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COMPARATIVE EVALUATION OF BLOOD LABORATORY PARAMETERS IN THROMBOCYTOPENIA

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Abstract

Thrombocytopenia is a critical hematological abnormality presenting a significant diagnostic challenge, requiring precise differentiation between peripheral platelet destruction and impaired central bone marrow production. This study provides a comparative evaluation of advanced laboratory parameters in patients with Primary Immune Thrombocytopenia (ITP) and secondary thrombocytopenia associated with hypersplenism (hepatic cirrhosis). A retrospective cross-sectional study was conducted involving 120 participants: 45 patients with ITP, 45 with cirrhosis-associated thrombocytopenia, and 30 healthy controls. Comprehensive peripheral blood analyses focused on advanced platelet indices, including Mean Platelet Volume (MPV) and Immature Platelet Fraction (IPF). Statistical evaluation utilized the Student's t-test and chi-square analysis. The results revealed profound differences in platelet morphology despite similar degrees of absolute thrombocytopenia in the pathological groups. The ITP cohort exhibited a significantly elevated MPV (11.8 ± 1.2 fL) and IPF (18.5 ± 2.4%) compared to the secondary thrombocytopenia group (MPV 9.2 ± 0.8 fL; IPF 6.2 ± 1.5%, $p < 0.001$), reflecting intense compensatory megakaryopoiesis in response to autoimmune peripheral destruction. Using a cut-off of MPV > 10.5 fL yielded a diagnostic sensitivity of 84.4% and specificity of 88.0% for identifying ITP. Routine assessment of advanced platelet indices offers a highly reliable, non-invasive, and cost-effective method for differentiating the etiology of thrombocytopenia, significantly optimizing diagnostic algorithms and minimizing the immediate need for invasive bone marrow aspirations in regional clinical settings.

Keywords

Thrombocytopenia, Immune thrombocytopenic purpura, Mean platelet volume, Immature platelet fraction, Hypersplenism, Megakaryopoiesis, Peripheral blood smear.

Introduction

Thrombocytopenia, defined as a peripheral blood platelet count of less than 150 x 10^9/L, is one of the most frequently encountered abnormalities in routine clinical laboratory practice. According to the World Health Organization (WHO) and international hematological registries, bleeding disorders associated with low platelet counts contribute to significant global morbidity, complicating surgeries, pregnancies, and chronic diseases.

The clinical challenge does not lie merely in identifying the low platelet count, but in accurately determining its pathophysiological mechanism. Broadly, thrombocytopenia results from either decreased bone marrow production (central failure) or accelerated peripheral

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destruction/sequestration (as seen in Immune Thrombocytopenia - ITP, or hypersplenism). Traditionally, differentiating these mechanisms required an invasive bone marrow aspiration to quantify megakaryocytes. However, modern automated hematology analyzers now provide advanced platelet indices—such as Mean Platelet Volume (MPV), Platelet Distribution Width (PDW), and Immature Platelet Fraction (IPF)—which reflect the functional status of megakaryopoiesis. Assessing the comparative diagnostic value of these non-invasive parameters in the specific clinical demographic of the Fergana Valley is highly relevant for optimizing local hematological protocols.

Literature Review

The diagnostic utility of platelet indices has been a focal point of hematological research over the past decade. A comprehensive review by Kuter (2020) in *Blood* emphasized that ITP is characterized by rapid peripheral platelet destruction mediated by autoantibodies, which simultaneously stimulates the bone marrow to release larger, hyperactive, immature platelets into the circulation.

Clinical studies by Arnold et al. (2017) and Michel et al. (2018) consistently demonstrated that patients with hyperdestructive thrombocytopenia (like ITP) possess significantly higher MPV and IPF compared to those with hypoproliferative states (such as aplastic anemia or chemotherapy-induced thrombocytopenia). Furthermore, research by Xu et al. (2021) highlighted that in secondary consumptive thrombocytopenia, such as that caused by portal hypertension and splenic pooling in liver cirrhosis, platelet indices remain relatively normal or only marginally elevated, as the primary defect is mechanical sequestration rather than intense autoimmune destruction. Despite these global insights, regional comparative data validating the exact diagnostic cut-offs of MPV and IPF in Central Asian populations remains scarce, necessitating targeted clinical-laboratory studies.

Materials and Methods

Study Design and Patient Population

A retrospective, comparative cross-sectional study was conducted at the clinical laboratory of the Andijan State Medical Institute. The study analyzed the diagnostic data of 120 adult participants evaluated over an 18-month period.

The cohort was divided into three distinct groups:

1. **Group 1 - Primary ITP (n=45):** Patients diagnosed with primary Immune Thrombocytopenia (isolated thrombocytopenia < 100 x 10^9/L with no identifiable secondary cause).
2. **Group 2 - Secondary Thrombocytopenia (n=45):** Patients with portal hypertension and hypersplenism secondary to liver cirrhosis, presenting with thrombocytopenia.
3. **Group 3 - Control Group (n=30):** Healthy age-matched volunteers with normal complete blood counts and no history of bleeding disorders.

Inclusion and Exclusion Criteria

- *Inclusion criteria:* Age between 18 and 65 years; newly diagnosed, untreated thrombocytopenia.
- *Exclusion criteria:* Pseudothrombocytopenia (EDTA-induced clumping), active hematological malignancies (leukemias), history of recent chemotherapy, disseminated intravascular coagulation (DIC), and pregnancy.

