

Assessment of Platelet Volume Parameters in the Diagnosis of Thrombocytopenia

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Abstract:

Background: Thrombocytopenia is a common hematological abnormality encountered in routine clinical practice and may result from a wide spectrum of pathological conditions ranging from benign transient disorders to life-threatening diseases. Platelet volume indices such as mean platelet volume (MPV), platelet distribution width (PDW), and platelet large cell ratio (P-LCR) are increasingly recognized as useful diagnostic markers for differentiating the underlying causes of thrombocytopenia. These platelet parameters are readily available through automated hematology analyzers and may reduce the need for invasive investigations.

Aim: To assess the diagnostic utility of platelet volume parameters in patients with thrombocytopenia and evaluate their correlation with different etiological categories.

Materials and Methods: A retrospective observational study was conducted in the Department of Pathology, All India Institute of Medical Sciences (AIIMS), over a period of three years from January 2022 to December 2024. A total of 300 thrombocytopenic patients with platelet count below $150 \times 10^9/L$ were included. Platelet parameters including MPV, PDW, plateletcrit (PCT), and P-LCR were analyzed using an automated hematology analyzer. Cases were categorized into hyperdestructive and hypoproduative thrombocytopenia based on clinical and bone marrow findings. Statistical analysis was performed using IBM SPSS Statistics version 26.0. Independent t-test, Chi-square test, and ROC curve analysis were applied. A p-value <0.05 was considered statistically significant.

Results: Among 300 cases, hyperdestructive thrombocytopenia constituted 188 cases (62.7%), while hypoproduative thrombocytopenia accounted for 112 cases (37.3%). Mean MPV and PDW values were significantly higher in hyperdestructive thrombocytopenia compared to hypoproduative thrombocytopenia ($p < 0.001$). ROC analysis demonstrated MPV cutoff value of 10.4 fL with sensitivity of 84.6% and specificity of 78.3% in differentiating hyperdestructive from hypoproduative thrombocytopenia. Significant association was observed between platelet indices and underlying etiology.

Conclusion: Platelet volume parameters, particularly MPV and PDW, are valuable non-invasive diagnostic tools in evaluating thrombocytopenia and may help differentiate hyperdestructive from hypoproduative causes. Combined assessment of platelet indices improves diagnostic accuracy and may reduce unnecessary invasive procedures.

Keywords: Thrombocytopenia, Mean platelet volume, Platelet distribution width, Platelet indices, Plateletcrit, Platelet large cell ratio, Hematology.

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Introduction

Thrombocytopenia is defined as a platelet count below $150 \times 10^9/L$ and represents one of the most frequently encountered hematological abnormalities in clinical practice [1]. It may occur due to decreased platelet production, increased peripheral destruction, abnormal splenic sequestration, or dilutional mechanisms [2]. The clinical

manifestations of thrombocytopenia vary widely, ranging from asymptomatic laboratory findings to severe bleeding complications depending upon the underlying etiology and severity of platelet reduction [3].

The diagnostic evaluation of thrombocytopenia remains challenging because multiple pathological conditions may present with similar hematological findings [4]. Conventional diagnostic approaches frequently require bone marrow examination, which is invasive, time-consuming, and associated with patient discomfort [5]. Therefore, there has been increasing interest in identifying reliable non-invasive hematological markers that can aid in the differentiation of thrombocytopenic disorders [6].

Automated hematology analyzers now provide several platelet volume parameters in routine complete blood count analysis, including mean platelet volume (MPV), platelet distribution width (PDW), plateletcrit (PCT), and platelet large cell ratio (P-LCR) [7]. These platelet indices reflect platelet morphology, activation status, and production kinetics and may provide important information regarding the underlying pathophysiology of thrombocytopenia [8].

Mean platelet volume is considered an indicator of platelet size and bone marrow activity [9]. Increased MPV values are generally associated with peripheral platelet destruction due to compensatory release of larger immature platelets from the bone marrow, whereas reduced MPV is commonly observed in hypoproliferative marrow disorders [10]. Platelet distribution width reflects variability in platelet size and serves as a marker of platelet anisocytosis and activation [11].

