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The role of platelet indices in diagnosis and identification of subgroups of acute coronary syndrome

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Abstract

The clinical manifestations of acute coronary syndrome (ACS) range from ST-segment elevation myocardial infarction (STEMI), which is characterized by irreversible myocardial necrosis, to unstable angina pectoris (USAP), which is characterized by reversible myocardial cell injury. Platelet count (PLT), mean platelet volume (MPV), and the MPV/PLT ratio have been shown in recent research to be useful indicators for atherothrombotic disease risk stratification as well as diagnosis. Our study's objective was to assess the diagnostic value of common laboratory tests utilized in emergency rooms, such as the MPV/PLT ratio, MPV, PLT count, and white blood cell (WBC) count, in patients with ACS. Because ACS is a fatal illness marked by platelet-rich thrombus development and plaque rupture, early detection is essential to lowering morbidity and mortality. There were 100 healthy controls and 137 ACS patients in the research. The subjects' clinical and demographic traits were noted. WBC, PLT, MPV, and MPV/PLT levels were compared between ACS subgroups as well as with the control group. According to our research, ACS patients had significantly lower MPV and PLT values than the control group. PLT and WBC counts were significantly greater across the ACS subgroups, although the STEMI group's MPV and MPV/PLT ratios were significantly lower than those of the NSTEMI and USAP groups. The MPV/PLT ratio was substantially lower in STEMI patients than in the control group. These findings imply that routine hemogram parameters can identify ACS before traditional biochemical markers become widely used. Specifically, low MPV and MPV/PLT ratios, as well as high PLT and WBC counts, could be early markers of STEMI.

Keywords: Acute coronary syndrome, mean platelet volume, MPV/PLT ratio, platelet, emergency medicine, STEMI, NSTEMI

Introduction

Cardiovascular diseases (CVDs) constitute the most prevalent and fatal conditions involving the heart and vascular system, including acute myocardial infarction (AMI) and ischemic heart disease [1]. Acute coronary syndrome (ACS) is an umbrella term describing a spectrum of clinical entities commonly encountered in emergency departments among patients presenting with chest pain. This spectrum includes unstable angina pectoris (USAP), ST-segment elevation myocardial infarction (STEMI), and non-ST-segment elevation myocardial infarction (NSTEMI). When left unrecognized or untreated, these conditions are associated with substantial morbidity and mortality. Early identification of pre-infarction myocardial ischemia is therefore essential, and clinicians must carefully evaluate patient-reported symptoms to detect ACS. However, due to the heterogeneity of clinical presentations, both diagnosis and management remain challenging [2].

AMI represents one of the most frequent medical emergencies presenting to emergency departments [3]. Although cardiac troponins are regarded as the gold standard biomarkers for the diagnosis of AMI, evidence indicates that troponin concentrations typically begin to rise approximately six hours after the onset of myocardial ischemia [4]. Consequently, growing attention has been directed toward identifying earlier and more sensitive diagnostic biomarkers for AMI, rather than relying solely on delayed troponin elevation. Inflammation plays a pivotal role not only in the initiation of atherosclerotic plaque formation but also in the progression and destabilization of existing plaques,

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ultimately contributing to disease development [5].

Platelets (PLTs) are essential components of hemostasis and play a central role in intravascular thrombus formation. Alterations in PLT activation significantly influence thrombus development and are therefore considered key factors in the pathogenesis of ACS. PLT dysfunction contributes to vascular disease progression by promoting atherosclerotic processes. Following plaque rupture and endothelial injury, PLT activation, aggregation, and subsequent thrombus formation are fundamental mechanisms leading to coronary artery occlusion. Thus, PLTs and PLT activation pathways are critically involved in both atherosclerosis and atherosclerosis-related ACS. Mean platelet volume (MPV) has emerged as a potentially useful clinical marker reflecting PLT activation status [6].