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Ethical Considerations

The study was approved by the Local Bioethics Committee of the Andijan State Medical Institute. All procedures adhered strictly to the ethical standards of the Declaration of Helsinki. Informed consent was obtained prior to blood sampling.

Laboratory Analysis and Statistical Methods

Venous blood was collected in standard K2-EDTA tubes and analyzed within 2 hours to prevent artifactual platelet swelling. An automated multiparameter hematology analyzer was used to measure absolute Platelet Count (PLT, 10^9/L), Mean Platelet Volume (MPV, fL), and Platelet Distribution Width (PDW, %). Immature Platelet Fraction (IPF, %) was quantified using flow cytometric channels.

Statistical analysis was performed using SPSS version 26.0. Continuous variables were expressed as mean ± standard error of the mean (M ± m). The Student's t-test was utilized to compare continuous variables between groups, and the chi-square test was used for categorical data. A 95% Confidence Interval (CI) was applied, with statistical significance defined as $p < 0.05$.

Results

The demographic characteristics were well-balanced; the mean age was 42.5 ± 5.2 years in the ITP group, 48.1 ± 4.5 years in the Secondary Thrombocytopenia group, and 40.2 ± 3.8 years in the control group.

The comparative analysis of routine and advanced platelet parameters is detailed in Table 1.

Table 1. Comparative analysis of platelet indices in ITP, Secondary Thrombocytopenia, and Controls (M ± m)

Parameter (Unit)	Primary ITP Group (n=45)	Secondary (Cirrhotic) Group (n=45)	Control Group (n=30)	p-value (ITP vs Sec.)
Platelets (10^9/L)	35.4 ± 8.5	42.5 ± 6.4	260 ± 25.2	> 0.05
MPV (fL)	11.8 ± 1.2	9.2 ± 0.8	8.5 ± 0.6	< 0.001
PDW (%)	18.4 ± 2.1	14.5 ± 1.5	12.1 ± 1.2	< 0.01
IPF (%)	18.5 ± 2.4	6.2 ± 1.5	3.5 ± 0.8	< 0.001

The laboratory data clearly demonstrates that while both pathological groups suffered from severe, comparable degrees of absolute thrombocytopenia (no statistical difference in total PLT count, $p > 0.05$), their platelet morphometry was fundamentally different.

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The ITP group exhibited profound macrothrombocytosis. The MPV (11.8 ± 1.2 fL) and the Immature Platelet Fraction (18.5 ± 2.4%) were significantly elevated compared to the secondary thrombocytopenia group ($p < 0.001$). This indicates a highly active bone marrow rapidly releasing large, reticulated platelets to compensate for immune-mediated destruction in the periphery.

To determine the clinical utility of MPV in differentiating destructive ITP from other forms of thrombocytopenia, we calculated its diagnostic value using a threshold of > 10.5 fL.

*Sensitivity = True Positives / (True Positives + False Negatives) * 100*
*Specificity = True Negatives / (True Negatives + False Positives) * 100*
The calculation demonstrated that an MPV > 10.5 fL possesses a Sensitivity of 84.4% and a Specificity of 88.0% for diagnosing peripheral immune destruction.

Discussion

The distinct laboratory profiles observed in this study perfectly align with the pathophysiological mechanisms of thrombocytopenia outlined by Kuter (2020). In primary ITP, autoantibodies destroy mature platelets in the spleen, causing the bone marrow megakaryocytes to undergo intense endomitosis and release larger, immature "stress" platelets (high IPF and MPV) into the bloodstream. Our findings confirm that these parameters are robust biomarkers of active thrombopoiesis.

Conversely, in patients with liver cirrhosis and hypersplenism, the primary issue is the anatomical pooling of up to 90% of the body's platelets within the enlarged spleen, combined with decreased hepatic synthesis of thrombopoietin (TPO). Because the bone marrow is not subjected to acute autoimmune stress, the released platelets remain relatively normal in size and maturity, explaining the significantly lower MPV (9.2 ± 0.8 fL) and IPF (6.2 ± 1.5%) compared to the ITP group. The strong statistical divergence of these indices between the two groups provides a critical, non-invasive diagnostic window.

Scientific Novelty

This study represents the first structured comparative validation of advanced platelet indices (MPV and IPF) specifically for differentiating primary immune thrombocytopenia from secondary hypersplenism within the clinical demographic of the Fergana Valley. The research mathematically establishes that an MPV > 10.5 fL serves as a highly specific, low-cost screening biomarker capable of confirming hyperdestructive megakaryopoiesis without the need for immediate invasive diagnostics.

Conclusion & Recommendations

1. **Conclusion:** While absolute platelet counts confirm the presence of thrombocytopenia, they offer no insight into its etiology. Advanced platelet indices (MPV, PDW, and IPF) exhibit striking, statistically significant differences depending on the pathomechanism. Elevated MPV and IPF strongly indicate peripheral immune destruction (ITP), whereas normal or mildly altered indices point towards sequestration or central suppression.

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2. **Recommendations for Practice:** Hematologists and general practitioners must incorporate the routine analysis of MPV and IPF in the primary diagnostic workup of any patient presenting with isolated thrombocytopenia.

- An MPV > 10.5 fL combined with an elevated IPF should rapidly direct the clinical focus towards autoimmune mechanisms (ITP), allowing for the prompt initiation of corticosteroid therapy while deferring traumatic bone marrow aspiration in classic presentations.

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