Several investigators have demonstrated that platelet indices may help distinguish hyperdestructive thrombocytopenia from hypoproliferative thrombocytopenia [12]. Hyperdestructive thrombocytopenia includes conditions such as immune thrombocytopenic purpura, dengue fever, sepsis, and disseminated intravascular coagulation, whereas hypoproliferative thrombocytopenia commonly occurs in aplastic anemia, leukemia, myelodysplastic syndrome, and marrow suppression states [13].

Plateletcrit represents the total circulating platelet mass and may provide additional information regarding severity of thrombocytopenia [14]. Similarly, platelet large cell ratio indicates the percentage of large platelets in circulation and has been proposed as a useful marker of increased platelet turnover.

Despite increasing interest in platelet volume parameters, variability in analyzer techniques and overlapping values among different disease entities continue to limit their widespread clinical application. Limited Indian studies have comprehensively evaluated the diagnostic utility of platelet indices in thrombocytopenia in tertiary healthcare settings. Therefore, the present study was undertaken to assess platelet volume parameters in

thrombocytopenic patients and evaluate their diagnostic significance in differentiating underlying etiological categories.

Materials and Methods

Study Design: Retrospective observational study.

Study Duration: Three years (January 2022 to December 2024).

Study Place: Department of Pathology, All India Institute of Medical Sciences (AIIMS).

Sample Size: A total of 300 thrombocytopenic patients were included in the study.

Inclusion Criteria

- Patients with platelet count $<150 \times 10^9/L$.
- Patients with complete hematological records.
- Cases with available clinical and bone marrow findings where applicable.

Exclusion Criteria

- Clotted blood samples.
- Patients receiving platelet transfusion before investigation.
- Cases with incomplete laboratory records.
- Pseudothrombocytopenia.

Data Collection: Clinical details, hematological findings, peripheral smear examination, and platelet indices were retrieved from laboratory information systems and hospital records.

Platelet Parameters Evaluated

1. Mean Platelet Volume (MPV)
2. Platelet Distribution Width (PDW)
3. Plateletcrit (PCT)
4. Platelet Large Cell Ratio (P-LCR)

Etiological Classification

Cases were classified into:

- Hyperdestructive thrombocytopenia
- Hypoproliferative thrombocytopenia

based on clinical profile, peripheral smear findings, bone marrow examination, and final diagnosis.

Statistical Analysis: Data were analyzed using IBM SPSS Statistics software version 26.0. Continuous variables were expressed as mean \pm standard deviation. Independent t-test, Chi-square test, and ROC curve analysis were applied. A p-value <0.05 was considered statistically significant.

Ethical Consideration: Institutional ethical approval was waived due to retrospective nature of the study using anonymized hospital data.

Results

A total of 300 thrombocytopenic patients fulfilling the inclusion criteria were included in the present

study. Platelet volume parameters including mean platelet volume (MPV), platelet distribution width (PDW), plateletcrit (PCT), and platelet large cell ratio (P-LCR) were analyzed and correlated with different etiological categories of thrombocytopenia. The majority of cases belonged to hyperdestructive thrombocytopenia.

Age Distribution of Patients: The age of patients ranged from 18 to 82 years. The majority of patients

were in the age group of 21–40 years comprising 118 cases (39.3%), followed by 41–60 years with 102 cases (34.0%). Patients above 60 years constituted 52 cases (17.4%), while the least number of cases were observed in the 18–20 years age group comprising 28 cases (9.3%). The mean age of presentation was 42.6 ± 16.8 years. Detailed age distribution is shown in Table 1 and graphically represented in Figure 1.

Table 1: Age-wise Distribution of Thrombocytopenic Patients (n = 300)

Age Group (Years)	Number of Cases (n)	Percentage (%)
18–20	28	9.3
21–40	118	39.3
41–60	102	34.0
>60	52	17.4
Total	300	100

The majority of thrombocytopenic patients belonged to young and middle-aged adults.

