

ORIGINAL ARTICLE

A Study on the Differences in the Probability of Iron Deficiency Anemia and the Severity of Anemia among People with Different Blood Types

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ABSTRACT

Background: This study aimed to explore the potential association between the ABO blood group system and the incidence probability as well as severity of Iron Deficiency Anemia (IDA), so as to provide a scientific basis for the personalized prevention, diagnosis, and intervention strategies of IDA.

Methods: Statistical analyses were performed using SPSS software, including descriptive statistics, chi-squared test, Tukey HSD, Dunnett T3 multiple comparisons, and binary logistic regression model. A p-value < 0.05 was considered statistically significant.

Results: Regarding hemoglobin distribution, the hemoglobin levels of 1,009 patients showed an approximately normal distribution, with a mean of 71 g/L and a standard deviation of 18 g/L. The median hemoglobin level of patients with blood type O (about 65 g/L) was significantly lower than that of other blood types, and the data distribution was more concentrated. For the association between blood type and gender, the sample size of females was generally larger than that of males, but the chi-squared test showed no significant association between blood type and gender ($p > 0.05$). In terms of anemia severity comparison, multiple comparison analysis indicated a significant difference only between blood types A and O ($p = 0.013$). Binary logistic regression showed that the risks of severe anemia in patients with blood type O (OR = 1.831, $p = 0.001$) and type A (OR = 1.488, $p = 0.024$) were 1.831 and 1.488 times that of type AB, respectively, while no significant association was found between blood type B and severe anemia ($p > 0.05$).

Conclusions: The ABO blood group is associated with the severity of IDA. Individuals with blood types O and A have a significantly higher risk of severe IDA than those with blood type AB. This study provides a theoretical basis for blood group-based personalized screening and intervention of IDA, but further studies are needed to clarify the specific mechanism by which blood type affects iron metabolism and to exclude the influence of confounding factors such as eating habits and genetic background.

(Clin. Lab. 2026;72:xx-xx. DOI: 10.7754/Clin.Lab.2025.251049)

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KEYWORDS

Iron deficiency anemia, blood type, severe anemia, hemoglobin

INTRODUCTION

Iron Deficiency Anemia (IDA) is the most common nutritional deficiency disease worldwide and the leading cause of anemia, especially in children and women of childbearing age. IDA is a type of hypochromic micro-

cytic anemia caused by decreased hemoglobin synthesis due to insufficient iron reserves in the body. IDA has far-reaching health consequences, it can cause irreversible neurodevelopmental and cognitive deficits, especially in infancy and early childhood, and is difficult to fully recover from, even after iron supplementation [1]. In recent years, as research has progressed, scientists have begun to focus on the association between IDA and various diseases, such as cardiovascular disease, infectious diseases, and cancer [2-4], which further highlights the importance of early identification and intervention. In addition, studies on the epidemiological characteristics of IDA and its potential relationship with certain genetic factors (e.g., different blood types) are gradually being conducted, providing a theoretical basis for future personalized prevention and treatment strategies. Globally, IDA remains a major public health problem, especially in developing countries, where children, women of childbearing age, and pregnant women are high-risk groups [5]. According to the World Health Organization (WHO), approximately more than 2 billion people worldwide suffer from anemia, a large proportion of which is attributed to iron deficiency. In addition, IDA during pregnancy should not be ignored, especially in economically underdeveloped regions, where the prevalence of IDA in pregnant women can be as high as 40% or more [6]. In China's Yunnan Province, for example, data from 2017 showed that the prevalence of IDA in children under 3 years of age reached 48.8%, higher than the national average [7]. The government has initiated a series of iron supplementation programs, such as the routine iron supplementation program during pregnancy, but the use of intravenous iron has still not been widely promoted due to poor individual tolerance of oral iron [8]. Therefore, enhancing screening for IDA and improving intervention coverage remain important current public health tasks.

