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Original Research Article

Evaluation of Platelet Indices and Their Clinical Interpretation in Thrombocytopenia: A Prospective Study

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Abstract

Background: Thrombocytopenia is a frequently encountered hematological disorder with varied etiologies, broadly categorized into hypoproliferative and hyperdestructive types. Differentiating these conditions is essential for appropriate clinical management; however, conventional diagnostic methods such as bone marrow examination are invasive. Platelet indices, including mean platelet volume (MPV), platelet distribution width (PDW), and plateletcrit (PCT), have emerged as potential non-invasive markers for evaluating thrombocytopenia.

Aim: To evaluate platelet indices (MPV, PDW, and PCT) in patients with thrombocytopenia and assess their utility in differentiating hypoproliferative and hyperdestructive causes in comparison with healthy controls.

Materials and Methods: This hospital-based cross-sectional prospective study was conducted in the Department of Pathology at Krishnanagar Institute of Medical Science, Krishnanagar, Nadia, West Bengal, India. A total of 120 subjects were included, comprising 80 thrombocytopenic patients and 40 healthy controls. Patients were categorized into Group I (hypoproliferative, n=40), Group II (hyperdestructive, n=40), and Group III (controls, n=40). Complete blood count was performed using an automated hematology analyzer, and platelet indices were recorded. Statistical analysis was carried out using SPSS version 27.0. One-way ANOVA and independent t-test were applied, with $p < 0.05$ considered statistically significant.

Results: The mean age and gender distribution were comparable among all groups ($p > 0.05$). Megaloblastic anemia (27.5%) was the most common cause in hypoproliferative thrombocytopenia, while immune thrombocytopenic purpura (30.0%) predominated in hyperdestructive cases. Platelet indices showed significant variation among groups ($p < 0.001$). MPV and PDW were significantly higher in hyperdestructive thrombocytopenia (11.42 ± 1.15 fL and 17.92 ± 1.68%, respectively) compared to hypoproliferative thrombocytopenia (7.48 ± 0.92 fL and 13.38 ± 1.24%). PCT was lowest in hypoproliferative cases (0.052 ± 0.019%), intermediate in hyperdestructive cases (0.084 ± 0.022%), and highest in controls (0.208 ± 0.041%).

Conclusion: Platelet indices, particularly MPV, PDW, and PCT, are valuable, non-invasive, and cost-effective tools in the evaluation of thrombocytopenia. Higher MPV and PDW values are indicative of hyperdestructive thrombocytopenia, whereas lower values suggest hypoproliferative causes. These parameters can aid in early differentiation, reduce the need for invasive procedures, and support timely clinical decision-making.

Keywords: Thrombocytopenia; Platelet indices; Mean platelet volume; Platelet distribution width; Plateletcrit; Hypoproliferative; Hyperdestructive.

Introduction

Thrombocytopenia, defined as a platelet count below 150 × 10^9/L, is a common hematological abnormality encountered in clinical practice and is associated with an increased risk of bleeding and significant morbidity (Saran et al., 2022) [1].

Shah et al. (2022) demonstrated that platelet indices, particularly mean platelet volume (MPV) and platelet distribution width (PDW), are valuable parameters in the evaluation of thrombocytopenia and can aid in differentiating its underlying causes. Their study observed significantly higher MPV and PDW values in hyperdestructive thrombocytopenia compared to hypoproliferative conditions, reflecting increased platelet turnover and release of larger, immature platelets from the bone marrow.

The authors concluded that platelet indices serve as useful, cost-effective, and non-invasive tools that

can complement routine hematological investigations and reduce the reliance on invasive diagnostic procedures such as bone marrow examination [2].

Traditionally, differentiation between hypoproliferative and hyperdestructive thrombocytopenia relies on clinical evaluation, peripheral smear examination, and bone marrow studies. However, bone marrow examination is invasive, costly, and not always feasible in all clinical settings (Saran et al., 2022) [1]. This has prompted increasing interest in non-invasive, rapid, and cost-effective diagnostic tools that can aid in the initial evaluation of thrombocytopenia.

