RESEARCH PAPER

Morphological Evaluation of Anemia and Its Correlation with Red Cell Indices and RDW: A Hospital-Based Study

Dr. Jaya Maisnam[1], Dr. Mohan M R[2], Dr. Jeshyca Shougrakpam[3], Dr. Sharmila C[4]

[1]Associate Professor, [2,3]Assistant Professor, [4]IIIrd year post-graduate student, The Oxford Medical College Hospital and Research Centre, Bangalore

Corresponding author:

Dr. Jaya Maisnam

Associate Professor, Department of Pathology

The Oxford Medical College Hospital and Research Centre, Bangalore

Address: 22nd cross, 22 'A' Main, Sector 2, HSR Layout, Bangalore – 560102

Ph. No: 9886479987

Email: Jayamaisnam75@gmail.com

ABSTRACT

Introduction: One of the most frequently requested hematological investigation performed in patients is CBC (Complete blood count). When interpreted carefully along with the clinical history it can provide very useful information to the clinicians which can assist in diagnosis and management of patients. Most importantly diagnosed condition is anemia which is a global health concern affecting vulnerable population such as children, adolescent girls and women of reproductive age. To understand the hemogram parameters and red cell indices is crucial for diagnosing anemia and its management, especially among rural population with insufficient resources.

Objective:

1. To study the morphological patterns of various types of anemia on peripheral smear.
2. To evaluate red cell indices (MCV, MCH, MCHC) and RDW in different types of anemia.
3. To correlate peripheral smear findings with red cell indices and RDW.

Materials and Methods: This is a retrospective observational study done at the hematology section of Pathology department, The Oxford medical college hospital and research center, Bangalore. The study included 160 cases of low hemoglobin identified over a 3 months period from July 2025 to September 2025. Data was retrieved from the records generated by a fully automated hematology analyzer. Relevant hematological parameters, including red blood cell (RBC) indices (MCV, MCH, MCHC) and Red Cell Distribution Width (RDW), were recorded. These findings were correlated with peripheral blood smear examination to assess morphological patterns of anemia.

Results: In the present study, anemia was most commonly observed in the 19–45 years age group, with a female predominance. Among the various morphological types, microcytic hypochromic anemia was the most frequently encountered pattern. The different morphological types of anemia were systematically correlated with red blood cell (RBC) indices—including Mean Corpuscular Volume (MCV), Mean Corpuscular Hemoglobin (MCH), and Mean Corpuscular Hemoglobin Concentration (MCHC)—along with Red Cell Distribution Width (RDW) and peripheral blood smear findings. Further analysis was carried out to evaluate the distribution and correlation of these parameters with respect to age and sex of the patients.

Conclusions: Proper evaluation of anemia with type and severity is very important in managing patients as anemia is one of the most common hematological conditions.

KEYWORDS: Anemia, Microcytic, Red cell distribution width (RDW), Hypochromic, Hemoglobin.

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1.Introduction: Anemia is a global public health concern, primarily affecting girls of adolescent age, women reproductive age(15-45yrs), pregnant women, and children in low and middle-income countries. According to estimates done by WHO in 2019, approximately 30% (571 million) of women aged 15–45 years, 37% (32 million) of pregnant women, and 40% (269 million) of children 6 months to 5 years of age were affected by anemia.[1] Classification of anemia is done based on the morphological characteristics which include red cell size, degree of hemoglobinization and shape of red blood cells (RBCs).[2] It is a manifestation of underlying disease. Further evaluation of Hemoglobin, red cell indices (MCV, MCH, MCHC) and RDW along with peripheral smear correlation helps in the typing of anemia. Appropriate guidelines for hemoglobin measurement and defining anemia are crucial for both

clinical and public health medicine but require consideration of a range of complexities across different populations. According to WHO, anemia is present if the blood concentration hemoglobin falls below 13g/dl in adult men or 12g/dl in adult women. The lower limits of hemoglobin concentration vary for infants, children, and pregnant women. Reference ranges for hemoglobin are influenced by several factors, including age, sex, population characteristics, environmental conditions, and dietary habits.[3]