Whether blood type affects the susceptibility to IDA has become a new direction of research in recent years. It has been suggested that different ABO blood types may have biological differences in iron metabolism and gastrointestinal absorption capacity, which may affect the occurrence of IDA [9,10]. Although there is no large-scale epidemiological data to confirm the direct causal relationship between ABO blood type and IDA, some indirect evidence suggests that people with O-type blood type may have a higher risk of IDA, which may be related to their gastric acid secretion pattern and higher rate of *Helicobacter pylori* infection [11].

MATERIALS AND METHODS

Study population

In this paper, we retrospectively analyzed the blood type and hemoglobin results from January 2019 - April 2025 of all patients diagnosed with iron deficiency anemia in our hospital. Adults ≥ 18 years of age were included (infants and children were excluded to avoid dif-

ferences in iron metabolism during growth and developmental stages interfering with the results), with a focus on those who have lived in the local area for a long period of time (≥ 6 months), to minimize the effect of mobility on confounding factors such as diet and environment. Exclude samples with an interval of more than 7 days between the test date and the medical record (to avoid fluctuations in physiological status affecting the relevance of the results), exclude patients with a clear diagnosis of other types of anemia (e.g., megaloblastic anemia, aplastic anemia, hemolytic anemia, etc.), exclude those who have received iron therapy, blood transfusion, or hematopoietic stem cell transplantation in the past 3 months (to avoid exogenous iron interfering with ferritin levels), and exclude those who suffer from underlying diseases that affect iron metabolism. Finally, 1,009 valid data were collected.

Basis of grouping

According to the ABO blood typing system, the study subjects were divided into four groups: A, B, AB and O. As the most basic classification of human blood types, the differences in the expression of antigens in the ABO blood typing system may affect the immune response and substance metabolism of the organism, which may be potentially related to the occurrence and development of iron-deficiency anemia, so the grouping of the study subjects can help to explore the correlation between blood typing and iron-deficiency anemia.

Diagnostic criteria of iron deficiency anemia

Referring to the World Health Organization (WHO) and China Iron Deficiency Anemia Diagnosis and Treatment Guidelines, those who meet all the following conditions are diagnosed as iron deficiency anemia:

- 1) Blood routine indexes: Hemoglobin (Hb) < 120 g/L for adult women and Hb < 130 g/L for adult men.
- 2) Iron metabolism indicators: serum ferritin (SF) < 15 $\mu\text{g/L}$, suggesting a lack of iron reserves; serum iron (SI) < 8.95 $\mu\text{mol/L}$, the total iron binding capacity (TIBC) > 64.44 $\mu\text{mol/L}$, transferrin saturation (TS) $< 15\%$, suggesting that the iron utilization disorder.
- 3) Exclude other causes of anemia: other types of anemia such as megaloblastic anemia, aplastic anemia, hemolytic anemia, etc. by means of bone marrow image examination, vitamin B12 and folic acid level test.

Anemia severity criteria: According to the hemoglobin concentration, the severity of iron deficiency anemia was divided into the following three levels: mild anemia: 90 g/L $\leq$ Hb $<$ lower limit of normal (adult female < 120 g/L, adult male < 130 g/L); moderate anemia: 60 g/L $\leq$ Hb < 90 g/L; severe anemia: Hb < 60 g/L.

Statistical methods

The study used SPSS software for statistical analysis of data, and all statistical tests were two-sided tests, with $p < 0.05$ as the criterion for statistically significant differences.

Table 1. Cross tabulation analysis of blood group and gender.

	A+	B+	O+	AB+
Male	127	90	166	25
Female	174	161	226	40
Total	301	251	392	65

Table 2. Multiple comparative analysis of the effect of different blood groups on the degree of anemia.