MPV, one of the routinely reported PLT indices in CBC analyses, reflects PLT stimulation and production. It is a relatively stable parameter that is not influenced by PLT lifespan. Elevated MPV values indicate increased PLT activation. Numerous studies have demonstrated that MPV is increased not only in MIbut also in cerebrovascular events, suggesting that elevated MPV may serve as a valuable clinical indicator in various vascular diseases. Moreover, high MPV levels have been associated with an increased risk of thrombotic events, including CVDs [7]. Among hematological biomarkers, white blood cell (WBC) count may also assist emergency physicians in estimating the risk of cardiovascular complications [8]. Recent evidence suggests that PLT count, MPV as an indicator of PLT activity, and the MPV/PLT ratio are inexpensive and readily available markers that may aid clinicians not only in diagnosing atherothrombotic disorders but also in risk stratification. These parameters are routinely evaluated in nearly all patients presenting to the emergency department [9–11].

Accordingly, the present study aimed to assess the diagnostic value of PLT count, MPV, and the MPV/PLT ratio parameters frequently obtained in the emergency department in supporting cardiac biomarkers with longer half-lives, facilitating early diagnosis, preventing disease progression, and reducing cardiovascular comorbidities in patients with ACS. Additionally, this study sought to evaluate the effectiveness of these hematological parameters in differentiating between STEMI, NSTEMI, and USAP.

Material and Methods

Following approval by the Hitit University School of Medicine Clinical Research Ethics Committee (Approval No: 2023-42, Date:29 March, 2023), this retrospective study included patients who were hospitalized with a diagnosis of ACS between September 1 and December 31, 2022. Demographic and clinical characteristics of eligible patients were retrospectively reviewed and recorded. Exclusion criteria comprised age younger than 18 years; elevated troponin levels attributable to non-cardiac causes such as pulmonary embolism, sepsis, or subarachnoid hemorrhage; incomplete records in the hospital information system; and missing follow-up data.

Collected variables included age, sex, presenting symptoms, length of hospital stays, type of myocardial infarction (MI), number and localization of occluded coronary arteries, treatment modality (primary percutaneous coronary intervention [PCI], medical therapy, or a combination of both), and laboratory parameters, including WBC count, PLT count, MPV, and the MPV/PLT ratio. CBC analyses for all study participants were performed using a BC-6800 Mindray automated hematology analyzer, while biochemical measurements were conducted with a Beckman Coulter AU5800 clinical chemistry analyzer.

Patients were categorized into three subgroups based on clinical presentation and electrocardiographic findings: STEMI, NSTEMI, and USAP. Patients presenting to the emergency department with cardiac-type chest pain and exhibiting ≥1 mm ST-segment elevation in at least two contiguous electrocardiographic leads, regardless of troponin I levels, were assigned to the STEMI group. Patients with cardiac-type chest pain and elevated serum troponin I levels not attributable to secondary causes, in the absence of ischemic electrocardiographic changes or ST-segment elevation, were classified as the NSTEMI group. Patients presenting with cardiac-type chest pain but without evidence of MI defined by normal troponin levels and the absence of ischemic changes on electrocardiography were categorized as the USAP group [12].

For comparative purposes, a control group was established comprising patients admitted to the emergency department for non-cardiac complaints and without a diagnosis of ACS. WBC, PLT, MPV, and MPV/PLT ratio values for both the ACS and control groups were obtained from the hospital information system and subjected to statistical comparison across groups.

Statistical Analysis

The Statistical Package for the Social Sciences (SPSS) for Windows, version 15.0 (SPSS Inc., Chicago, IL, USA), was used to perform statistical analyses. The Chi-square test was used to analyses categorical variables, which were represented as frequencies. The Kolmogorov–Smirnov test was used to determine whether quantitative data was normal. The independent samples t-test was used to compare two groups for normally distributed variables, whereas the Mann–Whitney U test was used for non-parametric data. The Kruskal-Walli's test was employed for non-normally distributed data and one-way ANOVA for regularly distributed data in multiple group comparisons. Levene's test was used to confirm that the variances in the ANOVA were homogeneous. Post-hoc analyses were performed using Tamhane's T2 test for heterogeneous variances and Tukey's test for homogeneous variances where the ANOVA results were significant. P-values less than 0.05 were regarded as statistically significant.

