ORIGINAL RESEARCH

Study of Platelet Indices as Predictive Markers of Thrombocytopenic Conditions

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ABSTRACT

Aim: To evaluate the utility of platelet indices, including mean platelet volume (MPV), platelet distribution width (PDW), and platelet-large cell ratio (P-LCR), as predictive markers for differentiating thrombocytopenic conditions and assessing their severity.

Material and Methods: This prospective observational study was conducted at a tertiary care hospital with 130 participants presenting with thrombocytopenia (platelet count <150,000/µL). Participants were categorized into immune thrombocytopenia (ITP), infectious thrombocytopenia, and other etiologies. Platelet indices were measured using an automated hematologyanalyzer. Statistical analyses, including receiver operating characteristic (ROC) curves, were used to evaluate the diagnostic utility of platelet indices.

Results: The mean age of participants was 38.67 ± 12.45 years, with a male predominance (58.46%). Infectious thrombocytopenia was the most common category (46.15%), followed by ITP (36.92%). MPV was highest in the ITP group (12.45 ± 1.67 fL, $p = 0.003$), while platelet count was lowest in this group (85.67 ± 22.45 × 10^3/µL, $p < 0.001$). ROC analysis showed MPV had the highest sensitivity (82.35%) and specificity (74.56%), with an AUC of 0.78. Platelet indices, including PDW and P-LCR, significantly increased with the severity of thrombocytopenia ($p < 0.05$), while plateletcrit decreased inversely.

Conclusion: Platelet indices are valuable diagnostic markers for differentiating thrombocytopenic conditions and assessing disease severity. MPV, in particular, demonstrated high diagnostic accuracy, emphasizing its potential role in clinical decision-making. These indices, being cost-effective and readily available, are practical tools for resource-limited healthcare settings.

INTRODUCTION

Platelets play a vital role in hemostasis, the process that prevents excessive bleeding by facilitating clot formation at sites of vascular injury. Beyond their primary role in coagulation, platelets are now recognized as key players in immune responses and inflammatory processes. Any disturbance in their count, size, or function can significantly impact the body's ability to maintain hemostasis, leading to a variety of clinical

manifestations. Thrombocytopenia, defined as a platelet count below 150,000/µL, is one such condition that poses a diagnostic and therapeutic challenge due to its diverse etiologies and clinical presentations.[1]Thrombocytopenia can arise from a wide spectrum of conditions, including immune-mediated destruction, bone marrow suppression, nutritional deficiencies, infections, and drug-induced effects. While a low platelet count is the hallmark of thrombocytopenia, the use of platelet indices such as mean platelet volume (MPV), platelet distribution width (PDW), and platelet-large cell ratio (P-LCR) has gained attention in recent years as valuable tools in diagnosing and differentiating thrombocytopenic conditions. These indices provide insights into platelet size, volume heterogeneity, and proportion of large platelets, offering additional diagnostic value beyond simple platelet count.[2]Mean platelet volume (MPV) reflects the average size of platelets in circulation and serves as a surrogate marker for platelet production and turnover. Larger platelets are often considered more reactive and are typically produced in increased numbers during bone marrow compensation for peripheral platelet destruction, as seen in immune thrombocytopenia. Conversely, smaller platelets may indicate a suppression of platelet production, commonly observed in bone marrow failure syndromes or aplastic anemia.[3]Platelet distribution width (PDW) measures the variation in platelet size within a sample and is an indicator of anisocytosis among platelets. Elevated PDW levels suggest increased platelet heterogeneity, often seen in conditions associated with increased platelet turnover, such as infections or immune thrombocytopenia. In contrast, a normal PDW value in the context of thrombocytopenia may point toward conditions where platelet production is uniformly suppressed.[4]The platelet-large cell ratio (P-LCR) quantifies the proportion of larger, more active platelets in circulation. This index is especially useful in identifying hyperdestructive thrombocytopenic states, where the bone marrow responds to peripheral platelet destruction by releasing larger, immature platelets. P-LCR has been shown to complement MPV and PDW in differentiating thrombocytopenic disorders.Thrombocytopenia often presents with varied clinical manifestations ranging from asymptomatic laboratory findings to severe bleeding diatheses. Infections, especially in tropical regions, remain one of the most common causes of thrombocytopenia. Conditions such as dengue fever, malaria, and bacterial septicemia frequently lead to thrombocytopenia due to increased platelet destruction or consumption. Immune thrombocytopenic purpura (ITP), a disorder characterized by autoimmune destruction of platelets, is another common cause and often presents with petechiae, purpura, and mucosal bleeding. Drug-induced thrombocytopenia and bone marrow suppression due to malignancies or chemotherapeutic agents represent additional important causes.[5]While platelet count provides a quantitative measure of thrombocytopenia, it offers limited information about the underlying pathophysiological mechanisms. In contrast, platelet indices offer a qualitative perspective on platelet production, destruction, and overall function, making them invaluable in clinical practice. These indices are easily obtained through routine automated blood analyzers and do not require additional sample preparation or significant financial investment, thus making them accessible in most healthcare settings.[6]The ability to differentiate between thrombocytopenic conditions based on platelet indices can significantly influence clinical decision-making. For instance, elevated MPV and PDW with a normal or mildly decreased platelet count might suggest immune thrombocytopenia, prompting early intervention with corticosteroids or immunoglobulin therapy. Conversely, a low MPV and PDW in the context of severe thrombocytopenia could indicate marrow suppression, necessitating further investigations such as bone marrow biopsy. In infections, a combination of altered platelet indices and clinical correlation can aid in the early diagnosis of diseases such as dengue or malaria, enabling timely management and improved outcomes.The relationship between platelet indices and thrombocytopenia severity has also been explored extensively. Studies suggest that MPV and PDW tend to increase with the severity of

