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Original Research Article

Correlation of Morphological Patterns of Anaemia with Red Blood Cell and Platelet Indices

Deepak Goyal[1], Sadhana Agrawal[2], Aditya Vyas[3]

[1]MBBS, MD (Pathology), Associate Professor, Department of Pathology, RVRS Medical College, Bhilwara, Rajasthan, India

[2]MBBS, MD (Physiology), Associate Professor, Department of Physiology, RVRS Medical College, Bhilwara, Rajasthan, India

[3]MBBS, MD (Medicine), Assistant Professor, Department of Gastroenterology, SMS Medical College, Jaipur, Rajasthan, India

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Corresponding author: Dr. Aditya Vyas
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Abstract

Background: Anaemia is one of the most common hematological disorders, particularly in developing countries. Objective- To evaluate the morphological patterns of anaemia and correlate them with red blood cell indices and platelet indices in anaemic patients attending a tertiary care hospital.

Materials and Methods: The present hospital-based cross-sectional observational study was conducted in the Department of Pathology at RVRS Medical College, Bhilwara over a period of one year from September 2024 to August 2025. A total of 276 patients diagnosed with anaemia were included in the study. Patients with hematological malignancies, recent blood transfusion, acute hemorrhagic conditions, and inadequate samples were excluded.

Results: The majority of patients belonged to the age group of 21–30 years (27.9%), and females constituted 62.0% of the study population. Microcytic hypochromic anaemia was the most common morphological type, observed in 132 patients, followed by normocytic normochromic anaemia in 77 patients. The overall mean hemoglobin level was 8.35 ± 1.53 g/dL, and the difference among various morphological types was statistically significant (p=0.038). The differences in red blood cell indices among different morphological patterns were statistically significant (p<0.001). Significant differences were observed in MPV, PDW, and PCT among various morphological types of anaemia (p<0.001).

Conclusion: Microcytic hypochromic anaemia was the predominant morphological pattern. Significant variations in red blood cell and platelet indices were observed among different morphological types of anaemia. Correlation of peripheral smear morphology with automated red blood cell and platelet indices provides a better understanding of the hematological profile of anaemic patients and may aid in early diagnosis and classification of anaemia.

Keywords: Anaemia; Peripheral Blood Smear; Red Blood Cell Indices; Platelet Indices; Morphological Classification.

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Introduction

Anaemia is one of the most common hematological problems, characterized by a reduction in haemoglobin concentration. WHO estimated that in 2019, anaemia affected 30% of women aged 15–49 years, 37% of pregnant women, and 40% of children aged 6–59 months worldwide. [1]

Anemia has multiple etiological factors, including nutritional deficiencies, chronic inflammation, infections, renal disease, blood loss, hemoglobinopathies, and bone marrow disorders. The Global Burden of Disease Study 2021 reported that anaemia affected approximately 1.92 billion people globally in 2021, with a prevalence of 24.3%, and the burden was particularly high among women, young children, and populations in South Asia and sub-Saharan Africa. [2]

Developing countries account for a major proportion of anaemia-related disability, and iron deficiency remains the dominant cause of anaemia worldwide. [3] Morphological classification of anaemia remains an important step in routine hematological evaluation. Based on red blood cell morphology, anaemia is commonly classified into microcytic hypochromic, normocytic normochromic, macrocytic, and dimorphic types. Peripheral blood smear examination provides direct visual assessment of red cell size, shape, hemoglobinization, anisocytosis, poikilocytosis, and platelet morphology. Careful smear examination helps in identifying the likely mechanism and guides further investigations.

Red blood cell indices such as mean corpuscular volume, mean corpuscular haemoglobin, mean corpuscular haemoglobin concentration, and red cell distribution width are useful in the morphological classification of anaemia. MCV, MCH, and MCHC help define red cell size and haemoglobin content, while RDW provides an estimate of anisocytosis. These indices are useful in differentiating microcytic, normocytic, and macrocytic patterns and in identifying mixed red cell populations. [4] Peripheral blood examination is especially important in dimorphic anaemia, where MCV may appear normal despite the presence of two different red cell populations. Therefore, correlation of automated indices with peripheral smear morphology remains important in routine diagnostic hematology.

