher Platelet Indices on Admission Predict Re-Infarction & Adverse Outcomes in STEMI Patients Undergoing Primary Percutaneous Coronary Intervention (PPCI)? A Single-Center Experience. EJMO 2024;8(3):311–321.*

Platelets are causally involved in coronary artery obstruction in acute coronary syndromes.[1] Larger platelets are more active, play a major role in the initiation of atherosclerotic lesions and their complications, and have a higher potential for thrombosis compared to smaller ones.[2] The degree of platelet activation can be assessed by platelet indices

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Submitted Date: February 12, 2024 **Accepted Date:** April 30, 2024 **Available Online Date:** September 10, 2024

such as PDW, MPV, and plateletcrit.[3] MPV, a component of complete blood count, is a reliable index for platelet size and acts as an indicator of platelet activation.[4] It could link the pathophysiology of diseases related to thrombosis and inflammation.[5] It seems to be a biomarker that links hematologic indices with CAD.[6] It is related to the extent and clinical presentation of CAD.[7] Elevated MPV is associated with cardiovascular risk factors.[4] A meta-analysis stated that MPV is associated with CAD and could be helpful in risk stratification in these patients.[8] Some studies have shown the correlation between elevated MPV and ACS and PCI outcomes, like mortality and stent restenosis.[9,10] Also, its predictive value in clinical assessments of CAD has been reported.[4]

MPV cut-off values (8.00 to 9.25 fL) predict poor clinical outcomes in patients with CAD treated by PCI.[11] Like MPV, high PDW was correlated with CAD severity in patients with ACS.[12] PDW was reported to have prognostic value in PCI-treated acute MI.[13] In patients with STEMI, an increased level of PDW and PCT can be associated with high platelet activity.[14]

The aim of this study was to assess platelet indices on admission and their relation to CAD severity and outcome in patients with acute STEMI undergoing PPCI.

Methods

Patients

This prospective cross-sectional study included 115 consecutive patients with STEMI (>18 years) who were subjected to PPCI at the Emergency Unit at Assiut University Heart Hospital, Assiut University Hospital, from January 2019 to the end of December 2022.

Patients with a previous history of revascularization procedures or who had ischemic heart disease and/or cardiomyopathy, patients on antiplatelet/anticoagulant therapy or who had primary platelet disorders, aplastic anemia, or malignancy, or who had inflammatory diseases, autoimmune disease, hematologic disease, renal or hepatic insufficiency, or who were on drugs that could decrease cell count, such as hydroxyurea or anti-neoplastic drugs, and patients with incomplete data were excluded from the study.

All the participants, on admission to the Emergency Unit, were subjected to history taking, including a history of baseline comorbidities, drug intake, ischemic heart disease risk factors, e.g., history of DM, HTN, smoking, renal impairment, and duration of chest pain, and clinical assessment to obtain information related to risk factors, presenting symptoms, and vital signs. Patients were classified into four classes according to Killip classification. Class I: patients with no abnormal clinical findings; Class II: patients with pulmonary congestion, elevated jugular venous pressure, or having S3 gallop; Class III: patients with pulmonary edema; and Class IV: patients with cardiogenic shock.[15]

Emergency baseline 12-lead ECG was done and analyzed for ST-segment elevation of >1 mV in two adjacent leads. Echocardiographic examination was performed to evaluate LV dimensions, volumes, systolic and diastolic function, assessment of segmental wall motion abnormalities, and any mechanical cardiac complications.

Laboratory Methods

Eight milliliters of venous blood were withdrawn from each participant under aseptic precautions for baseline laboratory tests before starting any medication. Samples were divided as follows: 2 ml was dispensed gently into a sodium citrate-containing vacutainer tube for the measurement of prothrombin time and concentration (using the Sysmex CS-5100 coagulation analyzer, Siemens, Germany). 4 ml was added to a serum vacuum tube, left to clot for 20–30 min at 37 °C, centrifuged at 2000 g for 10 minutes, and serum analyzed for cardiac enzymes (Troponin, CK (creatine kinase), CK-MB (creatine kinase-myocardial band)), and liver and kidney function tests on Dimension RxL Max and ADVIA 1800 chemistry systems (Siemens, Germany), respectively. The rest of the sample was placed in a tube containing tri-potassium ethylene diamine tetraacetic acid (K3-EDTA) for a complete blood count (CBC). CBC, including platelet count and indices (MPV, PDW, and plateletcrit "PCT"), was analyzed using the ADVIA 2120i hematology system (Siemens, Germany). All samples were kept at room temperature and processed within 1 hour of blood sampling at the hospital's central laboratory.