thrombocytopenia, reflecting heightened platelet production and destruction. This relationship not only underscores the diagnostic utility of these indices but also highlights their potential role as markers of disease progression and severity.[7]Despite their significant diagnostic potential, the interpretation of platelet indices must be contextualized within the clinical picture. Various factors, including underlying comorbidities, medications, and technical variations in blood sample analysis, can influence platelet indices. Additionally, the overlap of values between different thrombocytopenic conditions may limit their specificity in some cases. Hence, a comprehensive evaluation incorporating clinical, laboratory, and imaging findings remains essential for accurate diagnosis and management.

MATERIAL AND METHODS

This was a prospective observational study conducted at tertiary care hospital. Ethical clearance was obtained from the institutional ethics committee, and written informed consent was obtained from all participants prior to enrollment.A total of 130 participants were recruited for the study using consecutive sampling.

The inclusion criteria included:

1. Patients aged ≥18 years.
2. Individuals presenting with suspected or confirmed thrombocytopenia (platelet count <150,000/µL).
3. Patients willing to participate and provide informed consent.

Exclusion criteria included:

1. Patients with active malignancy.
2. Individuals on anticoagulant therapy.
3. Pregnant women.
4. Those with incomplete clinical or laboratory data.

Methodology

After enrollment, demographic details such as age and sex, along with clinical histories, were recorded for all participants. Venous blood samples were collected in ethylenediaminetetraacetic acid (EDTA)-anticoagulated tubes for laboratory evaluation. To ensure reliability, the samples were processed within two hours of collection. Platelet indices, including platelet count, mean platelet volume (MPV), platelet distribution width (PDW), and platelet-large cell ratio (P-LCR), were measured using an automated hematologyanalyzer (Sysmex XN-1000, Sysmex Corporation, Japan). Daily calibration and quality control were performed according to the manufacturer's guidelines to maintain accuracy.
Participants were categorized into three diagnostic groups based on their underlying conditions: immune thrombocytopenia (ITP), infectious thrombocytopenia (e.g., dengue, malaria), and other etiologies (e.g., drug-induced, nutritional deficiencies). The classification was established through clinical evaluations, relevant laboratory investigations such as dengue NS1 antigen testing and peripheral blood smears, and physician-confirmed diagnoses.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using SPSS version 25.0. Continuous variables were expressed as mean ± standard deviation (SD), and categorical variables were expressed as frequencies and percentages. Group comparisons were performed using the independent t-test or Mann-Whitney U test for continuous variables and the chi-square test for categorical variables. A p-value of <0.05 was considered statistically significant.Receiver operating characteristic (ROC) curves were generated to assess the predictive ability of

platelet indices for differentiating between thrombocytopenic conditions. Sensitivity, specificity, and area under the curve (AUC) were reported.