Platelet indices are increasingly being studied in anaemic patients. Platelet parameters such as platelet count, mean platelet volume, platelet distribution width, and plateletcrit reflect platelet production, size variation, and platelet mass. Budak et al. described that platelet indices can provide information regarding platelet morphology and activation, and PDW reflects variability in platelet size. [5] Iron deficiency anaemia is commonly associated with changes in platelet parameters.

Kadikoylu et al. studied platelet parameters in women with iron deficiency anaemia and observed that platelet counts were increased when serum iron, iron saturation, ferritin, and mean platelet volume were decreased. [6] Abbas et al. reported a significant correlation between red cell distribution width and peripheral smear findings in anaemic patients, suggesting that RDW can serve as a useful supportive marker of anisocytosis. [7] Jundi et al. also found that platelet count variation correlated with red cell indices and morphological types of anaemia in adult anaemic patients. [8] These findings indicate that combined assessment of peripheral smear morphology, red blood cell indices, and platelet indices may provide a more complete hematological profile.

Although automated hematology analyzers are widely used in routine practice, peripheral blood smear examination continues to have an important role in confirming and refining anaemia classification. The combined use of smear morphology with RBC and platelet indices may improve diagnostic accuracy, support early classification, and guide further evaluation. Therefore, the present study was conducted to evaluate the correlation of morphological patterns of anaemia with red blood cell and platelet indices among anaemic patients.

Materials and Methods

The present hospital-based cross-sectional observational study was conducted in the Department of Pathology at RVRS Medical College, Bhilwara to evaluate the morphological patterns of anaemia and correlate them with red blood cell indices and platelet indices in anaemic patients. The study was carried out over a period of one year from September 2024 to August 2025, and an additional three months were utilized for data analysis and report writing. Patients attending both outpatient and inpatient departments during the study period were included in the study. The study population comprised patients diagnosed with anaemia according to World Health Organization (WHO) criteria. Patients presenting with clinical features suggestive of anaemia and having reduced hemoglobin levels on laboratory evaluation were enrolled in the study.

A total of 276 patients fulfilling the inclusion criteria were included in the study. Patients were selected using a consecutive sampling technique, and all eligible patients presenting during the study period were enrolled until the required sample size was achieved. The study included patients aged 18 years and above, belonging to either gender, and diagnosed with anaemia as per WHO criteria, defined as hemoglobin levels less than 13 g/dL in males and less than 12 g/dL in females. Only those patients who were willing to participate in the study were included.

Patients with known hematological malignancies, primary bone marrow disorders, recent history of blood transfusion within the previous three months, and acute hemorrhagic conditions were excluded from the study. Pregnant females and patients with incomplete clinical details or inadequate laboratory samples were also excluded from the study. Prior approval was obtained from the Institutional Ethics Committee before commencement of the study. Written informed consent was obtained from all participants before their inclusion in the study. Confidentiality of patient information and laboratory findings was maintained throughout the study period.

A detailed clinical history was obtained from all patients, including demographic details, presenting complaints, dietary history, and history of chronic illnesses, drug intake, bleeding manifestations, and previous treatment history.

General physical examination and systemic examination were performed in all patients. Under aseptic precautions, approximately 2 mL of venous blood was collected from each participant using sterile disposable syringes and transferred into EDTA anticoagulated vacutainer tubes for hematological investigations.