STEMI was diagnosed based on the criteria recommended by the American College of Cardiology and European Society of Cardiology guidelines.[16]

STEMI is defined by the following criteria: (1) typical, prolonged chest pain at rest (more than 30 minutes); (2) ST elevation in at least two continuous electrocardiography leads or new onset of full left bundle branch block; and (3) elevated serial serum indicators of myocardial injury.[17]

Angiographic Analysis

Coronary angiogram was performed by an expert cardiologist. The type of culprit artery, culprit segment, dominance artery, number of diseased vessels, SYNTAX score, Gensini score, TIMI thrombus grades, TIMI thrombus grade 5 after opening the artery, and final TIMI flow were assessed. Judkins' standard method was used to perform emergency coronary angiography. Before and during coronary angiography, all patients received a chewable 300 mg aspirin and a 600 mg loading dose of clopidogrel. First, an injection was administered into the artery that was thought

to be unobstructed. When the coronary structure was established, heparin (100 IU/kg) was given to all patients. The severity of the atherosclerosis was assessed using the SYNTAX score. Every coronary lesion that has at least a 50% diameter stenosis in vessels at least 1.5 mm in diameter needs to be scored. A SYNTAX score calculator 2.1 was used to determine the SYNTAX score (www.syntaxscore.com).[18] The Gensini Score was also used.[19]

The severity score, region multiplication factor, and collateral adjustment are the three key parameters that have been taken into account when developing the GS to characterize the complexity of CAD.[20]

TIMI risk for STEMI: Data were calculated offline using the MD+ Calc app for TIMI risk score for STEMI, which estimates mortality in patients with STEMI.[21]

Patients were followed up for a period of 3 to 6 months with regard to the primary in-hospital outcome (arrest, re-infarction, stroke, arrhythmia, cardiogenic shock, heart failure). Secondary clinical outcomes (shock, stroke, re-infarction, heart failure, and major adverse cardiovascular events (MACE)) were also evaluated.

Patients were invited to participate in the study, and the aim of the study was explained to each participant. The study followed the principles of the 1975 Helsinki Declaration. The study was approved by our local ethical committee (IRB no: 17100975).

Sample Size Calculations

Using the G-Power Program revealed a total sample of 111, assuming a one-tail moderate effect of 0.3, an alpha error of 0.05, and a power of 0.95. The parameter in question was MPV mean in patients with acute STEMI.

Statistical Analysis

Results were analyzed using IBM-SPSS 24.0 (IBM-SPSS Inc., Chicago, IL, USA). Descriptive statistics: Means, standard errors, medians, inter-quartile ranges (IQR), and percentages were calculated. The Shapiro-Wilk test was used to test data normality. Student's t-test and Mann-Whitney U test were calculated to test the mean differences in continuous variables between groups (parametric and non-parametric). Pearson's/Spearman rank correlation coefficient was calculated for univariate correlations. ROC curve analysis was depicted to explore the predictive/diagnostic performance of platelet indices for primary and secondary cardiac disease outcome prediction, analyzed as area under the curve (AUC), standard error (SE), and 95% CI. Validity statistics (sensitivity, specificity, positive and negative predictive values –PPV & NPV–) were calculated. Optimal cutoff values of platelet indices were determined for the prediction of primary and secondary cardiac disease outcomes using the Youden index (Youden index: sensitivity + specificity – 1). A $p<0.05$ was considered significant.

Results

Patient Characteristics

This prospective cross-sectional study included 115 patients with acute STEMI. The mean age was 58.2±13.5 years, with male predominance (male-to-female ratio 3.8:1); the number of males was 91/115 (79.1%) and that of females was 24/115 (20.9%). The mean values of platelet indices (platelet count, MPV, PCT, and PDW), cardiac enzymes, and other baseline clinical and laboratory characteristics of the patients are shown in Table 1.