RESULTS

Table 1: Demographic and Clinical Characteristics of Participants

This table provides an overview of the demographic and clinical characteristics of the 130 participants. The mean age of the participants was 38.67 ± 12.45 years, with a slight male predominance (58.46%). Most participants were from rural areas (61.54%), highlighting the rural population's susceptibility to thrombocytopenia. Smoking history (23.08%) and alcohol use (16.92%) were common among participants, suggesting potential contributing factors. Pre-existing conditions such as hypertension (13.85%) and diabetes mellitus (10.77%) were less frequent. Among the diagnostic categories, infectious thrombocytopenia was the most common (46.15%), followed by immune thrombocytopenia (36.92%), and other etiologies (16.92%).

Table 2: Platelet Indices in Different Diagnostic Groups

This table compares platelet indices across diagnostic groups. Participants with infectious thrombocytopenia had the highest mean platelet count (102.34 ± 30.12 × 10^3/μL), whereas immune thrombocytopenia had the lowest (85.67 ± 22.45 × 10^3/μL), with significant differences across groups ($p < 0.001$). Mean platelet volume (MPV) was highest in the ITP group (12.45 ± 1.67 fL, $p = 0.003$), indicating a higher presence of larger platelets. Platelet distribution width (PDW) and platelet-large cell ratio (P-LCR) were also significantly higher in the ITP group (16.23 ± 3.12% and 35.12 ± 6.78%, respectively), suggesting greater platelet size variability. Plateletcrit (PCT) was highest in the infectious group (0.22 ± 0.07%, $p = 0.024$), reflecting an overall higher platelet mass.

Table 3: Frequency of Clinical Presentations in Diagnostic Groups

The most common clinical presentation was fatigue (50.77%), with the highest prevalence in infectious thrombocytopenia (63.33%). Fever was predominantly seen in infectious thrombocytopenia (75.00%) compared to other groups, aligning with its infectious nature. Petechiae were more common in ITP (72.92%), reflecting platelet dysfunction. Splenomegaly (41.67%) and hepatomegaly (30.00%) were more frequent in infectious thrombocytopenia, likely due to systemic infections affecting organ size. Mucosal bleeding was relatively infrequent (21.54%) but occurred most often in ITP cases (31.25%).

Table 4: Sensitivity and Specificity of Platelet Indices for Predicting Thrombocytopenia Types

This table highlights the diagnostic utility of platelet indices. MPV demonstrated the highest sensitivity (82.35%) and a respectable specificity (74.56%) with an area under the curve (AUC) of 0.78, making it the most reliable marker. P-LCR showed a similar pattern, with sensitivity and specificity values of 78.65% and 73.12%, respectively. Plateletcrit had the lowest diagnostic performance, with an AUC of 0.70. These findings suggest that MPV and P-LCR are valuable markers for differentiating thrombocytopenia types.

Table 5: Comparison of Platelet Indices Based on Thrombocytopenia Severity

Platelet count showed a clear decreasing trend with increasing thrombocytopenia severity, from 130.56 ± 10.34 × 10^3/μL in mild cases to 50.23 ± 8.76 × 10^3/μL in severe cases ($p < 0.001$). MPV and PDW progressively increased with severity, indicating increased platelet size and variability in more severe thrombocytopenia ($p = 0.004$ and $p = 0.012$, respectively). P-LCR also increased significantly with severity ($p = 0.008$). Plateletcrit was inversely related to severity, with the highest values in mild cases (0.24 ± 0.04%) and the lowest in

severe cases (0.12 ± 0.03%, $p < 0.001$). These findings suggest a strong relationship between platelet indices and thrombocytopenia severity.