Result

A total of 237 patients were included in the study, consisting of 137 individuals who presented to the emergency department with cardiac-type chest pain and were diagnosed with ACS, and a control group of 100 individuals without cardiac chest pain. Among patients with ACS, 31.3% (n=43) were diagnosed with

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STEMI, 57.6% (n=79) with NSTEMI, and 10.9% (n=15) with USAP.

The majority of patients in the ACS group were male (76.6%), with a mean age of 63.31±13.14 years. Assessment of presenting symptoms demonstrated that chest pain was the predominant complaint at emergency department admission, reported by 96.2% (n=132) of the ACS patients. The mean WBC count was 10.82±3.49×10⁹/L, the mean PLT count was 214.17±50.56×10⁹/L, the mean MPV was 8.72±0.81 fL, and the mean MPV/PLT ratio was 0.043±0.014. Regarding hospitalization characteristics, 90.0% (n=126) of the patients had a hospital length of stay between 1 and 3 days. Single-vessel coronary artery occlusion was identified in 62.8% of cases. The most commonly affected vessel was the left anterior descending (LAD) artery (56.9%, n=78), followed by the right coronary artery (35.8%, n=49). PCI was performed in 78.1% (n=127) of the patients. Detailed demographic, clinical, and laboratory findings are summarized in Table 1.

Table 1. Baseline characterstics of the patients with ACS

Variable		**Mean±Std. Deviation**	**Median**
Age		63.31±13.14	65
WBC (109 /L)		10.82±3.49	10,1
PLT (109 /L)		214.17±50.56	213
MPV (fL)		8.72±0.81	8.8
MPV/PLT		0.043±0.014	0.041
Variable		**Frequency**	**Percentage**
Complaint (Chi-Square=371.99; p≤0.001)	Chest Pain	132	96.4
	Diaphoresis	1	0.7
	Back Pain	2	1.5
	Altered mental status	2	1.5
Hospital Stay (Chi-Square=73.91; p≤0.001) Mean=2.13 Std. Deviation=0.94 Median=2	1 day	37	27
	2 days	58	40.3
	3 days	31	22.7
	4 days	9	6.6
	5 days	2	1.5
Occluded Vessel	LAD	78	56.9
	RCA	49	35.8
	Cx	40	29.2
	No occlusion	12	8.8
Treatment Method	PCI	127	92.7
	Medical	8	5.8
	Both	2	1.4

WBC: White blood cell, PLT: Platelet, MPV: Mean platelet volume, LAD: Left anterior descending, RCA: Right coronary artery, Cx: Circumflex, PCI: Percutaneous coronary intervention

In the healthy control group, the mean age was 42.75±9.84 years. The mean PLT count was 251.03±63.08×10⁹/L, the mean MPV was 10.26±0.85 fL, and the mean MPV/PLT ratio was 0.048±0.045. When patients with ACS, including STEMI, NSTEMI, and USAP, were compared with the healthy control group, MPV and PLT values were significantly lower in the ACS group. In contrast, no statistically significant difference was observed in the MPV/PLT ratio between the two groups ($p<0.001$, $p<0.001$, and $p=0.816$, respectively). Detailed comparative data are presented in Table 2.

Subgroup analysis within the ACS cohort evaluated PLT, MPV, MPV/PLT ratio, and WBC count across STEMI, NSTEMI, and USAP groups. In the STEMI subgroup, the mean PLT count was 231.93±53.86×10⁹/L, MPV was 8.49±0.73 fL,

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Table 2. Comparison of controls with patients with ACS (STEMI, NSTEMI, USAP)

Variables	Controls		Patients		Statistics	Significance*
	Mean±SD	Median	Mean±SD	Median		
Age	42.75±9.84	40.0	63.31±13.14	65.0	t=13.77	p≤0.001
MPV (fL)	10.26±0,85	10.2	8.72±0.81	8.8	t=-14.13	p≤0.001
PLT (109 /L)	251.03±63.08	241.5	214.17±50.56	213.0	t=-14.13	p≤0.001
MPV/PLT	0.048±0.045	0.042	0.042±0.014	0.041	μ=6729	p=0.816

