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Analysis of the Diagnostic Value of Blood Test Indicators for Anemia

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Abstract: *Objective:* To analyze the effectiveness of blood test indicators in the differential diagnosis of anemia. *Methods:* Sixty patients diagnosed with anemia (disease group) from June 2021 to June 2024 were selected. Based on the type of disease, the group was subdivided into iron deficiency anemia (IDA) with 31 cases, hemolytic anemia (HA) with 11 cases, and aplastic anemia (AA) with 18 cases. Based on the severity of the disease, the group was divided into mild anemia (30 cases), moderate anemia (19 cases), and severe anemia (11 cases). Sixty healthy individuals (control group) were also included, and all underwent blood tests. Comparisons were made between the red blood cell (RBC) indicators of the disease group and the control group, the blood test indicators of different types of anemia, and the serum iron levels of varying severity of anemia. *Results:* Except for red cell distribution width (RDW), the RBC indicators in the disease group were lower than those in the control group ($P < 0.05$). Comparisons of RBC indicators among different types of anemia showed significant differences ($P < 0.05$). Serum iron levels varied significantly among different degrees of anemia severity ($P < 0.05$). *Conclusion:* Blood tests can detect anemia, distinguish types of anemia, and assess anemia severity, offering high diagnostic value.

Keywords: Blood test indicators; Anemia; Differential diagnosis

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1. Introduction

The basis for diagnosing anemia is peripheral red blood cell (RBC) or hemoglobin (Hb) levels lower than normal. Common symptoms include pale complexion and dizziness, potentially leading to conditions such as erythrocytopenia or hemolytic disease. Anemia is often classified as iron deficiency anemia (IDA) or aplastic anemia (AA), with varying symptoms for different types requiring targeted treatment [1]. Based on Hb levels, anemia can be categorized into mild, moderate, and severe, with differences in disease severity and treatment principles. Therefore, it is essential to distinguish anemia types and severity to comprehensively assess the condition.

Currently, blood testing is the primary diagnostic technique for anemia, enabling the measurement of RBC and serum iron indicators. These test results allow for the differentiation of anemia types [2]. Moreover, blood tests are convenient, automated, and efficient, leading to high acceptance among patients. Based on this, the study selected 60 anemia patients and 60 healthy individuals to evaluate the diagnostic role of blood test indicators in determining anemia types and severity.

2. Materials and methods

2.1. General information

The disease group included 60 anemia patients diagnosed and hospitalized between June 2021 and June 2024. Based on disease type:

(1) Hemolytic anemia (HA): 11 cases (7 males, 4 females), aged 24–60 years, mean age (46.35 ± 3.94) years.

(2) AA: 18 cases (11 males, 7 females), aged 22–63 years, mean age (47.01 ± 4.05) years.

(3) IDA: 31 cases (19 males, 12 females), aged 26–63 years, mean age (47.09 ± 4.18) years.

Based on disease severity:

(1) Mild anemia (Hb level > 90 g/L): 30 cases (17 males, 13 females), aged 25–73 years, mean age (48.11 ± 4.23) years.

(2) Moderate anemia (Hb level 60–90 g/L): 19 cases (11 males, 8 females), aged 27–75 years, mean age (48.37 ± 4.34) years.

(3) Severe anemia (Hb level < 60 g/L): 11 cases (7 males, 4 females), aged 22–70 years, mean age (48.91 ± 4.29) years.

The control group included 60 healthy individuals (35 males, 25 females), aged 23–66 years, mean age (48.01 ± 4.21) years. There were no significant differences between the two groups ($P > 0.05$).

Inclusion criteria: Complete clinical data; normal verbal and written communication ability; full cooperation throughout the study; informed consent provided.

Exclusion criteria: Presence of other organ diseases; mental disorders; intellectual disability; withdrawal during the study.

2.2. Methods

Participants were required to fast for 6–8 hours before testing. Blood samples (2 mL) were collected under fasting conditions and placed in anticoagulant tubes, with participant information labeled externally. The blood samples were centrifuged at 4,000 r/min to separate plasma and serum, allowing red blood cells and platelets to settle at the bottom of the tube. The supernatant was extracted, and smears were prepared. Smears were stained on glass slides to ensure clear cellular visualization. A fully automated blood cell analyzer was used to observe cell morphology, size, and other characteristics.

For venous blood collection, 3–5 mL of fasting blood was drawn and centrifuged within 2 hours under the same parameters. After serum separation, serum iron indicators were tested using a fully automated biochemical analyzer and the colorimetric method.