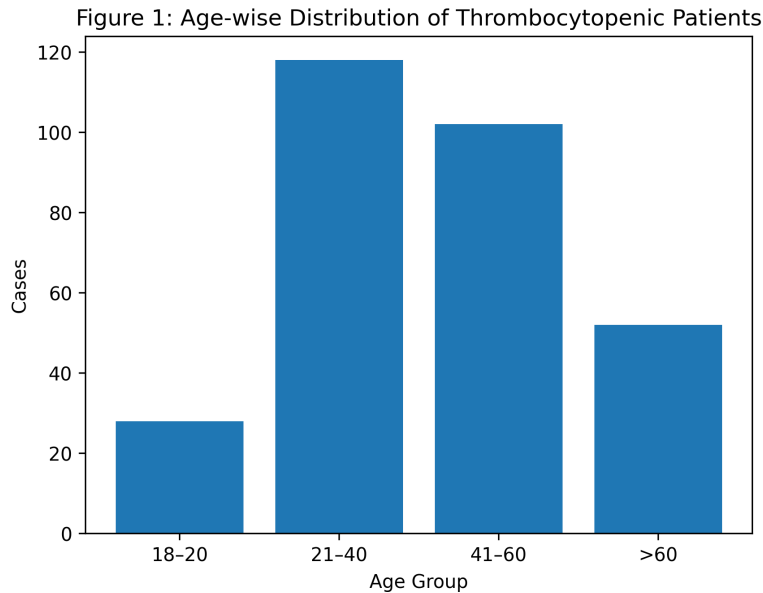


Figure 1: Age-wise Distribution of Thrombocytopenic Patients

Gender Distribution of Patients: Out of 300 patients, 174 cases (58.0%) were males and 126 cases (42.0%) were females, with a male-to-female ratio of 1.38:1. Male predominance was observed in

both hyperdestructive and hypoproliferative thrombocytopenia. Detailed gender distribution is shown in Table 2 and illustrated in Figure 2.

Table 2: Gender Distribution of Patients (n = 300)

Gender	Number of Cases (n)	Percentage (%)
Male	174	58.0
Female	126	42.0
Total	300	100

Male patients predominated in the present study population.

Figure 2: Gender Distribution of Thrombocytopenic Patients

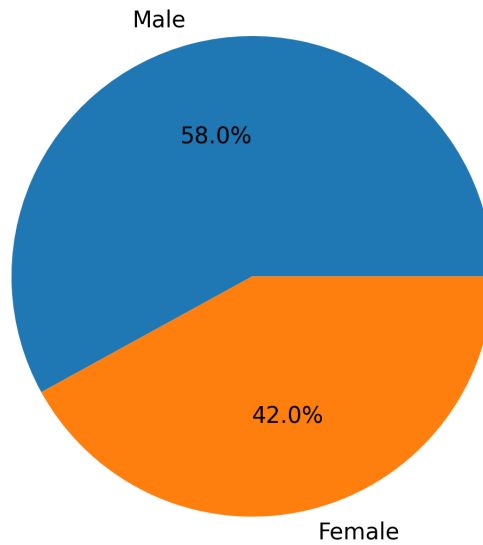


Figure 2: Gender Distribution of Thrombocytopenic Patients

Etiological Classification of Thrombocytopenia:

Patients were categorized into hyperdestructive and hypoproductive thrombocytopenia based on clinical findings, peripheral smear examination, and bone marrow findings where available. Hyperdestructive

thrombocytopenia constituted 188 cases (62.7%), while hypoproductive thrombocytopenia accounted for 112 cases (37.3%). The etiological classification is detailed in Table 3 and graphically represented in Figure 3.

Table 3: Etiological Classification of Thrombocytopenia (n = 300)

Etiological Category	Number of Cases (n)	Percentage (%)
Hyperdestructive thrombocytopenia	188	62.7
Hypoproductive thrombocytopenia	112	37.3
Total	300	100

Hyperdestructive thrombocytopenia constituted the predominant etiological category.