ECG/Echo findings of the studied patients, 58% (n=67) had anterior MI, 43% (n=49) had inferior MI, 17.4% (n=20) had extensive MI, 14% (n=16) had lateral MI, and only 7 and 4 patients (6.1% and 3.5%) had posterior and right MI, respectively. For the grade of diastolic dysfunction, the majority of the patients, 72% (n=83), had grade I; 27 patients

Table 1. Baseline clinical and laboratory characteristics of STEMI patients

Variable	STEMI Patients (n=115)	Mean±SD
Age/years		58.20±13.5
Sex, n (%)	Male	91 (79.1)
	Female	24 (20.9)
Smoking, n (%)	No	85 (73.9)
	Yes	30 (26.1)
Comorbidity, n (%)	HTN	36 (31.3)
	DM	26 (24.3)
	CVS	6 (5.2)
	COPD	3 (2.6)
WBCs x10^9 /L		11.52±6.8
Hb (g/dl)		13.36±1.6
Platelet x10^9 /L		286.47±78.6
MPV (fl)		10.18±1.1
PCT (%)		0.29±0.09
PDW (%)		50.20±11.9
BUN (mmol/L)		6.69±3.8
S. Creatinine (mmol/L)		0.88±0.4
CK (IU/L)		1459.29±955.1
CK-MB(IU/L)		358.15±287.6
Troponin (ng/l)		65.95±63.7

HTN: Hypertension; DM: Diabetes mellitus; CVS: cerebrovascular stroke; COPD: Chronic obstructive pulmonary disease; WBCs: White Blood Cells; Hb: hemoglobin; MPV: mean platelet volume; PCT: plateletcrit; PDW: Platelet distribution width; BUN: blood urea nitrogen; S.Creatinine: serum creatinine; CK: creatine kinase; CK-MB: creatine kinase-myocardial ban.

had grade II, 2 patients had grade III, and 3 patients had normal flow (Fig. 1). The mean EF% was 48.7% ±8.4.

Angiographic characteristics and extent of coronary artery disease of STEMI patients, according to the culprit artery, more than half of the patients (58.2%) had LAD affection. According to the number of vessels involved, 44.3% (n=51) of patients had single vessel disease, 32.2% (n=37) had double vessel disease, and 23.5% (n=27) had triple vessel disease (Table 2).

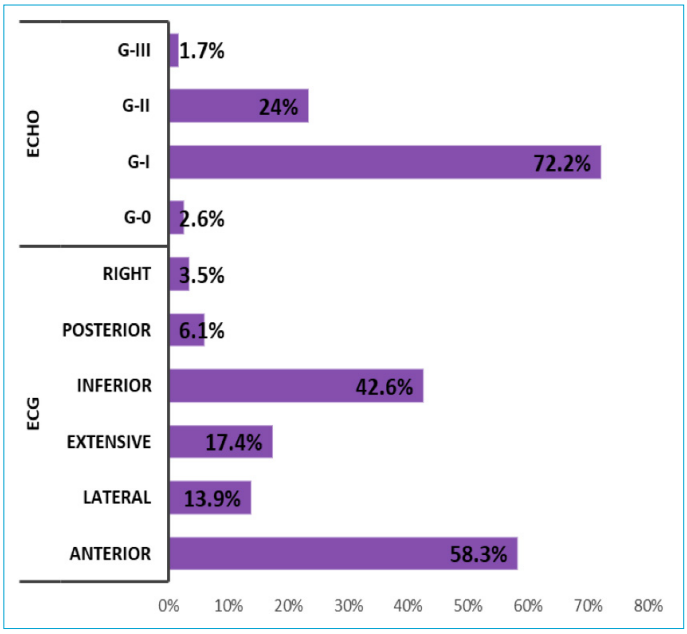

Figure 1. ECG findings and grade of diastolic dysfunction of STEMI patients.

Table 2. Angiographic characteristics and extent of coronary artery disease of STEMI patients

Variable	STEMI Patients (n=115)
Culprit Artery, n (%)	
LAD	67 (58.2)
LCX	17 (14.8)
RCA	31 (27)
Dominance Artery, n (%)	
RCA	102 (88.7)
LCA	13 (11.3)
Affected Vessel, n (%)	
LM	3 (2.6)
LAD	100 (87)
LCX	50 (43.5)
RCA	56 (48.7)
No. of Affected Vessels, n (%)	
One	51 (44.3)
Two	37 (32.2)
Three	27 (23.5)

Disease severity by SYNTAX score, gensini score, and timi risk score for STEMI patients, the median SYNTAX score was 18, and the Gensini score was 60. According to TIMI thrombus grade, about two-thirds of the patients (67.0%) had grade IV/V, and 4 patients (3.5%) had grade 0. According to TIMI thrombus grade after opening the artery, 48.6% had grade II and III, and only 5 patients (4.3%) had grade I. The final TIMI flow grade was grade III in 81.7% of the patients (Table 3).

Primary (in-hospital) and secondary (follow-up) disease outcomes, The overall MACE was reported in 27% of STEMI patients (Table 4).