2.3. Observation indicators

The study observed:

(1) RBC indicator levels in the disease and control groups.

(2) Blood test indicator levels for different types of anemia.

(3) Serum iron indicator levels based on anemia severity.

The normal ranges for the observed indicators are shown in **Table 1.**

Table 1. Normal ranges for different indicators

Indicators		Abbreviation	Normal range
RBC indicators	Red blood cell count	RBC	3.50–5.50×10^{12} L
	Red blood cell distribution width	RDW	< 14.5%
	Mean corpuscular volume	MCV	80–97 fl
	Hemoglobin	Hb	Male: 120–160 g/L Female: 110–150 g/L
	Mean corpuscular hemoglobin	MCH	26.5–33.5 pg
	Mean corpuscular hemoglobin concentration	MCHC	320–360 g/L
Serum iron indicators	Serum ferritin	SF	Male: 15–200 μg/L Female: 12–150 μg/L
	Serum iron	SI	Male: 10.7–26.9 μmol/L Female: 9.0–23.3 μmol/L
	Soluble transferrin receptor	sTfR	≤ 20.0 nmol/L

2.4. Statistical analysis

Data analysis was performed using SPSS 28.0. Measurement data were expressed as mean ± standard deviation (SD), and comparisons between two groups were conducted using *t*-tests. Multiple group comparisons used F-tests. Count data were expressed as [*n* (%)], and χ^2 tests were applied. Statistical significance was set at $P < 0.05$.

3. Results

3.1. Comparison of RBC indicators between the disease group and the healthy group

Except for RDW, the levels of RBC indicators in the disease group were significantly lower than those in the healthy group ($P < 0.05$), as shown in **Table 2**.

Table 2. Comparison of RBC indicators between the disease group and the healthy group (mean ± SD)

Group	*n*	RBC (×10^{12} L)	RDW (%)	MCV (fl)	Hb (g/L)	MCH (pg)	MCHC (g/L)
Disease	60	2.98 ± 0.41	20.31 ± 3.69	69.75 ± 8.32	81.56 ± 4.62	20.84 ± 2.66	275.65 ± 10.42
Healthy	60	4.45 ± 0.62	12.78 ± 3.15	83.99 ± 9.14	116.94 ± 5.71	29.42 ± 2.94	325.95 ± 15.34
t		15.319	12.022	8.924	37.312	16.763	21.010
P		0.000	0.000	0.000	0.000	0.000	0.000

3.2. Comparison of RBC indicators among different types of anemia

RBC, MCV, and MCHC levels in IDA patients were higher than those in AA patients. RDW levels in IDA patients were higher than those in HA and AA patients. RBC, MCV, and MCHC levels in HA patients were higher than those in AA patients. Hb and MCH levels in IDA patients were lower than those in HA and AA patients. Hb and MCH levels in HA patients were higher than those in AA patients ($P < 0.05$), as shown in **Table 3**.

Table 3. Comparison of RBC indicators among different types of anemia (mean ± SD)

Disease type	*n*	RBC ($\times 10^{12}$ L)	RDW (%)	MCV (fl)	Hb (g/L)	MCH (pg)	MCHC (g/L)
IDA	31	2.99 ± 0.24	22.16 ± 2.95	70.36 ± 4.95	72.25 ± 6.92	19.24 ± 2.60	280.65 ± 10.32
HA	11	3.20 ± 0.41	18.40 ± 2.42	74.26 ± 5.94	99.47 ± 6.13	25.15 ± 2.36	294.53 ± 11.33
AA	18	2.81 ± 0.33	16.32 ± 2.04	66.14 ± 4.02	92.12 ± 7.02	22.14 ± 2.31	263.86 ± 10.75
F		5.710	30.064	9.823	86.690	25.024	30.170
P		0.005	0.000	0.000	0.000	0.000	0.000

3.3. Comparison of serum iron indicators based on anemia severity

Serum ferritin (SF) and serum iron (SI) levels in mild anemia were higher than those in moderate and severe anemia, with moderate anemia levels higher than severe anemia. The soluble transferrin receptor (sTfR) level in mild anemia was lower than that in moderate and severe anemia, with moderate anemia levels lower than severe anemia ($P < 0.05$), as shown in **Table 4**.