	Blood type comparison		Mean difference	SE	p	95% CI	
						lower limit	upper Limit
Tukey HSD	A+	B+	0.034	0.056	0.928	-0.11	0.18
		O+	0.154	0.050	0.013	0.02	0.28
		AB+	0.081	0.090	0.807	-0.15	0.31
	B+	A+	-0.034	0.056	0.928	-0.18	0.11
		O+	0.119	0.053	0.112	-0.02	0.26
		AB+	0.046	0.092	0.958	-0.19	0.28
	O+	A+	-0.154	0.050	0.013	-0.28	-0.02
		B+	-0.119	0.053	0.112	-0.26	0.02
		AB+	-0.073	0.088	0.840	-0.30	0.15
	AB+	A+	-0.081	0.090	0.807	-0.31	0.15
		B+	-0.046	0.092	0.958	-0.28	0.19
		O+	0.073	0.088	0.840	-0.15	0.30
Dunnett T3	A+	B+	0.034	0.055	0.990	-0.11	0.18
		O+	0.154	0.050	0.013	0.02	0.29
		AB+	0.081	0.093	0.945	-0.17	0.33
	B+	A+	-0.034	0.055	0.990	-0.18	0.11
		O+	0.119	0.054	0.148	-0.02	0.26
		AB+	0.046	0.095	0.997	-0.21	0.30
	O+	A+	-0.154	0.050	0.013	-0.29	-0.02
		B+	-0.119	0.054	0.148	-0.26	0.02
		AB+	-0.073	0.092	0.963	-0.32	0.17
	AB+	A+	-0.081	0.093	0.945	-0.33	0.17
		B+	-0.046	0.095	0.997	-0.30	0.21
		O+	0.073	0.092	0.963	-0.17	0.32

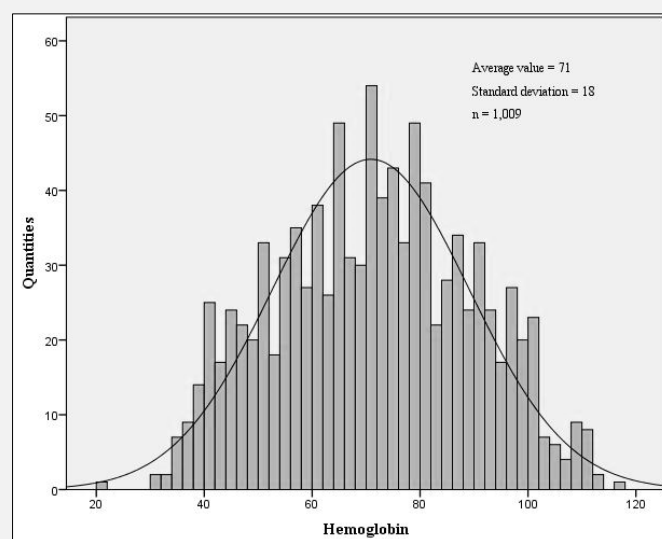
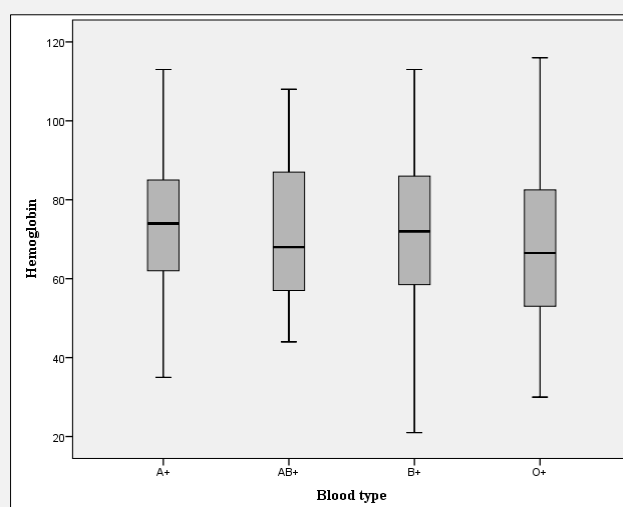
RESULTS

The hemoglobin levels of these 1,009 study subjects were measured and plotted in a histogram (Figure1).

The results showed that the hemoglobin values showed an approximately normal distribution with a mean value of $\bar{x} = 71$ and standard deviation $s = 18$. The frequency of hemoglobin values was higher around the mean value

Table 3. Binary logistic regression model analysis of the effect of different blood groups on the risk of developing severe anaemia.