All samples were processed within the recommended time period to avoid pre-analytical errors and alterations in hematological parameters. Complete blood count (CBC) analysis was performed using an automated 5-part hematology analyzer. Regular quality control procedures were followed according to standard laboratory protocols. The hematological parameters recorded included hemoglobin concentration (Hb), total red blood cell count (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), and plateletcrit (PCT). Peripheral blood smears were prepared from fresh EDTA blood samples immediately after sample collection. Thin blood smears were prepared on clean glass slides and stained using Leishman stain according to the standard staining procedure. The stained smears were examined under light microscopy by experienced pathologists. Red blood cell morphology, cell size, hemoglobinization, anisocytosis, poikilocytosis, and platelet morphology were carefully assessed. Based on peripheral smear findings and red blood cell morphology, anaemia was morphologically classified into microcytic hypochromic anaemia, normocytic normochromic anaemia, macrocytic anaemia, and dimorphic anaemia.

The morphological classification obtained from peripheral smear examination was correlated with red blood cell indices and platelet indices obtained from automated hematology analysis. Red cell indices including MCV, MCH, MCHC, and RDW were compared among different morphological types of anaemia. Similarly, platelet parameters such as platelet count, MPV, PDW, and PCT were analyzed and correlated with the various morphological subtypes of anaemia.

Statistical Analysis

Statistical analysis was performed using SPSS software version 25.0. Categorical variables were expressed as frequency and percentage, while continuous variables were expressed as mean±standard deviation.

Comparison of hematological parameters among different morphological types of anaemia was performed using One-way Analysis of Variance (ANOVA) test. Correlation between morphological patterns and hematological indices was assessed using appropriate statistical tests wherever applicable. A p-value of less than 0.05 was considered statistically significant.

Results

[Table-1] In the present study, the majority of patients belonged to the age group of 21–30 years (27.9%), followed by 31–40 years (23.9%). Patients aged 41–50 years and more than 50 years each constituted 17.0% of the study population, while 14.1% of patients were in the 18–20 years age group. Female patients (62.0%) were more commonly affected than male patients (38.0%).

[Table-2] In the present study, microcytic hypochromic anaemia was the most common morphological type, observed in 132 patients, followed by normocytic normochromic anaemia in 77 patients. Macrocytic and dimorphic anaemia were observed in 34 and 33 patients, respectively. The overall mean hemoglobin level of the study population was 8.35 ± 1.53 g/dL. Mean hemoglobin levels showed a statistically significant difference among different morphological types of anaemia (p=0.038).

[Table-3] In the present study, patients with microcytic hypochromic anaemia had the lowest mean MCV, MCH, and MCHC values, whereas patients with macrocytic anaemia showed the highest mean MCV and MCH values. Dimorphic anaemia showed intermediate values of red blood cell indices. The differences in MCV, MCH, and MCHC among different morphological types of anaemia were statistically significant (p<0.001).

[Table-4] In the present study, the mean platelet volume (MPV) was lowest in patients with microcytic hypochromic anaemia and highest in patients with macrocytic anaemia. Patients with dimorphic anaemia also showed relatively higher MPV values compared to normocytic normochromic anaemia. The overall mean MPV was 9.50 ± 1.26 fL. The difference in MPV among different morphological types of anaemia was statistically significant (p<0.001).

[Table -5] In the present study, platelet distribution width (PDW) was highest in patients with macrocytic anaemia, followed by dimorphic anaemia. Lower PDW values were observed in microcytic hypochromic and normocytic normochromic anaemia.

The overall mean PDW of the study population was 13.80 ± 2.17%. The difference in PDW among different morphological types of anaemia was statistically significant (p<0.001). [Table-6] In the present study, plateletcrit (PCT) was highest in patients with microcytic hypochromic anaemia and lowest in patients with macrocytic anaemia. Patients with normocytic normochromic and dimorphic anaemia showed intermediate PCT values. The overall mean PCT was 0.27 ± 0.05%. The difference in PCT among different morphological types of anaemia was statistically significant (p<0.001).

