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Original Research Article

Correlation of Morphological Patterns of Anaemia with Red Blood Cell and Platelet Indices: A Cross-Sectional Study

Anil Kumar

Associate Professor, Department of Pathology, Netaji Subhas Medical College and Hospital, Amhara, Bihta, Patna, Bihar, India

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Corresponding Author: Dr. Anil Kumar
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Abstract:

Background: Anaemia remains one of the most prevalent haematological disorders worldwide, characterized by reduced oxygen-carrying capacity of the blood due to decreased hemoglobin levels. Morphological classification of anaemia based on red cell indices offers valuable insight into underlying aetiologies, aiding in diagnostic differentiation. Additionally, platelet indices, though often underutilized, may reflect associated bone marrow or systemic alterations that accompany various anaemia subtypes.

Aim and Objective: The present study was undertaken to evaluate the morphological types of anaemia and correlate them with red cell and platelet indices to better understand the hematological profile associated with different forms of anaemia.

Materials and Methods: This cross-sectional study included 200 patients diagnosed with anaemia based on WHO criteria, attending the Department of Pathology, Netaji Subhas Medical College, and Hospital, Bihta, Patna. Complete blood counts were performed using automated hematology analyzers to record hemoglobin concentration, RBC indices (MCV, MCH, MCHC, RDW), and platelet indices (platelet count, MPV, PDW, PCT). Peripheral blood smears were examined for morphological categorization into microcytic, normocytic, macrocytic, dimorphic, and others. Statistical analysis was performed to evaluate associations between morphological types and hematological indices.

Results: Microcytic hypochromic anaemia was the most common morphological type, followed by normocytic normochromic and macrocytic anaemia. Dimorphic anaemia was also frequently observed. A significant correlation was noted between MCV and morphological classification ($p < 0.001$). Platelet indices showed variability across anaemia types, with thrombocytosis frequently seen in microcytic anaemia and thrombocytopenia more prevalent in macrocytic forms. Mean platelet volume and platelet distribution width also showed statistically significant variations among the different groups.

Conclusion: Morphological evaluation of anaemia, when integrated with red cell and platelet indices, provides a comprehensive hematological profile that enhances diagnostic accuracy and facilitates targeted investigations. Peripheral smear examination remains indispensable, and combined analysis with hematological indices serves as an effective, cost-efficient tool for routine anaemia work-up, especially in resource-limited settings.

Introduction

Anaemia is a globally prevalent hematological disorder, affecting individuals across all age groups, genders, and socioeconomic backgrounds. Defined by a reduction in the oxygen-carrying capacity of blood due to decreased hemoglobin levels, anaemia contributes significantly to morbidity and mortality worldwide [1]. Its impact is particularly pronounced in developing countries, where nutritional deficiencies, infectious diseases, chronic illnesses, and limited healthcare resources contribute to its high prevalence. Early identification and classification of anaemia are crucial for timely diagnosis, appropriate therapeutic intervention, and prevention of long-term complications [2].

Traditionally, the evaluation of anaemia involves clinical examination, laboratory investigations, and most importantly, morphological assessment of peripheral blood smears. Morphological classification of anaemia based on red blood cell size, shape, and hemoglobin content allows categorization into microcytic, normocytic, macrocytic, dimorphic, and other rarer forms. This morphological approach provides essential clues to the underlying etiology, ranging from iron deficiency, nutritional imbalances, hemolytic disorders, bone marrow failure syndromes, chronic inflammatory states, to megaloblastic disorders [3,4].

In addition to morphological features, complete blood count (CBC) parameters generated by automated hematology analyzers provide valuable quantitative indices that further support the diagnostic process. Red blood cell indices such as mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), and red cell distribution width (RDW) offer objective data on cell size variability, hemoglobin concentration, and anisocytosis. These indices not only assist in classifying anaemia but may also guide further investigations for specific etiological factors [5,6].

While red cell indices have traditionally been the focus of anaemia evaluation, platelet indices are emerging as additional markers reflecting underlying bone marrow activity and systemic involvement in various anaemia subtypes. Platelet parameters such as platelet count, mean platelet volume (MPV), platelet distribution width (PDW), and plateletcrit (PCT) may exhibit characteristic changes associated with different anaemia patterns, particularly in cases of nutritional deficiencies, bone marrow dysplasia, and inflammatory disorders. Thus, combined analysis of red cell and platelet indices offers a more integrated hematological profile, enhancing the diagnostic yield of routine laboratory workups [7,8].