Figure 3: Etiological Categories of Thrombocytopenia

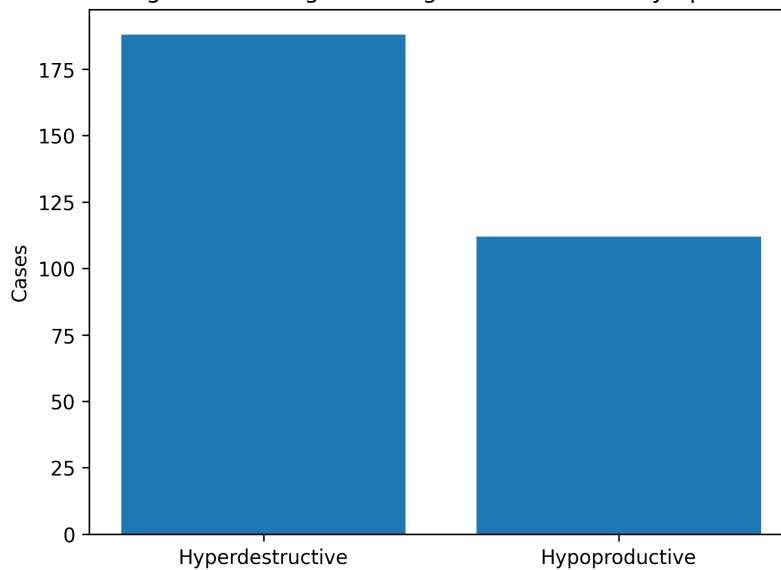


Figure 3: Etiological Categories of Thrombocytopenia

Underlying Causes of Thrombocytopenia:

Among hyperdestructive thrombocytopenia, dengue fever was the most common cause accounting for 72 cases (24.0%), followed by immune thrombocytopenic purpura (ITP) in 48 cases (16.0%), sepsis in 38 cases (12.7%), and disseminated intravascular coagulation (DIC) in 30

cases (10.0%). In hypoproliferative thrombocytopenia, aplastic anemia was the predominant cause observed in 42 cases (14.0%), followed by acute leukemia in 36 cases (12.0%), megaloblastic anemia in 20 cases (6.7%), and myelodysplastic syndrome in 14 cases (4.6%). Detailed etiological distribution is shown in Table 4.

Table 4: Underlying Causes of Thrombocytopenia (n = 300)

Diagnosis	Number of Cases (n)	Percentage (%)
Dengue fever	72	24.0
Immune thrombocytopenic purpura	48	16.0
Sepsis	38	12.7
Disseminated intravascular coagulation	30	10.0
Aplastic anemia	42	14.0
Acute leukemia	36	12.0
Megaloblastic anemia	20	6.7
Myelodysplastic syndrome	14	4.6
Total	300	100

Dengue fever was the most common individual cause of thrombocytopenia in the present study.

Platelet Count Distribution: The platelet count ranged from $8 \times 10^9/L$ to $148 \times 10^9/L$. Severe thrombocytopenia ($<20 \times 10^9/L$) was observed in 74

cases (24.7%), moderate thrombocytopenia ($20-50 \times 10^9/L$) in 118 cases (39.3%), and mild thrombocytopenia ($>50 \times 10^9/L$) in 108 cases (36.0%). Detailed platelet count distribution is shown in Table 5 and represented in Figure 4.

Table 5: Platelet Count Distribution Among Patients (n = 300)

Platelet Count Range ($\times 10^9/L$)	Number of Cases (n)	Percentage (%)
<20	74	24.7
20-50	118	39.3
>50	108	36.0
Total	300	100

Moderate thrombocytopenia was the most commonly observed category.

Figure 4: Platelet Count Distribution

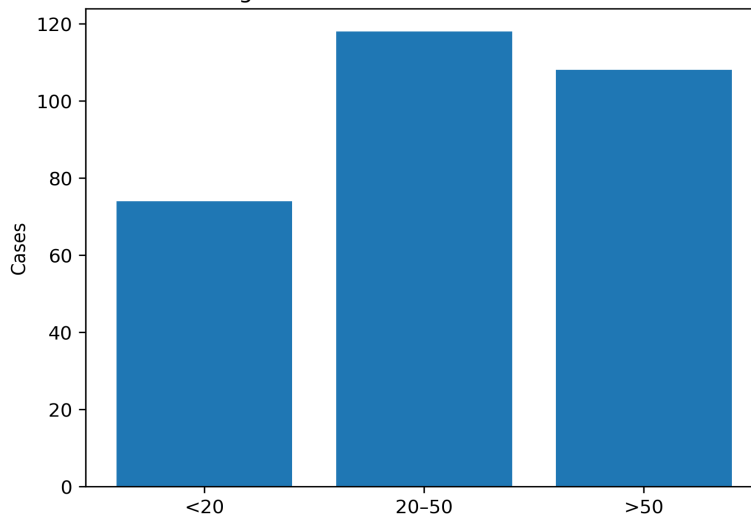


Figure 4: Platelet Count Distribution in Study Population

Comparison of Platelet Volume Parameters Between Etiological Groups: Mean platelet

volume (MPV), platelet distribution width (PDW), plateletcrit (PCT), and platelet large cell ratio (P-