* A p-value of <0.05 was considered statistically significant

WBC count was 12.33±4.78×10⁹/L, and the MPV/PLT ratio was 0.038±0.012. In the NSTEMI subgroup, the mean PLT count was 207.70±47.92×10⁹/L, MPV was 8.97±0.84 fL, WBC count was 10.00±2.28×10⁹/L, and the MPV/PLT ratio was 0.045±0.014. In the USAP subgroup, the mean PLT count was 197.12±42.34×10⁹/L, MPV was 8.59±0.79 fL, WBC count was 10.57±2.89×10⁹/L, and the MPV/PLT ratio was 0.045±0.011. Comparative analysis demonstrated that PLT and WBC levels were significantly higher in the STEMI group compared with the other ACS subgroups (p=0.013 and p=0.002, respectively), whereas MPV and MPV/PLT values were significantly lower (p=0.026 and p=0.004, respectively). Conversely, the NSTEMI group exhibited significantly higher MPV values (p=0.026) and significantly lower WBC counts compared with the remaining ACS subgroups (p=0.002). Detailed subgroup comparisons are summarized in Table 3.

When the ACS subgroups were compared with the control group, MPV values were significantly higher in the control group than in the STEMI, NSTEMI, and USAP groups (p<0.001). With respect to PLT counts, the NSTEMI and USAP groups demonstrated significantly lower values compared with both the STEMI and control groups (p<0.001). Additionally, the MPV/PLT ratio was significantly lower in the STEMI group than in all other groups (p=0.012). Detailed intergroup comparisons are presented in Table 4.

Table 3. Comparison of subgroups of ACS

Variables	STEMI		USAP		NSTEMI		Test Statistics	Significance*
	Mean±SD	Median	Mean±SD	Median	Mean±SD	Median		
MPV (fL)	8.49±0.73	8.3	8.59±0.79	9.0	8.89±0.83	8.8	F=3.746	p=0.026
PLT (109 /L)	231.93±53.86	238.5	197.12±42.34	192.0	207.70±47.92	208	F=4.528	p=0.013
MPV/PLT	0.038±0.012	0.036	0.045±0.011	0.045	0.045±0.014	0.043	KW=10.953	p=0.004
WBC (109 /L)	12.33±4.78	11.30	10.57±2.89	10.20	10.0±2.28	9.85	F=6.804	p=0.002

* A p-value of <0.05 was considered statistically significant F: Test Statistics of One Way ANOVA; KW: Test Statistics of Kruskal Wallis

Table 4. Comparison of subgroups of ACS with control group

Variables	STEMI		USAP		NSTEMI		Control Group		Test Statistics	Significance
	Mean±SD	Median	Mean±SD	Median	Mean±SD	Median	Mean±SD	Median		
MPV (fL)	8.49±0.73	8.30	8.59±0.79	9.00	8.89±0.83	8.8	10.26±0.85	10.20	F=70.331	p≤0.001
PLT (109 /L)	231.93±53.86	238.50	197.12±42.34	192.00	207.70±47.92	208	251.03±63.08	241.50	F=10.853	p≤0.001
MPV/PLT	0.038±0.012	0.036	0.045±0.011	0.045	0.045±0.014	0.043	0.048±0.045	0.042	KW=10.928	p=0.012

* A p-value of <0.05 was considered statistically significant F: Test Statistics of One Way ANOVA; KW: Test Statistics of Kruskal Wallis

Discussion

In the present study, patients presenting to the emergency department with cardiac complaints and diagnosed with ACS were compared with healthy controls, and significantly lower MPV and PLT values were observed in the ACS cohort. In subgroup analyses, although no significant difference in the MPV/PLT ratio was identified between the overall ACS population and the control group, the MPV/PLT ratio was significantly lower in patients with STEMI compared with controls. In addition, PLT counts were significantly reduced in the USAP and NSTEMI subgroups relative to the other groups. These findings suggest that

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routinely available hematological parameters, including MPV, PLT, and the MPV/PLT ratio, may provide supportive diagnostic information for emergency department clinicians, particularly in patients with NSTEMI and USAP, in whom electrocardiographic findings may be non-diagnostic and cardiac troponin elevations may be delayed. Although STEMI can be promptly diagnosed based on electrocardiographic criteria, these parameters may contribute to early risk assessment and clinical decision-making in non-ST-elevation ACS before definitive cardiac biomarker results become available.

