

Complete Blood Count Profile and Prevalence of Hematological Abnormalities among Pediatric Outpatients Attending Er-Rawashda Rural Hospital, Al-Qadarif State, Sudan: A Cross-Sectional Study

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Abstract: *Introduction: Complete blood count (CBC) indices are widely available and may provide useful information about iron status, particularly where advanced iron studies are limited. Objective: To describe CBC parameters among pediatric patients. Methodology: A descriptive cross-sectional study was conducted among 100 children aged 1–12 years at Er-Rawashda Rural Hospital, Al-Qadarif State, Sudan. CBC was performed using the Zybion Z3 hematology analyzer. Data analysis was performed by using SPSS. Results: The mean hemoglobin was (11.48±2.12 g/dL), hematocrit (34.62±5.92%), RBC (4.20±0.63×10⁶/μL), MCV (78.65±9.10 fL), MCH (26.05±3.78 pg), MCHC (33.08±2.58 g/dL), RDW-CV (15.44±2.31%), and RDW-SD (40.59±5.39 fL). Conclusion: The CBC profile showed a tendency toward microcytosis and anisocytosis. CBC indices, particularly hemoglobin, MCV, MCH and RDW-CV, may be useful screening indicators of altered iron status in resource-limited settings.*

Keywords: children, Complete blood count, hemoglobin, MCH, MCV, RDW, Sudan.

Introduction

Anemia is the most common and serious public health problems affecting children worldwide, particularly in low and middle income countries, where nutritional deficiencies, infections, and limited access to healthcare are coexist [1]. In Sudan anemia in children has been reported to be highly prevalent, with different variation according to region, age group, and causes [2].

Iron deficiency is the most common nutritional deficiency worldwide and represents the leading cause of nutritional anemia in children [3]. It develops through a continuum of stages, beginning with depletion of iron stores, progressing to iron-deficient erythropoiesis, and culminating in overt iron deficiency anemia when uncorrected [4,5]. This progression from depleted iron stores to iron-deficient erythropoiesis produces characteristic changes in red-cell indices, making the complete blood count (CBC) an important component of initial laboratory assessment [6–8].

Iron is the most important requirement for heme synthesis, accordingly it affects hemoglobin production and red cell development. As iron availability decreases, erythrocytes may become smaller and contain less hemoglobin and cause microcytic hypochromic anemia, resulting in reductions in MCV and MCH. Also increased RDW shows increasing heterogeneity in red cell size and may appear during evolving iron deficiency [7–9]. Comparable alterations in red cell indices have also been described when differentiating iron deficiency anemia from other microcytic conditions such as beta thalassemia minor, focusing on the need for careful interpretation of these parameters [10].

In rural areas, access to ferritin, transferrin saturation and other related and advanced investigations may be limited by many factors includes cost, infrastructure, and laboratory capacity. Understanding the pattern of CBC parameters can therefore help identify practical, low-cost screening indicators. Previous studies showed positive relationships between iron related measures and hemoglobin and erythrocyte indices, with inverse relationships involving RDW [7,8,11]. Many factors, including household food insecurity and inadequate dietary iron intake, further contribute to the high burden of iron deficiency among children [12]. Comparable patterns of iron deficiency have also been reported among apparently healthy preschool children in similarly resource-limited settings [13].

Elsewhere, CBC derived indices have been shown to be useful in identifying iron deficiency and iron deficiency anemia in other populations, supporting their broader applicability as accessible screening tools [14].

The present study describes the CBC profile of children attending a rural hospital in Al-Qadarif State, Sudan, with the aim of identifying practical CBC based indicators that could support early recognition of altered iron status in similar resource limited settings.

Methodology

Study design

This was a descriptive cross-sectional study designed to evaluate complete blood count parameters among pediatric patients.

Study area and duration

The study was conducted at Er-Rawashda Rural Hospital, Al-Qadarif State, Sudan. Er-Rawashda village is approximately 70 km from Al-Qadarif city. The study was conducted from July 2023 to February 2024.

Study population

The study population comprised pediatric patients aged 1–12 years who presented to Er-Rawashda Rural Hospital during the study period.

Selection criteria

Inclusion criterion: pediatric patients aged 1–12 years. Exclusion criteria were previously diagnosed anemia such as sickle cell anemia, hemolytic anemia or thalassemia; current iron supplementation; known chronic inflammatory or infectious disease; and recent blood transfusion.

Sample size and sampling

A total of 100 pediatric participants who met the eligibility criteria were included in the study.

Data collection and specimen processing

Demographic and clinical information was collected using a questionnaire after informed consent from the parent or legal guardian. Approximately 2.5 mL of venous blood was collected from each participant into an EDTA tube for CBC analysis. EDTA samples were analyzed immediately using the Zybio Z3 hematology analyzer.

Laboratory methods

CBC parameters were measured using the Zybio Z3 hematology analyzer.

Data analysis

Data were analyzed using SPSS. Descriptive statistics included mean, standard deviation, median, minimum, maximum and quartiles.

Ethical considerations

Ethical clearance was obtained from the Ministry of Health, Gezira State, and ethical permission was obtained from the Faculty of Medical Laboratory Science, University of Gezira. Informed consent was obtained from the legal guardian of each participating child.

Results**Participant characteristics**

The study included 100 children aged 1–12 years. The mean age was 6.65 ± 2.70 years. There were 53 males (53%) and 47 females (47%).