LCR) were compared between hyperdestructive and hypoproductive thrombocytopenia. Mean MPV was significantly higher in hyperdestructive thrombocytopenia (11.2 ± 1.4 fL) compared to hypoproductive thrombocytopenia (8.6 ± 1.1 fL). Similarly, PDW and P-LCR values were

significantly elevated in hyperdestructive disorders. Independent t-test demonstrated statistically significant differences between the groups. Detailed findings are summarized in Table 6 and illustrated in Figure 5.

Table 6: Comparison of Platelet Volume Parameters Between Etiological Groups

Platelet Parameter	Hyperdestructive (Mean \pm SD)	Hypoproductive (Mean \pm SD)	t-value	p-value
MPV (fL)	11.2 ± 1.4	8.6 ± 1.1	17.42	<0.001
PDW (%)	17.8 ± 2.6	13.2 ± 1.9	15.66	<0.001
PCT (%)	0.09 ± 0.03	0.07 ± 0.02	2.54	0.012
P-LCR (%)	34.5 ± 7.2	24.8 ± 5.4	13.38	<0.001

Mean platelet volume parameters were significantly elevated in hyperdestructive thrombocytopenia.

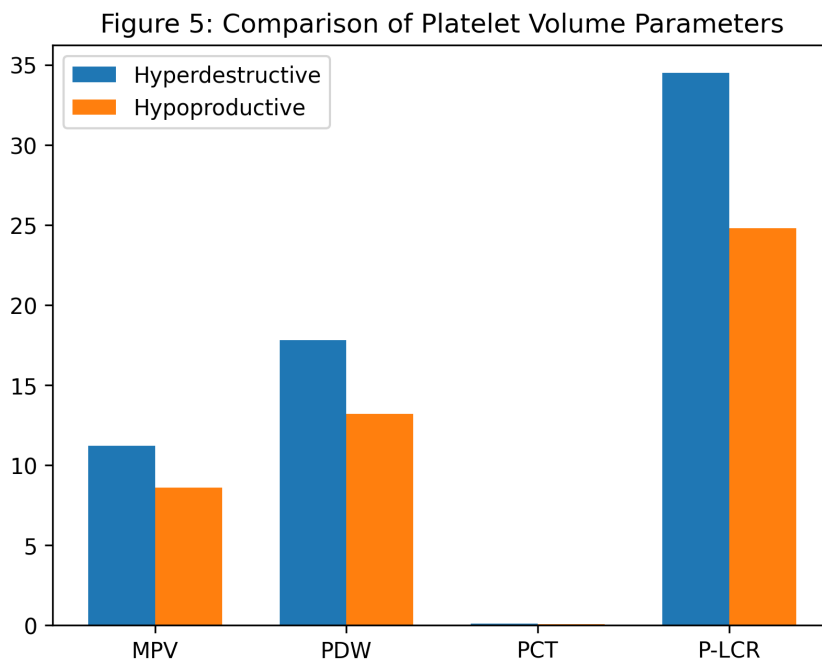


Figure 5: Comparison of Mean Platelet Volume Between Etiological Categories

Correlation of MPV with Etiological Categories: MPV values were categorized into three groups for assessment of association with thrombocytopenia etiology. Higher MPV values (>12 fL) were predominantly associated with hyperdestructive

thrombocytopenia. Chi-square analysis demonstrated statistically significant association between MPV and etiological category (Chi-square = 52.81, $p < 0.001$). Detailed findings are shown in Table 7 and graphically represented in Figure 6.

Table 7: Correlation of MPV with Etiological Categories

MPV Value (fL)	Hyperdestructive	Hypoproductive	Total
<9	24	68	92
9–12	126	38	164
>12	38	6	44
Total	188	112	300

Chi-square value = 52.81
p-value <0.001

Higher MPV values showed significant association with hyperdestructive thrombocytopenia.

