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Original Research Article

A Cross-Sectional Study of Evaluate Morphological Patterns of Anaemia and Their Correlation with Red Cell and Platelet Indices in Adult Patients

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Abstract:

Background: Anaemia emanates as a common hematological disease of varied aetiologies. The peripheral smear morphological classification and those of the red cell and platelet indices have been used as a quick and economical method of diagnosis particularly in areas with limited resources. The combination of the two modalities can complement the diagnostic sensitivity and knowledge on the type of anaemia.

Aim: To find out the frequency of morphological types of anaemia and correlate it with red blood cell indices (MCV, MCH, MCHC, RDW) and platelet indices (PLT, MPV PDW) of adult patients with anaemia.

Methodology: The study is a cross-sectional observational study and involved 350 anaemic patients aged between 18and 65 years and carried out in the Department of Pathology, Bhagwan Mahavir Institute of Medical Sciences, Pawapuri, Nalanda, Bihar, India between 6 months. A 5-part automated haematology analyser is utilized to study blood samples, and the morphology of anaemia is studied through microscopically examining peripheral blood smears. ANOVA and chi-square test are used to compare the red cell and platelet indices of groups of microcytic hypochromic, normocytic, normochromic, and macrocytic anaemia.

Results: Study stated that 60.6 percent of 350 patients were women and 39.4 percent males, and with a mean age of 34.8 years. Most common (48.6 per cent) was microcytic hypochromic anaemia with normocytic coming second (34.3 per cent) and macrocytic anaemia third (17.1 per cent). There was a significant difference in red cell indices of differently typed anaemia ($p < 0.001$) with RDW being significantly higher in both microcytic and macrocytic types of anaemia. Difference between groups was also found in platelet indices (MPV, PDW), the highest PDW was observed in macrocytic anaemia ($p < 0.01$).

Conclusion: It can be proposed that the combination of morphological classification and indices of red cells and platelets would provide a more strong and cost-efficient means of providing an evaluation of the state of anaemia. Such combined philosophy enhances a more accurate diagnosis and may direct early and selective treatment, especially in a situation of scarce diagnostic facilities.

Keywords: Anaemia, Morphological Classification, Red Cell Indices, Platelet Indices, RDW, MPV, Peripheral Smear.

Introduction

Anaemia 'remains the most common blood disorder which affects people throughout the world and especially develops into a serious health problem that endangers the health of people living in developing countries. The World Health Organization defines anaemia as the condition which occurs when a person lacks sufficient red blood cells for their body to meet its oxygen needs. The World Health Organization projects that more than 1.62 billion people worldwide experience anaemia with preschool children showing the highest rate of 47.4% and pregnant women facing a rate of 41.8% while all other groups show lower rates [1]. The public health programs in India during the last 30 years have failed to reduce

anaemia rates which currently affect more than 50% of women and children in the country. [7]

Anaemia has multiple causes which include low nutritional status (consumption of iron, vitamin B12 and folate), persistent infections, our inherited disorders, chronic kidney disease and suppression of the bone marrow. The underlying etiology is a key in preventing and treating the etiology. The main technique used to address this issue in haematology diagnostics depends on the morphological classification of anaemia. Anemia occurs in three forms which depend on red blood cell size and hemoglobin content because each form represents a distinct disease mechanism [2,3].

The examination of peripheral blood smear serves as the primary method used to determine the morphological typing of anaemia because this method needs only basic equipment and it delivers essential diagnostic information. The most common cause of microcytic hypochromic anaemia which demonstrates reduced size and decreased color of red blood cells occurs when a person has iron deficiency and thalassemia traits. The condition of normocytic normochromic anaemia occurs when an individual presents with normally shaped blood cells that contain adequate hemoglobin but show reduced total cell count which occurs in anaemia of chronic illness or acute haemorrhage. The condition of macrocytic anaemia occurs when red blood cells increase in size which commonly happens because of vitaminB12 and folate deficiencies or alcohol abuse or certain medications or liver disease [5,9].

The current diagnostic methods cannot use this morphological-based approach because it fails to meet their requirements. The introduction of' automatic haematology instruments known as haematology analyzers 'revolutionized anaemia diagnosis methods because they provide quantitative measurements that enable additional analysis of red blood cell properties. Red cell indices which include mean corpuscular volume (MCV) and mean corpuscular hemoglobin (MCH) and mean corpuscular hemoglobin concentration (MCHC) and red cell distribution width (RDW) function as effective tools that assist in evaluating blood cell morphology according to [3,6]. The parameters we can measure will enable them to identify the various anaemia types through their assessments. The person demonstrates iron deficient anaemia when he shows low MCV combined with high RDW while high MCV indicates either vitamin B12 or folic acid deficiency.