Modern automated instruments are capable of counting and assessing the size of circulating blood cells. The parameters measured of RBCs include hemoglobin, hematocrit, MCV and Red cell distribution width. The evaluation of RBC parameters like Hemoglobin, Hematocrit and RBC indices helps in characterizing the type of anemia and differential diagnosis of anemia. [4] Blood cell analysis by automated instruments, provide accurate and reliable results compared to the old manual procedures. Evaluation of RBC parameters like MCV, MCH and MCHC gives highest diagnostic accuracy. [5] The present study was carried out to know the morphological patterns of anemia in relation with hematological indices, RDW and peripheral blood smear findings.

Aims and Objective:

1. To study the morphological patterns of different types of anemia based on peripheral blood smear examination.
2. To evaluate red blood cell (RBC) indices (MCV, MCH, MCHC) and RDW in various types of anemia.
3. To correlate peripheral smear findings with RBC indices and RDW for better classification of anemia.

Materials and Methods: This retrospective observational study was conducted in the hematology section of the Department of Pathology at The Oxford Medical College Hospital and Research Centre, a tertiary care teaching hospital laboratory. The study was carried out over a period of three months, from July 2025 to September 2025.

Inclusion criteria: 1. Data of patients of all age groups with haemoglobin levels below the normal reference range for their age and sex.
2. Availability of corresponding peripheral blood smear reports for evaluation.

Exclusion criteria: Data of patients with complete blood count (CBC) indicating low hemoglobin but without an accompanying peripheral smear report.

A total of 160 cases with low hemoglobin levels, as identified by a fully automated hematology analyzer (Erba H7-100), were included in the study. These cases were subsequently analyzed and correlated with red blood cell (RBC) indices and RDW – CV parameters. The normal reference ranges for hemoglobin used in our laboratory are 13–18 g/dL for males and 12–16 g/dL for females. Anemia is diagnosed when hemoglobin levels fall below 13 g/dL in males and below 12 g/dL in females. Following initial detection, further evaluation is required to classify and confirm the specific type of anemia.

Selection criteria of the cases: Cases were selected based on the following haemoglobin cut-off values for the diagnosis of anemia:

- Adult males: Hemoglobin < 13 g/dL
- Adult females: Hemoglobin < 12 g/dL
- Children (6–12 years): Hemoglobin < 11.5 g/dL
- Children (6 months–6 years): Hemoglobin < 11 g/dL
- Infants (2–6 months): Hemoglobin < 10 g/dL

In addition, only those cases with available data of peripheral blood smear reports confirming anemia were included in the study.

Data Collection and Quality Control -

Data Collection: Data were collected retrospectively from the master logbook of both inpatient(IP) and outpatient (OPD) registers.

Quality Control: To ensure the accuracy and reliability of laboratory results, internal quality control (IQC) was performed twice daily. One level of quality control was run in the morning prior to processing patient samples, and another level was run in the evening.

Reference Ranges for Red Cell Indices and RDW

The following reference ranges were used for interpretation of red blood cell (RBC) indices:

- **Mean Corpuscular Volume (MCV):**
  - Normal: 80–100 fL
  - Below normal: < 80 fL
  - Above normal: > 100 fL
- **Mean Corpuscular Hemoglobin (MCH):**
  - Normal: 27–34 pg
  - Below normal: < 27 pg
  - Above normal: > 34 pg
- **Mean Corpuscular Haemoglobin Concentration (MCHC):**

- Normal: 32–36 g/dL
- Below normal: < 32 g/dL
- Above normal: > 36 g/dL

Red Cell Distribution Width (RDW-CV):

- Normal: 11–16%
- Increased: > 16%

Results:

Demographic Profile of Study Population –
In the present study of 160 anemia cases at a tertiary care hospital, the retrospective demographic data revealed that the majority of patients were in the 19-45 age group, constituting 33.7% of the total sample, followed by the 45-65 age group with 28.7%. Patients aged 0-18 accounted for 25% of the sample, while those aged 65 and above comprised 12.6%. Females represented a significantly higher proportion of the sample, constituting 68.7%, while males accounted for 31.3 %. [Table1, 2, 6]