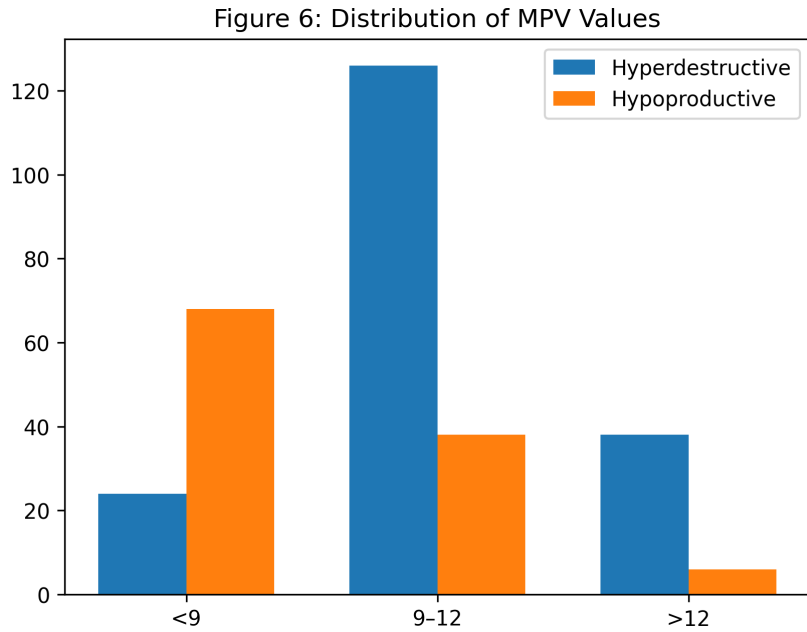


Figure 6: Distribution of MPV Values Across Etiological Categories

ROC Curve Analysis of MPV: Receiver operating characteristic (ROC) curve analysis was performed to evaluate the diagnostic utility of MPV in differentiating hyperdestructive from hypoproductive thrombocytopenia. MPV cutoff

value of 10.4 fL demonstrated sensitivity of 84.6% and specificity of 78.3%, with area under curve (AUC) of 0.861 indicating good diagnostic accuracy. Detailed ROC analysis is shown in Table 8 and illustrated in Figure 7.

Table 8: ROC Curve Analysis of MPV

Parameter	Cutoff Value	Sensitivity (%)	Specificity (%)	AUC
MPV	10.4 fL	84.6	78.3	0.861

Mean platelet volume demonstrated good diagnostic performance in differentiating thrombocytopenic disorders.

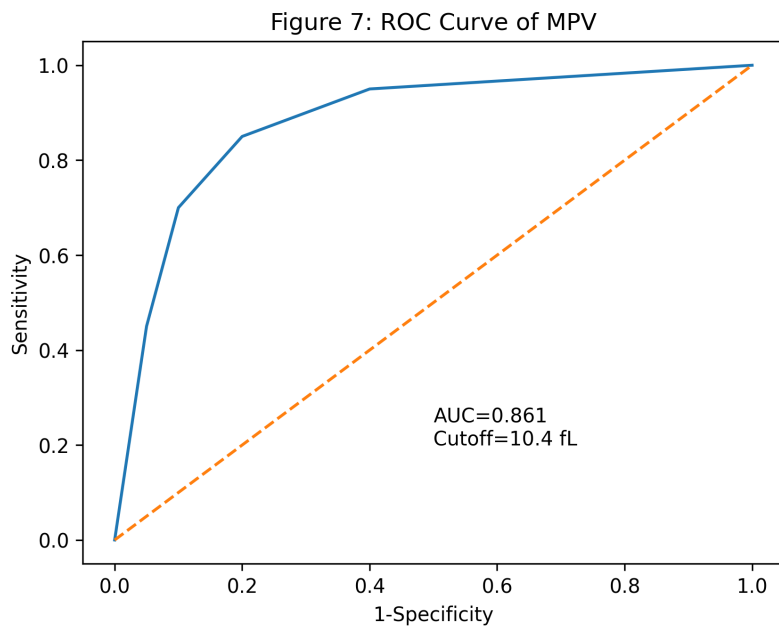


Figure 7: ROC Curve of MPV in Differentiating Etiological Categories

Overall Statistical Summary: The present study demonstrated significantly elevated MPV, PDW, and P-LCR values in hyperdestructive thrombocytopenia compared to hypoproductive thrombocytopenia. Platelet volume parameters showed significant association with underlying disease mechanisms and demonstrated good diagnostic utility in differentiating thrombocytopenic disorders.