RDW operates as a reliable measure for detecting isocytosis which involves different patterns of red blood cell distribution. The medical field has adopted RDW as a diagnostic tool to determine both mixed and developing types of anemia according to recent studies. The study found that RDW shows values above the normal range which indicates iron deficiency and shows the presence of previous hemoglobin changes [4,8]. The application of RDW to anaemia profiling gives doctors the ability to detect early and mixed pathologies which remain hidden until they conduct a peripheral smear examination.

Another new area of interest is the role of platelet indices (e.g., platelet counts (PLT), mean platelet volume (MPV), and platelet distribution widths (PDW)) in anaemic disorders. Studies that examine anaemic patients especially those with maternal and fetal anaemia show that researchers seldom investigate platelet characteristics, yet these characteristics serve as effective diagnostic tools. The PLT measurement can show low values or dysfunctional results in diseases that include megaloblastic anaemia and myelodysplastic syndromes. Recent studies showed that MPV and PDW measurements exhibit platelet size changes and reactive thrombocytosis to hypoproliferative states which occur with multiple anaemia types in both the anaemia group and the combined population group [6,8].

The new technological developments which exist today especially through automated blood counting systems have not achieved common acceptance in the medical field which requires blood tests to use platelets and red cell indices as nomogonal markers to assess different types of histological and labyrinth-related morphological studies. The automated blood smears used in the western medicine model will serve as the main screening method for healthcare providers in areas with limited resources who cannot access laboratory equipment because they need to control their expenses. The use of'' both observations as centric analytical points in every classification system provides a hematology service with budget-friendly solutions 'that operate in specific areas while enabling extra classification through medical conditions.

"The given study is based on the necessity to fill the gap between the historical morphological diagnosis and auto-blood indices to come out with more realistic classification and comprehension of anaemia. The research aims to establish patterns of anaemia through their association with morphological types and red cell and platelet indices which will result in reduced diagnostic tests and immediate implementation of targeted treatments. The operational success of this method will allow for the identification of both complex and overlapping types of anaemia.

The presence of iron deficiency together with vitamin B12 deficiency leads to difficulties in identifying morphological abnormalities. The combination of RDW, MCV, and MPV patterns enables the process of differentiation which requires additional investigation. The anaemia of chronic disease patient presents with normocytic morphology although automatic systems will detect its minor differences from standard values. The research results

demonstrate that diagnostic accuracy increases when these integrations are used which helps detect and manage anaemia cases that occur in outpatient clinics and primary care departments [5,10]. The integrative approach offers clinically beneficial outcomes and public health advantages because chronic illnesses and malnutrition-related anaemias are increasing in rural and semi-urban areas of India.

The study exists because researchers need to use both morphology-based analysis together with computerized CBC parameters which include red blood cell and platelet indices. The integrated diagnostic package improves diagnosis accuracy while it decreases treatment waiting times and leads to better patient results in anaemia treatment.

Materials and Methods

Study Design and Setting: This is across-sectional observational study conducted over a period of six months in the Department of Pathology, Bhagwan Mahavir Institute of' Medical Sciences, Pawapuri, located in Nalanda, Bihar, India.

Study Population: A 'total of 350 patients aged between 18 and 65 years, diagnosed with anaemia based on WHO criteria (hemoglobin <13 g/dL in males and <12 g/dL in females), are included. These patients attended the outpatient or inpatient departments for routine check-ups, weakness, fatigue, or other non-emergency concerns.

Inclusion Criteria

- Adults aged18–65years.
- Hemoglobin below reference range as per sex.
- Patients willing to participate and provide informed consent.
- No recent blood transfusion in the last1month.

Exclusion Criteria

- Patients with known hematologic malignancies (e.g., leukemia, lymphoma).
- Recent blood transfusion (within30days).
- Chronic renal failure patients on dialysis.
- Pregnant women.
- Patients on hematinic supplementation for >2weeks prior to recruitment.

Sample Size Justification: A sample size of 350 was determined based on the hospital's monthly anaemia caseload, with a confidence interval of 95%, and a margin of error of' 5%. The size was also sufficient to identify significant correlations between morphological types" and 'red cell/platelet indices.