Distribution of Red Cell Indices –
The distribution of patients based on Mean Corpuscular Volume (MCV) revealed that the majority had values below the normal range (<80 fL), accounting for 71.8% of cases, while 27.5% of patients had MCV values within the normal range (80–100 fL) and 0.6& above the normal range (>100fL)
Similarly, analysis of Mean Corpuscular Hemoglobin (MCH) showed that 52.5% of patients had values below the normal range (<27 pg), whereas 47.5% had MCH values within the normal range. [Table 3]

Table 1: Demographic data of the patients

Sl. No.	Age group	Number of patients	Percentage (%)
1.	0-18	40	25
2.	19-45	54	33.7
3.	46-65	46	28.7
4.	65 above	20	12.6

Table 2 : Gender distribution of the patient

Gender	Number of patients	Percentage (%)
Female	110	68.7
Male	50	31.3

Table 3: MCV, MCH and MCHC distribution:

	Normal	Reduced	Increased
MCV	44 (27.5%)	115 (71.8%)	- 1(0.6%)
MCH	76 (47.5%)	84 (52.5%)	-
MCHC	120 (75%)	40(25%	-

Table 4: Distribution of patients according to RDW- CV:

RDW-CV	Number of patients	Total Percentage (%)
	Male	**Female**	
Above range >16	35	86	121 (75.6%)
Normal Range (11 to 16)	15	24	39 (24.4%)

Table 5 : Sex distribution of anemia cases based on morphology:

Morphology	Male	Female	Total
Microcytic hypochromic	14(8.7%)	88(55%)	102(63.7%)
Normocytic normochromic	22(13.7%)	32(20%)	54(33.7%)
Dimorphic	1 (0.6%)	2(1.25%)	3(1.8%)
Marcocytic	1(0.6%)	-	1(0.6%)

Table 6: Age distribution of anemia cases based on morphology:

Morphology	0-18yrs	19-45 yrs	46-65yr	Above 65 yrs
Microcytic hypochromic	28(17.5%)	56(35%)	12(7.5%)	-
Normocytic normochromic	16(10%)	28(17.5)	16(10)	1(0.6%)
Dimorphic	-	3(1.8%)	-	-
Marcocytic	-	1(0.6%)	-	-

Discussion: The present study conducted at the Hematology section Central Diagnostic Lab, The Oxford Medical College Hospital and Research Centre, Bangalore provides valuable insights into the hemogram parameters and red cell indices of anemic patients in a rural setting. The demographic distribution indicates a higher prevalence of anemia in the younger population, with nearly half of the patients falling within the 19-45 age group. This could reflect nutritional deficiencies or chronic diseases prevalent in this demographic.[6] The marked female predominance (68.7%) is consistent with global trends and highlights the need for targeted interventions addressing women's health and it also suggests that gender-specific factors such as menstrual blood loss or

pregnancy-related anemia could be contributing to the higher incidence in females.[7]

The predominance of patients with MCV values below the normal range indicates a high prevalence of microcytic anemia, which is most commonly associated with iron deficiency and, to a lesser extent, anemia of chronic disease.[8] This finding is further supported by the parallel observation of reduced MCH values, reinforcing the likelihood that iron deficiency anemia constitutes a major proportion of cases in this population. The majority of patients exhibiting MCV, MCH, and MCHC levels below the normal range is indicative of microcytic and hypochromic anemia, commonly associated with iron deficiency. This is further supported by the high percentage of patients with elevated RDW-CV levels, suggesting a significant variation in red blood cell size, which is a hallmark of iron deficiency anemia. RDW has emerged as a better RBC index to differentiate iron deficiency anemia from other causes of microcytosis especially thalassemia trait.[9] It is the first RBC index to become abnormal during the development of IDA. RDW represents the coefficient of variation of RBC volume distribution and is an index of heterogeneity. In present study, 121(75.6%) cases had an abnormal RDW which is more seen in females accounting for 86 cases [Table 4]. It is most commonly seen in microcytic hypochromic anemia associated with iron deficiency anemia.