Table 1: Distribution of Study Participants According to Age Group and Gender

Variable		Number	Percentage
Age Group (Years)	18–20 years	39	14.10%
	21–30 years	77	27.90%
	31–40 years	66	23.90%
	41–50 years	47	17.00%
	>50 years	47	17.00%
Gender	Male	105	38.00%
	Female	171	62.00%

Table 2: Comparison of Mean Hemoglobin Levels among Different Morphological Types of Anaemia

Morphological Type	Number	Mean Hb (g/dL)	p-value
Microcytic hypochromic	132	8.1 ± 1.4	**0.038**
Normocytic normochromic	77	8.7 ± 1.6	
Macrocytic	34	8.3 ± 1.8	
Dimorphic	33	8.6 ± 1.5	
Overall	**276**	**8.35 ± 1.53**	

Table 3: Comparison of Red Blood Cell Indices among Different Morphological Types of Anaemia

Morphological Type	MCV (fL)	MCH (pg)	MCHC (g/dL)	RDW (%)
Microcytic hypochromic	68.4 ± 6.5	21.3 ± 2.5	29.6 ± 1.8	18.2 ± 3.0
Normocytic normochromic	83.1 ± 5.8	27.8 ± 2.2	32.1 ± 1.5	14.6 ± 2.0
Macrocytic	103.5 ± 9.2	33.9 ± 3.2	32.8 ± 1.7	15.3 ± 2.4
Dimorphic	79.5 ± 12.5	25.1 ± 4.0	31.5 ± 1.8	22.5 ± 4.0
p-value	**<0.001**	**<0.001**	**<0.001**	**<0.001**

Table 4: Comparison of Mean Platelet Volume among Different Morphological Types of Anaemia

Morphological Type	No. of Patients	MPV (fL)	p-value
Microcytic hypochromic	132	9.0 ± 1.1	**<0.001**
Normocytic normochromic	77	9.5 ± 1.0	
Macrocytic	34	10.8 ± 1.3	
Dimorphic	33	10.2 ± 1.2	
Overall	**276**	**9.50 ± 1.26**	

Table 5: Comparison of Platelet Distribution Width among Different Morphological Types of Anaemia

Morphological Type	No. of Patients	PDW (%)	p-value
Microcytic hypochromic	132	13.2 ± 2.0	**<0.001**
Normocytic normochromic	77	13.7 ± 1.9	
Macrocytic	34	15.3 ± 2.1	
Dimorphic	33	14.9 ± 2.2	
Overall	**276**	**13.80 ± 2.17**	

Table 6: Comparison of Plateletcrit among Different Morphological Types of Anaemia

Morphological Type	No. of Patients	PCT (%)	p-value
Microcytic hypochromic	132	0.29 ± 0.05	**<0.001**
Normocytic normochromic	77	0.26 ± 0.04	
Macrocytic	34	0.21 ± 0.03	
Dimorphic	33	0.25 ± 0.04	
Overall	**276**	**0.27 ± 0.05**	

Discussion: In the present study, the majority of patients belonged to the age group of 21–30 years (27.9%), followed by 31–40 years (23.9%), and least 14.1% of patients belonged to the 18–20 years age group. Female patients constituted 62.0% of the study population. The higher prevalence of anaemia among females in the younger and middle age groups may be attributed to nutritional deficiencies, menstrual blood loss, repeated pregnancies, and increased iron requirements during the reproductive period. In addition, dietary insufficiency and poor socioeconomic conditions may also contribute to the higher burden of anaemia among females. Similar findings were reported by Archana Shetty et al [9], who observed that most anaemia cases were microcytic hypochromic in type and that females formed a major proportion of anaemic patients. Vertika Gupta et al [10] also reported a higher prevalence of anaemia among females (69%) compared to males (31%). Anuradha Shah et al [11] observed that microcytic hypochromic anaemia was more common among females, mainly due to nutritional deficiency, menstrual blood loss, pregnancy, and reduced iron intake. Shivaji Dadarao Birare et al [12] reported that the commonest age group affected by anaemia was 15–24 years, accounting for 37.69% of cases, with a mean age of 32.8 years, which is comparable to the younger age predominance observed in our study.

