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2025 Volume 6, Issue 4
Cell Biology Research
ISSN: 2529-7627 (Online)

Evaluation of the Application Value of Routine Blood Tests in the Diagnosis of Iron Deficiency Anemia

Xilin Kuai*
Guanyun County People's Hospital, Lianyungang 222200, Jiangsu, China

**Author to whom correspondence should be addressed.*

Abstract: *Objective:* To explore the application significance of routine blood testing in the diagnosis of iron deficiency anemia (IDA), analyze the diagnostic effects of different single indicators and combinations of indicators, and provide optimization strategies for early and accurate clinical diagnosis. *Methods:* 86 patients with suspected iron deficiency anemia admitted to our hospital from August 2024 to August 2025 were selected. Routine blood tests were performed on all patients. Serum ferritin detection combined with bone marrow iron staining was used as the benchmark standard to compare and analyze each individual indicator and the sensitivity, specificity and accuracy of 5 indicator combinations (MCV + MCH, MCV + MCH + MCHC, MCV + MCH + RDW, RBC + Hb + MCV, Hb + MCV + MCH + MCHC). *Results:* There were 62 IDA patients and 24 non-IDA patients diagnosed according to the baseline standards. Among single indicators, MCV and MCH have the best diagnostic effect; among indicator combinations, the Hb + MCV + MCH + MCHC quadruple combination has the highest diagnostic efficiency (sensitivity 95.16%, specificity 91.67%, accuracy 94.19%), followed by the MCV + MCH + MCHC triple combination. Both groups are significantly better than other combinations and single indicators ($P < 0.05$). *Conclusion:* Among routine blood tests, the quadruple combination of Hb + MCV + MCH + MCHC is the most effective in diagnosing IDA, and the triple combination of MCV + MCH + MCHC is more cost-effective. It can be combined with actual clinical selection to provide reliable support for early screening and auxiliary diagnosis of IDA.

Keywords: Iron deficiency anemia; Routine blood testing; Mean corpuscular volume; Mean corpuscular hemoglobin content; Diagnostic value

Online publication: December 26, 2025

1. Introduction

Iron Deficiency Anemia (IDA) is a nutritional deficiency anemia with the highest clinical incidence. The core cause is insufficient iron intake, blocked absorption, or excessive iron loss in the body, resulting in insufficient hemoglobin synthesis and inducing various clinical symptoms [1]. The early symptoms of IDA are mostly atypical, often manifesting as fatigue, dizziness, etc., which are easily ignored. Delayed treatment may cause reduced immunity and affect the function of multiple organs, which is particularly harmful to the health of children and the elderly [2]. Therefore, early and accurate diagnosis of IDA is very important for timely intervention and improved prognosis. Currently, serum ferritin (SF) testing combined with bone marrow iron staining is the benchmark standard for diagnosing IDA. However, bone

marrow iron staining is an invasive examination, complicated to operate and not well accepted by patients. Serum ferritin testing is relatively expensive, which is not conducive to primary hospitals and large-scale screening [3]. As a routine clinical examination item, routine blood testing is easy to operate, fast, efficient, low-cost, and non-invasive. Its detection indicators can reflect the status of the body's hematopoietic function and are widely used in anemia screening. This study analyzes the diagnostic effect of core indicators of routine blood tests on IDA, clarifies its application significance, and provides a reference for clinical optimization of IDA diagnostic programs.

2. Materials and methods

2.1. General information

86 patients with suspected iron deficiency anemia admitted to our hospital from August 2024 to August 2025 were selected as the research subjects, including 35 males and 51 females, aged 18–76 (45.62 ± 12.38) years old. Inclusion criteria: (1) Existing anemia-related symptoms such as fatigue, dizziness, pale complexion, palpitations after activity; (2) Not receiving iron supplementation therapy or blood transfusion treatment; (3) Voluntarily participating in this study and signing an informed consent form. Exclusion criteria: (1) Combined with megaloblastic anemia, aplastic anemia, hemolytic anemia and other types of anemia; (2) Combined with severe liver and kidney insufficiency, malignant tumors, chronic infectious diseases; (3) Recent history of surgery, trauma or massive bleeding; (4) Pregnant and lactating women (separate analysis, not included in the overall statistics).