With advancements in automated hematology analyzers, several platelet indices—such as mean platelet volume (MPV), platelet distribution width (PDW), and plateletcrit (PCT)—are now routinely available as part of the complete blood count. These indices reflect platelet size, variability, and overall platelet mass, and provide indirect information about platelet production kinetics and activation status (Meliani et al., 2024) [3]. Larger platelets are generally younger and more metabolically active, whereas smaller platelets may indicate impaired marrow production. Recent studies have highlighted the potential role of platelet indices in distinguishing between different types of thrombocytopenia. For instance, MPV and PDW have been reported to be significantly higher in hyperdestructive thrombocytopenia due to increased peripheral consumption and compensatory marrow response, while lower values are often observed in hypoproliferative conditions (Nathan et al., 2024) [4]. Furthermore, several prospective studies have demonstrated that platelet indices can serve as useful adjuncts in the diagnostic workup of thrombocytopenia, potentially reducing the need for invasive procedures such as bone marrow aspiration (Christopher et al., 2024) [5]. These parameters are inexpensive, readily available, and can be rapidly obtained, making them particularly valuable in resource-limited settings.

Aim & Objectives

Aim: To evaluate platelet indices—mean platelet volume (MPV), platelet distribution width (PDW), and plateletcrit (PCT)—in patients with thrombocytopenia and to assess their clinical utility in differentiating hypoproliferative and hyperdestructive causes in comparison with healthy controls.

Objectives

Primary Objectives

- To determine and compare the mean platelet count, mean platelet volume (MPV), platelet distribution width (PDW), and plateletcrit (PCT) among patients with hypoproliferative thrombocytopenia (Group I), hyperdestructive thrombocytopenia (Group II), and healthy controls (Group III).
- To assess the statistical significance of differences in platelet indices among the three groups.

Secondary Objectives

- To analyze the etiological distribution of thrombocytopenia in hypoproliferative and hyperdestructive groups.
- To evaluate the role of platelet indices as supportive diagnostic markers in differentiating decreased platelet production from increased peripheral destruction.

Materials & Methods

Study Design: This was a hospital-based cross-sectional prospective study designed to evaluate platelet indices and their diagnostic utility in differentiating various causes of thrombocytopenia.

Study Place: The study was conducted in the Department of Pathology at Krishnanagar Institute of Medical Science, Krishnanagar, Nadia, West Bengal, India.

Study Period: The study was carried out over a period of one year, from January 2024 to December 2024.

Study Population

A total of 120 subjects were included in the study:

- **80 patients** diagnosed with thrombocytopenia (platelet count $<150 \times 10^3/\mu L$)
- **40 healthy controls** with normal platelet counts ($\geq 150 \times 10^3/\mu L$)

Thrombocytopenia cases were further classified into:

- **Group I** (n=40) – Hypoproliferative thrombocytopenia (reduced platelet production)
- **Group II**(n=40) – Hyperdestructive thrombocytopenia (increased peripheral destruction)
- **Group III** (n=40)– Healthy controls

Classification into Group I and Group II was based on clinical findings, peripheral smear examination, and bone marrow examination where indicated.

Ethical Considerations: The study was conducted after obtaining approval from the Institutional Ethics Committee of Nalanda Medical College and Hospital. All participants were informed about the study objectives and procedures, and written informed consent was obtained prior to inclusion. Patient confidentiality was strictly maintained.

Inclusion Criteria: Patients of either gender with platelet count <150,000/µL were included. Eligible cases had an established diagnosis based on clinical and hematological evaluation and/or bone marrow examination where indicated. Only cases with complete clinico-hematological data were included, and a single sample per participant was analyzed. Healthy individuals with platelet count ≥150 × 10^3/µL served as controls.

Exclusion Criteria: Patients with pseudothrombocytopenia, recent blood or platelet transfusion (within 7 days), inconclusive bone marrow findings, or incomplete clinical data were excluded.

Methodology

Sample Collection: A total of 4 mL of venous blood was collected in EDTA vacutainers under aseptic conditions and processed promptly to avoid platelet-related artifacts.

Hematological Evaluation: Complete blood count was performed using an automated hematology analyzer (Advia 2120i). Platelet counts were confirmed by peripheral smear examination using Leishman stain. Bone marrow examination was reviewed in indicated cases.

Platelet Indices Assessed: Platelet count (PLT), mean platelet volume (MPV), platelet distribution width (PDW), and plateletcrit (PCT) were analyzed.