CAD remains one of the leading causes of mortality worldwide. Its pathogenesis is initiated by atherosclerosis, a complex process in which PLTs play a central role. The development and progression of atherosclerosis are influenced by numerous endogenous and exogenous risk factors, including smoking, alcohol consumption, diabetes mellitus, hypertension, psychological stress, and a positive family history. Among these factors, advancing age and male sex have been consistently identified as independent predictors of CAD [2,3]. Previous studies have reported that patients with ACS most commonly present to the emergency department with acute chest pain, often described as sharp or pressure-like, radiating to the back, jaw, or upper extremities, and occasionally exacerbated by inspiration or physical movement [13]. In line with these reports, the majority of patients with ACS in the present study were male, and chest pain constituted the predominant presenting complaint at emergency department admission. These findings underscore the importance of maintaining a high index of suspicion for ACS in male patients presenting with chest pain. Angiographic studies have demonstrated that ACS is most frequently associated with single-vessel coronary artery occlusion, with the LAD artery being the most commonly involved vessel [14]. Consistent with the existing literature, our findings revealed a predominance of single-vessel disease, with the LAD artery identified as the most frequently affected coronary artery.

Our findings demonstrated that although MPV and the MPV/PLT ratio were significantly lower in the STEMI group compared with the NSTEMI and USAP groups, PLT and WBC levels were significantly higher in patients with STEMI. Notably, the MPV/PLT ratio was significantly lower in the STEMI group than in all other groups, including the control population. It is well established that alterations in PLT activation play a pivotal role in the pathogenesis of atherosclerosis and thrombus formation [15]. During thrombotic processes, PLTs typically become larger and more reactive, a phenomenon reflected by an increase in MPV, which serves as a surrogate marker of PLT activation [16]. Mean platelet volume, a routinely reported parameter in complete blood count (CBC) analyses commonly performed in emergency departments, provides a reliable indicator of PLT size and functional activity [17]. In a population-based study involving 326 healthy Turkish adults, the mean MPV value was reported as 8.9±1.4 fL, with 95% of individuals demonstrating MPV values within the range of 7.2–11.7 fL. MPV values falling outside this reference interval have been suggested to warrant further clinical evaluation for potential occlusive arterial disease [18].

Alvitigala et al. reported significantly higher MPV values in patients with STEMI compared with healthy controls [16]. In contrast, our findings demonstrated that patients with NSTEMI exhibited higher MPV values than those with STEMI, while the control group showed the highest MPV values among all study groups. Previous investigations have suggested that both NSTEMI and STEMI patients may demonstrate reduced MPV and PLT levels during the early phase of ACS, particularly within the first three hours following symptom onset, followed by a gradual increase over the subsequent 3–7 days. This initial reduction in larger PLTs has been attributed to PLT consumption during active thrombus formation [17]. Accordingly, the overall lower platelet-related parameters observed in our ACS cohort including PLT count, MPV, and the MPV/PLT ratio may reflect early PLT activation and consumption during the acute thrombotic phase of ACS. These findings support the hypothesis that dynamic changes in PLT indices occur early in the disease course and may influence the interpretation of MPV-based biomarkers at the time of emergency department presentation.