In our study, microcytic hypochromic anaemia was the most common morphological type (132 cases), followed by normocytic normochromic anaemia (77 cases). The overall mean hemoglobin level was 8.35±1.53 g/dL. The lowest mean hemoglobin level was seen in microcytic hypochromic anaemia (8.1±1.4 g/dL), while normocytic normochromic anaemia showed relatively higher hemoglobin values (8.7 ± 1.6 g/dL). The difference in hemoglobin levels among different morphological types of anaemia was statistically significant ($p=0.038$). The lower hemoglobin levels in microcytic hypochromic anaemia may be related to chronic iron deficiency and impaired hemoglobin synthesis, while normocytic anaemia may include milder forms associated with chronic diseases or early nutritional deficiency states. Anil Kumar et al [13] observed that microcytic hypochromic anaemia was the most common morphological type, followed by normocytic normochromic and macrocytic anaemia. Archana Shetty et al [9] also reported that 67.1% of anaemia cases were microcytic hypochromic, making it the predominant morphological subtype. Similarly, Raja Vojjala et al [14] observed that microcytic hypochromic anaemia accounted for 46.0% of cases, followed by normocytic normochromic anaemia in 38.0% of patients.

Anuradha Shah et al [11] reported that 55% of patients had microcytic hypochromic anaemia, whereas normocytic normochromic and macrocytic patterns were observed in 29% and 16% of patients, respectively. These findings are consistent with the present study and indicate that iron deficiency-related anaemia remains the predominant morphological pattern in hospital-based populations.

In current study, patients with microcytic hypochromic anaemia had the lowest mean MCV (68.4 ± 6.5 fL), MCH (21.3 ± 2.5 pg), and MCHC (29.6 ± 1.8 g/dL) values, whereas patients with macrocytic anaemia showed the highest mean MCV (103.5 ± 9.2 fL) and MCH (33.9 ± 3.2 pg) values. Dimorphic anaemia showed intermediate values of red blood cell indices with the highest RDW value (22.5 ± 4.0%), indicating marked anisocytosis and mixed red cell populations. The differences in MCV, MCH, MCHC, and RDW among different morphological types of anaemia were statistically significant ($p<0.001$). The reduced MCV and MCH values in microcytic hypochromic anaemia reflect defective hemoglobin synthesis, whereas elevated MCV in macrocytic anaemia may result from impaired DNA synthesis associated with vitamin B12 or folate deficiency. Increased RDW in dimorphic anaemia suggests coexistence of multiple nutritional deficiencies leading to variable red cell size. Shivaji Dadarao Birare et al [12] reported that MCV values were increased in most cases of megaloblastic anaemia and decreased in iron deficiency anaemia. They also observed increased RDW in most hematological disorders. Similar findings were reported by Sumira Abbas et al [15], who found that microcytic red blood cells were present in 60.0% of patients and hypochromia in 66.9% of cases, with a significant correlation between RDW and peripheral smear findings. Mohammedamin Jundi et al [16] observed a significant negative correlation between platelet count and MCV, MCH, and MCHC values, further supporting the association between red blood cell indices and morphological patterns of anaemia. Archana Shetty et al [9] also observed increased RDW in microcytic hypochromic anaemia and normocytic normochromic anaemia. Lalit Aseri et al [17] reported that most discordant cases identified by automated indices alone required peripheral smear examination for correct morphological typing, particularly in cases with raised RDW. Vertika Gupta et al10 similarly concluded that peripheral smear examination remains important because automated indices alone may not completely identify dimorphic or mixed nutritional anaemias.