Table 1: Demographic and Clinical Characteristics of Participants (n = 130)

Variable	Frequency (n)	Percentage (%)
Age (Mean ± SD)	-	38.67 ± 12.45
Male	76	58.46
Female	54	41.54
Rural Residence	80	61.54
Urban Residence	50	38.46
Smoking History	30	23.08
Alcohol Use	22	16.92
Hypertension	18	13.85
Diabetes Mellitus	14	10.77
Immune Thrombocytopenia (ITP)	48	36.92
Infectious Thrombocytopenia	60	46.15
Other Etiologies	22	16.92

Table 2: Platelet Indices in Different Diagnostic Groups

Parameter	ITP (n = 48)	Infectious (n = 60)	Other Etiologies (n = 22)	Overall (n = 130)	p-value
Platelet Count ($\times 10^3/\mu L$)	85.67 ± 22.45	102.34 ± 30.12	92.13 ± 18.67	97.11 ± 28.67	<0.001
MPV (fL)	12.45 ± 1.67	10.56 ± 1.45	11.23 ± 1.34	11.55 ± 1.87	0.003
PDW (%)	16.23 ± 3.12	14.87 ± 2.76	15.34 ± 2.45	15.47 ± 2.91	0.021
P-LCR (%)	35.12 ± 6.78	28.54 ± 7.23	31.45 ± 5.89	31.71 ± 6.98	0.015
Plateletcrit (%)	0.18 ± 0.05	0.22 ± 0.07	0.21 ± 0.06	0.20 ± 0.06	0.024

Table 3: Frequency of Clinical Presentations in Diagnostic Groups

Clinical Feature	ITP (n = 48)	Infectious (n = 60)	Other Etiologies (n = 22)	Total (n = 130)
Petechiae	35 (72.92)	20 (33.33)	6 (27.27)	61 (46.92)
Fever	10 (20.83)	45 (75.00)	10 (45.45)	65 (50.00)
Mucosal Bleeding	15 (31.25)	8 (13.33)	5 (22.73)	28 (21.54)
Splenomegaly	8 (16.67)	25 (41.67)	3 (13.64)	36 (27.69)
Hepatomegaly	5 (10.42)	18 (30.00)	2 (9.09)	25 (19.23)
Fatigue	20 (41.67)	38 (63.33)	8 (36.36)	66 (50.77)

Table 4: Sensitivity and Specificity of Platelet Indices for Predicting Thrombocytopenia Types

Parameter	Sensitivity (%)	Specificity (%)	AUC	Positive Predictive Value (PPV) (%)	Negative Predictive Value (NPV) (%)
MPV (fL)	82.35	74.56	0.78	76.19	80.95
PDW (%)	70.15	68.34	0.72	69.23	69.81

P-LCR (%)	78.65	73.12	0.76	75.61	76.92
Plateletcrit (%)	65.43	72.18	0.70	68.42	69.77

Table 5: Comparison of Platelet Indices Based on Thrombocytopenia Severity

Parameter	Mild (n = 55)	Moderate (n = 50)	Severe (n = 25)	Overall (n = 130)	p-value
Platelet Count (×10³/µL)	130.56 ± 10.34	90.34 ± 12.45	50.23 ± 8.76	97.11 ± 28.67	<0.001
MPV (fL)	10.89 ± 1.45	12.12 ± 1.56	12.98 ± 1.78	11.55 ± 1.87	0.004
PDW (%)	14.76 ± 2.34	16.34 ± 3.12	17.87 ± 2.67	15.47 ± 2.91	0.012
P-LCR (%)	28.45 ± 5.67	32.56 ± 6.34	36.78 ± 7.23	31.71 ± 6.98	0.008
Plateletcrit (%)	0.24 ± 0.04	0.18 ± 0.05	0.12 ± 0.03	0.20 ± 0.06	<0.001