Table 3. Disease severity by SYNTAX Score, GENISINI score and TIMI risk score for STEMI patients

Variable	STEMI Patients (n=115)
SYNTAX Score	
Mean±SD/Median (Range)	17.60±8.7/18 (5-51)
GENISINI Score	
Mean±SD/Median (Range)	68.54±34.6/60 (16-210)
TIMI Thrombus Grade	
Grade 0	4 (3.5)
Grade I	8 (7)
Grade II	14 (12.2)
Grade III	12 (10.4)
Grade IV/V	77 (67)
TIMI Thrombus Grade after Opening the Artery	
Grade I	5 (4.3)
Grade II	28 (24.3)
Grade III	28 (24.3)
Grade IV	15 (13)
NA	39 (33.9)
Final TIMI Flow Grade	
Grade 0	2 (1.7)
Grade I	4 (3.5)
Grade II	15 (13)
Grade III	94 (81.7)
TIMI Risk	
Score for STIMI	
G-0	6 (5.2)
G-I	19 (16.5)
G-II	14 (12.2)
G-III	15 (13)
G-IV	18 (15.7)
G-V	13 (11.3)
G-VI	7 (6.1)
G-VII	8 (7)
G-VIII	7 (6.1)
G-IX	6 (5.2)
G-X	2 (1.7)

Table 4. Primary (in hospital) and secondary (follow-up) outcome of STEMI patients

Variable	Category	n=115
1ry Outcome (In-hospital)	Arrested	3 (2.6%)
	Re-infarction	3 (2.6%)
	Stroke	1 (0.9%)
	Arrhythmia	19 (16.5%)
	Shock	23 (20%)
	HF	10 (8.7%)
2ry Outcome (Follow-up)	Cardiogenic Shock	4 (3.4%)
	Stroke	2 (1.7%)
	Re-infarction	13 (11.3%)
	HF	16 (13.9%)
	MACE	31 (27%)

HF: heart failure; MACE: major adverse cardiovascular events.

Univariate correlation between platelet indices and disease severity/cardiac enzymes in STEMI patients, MPV and PDW (r=0.235, p=0.006, and r=0.321, p<0.001) had a moderate positive correlation with the SYNTAX score. PDW had a moderate positive correlation (r=0.270, p=0.002) with the Gensini score. PDW had a mild negative correlation with the final TIMI flow and EF% (r=-0.199, p=0.017, and r=-0.170, p=0.034). However, the correlation between platelet count, PCT, and disease severity was statistically insignificant (p>0.05 for all) (Table 5a). Correlations between platelet indices and cardiac enzymes were statistically insignificant (p>0.05) (Table 5b).

Relationship between Platelet Indices and Primary Disease Outcome

Notably, there were no significant differences in median levels of platelet indices (MPV, PCT, PDW) and platelet count between patients with (arrhythmia, heart failure, cardiac arrest) and those without. A significantly lower median level of platelet count (p=0.039) and PCT (p=0.045) was observed in patients with re-infarction compared to those without. For shock, a statistically significant higher median level of PDW (p=0.008) was observed in patients with shock compared to those without. For patients with the total primary outcome, a statistically significant higher median level of PDW (p=0.001) was observed in patients with the outcome compared to those without (Table 6).

Relationship between Platelet Indices and Secondary Disease Outcome

There was a significant (p=0.042 and 0.036) lower platelet count and PCT level, and a significant (p=0.041) higher MPV level was observed in patients with cardiac shock. PDW was significantly higher among patients with stroke and those with heart failure (p=0.015 and 0.025, respectively). Patients with MACE had significantly higher MPV and PDW compared to their counterparts (p=0.008 and <0.001, respectively), as shown in Table 7.

The Validity of Different Platelet Indices for Prediction of Primary Disease Outcome

Only PDW proved to be a significant predictor of the primary outcome, at a cutoff of 48; (AUC=0.689, 95% CI: 0.59-

Table 5a. Correlation between platelet indices and disease severity

Parameters	Platelet Count r* (p)	MPV	PCT	PDW
Disease Severity				
SYNTAX Score	-0.154 (=0.051)	0.235 (=0.006)	-0.144 (=0.062)	0.321 (<0.001)
GENISINI Score	-0.104 (=0.134)	0.126 (=0.089)	-0.083 (=0.188)	0.270 (=0.002)
TIMI Risk for STIMI	0.085 (=0.183)	-0.088 (=0.176)	-0.067 (=0.240)	-0.199 (=0.017)
EF%	-0.029 (=0.381)	-0.048 (=0.304)	-0.070 (=0.228)	-0.170 (=0.034)

*Spearman Ranked correlation coefficient.