2.2. Method

All research subjects collected 5 mL of venous blood in the early morning on an empty stomach and divided it into two tubes, one tube was used for routine blood testing and the other tube was used for serum ferritin testing.

(1) Routine blood testing: Use a fully automatic blood cell analyzer (model: Sysmex 2800) for testing, and operate in strict accordance with the instrument operating instructions. The testing indicators include red blood cells (RBC), hemoglobin (Hb), mean corpuscular volume (MCV), mean corpuscular hemoglobin content (MCH), mean corpuscular hemoglobin concentration (MCHC), and red blood cell distribution width (RDW). Reference value range: RBC (3.80–5.10) × 10^{12}/L (female), (4.30–5.80)×10^{12}/L (male); Hb110–150g/L (female), 120–160g/L (male); MCV80–100fL; MCH27–34pg; MCHC320–360g/L; RDW11.5%–14.5%.

(2) Gold standard test: Chemiluminescence immunoassay is used to detect serum ferritin (SF). The instrument is a fully automatic chemiluminescence immunoassay analyzer (Model: Antu 6200). The reference value range: SF < 12 μg/L (female), < 15 μg/L (male) is iron deficiency; combined with bone marrow iron staining examination, bone marrow iron staining shows negative extracellular iron and reduced intracellular iron, which is the basis for the diagnosis of IDA [4]. Two laboratory doctors with rich clinical experience will jointly read the films to ensure the accuracy of the diagnostic results.

2.3. Observation indicators

Using serum ferritin detection combined with bone marrow iron staining results as the gold standard, the study subjects were divided into the IDA group (confirmed patients) and the non-IDA group (excluded patients). The diagnostic sensitivity, specificity, and accuracy of every single indicator of blood routine (RBC, Hb, MCV, MCH, MCHC) and different indicator combinations (MCV + MCH, MCV + MCH + MCHC, RBC + Hb + MCV) were calculated, respectively. Diagnostic criteria: If the test result of a single indicator is lower than the lower limit of the corresponding reference value, it is positive; if at least 2 indicators in the indicator combination are lower than the lower limit of the reference value, it is positive.

2.4. Statistical methods

Data were analyzed using SPSS24.0 software. Count data are expressed in [*n* (%)]. Sensitivity = true positive/(true positive + false negative) × 100%; specificity = true negative/(true negative + false positive) × 100%; accuracy = (true positive + true negative) / (total number of samples) × 100%.

3. Results

3.1. Gold standard diagnostic results

Among the 86 suspected IDA patients, 62 were diagnosed as IDA patients (IDA group) by serum ferritin detection combined with bone marrow iron staining, including 21 males and 41 females, aged 18–74 (44.85 ± 11.96) years old; there were 24 non-IDA patients (non-IDA group), including 14 males and 10 females, aged 20–76 (47.23 ± 13.12) years old.

3.2. Comparison of diagnostic performance of individual blood routine indicators

Among the individual indicators of blood routine, MCV has the highest diagnostic sensitivity (87.10%) and accuracy (84.88%), MCH has the highest diagnostic specificity (83.33%), and RBC has the lowest diagnostic sensitivity (74.19%) and accuracy (73.26%). See **Table 1** for details.