Despite the widespread availability of automated hematology analyzers capable of providing detailed red cell and platelet indices, peripheral smear examination remains indispensable. Morphological assessment complements automated indices, especially in detecting abnormal cell shapes, inclusion bodies, and atypical cells, which may escape automated detection but hold diagnostic significance [9]. While several studies have explored the individual roles of red cell indices and morphological assessment in anaemia, relatively few have integrated both red cell and platelet indices to correlate with morphological subtypes of anaemia. Such integrated evaluation could serve as a valuable diagnostic tool, particularly in resource-limited settings where extensive laboratory investigations may not always be feasible [10].

In this context, the present study was designed to analyze the morphological patterns of anaemia and correlate them with red blood cell and platelet indices in patients presenting with anaemia. The study aims to provide comprehensive hematological insights that may assist clinicians in early identification of the likely etiology, streamline diagnostic algorithms, and initiate timely and appropriate therapeutic interventions.

Materials and Methods

The present cross-sectional observational study was conducted in the Department of Pathology, Netaji Subhas Medical College and Hospital, Amhara, Bihta, Patna, Bihar, India.

Study Duration and Sample Size

The study was conducted over a period of one year . A total of 200 patients diagnosed with anaemia as per WHO guidelines (hemoglobin <13 g/dL for males and <12 g/dL for females) were included in the study. The sample size was calculated to ensure adequate representation of various morphological types of anaemia and sufficient statistical power for subgroup analysis.

Inclusion Criteria

- Patients of either gender, aged 15 years and above.
- Hemoglobin levels below WHO-defined cut-off for anaemia.
- Complete clinical and laboratory data available including peripheral smear, red cell, and platelet indices.

Exclusion Criteria

- Patients with known hematological malignancies or primary bone marrow disorders.
- Recent history of acute hemorrhage or blood transfusion within the past 3 months.
- Pregnant females.
- Incomplete or inadequate laboratory data.

Data Collection Protocol

Following clinical examination, 2 mL of venous blood was collected in EDTA vials from each patient for laboratory investigations. The complete blood count (CBC) was performed using an automated 5-part hematology analyzer. The following parameters were recorded for each patient:

- Hemoglobin (Hb)
- Total RBC count
- Mean Corpuscular Volume (MCV)
- Mean Corpuscular Hemoglobin (MCH)
- Mean Corpuscular Hemoglobin Concentration (MCHC)
- Red Cell Distribution Width (RDW)
- Platelet count
- Mean Platelet Volume (MPV)
- Platelet Distribution Width (PDW)
- Plateletcrit (PCT)

Peripheral Smear Examination

In addition to automated hematology analysis, all samples underwent peripheral blood smear preparation and microscopic examination. Smears were stained using Leishman stain and assessed under light microscopy by two independent pathologists to minimize observer bias. Morphological classification was done based on red

cell size, shape, and staining characteristics as follows:

- Microcytic hypochromic anaemia
- Normocytic normochromic anaemia
- Macrocytic anaemia
- Dimorphic anaemia
- Other variants (if present)

Correlation and Integration of Data

Morphological findings were correlated with red cell indices (MCV, MCH, MCHC, RDW) and platelet indices (Platelet count, MPV, PDW, PCT). Particular emphasis was placed on evaluating the distribution of platelet indices in relation to the morphological types of anaemia.

Statistical Analysis

All data were compiled and analyzed using SPSS software version 25.0. Descriptive statistics (mean, standard deviation, percentage) were calculated for all hematological indices. The association between morphological types of anaemia and hematological indices was evaluated using Chi-square test, ANOVA, and Pearson correlation wherever applicable. A p-value of <0.05 was considered statistically significant.

Results

The present study included 200 patients diagnosed with anaemia, with a female predominance observed (62%) and most patients falling within the 21–40 years age group. Morphologically, microcytic hypochromic anaemia was the most prevalent type, accounting for 48% of cases, followed by normocytic normochromic anaemia (28%), macrocytic anaemia (12%), and dimorphic anaemia (10%). The mean hemoglobin level across the study population was 8.4 ± 1.6 g/dL. Significant variations in red cell indices were observed across the different morphological types; microcytic anaemia cases demonstrated the lowest mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC), while macrocytic anaemia showed elevated MCV values. Red cell distribution width (RDW) was markedly increased in dimorphic anaemia cases, indicating greater anisocytosis. Platelet indices also showed variation across morphological types; thrombocytosis was most frequently seen in microcytic anaemia, whereas macrocytic anaemia cases demonstrated higher frequencies of thrombocytopenia. Mean platelet volume (MPV) and platelet distribution width (PDW) were significantly elevated in dimorphic and macrocytic anaemia subgroups. Statistical analysis revealed significant associations between morphological types of anaemia and both red cell and platelet indices ($p < 0.001$).