Table 5b. Correlation between platelet indices and cardiac enzymes

Parameters	Platelet Count r* (p)	MPV	PCT	PDW
Cardiac Enzymes				
CK	0.023 (=0.403)	-0.107 (=0.141)	0.015 (=0.436)	0.114 (=0.112)
CKMB	-0.038 (=0.345)	-0.071 (=0.226)	0.007 (=0.471)	0.079 (=0.201)
Troponin	0.071 (=0.224)	-0.030 (=0.375)	0.121 (=0.099)	0.151 (=0.054)

*Spearman Ranked correlation coefficient.

Table 6. Relationship between platelet ındices and primary disease outcome

Median (IQR)	Platelet Indices			
	Count	MPV	PCT	PDW
Arrested				
No	282 (103)	10 (1.5)	0.28 (0.09)	49 (19.5)
Yes	320 (57)	10 (2.3)	0.30 (0.1)	57 (9)
p	0.454	0.553	0.486	0.365
Re-infarction				
No	284.5 (99)	10 (1.5)	0.28 (0.09)	49 (19)
Yes	168 (73)	10 (1.7)	0.20 (0.1)	66 (15)
p	0.039	0.576	0.045	0.422
Arrhythmia				
No	286.5 (112)	10 (1.6)	0.29 (0.1)	49 (19)
Yes	279 (81)	10 (1.4)	0.26 (0.08)	57 (13)
p	0.433	0.611	0.384	0.156
Shock				
No	297 (113)	10 (1.6)	0.29 (0.1)	48.5 (19)
Yes	269 (69)	10.5 (1)	0.26 (0.08)	57 (18)
p	0.145	0.117	0.337	0.008
HF				
No	284 (100)	10 (1.5)	0.28 (0.09)	49 (19)
Yes	279 (97)	10.4 (2)	0.27 (0.11)	59 (21)
p	0.652	0.648	0.515	0.079
Total 1ry Outcome				
No	299 (116)	10 (1.6)	0.30 (0.1)	48 (18.5)
Yes	278 (72)	10.5 (1.5)	0.27 (0.08)	57.5 (18)
p	0.114	0.154	0.153	0.001

*Mann-Whitney U-test was used to compare the differences in Median between group; HF: heart failure.

Table 7. Relationship between platelet indices and secondary disease outcome

Median (IQR)	Platelet Indices			
	Count	MPV	PCT	PDW
Cardiogenic Shock				
No	286 (100)	10 (1.5)	0.28 (0.09)	49.5 (19)
Yes	213.5 (112)	11.2 (1.4)	0.21 (0.11)	63 (21)
p	0.042	0.041	0.036	0.099
Stroke				
No	284 (102)	10.1 (1.5)	0.28 (0.09)	50 (18.5)
Yes	272.5 (113)	10.7 (1.6)	0.31 (0.07)	68.5 (16.5)
p	0.733	0.703	0.513	0.015
Re-infarction				
No	285 (102)	10.1 (1.5)	0.28 (0.08)	50 (19)
Yes	261 (102)	10.8 (1.6)	0.26 (0.1)	49.5 (20.5)
p	0.744	0.460	0.929	0.301
HF				
No	287 (112)	10 (1.5)	0.28 (0.09)	49 (19)
Yes	278.5 (77)	11 (1.5)	0.27 (0.07)	58 (16.5)
P-value	0.419	0.092	0.829	0.025
Total MACE				
No	298.5 (113)	10 (1.4)	0.29.5 (0.09)	48 (17.5)
Yes	262 (69)	10.8 (1.6)	0.26 (0.06)	60 (20)
P-value	0.063	0.008	0.450	<0.001

*Mann-Whitney U-test was used to compare the differences in Median between groups.

0.79, p=0.001, with 82% sensitivity and 67% specificity). The test had 71% precision and 79% NPV. Overall, the test had 74.5% accuracy. Youden's J was fair (50%), indicating that the test meets empirical levels for diagnosis/prediction (Table 8) (Fig. 2).

The Validity of Platelet Indices for Prediction of MACE

Only MPV and PDW were significant predictors of MACE among the studied participants. For MPV, at a cutoff of 10, (AUC=0.662, 95% CI: 0.54-0.78, p=0.008, with 81% sensitivity and 42% specificity), the test had 58% precision and 69% NPV. Overall, the test had 61.5% accuracy. Youden's J was low (23%), indicating that the test does not meet empirical benchmarks.