Table 1. Descriptive statistics of RBC and RBC indices

Parameter	N	Mean $\pm$ SD	Median	Minimum	Maximum
Age (years)	100	6.65 ± 2.70	6.5	1	12
RBC ($\times 10^6/\mu\text{L}$)	100	4.20 ± 0.63	4.45	2.60	5.76
Hemoglobin (g/dL)	100	11.48 ± 2.12	11.50	6.30	15.70
Hematocrit (%)	100	34.62 ± 5.92	35.15	20.90	44.50
MCV (fL)	100	78.65 ± 9.10	80.65	53.90	99.10
MCH (pg)	100	26.05 ± 3.78	26.50	14.10	36.40
MCHC (g/dL)	100	33.08 ± 2.58	32.60	26.10	38.30
RDW-CV (%)	100	15.44 ± 2.31	14.70	12.40	24.30
RDW-SD (fL)	100	40.59 ± 5.39	39.35	33.60	74.50

The mean MCV was below the stated reference interval, while the mean RDW-CV was above its reference interval. The mean MCH was within the stated interval but close to its lower boundary. These findings indicate a population tendency toward smaller and more heterogeneous red cells.

Discussion

This study demonstrated a CBC pattern in the pediatric patients. The mean hemoglobin was 11.48 g/dL, close to the lower reference boundary, while the mean MCV was 78.65 fL and the mean RDW-CV was 15.44%. The combination of relatively small red cells and increased size variability is biologically compatible with iron-restricted erythropoiesis [4,7,8]. This pattern can occur because

inadequate iron limits heme synthesis, producing smaller erythrocytes, while ongoing production of cells under changing iron availability increases the variability of cell size.

The mean hemoglobin value observed in this cohort was close to the lower limit of the reference range, reflecting a tendency toward mild anemia in a substantial proportion of participants. Because iron is an essential component of heme, inadequate iron availability limits hemoglobin synthesis, and reduced hemoglobin is therefore commonly used as an initial indicator of iron-restricted erythropoiesis [4,7]. Comparable findings of reduced hemoglobin among children with iron deficiency have been reported previously [6,11].

The mean hematocrit value observed in this study together with the wide range recorded, reflects variability in red cell mass. Hematocrit reflects the proportion of blood occupied by red cells and therefore, reduced erythropoiesis and reduced hemoglobinization associated with iron deficiency can contribute to a lower packed cell volume.

The mean MCV observed in this study was below the stated reference interval, and the mean MCH was close to its lower boundary, consistent with a tendency toward microcytic, mildly hypochromic red cells. Reduced iron availability limits the amount of hemoglobin incorporated into each erythrocyte and can result in the production of smaller cells, producing the reductions in MCV and MCH characteristic of iron-restricted erythropoiesis [7,8]. Comparable patterns of reduced erythrocyte indices have been described among children with iron deficiency in other settings [7,11].

The mean RDW-CV in this cohort was above its reference interval, indicating increased anisocytosis. Lower iron availability can produce a mixture of newly formed smaller cells and older cells of different sizes, increasing anisocytosis and therefore RDW. This finding agrees with the established role of RDW as a marker of heterogeneity in red-cell size and with studies supporting its usefulness in the evaluation of iron deficiency [8,9]. In contrast, RDW-SD, which reflects the absolute rather than relative variation in cell size, showed a wide range in this cohort; this difference may reflect the distinct statistical properties of the two RDW measures, and RDW-CV should not automatically be assumed to be interchangeable with RDW-SD.

The mean MCV below the stated reference interval and elevated RDW-CV further support the possibility of iron-restricted erythropoiesis. However, these CBC findings are not specific for iron deficiency. Thalassemia traits and other causes of microcytosis can produce similar patterns, while inflammation and infection can alter iron handling and hematological indices [4,5,10]. The study excluded children with known chronic inflammatory/infectious disease and previously diagnosed hemoglobin disorders, but unrecognized conditions cannot be completely excluded.

The findings are particularly relevant to rural practice because CBC testing is generally more accessible than comprehensive iron studies. The observed pattern of reduced hemoglobin, low MCV and elevated RDW-CV suggests that these indices can function as useful screening signals for children who may require further iron assessment. Nevertheless, CBC should be considered a screening approach rather than a definitive biochemical diagnosis, especially because serum ferritin and other iron measures have complementary diagnostic roles [4,13].

The observed pattern may also be influenced by broader determinants such as dietary iron availability, poverty and household food security. Such factors can contribute to iron deficiency in children, particularly in rural communities [12].

Conclusion

The CBC profile of the pediatric study population showed a tendency toward microcytosis and increased red-cell size variability, reflected by a low mean MCV and elevated mean RDW-CV. These findings demonstrate the value of CBC as an accessible first-line hematological assessment in children and support further evaluation when abnormal erythrocyte indices are identified.

The pediatric cohort showed a tendency toward microcytosis and increased red-cell size variability, most notably reflected by reduced mean hemoglobin, MCV and MCH values together with an elevated mean RDW-CV. These findings support the recognized association between altered iron availability and erythrocyte production and suggest that selected CBC indices can provide useful screening information where advanced iron investigations are limited.

Recommendations

- Use CBC, particularly hemoglobin, MCV, MCH and RDW-CV, as an initial screening profile for children suspected of iron deficiency.
- Confirm suspected iron deficiency with appropriate iron studies when available rather than relying on CBC indices alone.
- Consider nutritional and socioeconomic factors when evaluating children with microcytosis or elevated RDW.
- Future studies should include ferritin, transferrin saturation and inflammatory markers such as CRP to improve diagnostic classification.

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