Table 4. Comparison of serum iron indicators based on anemia severity (mean ± SD)

Disease severity	*n*	SF (μg/L)	SI (μmol/L)	StfR (nmol/L)
Mild	30	13.25 ± 2.30	9.38 ± 1.45	50.49 ± 6.33
Moderate	19	4.59 ± 0.67	5.42 ± 1.02	61.95 ± 7.21
Severe	11	1.14 ± 0.36	2.30 ± 0.53	73.94 ± 8.02
F		273.207	158.401	49.628
P		0.000	0.000	0.000

4. Discussion

A prolonged course of anemia can lead to reduced oxygen supply in the body, thereby affecting the function of multiple systems. The causes of anemia are complex, including genetic defects, malnutrition, or adverse drug reactions, with malnutrition being the most common, such as deficiencies in folic acid and iron. Additionally, chronic diseases such as rheumatoid arthritis or kidney disease are also common causes of anemia [3]. Anemia increases the burden on the heart, leading to cardiovascular problems or immune system damage, ultimately reducing the quality of life for patients.

Among the types of anemia, IDA is the most prevalent. Its causes include impaired iron absorption and insufficient dietary intake of iron, leading to reduced efficiency in the synthesis of Hb in red blood cells, thereby resulting in anemia. Iron is predominantly distributed in myoglobin and Hb and is an essential trace element for the body, playing a physiological role in oxygen transport [4]. Iron from food is absorbed through the small intestine and provides energy to cells, promoting the growth and development of red blood cells. Insufficient iron intake leads to IDA, which manifests as symptoms such as insomnia, headaches, or loss of appetite. HA is caused by the rapid destruction of red blood cells, resulting in a decreased red blood cell count. HA can be classified into acquired and hereditary types [5]. Acquired HA is caused by external factors, including infectious HA, autoimmune HA, and drug-induced HA. Hereditary HA is based on genetic mutations and includes conditions such as thalassemia and sickle cell anemia, characterized by functional and morphological abnormalities in red blood cells. AA is characterized by hematopoietic stem cell dysfunction or deficiency, impairing the bone marrow's ability to produce large quantities of red blood cells and platelets, which induces anemia or bleeding tendencies [6,7]. Its causes include autoimmune diseases, prolonged exposure to chemical substances, or infections, leading to persistent immune attacks on hematopoietic stem cells, reducing the speed of blood cell differentiation and maturity. Symptoms of AA include sore throat, fever, or oral ulcers, often accompanied by bleeding tendencies such as gum bleeding [8].

The levels of red blood cell indicators differ according to the type and severity of anemia. RBC reflects the number of red blood cells per unit volume of blood. Anemia reduces red blood cell production efficiency, disrupts the production process, and lowers RBC levels [9]. RDW reflects the degree of variation in red blood cell volume; elevated RDW levels indicate reduced red blood cell production and increased destruction. MCV reflects the specific volume of individual red blood cells, and changes in its level can be used to evaluate red blood cell size [10]. Hb reflects the proportion of red blood cells in whole blood and is an oxygen-transporting protein that delivers oxygen to organs and tissues. MCH reflects the Hb content within individual red blood cells, while MCHC reflects the Hb content per unit volume of red blood cells and can be used to assess the severity of anemia [11]. Results showed that, except for RDW, the RBC indicators in the disease group were lower than those in the healthy group. Comparing RBC indicators among different types of anemia revealed statistically significant differences ($P < 0.05$). This indicates that RBC indicators can help identify anemia types, as each indicator demonstrates specific characteristics, allowing for differentiation among anemia types. The underlying reason is that blood tests comprehensively assess various indicator levels, integrate multiple parameters, and compare them to normal values, facilitating the early diagnosis of anemia types.

SF is the storage form of iron in the body and can be used to evaluate iron reserves. This indicator assesses the severity of anemia, with lower SF levels indicating more severe anemia. SI refers to the concentration of free iron in the serum and evaluates the state of the iron supply [12,13]. Lower SI levels indicate more severe anemia. sTfR participates in the transport of iron by binding to iron carriers and transferrin, facilitating iron entry into cells. It evaluates iron supply, with higher concentrations indicating more severe anemia. Results showed significant differences in serum iron indicator levels across different anemia severities ($P < 0.05$). This suggests that serum iron indicators can effectively assess the severity of anemia. This is because serum iron indicators reflect iron reserves, supply status, and transport processes from multiple perspectives. Based on their level changes, they can predict the progression of anemia, making them effective for distinguishing disease severity [14,15].

5. Conclusion

In summary, blood test indicators can efficiently detect anemia, determine the type and severity of anemia, and offer significant diagnostic advantages.

Disclosure statement

The author declares no conflict of interest.

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