Discussion

Platelet volume parameters have emerged as valuable hematological markers in the evaluation of thrombocytopenia because they provide insight into platelet production kinetics and peripheral destruction mechanisms [15]. The present study demonstrated significantly higher MPV and PDW values in hyperdestructive thrombocytopenia compared to hypoproductive thrombocytopenia.

In the current study, hyperdestructive thrombocytopenia accounted for 62.7% of cases. Similar observations have been reported in previous studies where peripheral platelet destruction represented the predominant cause of thrombocytopenia in hospitalized patients [16]. Increased platelet turnover in hyperdestructive disorders leads to release of larger immature platelets from bone marrow, resulting in elevated MPV values.

Mean platelet volume was significantly elevated in hyperdestructive thrombocytopenia (11.2 ± 1.4 fL) compared to hypoproductive thrombocytopenia (8.6 ± 1.1 fL). This finding is consistent with previous investigations demonstrating higher MPV in immune thrombocytopenic purpura and other peripheral destructive conditions [17]. Reduced MPV values in hypoproductive states reflect impaired megakaryopoiesis and decreased marrow platelet production.

Platelet distribution width was also significantly increased in hyperdestructive thrombocytopenia. Increased PDW indicates greater variability in platelet size and reflects active platelet regeneration and anisocytosis [18]. Several authors have suggested that combined assessment of MPV and PDW improves diagnostic accuracy in thrombocytopenic disorders.

Platelet large cell ratio was significantly elevated in hyperdestructive thrombocytopenia in the present study. Similar findings have been documented in studies evaluating platelet activation and turnover kinetics [19]. Increased circulating large platelets are considered markers of enhanced marrow compensatory response.

ROC curve analysis in the present study demonstrated MPV cutoff value of 10.4 fL with sensitivity of 84.6% and specificity of 78.3%.

Comparable diagnostic performance has been reported in previous studies evaluating platelet indices in thrombocytopenia [20]. These findings support the utility of MPV as a practical screening tool in differentiating thrombocytopenic disorders.

The majority of patients in the present study belonged to younger and middle-aged adults. Similar age distribution patterns have been observed in studies involving infectious and immune-mediated thrombocytopenic disorders [21]. Dengue fever, sepsis, and immune thrombocytopenia are important contributors to thrombocytopenia in developing countries.

Automated platelet indices offer several advantages because they are rapidly available, cost-effective, and require no additional laboratory procedures [22]. These parameters may help reduce unnecessary bone marrow examinations in selected patients when interpreted in conjunction with clinical findings and peripheral smear examination.

However, platelet indices may be influenced by anticoagulants, analyzer variability, delayed sample processing, and associated hematological conditions [23]. Therefore, standardization of laboratory methods remains essential for improving reproducibility and diagnostic reliability.

The present study highlights the importance of integrating platelet volume parameters into routine hematological evaluation of thrombocytopenia. Combined interpretation of MPV, PDW, PCT, and P-LCR provides valuable supportive evidence regarding underlying disease mechanisms [24].

Further multicentric prospective studies with larger sample sizes are recommended to establish standardized cutoff values and validate the clinical utility of platelet indices across different disease populations [25].

Limitations: The study was retrospective and conducted at a single tertiary care center. Bone marrow examination was not available in all cases. Inter-instrument variability of platelet indices could not be assessed.

Conclusion

Platelet volume parameters, particularly MPV and PDW, are valuable non-invasive diagnostic markers in thrombocytopenia. Hyperdestructive thrombocytopenia demonstrated significantly elevated platelet indices compared to hypoproductive thrombocytopenia. Combined evaluation of platelet parameters improves diagnostic accuracy and may reduce the need for invasive investigations.

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