Blood Sample Collection and Processing: Blood samples (2 mL) were collected from each participant in EDTA vials using aseptic precautions. Samples were analyzed within two hours using a 5-part automated haematology analyzer to measure hemoglobin, RBC indices (MCV, MCH, MCHC, RDW), and platelet indices (PLT, MPV, PDW). Peripheral blood smears were prepared and stained with Leishman stain for morphological assessment under a microscope.

Morphological Classification: Anaemia was classified morphologically into microcytic hypochromic, normocytic normochromic, and macrocytic types based on peripheral smear findings. The evaluation was done by two senior pathologists independently to ensure diagnostic accuracy, and the results were cross-referenced with automated red cell indices.

Statistical Analysis

Data were analyzed using SPSS version 27.0. Descriptive statistics were used for baseline parameters. Chi-square tests assessed associations between categorical variables, while ANOVA compared mean red cell and platelet indices across anaemia types. Pearson's correlation was used for continuous variables, with $p < 0.05$ considered statistically significant.

Results

Distribution of Morphological Types of Anaemia: A total of 350 anaemic patients were enrolled in the study. Of these, 212 (60.6%) were female and 138 (39.4%) were male, with a mean age of' 34.8 ± 12.5 years. Morphological classification based on peripheral smear showed 'that the microcytic hypochromic type was the most common (n = 170, 48.6%), followed by normocytic normochromic (n = 120, 34.3%) and macrocytic anaemia (n = 60, 17.1%).

Table 1: Morphological Types of Anaemia among Patients (N = 350)

Morphological Type	Frequency (n)	Percentage (%)
Microcytic Hypochromic	170	48.6%
Normocytic Normochromic	120	34.3%
Macrocytic	60	17.1%
Total	**350**	**100%**

These findings are consistent with previous Indian studies that report a predominance of microcytic anaemia due to nutritional iron deficiency [5,10].

Comparison of Red Cell Indices by Anaemia Type: Analysis of" red cell indices showed that MCV values were significantly lower in microcytic "anaemia (mean MCV = 72.4 ± 5.1 fL) and

significantly higher in macrocytic anaemia (mean MCV = 106.3 ± 6.2 fL). RDW was elevated in both microcytic and macrocytic types, reflecting anisocytosis. The differences in MCV, MCH, MCHC, and RDW across the three anaemia groups were statistically significant ($p < 0.001$).

Table 2: Red Cell Indices Across Morphological Types

Parameter	Microcytic (n=170)	Normocytic (n=120)	Macrocytic (n=60)	p-value
MCV (fL)	72.4 ± 5.1	85.2 ± 4.8	106.3 ± 6.2	<0.001
MCH (pg)	22.8 ± 2.1	28.1 ± 1.9	31.7 ± 2.4	<0.001
MCHC (%)	29.6 ± 1.8	31.3 ± 1.5	30.1 ± 1.7	0.002
RDW (%)	17.4 ± 2.3	14.9 ± 1.8	19.2 ± 2.6	<0.001

This pattern correlates with studies by Jain et al. and Dhingra et al. where RDW served as a distinguishing index between types [8,10].

Comparison of Platelet Indices by Anaemia Type: Platelet indices also showed variation. Mean platelet volume (MPV) was lowest in normocytic anaemia and higher in microcytic and macrocytic types, likely' reflecting compensatory marrow activity. PDW was elevated 'in macrocytic cases, suggesting variable platelet size, often seen in megaloblastic states. These differences were also statistically significant ($p < 0.05$).

Table 3: Platelet Indices Across Morphological Types

Parameter	Microcytic (n=170)	Normocytic (n=120)	Macrocytic (n=60)	p-value
PLT (10^9/L)	308 ± 74	256 ± 61	240 ± 68	0.014
MPV (fL)	10.3 ± 1.4	9.2 ± 1.1	10.8 ± 1.5	0.006
PDW (%)	13.8 ± 2.3	12.7 ± 1.9	15.1 ± 2.7	0.001

These findings reflect marrow response and possible subclinical platelet activation, as also noted in previous clinical studies on combined erythrocyte-thrombocyte evaluation [6,8].