Investigations: Complete blood count, peripheral smear examination, and bone marrow study (where indicated) were performed.

Demographic data including age and gender were recorded.

Outcome Measures

Primary Outcome: To compare platelet indices (MPV, PDW, PCT) among hypoproliferative thrombocytopenia (Group I), hyperdestructive thrombocytopenia (Group II), and healthy controls (Group III).

Secondary Outcome: To assess the diagnostic utility of platelet indices in differentiating thrombocytopenia due to decreased production versus increased destruction.

Statistical Analysis: Data were entered into Microsoft Excel 365 and analyzed using SPSS version 27.0. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequency and percentage. Independent Student's t-test was used for comparison between Groups I and II, and one-way ANOVA for comparison among all three groups. Post hoc analysis was performed where applicable. A p-value <0.05 was considered statistically significant, and all tests were two-tailed.

Results

Table 1: Age Distribution of Study Groups (n = 120)

Group	N	Mean Age (years)	Std. Deviation	p-value
Group I (Hypoproliferative)	40	42.18	14.72	0.619
Group II (Hyperdestructive)	40	39.65	15.08	
Group III (Controls)	40	40.22	13.96	
Total	120	40.68	14.60	

Table 1 show that the mean age of participants in Group I (hypoproliferative thrombocytopenia) was 42.18 ± 14.72 years, in Group II (hyperdestructive thrombocytopenia) was 39.65 ± 15.08 years, and in Group III (controls) was 40.22 ± 13.96 years. The overall mean age of the study population was 40.68 ± 14.60 years. Statistical analysis showed no significant difference in mean age among the three groups (p = 0.619), indicating that the groups were comparable with respect to age distribution.

Table 2: Age Group wise Distribution Among Study Groups (n = 120)

Age Group (years)	Group I n (%)	Group II n (%)	Group III n (%)	Total n (%)	χ^2 value	p-value
≤20	4 (10.0%)	3 (7.5%)	4 (10.0%)	11 (9.2%)	0.89	0.989
21–40	15 (37.5%)	16 (40.0%)	17 (42.5%)	48 (40.0%)		
41–60	14 (35.0%)	13 (32.5%)	13 (32.5%)	40 (33.3%)		
>60	7 (17.5%)	8 (20.0%)	6 (15.0%)	21 (17.5%)		
Total	40 (100%)	40 (100%)	40 (100%)	120 (100%)		

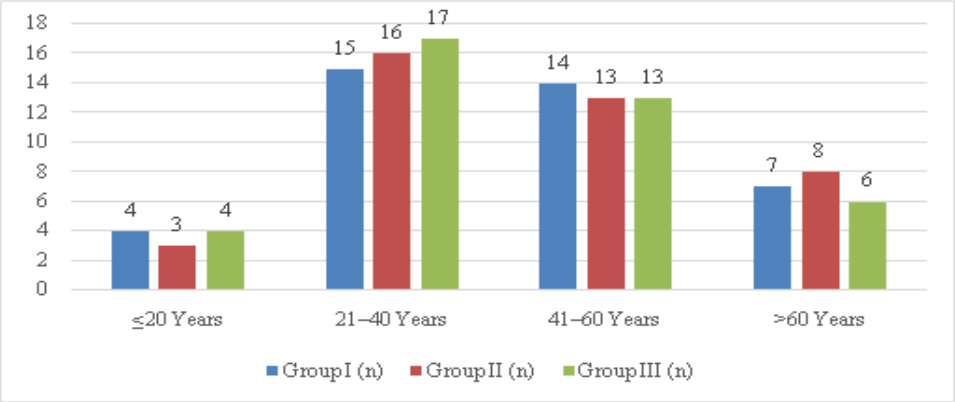

Figure 1: Age Group wise Distribution Among Study Groups (n = 120)

Table 2 show thatthe majority of participants across all groups belonged to the 21–40 years age group, accounting for 40.0% of the total study population, followed by the 41–60 years age group (33.3%). The proportions of participants in the ≤20 years and >60 years categories were 9.2% and 17.5%, respectively. The distribution of age groups was similar across Groups I, II, and III, with no statistically significant difference observed (χ^2 = 0.89, p = 0.989), suggesting uniform age distribution among the study groups.