Raised RDW in iron deficiency anemia was also noted in Chaudhary et al. [10] Maximum RDW CV value noted in our study was 20.1 with Hb value of 5.1g/dL. The predominance of patients with MCV, MCH, and MCHC values below the normal range is indicative of microcytic hypochromic anemia, which is most commonly associated also with iron deficiency. This is further supported by the high percentage of patients with elevated RDW-CV levels, suggesting a significant variation in red blood cell size, which is a hallmark of iron deficiency anemia.[11] Peripheral smear examination and interpretation were done for all the 160 cases selected in the study which revealed that microcytic hypochromic anemia was the most common morphological type, accounting for 63.7% of cases, followed by normocytic normochromic anemia (33.7%) , dimorphic anemia (1.8%) and macrocytic anemia(0.6%) [Table 5]. Similar to the present study, correlated with previous studies conducted by Jignesh Patel, Sandhya V. [12,13] In Dimorphic anemia automated values alone can mislead in the diagnosis of dimorphic blood pictures, which consist of a mixed population of microcytic and normocytic or normocytic and macrocytic red cells, or a combination of microscopic, normal, or big cells of varying sizes and shapes. It should always be checked with peripheral blood smear, RBC indices, and histogram. In the present study there were 3 cases of dimorphic anemia. One case of macrocytic anemia was found reported in the stydy which showed Hb 10.2g/dL, MCV of 116fL, RDW of and confirmed on peripheral smear.

In the present study, a female preponderance (68.7%) was observed compared to males (31.3%), which is consistent with findings reported in a similar study by Aparna S et al. [14] Anemia can be evaluated through multiple approaches based on its pathogenesis, red cell morphology, and clinical presentation. A range of investigations may be required, including a complete blood count (CBC) with differential, corrected reticulocyte count, red blood cell (RBC) indices, and peripheral blood smear examination. Additional tests such as Direct Coombs Test (DCT), lactate dehydrogenase (LDH), serum bilirubin, and haptoglobin levels may be useful in specific clinical contexts. Further evaluation for underlying causes may include upper gastrointestinal endoscopy to detect upper GI bleeding, colonoscopy for lower GI bleeding, and appropriate imaging studies when malignancy or internal hemorrhage is suspected. If a menstruating woman has heavy vaginal bleeding, evaluate the presence of fibroids with a pelvic ultrasound.

However, in routine clinical practice, it is often more practical to begin evaluation with hematological parameters obtained from the hemogram. Peripheral blood smear (PBS) examination plays a crucial role in the diagnosis and morphological classification of anemia. Iron deficiency is the most common cause of anemia; therefore, the initial step in evaluation should be directed toward confirming or excluding iron deficiency anemia (IDA). It is also the most prevalent nutritional deficiency worldwide. [15] The prognosis of anemia largely depends on its underlying etiology. Anemias due to nutritional deficiencies generally have a favorable prognosis when diagnosed early and treated appropriately. Similarly, anemia resulting from acute blood loss has a good outcome if the source is promptly identified and managed. However, if anemia remains undiagnosed or untreated for a prolonged period, it may lead to serious complications, including multiorgan dysfunction and even death. The risk of complications is higher in elderly patients and those with associated comorbid conditions. [16]

Conclusion: Anemia is a frequently encountered hematological condition with a high prevalence in India. Prompt identification and precise classification are crucial for initiating appropriate treatment and minimizing related complications. Data derived from

automated cell counters, in conjunction with peripheral smear evaluation, play a crucial role in enhancing diagnostic reliability and enabling proper categorization of anemia.. The present study demonstrated a higher occurrence of anemia among females in their second decade, predominantly of the microcytic hypochromic type. Hematological indices indicating decreased MCV, MCH, and MCHC in association with increased RDW-CV point toward iron deficiency as the principal underlying cause.

These findings not only indicate the current health status but also highlight the need for targeted public health measures aimed at improving nutrition and ensuring better access to healthcare. The use of advanced automated hematology analyzers along with strict quality control measures strengthens the credibility of the findings. Overall, this study adds meaningful insight into anemia in rural populations and highlights the need for focused health interventions.

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