Table 1. Comparison of diagnostic performance of individual indicators of blood routine [*n* (%)]

Indicator	Sensitivity	Specificity	Accuracy
RBC	74.19 (46/62)	70.83 (17/24)	73.26 (63/86)
Hb	80.65 (50/62)	79.17 (19/24)	80.23 (69/86)
MCV	87.10 (54/62)	80.00 (19/24)	84.88 (73/86)
MCH	83.87 (52/62)	83.33 (20/24)	83.72 (72/86)
MCHC	79.03 (49/62)	75.00 (18/24)	77.91 (67/86)

3.3. Comparison of diagnostic performance of different combinations of blood routine indicators

Among different indicator combinations, the Hb + MCV + MCH + MCHC quadruple combination has the best diagnostic performance, followed by the MCV + MCH + MCHC triple combination. Both are more efficient than the MCV + MCH double combination, MCV + MCH + RDW triple combination and RBC + Hb + MCV triple combination, and the diagnostic efficacy of each combination is significantly higher than the single indicator ($P < 0.05$). Among them, the triple combination of MCV + MCH + MCHC is more effective than the double combination of MCV + MCH. See **Table 2** for details.

Table 2. Comparison of diagnostic performance of different combinations of blood routine indicators [n (%)]

Indicator combination	Sensitivity	Specificity	Accuracy
MCV + MCH (two combinations)	90.32 (56/62)	83.33 (20/24)	88.37 (76/86)
MCV + MCH + MCHC (triple)	93.55 (58/62)	87.50 (21/24)	91.86 (79/86)
MCV + MCH + RDW (triple)	91.94 (57/62)	83.33 (20/24)	89.53 (77/86)
RBC + Hb + MCV (triple)	87.10 (54/62)	81.25 (19/24)	84.88 (73/86)
Hb + MCV + MCH + MCHC (quadruple)	95.16 (59/62)	91.67 (22/24)	94.19 (81/86)

4. Discussions

Iron-deficiency anemia is a microcytic, hypochromic anemia caused by depletion of the body's iron reserves and lack of hemoglobin synthesis. Its pathogenesis is closely related to iron metabolism disorders [4]. Confirming the condition as early as possible and supplementing iron in a timely manner can effectively reduce the patient's discomfort and prevent the condition from worsening. Therefore, the use of efficient and simple diagnostic methods plays a very critical clinical role. Bone marrow iron staining is the core standard for diagnosing iron deficiency anemia. Although the detection accuracy is good, it is an invasive operation, and the operation steps are complicated and time-consuming, making patients less willing to cooperate. It is difficult to use it as a routine screening method. Serum ferritin detection can reflect the body's iron reserve status, but its detection results are easily interfered by factors such as inflammatory tumors and the detection cost is relatively high, which is not conducive to the implementation of primary medical institutions [5].

Routine blood testing is the most basic clinical blood test item, which can quickly obtain multiple indicators such as the red blood cell system and platelet system. Among them, red blood cell-related indicators can directly reflect the body's hematopoietic function and anemia type. The results of this study show that among the single indicators of blood routine, MCV and MCH have the most ideal diagnostic effects, with sensitivities of 87.10% and 83.87%, and specificities of 80.00% and 83.33%, respectively. This is because patients with iron deficiency anemia suffer from insufficient hemoglobin synthesis due to insufficient iron. During the production of red blood cells, due to a shortage of raw materials, the volume becomes smaller and the hemoglobin content decreases, showing microcytic and hypochromic changes. MCV can reflect the average volume of red blood cells. MCH can reflect the average hemoglobin content in a single red blood cell and can directly reflect this morphological change. Therefore, it is highly targeted for the diagnosis of iron deficiency anemia [6]. In contrast, although RBC and Hb are commonly used indicators for diagnosing anemia, due to individual differences, blood loss and other factors, there may be no obvious abnormalities in the early stages of iron deficiency anemia, making the diagnostic sensitivity low and it is easy to miss the diagnosis when used alone.