Discussion

The research study examined how anaemia affects different body systems, which resulted in tested numerous medical conditions for study analysis across 350 examined patients. The predominant type observed was microcytic hypochromic anaemia, which constituted 48.6% of cases, followed by normocytic normochromic (34.3%) and macrocytic anaemia (17.1%). This pattern shows a close resemblance to multiple previous research studies which took place in Indian medical facilities that function as teaching hospitals and tertiary care centers. The research of Dhingra et al. showed a similar pattern, which demonstrated that adults most commonly developed microcytic anaemia because of' nutritional deficiencies, which caused them to experience chronic blood loss [11]. The 'research of'' Tiwari et al. showed that microcytic hypochromic anaemia served as the primary morphological type found in their study group, which confirmed our results from the north Indian population study [12].

The study "results show that female participants made up 60.6% of the research sample which confirms that women experience higher rates of anaemia according to Jain et al. who studied how gender-based dietary and biological factors including menstrual cycles and pregnancy and breastfeeding affect nutritional needs [13]. The mean age of 34.8 years shows that people in the economically active age group experience a high rate of anaemia which matches the patterns that Mehta and Dave found during their extensive study of anaemia cases in hospitalized patients [15].

The research discovered that different morphological types show distinct patterns of red cell index measurements. Microcytic cases showed a mean MCV of 72.4 fL which remained lower than the macrocytic anaemia condition that exhibited MCV results above 106 fL and both conditions presented high RDW values. The study results support Bessman et al. classification algorithm which uses MCV and RDW measurements to identify different types of anaemia especially for distinguishing between iron deficiency and thalassemia or megaloblastic disorders [16].Our study demonstrated that RDW levels rose above normal limits for both microcytic and macrocytic anaemias because of anisocytosis which medical research identifies as a typical feature of mixed nutritional deficiencies or early bone marrow response according to the Thomas and Thomas review [14].

The 'research found that 34.3% of' the sample had normocytic normochromic anaemia which developed as a common complication of chronic diseases and hidden inflammatory conditions according to Das et al. who discovered a strong connection between normocytic patterns and chronic infections or renal insufficiency in their Assamese hospital-based study [17]. The hematological results of normocytic anaemia demonstrate normalcy but physicians can use RDW and platelet index changes to direct their investigation of the underlying causes.

The analysis of platelet indices produced significant results in our investigation. The macrocytic and microcytic anaemia groups showed elevated MPVand PDW values which indicated that their bone marrow produced excessive blood cells while they generated new platelets. Jain et al. established that platelet anisocytosis functions as a secondary characteristic which occurs when bone marrow compensates for anemia [13]. The highest PDW value in macrocytic anaemia showed accordance with scientific studies that demonstrate how PDW changes relate to megaloblastic anaemia and ineffective thrombopoiesis.

The study demonstrates its main academic value through its unique method of studying red blood cell, platelet blood measurements and their application to morphological classification. The qualitative visual patterns of morphology testing provide visual appearance results while red cell indices MCV and MCH and MCHC and RDW and platelet parameters MPV and PDW create diagnostic information that extends beyond basic testing. Bessman et al. proposed early on that such integrated analysis improves the sensitivity of anaemia classification, especially in mixed or evolving conditions [16]. The study "results demonstrate that CBC with peripheral smear testing functions as a cost-effective diagnostic method which low-resource facilities can use. Blood tests serve as essential tools for medical professionals according to Thomas and Thomas because biochemical markers face accessibility problems while doctors use blood test results for both screening and treatment decisions [14].

Despite its strengths the study presents certain limitations. The study failed to include bone marrow correlation data and serum biochemical markers which include ferritin and B12 and folate. The cross-sectional design of the study prevents researchers from establishing causal relationships. The study results become applicable to primary care practitioners and pathologists because of the combination of a large sample size with real-world clinical settings and statistical strength of' the study.

Conclusion

The present study demonstrated that integrating morphological classification of anaemia with red cell and platelet indices provides a more comprehensive and clinically meaningful approach to diagnosis. Microcytic hypochromic anaemia emerged as the most prevalent type, particularly among women, reflecting underlying iron deficiency. Significant variations in red cell indices such as MCV, MCH, MCHC, and RDW, along with platelet parameters like MPV and PDW, were observed across different morphological types, reinforcing their diagnostic relevance. This integrated assessment not only enhances diagnostic accuracy but also helps in predicting underlying aetiologies in a cost-effective manner. Such an approach is especially valuable in resource-limited settings where access to advanced investigations is restricted. Therefore, the combined use of peripheral smear morphology and automated haematological indices should be encouraged in routine clinical practice for better evaluation and management of anaemia.

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