Recent studies investigating ACS with the aim of reducing associated mortality and morbidity and improving early diagnosis have proposed the MPV/PLT ratio as a potential biomarker for the early detection and risk stratification of ACS, as well as other atherosclerotic vascular diseases, particularly ischemic stroke [18,20]. Several reports have demonstrated that elevated MPV/PLT ratios are associated with adverse clinical outcomes in both STEMI and NSTEMI populations, and that a high MPV/PLT ratio serves as an independent predictor of long-term unfavorable outcomes in patients undergoing PCI following STEMI [21–23]. Moreover, the MPV/PLT ratio has been shown to exhibit good predictive accuracy for major adverse cardiovascular events. In contrast to these findings, our study demonstrated that a lower MPV/PLT ratio was significantly associated with STEMI. This discrepancy may reflect differences in PLT consumption, activation, and turnover during the early acute phase of coronary thrombosis, as opposed to later phases assessed in prognostic studies. These results suggest that the clinical interpretation of the MPV/PLT ratio may be time-dependent and influenced by the dynamic PLT response during acute myocardial ischemia.

Another routinely assessed hematological marker in emergency department practice, the WBC count, serves as an indicator of systemic inflammatory response. Nyu et al. demonstrated that elevated WBC counts were independent predictors of major adverse cardiovascular events during one-year follow-up in patients with MI [24]. Similarly, Kaminska et al. reported significantly higher WBC and MPV levels in patients with ACS compared with healthy controls [5]. In accordance with these observations, our findings indicate that patients presenting to the emergency department with cardiac-type chest pain and subsequently diagnosed with STEMI may exhibit elevated WBC values at the time of admission. Electrocardiography,

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along with routine hematological and biochemical testing, constitutes the cornerstone of initial evaluation in patients presenting to the emergency department with cardiac symptoms. The present study may contribute to the early assessment and clinical management of ACS by highlighting the potential utility of rapidly available hematological parameters, particularly in patients presenting with non–ST-segment elevation symptoms. Nevertheless, as outlined in the study limitations, the relatively small sample size and the absence of longitudinal outcome data, such as mortality or discharge status, preclude the use of these parameters as standalone tools for clinical decision-making. Despite these limitations, we suggest that MPV, PLT, MPV/PLT ratio, and WBC values may serve as adjunctive indicators to support clinical judgment in patients at high risk for ACS.

Limitations

Several limitations of this study should be acknowledged. First, the retrospective design inherently carries methodological constraints, including potential selection bias and incomplete data capture. In addition, owing to the retrospective nature of the study, the interval between symptom onset and blood sample collection could not be reliably determined, which may have influenced platelet-related parameters.

Another limitation is the relatively small sample size, which may restrict the generalizability of the findings. Moreover, no matching or adjustment was performed between the patient and control groups with respect to age, comorbidities, or demographic characteristics. This approach was intentionally chosen to reflect a real-world emergency department population; however, it may have introduced confounding effects. The absence of an a priori power analysis represents an additional limitation. Future studies designed with appropriate sample size calculations may provide more robust and reliable results.

Furthermore, the lack of patient follow-up precluded evaluation of the prognostic value of PLT indices and their associations with long-term clinical outcomes, including mortality. The study also did not categorize ACS patients according to occlusive versus non-occlusive coronary lesions, thereby limiting the assessment of PLT indices in relation to angiographic severity and prognostic stratification. Finally, the observational design did not allow for exploration of the underlying pathophysiological mechanisms responsible for the observed alterations in PLT parameters.

Conclusion

In conclusion, MPV and PLT counts were significantly lower in patients with ACS compared with the control group. Elevated WBC and PLT levels may serve as supportive indicators for identifying STEMI among patients with ACS, whereas higher MPV and MPV/PLT ratios may be more suggestive of NSTEMI presentations. In emergency department settings, CBC parameters obtained before the availability of cardiac biomarker results may assist clinicians in the early evaluation of patients with suspected ACS. Nevertheless, large-scale prospective studies are required to validate these findings and to further elucidate the potential prognostic value of hematological parameters in ACS.

Conflict of Interests
The authors declare that there is no conflict of interest in the study.

Financial Disclosure
The authors declare that they have received no financial support for the study.

Ethical Approval
The study received ethical approval from the Hitit University School of Medicine Clinical Research Ethics Committee (Approval No: 2023-42, Date:29 March, 2023).

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