Table 1: Age-wise Distribution of Study Participants

Age Group (Years)	No. of Patients
15 – 20	28
21 – 30	56
31 – 40	48
41 – 50	34
>50	34

Table 2: Gender-wise Distribution of Study Participants

Gender	No. of Patients
Male	76
Female	124

Table 3: Distribution of Morphological Types of Anaemia

Morphological Type	No. of Patients	Percentage (%)
Microcytic Hypochromic	96	48%
Normocytic Normochromic	56	28%
Macrocytic	24	12%
Dimorphic	20	10%

Table 4: Mean Hemoglobin Levels Across Morphological Types

Morphological Type	Mean Hemoglobin (g/dL)	Standard Deviation (SD)
Microcytic Hypochromic	8.1	1.4
Normocytic Normochromic	8.7	1.6
Macrocytic	8.3	1.8
Dimorphic	8.6	1.5

Table 5: Red Cell Indices in Different Morphological Types

Morphological Type	MCV (fL)	MCH (pg)	MCHC (g/dL)	RDW (%)
Microcytic	68.4	21.3	29.6	18.2
Normocytic	83.1	27.8	32.1	14.6
Macrocytic	103.5	33.9	32.8	15.3
Dimorphic	79.5	25.1	31.5	22.5

Table 6: Platelet Count Distribution Across Morphological Types

Morphological Type	Mean Platelet Count (x10⁹/L)	Standard Deviation (SD)
Microcytic	340	90
Normocytic	285	80
Macrocytic	210	75
Dimorphic	290	85

Table 7: Mean Platelet Volume (MPV) Across Morphological Types

Morphological Type	Mean MPV (fL)	Standard Deviation (SD)
Microcytic	9.0	1.1
Normocytic	9.5	1.0
Macrocytic	10.8	1.3
Dimorphic	10.2	1.2

Table 8: Platelet Distribution Width (PDW) Across Morphological Types

Morphological Type	Mean PDW (%)	Standard Deviation (SD)
Microcytic	13.2	2.0
Normocytic	13.7	1.9
Macrocytic	15.3	2.1
Dimorphic	14.9	2.2

Table 9: Plateletcrit (PCT) Across Morphological Types

Morphological Type	Mean PCT (%)	Standard Deviation (SD)
Microcytic	0.29	0.05
Normocytic	0.26	0.04
Macrocytic	0.21	0.03
Dimorphic	0.25	0.04

Table 10: Correlation Between Morphological Type and MCV (ANOVA Analysis)

Test	F-Value	p-Value
MCV	112.36	<0.001

Table 11: Correlation Between Morphological Type and Platelet Count (ANOVA Analysis)

Test	F-Value	p-Value
Platelet Count	21.74	<0.001

Table 12: Correlation Between Morphological Type and MPV (ANOVA Analysis)

Test	F-Value	p-Value
MPV	9.48	<0.001

Table 1 shows the majority of patients belonged to the 21–30 years age group. Table 2 indicates female predominance among anaemic patients. Table 3 reveals microcytic hypochromic anaemia as the most common morphological type followed by normocytic, macrocytic, and dimorphic patterns. Table 4 presents mean hemoglobin levels with lowest levels noted in microcytic anaemia. Table 5 demonstrates significant variations in red cell indices, with low MCV and MCH in microcytic anaemia, and high MCV in macrocytic anaemia. Table 6 shows thrombocytosis more frequent in microcytic anaemia and lower platelet counts in macrocytic forms. Table 7 and Table 8 highlight higher MPV and PDW in macrocytic and dimorphic anaemias. Table 9 presents PCT variations, with highest PCT in microcytic anaemia. Table 10, Table 11, and Table 12 confirm statistically significant correlations between morphological types of anaemia and MCV, platelet count, and MPV respectively ($p<0.001$).

Discussion

Anaemia remains a significant global health concern and represents one of the most frequently encountered haematological abnormalities in clinical practice. Morphological classification of anaemia, when integrated with comprehensive hematological indices, plays a critical role in guiding diagnosis, investigating underlying aetiologies, and determining appropriate management strategies [11]. The present study attempted to analyze the distribution of morphological types of anaemia and correlate these findings with red blood cell and platelet indices to enhance the diagnostic approach for anaemic patients [12].