In the present study, the mean platelet volume (MPV) was lowest in microcytic hypochromic anaemia (9.0 ± 1.1 fL) and highest in macrocytic anaemia (10.8 ± 1.3 fL). Patients with dimorphic anaemia also showed relatively higher MPV values (10.2 ± 1.2 fL) compared to normocytic normochromic anaemia (9.5 ± 1.0 fL). The difference in MPV among different morphological types of anaemia was statistically significant ($p<0.001$). Increased MPV in macrocytic and dimorphic anaemia may be due to increased platelet turnover and altered megakaryocyte maturation associated with nutritional deficiencies. Lower MPV values in microcytic hypochromic anaemia may reflect reactive thrombopoiesis with production of relatively smaller platelets. Comparable findings were reported by Archana Shetty et al [9], who observed increased mean platelet count and MPV values in microcytic anaemia compared to other forms of anaemia. Anil Kumar et al [13] also reported statistically significant variations in MPV among different morphological types of anaemia. Ajeet Kumar Prajapati et al [18] concluded that platelet parameters showed significant association with iron deficiency anaemia. Mohammedamin Jundi et al [16] observed that platelet count variation correlated significantly with red blood cell indices and morphological patterns of anaemia, suggesting an important interaction between erythropoiesis and thrombopoiesis in anaemic patients.

In the present study, platelet distribution width (PDW) was highest in macrocytic anaemia, followed by dimorphic anaemia, and lower PDW values were observed in microcytic hypochromic anaemia and normocytic normochromic anaemia. The overall mean PDW of the study population was 13.80 ± 2.17%, and the difference among different morphological types of anaemia was statistically significant ($p<0.001$). Increased PDW in macrocytic and dimorphic anaemia may indicate greater platelet size variability due to ineffective hematopoiesis and abnormal marrow response associated with nutritional deficiencies. Anil Kumar et al [13] similarly reported significant variability in platelet distribution width among different morphological types of anaemia. Ajeet Kumar Prajapati et al [18] also observed significant alterations in platelet parameters in iron deficiency anaemia. Mohammedamin Jundi et al [16] reported that platelet count and red blood cell indices were significantly correlated in anaemic patients, supporting the close relationship between platelet abnormalities and red blood cell morphology. These findings are comparable with the present study and indicate that platelet indices may provide additional supportive information in the evaluation of anaemia.

In the present study, plateletcrit (PCT) was highest in patients with microcytic hypochromic anaemia and lowest in patients with macrocytic anaemia. Patients with normocytic normochromic and dimorphic anaemia showed intermediate PCT values of 0.26 ± 0.04% and 0.25 ± 0.04%, respectively. The overall mean PCT was 0.27 ± 0.05%, and the difference among different morphological types of anaemia was statistically significant ($p<0.001$). Increased PCT in microcytic hypochromic anaemia may be related to reactive thrombocytosis commonly associated with iron deficiency anaemia, whereas lower PCT in macrocytic anaemia may result from ineffective hematopoiesis and associated thrombocytopenia. Anil Kumar et al [13] observed variability in platelet indices including plateletcrit among different morphological forms of anaemia. Ajeet Kumar Prajapati et al [18] also demonstrated significant association between platelet parameters and iron deficiency anaemia. Mohammedamin Jundi et al [16] reported that platelet count correlated significantly with various red blood cell indices in anaemic patients. These findings support the observations of the present study and suggest that plateletcrit may serve as an additional hematological marker in the evaluation of anaemia patterns.

Conclusion

The present study demonstrated that microcytic hypochromic anaemia was the most common morphological pattern among anaemic patients, followed by normocytic normochromic, macrocytic, and dimorphic anaemia. Female predominance was observed, and most patients belonged to the younger and middle age groups.

Significant variations in red blood cell indices were observed among different morphological types of anaemia. Patients with microcytic hypochromic anaemia showed lower MCV, MCH, and MCHC values, whereas macrocytic anaemia was associated with higher MCV and MCH values. Dimorphic anaemia showed marked variation in red cell indices with higher RDW values, indicating increased anisocytosis. Platelet indices also showed significant differences among various morphological types of anaemia. Higher MPV and PDW values were observed in macrocytic and dimorphic anaemia, while plateletcrit was highest in microcytic hypochromic anaemia and lowest in macrocytic anaemia.

The study highlights that correlation of peripheral smear morphology with automated red blood cell and platelet indices provides a better understanding of the hematological profile of anaemic patients. Combined evaluation of morphological patterns with hematological indices can be useful in the early diagnosis and classification of anaemia and may help in planning further investigations and management.

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