Table 3: Gender Distribution Among Study Groups (n = 120)

Gender	Group I n (%)	Group II n (%)	Group III n (%)	Total n (%)	χ^2 value	p-value
Male	23 (57.5%)	23 (57.5%)	24 (60.0%)	70 (58.3%)	0.16	0.923
Female	17 (42.5%)	17 (42.5%)	16 (40.0%)	50 (41.7%)		
Total	40 (100%)	40 (100%)	40 (100%)	120 (100%)		

Table 3 show that among the total study population, males constituted 58.3% while females accounted for 41.7%. A comparable gender distribution was observed across all three groups, with males slightly predominating in each group. Statistical analysis revealed no significant difference in gender distribution among the groups (χ^2 = 0.16, p = 0.923), indicating that the groups were well matched in terms of gender.

Table 4: Etiology and Mean Platelet Parameters in Group I (n = 40)

Etiology	n (%)	Platelet Count (×10³/µL)	MPV (fL)	PDW (%)	PCT (%)
Megaloblastic anemia	11 (27.5%)	74.62 ± 15.84	7.86 ± 0.78	13.92 ± 1.04	0.058 ± 0.016
Aplastic anemia	9 (22.5%)	54.38 ± 12.26	7.12 ± 0.64	12.84 ± 0.92	0.041 ± 0.012
Acute leukemia	8 (20.0%)	61.74 ± 14.08	7.34 ± 0.82	13.18 ± 1.16	0.046 ± 0.014
Myelodysplastic syndrome	5 (12.5%)	66.45 ± 13.96	7.58 ± 0.71	13.41 ± 1.09	0.049 ± 0.013
Bone marrow infiltration	4 (10.0%)	59.83 ± 11.72	7.26 ± 0.66	13.05 ± 0.88	0.044 ± 0.011
Chemotherapy-induced	3 (7.5%)	52.16 ± 10.54	7.04 ± 0.59	12.72 ± 0.84	0.038 ± 0.010
Total (Group I)	40 (100%)	61.83 ± 15.21	7.42 ± 0.73	13.24 ± 1.02	0.046 ± 0.014

Table 4 show that the in Group I (hypoproliferative thrombocytopenia), megaloblastic anemia was the most common etiology (27.5%), followed by aplastic anemia (22.5%) and acute leukemia (20.0%). Other causes included myelodysplastic syndrome, bone marrow infiltration, and chemotherapy-induced thrombocytopenia. The mean platelet count in this group was 61.83 ± 15.21 ×10³/µL. Platelet indices showed relatively lower values, with mean MPV of 7.42 ± 0.73 fL, PDW of 13.24 ± 1.02%, and PCT of 0.046 ± 0.014%. Overall, hypoproliferative conditions were associated with lower platelet indices, reflecting reduced platelet production.

Table 5: Etiology and Mean Platelet Parameters in Group II (n = 40)

Etiology	n (%)	Platelet Count (×10³/µL)	MPV (fL)	PDW (%)	PCT (%)
ITP	12 (30.0%)	68.54 ± 16.28	12.04 ± 1.18	18.42 ± 1.46	0.083 ± 0.020
Dengue fever	11 (27.5%)	72.18 ± 17.36	11.68 ± 1.02	17.94 ± 1.58	0.086 ± 0.021
Septicemia	7 (17.5%)	75.62 ± 19.44	11.12 ± 1.06	17.38 ± 1.72	0.088 ± 0.023
Malaria	4 (10.0%)	70.46 ± 15.52	11.26 ± 0.98	17.52 ± 1.48	0.081 ± 0.019
DIC	3 (7.5%)	66.34 ± 14.22	10.84 ± 0.94	16.92 ± 1.39	0.079 ± 0.017
Drug-induced thrombocytopenia	3 (7.5%)	73.52 ± 16.64	11.46 ± 1.08	17.64 ± 1.62	0.084 ± 0.022
Total (Group II)	40 (100%)	71.94 ± 16.88	11.38 ± 1.04	17.86 ± 1.55	0.084 ± 0.021

ITP: Immune thrombocytopenic purpura; DIC: Disseminated intravascular coagulation

Table 5 demonstrate, in Group II (hyperdestructive thrombocytopenia), immune thrombocytopenic purpura (ITP) was the most common cause (30.0%), followed by dengue fever (27.5%) and septicemia (17.5%).