This study further analyzed the diagnostic effects of different indicator combinations. The results showed that the diagnostic efficiency did not increase linearly with the increase in the number of indicators, but was closely related to the pertinence of the indicators to the core characteristics of iron deficiency anemia. Among them, the Hb + MCV + MCH + MCHC quadruple combination had the best diagnostic efficiency, with sensitivity, specificity, and accuracy, respectively. The results reached 95.16%, 91.67%, and 94.19%, which were significantly better than other combinations; followed by the MCV + MCH + MCHC triple combination, its efficacy was significantly higher than the MCV + MCH double combination. This result is in line with the diagnostic logic of multi-indicator combination and complementation, and also verifies the added value of MCHC in the diagnosis of iron deficiency anemia. The core hematological characteristic of iron deficiency anemia is microcytic hypochromia. MCV reflects the volume of red blood cells, which is microcytic manifestations. MCH reflects the hemoglobin content of single red blood cells, which is hypochromic manifestations. MCHC further quantifies the hemoglobin concentration in red blood cells. The combination of the three can comprehensively capture the morphological abnormalities of iron deficiency anemia from multiple aspects of volume content. Compared with the double combination that only reflects volume content, it can more accurately distinguish iron deficiency anemia from other non-microcytic hypochromic anemias, thus reducing the risk of misdiagnosis and missed diagnosis [7].

The difference in efficacy of different triple combinations also confirms the importance of indicator targeting: the efficacy of the MCV + MCH + RDW triple combination is slightly higher than the MCV + MCH double combination, but significantly lower than the MCV + MCH + MCHC combination. The reason is that although RDW can reflect the heterogeneity of red blood cells, it can increase due to uneven red blood cell production in the advanced stage of iron deficiency anemia. However, the change in red blood cell heterogeneity in patients with early iron deficiency anemia is not obvious, and the increase in RDW is not unique to iron deficiency anemia. , may also occur in megaloblastic anemia and hemolytic anemia, resulting in limited specificity improvement in the diagnosis of iron deficiency anemia; the RBC + Hb + MCV combination has the lowest efficacy, and the core reason is that this combination lacks MCH and MCHC The

assessment of hypochromic characteristics can only determine the presence of microcytic and anemia, that is, reduced Hb and RBC, and cannot accurately fit the core phenotype of microcytic hypochromicity in iron deficiency anemia, and is easily confused with other microcytic anemias such as thalassemia [8].

However, this study has certain flaws. The number of samples is relatively small and it is a single-center study. The results may be biased. It does not take into account the differences in blood routine indicators among patients with iron deficiency anemia of different age groups and different causes such as nutritional deficiencies and chronic blood loss. In the future, the number of samples can be expanded to conduct multi-center studies to further refine the analysis. In addition, actual indicator combinations need to be selected in clinical applications: Although the Hb + MCV + MCH + MCHC quadruple combination has the best diagnostic performance, there is no need to excessively pursue the combination of all indicators. For primary hospitals or large-scale screening, the MCV + MCH + MCHC triple combination can meet clinical needs and is both accurate and economical; for diagnosing difficult cases, the quadruple combination can be used to improve the diagnosis rate. At the same time, it should be noted that routine blood testing is only an auxiliary diagnostic method. For patients with positive combinations of indicators but atypical clinical symptoms, core standard examinations such as serum ferritin and bone marrow iron staining need to be combined for further diagnosis to avoid misdiagnosis.

5. Conclusion

In summary, among routine blood tests, the quadruple combination of Hb + MCV + MCH + MCHC has the best diagnostic performance for iron deficiency anemia, and the triple combination of MCV + MCH + MCHC is more cost-effective. Routine blood testing has the advantages of simple operation, rapid efficiency, low cost, and non-invasiveness. Among them, the targeted indicator combination can accurately capture the core characteristics of small cell hypochromia of iron deficiency anemia. It can be used as the first choice method for early screening and auxiliary diagnosis of clinical iron deficiency anemia, especially suitable for primary hospitals and large-scale population screening. Combined with serum ferritin detection or bone marrow iron staining, it can further improve the diagnostic accuracy and provide reliable basis for clinical treatment, which has very important clinical promotion value.

Disclosure statement

The author declares no conflict of interest.

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