Blood type	B	SE	Wals	df	p	OR
O+	0.605	0.171	12.440	1	0.001	1.831
A+	0.398	0.177	5.066	1	0.024	1.488
B+	0.174	0.286	0.371	1	0.542	1.190

**Figure 1. Histogram of the distribution of hemoglobin levels in 1,009 study subjects.****Figure 2. Box plots of the distribution of hemoglobin levels in different blood type populations.**

and decreased gradually to both sides, indicating that most of the subjects' hemoglobin levels were concentrated around the mean value, and the degree of dispersion of the data was measured by the standard deviation, suggesting that there were some differences in hemoglobin levels between individuals.

A box plot of the distribution of hemoglobin levels among different blood types was then analyzed (Figure 2). The results showed that the median hemoglobin levels of different blood types were close to each other, fluctuating around 60 g/L - 70 g/L, suggesting that the concentration of hemoglobin levels was similar among different blood types in general. The median hemoglobin level of patients with O blood type was significantly lower than those of other blood types, which was around 65 g/L. The box is also relatively narrow, indicating that the middle 50% of hemoglobin level of patients with blood type O is more concentrated and the overall level is lower than other blood types. Meanwhile, there are some differences in the degree of dispersion of hemoglobin data among blood types, and the data distribution range of each blood type is wider, indicating that there are inter-individual differences in hemoglobin levels among different blood types.

In order to investigate the distribution relationship between blood group and gender, 1,009 study subjects were analyzed by cross tabulation of blood group and gender (Table 1). The results showed that there were differences in the distribution of different blood groups between male and female genders. For example, among A blood group, there were 127 males (42.2% of A+ blood group and 31.1% of male group) and 174 females (57.8% of A+ blood group and 29.0% of female group); among AB+ blood group, there were 25 males (38.5% of AB+ blood group and 6.1% of male group) and 40 females (61.5% of AB+ blood group and 6.7% of female group). Among the blood groups, 25 were male (38.5% of AB+ blood group and 6.1% of male group) and 40 were female (61.5% of AB+ blood group and 6.7% of female group). There were some differences in the distribution of blood groups between the two genders, and the number of female samples was generally larger than that of male samples. Further chi-squared test (Pearson's chi-squared test: $X^2 = 3.271$, $df = 3$, $p = 0.352$); likelihood ratio test: value of 3.297, $df = 3$, $p = 0.348$ showed that there was no significant correlation between blood group and gender within the sample of this study ($p > 0.05$).

In order to investigate whether there is a difference in the degree of anemia between different blood groups, this study used both Tukey HSD and Dunnett T3 for multiple comparison analysis. The results showed (Table 2) that in the Tukey HSD test, the difference in the mean value of the degree of anemia between blood groups A+ and O+ was 0.154 ($p = 0.013$), which was statistically significant, while the difference in the mean value of the degree of anemia between most of the other blood groups was not statistically significant ($p > 0.05$). The results of the Dunnett T3 test were similar,

with a significant difference between only A+ and O+ , the difference in mean values was 0.154, $p = 0.013$. The study suggests that only the degree of anemia corresponding to blood groups A+ and O+ differed significantly in the present sample, while the degree of anemia among the other blood groups was not significant.

We redefined the degree of anemia as severe and non-severe anemia and constructed a regression model to explore the effect of different blood types on the degree of anemia. The results showed (Table 3) that among the blood group variables, blood group O+ ($B = 0.605$, $p = 0.001$, $OR = 1.831$) and blood group A+ ($B = 0.398$, $p = 0.024$, $OR = 1.488$) were significantly associated with the degree of anemia, while the risk of severe anemia in patients with blood groups O+ and A+ was 1,831 times and 1,488 times higher than that of blood group AB+ respectively, while there was no significant association for B+ blood group ($p > 0.05$).