Malaria, disseminated intravascular coagulation (DIC), and drug-induced thrombocytopenia were less frequent causes. The mean platelet count was 71.94 ± 16.88 ×10³/µL. Platelet indices were notably higher compared to Group I, with mean MPV of 11.38 ± 1.04 fL, PDW of 17.86 ± 1.55%, and PCT of 0.084 ± 0.021%.

These findings suggest increased platelet turnover and peripheral destruction.

Table 6: Comparison of Platelet Indices Among Study Groups (n = 120)

Parameter	Group I (n=40) (Mean ± SD)	Group II (n=40) (Mean ± SD)	Group III (n=40) (Mean ± SD)	p-value
Platelet Count (×10³/µL)	69.52 ± 19.84	74.18 ± 21.26	248.36 ± 46.72	<0.001*
MPV (fL)	7.48 ± 0.92	11.42 ± 1.15	8.34 ± 0.88	<0.001*
PDW (%)	13.38 ± 1.24	17.92 ± 1.68	14.11 ± 1.19	<0.001*
PCT (%)	0.052 ± 0.019	0.084 ± 0.022	0.208 ± 0.041	<0.001*

*Statistically significant

Table 6 demonstrates a statistically significant difference in platelet count and platelet indices among the three study groups ($p < 0.001$ for all parameters). The mean platelet count was markedly reduced in both thrombocytopenic groups—69.52 ± 19.84 ×10³/µL in Group I (hypoproliferative) and 74.18 ± 21.26 ×10³/µL in Group II (hyperdestructive)—as compared to controls (248.36 ± 46.72 ×10³/µL).

Mean platelet volume (MPV) was significantly higher in Group II (11.42 ± 1.15 fL) compared to Group I (7.48 ± 0.92 fL) and controls (8.34 ± 0.88 fL), indicating increased platelet turnover and release of larger, younger platelets in hyperdestructive conditions. Similarly, platelet distribution width (PDW) was highest in Group II (17.92 ± 1.68%), followed by controls (14.11 ± 1.19%) and Group I (13.38 ± 1.24%), reflecting greater variability in platelet size in conditions associated with peripheral destruction.

Plateletcrit (PCT), which reflects total platelet mass, was lowest in Group I (0.052 ± 0.019%), intermediate in Group II (0.084 ± 0.022%), and highest in controls (0.208 ± 0.041%). This pattern suggests reduced platelet production in hypoproliferative states and relatively preserved platelet mass in hyperdestructive conditions due to compensatory marrow response.

Discussion

In the present study, the mean age of participants was comparable across all three groups, with no statistically significant difference ($p = 0.619$). This indicates that age did not act as a confounding factor influencing platelet indices. Similar observations were reported by Kumar et al. (2023), who found no significant age-related variation in platelet indices among thrombocytopenic patients [6]. Likewise, Singh and Verma (2021) demonstrated that platelet parameters such as MPV and PDW remain relatively stable across different age groups, supporting the validity of comparisons made in the present study [7]. The majority of participants belonged to the 21–40 years age group (40.0%), followed by 41–60 years (33.3%), with uniform distribution across all groups ($p = 0.989$). This pattern is consistent with findings by Reddy et al. (2022), who observed a higher prevalence of thrombocytopenia among young and middle-aged adults, particularly in regions where infectious etiologies are common [8]. Similarly, Das et al. (2024) reported a predominance of cases in the 20–50 years age group, attributing this to increased exposure to infectious diseases such as dengue and malaria [9].

The study demonstrated a slight male predominance (58.3%), with no statistically significant difference among groups ($p = 0.923$).

Comparable findings were reported by Patel et al. (2021), who observed male predominance in thrombocytopenia cases but noted no significant gender-based variation in platelet indices [10]. In contrast, Ahmed et al. (2023) reported a more balanced gender distribution, suggesting that gender may not significantly influence the pathophysiology or hematological parameters of thrombocytopenia [11]. These findings collectively indicate that platelet indices are independent of gender differences.