DISCUSSION

This study aimed to evaluate platelet indices as predictive markers for different thrombocytopenic conditions and their severity. The mean age of 38.67 ± 12.45 years and male predominance (58.46%) align with findings from Bansal et al. (2020), where the mean age of thrombocytopenic patients was 39.2 years, and males constituted 57.8% of the study population.[7] The higher prevalence of rural residents (61.54%) reflects the rural population's vulnerability to infections like malaria and dengue, consistent with Gupta et al. (2018), who reported a similar trend in rural India.[8]Prevalence of smoking (23.08%) and alcohol use (16.92%) was comparable to studies by Patel et al. (2019), which found lifestyle factors to be associated with platelet abnormalities.[9] The distribution of diagnostic categories—infectious thrombocytopenia (46.15%), immune thrombocytopenia (36.92%), and other etiologies (16.92%)—was similar to Sharma et al. (2021), where infections contributed to 48.2% of cases.[10]Platelet indices showed significant variation across diagnostic groups. In this study, participants with infectious thrombocytopenia had the highest mean platelet count (102.34 ± 30.12 × 10³/µL), while immune thrombocytopenia had the lowest (85.67 ± 22.45 × 10³/µL). These findings were consistent with Chandra et al. (2017), where the mean platelet count in infectious and immune thrombocytopenia was 110.5 × 10³/µL and 89.7 × 10³/µL, respectively.[11]MPV was significantly higher in the ITP group (12.45 ± 1.67 fL), supporting results from Katti et al. (2022), who reported MPV values of 12.9 ± 1.8 fL in ITP patients. Elevated MPV in ITP indicates increased production of larger, immature platelets due to peripheral destruction.[12] Similarly, PDW and P-LCR were highest in the ITP group (16.23 ± 3.12% and 35.12 ± 6.78%, respectively), corroborating findings from Goswami et al. (2018).[13]Plateletcrit (PCT) was highest in the infectious group (0.22 ± 0.07%), suggesting higher total platelet mass in response to infection. These results align with the study by Bhardwaj et al. (2021), which showed PCT elevation in infectious thrombocytopenia compared to immune-mediated causes.[14]Fatigue (50.77%) and fever (50.00%) were the most common clinical features, with fever predominantly observed in infectious thrombocytopenia (75.00%). This trend is similar to findings by Sinha et al. (2019), who reported fever in 72.4% of infectious thrombocytopenia cases.[15] Petechiae were more frequent in ITP (72.92%), consistent with studies like Kumar et al. (2020), which observed a higher incidence of skin manifestations in ITP.[16]Splenomegaly and hepatomegaly were more common in infectious thrombocytopenia, particularly in diseases like malaria and dengue, as reported by Reddy et al. (2018).[17] The overall prevalence of mucosal bleeding (21.54%) aligns with

Mishra et al. (2017), which found bleeding manifestations in 20.9% of thrombocytopenic patients.[18]MPV demonstrated the highest sensitivity (82.35%) and specificity (74.56%) with an AUC of 0.78, making it the most reliable marker in this study. Similar diagnostic accuracy of MPV has been reported by Verma et al. (2020), where MPV showed an AUC of 0.76 in differentiating ITP from other causes.19 P-LCR also showed good diagnostic performance (AUC = 0.76), comparable to Sharma et al. (2021), which highlighted its utility in infectious thrombocytopenia.[10]In contrast, plateletcrit had the lowest diagnostic accuracy (AUC = 0.70), consistent with findings from Patil et al. (2018), which suggested its limited role in distinguishing between thrombocytopenia types.[20]Platelet count decreased significantly with severity, from $130.56 \pm 10.34 \times 10^3/\mu L$ in mild cases to $50.23 \pm 8.76 \times 10^3/\mu L$ in severe cases ($p < 0.001$). This inverse relationship is well-documented in the literature, including studies by Agarwal et al. (2019). MPV, PDW, and P-LCR progressively increased with severity, highlighting enhanced platelet production and destruction in severe cases.[21] Similar trends were reported by Joshi et al. (2021), where MPV and PDW were significantly elevated in severe thrombocytopenia.[22]Plateletcrit (PCT) was inversely related to severity, with the highest values in mild cases ($0.24 \pm 0.04\%$) and the lowest in severe cases ($0.12 \pm 0.03\%$, $p < 0.001$). This finding aligns with Pandey et al. (2023), emphasizing its role in reflecting total platelet mass.[23]

CONCLUSION

This study highlights the utility of platelet indices, particularly mean platelet volume (MPV), platelet distribution width (PDW), and platelet-large cell ratio (P-LCR), as valuable diagnostic markers for differentiating thrombocytopenic conditions. MPV demonstrated the highest sensitivity and specificity, making it the most reliable indicator across diagnostic groups. The progressive changes in platelet indices with increasing thrombocytopenia severity further underscore their role in assessing disease progression. These indices, being cost-effective and easily accessible, provide a practical tool for guiding clinical decision-making, particularly in resource-limited settings.

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