For PDW, at a cutoff of 48, (AUC=0.717, 95% CI: 0.61-0.82, p<0.001, with 81% sensitivity and 66% specificity), the test had 70.5% precision and 77.5% NPV. Overall, the test had 73.5% accuracy. Youden's J was fair (51%), indicating that the test meets empirical benchmarks for diagnosis/prediction (Table 9) (Fig. 3).

Table 8. Diagnostic criteria of platelet indices for primary outcome prediction

Diagnostic criteria	Platelet Indices			
	Count	MPV	PCT	PDW
AUC	0.409	0.582	0.418	0.689
95% CI	0.305-0.513	0.472-0.692	0.311-0.524	0.587-0.791
SE**	0.053	0.056	0.054	0.052
p***	0.114	0.154	0.154	0.001
Cut-off	250	10	0.25	48
Accuracy	51.5	62.5	51.5	74.5
Sensitivity%	71	69	68	82
Specificity%	32	56	35	67
PPV%	51	61	51	71
NPV%	52.5	64	52	79
Youden's J	0.03	0.25	0.03	0.50

*AUC=Area under the Curve **SE: Standard Error; CI: Confidence Interval; ***Null hypothesis: true area=0.5.

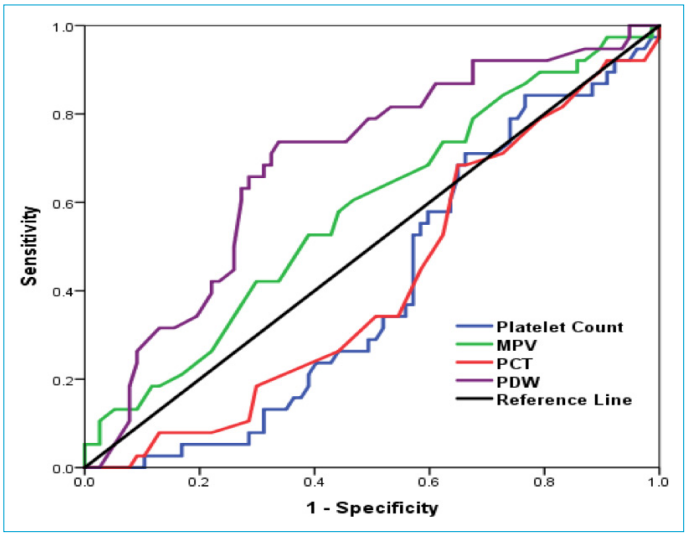

Figure 2. ROC curve for platelet indices as biomarkers for primary outcome prediction.

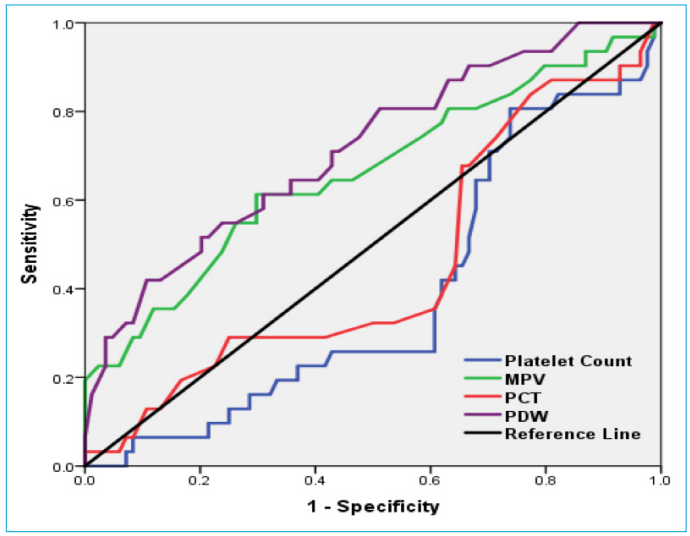

Figure 3. ROC curve for platelet indices as biomarkers for MACE prediction.

Table 9. Diagnostic criteria of platelet indices as biomarkers for MACE prediction

Diagnostic criteria	Platelet Indices			
	Count	MPV	PCT	PDW
AUC	0.387	0.662	0.454	0.717
95% CI	0.275-0.498	0.542-0.781	0.334-0.575	0.610-0.823
SE**	0.057	0.061	0.061	0.054
p***	0.063	0.008	0.451	<0.001
Cut-off	250	10	0.25	48
Accuracy%	51	61.5	49.5	73.5
Sensitivity%	71	81	68	81
Specificity%	31	42	34	66
PPV%	50.5	58	50	70.5
NPV%	52	69	49	77.5
Youden's J	0.02	0.23	0.01	0.51

*AUC: Area under the Curve **SE: Standard Error; CI: Confidence Interval
***Null hypothesis: true area=0.5.