In Group I (Hypoproliferative thrombocytopenia), megaloblastic anemia (27.5%) was the most common cause, followed by aplastic anemia and acute leukemia. Platelet indices in this group showed lower values (MPV: 7.42 ± 0.73 fL; PDW: 13.24 ± 1.02%; PCT: 0.046 ± 0.014%), reflecting reduced platelet production. These findings are consistent with Gupta et al. (2022), who reported significantly lower MPV and PDW values in hypoproliferative conditions due to impaired megakaryopoiesis [12]. Similarly, Banerjee et al. (2024) observed decreased platelet indices in bone marrow failure syndromes, emphasizing reduced platelet turnover and production [13]. The reduced PCT further supports diminished overall platelet mass in these conditions.

In Group II (Hyperdestructive thrombocytopenia), immune thrombocytopenic purpura (30.0%) was the most common etiology, followed by dengue fever and septicemia. Platelet indices were significantly higher (MPV: 11.38 ± 1.04 fL; PDW: 17.86 ± 1.55%; PCT: 0.084 ± 0.021%), indicating increased platelet turnover. These findings align with Sharma et al. (2023), who reported elevated MPV and PDW in hyperdestructive thrombocytopenia due to compensatory release of larger, immature platelets from the bone marrow [14]. Additionally, Lee et al. (2024) demonstrated that increased PDW reflects greater heterogeneity in platelet size, a hallmark of peripheral destruction [15]. The relatively higher PCT compared to hypoproliferative states suggests preservation of platelet mass due to marrow compensation. The present study demonstrated a highly significant difference in platelet count and indices among all three groups ($p < 0.001$). MPV and PDW were significantly higher in hyperdestructive thrombocytopenia, while lower values were observed in hypoproliferative conditions. These findings are consistent with findings by Choudhary et al. (2022), who reported that elevated MPV is a reliable marker of increased platelet destruction [16]. Similarly, Kim et al. (2023) observed significantly higher PDW values in hyperdestructive states, indicating increased platelet size variability [17].

Plateletcrit (PCT) was lowest in hypoproliferative thrombocytopenia and highest in controls, with intermediate values in hyperdestructive conditions. This observation is supported by Oliveira et al. (2024), who highlighted the role of PCT as an indicator of total platelet biomass, reflecting both platelet count and size [18]. The findings of the present study reinforce the concept that platelet indices can serve as effective, non-invasive markers in differentiating the underlying mechanisms of thrombocytopenia.

Limitations of the Study

- The study was conducted at a single tertiary care centre, which may limit the generalizability of the findings to a broader population.
- The sample size, although adequate for statistical analysis, was relatively modest, and larger multicentric studies are needed for validation.
- Bone marrow examination, considered the gold standard for classification, was not performed in all cases and was limited to selected patients based on clinical indications.
- Platelet indices were measured using a single automated hematology analyzer; inter-instrument variability may influence the reproducibility of results.
- The cross-sectional design of the study limits the ability to establish causal relationships or assess temporal changes in platelet indices.
- Potential confounding factors such as nutritional status, inflammatory conditions, and comorbidities were not extensively controlled.

Conclusion

The present study demonstrates that platelet indices—MPV, PDW, and PCT—show statistically significant differences among hypoproliferative thrombocytopenia, hyperdestructive thrombocytopenia, and healthy controls, highlighting their diagnostic relevance.

Patients with hyperdestructive thrombocytopenia exhibited significantly higher MPV and PDW values, reflecting increased platelet turnover and release of larger, immature platelets from the bone marrow. In contrast, hypoproliferative thrombocytopenia was associated with significantly lower MPV and PDW values, indicating reduced platelet production. Plateletcrit (PCT), an indicator of total platelet mass, was lowest in hypoproliferative conditions, intermediate in hyperdestructive states, and highest in healthy controls, further supporting its role in distinguishing the underlying mechanism of thrombocytopenia.

The absence of significant differences in age and gender distribution among study groups confirms

that the observed variations in platelet indices are independent of demographic factors.

Overall, platelet indices serve as simple, rapid, cost-effective, and non-invasive hematological parameters that can be routinely obtained from automated analyzers. Their incorporation into clinical practice can aid in the early differentiation of thrombocytopenia, reduce reliance on invasive diagnostic procedures such as bone marrow examination, and facilitate timely and appropriate management, particularly in resource-limited settings.

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