In this study, microcytic hypochromic anaemia was found to be the most prevalent morphological type, accounting for 48% of cases. This finding aligns with global trends, where iron deficiency anaemia remains the leading cause of microcytic anaemia, particularly among young females, due to nutritional deficiencies, menstrual blood loss, and poor dietary habits [13]. The present study also demonstrated a clear female predominance, which is consistent with several previous studies reporting higher anaemia prevalence among women of reproductive age. Normocytic normochromic anaemia, constituting 28% of cases, was the second most common type and may reflect anaemia of chronic disease, early iron deficiency, or underlying chronic systemic disorders [14]. Macrocytic anaemia, observed in 12% of patients, is often attributed to deficiencies of vitamin B12 or folate, alcoholism, liver disease, or bone marrow disorders, while dimorphic anaemia seen in 10% of patients typically results from combined nutritional deficiencies or post-treatment phases of iron therapy [15].

The red cell indices provided valuable quantitative support for morphological classification. Microcytic anaemia demonstrated significantly lower mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC), while macrocytic anaemia showed elevated MCV values, which is characteristic of megaloblastic processes. RDW, a marker of anisocytosis, was markedly increased in dimorphic anaemia cases, reflecting the coexistence of microcytic and macrocytic populations within the peripheral blood, and highlighting its diagnostic relevance in mixed nutritional deficiency states [16].

In addition to red cell indices, platelet indices have recently gained attention as adjunctive markers in anaemia evaluation. In the present study, significant variations in platelet counts were observed across morphological types. Thrombocytosis was frequently seen in microcytic anaemia, which may reflect reactive thrombocytosis often associated with iron deficiency. Conversely, thrombocytopenia was more commonly seen in macrocytic anaemia, possibly due to bone marrow suppression or ineffective hematopoiesis often seen in megaloblastic anaemia. These findings are consistent with previous reports highlighting bone marrow involvement in the pathophysiology of macrocytic anaemia [17].

Mean platelet volume (MPV) and platelet distribution width (PDW), which reflect platelet production kinetics and size variability, were significantly higher in macrocytic and dimorphic anaemias. Increased MPV may indicate compensatory bone marrow response to thrombocytopenia, while elevated PDW reflects a wider range of platelet sizes associated with ineffective platelet production or peripheral destruction. Plateletcrit (PCT), representing the total platelet mass, was highest in microcytic anaemia and lowest in macrocytic anaemia, correlating with platelet count trends [18].

The integration of red cell and platelet indices with morphological evaluation provides a more holistic understanding of the haematological profile of anaemic patients. Automated hematology analyzers, while offering precise measurements, should always be supplemented with peripheral smear examination, which remains indispensable for detecting morphological abnormalities such as poikilocytosis, anisocytosis, polychromasia, and abnormal inclusion bodies that cannot be quantified by automated methods [19].

The findings of this study reinforce the clinical value of integrating simple, routinely available hematological indices with careful morphological assessment to achieve a more accurate diagnosis. This approach is particularly valuable in resource-constrained settings where advanced investigations may not be readily accessible. Early identification of specific anaemia patterns facilitates timely intervention, nutritional supplementation, and appropriate workup for systemic disorders or bone marrow dysfunction [20].

The study is not without limitations. Being a cross-sectional study, causal relationships between platelet indices and specific anaemia subtypes could not be established. Moreover, bone marrow examination and iron studies were not performed in all patients, which could have further strengthened the etiological diagnosis. Future large-scale prospective studies incorporating nutritional markers, bone marrow evaluation, and long-term follow-up may provide additional insights into the complex interplay between red cell and platelet indices in anaemia.

Conclusion

The present study demonstrated that integrating morphological classification of anaemia with red blood cell and platelet indices provides a

comprehensive hematological profile that significantly enhances diagnostic precision and aids in differentiating various types of anaemia. Microcytic hypochromic anaemia emerged as the most prevalent morphological type, with red cell indices such as MCV, MCH, and RDW showing strong correlation with morphological patterns. Platelet indices, including platelet count, mean platelet volume, platelet distribution width, and plateletcrit, exhibited significant variations across different anaemia subtypes, reflecting underlying bone marrow dynamics and systemic influences. The combination of automated hematology analyzer parameters with peripheral smear examination offers a simple, effective, and economical diagnostic approach, particularly valuable in resource-limited settings. These findings emphasize the importance of a detailed and integrated haematological workup in routine anaemia evaluation, and larger multicentric studies with advanced investigations are recommended to further validate and expand upon these observations.

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