Discussion

A causal relationship between the existence of large platelets in the circulation and ACS is supported by many studies.[1] Platelet activation, inflammation, and thrombosis play key roles in the initiation and progression of ACS.[22]

Larger platelets are more likely to contribute to the thrombotic process than smaller ones.[23] At the ruptured atherosclerotic plaque, platelets contribute to vascular occlusion and impairment of coronary microcirculation. Larger platelets are more active, intense, and have more glycoprotein Ib and IIb/IIIa receptors, higher levels of thromboxane A2, and higher thrombotic potential, allowing platelets to aggregate more rapidly with collagen than smaller platelets.[23]

Platelet activity can be assessed with platelet indices (MPV, PDW, and PCT). These indices have been reported as markers of a prothrombotic state in cardiovascular diseases.[14] MPV is a reproducible marker and indicator of platelet activity. However, PDW is a more specific indicator of activity than MPV. It measures the variability in platelet size, detects the fractions of larger platelets that are more active, and remains unaffected by the single platelet distention caused by platelet swelling.[24] PCT provides data about platelet mass. It is calculated by the equation (PLT × MPV/107). Increased PCT may reflect increased platelet activity, subsequent release of inflammatory mediators, initiation of inflammatory response, and prothrombotic status, and it also correlates with CAD.[14] Ugur et al.[25] reported that PCT is an important prognostic marker that can predict long-term cardiovascular mortality in STEMI patients. PCT could be a valuable predictor of coronary slow flow phenomenon.[26]

Effective risk stratification plays an important role in the treatment plan and prognosis of STEMI patients. Moreover, higher-risk STEMI patients may be managed more aggressively than patients with lower risk.[27] These patients may have higher mortality and long-term cardiac events. Therefore, there is a need for a reliable and noninvasive hematological prognostic marker that would identify patients with higher cardiovascular risk in secondary prevention and individualize treatment to their needs.[28]

MPV was reported to have predictive and prognostic value in ACS.[6] PDW is identified as a prognostic predictor after MI, and its prognostic value is stronger than that of MPV. Thus, using PDW for the prediction of reinfarction and revascularization became reasonable.[13]

In the present study, we assessed the mean values of platelet indices (PDW, MPV, PCT) and platelet count in patients with acute STEMI at the time of admission who underwent PPCI. Our results revealed increased mean values of platelet indices. In addition, both MPV and PDW had a moderate positive correlation with the SYNTAX score, and PDW had a moderate positive correlation with the Gensini score. Furthermore, PDW had a mild negative correlation with final TIMI flow and EF%.

The results of this study were consistent with previous studies by Khandekar et al.,[9] Kiliçli-Çamur et al.,[29] Bharihoke et al.,[30] and Sušilović Grabovac et al.,[31] who reported significantly higher admission MPV values in MI patients than in stable CAD patients or controls of the same age. Also, studies by Khandekar et al.,[9] Ardakani et al.,[32] Pervin et al.,[33] Dehghani et al.,[34] and Celik et al.[35] demonstrated that elevated admission PDW value was associated with ACS, similar to MPV.

Huczek Z et al.[36] postulated that larger hyperactive platelets could contribute to the initiation of STEMI. Also, Leader A et al.[37] stated that platelet aggregation in response to collagen and ADP, thromboxane release, and membrane expression of P-selectin or GP1b and GP IIb/IIIa increased in these larger platelets.

There is a relationship between MPV and both proinflammatory and prothrombotic states, where thrombopoietin and various inflammatory cytokines, such as interleukin (IL1, 3, and 6) and tumor necrosis factor (TNF)-α, organize thrombosis. Moreover, in STEMI patients, platelets contribute to inflammation by binding to and activating monocytes.[38]

The mechanism of larger platelets after admission remains unclear. Newly produced platelets are usually bigger; differentiation and maturation of megakaryocytes take about 4–5 days, and the production and release of platelets from mature megakaryocytes require 24 hours.[39] Thus, it is less likely that admission high MPV after MI is only the result of newly produced bigger platelets from bone marrow. The spleen also serves as a reservoir for about one-third of peripheral platelets, with the MPV of these platelets being 20% larger than peripheral platelets. Thus, the spleen could be a reservoir of large platelets and may be responsible for quick changes in circulating large platelet count under stress and stimulation by cytokines or catecholamines.[40]