DISCUSSION

Based on these observations, there is clinical value in incorporating blood group into the personalized diagnostic process for IDA. By comparing iron metabolism parameters among people with different blood groups, high-risk individuals can be identified at an early stage and targeted nutritional supplementation programs can be developed. In addition, the combination of genomic studies, such as the correlation between mutations in the SLC25A13 gene and abnormalities in iron metabolism, can also help to achieve more precise IDA prevention and intervention strategies [12]. Understanding the potential link between blood group and IDA can help develop more personalized preventive measures. For example, for people with blood group O, fortification of iron intake or regular monitoring of iron status may be preferentially recommended. In conjunction with existing dietary guidelines and supplementation policies, such stratified management based on blood type may improve the effectiveness of interventions. As a cross-sectional observational study, this study only reveals the association between blood group and anemia level, and cannot clarify the causal relationship, which may be affected by unincluded confounders (e.g., dietary habits, history of chronic diseases, genetic background, etc.) that may affect the accuracy of the results. At the same time, the regression model did not adjust for other potential confounders, and multiple comparisons may increase the probability of type I error; sensitivity analysis was not performed to test the stability of the results, and the robustness of the conclusions needs to be further verified.

With the development of precision medicine, incorporating blood group as a biomarker into the diagnostic criteria for IDA can help improve the specificity of the test. For example, a multidimensional scoring system combining blood type, serum ferritin, hemoglobin levels and dietary habits is expected to improve the accu-

racy of early identification of IDA [13]. In terms of treatment, blood group-based management of IDA may lead to new ideas. For example, individuals with blood group O who exhibit intolerance to oral iron may be treated with intravenous iron preparations earlier, thereby improving treatment compliance and efficacy. In addition, Chinese medicines such as Shengxuening Tablet have demonstrated good efficacy and safety in IDA treatment, and their efficacy in specific blood group populations could be explored in the future [14]. The ABO blood group system is thought to be associated with a variety of disorders of iron metabolism, such as changes in serum ferritin levels, transferrin saturation (TSAT), and so on. For example, individuals with blood group O usually have lower von Willebrand factor (vWF) and factor VIII concentrations, which may affect the efficiency of iron utilization. Also, the structure of the gastric mucosa in individuals with blood group O may make them more susceptible to *Helicobacter pylori* infection, which has been shown to be closely associated with impaired iron absorption and IDA.

In summary, iron deficiency anemia (IDA) remains a major public health challenge worldwide, especially in developing countries, and its hazards encompass a wide range of aspects, including child development, pregnancy outcomes, chronic disease progression, and prognosis of critically ill patients. Recent studies have not only deepened our understanding of the pathogenesis of IDA and intervention strategies, but also provided a scientific basis for exploring the potential association between blood group and IDA. Incorporating blood group into the early prevention and personalized diagnosis of IDA can help achieve more accurate health management. Future studies should further reveal how blood group affects iron metabolism pathways and develop nutritional interventions and pharmacological treatments applicable to people with different blood groups to ultimately reduce the global burden of IDA.

CONCLUSION

A total of 1,009 study subjects were included in this study and analyzed for hemoglobin level, blood group, gender and degree of anemia. The results showed that hemoglobin levels were approximately normally distributed with a mean value of 71 and a standard deviation of 18, with inter-individual variability. The concentration of hemoglobin levels was similar among different blood groups, but the median value of O+ blood group was significantly lower than that of other blood groups, and the distribution of data was more concentrated. Although there was a difference in the distribution of blood group and gender, with females having more samples than males overall, the chi-squared test confirmed that there was no significant association between the two. Regarding the degree of anemia, Tukey HSD and Dunnett T3 multiple comparisons showed that there was a significant difference in the degree of anemia

only between A+ and O+ blood groups. Further binary logistic regression analysis revealed that after categorizing the degree of anemia into severe and non-severe, O+ and A+ blood groups were significantly associated with severe anemia, with a risk of severe anemia 1,831 and 1,488 times higher than that of AB+ blood group, respectively, while B+ blood group was not significantly associated with severe anemia.

Declaration of Generative AI in Scientific Writing

All content generated or modified by AI was thoroughly reviewed, verified, and revised by the authors to ensure consistency with research data, accuracy of scientific expressions, and compliance with academic ethics. The authors retain full responsibility for the final content of the manuscript. No AI tool was used to generate core research data, interpret experimental results, or draw critical scientific conclusions

Declaration of Interest:

None.

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