Furthermore, Yetkin E[41] suggested that platelet consumption during ACS can lead to the production of larger ones by megakaryocytes and consequent higher MPV value. He added that platelet count is inversely associated with MPV. Also, Huczek Z et al. reported a strong negative correlation between platelet count and MPV.[36]

Fewer studies have evaluated the mean values of PDW and PCT in STEMI patients. They postulated that the underlying mechanism of elevated PDW and PCT is increased inflammatory activity and provoked prothrombotic state.[14]

Our results were in agreement with previous studies by Akin et al.[42] who found that PDW was positively correlated with the SYNTAX score ($r=0.209$, $p<0.001$) in STEMI patients, inadequate coronary collateral, chronic total occlusion, and in-stent restenosis in patients with CAD.[43] Also, Bekler et al.[12] demonstrated that PDW was positively correlated with the Gensini score. Murat et al.[44] revealed a significant association between MPV and both the Gensini and SYNTAX scores. They added that MPV was associated with poor outcomes.Vogiatzis et al.[45] showed that MPV was significantly correlated with the SYNTAX score. Contrary to our results, Ekici et al.[46] found a significant correlation between MPV and the Gensini score. Also, Khode V et al.[47] concluded that there were no significant differences in PDW level between STEMI and stable CAD or controls; they added that higher MPV was associated with STEMI.

In the current study, regarding primary disease outcome, our results revealed that PDW was significantly associated with cardiac shock and total primary outcome. Platelet count and PCT were associated with re-infarction. However, in secondary disease outcomes, PDW was significantly associated with stroke, HF, and total MACE; platelet count, MPV, and PCT were associated with cardiogenic shock.

In agreement with the current study, Kowara et al.[48] showed that PDW was correlated with heart failure with EF ≤35% ($p=0.0248$). Huczek Z et al.[36] reported a strong relationship between MPV and prognosis post-PCI, with a higher 6-month mortality rate in patients with higher MPV ($p=0.0125$). Vogiatzis et al.[45] revealed that MPV was an independent predictor of MACE (HR=6.8, 95% CI 1.46-33.36).

Furthermore, studies observed that PDW may be considered a more specific marker than MPV, enabling early and easy identification of patients with poor prognosis. It was demonstrated that PDW had a strong association with MACE in patients undergoing PCI. Ulucan et al.[49] reported that PDW was an independent predictor of both in-hospital and long-term adverse outcomes in STEMI patients. Cetin et al.[50] observed that PDW was significantly higher in the thrombolysis failure group ($p<0.001$). They added that PDW was an independent predictor of thrombolysis failure in STEMI patients. Hu et al.[51] showed that PCT was a significant risk factor for stent restenosis.

To test the validity of platelet indices for the prediction of primary disease outcomes, ROC curve analysis revealed that only PDW and MPV were found to be significant predictors of MACE. Our results indicated that PDW is a reliable marker for predicting primary and secondary outcomes.

Limitations

The present study has some limitations, such as the small number of STEMI patients. Further studies with a larger number of patients and longer follow-up are recommended.

Conclusion

In this study, we evaluated platelet indices in STEMI patients who underwent PPCI. We concluded that PDW is a reliable marker for predicting primary and secondary outcomes and could be used as a predictor of re-infarction and adverse outcomes in STEMI patients. Further studies are required.

Disclosures

Ethics Committee Approval: Ethical Approval Patients were invited to participate in the study after getting informed consent and the steps and aim of the research were explained to participants. The authors assert that all procedures performed in this study were in accordance with the ethical standards of the institutional committee of medical ethics and with the 1964 Helsinki declaration.

Peer-review: Externally peer-reviewed.

Conflict of Interest: The authors declare that they have no conflict of interest.

Authorship Contributions: Concept – A.E.A., S.M.M., A.F.T., M.A.F., I.H.A.; Design – A.E.A., S.M.M., A.F.T., M.A.F., I.H.A.; Supervision– A.E.A., S.M.M., A.F.T., M.A.F., I.H.A. ; Materials – G.N.; Data collection and processing – A.E.A., S.M.M., A.F.T., M.A.F., I.H.A.; Analysis and interpretation – A.E.A., S.M.M., A.F.T., M.A.F., I.H.A.; Literature search – A.E.A, S.M.M, A.F.T, M.A.F., I.H.A.; Writing – A.E.A, S.M.M, A.F.T, M.A.F., I.H.A.; Critical Review – A.E.A., S.M.M., A.F.T., M.A.F.

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